CHAPTER 1

BACKGROUND TO SEA

SEA helps to warn decision-makers at an early stage about unsustainable development options. Ultimately, this saves time and money as problematic options are disregarded at a point in time when only few resources have been spent on their development[1].

SEA is globally recognized as one of the most useful processes to promote sustainable development . About 100 of the 193 UN countries have legislation making provision for the use of SEA. In the remaining countries, where SEA is applied, it is on a voluntarily basis. Legislation and associated regulations provide a formal national (and in some cases sub-national/regional) platform setting out the circumstances in which SEA must be undertaken, the policies, plans and programmes (PPPs) to which it must be applied, and the specific requirements for how the process should be conducted, including roles, responsibilities, required documentation, monitoring procedures, etc. Chapter 2 discussed these issues in detail. This guidance will be of utility to SEAs applied in both cases – by legal requirement or voluntarily.

1.1 What is SEA and how does it differ from Environmental Impact Assessment (EIA) and Cumulative Impact Assessment (CIA)

SEA is defined as a process for assessing the environmental and social risks and impacts of implementing policies, plans and programmes (PPPs) and providing information to decision-makers so that the implications of such impacts can be considered and responded to when formulating and implementing PPPs[2] (Box 1.1). But SEA can also be usefully applied in circumstances where no actual PPP has yet been prepared (e.g. to assess the impacts of options for renewable energy development). The basic steps in SEA are illustrated in Figure 1.1. These steps are elaborated in detail in Chapter 3.

Whilst the term SEA does not specifically incorporate the social dimension, this is nevertheless an integral focus of the process[3]. To indicate clearly that social considerations are fully included in SEA, some organisations (particularly multi-lateral development banks) prefer to use the synonymous term Strategic Environmental and Social Assessment (SESA). In this guidance, the term SEA is used as this is overwhelmingly used in individual countries in legislation and regulations.

Box 1.1: The purpose of SEA

In summary, the purpose of SEA is to ensure that environmental and social considerations (and their relationship with economic concerns and drivers) inform and are integrated into strategic decision-making in support of environmentally and socially sound and sustainable development. Thus, SEA identifies the relevant environmental and social effects/impacts (both positive and negative) on receptors[4] of implementing a PPP

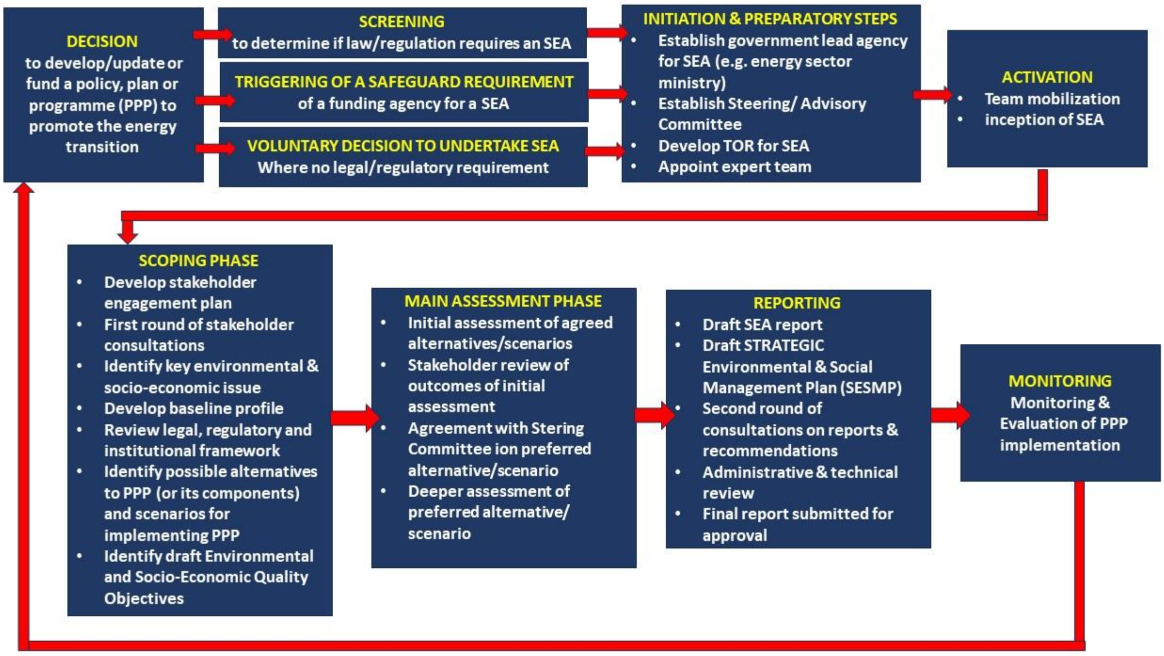
In particular, the SEA process assists authorities responsible for PPPs, as well as decision-makers, to consider:

[1] UNDP/REC (1996).
[2] OECD-DAC (2006)
[3] In the past, some statutory bodies required that SEA should focus only on environmental issues.
[4] A receptor is a component of the environment or social fabric that could be adversely affected by the implementation of a PPP, e.g. habitats, biodiversity, land, soil, water, air and climate, material assets, cultural heritage and landscape, communities, human health, rights, etc..

- Key environmental and social trends, opportunities and constraints that may affect or may be affected by the PPP;
- Environmental and social objectives and indicators that are relevant to the PPP;
- Likely significant environmental and social effects of available options in the implementation of the PPP;
- Priority environmental and social receptors[5];
- Measures to avoid, reduce or mitigate and manage adverse effects and to enhance positive effects;
- Views and information from relevant authorities, the public and — as and when relevant — in potentially affected states (e.g., where cross-border initiatives or impacts are involved).

In the context of applying SEA to PPPs concerned with the energy transition, a core aim of SEA is to support spatial planning by identifying areas where renewable energy development and associated infrastructure (e.g. transmission lines, access roads, electricity storage facilities, and ports, harbours and terminals) may pose a high risk, especially areas of high environmental and social sensitivity, and recommending how such risks can be mitigated and managed..

Figure 1.1.: Steps in SEA



The scope of application of SEA collectively encompasses policy, legislation, plans, programmes and development-related strategies across a range of sectors (such as, energy or transport), geographical areas (national, regional, or local) or issues (such as, climate change or biodiversity). But SEA is most commonly – although not exclusively – applied to development-related policies, plans and programmes (PPPs) with a particular focus on the energy, transport, waste and water sectors and spatial and land use zoning plans. Lead government agencies usually initiate the SEA process, but external financing organisations (e.g., multilateral development banks and bilateral donors) may also require an SEA to be undertaken to comply with their safeguard policies.

[5] Receptors are environmental or social components (e.g., habitats, wildlife, groundwater, communities, people, livelihoods) that could be affected or impacted by a causal factors (e.g. pollution, dust).

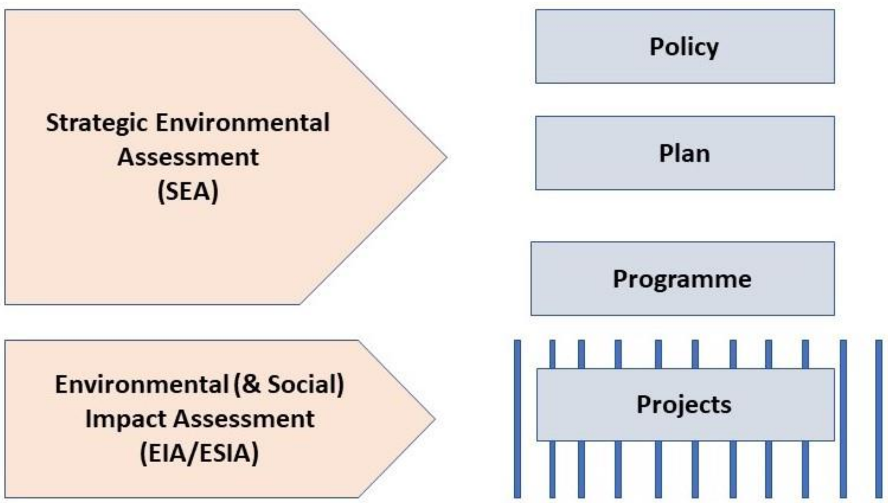
Generally, the application of SEA within a country depends on the types of PPPs being undertaken and the specific SEA provisions (laws and regulations) of that country.

The SEA process is based on key principles (see also Section 1.4) including:

- Early proactive consideration of the environmental and social effects of strategic actions;
- Broad institutional and public engagement;
- Analysis and integration of qualitative and quantitative information;
- Early warning of potential cumulative effects and large-scale changes, and
- Identification of best practicable options for implementing the PPP, including projects that may be undertaken as a result of their implementation.

As noted by the OECD/DAC guidance for SEA (2006), there is a hierarchy of levels in decision-making comprising policies, plans, programmes, and projects (Figure 1.2). Logically, policies shape the subsequent plans, programmes and projects that put those policies into practice. Policies are thus at the top of the decision-making hierarchy. Policies, plans, and programmes (PPPs) are more 'strategic' than projects as they determine the general direction or approach to be followed towards broad goals.

Figure 1.2: SEA, EIA and the decision-making hierarchy



SEA is applied to these "higher" strategic levels and deals with assessing broadly defined proposals with a wide range of options usually available for assessment. As one moves down the hierarchy from policies to projects, the nature of decision-making changes, as does the type of environmental assessment needed. Environmental Impact Assessment (EIA)[6] is used to assess the impact of projects that put PPPs into tangible effect. It is done at the project level and deals with assessing well-defined proposals where a limited range of alternatives are usually available to assess.

There is no one approach to SEA. Rather it embraces a family of approaches (on a continuum of increasing integration of environmental, social and economic considerations) and uses a variety of tools. This is in contrast to EIA which tends to follow a single, fixed, prescriptive approach. SEA extends the aims and principles of EIA further upstream in the decision-making process, beyond the project level, when major alternatives to a project are still possible. SEA fills a critical gap left by the relatively codified procedures and process of project-level EIA procedures and processes differ, in that SEA uses much

[6] As with SEA, EIA should address both the environmental and the social dimensions of projects. Some organisations prefer to use the term Environmental and Social Impact Assessment (ESIA) to emphasise this point. However, sometimes, stand-alone social impact assessment (SIA) are undertaken as well as other more focused (spin-off) forms of impact assessment such as biodiversity impact assessment and health impact assessment. Good practice EIA should cover all these aspects.

more flexible, adaptive, and diversified approaches to inform strategic decision-making at the PPP level. In other words, there is no single recipe for an SEA. Every SEA needs to be designed and undertaken in a manner that to suits the specific context and needs.

SEA can complement and strengthen EIA at the project level by: (a) identifying prior information needs and potential impacts, providing the planning context and parameters for subsequent EIAs of projects designed to implement a PPP; and (b) making EIA and the project review process more streamlined and efficient by addressing many issues at a higher strategic level - including concerns that may relate to project justification so that EIAs can be designed to focus on local and site- or project-specific concerns.

Table 1.1 compares and contrasts SEA and EIA and summarises their roles in decision-making.

Table 1.1: SEA and EIA compared

SEA	EIA
Applied to PPPs and sometimes legislation, with a broad and long-term strategic perspective.	Applied to specific and relatively short-term (life-cycle) projects and their specifications.
Ideally, takes place at an early stage in strategic planning.	Takes place at early stage of project planning once parameters are set.
Considers a broad range of alternatives to the PPP, or alternative scenarios for a PPP, taking into account environmental and socio-economic objectives	Considers limited range and types of alternatives - those for achieving the objectives of the individual project
Conducted independently of any specific project proponent.	Usually prepared and/or funded by the project proponent.
Focus on decision on policy, plan and programme implications for future lower-level decisions.	Focus on obtaining project approval, and rarely with feedback to policy, plan or programme consideration.
Multi-stage, iterative process with feedback loops.	Well-defined, linear process with clear beginning and end (e.g., from feasibility to project approval).
May not require a SEA report in a formally prescribed format (as there is no single approach to SEA). Sometimes may require that a draft PPP include an environmental statement.	Preparation of an EIA document with prescribed format and contents is usually mandatory (EIA usually follows a standardised approach). This document provides a baseline reference for monitoring.
Emphasis on meeting sustainability objectives in policies, plans and programmes. Includes identifying macro-level development outcomes.	Emphasis on mitigating environmental and social impacts of a specific project, but with identification of some project opportunities, off-sets, etc.
Should incorporate consideration of cumulative impacts relating to implementation of PPPs.	Considers cumulative impacts of a particular project in combination with all other projects and activities in a given time and space.

1.2 SEA AND CUMULATIVE IMPACT ASSESSMENT (CIA)

Cumulative impact assessment (CIA) is typically applied at the individual project level as part of the environmental impact assessment process (EIA). It is often used to assess how the specific (and possibly limited) impacts of an individual project (pressures/stressors), when combined with other related projects and activities (including for example in the same geographical area or acting on the same receptor), might combine to generate significant cumulative impacts on selected valued environmental and social components (VEC) (receptors) in a given time and space.

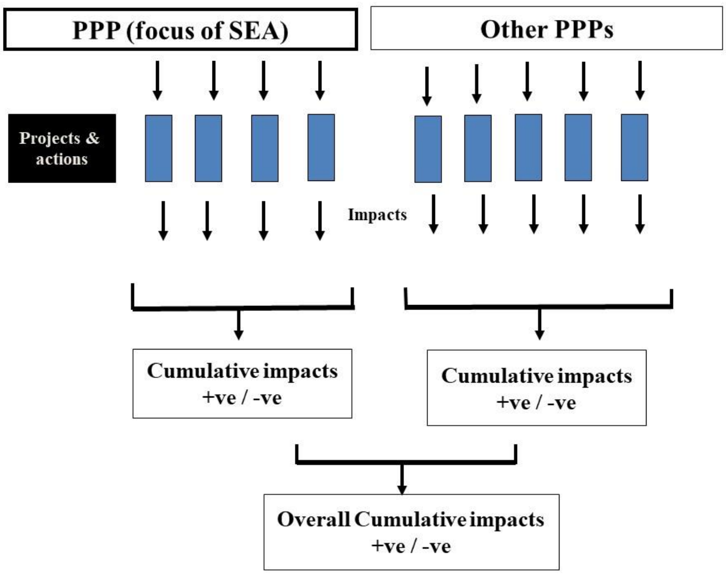
Sometimes, regional impact assessments are needed to identify the effects that various projects or actions can produce at a regional level beyond the areas of the individual projects. The identification, evaluation and management of such impacts is normally done under a SEA process.

Any pressures/stressors on a receptor will contribute to its state at the time of assessment. But when developing and implementing a PPP (through multiple projects), it is critical to have a perspective on how receptors will be affected in the future. This is why CIA is a core and fundamental component (a key principle) of SEA – by setting thresholds for future projects for environmental and social factors. These thresholds can then be used by project-level EIAs in a much more effective and robust way than can be achieved by 'traditional' project-level CIA.

Guidance is being prepared by The Biodiversity Consultancy[7] and IUCN plus a range of industry and NGO partners to address this gap in the context of the renewable energy transition. If CIA is done well at the strategic level, developers can integrate the identified thresholds directly into ESIA in a much more robust way than can be achieved via 'traditional' project-level CIA-in-ESIA.

SEA focuses on evaluating government policies, programs, and plans (PPP) rather than individual projects. It seeks to identify and recommend management measures for the impacts on selected VEC that are likely to arise from implementing PPPs or their alternatives. Figure 1.3 indicates how a particular PPP (being subjected to an SEA) will lead to a range of projects and development actions (to develop renewable energy and associated infrastructure), each of which may give rise to impacts (environmental and/or socio-economic, and positive or negative). Projects and actions resulting from implementing other renewable energy PPPs as well as PPPs for other non-energy sectors may also give rise to such impacts. The overall cumulative effective of all such impacts may be considerable.

Figure 1.3: The cascade of cumulative impacts



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[7] Home - The Biodiversity Consultancy

Thus, as an example, if the effects of renewable energy development projects are assessed to have significant potential cumulative impacts in a particular geographical area or nationally (e.g. by destroying habitat for endangered wildlife species), these impacts may be even more significant (and may even threaten extinction of a species in an area or nationally) when the cumulative impacts arising from developments in other, non-energy sectors, are also taken into account. Thus, an SEA must look beyond the specific energy transition PPP it is concerned with and consider whether implementing other energy PPPs as well as non-energy PPPs may compound potential cumulative impacts.

Through addressing potential cumulative impacts, a SEA can recommend overall mitigation requirements including acceptable thresholds of impacts that should apply to individual projects. However, managing and mitigating impacts at the project level so that they remain below a threshold is the responsibility duty of the individual project developer (which should be monitored via the appropriate regulatory process). Managing cumulative impacts beyond the project level will require collaborative actions between multiple parties and will require coordination by a responsible agency or regulator to be successful.

1.3 BASIC OBJECTIVES AND PRINCIPLES FOR SEA

SEA aims to systematically integrate environmental and social considerations (and their relationship with economic concerns and drivers) into policymaking, planning, and decision-making processes to better ensure that a proposed PPP is compatible with sustainable environmental and social management. It aims to support time-efficient and cost-effective development planning by avoiding the need to reassess some issues and impacts at the project level at a time when changes to the overarching policy and planning framework is more difficult (e.g., when an issue or impact was effectively dealt with at a strategic level).

Early suggestions for SEA principles have been made[8] and performance criteria for SEA were developed by IAIA in 2002[9]. The latter concentrate primarily on procedural aspects of an effective or good quality SEA. Building on these, SEA Guidance developed by the OECD Development Assistance Committee provide a set of SEA principles which have broad support[10]. They recommend that. to be influential and help improve policymaking, planning and decision-taking, an SEA should:

- Establish clear goals;
- Be integrated with existing policy and planning structures. Ideally the SEA process/steps should be aligned closely with the planning process so that key information is provided at the critical stages of policy-making and planning, in the right (usable) manner and delivered to the appropriate decision-makers to support them in their roles/tasks (see Box 1.2);
- Be flexible, iterative and customised to context;
- Analyse the potential effects and risks of the proposed PPP, and its alternatives (including the do-nothing' option), against a framework of environmental and social quality (sustainability) objectives, principles and criteria, at an early stage when an agency has greater flexibility;
- Such analysis includes identifying environmental and socio-economic impacts (positive and negative; direct, indirect, and cumulative; trans-boundary and other unintended consequences) and proposing mitigation measures for negative potential impacts and to enhance environmental and social management. It should identify how to achieve the best environmental and/or social benefits whilst minimising damaging environmental and/or social risks and impacts;
- Identify environmental and socio-economic opportunities and constraints;

[8] Sadler and Verheem (1996); and Dalal-Clayton and Sadler (1998)
[9] Available at: C:\IAIA\Pubs\SP1.PDF
[10] OECD DAC (2006)

- Address the linkages and trade-offs between environmental, social and economic considerations (and their relationship with economic concerns and drivers);
- Provide explicit justification for the selection of preferred options (alternatives) and for the acceptance of significant trade-offs (e.g. between different sectoral policy objectives);
- Involve key stakeholders and encourage public consultation;
- Include an effective, preferably independent, quality assurance system;
- Be transparent throughout the process, and clearly communicate the results;
- Be cost-effective; encourage synergies, and avoid duplication of efforts;
- Propose an effective, formal, independent, quality-assurance, review, and performance-evaluation mechanism for after SEA completion; and for monitoring of PPP outputs and environmental and social indicators, and
- Provide opportunities to build capacity to conduct SEA and to use the SEA results.

In designing effective SEA approaches, practitioners need to be aware of the following:

- Strategic planning is not linear, but a complex and iterative process influenced by interest groups often with often conflicting interests and different agendas; it is therefore important to look for 'windows of opportunity' to initiate SEA during cycles of the decision-making process and to influence and inform PPP development and decision-making. SEA needs to be flexible and responsive to these opportunities;
- Relationships between alternative options and environmental and social effects are often indirect; so, they need to be framed in terms relevant to all stakeholders (e.g. politicians, government agencies and interest groups). One way of doing this is by linking environmental and social effects to policy priorities;
- Strategic issues cannot be tackled by a one-off analysis; they need an adaptive and sustained approach as strategies and policymaking take shape and are implemented; and
- The value of SEA in strategic planning depends greatly on capacity within the responsible authorities to maintain the process and act on the results, and willingness to engage with the process; and
- The success of an SEA depends upon its effective implementation which will require preparation of a strategic environmental and social management plan (SESMP – see Chapter 3, section 3.5).

Box 1.2: SEA integrated with land use planning in Namibia

A ***parallel but integrated SEA model*** has been applied several times in Namibia over the past 10 years. In all cases, the SEA was commissioned to run in parallel with the development of an Integrated Rural Land Use Plan (IRLUP) for five different regions of the country. Whilst the SEA teams had their own terms of reference, they worked closely with the IRLUP teams. Combined meetings involving both teams (each comprising consultants) and the client (the Ministry of Lands and Resettlement) were held at the inception stage. These meetings enabled the teams to plan their respective activities and ensure appropriate coordination between them. Examples of combined activities included:

- Joint stakeholder consultations with rural communities (typically villages);

- Focus group meetings with government agencies and private sector interest groups;
- Baseline data gathering, data and sharing; and
- GIS outputs (mostly maps).

Draft IRLUP reports were shared with the SEA team, and SEA analysis was provided back to the ILRUP teams. The cross-fertilisation of evolving ideas, analyses and outcomes resulted in IRLUPs that generally incorporated sustainability thinking. It also meant that environmentally inappropriate development ideas could be ‘red flagged’ or, in some cases, scrapped altogether before the final IRLUP was compiled. Whilst this parallel SEA approach resulted in a stand-alone SEA report, another outcome could have been a “sustainability driven” IRLUP with no SEA report at all.

Source: Peter Tarr, SAIEA, Namibia

1.4 IMPACTS-LED VERSUS OBJECTIVES-LED SEA

Most of the world's SEA systems are ***'impacts-led'***. Like EIA, they start from an existing baseline of environmental and social conditions and make predictions about how a proposed or revised PPP will change this baseline over time. They have a strong focus on assessing impacts and recommending mitigating measures to remedy the negative impacts. Impact-led SEAs are dominant in lower- and middle-income countries.

Some SEA systems, in addition or instead of, are ***'objectives-led'***: they predict whether the PPP will help or hinder achieving a range of Environmental and Social Quality Objectives (ESQOs) (discussed in section 3.3.4). Although the ESQOs may overlap with the PPP’s objectives, they essentially act as an independent sustainability/environmental/socio-economic benchmark against which implementation of the PPP can be tested. In situations where critical baseline data may be lacking, inadequate, outdated, or unreliable, and/or where environmental aspects are less tangible 'on the ground' for spatial mapping purposes (e.g. greenhouse gas emissions), an objectives-led approach to the SEA is preferable. An objectives-led approach may also be more suitable for those PPPs that specify desired outcomes or endpoints. For such PPPs, the SEA can help evaluate whether these PPP outcomes will be impeded or aided by pursuing the ESQOs.

Impact-led SEA is more re-active and less influential, whilst objectives-led SEA is more proactive and more influential.

A key consideration in deciding if a baseline led approach is possible and therefore if an objective led is necessary, will be the nature of the PPP including the level of detail and specificity. A high-level policy is likely to require an objective led approach as it will be impossible to assess change in the baseline and attribute impacts to the PPP. Whereas for a more geographically specific programme of potential projects it is more likely that a baseline / impact approach will be possible / appropriate.

1.5 THE RELATIONSHIP BETWEEN SEA AND THE PPP PROCESS

PPPs include a range of instruments, e.g., national, and sectoral policies, spatial development frameworks, environmental and social management frameworks, integrated development plans, master plans and land use plans. Frequently, SEA is formally required for such PPPs (see Chapter 2). But it can also be applied where multiple similar projects are concentrated in time and space and for very large developments or ‘mega projects’ (e.g., transnational pipelines) which can give rise to extensive and cumulative impacts (direct and indirect) over large geographical areas. In this guidance, the latter are included under the umbrella of PPPs. In many ways such SEAs are like regional assessments.

A critical question is when should SEA be carried out? There are two options: *ex ante* and *ex-post.*

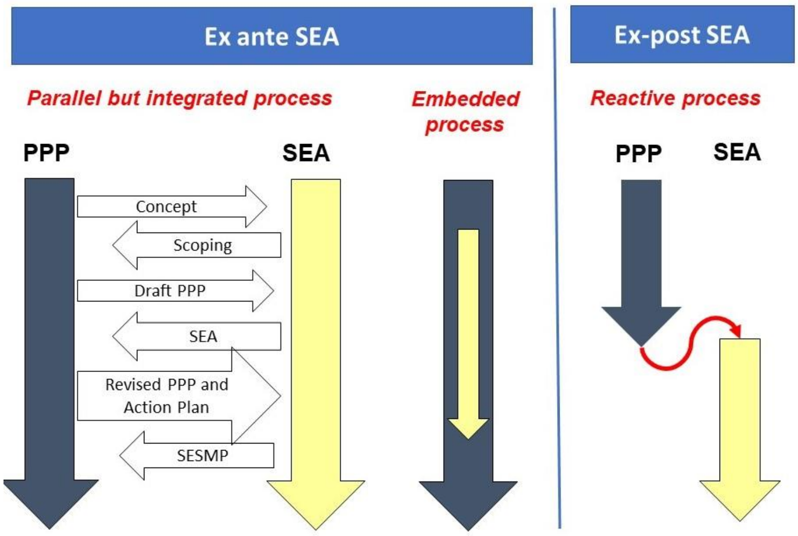
- **Ex-ante SEA**: Ideally, a SEA is most beneficial when undertaken prior to or during the preparation of a PPP. The processes of developing a PPP and undertaking a SEA should be mutually reinforcing to promote more sustainable development. The environmental and socio-economic information and analysis provided by the SEA can optimally inform the preparation of the PPP, can help focus decisions on the most sustainable options (alternatives) to be the focus of the PPP, and can assist in clarifying (restructuring, rewording) PPP drafts to promote effective implementation. The SEA can identify new opportunities – particularly to maximise benefits and minimise, avoid, or mitigate negative impacts and promote positive outcomes, and can highlight where there may be potential risks and conflicts or inconsistency between PPPs. This can prevent costs of rectifying mistakes.

- **Ex-post SEA**: An SEA can also be undertaken on a PPP that has already been drafted or on an existing PPP that is already being implemented. This is a reactive process (Figure 1.2). Such SEAs are less influential on a PPP than those carried out in parallel to PPP development. A reactive SEA sometimes results in less potential for the uptake of their recommendations; however, it can still be beneficial to identify environmental and social problems that have arisen and identify where modification of the PPP may be required. This will be particularly useful where revision of a PPP is being considered.

No matter which “model” of SEA is followed, the desired outcome is a better PPP, rather than production of a SEA report, as well as better environmental and socio-economic outcomes.

As Figure 1.4 shows, it is common for an *ex ante* SEA to be organised in parallel with the PPP process. In these circumstances, the SEA should be planned so that it is integrated with the PPP process as fully as possible, with the steps in the two processes fully synchronised. Thus, the emerging outputs of the SEA process can feed directly into the PPP preparation process at the most opportune stages. Usually, a government ministry/department/agency) that is developing or revising a PPP will be responsible for undertaking a SEA - if one is specified as required by national laws/regulations (i.e., because the PPP is expected to result in significant environmental and/or social impacts).

Figure 1.4: How SEA can relate to the PPP process



In practice, governments will usually need to commission experts to carry out the SEA process. The teams involved in both the PPP and SEA processes should work together, as closely as possible, be fully aware of what each other is doing, and seek opportunities to organise common events, e.g., stakeholder meetings and workshops to achieve the best possible PPP and SEA outcomes. However, in many situations, SEAs are still undertaken in isolation from the process of developing the PPP to which they relate, thus reducing their utility and influence. Undertaking an SEA in isolation from the PPP process should be avoided.

Development of the PPP normally enables public authorities to analyse development trends, opportunities, and threats and to propose development interventions and implementation arrangements. The SEA process should ideally examine individual outputs of the PPP-making process and it may propose necessary amendments to maximize their environmental and social benefits and to minimize their negative environmental and social impacts and risks. As such, the development of PPPs and the SEA process follow a very similar logic, and this is the basis for the approach recommended in this guidance.

The lead process is the elaboration of the PPP, and the SEA should fit into the logic and steps of this PPP-making process. In this respect, it is important to treat the SEA as a flexible process which needs to be tailored to the needs of the different types of PPP.

Planning procedures tend to be well codified with a linear sequence of steps as suggested by the arrows in Figure 1.2. Each of these steps provides a 'window of opportunity' for the outputs of a SEA to influence the focus and content of the PPP. Ideally, to have maximum utility, an SEA process should be fully embedded within the PPP process so that its outcomes immediately and directly can influence PPP development without having to seek opportunities to do so. In effect, they would be a single intertwined process. But there are few, if any, examples where this is yet the case. Thus, as indicated above, SEA is currently better carried out in parallel with PPP development, with their steps aligned and integrated.

Policies are often general and directional and rarely include specified activities. So, from a procedural perspective, an SEA at the policy level will have little in common with the simple, linear, technical nature of a project level EIA. It will require a greater focus on understanding the policy formulation process and identifying windows of opportunity for influencing decision-making on the policy. It is also argued that SEA at the policy-level also requires a particularly strong focus on institutional factors and facilitating constituency building and strengthening of stakeholders in the policy process[11].

There may be situations where multiple development activities in a particular sector or across a particular geographical area are reported to be giving rise to environmental and social impacts, but are not currently being addressed, controlled, or regulated because a PPP has not yet been developed or is not yet proposed. In these circumstances, an SEA can be very helpful to assess and establish the nature and extent of environmental and social issues arising and to provide recommendations on policy/planning measures that could be taken to address such concerns. It can also set the stage for the project level environmental and social impact assessments that may follow.

1.6 COSTS OF SEA

Undertaking SEA usually involves the costs for the following inputs and steps:

- Fees and operational costs (e.g., travel/accommodation, workshops/meeting costs and administration) for the practitioners engaged to undertake the SEA.
- Designing the approach and methodology and testing tools - usually during the initial stages of SEA application. Costs may be reduced by using previously tested methods;
- Gathering basic data sets and analysing the baseline. In many SEAs, field work is often limited to ground-truthing visits, especially where there is good available information. Where there is limited basic data, field work may be necessary, and this can add significant costs (and time). However, most of this work occurs during the first SEAs undertaken in a particular region/sector. Subsequent SEAs (e.g., when a PPP is revised) can build upon the data gathered by previous SEAs and the additional costs will be limited to obtaining specific new data that may be required;
- Carrying out analyses and providing inputs to support the elaboration of the PPP concerned (always needed);
- Implementation and monitoring frameworks for SESA recommendations;
- Training in circumstances where capacity and understanding of SEA is low, and
- Consulting stakeholders and managing the entire SEA process (always needed).

[11] OECD/DAC (2006); World Bank (2011)

There is very limited information on the actual costs of SEAs – it tends to be a confidential matter. But the cost will vary due to the length of the process and the complexity of the chosen design: from as little as US$ 20,000 - $50,000 (e.g., for a rapid, desk-based SEA) to US$1 - 2 million (for a full SEA of a complex PPP over say an entire year or longer). Comprehensive SEAs typically average US$ 500,000 to US$ 700,000. Contingency reserves are very important as SEAs often require additional or unforeseen tasks to be undertaken. They should be budgeted for – at least 10-15% of overall SEA budget. Additional costs may be foreseen for any follow-up activity to the SEA to evaluate the effectiveness of its implementation. It is particularly important to ensure that costs for a fully inclusive and transparent stakeholder consultation process are included.

A study for the European Commission on the costs and benefits of EIA indicated that introducing SEA to regional and local land-use planning usually increased planning costs by 5 to 10%[12]. and these costs are marginal in comparison with the costs of the implementation of plans or programmes (i.e., financing all activities and projects proposed by the planning document). It also found examples of good SEAs that increased planning costs by less than 5%, but the costs depend on the amount and detail of alternatives elaborated and the extent of their assessment.

A study by Therivel and Walsh (2005) on the first year of application of the European SEA Directive in the United Kingdom surveyed 201 authorities that had conducted SEAs. It concluded that most SEAs required approximately 70–80 person days to complete (roughly half for scoping and half for the environmental report). According to the Netherlands Commission for Environmental Assessment, experience shows that small municipal SEAs can be carried out in as little as 30 working days; medium-scale SEAs require 50 - 100 working days; while more complex large-scale SEAs require between 150 - 300 working days depending on the amount of information to be processed[13].

The costs of SEA can be regarded as marginal compared with the overall costs of implementation of PPPs, the costs of dealing with unintended negative impacts and consequences (e.g., environmental reparation, social compensation, or health costs as a result of increased air pollution due to increased industrial output), and other costs such as delays in subsequent projects - SEAs may address issues in advance to avoid this.

1.7 SCALE AND TIME REQUIRED FOR AN SEA

There is no one-size-fits-all approach to SEA. In all circumstances an SEA will need to be carefully thought through and designed according to a range of possible background factors:

- *The particular focus of the SEA*, e.g., whether a PPP or other instrument such as a strategy, or a spatially extensive development such as a large regional infrastructure initiative, or a cross-border initiative such as a proposed railway, pipeline or trans-national protected area. In some circumstances, there may be a complex, larger scale environmental challenge that does not fit into existing/proposed PPPs – a common situation in lower- and middle-income countries that lack a strong tradition of strategic planning. In such cases, an SEA may be commissioned to feed into a decision-making framework developed on a case-by-case basis.

- *The PPP preparation and decision making process* (key steps, who involved, timescales etc) as this will dictate the SEA design.

- *Key factors influencing the SEA* like a) geographic and/or jurisdictional scope, b) existing data, c) timeframe for rolling out renewable energy to meet a country's climate targets;

- *The context*, including geographical factors that may limit access (e.g., in particular seasons), or requirements to gather new data including seasonal or multi-year data;

- *The availability of existing information* and any gaps which may require additional time and cost to address;

[12] EC (2006)
[13] NCEA 2020

- *The capacity of the requesting institution* – sometimes this can prolong the process until internal consensus of the requirements of the SEA is met;

- *Available time and budget* (it is important to understand that time and budget constraints imposed on an SEA will limit what can be done and its utility), and

- *Political and security considerations*.

Thus, a complex SEA, especially one covering multiple sectors, may take over a year to undertake, sometimes much longer, and require a large team of experts (Section 1.6). A longer pre-SEA period may be necessary to collect data that may be required, particularly when time series information or data covering several seasons is deemed necessary. At the other end of the spectrum, in some circumstances, it is possible to conduct SEA as a rapid exercise. For an example a rapid, desk-based SEA of Namibia's Fourth National Development Plan was undertaken over a month. It was led by two SEA experts working with invited subject-expert focus groups (Dalal-Clayton and Tarr 2015). Table 1.2 compares Full SEA with rapid SEA.

Table 1.2: Full and rapid SEA compared

Stage/component	Full SEA	Rapid SEA
Overall nature and aim	• A comprehensive assessment following international principles/standards of good practice. • Usually undertaken when required by law/regulation or by safeguard policies/framework of funding agencies	• Light dive aiming to provide critical information on key issues and the main likely impacts • Particularly useful where there are budget or time limitations. • May point to the need for a subsequent full SEA.
Timeframe and budget	• Generally 6-12 months (sometime longer depending on complexity) • Considerably more for a rapid SEA. Varies according to the length of the process and the complexity. Comprehensive SEAs typically average US$ 500,000 to US$ 700,000	• 1-2 months, depending on complexity • Usually a small budget (US$40-60K)– to cover professional fees and venue hire
Steering/Advisory committee	Very useful to have in the case of a complex and large SEA that spans many sectors and government agencies, and possibly also representation from the private sector and NGOs	Not needed
Baseline studies	Required.- maybe a combination of existing and new studies	Not required, primarily desktop review
Specialist studies/research	Additional specialist studies may be required, especially where critical data is lacking or out of date, or where seasonal issues require to be addressed.	Not required
Stakeholder consultation	• Required. They are a basic principle of SEA and should be extensive: at least two rounds during the SEA process - once during scoping to help identify key issue and enable stakeholders to present their perspectives; and again towards the end to	• Generally not required – except if there are directly affected parties and the impacts on them are likely to be significant • Focus group meeting(s) of key involved players

Stage/component	Full SEA	Rapid SEA
	present/discuss the findings and recommendations.	
Team and resources required	Usually a much larger multidisciplinary team, with a senior team leader and other members clustered thematically Budget triple or more than for a rapid SEA.	Usually a small team of experts from key disciplines will suffice..
Process	• Starts with initial literature review, baseline study/report if literature readily available. May require specialist studies (see above) • Stakeholder engagement (see above), and carefully-planned focus group meetings • Review of the legal and regulatory framework and institutional roles and capacities, • interactive brainstorming/ workshopping within the team and including key stakeholders. • Can be impacts-led or objectives-led, or both. • For objectives led SEA. development of Environmental and Socio-economic Quality Objectives (ESQOs) as basis for assessment • Consideration of alternatives and scenarios. • Use of linkage diagrams to indicate impact flows and routes to cumulative impacts. • Impact identification and assessment of likely impacts and significance (scoring) etc. of alternatives/scenarios, possibly with deeper drive for preferred alternative/scenario • Preparation of environmental and social management plan (SESMP) •	• Usually some initial literature review, • Interactive brainstorming/ workshopping within the team and possibly including a few “outside” subject experts to add information and value. Identification of key environmental and socio-economic issues • Development of linkage diagrams to indicate impact flows and routes to cumulative impacts. • Assessment of likely impacts and significance (scoring) etc. enable the team to quickly identify key issues, alternatives, assessment likely impacts and measures for mitigation/impact management • Generalized management actions and road map of key actions and next steps
Report	• Usually a substantial and well illustrated report and SESMP with many appendices – depending on the subject and context. • In some cases, the key outcome is the revised PPP, rather than a comprehensive SEA report.	• Usually a very brief report (10-30 pages, plus annexes) • Should include narrative and tables • Unlikely for there to be a detailed Strategic Environmental and Socio-Economic Management Plan (SESMP) but a road map of key management actions could be prepared.
Formal review and approval	• Depends on the jurisdiction. • In only a few countries is a formal technical review of an SEA required (e.g. Bhutan), prior to an approval. • In some countries it is required to provide the final draft to stakeholders for review. In any	• Depends on the jurisdiction, but unlikely to be required. • Usually a rapid SEA would serve the purpose of an “advisory memorandum” that is similar to an executive summary.

Stage/component	Full SEA	Rapid SEA
	case, it is good practice to make this available on a SEA website. • Often the SESMP requires some monitoring and evaluation – possibly for decades into the future.	

1.8 WHO SHOULD CARRY OUT SEA?

The SEA process needs to be owned by the authority responsible for the PPP concerned. This will help to avoid the SEA report being ignored and shelved. Such 'ownership' means that the authority concerned should 'lead' the process (provide strategic direction, coordinate with other government agencies, undertake necessary formalities, assist with access to information, etc.). However, in most situations, the responsible authorities lack SEA experience and skills, and a team of knowledgeable and experienced experts needs to be engaged to conducted the SEA. This team needs to coach the responsible authority on the role, benefits, and modalities of SEA to help increase its awareness and capacity regarding SEA. Such coaching will, in turn, enhance the authority's ability to lead and guide the team of SEA consultants on aspects of the SEA.

A team of knowledgeable and experienced experts should comprise core experts with environmental and social knowledge and skills, and experience of conducting SEAs. One of these should take the role of Team Leader with responsibility for overall coordination, liaison with the SEA proponent, team management, quality control, etc. A range of other subject specialists may be required to make shorter specific inputs/studies on required subjects.[14] Ideally, the team should comprise national experts with the relevant range of environmental and social expertise. In circumstances where national experience and skills in undertaking SEA is limited, it will be advisable to engage a few experienced international consultants to work with the national team members (at least lead environmental and social experts, one of whom should be the team leader to guide the process). The team should ensure that they have capacity in the local language.

The SEA team should be integrally linked to the team developing the PPP and they should be invited to all planning meetings and other relevant activities and have full access to all relevant documents or other sources of information produced or referred to within the PPP process.

The SEA team should have the right to express any view in the SEA Report. While the PPP team should make the decisions on what to present in the final PPP, the latter should provide reference to the findings of the SEA, and it should explain how the results of the SEA were used in the development of the PPP and explain / justify why recommendations from the SEA are not accepted/incorporated - emphasizing the importance of transparency.

Wherever possible, the SEA team must be responsible for leading out and coordinating consultation efforts related to the SEA (see section 1.10). This will ensure that stakeholders fully understand who is conducting the SEA, on whose behalf and the purpose it to fully gain stakeholder support and buy-in to the SEA process (see below).

In some circumstances the SEA proponent may elect to establish a broad-based, multi-stakeholder Steering Committee for the SEA to provide oversight, advice, support, and guidance (see Chapter 12). This is a form of collaborative governance that is crucial to tackle multi-sector challenges and to ensure inclusive stakeholder engagement throughout the SEA process. It also helps to ensure that the process and outcome are more influential.

[14] Examples of expertise that may be required include (note that this is not a comprehensive list): energy technologies, coal-fired power plants and coal-mining, health and safety, biodiversity, transport, tourism, protected areas, planning, urban issues, archaeology and cultural heritage, GIS, public consultation, governance, institutional and legal issues.

1.9 ENGAGING WITH STAKEHOLDERS

For SEA to be successful and meaningful, and support progress towards sustainable development, it will need to engage with a wide range of stakeholders. These should include all those with a legitimate interest and who may be affected by PPP outcomes and those involved in decision-making at all levels (from national to local), and from government, civil society, and the private sector, as well as with funding and aid agencies that may be funding the SEA or supporting the implementation of the PPP. Many of these actors will have roles to play in developing and/or implementing the PPP or will be likely to be affected by its implementation.

PPPs concerned with the energy transition are likely to affect all inhabitants in a country. But in many low- and middle-income countries where public consultation is a rather new concept/practice, it is almost impossible to give all inhabitants the opportunity to be engaged in the process. Therefore, the option that CSOs represent the voice of the people is a reasonable and acceptable approach. However, this decision will not be simple and will require engagement with a range of stakeholders to ensure that this representation of interests will be acceptable to all.

For the PPP to be well constructed and to address the most important issues and be successfully implemented, it will be necessary for stakeholders (including representatives of local communities and the public) to understand the process, to be able to engage meaningfully with it, and to influence its outcomes. In other words, stakeholder ‘buy-in’ to the SEA process is vital.

1.9.1 Roles and responsibilities of key stakeholders

Table 1.3 sets out the roles and responsibilities of stakeholders, including government agencies, communities and individuals, private organizations, non-governmental organizations, and others having an interest or stake in the SEA process and outcomes of the PPP.

1.9.2 Methods to engage with stakeholders

Stakeholder participation should be a continuing process that runs throughout all stages of the SEA (as described in detail in section 3.3.6).

The SEA process should be ideally conducted in conjunction with consultation organized for the preparation of the PPP itself. Also, existing communication channels can offer efficient means for conducting consultations for the SEA. However, at times, additional methods will be required. Participation processes should be used that provide the best means to ensure that stakeholders can engage effectively, and that their viewpoints are given proper consideration.

The method of engagement should be to a large extent dictated by the purpose - i.e. information giving, information gathering, consultation, participation, collaboration or delegated authority. Different methods lend themselves to these different purposes. Annex 1 describes various approaches that can be used to engage with stakeholders, including:

- Printed material inviting comments;
- Displays and exhibits;
- Information hotline/ staffed telephone lines;
- Internet/web-based consultations;
- Questionnaires and response sheets;
- Surveys;
- Public hearings;
- Workshops and focus group sessions;
- Advisory committees;
- Social media, and
- A dedicated and interactive website.

Table 1.3: Roles and responsibilities of key stakeholders

Stakeholder	**Role and responsibilities**
Lead agencies	PPPs are mainly developed by sector ministries and implemented by their respective line agencies. The responsibility for instigating a SEA of a PPP, therefore, should lie with the relevant sector ministry. The lead agency is responsible to undertake the SEA, usually through the commissioning of a team of expert consultants to undertake the technical process. Where SEA is formalized by legislation and a government agency is designated to be responsible for the system, the lead agency will usually also be required to submit a SEA report (and accompanying strategic environmental and social management plan) to that designated body to be reviewed and approved. The lead agency will likely be involved in implementing the SESA recommendations together with other responsible agencies and institutions. Increasingly, influential SEAs are the responsibility of an inter-agency steering committee where sharing of responsibility and decision-making is a starting point. Where international organisations (e.g., multilateral development banks or bilateral donors) are involved in supporting the SEA or in funding PPP implementation, the lead agency will be usually be required to submit the SEA report to such organisations for review and approval (particularly where such organisations are required to satisfy their own environmental and social safeguard requirements) and to meet funding requirements.
Statutory bodies with designated responsibility regarding SEA	Legislation covering SEA usually will assign formal responsibility for overseeing the national SEA system, developing regulations, providing guidance, and reviewing SEA reports to a particular government agency (often the Ministry/Department of Environment or Environmental Protection Agency).
Civil society (including communities, individuals, marginalized groups,)	All those members of civil society (either individually or through representative bodies) who have an interest in or might be affected by a PPP should be provided with opportunities to be informed about the PPP. They should be able to engage in the SEA process (expressing their concerns and perspectives on issues and proposals), commenting on draft SEA reports, and being informed of its results, etc. To foster engagement, information should be available and communicated in ways that different stakeholders (e.g. indigenous people) can access and understand (e.g. summarised in local language). Legislation and/or the environmental and social safeguards policies of financing organisations may expect or require indigenous communities to give their prior and informed consent to certain projects and activities arising when implementing a PPP.
Indigenous peoples	Sometimes indigenous peoples' organisations are erroneously lumped into civil society organisations (CSOs). But Indigenous Peoples (IPs) form distinct societies, with their own laws, languages, epistemologies, ontologies, and methodologies, including in the area of Renewable Energy. They can often be adversely affected by renewable energy developments. Strong efforts are required to ensure that indigenous peoples are engaged in an SEA, fully informed, enabled to present their perspectives and concerns.
Environmental assessment practitioners, academics, and researchers	Lead agencies will usually depend on environmental assessment practitioners (national and international) to undertake an SEA. There may a need for specialized research or case studies to provide key data for an SEA which would usually be undertaken by national experts, academics, and researchers.
Development finance organizations and donors	It is common practice for international development finance organizations (e.g. MDBs) or donors to require SEA for sectoral support and large development programmes They may provide funding for individual SEAs. They will usually be required to approve the terms of reference (TOR) for the SEA and to review SEA reports. National finance organizations, including banks and trust funds, may also require SEA if they are funding part of PPP implementation.
Private sector	The private sector is likely to be involved in implementing many aspects of PPPs (particularly in the energy sector) by investing in the business opportunities that they create. It is important that their views on the PPP are considered

Stakeholder	Role and responsibilities
	The private sector can also be responsible for a SEA of a PPP where a sector has been privatised (as in some countries, e.g. the rail sector in the UK)).
NGOs/CSOs and other independent organizations (e.g. trade unions, religious organisations)	NGOs and independent organization should be involved as stakeholders in SEA, where appropriate. Often, they hold important information and can make expert contributions to the assessment process and analyses.

It is important to note that public hearings or questionnaires which are often used for consulting the public during EIA processes may not deliver the most effective consultations within the SEA process. Instead, problem-solving workshops, roundtables, an advisory panel, focus groups or structured interviews with key informants, and online exchanges may provide more efficient and user-friendly means for obtaining inputs from the relevant stakeholders during the SEA. It will be important to organize targeted meetings/sessions with women (facilitated by a woman) in communities or with women's or other vulnerable groups as, in many societies, they are often reluctant (or even restricted) to express their views in mixed gender events.

Usually, the following analyses benefit from stakeholder input (particularly as a consequence of their local knowledge):

- Determination of key environmental and socio-economic issues related to the PPP;
- Analysis of environmental and socio-economic trends without the PPP and under different development scenarios, and assessment of alternatives;
- Assessment of future environmental and social trends as influenced by the actions proposed in the PPP;
- Identification of appropriate mitigation and enhancement measures, and
- Suggestions for monitoring and follow-up for SEA implementation.

Stakeholder input in each of these stages can be facilitated by formulating clear questions to help them in submitting or making their comments.

A grievance mechanism should be established to enable stakeholders to complain if they feel that their opinions have not been sufficiently addressed nor responded to.

1.10 INSTITUTIONAL ARRANGEMENTS FOR SEA

As indicated in Table 1.2, the government ministry developing or revising the PPP will usually be the ***lead agency*** responsible for instigating an SEA. For renewable energy PPPs, this will normally be the ministry with a mandate for energy, or a sub-directorate specifically responsible. The lead agency will be responsible for conducting the SEA (usually through hiring consultants to undertake the technical work). However, increasingly, inter-agency steering committees are being established for SEAs to share responsibility and decision-making and to foster buy-in to the process - with the lead agency as the chair/convenor. In some situations, it has been found useful to establish an advisory committee in which representatives of the key authorities (executive staff), other authorities and NGOs are represented.

Where there is a formal SEA system, usually prescribed by legislation and regulations (or their equivalent), a government agency will normally be designated as the '***competent authority***' for SEA (usually a department within the ministry responsible for environmental affairs, or a specialist environmental protection agency) and will have responsibility to develop guidelines and, in some countries, to review and approve SEA reports. Depending on the particularities of the legislation/regulations, such competent authorities may also be designated to issue approvals or authorisations (normally in writing and possibly notified in the government gazette (or equivalent). To ensure close integration of social, labour and health issues, multiple ministries may require to be consulted and coordinated early in the SEA process.

For an renewable energy sector PPP, the SEA Steering Committee should be convened and chaired by the lead agency (ministry responsible for energy) and include members from all key sector ministries, financing organisations (e.g. MDBs, donors), renewable energy associations, private sector companies (or the representative body) involved in investing in renewable energy facilities, national NGOs, civil society organisations, indigenous peoples and others (as appropriate, e.g women's organizations and vulnerable groups, special interest groups and labour unions). Its role will be to provide overall support and guidance for the SEA process, to facilitate access to critical information, to review reports, to build ownership of the SEA process amongst key actors, to disseminate information about the SEA process and its results and to advocate for the uptake of its recommendations, and to review the latter.

Having a Steering Committee in place helps to provide transparency for the SEA process and provide a mechanism for holding the government to account over how it addresses the recommendations put forward in the SEA. It also helps to build credibility, trust and transparency and provides an additional senior-level platform for all stakeholders to channel their views into the SEA process.

The ***Strategic Environmental and Social Management Plan*** (SESMP) produced alongside the SEA report will set out the proposed institutional arrangements, roles and responsibilities for its implementation, and grievance mechanisms. These will aim to ensure maximum efficacy to deliver environmental and social safeguards and required mitigation and management actions to minimize environmental and social risks and impacts and maximize opportunities for benefits. A SESMP often acts as an action and investment plan. See also Chapter 12 for more on SEA and institutions.

Tips for practice

- *The lead process is the elaboration of the PPP, and the SEA should fit into the logic and steps of this PPP-making process. In this respect, it is important to treat the SEA as a flexible process which needs to be tailored to the needs of the different types of PPP.*
- *Focus on the key stakeholders that may be interested or significantly affected by the proposed PPP.*
- *Complete a stakeholder mapping exercise very early on in the SEA process to identify all interests, including those that may not be reached.*
- *Remember that the primary purpose of consultation is to obtain additional data and inputs for improving analyses and for developing alternative options with improved environmental and social performance.*
- *Do stakeholder mapping to ensure that all affected parties are included in consultation.*
- *Target the consultations on the most important analyses performed within the SEA process.*
- *Try to use established consultation channels where possible.*
- *Discuss the stakeholder identification and engagement strategy with the team developing the PPP. Consultations within the SEA should be ideally carried out together with those during the PPP process.*
- *Ensure there is a stakeholder feedback mechanism to make consultees aware of how their views have been taken account of in the SEA/PPP throughout its preparation and implementation and that the results of the SEA are fully communicated to them.*

CHAPTER 2

LEGAL REQUIREMENTS AND COMMITMENTS TO APPLYING SEA

2.1 THE LEGAL BASIS FOR SEA

EIA was first introduced in the USA under the National Environmental Policy Act (NEPA) in 1969. The Act applies to "proposals for legislation and other major federal actions significantly affecting the environment". The US Council on Environmental Quality interpreted this to include policy, programmes, and plans (PPPs). Whilst EIA practice in the US tended to focus mainly on projects, programmatic environmental impact statements (focused on PPPs) also became an integral element of the implementation of the Act.

During the 1990s, SEA (or SEA-like processes) were introduced, by legislation, as a separate process from EIA in a small number of high-income countries, e.g., Australia, Canada, Denmark, Netherlands. But since then, nearly all high-income countries have adopted SEA and the number of low- and middle-income countries adopting SEA is rapidly increasing, with around 100 countries across the world now having legal provisions its application. Whilst many of these countries have formalised SEA through regulation and have established mandatory procedures, in others the legislation remains more of a framework nature with regulation pending. Processes across countries vary considerably. In those countries with no formal provision for SEA, it is often applied on a voluntary basis and some countries have developed an active body of voluntary SEA practice (e.g., Colombia, South Africa and Thailand). Thus, several categories of practice can be recognized:

- Mandatory regulation for SEA including a procedural regulation;
- General provisions for SEA but no procedural regulation;
- Application of EIA regulation for policies plans and or programmes;
- Voluntary regulation of SEA, often based upon a policy and guidelines, but no procedure;
- No regulation of SEA, but voluntary practice.

Some countries have made statutory provision for SEA under EIA or planning law. In these systems, EIA-like requirements and procedures usually are followed and apply particularly to SEA for plans and programmes. Other countries have established SEA through administrative order, Cabinet directive, or policy guidelines. In these systems, SEA is applied as a separate or modified process from EIA, as in Denmark, Hong Kong, The Netherlands, and the UK (which also has a comparable process of sustainability appraisal for land use and spatial plans). In Canada, the Impact Assessment Act ~~(the Act)~~ requires SEA for any government policy, plan or program – proposed or existing – that is relevant to conducting impact assessments, or any issue that is relevant for impact assessments of designated projects or classes of designated projects[1]. All these countries also use a less formal, minimum procedure of SEA of policy or legal acts.

2.2 INTERNATIONAL DIRECTIVES, PROTOCOLS, SAFEGUARDS, DECLARATIONS AND COMMITMENTS

A number of international directives and protocols have set legal requirements to undertake SEA. Most notable is the EU SEA Directive 2001 which introduced a standardised approach and was transposed into domestic law by 2004 in all 27 members states of the EU. The Directive applies to a wide range of public plans and programmes (but not policies): those prepared for agriculture, forestry, fisheries, ***energy***, industry, transport, waste/ water management, telecommunications, tourism, town & country planning, or land use and which set the framework for future development consent of projects.

[1] https://www.canada.ca/en/impact-assessment-agency/services/policy-guidance/fact-sheet-strategic-assessment.html

The provisions of the Directive strongly influenced those of the SEA Protocol to the UNECE Convention on EIA in a Transboundary Context[2] (agreed in 2003). The latter is similar to the EU Directive on SEA, but with distinctive features, such as a special emphasis on health impacts alongside environmental ones. The protocol is legally binding on convention signatories with regard to plans and programmes and is discretionary concerning policies and legislation.

Some UN conventions have started to recognize the value of SEA. The Convention on Biodiversity has prepared voluntary guidelines on the integration of biodiversity in EIA and SEA, 2006[3]. In March 2023, a new treaty on protecting marine life in international waters (High Seas Treaty) was concluded under the Convention on the Law of the Sea (UNCLOS), and due to be formally adopted in June 2023. Under the treaty, participating parties are obliged to conduct environmental impact assessments when a planned activity may have an effect on the marine environment, or when there is insufficient knowledge about its potential effects. In such cases, the party possessing jurisdiction or control over the activity is required to conduct the assessment. Parties under the treaty are required to consider conducting a SEA for plans and programmes related to their activities in areas beyond national jurisdiction but are not obliged to conduct one[4].

SEA and EIA remain the only sustainable development 'tools' that have legal status with government bodies dedicated to their regulation and oversight.

A number of multilateral development banks have adopted environmental and social safeguards which either promote or require borrower countries to undertake SEAs, SESAs or equivalent processes for particular proposed initiatives that they are financing (e.g., the World Bank, Inter-American Development Bank (see Table 2.1)).

Table 2.1 International financial institutions requirements for and reference to SEA

IFI	Requirement for or Reference to SEA
UN Development Programme	• Social and Environmental Standards (2019)[5].. • Social and environmental screening procedure (2019). P.21, entry 58.
World Bank	• Environmental and Social Safeguards framework (2017): ESS 1: Part B. Entry 23.
African Development Bank	• Integrated Safeguards System Policy Statement and Operational Safeguards (2013)[6].
Asian Development Bank	• Safeguard Policy Statement (June 2009) (p66). Currently under review.
Inter-American Development Bank	• Environmental and Social Policy Framework (2020)[7]: (Ch 3.5). • Implementation Guidelines for the Environment and Safeguards Compliance Policy, Revised version, July 2019. Policy Directives B.3 and B.5. [new guidelines are currently under review]
European Investment Bank	• Statement on Environmental and Social Principles (2009)[8] • Environmental, Climate and Social Guidelines on Hydropower Development (2019)[9] - Cumulative Basin Wide impacts, P.7.

[2] 1609217_UNECE_HR.pdf. The UNECE Protocol on SEA was negotiated under the 1991 UNECE Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) to extend the scope of the Convention, but it is a legally distinct instrument. It is an international agreement open to all UN member states – so far 37 states and the EU are signatories. The Protocol provides for legal obligations and a procedural framework for the implementation of SEA in countries that are Parties to it.

[3] CBD voluntary guidelines for the consideration of biodiversity in environmental impact assessments (EIAs) in marine areas (CBD COP Decision XI/18)

[4] High Seas Treaty - Wikipedia

[5] Pre-Launch.pdf: P 58

[6] https://www.afdb.org/fileadmin/uploads/afdb/Documents/Policy-Documents/December_2013_-AfDB%E2%80%99S_Integrated_Safeguards_System__-_Policy_Statement_and_Operational_Safeguards.pdf.:P.8, P. 17, P.24.

[7] https://www.iadb.org/en/mpas

[8] https://www.eib.org/attachments/strategies/eib_statement_esps_en.pdf. Article 20.

[9] https://www.eib.org/attachments/eib_guidelines_on_hydropower_development_en.pdf.

Other international organisations have also made commitments to promote SEA. For example, the Paris Declaration on Aid Effectiveness was adopted in 2005, and reaffirmed in Accra in 2008, at ministerial-level forums convened by the Organisation for Economic Co-operation and Development (OECD). It committed bilateral donors and partner countries to "develop and apply common approaches to SEA". More recently, the fifth session of the UN Environment Assembly (March 2022) adopted a resolution supporting strategic planning of sustainable infrastructure by applying SEA[10].

By identifying and focusing on the key environmental and social concerns related to a PPP, SEA is able to identify where opportunities can be maximised and risks/impacts avoided or mitigated in relation to environmental and social commitments made under international legal conventions and agreements to which a country is a signatory, and to regional and UN organisations. Similarly, for the same reason, SEA can also support countries/agencies to ensure that individual PPPs contribute positively to the achievement of the Sustainable Development Goals and meet international commitments to combat climate change and promote corporate social responsibility.

2.3 SCOPE AND CONTENT OF LEGAL INSTRUMENTS

Laws prescribing the use of SEA vary considerably in their scope and content. In some countries they are of a framework or enabling nature and merely make provision for its introduction. They assign responsibility for SEA to a designated authority (e.g., ministry or agency) - establishing a new government body or designating additional responsibility to an existing agency - but leave such a body to make subsequent regulations for the formal activation of the SEA system. In other countries, laws are more detailed and set out all the major provisions for the SEA system. Thus, either a law or a regulation will usually:

- State the objectives of the law/regulation;
- Set out any general principles;
- Assign functions, powers, roles, responsibilities and staffing for aspects of the SEA process;
- Establish any related or supporting bodies (e.g., Advisory Council), their composition, terms of reference, and regulatory of meetings;
- Indicate the types of PPPs for which SEA is mandatory;
- Define terms used in the law/regulation;
- Set out required steps and procedures;
- Establish appeals procedures (e.g. concerning decisions);
- Indicate reporting requirements;
- Describe administrative arrangements;
- Set any fees or payments that may be due.

A regulation for SEA may cover some of the above elements, but would usually focus much more on specific aspects of the SEA process such as:

- Preliminaries, e.g., definitions, objectives, role of SEA proponents, access to information, modalities and general requirements;
- Screening: for which PPPs require SEA;
- Public participation requirements;
- Scoping requirements;
- Steps in the main assessment stage;
- Reporting requirements;
- Monitoring and evaluation;
- Notification and registering of documents and decisions;
- Administrative matters;
- Annexes (e.g., forms).

[10] Proceedings, Report, Ministerial Declaration, Resolutions and Decisions UNEA 5.2 (unep.org)

2.4 THE CHALLENGE OF MEETING GOOD PRACTICE IN SEA

Chapters in Part A of this guidance describe good practice in undertaking SEA. They draw from the best elements of existing international and national guidelines and build on experience from SEA practice over the last 30 years of what works well and what is required to deliver credible and beneficial outputs and influential outcomes. This guidance is also framed around internationally agreed principles for SEA, as described in section 1.3. It can therefore be viewed as a standard to aim for. But this guidance may differ from the specific requirements set out by country SEA regulations or guidelines.

A country's SEA system requirements and regulations may differ from those of an external financier or organisation (e.g., a multilateral development bank). The latter usually set their requirements at a high level based on good practice principles.

There is no one size-fits-all approach or single recipe for SEA. Each one must be designed to be fit and appropriate for purpose and tailored to the specific need and context. The SEA practitioner(s)/consultants must interpret the terms of reference for each SEA, then propose, discuss, and agree on the approach to be followed with the client, and aim to pursue the best practice possible in the prevailing circumstances. The goal should always be to try to undertake the SEA according to the principles in Chapter1, section 1.3.

In some countries, SEA is still a relatively new process where skills and experience may be limited or lacking. So, it must be acknowledged that it might not always be feasible to achieve or meet the ambitions of international good practice. For everyone, SEA remains a journey of 'learning by doing' with progressive improvement through usage and iteration (at least not in the early stages of SEA application in a country).

A compendium of available SEA guidelines for countries, regions, and various organisations is provided on the IAIA website (see: https://www/iaia.org/hot-topics/inventory-of-SEA-guidelines.pdf)

CHAPTER 3

STAGES AND STEPS IN UNDERTAKING SEA

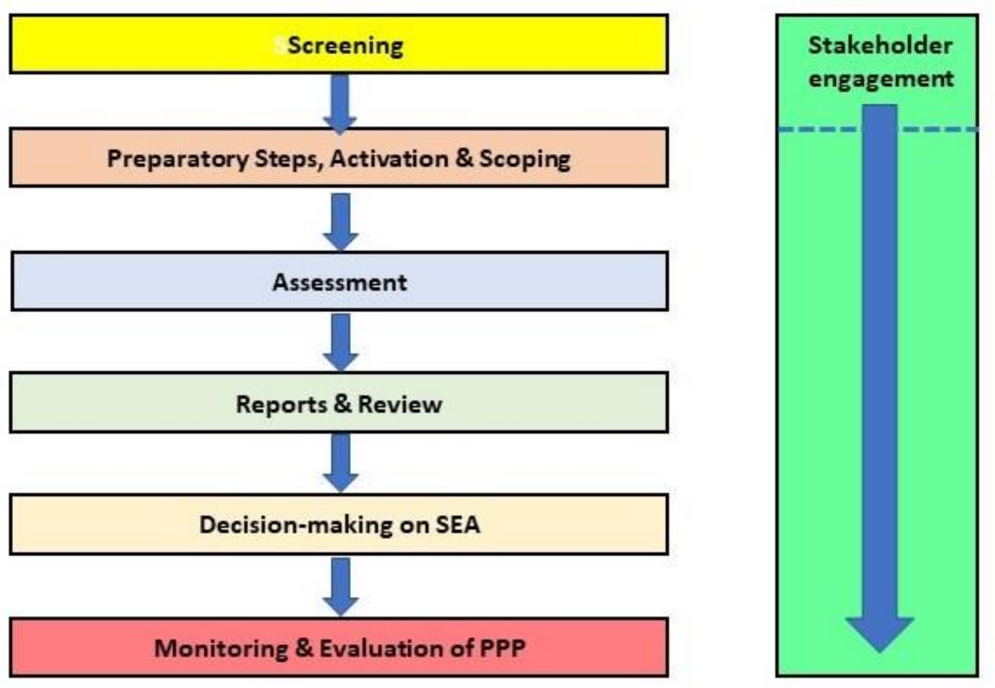
The steps discussed in this chapter are generic to all SEAs and will be applicable to any SEA undertaken for a PPP concerned with the energy transition. They are not repeated in the chapters on renewable energy sub-sectors in Parts B and C. These steps are based on accepted internationally principles for SEA good practice[1]

The content of this chapter is of a technical nature and will be particularly useful to SEA practitioners.

3.1 THE SEA PROCESS AT A GLANCE

The main stages and steps in the SEA process will be determined by any national legal or regulatory requirements and may, therefore, differ from country to country. Typical stages are shown in Figure 3.1, summarised in Table 3.1, and described in the following sections.

Figure 3.1: Typical stages in the SEA process



3.2 SCREENING

Applying SEA can be a lengthy and expensive procedure (although rapid, less costly SEAs can sometimes be warranted). So, a SEA should be conducted when it is formally needed by law or regulation, is required by the safeguard policies of a lender/financing organisation (e.g. a multilateral development bank), or where concerns are expressed that there is a clear likelihood that an energy PPP or regional energy development proposal will lead to significant environmental and socio-economic consequences.

[1] OECD DAC (2006)

Table 3.1: Summary of stages in the SEA process

STAGE OF THE SEA
STAGE 1: SCREENING • The proponent screens its proposed PPP to determine if it is required by law/regulation to be subjected to an SEA. Depending on national legislative requirements, this may involve determining if the PPP is likely to have significant environmental and social risks or impacts. The proponent may convene an expert group to help with screening and/or seek advice from the competent authority. • The environmental and social safeguard policies/frameworks of a funding organisation (e.g. a MDB) may also trigger the need for a SEA or equivalent – whether or not one is formally required by a country's law/regulation. • In other circumstance (e.g., where there is no legal mandate/requirement for SEA), it may be apparent and agreed that a proposed PPP or proposed major development activities in a geographical area, would benefit from information/recommendations generated through a SEA undertaken on a voluntary basis. • In any of the above circumstances, where it is determined that an SEA is required, the proponent should proceed to Stage 2. • In cases where the SEA is examining the energy transition, screening should also examine how, when and where renewable energy sources will deployed and replace fossil fuel-based power generation, and examine what considerations are in place to ensure sustainability of doing so and that processes are in place to meet just transition requirements.
STAGE 2: PREPARATORY STEPS, ACTIVATION AND SCOPING **Preparatory steps** (***undertaken by the proponent***) **(elaborated in Box 3.2)**: • Develop SEA Terms of Reference (refer to Annex 2 for an example). • Establish an in-house management group (one or more people) to oversee the SEA process. • Establish an SEA Steering Committee, and/or an Advisory Committee. • Appoint a team of experts to undertake SEA, and to activate the process. **Scoping** *(some elements may be done in parallel;* ***not all elements will be appropriate for all SEAs*** *):* • Undertake stakeholder mapping/analysis and prepare a stakeholder engagement plan and communication mechanism; • Undertake stakeholder consultations and a scoping workshop – to explain the SEA (reason and process), identify baseline data and PPPs held by stakeholders and to enable consultees to assist in scoping key issue and identifying environmental and social quality objectives (ESQOs); • Analysis of the country's relevant laws, policies, regulations, strategies, plans and programs (including their objectives and key themes of relevance to the PPP being assessed); • Review of the country's institutional framework, mandates and responsibilities; • Analysis of the country's environmental and social safeguards; • Review of relevant literature on the environmental and social baseline; • Identify key sources of data and information and identify data gaps; • Initiate collection of baseline data and new research/field studies (where required); • Identify key environmental and socio-economic issues that the PPP should take into consideration • Decide on the approach required for the particular SEA and appropriate methods to be used; • Identify international conventions, treaties and protocols to which the country is a signatory; • Based on key themes and issues, develop draft environmental and social quality objectives targets and indicators to provide a framework for assessment and monitoring of the PPP; • Start identifying potential alternatives (to PPP or to possible PPP components); • Identify scenarios under which the PPP might be implemented (scenarios can also be used as alternatives during assessment);

- Initiate an institutional survey of all relevant government agencies and other organisations likely to have a role in implementing the strategic environmental and social management plan (SESMP) (functions, roles and responsibilities, and capacities);
- Establish dedicated SEA prospectus;
- Establish SEA website;
- Preparation of scoping report and circulation/disclosure for stakeholder and public comment;
- Subjection of the scoping report to public comment, and
- Update of scoping report in response to comments**.**

STAGE 3: ASSESSMENT

Assessment steps will need to be designed according to the context, nature of the PPP and other factors; but would usually involve:

- *Initial assessment of agreed alternatives* to PPP or its components (possibly leading to an *interim SEA report* – circulated to stakeholders for comment). The proponent should select a preferred alternative(s) and provide an explanation of how the findings of the initial assessment of alternatives and consultations were considered in its selection.

- *Deeper assessment of preferred alternative(s)* – more focused and detailed **-** (leading to *SEA port and SESMP* recommending detailed mitigation measures needed to avoid significant adverse **effects.**

The assessment should involve:

- Continued analysis of available baseline data, filling of data gaps and collection of critical new data from research/field studies;
- Continued stakeholder engagement;
- Identification of potential environment and social risks and impacts (positive and negative; direct and indirect, cumulative, transboundary). This is best done to compare two situations: (a) *risk situation* when no safeguards are applied and no mitigation measures applied; and (b) *mitigated situation* when safeguard and mitigation measures are fully and effectively applied;.
- Identification of whether the ESQOs will be likely to be enhanced or impeded by implementing the PPP under consideration;
- Identification of options for enhancing positive impacts and avoiding/minimizing/mitigating negative impacts;
- Preparation of the framework for the SESMP/SESMP.

STAGE 4: REPORTS AND REVIEW

Draft reports

- Preparation of *inception report* (if required) and *scoping report* (during Stage 3);
- Preparation of *first draft SEA report* (with non-technical executive summary) and *ancillary reports* (e.g., reports on special studies);
- In some circumstances, a stand-alone draft *Strategic Environmental and Social Management Plan* (SESMP) may be warranted, and
- Disclosure of the reports on the SESA website or by other means (print copies of Executive Summary etc.).

Review

- *Administrative and technical review* of first draft reports by the proponent and competent authority may be required to ensure compliance with basic requirements.
- Release of the draft reports to key stakeholders for comment and feedback, and organisation of one or more stakeholder workshops to present and discuss the reports.

Finalisation of SEA report and SESMP

- Preparation of final version of SEA report (and SESMP where required).
- Additional review by the proponent, other institutions and civil society stakeholders may be warranted.

Regulatory review

- In some countries, the competent authority may formally review the final SEA documents. For complex PPPs/SEAs, the competent authority may decide to commission an independent review by external experts or a technical advisory committee or independent commission (e.g., where there are likely to be trans-boundary impacts (*this would require agreement/collaboration with other affected countries. Such SEAs would need to be undertaken in collaboration with appropriate agencies in the other affected country, and the review mechanism agreed to at the outset*).

STAGE 5: DECISION-MAKING ON SEA

- The proponent will make a decision on the acceptability of the SEA report and SESMP/SESMP prepared by consultants. But the competent authority may be required (depending on national legislation/regulations) to make the final decision on the adequacy/acceptability of the SEA/ and SESMP by issuing an approval (with conditions, if necessary).

STAGE 6: MONITORING AND EVALUATION OF PPP

- The SESMP will set out roles and responsible for monitoring and evaluation of the implementation of the PPP. This is likely to involve a range of ministries and organisations and their agreement to undertake monitoring, evaluation and follow-up will be required;
- The competent authority may have a statutory duty to oversee the monitoring and evaluation process.

Arguably, given the scale and speed of the energy transition, SEA (or SEA-type exercises, and complementary/component processes such as spatial planning) are essential for renewable energy roll out and expansion. Government-led SEA for the energy transition is recommended but must be pragmatic and proportionate. 'Full scale' SEA may be an unrealistic expectation in many emerging market countries, not just because it is a lengthy and expensive procedure, but also because of often limited available capacity and resources. Furthermore, there is a small and narrowing window of opportunity for carrying out such strategic assessments before either development proceeds in earnest in any case (potentially unsustainably), or country climate targets/obligations are missed.

A country’s SEA law and/or regulations will indicate whether SEA is required for all types of PPP or for specific categories of PPP. Screening is used to determine whether a proposed PPP (or revision of an existing one) falls into one of these categories. In some countries, the proponent of a PPP (usually a line ministry/department) may be required to undertake some initial analysis to determine if there is potential for a PPP to result in significant environmental and social effects which might trigger a formal requirement for an SEA. Screening should be undertaken by the proponent of a PPP.

Where a country has no regulatory mandate for SEA, an SEA-type exercise may still be extremely beneficial – e.g., in terms of how best to meet obligations, targets or goals under international/national obligations (Paris Agreement, Global Biodiversity Framework, Sustainable Development Goals, etc.) or for increasing lender/developer confidence. The energy transition is global and, potentially, countries without an existing legal requirement for SEA could be the ones where the benefits of SEA are greatest in terms of promoting sustainable development. There is a need for pragmatic and scalable approaches to SEA that can be implemented in countries without legislation for SEA, or where it is still emerging.

Lenders' environmental and social safeguard policies/frameworks will also indicate whether an SEA (or equivalent, e.g., SESA) is required and Lenders will usually engage with the relevant government ministry(ies) about initiating the process, and may provide funding for it.

Where national laws or regulations do not specifically prescribe which PPPs require a SEA, then the criteria listed in Box 3.1 can be used to determine whether a SEA would be beneficial. A screening form is provided in Annex 3, based on these criteria. It can be used to document the result of the screening procedure and includes a record of the decision on whether an SEA should or should not be carried out.

Box 3.1: Screening criteria

1. Characteristics of the PPP itself:

- Degree to which the PPP sets a framework for projects and other activities, either with regard to the location, nature, size and operating conditions or by allocating resources.
- Degree to which the PPP influences other policies, plans and programmes including those in a hierarchy.
- Relevance of the PPP for the integration of environmental and socio-economic considerations (and their relationship with economic concerns and drivers), with a view to promoting sustainable development.
- Environmental and social concerns relevant to the PPP.
- Relevance of the PPP for the implementation of national legislation on the natural or human environment (for example, PPPs linked to waste management or water protection) or social conditions.
- Extent to which the proposed PPP is likely to be politically or publicly acceptable or contentious.
- The PPP is unprecedented.

2. Characteristics of the effects and of the area likely to be affected:

- Probability, magnitude, duration, spatial extent (geographical area and size of the population likely to be affected), frequency, uncertainty and reversibility of the effects.
- There are inherent uncertainties and the level of confidence in predicting the effects of the proposed PPP is low.
- There are important information gaps, making it difficult to predict impacts.
- Cumulative nature of the effects, and whether they are likely to be significant (both additive and synergistic effects);
- There are likely to be trans-boundary effects (i.e., the PPP is likely to affect other administrative units, regions or countries).
- Risks to the environment, social conditions or human health (e.g., due to accidents), safety and/or the integrity of social or ecological systems are considered to be high.
- Social and/or ecological systems have low resilience and high vulnerability to disturbance or impact (e.g., poor communities, vulnerable groups or sensitive ecosystems).
- Value and vulnerability of the area likely to be affected due to:
  - Having unique, special, or highly valued natural elements (e.g., threatened biodiversity, critical or sensitive habitats);
  - Protected areas (e.g., nature reserves, heritage sites, Ramsar sites) or areas of recognized local, district, national, or international importance for conservation and biodiversity importance;
  - Areas of unique, special or highly valued cultural or spiritual elements;
  - Existing levels of environmental quality are close to defined limits of acceptable change (i.e., there is a definite risk that limits of acceptable change will be exceeded); or environmental quality standards have been exceeded; or
  - Areas subject to intensive land-use and rapid change.
  - Vulnerable groups that could be affected
- Effects on areas or landscapes that have a recognized national or international protection status.

- The PPP is likely to result in major changes in actions, behaviours, or decisions by individuals, businesses, NGOs, or government that could lead to:
    - Induced development of infrastructure or other changes in urban or rural land use;
    - Loss or degradation of natural habitat or of areas important for nature conservation;
    - Adverse impacts to biodiversity or provision of ecosystem services;
    - Major changes in the pattern of settlement, land occupation, and/or demographics in an area;
    - Major changes in the development or use of technology that could have negative implications for worker, community and individual health and/or safety;
    - Introduction of alien and potentially invasive organisms;
    - Changes in society's consumption of energy and in particular fossil fuels, and therefore, in emissions of pollutants, carbon dioxide and other greenhouse gases;
    - Changes in the rate of society's consumption of and/or demand on natural resources, including water and materials; or
    - Transport, storage, processing of hazardous and non-hazardous waste materials.

3.3 PREPARATORY STEPS AND SCOPING

3.3.1 Understanding and clarifying terms of reference

Unfortunately, in many cases, terms of reference for SEAs remain poorly constructed. It is, therefore, critical that when a proponent seeks to commission consultants (usually through a bidding process), that the prospective/applicant consultants review and fully understand the terms of reference and, if necessary, raise points for clarification with the client.

Because bidding involves competition and the client will normally share all points of clarification with other candidates, the consultant may wish to 'protect' any methodological suggestions they might have and suggest meeting instead with the client, if appointed, to discuss these in detail. In such circumstances, if appointed, the consultants should meet with the client at the earliest opportunity to raise their concerns and suggest appropriate modification to the orientation of the SEA and/or the terms of reference. If the suggested changes make sense and are likely to improve achieving the desired outcomes, a client will normally be happy to change the terms of reference to improve them.

3.3.2 Preparatory tasks

As soon as a decision is made to conduct a SEA, preparatory tasks can be initiated by the proponent of the PPP and the SEA team, even before the official start of the scoping process – although many of them will be completed during scoping. Box 3.2 lists a range of preparatory tasks that can be initiated at this stage.

Box 3.2: Preparatory tasks in SEA

Tasks for the proponent

- Determine whether other institutions (including donors) have carried out or intend to carry out an SEA relevant to the PPP in question and, in such circumstances, seek to engage in a joint process.
- Determine who will engage/fund the consultant team (the lead government agency or development cooperation agency?)
- Develop SEA ***Terms of Reference*** (refer to Annex 2 for an example) - based on the basic principles of SEA (see section 1.3).
- Appoint team of experts (***consultant team***) to undertake SEA. It is likely that, where national skills and expertise in SEA are limited or lacking, that proponents will need to rely on external (expatriate) consultants to lead the work. But it will be important to include national consultants to ensure the team has access to critical local knowledge and also to build capacity.

- Establish an ***in-house management group*** – one or more individuals with responsibility for managing the SEA process and any expert consultants engaged to conduct the technical aspects of the SEA. A person should be designated as a point of contact for the SEA;
- Consider establishing a multi-stakeholder ***Steering Committee*** (or an Advisory Committee) for the SEA (to offer leadership, a cross-institutional platform, advice and guidance when needed).

Also:

- Confirm sources of funding (if not from proponent's budget);
- Identify the schedule for SEA start and completion;
- Identify opportunities for integrating the SEA process with the PPP development and decision-making process.
- Undertake initial consultations with key government agencies and institutions likely to be involved in the SEA or implementing a SESMP to explain about the SEA and to build understanding and support.

Tasks for the SEA team (usually consultants) – once appointed:

- Clarify with the proponent a definite and realistic time scale for the SEA (start to completion);
- Clarify any concerns regarding the TOR (even suggesting modifications based on professional experience);
- Agree with the proponent on the required documentation (reports to be prepared).
- Define the mechanisms for consultation and engagement of stakeholders and the participation of both the proponent and SEA consultant in the process.

And start clarifying/identifying:

- What stages of the PPP decision-making process should the various aspects of SEA be aligned with? (Need to map out decision-making process to identify 'windows' of opportunity).
- How to integrate SEA findings/outcomes/conclusions into decision-making at points when options and proposed activities are being developed and evaluated.
- What stakeholders should be involved, when, how, and in what capacity? (a draft participation strategy should be completed during scoping and included in the scoping report). This may require consultations with the government where there are any sensitivities regarding stakeholder engagement.
- Whether other assessment processes apply to the PPP? If so, determine the best way to deal with any overlaps between the assessment systems.
- Whether the SEA should be (a) impacts-led (i.e. like EIA, start from an existing baseline and make predictions about how implementing the PPP will change this baseline); or (b) objectives-led (predict whether the strategic action will help to fulfil a range of environmental and social quality objectives), or (ideally) both?
- Whether the SEA report should be topic-based or task-based? (a suggested list of issues to be covered in an SEA report is provided in Annex 4).
- Likely data requirements and potential sources.
- Goals, objectives and decision criteria (e.g., for selecting the preferred alternative to the PPP or components of it) and who should be involved (other agencies, stakeholders, etc.) (this continues during scoping).
- The timing of the EIA regarding stakeholder consultations, disclosure of results and specifying dates for receipt of deliverables.

3.3.3 Issues for scoping

A scoping process should confirm the focus and establish the content of a SEA, the scope of the analyses needed, the stakeholders to be involved, the approach and methods to be used and the relevant criteria for assessment. It provides an opportunity to focus the report on the important issues to maximise its usefulness to the authorities, decision-makers and public. It does not preclude changes in the scope of the report if the need for them becomes apparent at a later stage.

The scoping process should be open and iterative, involving key stakeholders, to:

- Review the context of the SEA;
- Identify alternatives (to the PPP or elements of the PPP) to be assessed in the next stage;
- Identify key environmental and socio-economic issues. It is important to focus the assessment on these key issues that really matter and avoid scoping 'bottom trawling' to cover all possible (minor) concerns – addressing 'everything and the kitchen sink' will overload the SEA and lead to legitimate criticism that it is overpowering and impenetrable.
- Identify and confirm the focus and content of the SEA;
- Identify relevant environmental and social quality objectives (ESQOs), targets, indicators, and decision criteria to use during the subsequent stages to select a preferred alternative – helped by stakeholder interviews, review of the policy and legal framework, situation analysis, and the identified critical issues, and
- Identify baseline and other data requirements and initiate collection; and identify any critical information gaps.

A pragmatic view needs to be taken on how much can be achieved during an SEA, given the available time, resources, and existing knowledge about key issues (is sufficient and reliable baseline data available? is there a need for research or supplementary field work – and how will this be carried out?).

Box 3.3 indicates the tasks to be undertaken during scoping.

Box 3.3: Tasks to undertake during scoping

- ***Clarify TOR*** with the client (PPP proponent) and agree any adjustments required.
- Clarify PPP objectives.
- Meet with the ***Steering Committee*** (or Advisory Committee) to present the approach to be followed and seek its assistance to support the scoping work.
- Establish a dedicated ***SEA website.***
- ***Stakeholder analysis*** – map primary stakeholders – those who have a direct interest in the PPP and may be affected by it – and what their main concerns about the environmental and/or social issues are likely to be; and secondary stakeholders – those who have an indirect interest.
- Prepare a stakeholder engagement strategy/action plan (SEP) - setting out who should be involved in the SEA (including agencies that have various decision-making mandates within the spatial boundaries of the PPP and the SEA study area), how and when (identifying their roles and responsibilities and practical arrangements) and to conduct preliminary stakeholder mapping (see section 3.3.6);
- Develop and agree the ***methods*** to be used;
- Identify ***key sources of data and information***; determine what data and studies are already available and what the remaining gaps are.
- Initiate ***collection of baseline data*** and ***new research/field studies*** (where required), and determine the ***minimum information*** needed to carry out SEA scoping effectively, and when this needs to be made available during PPP development (*Note: in some circumstances, where critical information is lacking and requires special studies that may need considerable time to undertake (e.g. to gather seasonal data), this may signal a need to consider deferring the SEA or extending the timeframe*] (see section 3.3.8).
- Start ***stakeholder consultations*** (including ***interviews*** with key stakeholders - organizations and individuals) and ***stakeholder workshops*** – to explain the SEA (reason and process), to identify baseline data and PPPs held by consultees, and for consultees to assist in scoping key issues and identifying SEA objectives. Note: stakeholder consultation should be undertaken throughout the duration of the SEA process.

- ***Initial literature review*** – (published, unpublished, reports by government or others, grey literature, donor documents, etc.) to identify relevant environmental and socio-economic concerns, information/data and trends.
- ***Inventory and review of other PPPs*** (to include PPPs related to the PPP being assessed – the target PPP, or that might have an influence on the target PPP, or that might be affected by implementing the target PPP) to document aims, objectives and key themes of relevance to the target PPP (see section 3.3.10 and Annex 5).
- Analyse the ***legal, regulatory and governance framework*** (laws, decrees, directives, regulations, etc.) – and identify ***synergies and conflicts*** in their objectives (this may signal where policy revision may be required to achieve PPP and sustainable development objectives.
- Initiate a ***review of institutions*** that are likely to have a role in implementing the strategic environmental management plan (SESMP), covering mandates, roles, responsibilities and capacity to undertake their functions;
- Identify international conventions, treaties and accords to which the country is a signatory;
- Identify key environmental and socio-economic issues that the PPP should take into consideration, and the main ecosystem services that stakeholders depend upon and in what ways; and screen out issues that are less important at this stage.
- Decide what technical studies/consultations are required to assess the impacts; and identify analytical methods to be used and data needs.
- Based on key themes and issues, develop draft environmental and social quality objectives (ESQOs), targets and indicators to provide a framework for assessment and monitoring of the PPP (see section 3.3.4).
- Build on earlier discussion during the preparatory stage to start identifying reasonable alternatives or scenarios (to the PPP or to possible PPP components). These should be realistic, practicable, and relevant, and should include the ‘status quo’ or ‘do nothing’ option (see section 3.3.7).
- Determine Limits of Acceptable Change (LAC) (see section 3.3.5).
- Clarify the decision-making process for the PPP.
- Identify the relationship between the SEA being undertaken and other SEAs and project EIAs.
- Determine the assessment methodologies to be used (see Annex 6 for an overview of selected analytical and decision-making tools for SEA).
- Preparation of a draft scoping report and circulation/disclosure for stakeholder/public comment.
- Convene a scoping workshop to obtain stakeholder feedback.
- Preparation of final scoping report – updated in response to comments.

3.3.3.1 Identifying and reviewing other PPPs

As indicated in Box 3.3, one of the critical steps in scoping is to identify and review other PPPs that may be relevant to the assessment of the PPP which the SEA focuses on – particularly their aims, objectives, and key themes. The results of this may be presented in a tabular format. Annex 5 provides an example of such a review conducted for the Preliminary SEA of Bhutan’s Road Sector Management Plan (2016). [Note to reviewers: this Bhutan example is there as a place holder. Please suggest (preferably provide) an example relevant to the energy transition)]

3.3.4 Setting SEA environmental and social quality objectives (ESQOs)

As discussed in Chapter 1 (section 1.4), an SEA can be impacts-led or objectives-led. A decision needs to be reach which approach is appropriate, or both. Where the SEA involves an objectives-led approach, Environmental and social[2] quality objectives (ESQOs) should be developed to help to focus the SEA and ensure important issues are not left out in the process. They can provide a framework for the assessment of the PPP and its alternatives, particularly when an objectives-led

[2] Social objectives may also include health, cultural, aesthetic and other values; and may include economic objectives.

approach is preferred[3] or when an impacts-based approach is likely to be problematic (e.g., when there are inadequacies in the availability of baseline data (see section 1.3). In an objectives-led SEA, the assessment determines whether implementation of the PPP will enhance or impede achieving the agreed to environmental and social quality objectives. Consideration of the broad environment and socio-economic categories helps to balance the impact analysis so that issues are not consistently ignored. It may be useful to not only identify objectives but also sub-objectives to assist in the subsequent assessment.

The following processes will help in the development of ESQOs.

- ***Clarification of PPP objectives*** to assist in derivation of the spatial and temporal scale to be covered in the SEA environmental and socio-economic objectives.

- ***Compatibility analysis*** to determine if the objectives of the PPP being assessed are in line with the proposed environmental, social, or other objectives, as well as with those in other government PPPs or commitments to international conventions, regional agreements, etc, or with the UN Sustainable Development Goals (SDGs). This may involve careful examination of the policy and legal framework.

- Relations between the proposed PPP's objectives and the relevant ESQOs may be easily presented through simple matrices that may provide the basic description of impacts. An example of a simple compatibility matrix is provided in Annex 7. Various conflicts and synergies may be also easily visualized using, for example, simple symbols or colours that indicate:

  - Absolute conflict/constraint (red),
  - Considerable conflict/constraints (orange),
  - Considerable positive impact or synergy (light green),
  - Full synergy – the proposed objectives resolves an existing environmental or sustainability problem (dark green),
  - Impact is uncertain (blue),
  - Impact is insignificant (no color).

- Conflicts need to be resolved or specific recommendations given on which areas may require resolution to ensure that the objectives are mutually supportive.

- Stakeholder consultation with relevant lead agencies and the public to determine how they will be affected – to ensure that their concerns are included in setting ESQOs. It will also assist in prioritisation of boundaries, issues, or alternatives to consider as well as outcomes. Stakeholder comments may lead to development of other pertinent social and environmental objectives.

- Obtain consensus from stakeholders.

Some examples of ESQOs and indicators are shown in Table 3.2. More are provided in Annex 8.

[3] An objectives-led approach to SEA may be preferable when the focus is complex and at a very high level covering multiple PPPs, thus making it difficult to separate impacts likely to arise under different PPPs.

Table 3.2: Some example SEA environmental and socio-economic quality objectives and indicators

SEA topics / key issues	Possible environmental and social quality objectives	Possible Indicators (ways of quantifying the baseline, prediction, monitoring)
Biodiversity, fauna and flora	1. Avoid damage to designated wildlife and ecological sites and protected species	1. Reported levels of damage to designated sites/species
Population and human health	2. Create conditions to improve health and reduce health inequalities	3. Life expectancy 4. Hospital admissions
Water and soil	5. Limit water pollution to levels that do not damage natural systems	6. Quality (biology and chemistry) of rivers, canals and freshwater bodies and of soil
Air	7. Limit air pollution to levels that do not damage natural systems	8. Number of days of air pollution 9. Levels of key air pollutants / by sector and per capita
Climate factors	10. Reduce greenhouse gas emissions	11. Carbon dioxide (CO_2) emissions
Cultural heritage and landscape	12. Preserve historic buildings, archaeological sites and other culturally important features	13. Percentage of historic buildings and archaeological sites 'at risk'

Indicators are useful to communicate, in a-simple-way, complex information for decision-making and management. In SEA, indicators help to:

- Describe current levels and trends in environmental and social quality;
- Predict and assess impacts;
- Evaluate progress towards achieving sustainability objectives;
- Relate key strategic issues and Limits of Acceptable Change (LAC) and/or thresholds to the SEA study;
- Enable adaptive and corrective management during PPP implementation;
- Establish criteria for an ongoing monitoring framework.

3.3.5 Limits of acceptable change

Scoping should also determine Limits of Acceptable Change (LAC) or thresholds to inform the evaluation of the potential significant environmental and social effects of a PPP, and/or to determine appropriate indicators. A key principle of SEA is that it sets the criteria for levels of environmental or social quality and identifies what change is considered acceptable.

LAC can be derived from various sources, such as existing international or national standards, legislation, guidelines, targets for environmental quality in management plans or programmes, and State of the Environment (SoE) reports. If there are no appropriate LAC, they can be developed during the SEA through stakeholder engagement, inputs of specialists, and the findings of the situation assessment. LAC and thresholds may also be identified or clarified during the subsequent detailed-assessment stage.

3.3.6 Stakeholder identification and participation

SEA is a participatory process that allows lead agencies, civil society, the private sector, and other relevant stakeholders (to be identified through stakeholder analysis - see section 3.7.5.2) that will affect or be affected by the proposed PPP (or PPP being revised) to contribute to its development/revision and make inputs to strategic decision-making (see also section 1.9).

Stakeholders should be involved throughout all stages of the SEA process. Even during screening, there can be some limited / specific stakeholder engagement (e.g. with statutory environmental agencies).

Relevant regional and/or country representatives should also be included when trans-boundary impacts are anticipated.

3.3.6.1 Minimum requirements for participation

At an absolute minimum, the PPP proponent must meet with the main stakeholders to inform them about the PPP and the SEA being undertaken and to solicit their views about it. Understanding the decision-making authority of different stakeholders, and how they interact with each other and the environment and socio-economic conditions, is essential for good analysis and process management.

PPPs concerned with the energy transition are likely to affect all inhabitants in a country. But in many low and middle income countries where public consultation is a rather new concept/practice, it is almost impossible to give all inhabitants the opportunity to be engaged in the process. Therefore, the option that CSOs represent the voice of the people is a reasonable and acceptable approach. In any case, there should be discussions between the proponent and the SEA consultant as to how consultation will be undertaken, to whom should consultation take place (identification of SEA stakeholders), what preparations will be needed before, during and after consultation and how the results of consultation should be disclosed.

3.3.6.2 Stakeholder analysis, participation strategy and communication plan

A *stakeholder mapping analysis* should be undertaken to identify stakeholders, to determine their potential interest and influence and as a basis for preparing a draft *participation strategy (action plan) and communication plan. We use a number of terms in this chapter – should we stick with stakeholder engagement plan – this is the most common form.*

The methods adopted to engage stakeholders will need to be determined according to their purpose. Box 3.4 provides a typology of varies types of possible participation (with increasing involvement) in an SEA process.

Box 3.4: Typology of participation in an SEA process:

1. Participants listening or reading only (e.g., receiving information from the SEA team, a government PR campaign or open database).

2. Participants listening and giving information (e.g., through public meetings, media activities, "hot-lines").

3. Participants being consulted (e.g., through workshops, focus groups and meetings held to discuss the SEA and PPP).

4. Participation in analysis and agenda-setting (e.g., through multistakeholder groups, round tables).

5. Participation in reaching consensus on the main PPP elements (e.g. through national/regional round tables, multi-stakeholder committees, and conflict mediation).

6. Participants involved in decision-making on the PPP or its components.

At each level, participation may be narrow (few actors); or broad (covering all major groups as well as government).

At each level, participation may be narrow (few actors) or broad (covering all major stakeholder groups as well as government).

Source: Adapted from: Bass, Dalal-Clayton and Pretty (1995)

Stakeholder scoping meetings should help to determine and agree the scope or focus of the SEA and help improve (as needed) the draft participation/engagement strategy developed during the preparatory stage to ensure that it is appropriate and workable/acceptable. Active public engagement and stakeholder involvement should take place from the scoping stage onwards, including during the review of the draft SEA and SESMP reports and even during PPP monitoring (Table 3.1). A variety of meeting methods should be considered to ensure that all stakeholders are reached and involved including "town hall" meetings, workshops, focus groups, key informant interviews (one-on-one or small groups), surveys, social media etc.

Generally, SEAs draw the attention of 'public representatives' rather than individuals. If the public has limited experience with being engaged at the strategic level, it is critical to include an *education component* in the public engagement process – to inform stakeholders what SEA is about and its objectives and to raise awareness of the ways in which they can make their views known and contribute. It is important to identify and engage those stakeholders who may be the most exposed to environmental degradation and adverse social change as a result of the PPP. In general, environmental, and social pressures tend to affect the poor and vulnerable populations more significantly. Women, men and youth, and indigenous peoples' groups should be included in this public-engagement process to draw on all relevant knowledge and ensure their meaningful inclusion. Culturally sensitive consultation norms should be taken into account (e.g., language, representation, world views etc.).

As mentioned above, the SEA process relies on effective and sustained public engagement. PPP decisions are embedded in the political domain and involve political dynamics – including the engagement of the stakeholders who are likely to be most affected or who are most vulnerable. One challenge is to ensure that public engagement is meaningful, transparent, and continuous and not just a case of providing stakeholders with detailed, comprehensive information. The engagement process must provide an *opportunity to influence decisions* over the life of the SEA process.

Stakeholders are comprised of many interest groups, often with conflicting objectives, e.g., gender differences - with different rights and responsibilities, educated and uneducated people, young people and elders, indigenous groups, different economic and cultural groups. The role of the public consultation in SEA should be to provide a mechanism for identifying and trying to *solve differing views in a constructive and meaningful way.*

Stakeholder groups identified as most affected by a given PPP may be politically and/or socially marginalized and may have little or no experience in providing input to decision-making. Public consultation processes will have to identify the best way to ensure that the socially marginalized groups (e.g., the poor, minority ethnic groups, itinerant/migrant groups, other vulnerable groups) can participate effectively and can have their viewpoints given proper consideration. This may involve reaching out to stakeholders who do not have access to the internet, lack access to public libraries, speak a different language, are illiterate; have cultural differences, or other characteristics that need to be considered when planning for their engagement. In some cases, special means of engagement may be required e.g women of the SEA team meeting with a women's group or use of an indigenous led facilitator when meeting with indigenous groups.

Authorities which, because of their environmental and social responsibilities, are likely to be concerned by the effects of implementing the PPP must be consulted on the scope and level of detail of the information to be included in the SEA Report.

Depending on the nature of the political institutions and their internal functions, there will be a need to integrate the SEA process with the public engagement process as a whole and to adopt other approaches where needed. Of note, public engagement needs to be sustained, structured, and coordinated with all phases of the PPP formulation and implementation – emphasizing equally the positive contributions and harmful effects. More problematic issues should involve more extensive consultation.

3.3.7 Identifying alternatives to a PPP or elements of a PPP and scenarios

A key principle of SEA is to consider alternatives to a PPP, or elements of a PPP. This provides an means to identify and explore different ways (different options, choices, or courses of action) to deliver a PPP's objectives while addressing environmental and socio-economic issues. [4] The timely consideration of alternatives in SEA and the planning process provides an opportunity to identify and explore ways of accommodating the future development needs of an area or sector, taking into account the intrinsic environmental and socio-economic conditions[5]. Alternatives should be realistic, reasonable, viable and implementable alternatives that promote environmental and socio-economic benefits while fulfilling a PPP's objectives.

Identifying alternatives is likely to be easier where the SEA is focused on a specific PPP (e.g., for hydropower, solar or wind generation). However, where the SEA is at a broader or more generic level (e.g., for the wide range of energy options likely to be considered for the energy transition), considering PPP-specific alternatives is likely to be impossible. In such circumstances, it may be preferred to assess the impacts of implementing transition changes under different scenarios (see below).

As already indicated in Section 3.3.1, a key requirement in scoping is to start identifying alternatives to the PPP (or elements of the PPP) to be assessed during the SEA. Considering such alternatives during PPP development is the most effective way to "shape" the outcome of a development process.

SEA has the most influence during this PPP development stage because a comparative evaluation of the need or demand and an impact evaluation of a broad range of alternatives can be conducted before any irrevocable decisions are made. Such early consideration of alternatives can reduce the need for remedial measures at later stages in the development planning process - particularly when alternatives become increasingly constrained when moving 'downstream" in that process, ultimately reaching the project level.

A range of sources can trigger how to identify alternatives. These include:

- Analysis of strategic policy or action objectives, the policy context, environmental and social quality objectives, and existing and predicted environmental, social or sustainability problems;
- Consideration of hierarchy alternatives (Box 3.5), and
- Suggestions raised by key stakeholders and by planners or contained in previous SEAs or other assessments.

The alternatives assessed in the SEA could represent different ways of delivering each target.

The early (initial) consideration and assessment of alternatives can reduce the need for remedial measures at later stages in the development-planning process, given that alternatives become increasingly constrained as planning moves from policy- to plan- to programme-level, ultimately arriving at the project-level. This concept is usually referred to as the hierarchy of alternatives, illustrated in Box 3.5.

[4] González et al. (2015)
[5] Gonzalez *et al*. (2015)

Box 3.5: Hierarchy of alternatives

Need or demand: is it necessary? (often relevant to policy-level)'

- Are the developments envisaged in the PPP necessary?
- Can the need be met without implementing the PPP and without any new developments or infrastructure, etc.?
- Can the developments envisaged in the PPP be avoided?
- Are there any realistic opportunities for managing development demand, e.g., through regulatory, economic or administrative tools or other measures that promote behavioural changes?

Mode or process: how should it be done? (often relevant to plan-level)

- Are there technologies, methods or processes that can meet the need with less environmental damage or social change than 'obvious' or traditional methods?
- Has best-available technology been considered?

Location and Timing: where should it go?(often relevant to programme-level)

- What alternative locations could be considered?
- Timing and implementation (when and what-to-do in detail? (usually considered by project-level EIA):
- When and in what sequence should development be carried out?
- What details matter and what requirements should be formulated to ensure effective implementation?

Alternatives are formulated bearing in mind the situation assessment and the analysis of opportunities and constraints. Generally, expert judgment, authority requirements and key stakeholder inputs are combined to formulate and agree reasonable alternatives.

The Steering Committee (or Advisory Committee) should confirm which alternatives should be initially assessed by the SEA, and subsequently determine which is/are the preferred alternative(s) for deeper assessment.

Scenarios (existing or developed for the SEA) can be used to examine how implementation of the energy transition might unfold different under different potential futures. These scenarios could represent, for example, different rates for the energy transition and replacement by renewables (e.g. high. medium, low) or different time periods (e.g., near-term, medium-term, longer term). Scenarios will be influenced by key drivers of change (see Box 3.7). They can also be considered as alternatives (see Annex 9 on scenario development).

Box 3.6 presents examples of scenarios used for a SESA undertaken for the energy transition in Indonesia.

Box 3.6: Scenarios for the energy transition in Indonesia

In November 2022, the Government of Indonesia (GoI), the Asian Development Bank (ADB) and key development partners signed a Memorandum of Understanding (MOU) towards the retirement of coal fired power plants (CFPPs), a reduction of CO2 emissions and a transition to renewable power under ADBs' Energy Transition Mechanism (ETM).

A Strategic Environmental and Social Assessment is being prepared to assess the environmental and social risks, impacts and opportunities of the energy transition in Indonesia. To do this, three scenarios were developed:

Scenario 1: Business as Usual considers continued fossil fuel (coal) energy production, no early retirement of CFPPs and increased use of natural gas. In this scenario there is a slight/natural increase in renewable energy generation.

Scenario 2: Moderate Energy Transition demonstrates a slight retirement of CFPPs by 2060 where there is no new growth in fossil fuel usage and renewable energy responds to any new additional energy demand.
Scenario 3: Rapid Energy Transition represents a total retirement of CFPPs by 2060 where a full transition to renewable energy production meets or exceeds future energy demand.

Source: Ciera Group and PT Hatfield Indonesia. 2023.

Where scenarios are used/developed, these should be agreed by the Steering Committee or Advisory Committee.

3.3.8 Identifying baseline information requirements and initiating collection

SEA needs to be based on a thorough understanding of the potentially affected environment and social systems. So, a critical step for the SEA team is to identify and acquire critical baseline information, drawing from all relevant sources. This must involve more than a mere inventory (e.g., listing flora, fauna, landscape, urban environments, ethnological or cultural groups). Particular attention should be paid to important ecological systems and services, their resilience and vulnerability, and significance for human well-being. Existing environmental and social protection measures and /or objectives set out in international, regional, national, and local PPPs should also be reviewed. Scoping will be very important in identifying what issues are important and to focus what data collection is required.

Baseline data should cover the issues listed in Box 3.7.

Box 3.7: Required baseline information

Note: Not all of the listed information will be 'required' in all cases - scoping key issues should be used to focus on what is relevant

Biophysical
- Air quality, with particular focus on the occurrence of pollutants in the air;
- Climate, including future climatic change scenarios for the region and country, and vulnerability to climate change;
- Noise and vibration;
- Topography, soils, geology;
- Risks of natural disasters, particularly earthquakes, landslides and flooding;
- Surface and groundwater resources, quality and quantity and chemical characteristics;
- Ecosystem services, especially wetlands (riverine areas, lakes, etc.) and forest areas, nature conservation and protected ecosystems, and biological corridors;
- Biodiversity (flora and fauna), rare and threatened/endangered species, endemic species and habitats), species of commercial importance, invasive species (terrestrial, aquatic, marine);
- Land use and use of natural resources.

Socio-economic conditions and human health
- Population dynamics;
- Un/employment, poverty, skills, livelihood and education profile;
- Sanitation issues;
- Economic profile of the country, including analysis of key economic drivers (e.g. tourism, hydropower, lifestyle investments, recreation) and associated multipliers and spin-offs;
- Human health profile, especially communicable (e.g. HIV /AIDS, COVID) and non-communicable diseases (e.g. diabetes, cancer prevalence);
- Archaeology and cultural heritage;
- Recreational aspects;
- Social-economic aspects;
- Land use, transportation, infrastructure, agricultural development and tourism.

Physical infrastructure and social facilities and services

- Distribution of current and planned energy infrastructure (including planned renewable energy facilities, transmission lines and grid analysis);
- Distribution of urban centres, types of current and expected future settlement development (e.g., municipal changes/expansion), population dynamics, land and property values, land use and availability;
- Water supply and use (city/towns, other settlements, agriculture, etc.) and likely future scenarios for demand and use;
- Dams (hydropower, storage);
- Transport, traffic, power lines, pipelines and other related infrastructure;
- Industrial infrastructure;
- Current and planned water and waste management and supply infrastructure (including assessment of state of infrastructure); and
- Current and planned schools, hospitals, clinics, recreation, religious, cultural and retail facilities.

Governance and decision-making

- Institutions, structures and decision-making systems relevant to energy management and ETM implementation (e.g., regarding the allocation of permits and associated compliance monitoring for large projects) and for those institutions at a regional or international level that may influence ETM implementation.

3.3.9 Sensitivity mapping

An SEA can be supported by a robust and data-led spatial planning exercise, involving identification of technical, environmental, and social constraints to implementing a PPP. A core component of such planning is sensitivity mapping, or what is also called the identification of "go no-go zones" (see Box 3.8) to identify areas where renewable energy developments should be avoided due to their sensitivity for biodiversity and social receptors. Such mapping can be undertaken relatively rapidly with existing data (desk-based) or can be a more intensive process such as full scale Marine Spatial Planning[6]. Sensitivity maps are a powerful tool for protecting nature and vulnerable communities whilst facilitating the transition to renewable energy to reduce global emissions.

Box 3.8: Sensitivity mapping

Sensitivity mapping provides a visual representation of risks, and assets which may be exposed to them. Multiple environmental sensitivity mapping approaches exist, with methods and uses varying based on stakeholders' values, drivers of change, data availability, and the technical capacity of the users. Sensitivity mapping is often carried out using geographic information systems (GIS) technology. The amount and/or type of data used to produce a sensitivity map will affect and limit its potential uses. Nevertheless, environmental sensitivity mapping can have a wide variety of applications. These include but are not limited to:

- Helping decision-makers understand where protection of valuable environmental assets is needed, which could aid the development of protected area networks;
- Informing governmental and private sector spatial planning at the project level, targeting activities to the locations where they will have the lowest impact;
- Supporting all stages of impact management, including prevention, mitigation, preparedness, operations, relief, recovery and integration of lessons learned;
- Aiding situational awareness and response strategy development for responders and decision makers during an incident.

Source: [Environmental Sensitivity Mapping definition | Biodiversity A-Z]

[6] See: mspglobal2030.org

During scoping, sensitivity mapping of areas vulnerable to environmental and social pressures should be initiated by evaluating and interpreting the environmental and social baseline information, taking account of drivers of change (Box 3.9). This will help to identify the environmental and socio-economic opportunities and risks/constraints in relation to the proposed PPP. The baseline information also provides a benchmark against which alternatives/scenarios can be evaluated.

Box 3.9: Analysing baseline information and drivers of change

When analysing the current and potential future environmental and socio-economic conditions, it is important to reflect on how drivers of environmental and socio-economic change (such as urbanization, climate change and globalisation) will affect ecosystem functions and services, as well as human well-being and economic development. The sources of risk stemming from the environment and social activity as well as the risks to the environment and socio-economic fabric should be examined. For example, degraded ecosystems may in the long run lead to a lack of clean water or reduced soil fertility which, in turn, will affect human health and livelihoods. The links between livelihoods and specific ecosystem functions should be addressed, e.g., how is food produced and housing constructed, how finite are available resources, how do social power relations influence the use of livelihoods by different gender groups? How does poverty affect access to services, education, employment, and health? Consideration should be given to how PPP implementation as well as disasters may affect ecosystem functions and have an impact on health and livelihoods.

If placed in poorly chosen areas, renewable energy developments can end up have serious consequences for ecosystems or local communities. For example, offshore wind farms can cause considerable harm to fragile marine ecosystems, with seabirds being particularly sensitive. Whilst not replacing site-specific assessments of environmental impacts, sensitivity maps can dramatically reduce conflicts with nature by identifying areas where the negative impacts of offshore wind farms and grid infrastructure will be higher or lower.

Figure 3.2 shows a map depicting pressure and sensitivity in the Chobe Forest Reserve, Botswana (see Annex 18 for further details of the sensitivity mapping process).

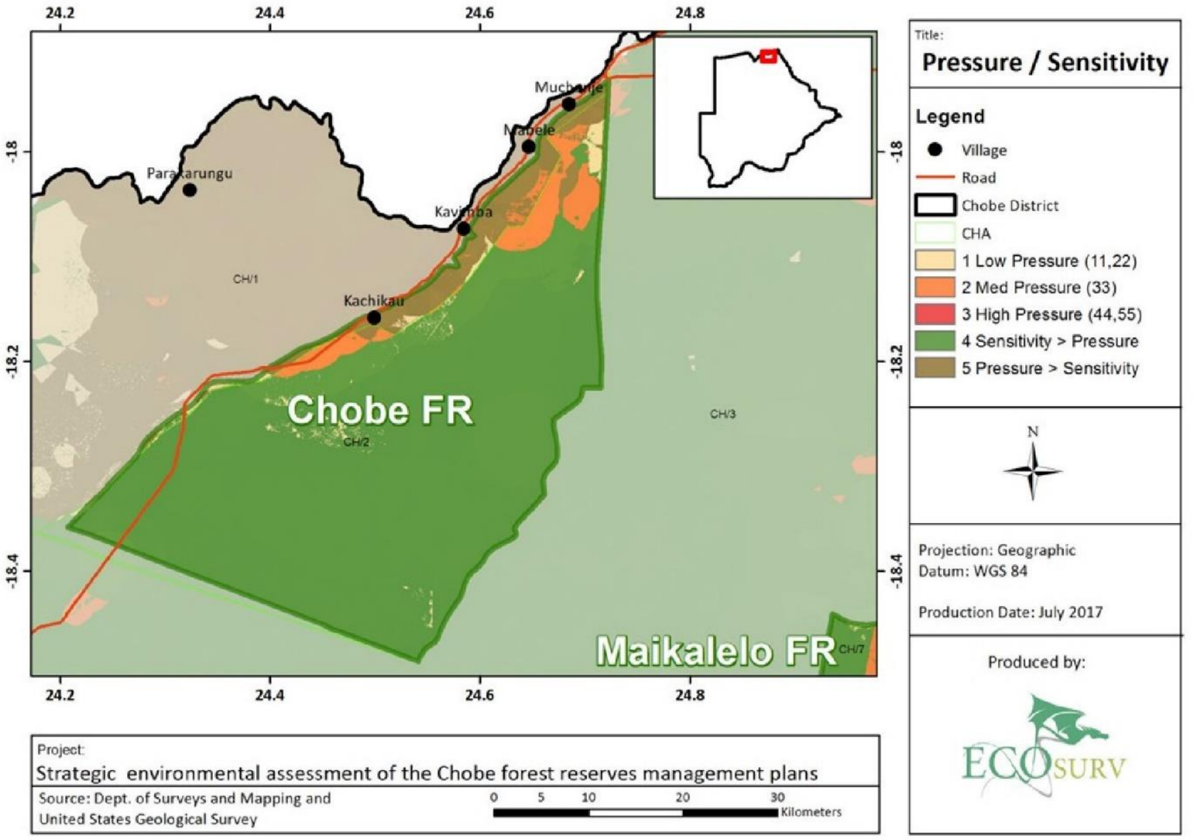
Such information allows the selection of locations for development that minimize harm to nature and communities. It can reduce uncertainty, save time and eventually costs for developers. Sensitivity maps can help to speed up existing planning processes, inform and corroborate EIAs for projects once locations are selected for development, and avoid conflicts between stakeholders, which can lead to significant delays.

The World Bank, via the Energy Sector Management Assistance Program (ESMAP), is currently developing guidance for environmental and social sensitivity mapping to support early spatial planning for offshore wind development in emerging market contexts, which is designed to be complementary (or a precursor to) full scale spatial planning processes like marine spatial planning or SEA.

Existing guidance for sensitivity mapping include Birdlife's AVISTEP (Avian Sensitivity Tool for Energy Planning)[7], and the EU Wildlife Sensitivity Mapping Manual[8].

[7] AviStep- BirdLife International
[8] The wildlife sensitivity mapping manual - Publications Office of the EU (europa.eu)

Figure 3.2: Map showing pressure and sensitivity in the Chobe Forest Reserve, Botswana
Source: Ecosurv (2018)



Sensitivity mapping and analysis will also enable the SEA team to assess the adequacy and reliability of available information/data and identify whether additional information may be required. In some cases, it may be necessary to commission specialist studies on subjects/themes of particular importance to the PPP/SEA. Where vital information is lacking or inadequate, there may be a need to undertake or commission new research, e.g., where data is required on annual or seasonal trends, or from other jurisdictions (such as adjacent countries in the case of an SEA of a PPP with cross-border implications).

The sensitivity mapping and analysis should be informed by the scoping process and, in turn, help to inform it.

3.3.10 Consistency analysis of PPPs and legal instruments

Box 3.3 indicates the need to make an inventory of and review (a) all relevant PPPs that might be related to the PPP being assessed (the target PPP) or that might have influence on or be affected by the target PPP, and (b) legal and regulatory instruments (laws, decrees, directives, regulations, etc.). Analysis should be undertaken of such PPPs and legal instruments to check their consistency with each other and with the target PPP. This should include identifying synergies, overlaps and antagonisms (particularly in terms of their environmental and social objectives). Such analysis will help:

- To identify where the target PPP and candidate environmental and social quality objectives to be used in the SEA might conflict with other instruments; or where there is potential to generate synergies, enhanced benefits and win-win outcomes;
- To increase the efficiency of the new/revised target PPP;
- To identify where policy reform or modification of legal instruments might be necessary to ensure alignment to foster progress towards sustainable development.

Analysis can be summarised in a comparative matrix format. Table 3.3 provides an example from Nepal.

3.3.11 Submission and review of scoping report

A *Scoping Report* should be prepared incorporating (as an annex) the terms of reference as finally agreed by the proponent. It should indicate how the scoping was conducted and cover the issues listed in Box 3.3.

The proponent should circulate the draft scoping report to key stakeholders (including the competent authority) for review and make it available for public comments. A workshop may be considered to discuss the scoping report and obtain feedback from participants. The scoping report should also be posted ot the SEA website, if developed, to obtain additional feedback. Other forms of social media may also be used.

Annex 10, Section 1, *Scoping* (*Consolidated Checklist for the Quality Assurance, Review, and Performance Evaluation of a Comprehensive SEA*) can be used to review the scoping process and scoping report. The checklist should be included in the scoping report as annex so that a check can be made by interested parties to determine that the scoping has been conducted thoroughly.

3.4 THE MAIN ASSESSMENT

3.4.1 Introduction

This stage is the heart of the SEA process and involves an assessment of the likely risks and impacts of implementing the PPP and its alternatives; or of implementation of energy transition options under different scenarios. Impacts may be positive or negative, direct, or indirect, cumulative, or transboundary. Various methods (analytical tools) can be used, as described in Annex 6.

The baseline trend and situation analysis (Section 3.3.9) initiated during scoping (see section 3.3.7) should be completed. One of the approaches available for this is trend analysis to examine changes over time - without and with the proposed PPP. See Annex 11 for more details on trend analysis. It provides fictional examples of the assessment of impacts of past and future environmental and social trends as influenced by the actions proposed in a PPP - for terrestrial biodiversity.

Where a SEA is concerned with a single PPP (new or being revised), and where it has been agreed to consider different alternatives to the particular PPP, the main assessment should be undertaken in two main stages:

- ***Initial assessment of the alternatives*** to the target PPP or its components (leading to ***initial SEA report*** (if specified as required by the TOR). This report should be circulated to stakeholders for comment and then selection of a preferred alternative(s) should be confirmed by the proponent, taking account of the views of the Steering Committee (or Advisory Committee). The proponent should provide an explanation of how the findings of the initial assessment of alternatives and consultations were considered in deciding on the preferred alternative(s). and

- ***Deeper assessment of preferred alternative(s)*** – more focused and detailed (leading to an SEA report).

In some circumstance, an SEA may focus on multiple PPPs. In such circumstance, a different approach should be designed, tailored to the specific needs of the SEA. An example is a SEA conducted for the SW Region of Bangladesh for Conserving the Outstanding Universal Value of the Sundarbans (which address 89 separate PPPs across 28 sectors and key themes[9]. In this case, the SEA involved: (a) preliminary assessment of all 89 PPPs (using simple scoring: high, medium, low potential impacts); (b) initial assessment of the impacts of implementing this suite of PPPs under three scenarios (alternatives) – high, medium, and low growth; followed by (c) deeper assessment of

[9] CEGIS/Integra (2021)

Table 3.3: Comparison laws, policies, plans, and strategies relevant to Nepal's REDD+ strategy

Laws/Policies/Plans	Climate Change Policy, 2011	Forest Act 1993	Hydropower Development Policy, 2001	Water Resource Act 1992	Electricity Act 1992	Leasehold Forestry Policy 2002	Local Self-Governance Act, 1999	Mines and Minerals Act, 1985	National Parks and Wildlife Conservation Act 1973	Public Road Act, 1974	Revised Forestry Sector Policy, 2000	Soil and Watershed Conservation Act 1982	Nepal Biodiversity Strategy, 2002	Water Resources Strategy, 2002
Climate Change Policy, 2011		O	N	N	N	N	N	N	N	N	N	N	O	O
Forest Act 1993			C	C	C	O	C	C	C	C	O	O	O	C
Hydropower Development Policy, 2001				O	O	N	C	N	C	N	C	N	N	O
Water Resource Act 1992					N	N	N	N	C	N	N	N	N	O
Electricity Act, 1992						N	N	N	C	N	C	N	O	O
Leasehold Forestry Policy 2002							C	C	O	C	O	N	O	N
Local Self-Governance Act, 1999								C	C	N	N	N	O	N
Mines and Minerals Act, 1985									C	N	C	C	C	N
National Parks and Wildlife Conservation Act 1973										C	O	O	O	C
Public Road Act, 1974											C	C	N	N
Revised Forestry Sector Policy, 2000												O	O	N
Soil and Watershed Conservation Act 1982													O	C
Nepal Biodiversity Strategy, 2002														N
Water Resources Strategy, 2002														

Source: ICEM/IIED/SchEMS, 2014

Notes:

1. O- Overlaps; C- direct contraction; N- neutral
2. The report provides extensive footnotes detailing the conflicts

the high growth scenario (the government's primary economic development policy) on a key sector basis.

3.4.2 Assessment of a proposed PPP and scenarios/alternatives to a PPP or its components

Where the SEA is concerned with a specific PPP (e.g. for solar power), the initial step should be to assess the likely environmental and socio-economic risks and impacts of the agreed alternatives to the PPP (or its components), including the zero alternative (the 'do nothing' 'business-as-usual' or 'without the PPP' alternative – which implies the continued use of fossil energy systems and all of the impacts associated with these),.The complexity of the assessment can be greatly reduced if there is sufficient detail to identify the significant impacts.

The full spectrum of potential effects must be considered, including positive and negative, direct, and indirect, cumulative, and transboundary environmental and social impacts. Such impacts can result from individually minor but collectively significant actions taking place over a period when implementing the PPP (see section 3.4.5. for discussion of cumulative effects). In addition, the impacts should be considered over time and spatial scale (e.g., short-, medium- and long-term). Permanent effects at local, national, regional, or international scales should be identified. The comparative evaluation of alternatives should highlight potential irreversible effects or irreplaceable loss of natural capital, as well as risks to social and ecological systems.

An initial SEA report on the assessment of the alternatives (if an initial report is particularly specified as required in the TOR) should set out the results of the assessment of the alternatives and should be circulated to key stakeholders for review and made available for public comment. Based on the interim SEA report and comments received, agreement should be reached on the preferred alternative(s). This/these should then be subjected to fuller (deeper) assessment in the next stage.

3.4.3 Assessment of the preferred alternative and scenarios

Achieving agreement on a preferred alternative(s) for the PPP or component of the PPP – based on consideration of the environmental and socio-economic impacts associated with the different alternatives, marks a significant interim achievement for the SEA. It demonstrates how an integrated approach' to SEA, as illustrated in Figure 1.2, can achieve a beneficial outcome and influence decision-making concerning the PPP.

The next step is to continue and deepen the level of assessment, now focusing on the agreed preferred alternative. This will lead to the preparation of a *draft SEA report*.

The assessment should involve a more in-depth examination of the full range of potential effects (positive and negative), including, direct, indirect, and cumulative effects, and their nature over time and spatial scale. The impacts of the preferred alternative should also be addressed under different relevant scenarios under which the PPP or suite of energy transition changes would be implemented (see Annex 9) as well as any permanent effects at local, national, regional, or international scales.

3.4.4 Conducting the assessment

There is a wide variety of tools that can be applied for impact assessment. Common tools are listed in Table 3.4. These and others are described in Annexes 6 and 12 (with additional information in Annex 9 on scenario development). The most suitable method depends on the approach adopted (whether impacts-led or objective-led, or both) and the SEA team members' specialized competence in the analytical subject area, professional experience and judgment.

Both the initial assessment of alternatives and the deeper assessment of the preferred alternative(s) should identify those components of the PPP (or its alternatives) which may have significant effects on environmental, social and economic trends and objectives.

The assessments may focus on the overall PPP or on policy components. In some circumstance, assessment may be required for clusters of proposed developments (including projects) that might arise when a PPP is implemented, or even for an individual activity/mega-project (e.g. if it covers a large area and is likely to have widespread and significant impacts).

The assessment should address:

- The character of the risks/impacts (what exactly causes the risks/impacts or assumptions for the predictions);
- The opportunities and the positive impacts or benefits that may arise from PPP implementation;
- Probability and key uncertainties (Box 3.10). Uncertainties must be properly acknowledged and handled to caveat the SEA conclusions and recommendations, and subsequent decisions;
- Geographic scale - directly and indirectly affected geographic areas that will become of specific concern;
- Frequency, duration, and reversibility, and
- Key concerns associated with the impacts.

If symbols are used to facilitate summary and easy reading of the results of the assessments, they should be accompanied with summary descriptive text, to ensure clarity.

Table 3.4: Common assessment tools available to SEA

Tools for predicting environmental and socio-economic effects/impacts	Tools for analysing and comparing options/alternatives
• Carrying capacity analysis • Checklists • Delphi technique • Ecological/environmental footprint analysis • Expert judgement* • Land use partitioning analysis • Mapping transmission channels • Matrices* • Modelling/forecasting* • Network analysis and linkage/flow diagrams* • Participatory assessment • Quality of life assessment • Indicators, multi-metric indices* • Scenario analysis* • Significance thresholds • Social and economic analysis/surveys • Spatial analysis*, e.g. GIS-based analysis (including overlays, capacity/habitat analysis) • SWOT (strengths, weaknesses, opportunities, threats) analysis • Trends analysis/extrapolation	• Compatibility appraisal • Cost-benefit analysis • Least cost analysis • Impact matrices • Multi-criteria analysis • Opinion surveys • Policy impact matrix • Risk analysis/assessment • Modelling • Scenario analysis • Vulnerability analysis

* Tools often used to assess cumulative impacts
Note: See annexes 6 and 12 for descriptions of methods

Box 3.10: Role of uncertainties in the SEA

Each SEA process is naturally constrained by numerous uncertainties. These may be caused either by the lack of data (e.g., baseline trends in the affected environment, about scales or locations of proposed developments, etc.) or by the built-in limitations in analytical approaches and tools used in the SEA. It is important to ensure that all key uncertainties that inevitably occur in the SEA process are properly understood and acknowledged.

Where SEA is performed ex ante, it is clearly focusing on predictions ahead of implementation -a key source of uncertainty.

A capability to explain uncertainties has always been a sign of an advanced professionalism and solid judgment. Well outlined uncertainties may become an excellent stimulus for both professional and public debate which may in turn provide further inputs into the assessment.

The initial and full SEA reports must therefore document any uncertainties or limitations in the SEA. SEA experts should not be afraid to acknowledge such limitations – on the contrary, a proper acknowledgement of uncertainties increases the quality and credibility of the entire SEA.

Source: MONRE (2008)

If the PPP includes proposals for individual projects that will require EIA, the SEA should provide suggestions on the specific scope and focus of such EIAs (e.g., recommending specific issues that should be assessed).

3.4.5 Direct, indirect, cumulative, and transboundary impacts

Potential positive and negative environmental and socio-economic impacts need to be identified which may fall into different categories, including:

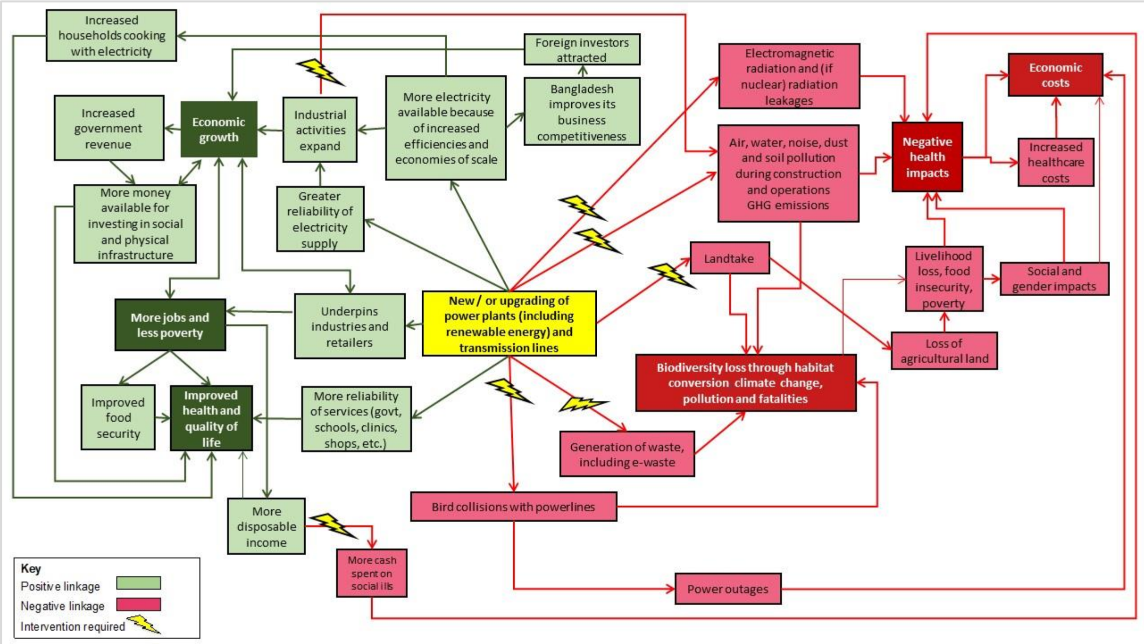
- ***Direct impacts*** – the direct interaction with an environmental, social, or economic component of activities associated with options within the PPP or its alternatives that initiate and locate specific project activities;
- ***Indirect impacts*** - those which are not a direct result of activities undertaken when implementing the PPP (usually projects and developments), often produced away from or as a result of a complex impact pathway. Indirect impacts are also known as secondary or even third level impacts;
- ***Cumulative impacts*** and induced/synergistic impacts, e.g., those arising from large-scale schemes such as infrastructure project development in combination with other multiple projects and activities in a given time and space that lead to snowballing and cumulative impacts on valued ecosystem components, as well as those from implementing other PPPs and major development initiatives.
- ***Large-scale impacts*** that that have regional and global effects. Impacts also may be permanent, temporary, or synergistic.
- ***Trans-boundary impacts –*** those that occur outside the immediate focal area of the PPP, e.g. in another district or region, or in another country.

The target PPP is likely to be implemented through a variety of actions and initiatives (often projects), each of which will give rise to a range of impacts. The impacts of an individual project may not be particularly significant or may be confined to a particular area and be capable of management or mitigation. But the impacts from multiple projects and actions, whether of the same kind or different initiatives, can be very considerable and spread across a very wide area. These are their *cumulative effects*. But it is also necessary to consider the impacts of other PPPs, strategies, plans and projects in the area covered or influenced by the PPP. They will also generate their own suites of impacts. When all of those impacts are combined with the impacts of the PPP being assessed, then the overall cumulative impacts can be very large indeed – as depicted in Figure 1.2.

Impacts are not a matter of simple cause-and effect. They are subject to cascading primary, secondary, tertiary, and subsequent level impacts. This generates a complex web of interacting and cumulative linkages which need to be understood by policy makers and decision-takers. Developing a picture of such linkages is a complex process and takes considerable time to brainstorm. Figures 3.3 is an example of linkage diagrams that show how cumulative impacts arise developed for an SEA in Bangladesh[10]. Figure 3.4 shows workshop participants constructing a linkage diagram during an SEA of development in Pohnpei State, Federated States of Micronesia. Figure 3.5 is an example of how cumulative impacts are the total impacts of multiple actions on a receptor.

[10] CEGIS/Integra (2021)

Figure 3.3: **Linkage diagram for power and energy: new or upgrading of powerplants and transmission lines in Bangladesh** (*Source: CEGIS/Integra 2021)*



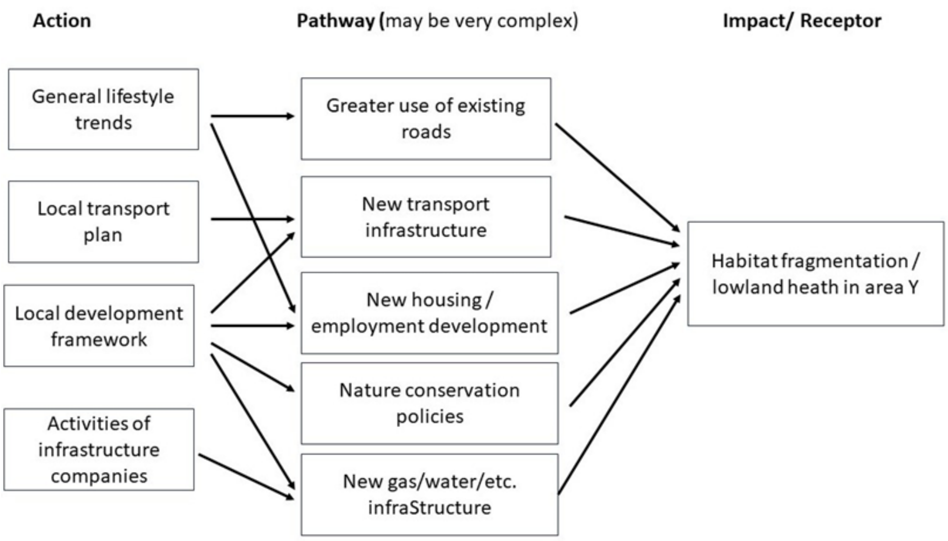
Main cumulative impacts

Positive: Economic growth; more jobs and less poverty; and improved health and quality of life;
Negative: Economic costs, negative health impacts, loss of biodiversity through habitat conversion, climate change, pollution and fatalities.

Figure 3.4: Constructing a linkage diagram for SEA of Pohnpei State, Federation of Micronesia, March 2019

Source: B. Dalal-Clayton

Figure 3.5: Example of how a cumulative impact is caused
Source: Therivel (2005



3.4.6 Evaluating the significance of impacts

The concept of significance is at the core of impact assessment, impact evaluation and decision-making. Deciding whether a PPP is likely to cause significant environmental and/or social effects is central to the practice of EIA. Similarly, in SEA, effects, impacts, trade-offs, and options or alternatives need to be assessed in terms of significance, to determine optimum choices and eliminate unacceptable ones.

There is no single best method for determining the significance of impacts. Various formal methods, using rating (see examples in Table 3.5 and Annex 13), ranking, weighting and/or scaling, future scenario building, and back-casting methodologies can be used to determine significance in particular sectors, and/or to help translate “facts into meaning”. The review of other PPPs and targets, etc., during scoping is key to providing information on significance.

Table 3.5: Example of scale for rating significance of impacts used in Kenya
(Source: NEMA 2012)

Significance	Criteria
High	• Exceeds or threatens to exceed legal thresholds or standards • Exceed or threatens to exceed functional thresholds or LAC for health and safety; may result in irreversible, irretrievable or irreplaceable loss of ecosystem services • Norms or Limits of Acceptable Change (LAC) established by society
Medium	• Controversial LAC; no societal agreement on these limits
Low	• Preference thresholds for individuals, groups or organizations; not for broader communities or society

Key elements that should be considered in determining significance include the characteristics of the actual effects and the area likely to be affected:

Impact characteristics:

- The probability, duration, frequency and reversibility of the effects (e.g., ecosystem fragmentation);
- The cumulative nature of the effects;
- The trans-boundary nature of the effects;
- The risks to human health or the environment (e.g., due to accidents); and
- The magnitude and spatial extent of the effects (i.e., geographical area and size of the population likely to be affected).

Importance of the affected area due to:

- Its value and vulnerability;
- Special natural characteristics or cultural heritage;
- Exceeded environmental quality standards or limit values; or
- Intensive land use.
- The effects on areas or landscapes, which have a recognized community, district, national or international protection status or value.

In determining the significance of impacts, it is helpful to relate them to the institutional, public or technical recognition given to particular environmental/social attributes or resources (Table 3.6).

Table 3.6: Forms of recognition of environmental or social attributes

Form of recognition	Criteria
Institutional recognition	The importance of an environmental/social attribute or resource is acknowledged in the laws, plans or policy statements of government agencies or private groups
Public recognition	Segments of the public recognize the importance of an environmental/social resource or attribute. Public recognition may take the form of support, conflict or opposition. Public action may be expressed formally (e.g. letters) or informally (e.g. protest action).
Technical recognition	The importance of an environmental/social resource or attribute is based on scientific or technical knowledge or judgment of critical resource characteristics.

Annex 14 provides a checklist of questions that can be applied when determining impacts and their significance.

3.4.7 Identification of measures to enhance opportunities and mitigate adverse impacts

The SEA should propose measures to maximise the positive environmental and social opportunities of the PPP and activities/projects that are likely to arise during its implementation; and propose mitigation measures to avoid, offset or minimise any negative risks. There are no blueprints for this task. SEA experts may use whatever format is suitable to provide commentary on the issues listed below and to explain their recommendations:

- Opportunities for optimizing development objectives or priorities pursued by the PPP;
- Opportunities for optimizing specific proposals/components within the PPP (e.g. alternative development methods; and locations, scale and sequencing/timing of proposed developments);
- Opportunities for optimizing implementation of the PPP such as issues to be addressed in project-level assessments (e.g., preliminary advice on the scope of EIAs for specific projects or prescribing assessment for projects that are vulnerable to extreme climatic change conditions);
- Proposed mitigation or enhancement measures for those environmental or social effects of the PPP that could not be avoided through the changes in the proposed development objectives, priorities or actions, and
- Proposed changes in other relevant PPP (often called ‘flanking measures’).

Opportunities will generally enhance achievement of the Sustainable Development Goals (SDGs) and other sustainable development objectives. The aim is to develop "win-win" situations where multiple, mutually reinforcing gains can simultaneously:

- Strengthen the economic base and enable economic objectives to be achieved;
- Improve social conditions and provide equitable conditions for all, and
- Protect and improve management of the environment.

Where this is impossible, the trade-offs must be clearly documented to guide decision-makers.

A *mitigation hierarchy* should be followed for identified negative impacts: avoid, minimise, rectify, reduce, restore/rehabilitate, compensate and finally offset for impacts using appropriate measures. Caution should be exercised if the analysis indicates a potential for major, irreversible, negative impacts on the environment or social conditions. Often this may suggest selecting less risky alternatives. For less-threatening situations, standard mitigation measures can be used to minimize adverse impacts to "as low as reasonably practicable" (ALARP level).

The mitigation measures should be summarised in a table and elaborated in the text of the SEA report or in an accompanying Strategic Environmental (and Social) Management Plan (SESMP).

Once mitigation has been considered, the significance of residual adverse impacts can be evaluated. This is an important measure of the environmental and social acceptability of the PPP. It is usually carried out against selected environmental/social quality objectives (ESQOs) and criteria. The energy sector is one with clear environmental and social implications. Residual impacts will require additional mitigation and management in the SESMP.

3.4.8 Restoration

Implementing a PPP will usually involve a range of actions which, often, will take the form of individual projects/developments. Where mitigation measures proposed by a SEA (and subsequent project-level EIAs) are inadequate, ineffective or not undertaken, actions/projects can result in environmental or social harm and degradation (e.g. unnecessary or excessive deforestation, loss of habitats, biodiversity and ecosystem services, soil erosion, pollution, involuntary resettlement etc.). The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. It will usually lead to demand for and need for land and ecosystem restoration (see Box 3.11) . This need will also arise at sites of projects that have come to the end of their useful life (e.g., coal mines or retirement of coal fired power plants),

Box 3.11: Land and ecosystem restoration

Land restoration, which may include renaturalisation or rewilding, is the process of ecological restoration of a site to a natural landscape and habitat, safe for humans, wildlife, and plant communities. Ecological destruction, to which land restoration serves as an antidote, is usually the consequence of pollution, deforestation, salination or natural disasters. Land restoration is not the same as land reclamation, where existing ecosystems are altered or destroyed to give way for cultivation or construction. Land restoration can enhance the supply of valuable ecosystem services that benefit people.

Land restoration can include the process of cleaning up and rehabilitating a site that has sustained environmental degradation, such as those by natural cause (e.g. desertification) and those caused by human activity (strip mining), to restore that area back to its natural state as a wildlife home and balanced habitat.

Land restoration is also at the core of the UNCCD's mission, as actions that protect and revitalize land resources such as soil, water and biodiversity are critical to achieving Land Degradation Neutrality (LDN) by 2030 and constitute a proactive way to build resilience to drought[11].

[11] Land management & restoration | UNCCD

The Kunming-Montreal Global Biodiversity Framework was developed under the UN Convention on Biodiversity and was adopted in December 2022[12]. It includes four global goals and 23 targets for 2030. Target 2 is to: "*Ensure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity".*

The UN Decade on Ecosystem Restoration (2021 – 2030) aims to promote the UN's environmental goals - specifically, to facilitate global cooperation for the restoration of degraded and destroyed ecosystems, along with fostering efforts to combat climate change, safeguard biodiversity, food security, and water supply. While much focus is on promoting restoration activity by national governments, the UN also wishes to promote such efforts from other actors, ranging from the private sector and NGOs to individuals.

Ecosystem restoration promotes the idea that developments should transition from a 'do no harm" approach to 'do more good'. Thus, SEAs should not only identify how the energy transition and renewable energy PPPs can be framed to avoid, minimise and mitigate harm to the environment; but consider how such PPPs can promote opportunities to 'do more good', particularly downstream when individual projects are planned, sited and implemented. This could look at measures such as the repurposing of retired coal fired power plants, the reclamation of coal mines and reparations for outstanding environmental and social legacies.

3.4.9 Assessing trade-offs

SEA is a process that should support the consideration of environmental, social (and economic) concerns in policy-making and planning. This includes indicating where such concerns (the three main pillars of sustainable development) interact, either positively or negatively. This is often achieved by highlighting potential synergies or conflicts (antagonisms) between elements of the PPP or between the assessed PPP and other PPPs.

Synergies provide potential to maximise positive environmental, social, and even economic, benefits and impacts. Conflicts between PPP (or elements of a PPP) have potential to generate negative impacts and an SEA should analyse these to identify where such impacts can be minimised, avoided or mitigation measures put in place. Addressing conflicts will often require planners and decision-makers to make trade-offs. It is the role of SEA to highlight the areas of potential trade-off that would enable positive impacts to be enhanced and negative ones minimised, and to provide appropriate data and analysis. The provisions on trade-offs in existing agency guidelines should be followed.

Consideration of trade-offs is increasingly becoming a standard practice in SEA, and it is an effective measure to help reverse the current ecological deficit[13], in terms of biodiversity and ecosystem services. SEA can be a catalyst for addressing complex development problems and alternatives under conditions of high uncertainty, where multi-stakeholder groups with diverse and sometimes conflicting objectives could be affected. In addressing sustainability, the goal is to seek 'win-win' outcomes from development. In a situation where resources are limited and when two or more conflicting objectives are being pursued, the most common outcome is that society loses in one aspect (e.g., loss of biodiversity) at the expense of another (e.g. socio-economic development). To promote sustainability, it is critical to consider a holistic balance of various forms of capital: financial, natural, human, social and public (i.e. infrastructure which supports production). SEA can play a critical role in identifying where such balance is possible and where trade-offs may be required.

[12] RECOMMENDATION ADOPTED BY THE WORKING GROUP ON THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK (cbd.int) and
Kunming-Montreal Global Biodiversity Framework (cbd.int)

[13] An 'ecological deficit' occurs when the footprint of a population exceeds the biocapacity of the area available to that population. Conversely, an 'ecological reserve' exists when the biocapacity of a region exceeds its population's footprint.

A trade-off usually refers to losing one quality or aspect of something in return for gaining another quality or aspect. It implies a decision to be made with full comprehension of both the upside and downside of a particular choice.

Trade-off decisions are generally of two types:

- *Compensation and substitutions*. These can be straight forward where one option can be substituted for another, e.g., to eliminate a natural wetland and replace it with a constructed wetland of comparable ecological value elsewhere in the watershed – provided it provides the same values as a natural one; or an option can be provided to compensate for a particular risk or loss.

- *Net gain and loss calculations*. These are not always done explicitly or openly, and the measurement and comparisons are often difficult and sometimes objectionable, e.g. the jeopardized interests of a local community displaced by a new dam balanced against water supply security for a larger number of downstream rural communities

  Loss/gain accounting is quite a different prospect for biodiversity than for social values. In terms of biodiversity, loss/gain accounting is foremost about identifying the required amount of mitigation associated with an option, making sure the preventative stages of the mitigation hierarchy are optimised, and then reviewing the feasibility of achieving net gain via remediation measures. Trade-offs might be a consideration then for offsets (e.g., if net gain cannot be achieved like for like). In this sense, trade-offs MUST be acceptable to stakeholders, or the option should not be pursued (the exception might be where it is legally mandated - but stakeholder acceptance is still a key factor).

While trade-offs may not always be acceptable, it is important that a justification is always provided and that the process is as transparent as possible. Significant adverse effects could be justified 'if the alternative is worse'.

Table 3.7 provides a basic working list of rules to guide trade-off deliberations. These rules can be used as a checklist when dealing with trade-offs within SEA.

Table 3.7: General trade-off rules
Source: NEMA (2012)

Rule	Description
Maximum net gains	Seek to attain mutually reinforcing, cumulative and lasting contributions that bring the most positive overall results in sustainability (including ecological, social and economic aspects).
Burden of argument on trade-off proponent	Burden of proof rests on the proponent of the trade-off who has to prove that the trade-off is unavoidable and acceptable.
Avoidance of significant adverse effects	No trade-off that causes significant adverse effects on any sustainability areas (ecological, social, economic) can be justified unless the alternative is worse.
Protection of the future	No displacement of significant adverse effects from the present to the future can be justified unless the alternative is of an even more significant adverse effect.
Open process	Proposed trade-offs must be addressed through open involvement of all stakeholders, particularly those who will be affected by the trade-offs.

A number of tools have been designed specifically for dealing with trade-offs, for example, cost-benefit analysis and consideration of opportunity costs, matrix-based appraisal methodologies, multi-criteria assessment scenario comparisons, or life cycle assessment.

3.4.10 Stakeholder engagement during the main assessment stage

Section 3.3.6 discusses the minimum requirements for stakeholder engagement/participation in the SEA Process and its role during the scoping phase. But stakeholder engagement should be a continuing process throughout all stages of the SEA including during implementation of the Strategic Environmental and Management Plan (SESMP).

Much of the main assessment activities will be expert-led involving analysis of data, prediction of trends/modelling, brainstorming to assess/score potential impacts, etc. The assessment process will be intensive and will need to be undertaken by a small professional team, drawing from international experience and lessons regarding the potential impacts of particular developments and local scientific and contextual knowledge.

But stakeholders have a clear role to review the outcomes of the draft SEA report and draft SESMP, to examine the analyses and recommendations, identify gaps and errors, and challenge assumptions and conclusions.

Equally, once the PPP is approved and is being implemented, stakeholders will have key roles to play in monitoring whether the environmental and social quality objectives - agreed to and used in the SEA, are being met, and whether mitigation plans are being fully and effectively carried out. The SESMP will recommend a monitoring and auditing programme for this purpose. It should also set out the roles and responsibilities of governmental bodies and other stakeholders to implement the SESMP as well as the opportunities for civil society groups to engage in this process (e.g., data gathering, informal reporting of changes, etc.).

3.5 STRATEGIC ENVIRONMENTAL (AND SOCIAL) MANAGEMENT PLAN (SESMP)

For many PPPs, particularly those at a policy level where actions for its implementation are generic, a section on mitigation and monitoring can be included in the SEA providing sufficient information for the proponent to include appropriate measures in the PPP to address these issues.

It is becoming increasingly common for a proponent to require the preparation of a separate Strategic Environmental Management Plan (SESMP).[14] This may be in circumstances where either (i) the SEA results in the identification of numerous significant potential impacts, so it would be beneficial to have a separate SESMP, or (ii) where institutional reform/management planning has a significant role to play during PPP implementation. Prepared as a standalone document, a SESMP is an effective reference document and management tool for assuring that SEA recommendations are implemented.

Where a proponent requires a stand-alone SESMP, it should amplify (but not replace) the text in the SEA. Further details on the role of a SESMP and what it should cover are provided in Annex 15.

Annex 16 provides a list of issues that should be covered by a SESMP.

3.6 REPORTS AND REVIEW

A variety of reports (formal and informal) may be produced during a SEA process (Table 3.8). Some will require circulation to stakeholders (and in some cases to the public) with a request for comments. Some of these will require formal review.

Every effort should be made to make SEA reports accessible to stakeholders and the public, particularly to non-specialists (e.g., non-technical summaries) and in major local language(s). The use of social media is gaining increasing importance to effective disclosure of SEA reports.

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[14] A SESMP should address both environmental and social concerns. To emphasise this point, the term Strategic Environmental and Social Management Plan (SESMP) is sometimes used in preference to SESMP. In this guidance, SESMP is used.

Table 3.8: Reports produced during an SEA

Report	SEA stage when report required (Table 3.1)	Requires circulation to stakeholders for information and comment	Must be provided to the public for information and comment	May require formal review	Comment
Inception report	Stage 2				If required by TOR
Scoping report	Stage 2	√	√		Should incorporate stakeholder engagement and communications plan
Special studies and research reports	Stage 2/3				May require to be completed before SEA can proceed to Stage 3. Should be submitted with the SEA report
Initial SEA report	Stage 3	√	√		
Draft SEA report	Stage 4	√	√		
Draft SESMP (when required as stand-alone)	Stage 4	√	√		
Final SEA report	Stage 4	√	√	√	
Final SESMP (when required as stand alone)	Stage 4	√	√	√	
Record of stakeholder events	Stage 4		√		A record of numerous meeting/workshops (participants, comments) may better be presented as a stand-alone report, to reduce undue length of the SEA report
Monitoring reports on PPP implementation – may be subsumed in SESMP (where required) annual reports	Stage 6			√	On-going throughout PPP implementation

Note: In some countries there may be requirements to submit other reports/documentation.

3.6.1 Scoping report

The scoping report should cover the issues listed in Box 3.3 (section 3.3.3).

3.6.2 Initial SEA report

The initial SEA report should present the assessment of the PPP alternatives (section 3.4.5).

3.6.3 Special reports

The scoping process may identify the need for special reports or research where critical information or data is inadequate, unreliable, or not available. Supporting reports should be prepared on any such specialist studies, including on methods used, data acquired and analysed, etc. They may be concerned with, but not limited to, specific subject matter areas such as health issues, biodiversity, ecosystems, land use, protected areas, archaeological and heritage sites, institutional arrangements, skills and capacities, or review of legal instruments.

3.6.4 Draft SEA report

The SEA results need to be reported (e.g., aspects of the technical analysis and the rationale for conclusions and recommendations). A SEA report can at times be very technical, but it must be presented in an understandable format, in the official language used in the country for government business (and in English where international financiers are involved in funding the implementation of the PPP), with a non-technical executive summary also in the main local language(s).

A SEA is usually complex and can run to a considerable length. But is very helpful to minimise unnecessary text by using diagrams, graphics, and summary tables. In addition, a concise, non-technical summary is critical and should adequately summarize and explain the SEA findings to all stakeholders, including local communities. The non-technical executive summary should contain the title of the report and it should summarize:

- Proposed PPP , objectives and SEA methodology
- Consultation process
- Alternatives that were studied and the selected option(s) (preferred alternative(s)),
- the affected area(s),
- Environmental and socio-economic analysis,
- Impacts expected,
- Proposed mitigation and enhancement measures, and
- Proposed monitoring programme.

Because the non-technical executive summary is likely to be the only part of the SEA report that is read by the public (and by other stakeholders), its quality is critically important to obtaining informed stakeholder comments on the Draft SEA Report. This executive summary should also be made available in the dominant local languages.

Annex 4 lists issues that are usually required to be covered in a SEA report. Additional chapters/sections may be added, as required.

The main SEA report should include an annex analysing the main stakeholder perspectives and indicating how they have been addressed (these can be presented in an issue-response table). However, the inclusion of annexes detailing all stakeholder events, all participants, and all comments (many of which may cover essentially similar issues) will considerably lengthen a SEA report and may better be presented as a stand-alone Record of Stakeholder Events.

Key points from all special and supplementary reports should be reflected in the appropriate chapters of the main SEA report.

3.6.5 Draft Strategic Environmental and Social Management Plan (SESMP)

Where a separate Strategic Environmental and Social Management Plan (SESMP) is required by the proponent, it should amplify (but not replace) sections on mitigation and monitoring included in the draft SEA report. This should not be seen as duplication of effort. Both the SEA report and SESMP will serve different functions and should be capable of being used without having to cross-reference each other. The SESMP should be incorporated as an integral part of the PPP even though it may be presented in a stand alone document.

The draft SESMP should set out, in detail:

- Strategies and procedures to implement the SESMP to enhance positive, and prevent, minimise or mitigate adverse, environmental and social impacts associated with the PPP and projects, activities, or regulations that may occur in the future when implementing it.

- The roles and responsibilities of different jurisdictions, authorities, and actors in implementing the SESMP. As far as possible, recommendations should identify responsible parties.

- The practical arrangements for environmental and social monitoring to ensure that:

  - Information is recorded and assessed (against environmental and social quality objectives and indicators identified by the SEA and those incorporated in the PPP) on the environmental and social impacts (including cumulative and transboundary impacts) of the PPP and downstream development projects/initiatives that may be implemented – to determine if the objectives and recommendations are being met;
  - Any unforeseen adverse effects are identified in order to be able to undertake appropriate remedial actions;
  - A mechanism is included to signal when steps are required to enhance benefits or to remove or reduce risks and negative impacts. The proposed mechanism should take into account existing national legislation and provisions regarding EIA, and
  - A timeline is presented for monitoring and follow-up actions. Where possible, it may also be useful to present a summary of costs of SEA implementation.

- Procedures and measures to ensure ***compliance with relevant safeguards*** (national and international where applicable) during implementation of the PPP and downstream projects/initiatives. National regulations should take precedence in the case of A nationally-driven SEA. Where such national safeguards do not exist, then reference can be made to incorporate the requirements of other international standards (e.g. IFC, WHO, multi-lateral development banks).

- A ***stakeholder consultation procedure*** for the mechanism to monitor and evaluate the environmental and social dimensions of PPP implementation.

- ***Guidance and recommendations for EIAs*** of individual projects that may arise during PPP implementation.

Thus, the SESMP should act as an over-arching framework and roadmap for addressing the cumulative impacts of projects, development initiatives and activities planned to be implemented under the PPP. Commitments in this regard should be incorporated in the PPP as an integral part – but they may be in less detail than in the SEA, and the PPP will cover much more ground. The aim of the SESMP is to provide a management tool for ensuring that the recommendations in the SEA are followed, to identify the responsible party or agency for doing so and how the environmental and social commitments in the PPP will be effectively realised.

Further information on the role of a SESMP is provided in Annex 15.

3.6.6 Quality assurance / technical review of SEA/SESMP

Designing a SEA to include the steps and practices outlined in the various stage of the process (Table 3.1) will provide a basic level of process quality. However, a specific measure of quality control assurance will be needed, e.g., to ensure the credibility of the assessment in the eyes of stakeholders. These measures will depend on the nature, context, needs and timeframe of the specific PPP. For further guidance, see Annex 10.

The SEA process described in these guidelines sets out the following options for quality control checks.

Administrative review

Administrative review of draft SEA reports and SESMPs should be undertaken by the PPP proponent (Section 2 (Report Presentation) of Annex 10 (Consolidated Checklist for the Quality Assurance, Review, and Performance Evaluation of a Comprehensive SEA) can assist with this step).

3.6.6.1 Scrutiny workshop

A scrutiny workshop may be organised by the proponent with the competent authority to jointly examine the first draft of the SEA report and its recommendations and agree any revisions and amendments.

3.6.6.2 Lead agency and stakeholder review

The PPP proponent should send the draft SEA report (and draft SESMP when a stand-alone document is required) at the same time to relevant sector lead agencies (e.g. Ministries of Energy, Health; Agriculture, and Transportation). Lead agencies and other stakeholders should be allowed sufficient time (generally 30 working days) to review the documents and submit comments.

One of more stakeholder workshops should be organised to discuss the reports. A national workshop should be organised (Figure 3.6). In countries that have disparate and remote regions (e.g., geographically dispersed island nations), a number of regional workshops will be advisable to enable stakeholders to participate. The use of remote consultation techniques (e.g., Microsoft Teams, Zoom, Google Meet, WhatsApp) may be useful where face to face meetings are not possible.

Figure 3.6: **National workshop to discuss draft report of SEA of SW Bangladesh and the Sundarbans, February 2021**

3.6.6.3 Public review

Where possible, the PPP proponent should ensure that at least two *notices* regarding the draft SEA report (and draft SESMP) are published, each one week apart in newspapers, on the SESA website or via social media with a nationwide circulation, and announced in other local media. The public generally should be allowed 30 working days (from the date of the first advertisement) to submit comments.

The invitation for public comments (notice) should state (a) the nature of the PPP, (b) where the PPP and SEA documents can be found (e.g., on the dedicated SEA website, at particular government offices), and (c) how, by when, and to whom comments should be submitted.

3.6.6.4 Formal technical review

The PPP proponent may be required by some national SEA regulations to submit a specified number of copies (possibly in specified format) of the draft SEA report and draft SESMP, and possibly additional documents (e.g., an Environmental Statement summarising information in the SEA report) to the competent authority for formal review. The PPP proponent may be required to cover various related costs, such as:

- Verification surveys;
- Formal review by the competent authority;
- Coordination of the stakeholder-engagement review process (e.g., coordination of a Technical Advisory Committee) and the public review process;
- Monitoring checks by the competent authority or others of the PPP implementation; and
- Any other required steps or functions as may be determined by the competent authority.

A formal technical review by the competent authority of the final SEA report and final SESMP may also be required in some jurisdictions (see sections 3 -8 of Annex 10).

The competent authority may seek support for such review by the following:

- Commissioning ***independent external experts*** to conduct a technical review;
- Establishing a ***Technical Advisory Committee*** (TAC) to undertake the review; or
- Establishing an ***Independent Expert Commission*** (applicable for trans-national shared resources).
- [Note: where an SEA is likely to have trans-national impacts, it will be necessary to advise the authorities of the concerned country at the outset, agree on how to address such impacts (perhaps with experts from both countries taking part in the SEA), and agree how to jointly review the SEA report. As indicated above, the nomination of experts to the Independent Expert Commission to represent the country on trans-boundary issues will be necessary. The respective notification protocols and procedures would apply].

Before submitting the final SEA report (and final SESMP where required) to the competent authority, the PPP proponent shall ensure quality-assurance of the SEA using the same checklists as the internal and external reviewers will use (see Annex 10). The PPP proponent should endorse the final SEA report (and final SESMP where required).

3.6.6.5 Key questions and criteria for reviewing the SEA report

Note: Reviewing the SEA process (rather than the report), outcomes, or performance is considered in Section 3.7, *'Monitoring and Evaluation*'.

The most important outcome of a SEA, and thus measure of success, are the positive changes that are made to the PPP. Key questions related to the comprehensive review of a SEA Report include:

- The changes made to the PPP as a result of the main assessment stage of the SEA (Stage 4);
- The quality of information presented in the SEA report;
- The level of stakeholder participation and response to stakeholder comments;
- The definition of the environmental and social quality objectives (ESQOs);
- The adequacy and quality of the assessment and mitigation of environmental and social impacts; and
- The planned implementation framework, timing, follow-up activities and constraints.

Box 3.12 presents criteria that can be used for internal, informal, or formal review of SEA reports by the proponent, the competent authority, expert committees, or others to check whether a SEA has been conducted properly and whether all required information is included in the SEA Report.

Box 3.12: Review criteria for SEA reports

Addressing key issues
- The purpose and objectives of the PPP and SEA are made clear.
- Links with other related PPP are identified and explained.
- Environmental and social issues that are relevant to the PPP are determined.
- The assessment focuses on significant issues.
- Reasons are given for eliminating issues from further consideration.
- The framework of SEA objectives is appropriate to the PPP and identified environmental and social issues.
- Mechanisms have been provided to allow stakeholder inputs into SEA recommendations and decisions.

Alternatives
- Realistic alternatives of the PPP are considered and the reasons for choosing them are documented.
- Alternatives include 'do minimum' and/or 'business as usual' scenarios wherever relevant.
- The environmental and social effects (both adverse and beneficial) of each alternative are identified and compared.
- Inconsistencies between the alternatives and other relevant PPP are identified and explained.
- Assumptions behind the development of alternatives are provided and reasons are given for selection or elimination of alternatives.

Baseline information
- Relevant aspects of the current state of the environment and social conditions and their likely evolution without the PPP are described.
- Environmental and social characteristics of areas likely to be significantly affected are described, including areas wider than the physical boundary of the PPP area where it is likely to be affected by the PPP.
- Relevant data gaps are identified as are means to address them.

Prediction and evaluation of likely significant environmental and social effects
- Both positive and negative effects are considered, and the duration of effects (short, medium or long-term) is addressed.
- Likely secondary, cumulative, and synergistic effects (positive and negative) are identified where practicable.
- Inter-relationships between effects are considered where practicable.
- The prediction and evaluation of effects makes use of relevant accepted standards, regulations, and thresholds.
- A ranking of significance is provided.

Uncertainties
- Methods used to carry out the SEA are described.
- Deficiencies in background information or methods are explained.

Mitigation
- Measures envisaged preventing, reducing and offsetting any significant adverse effects of implementing the PPP are indicated.
- Issues to be taken into account in project consents are identified.

SEA Report
- Is clear and concise in its layout and presentation.
- Uses simple, clear language and avoids or explains technical terms.
- Uses maps and other illustrations where appropriate.
- Explains the methodology used.
- Explains who was consulted and what methods of consultation were used, and how the consultees' views have been taken into account.
- Identifies sources of information, including expert judgement and matters of opinion.

- Contains a non-technical summary covering the overall approach to the SEA, the objectives of the PPP, the main options considered, and any changes to the plan resulting from the SEA. The summary is provided in local languages as required.
- Technical, procedural and other difficulties encountered are discussed; assumptions and uncertainties are made explicit.
- Clearly identifies how recommendations have been incorporated in the PPP.

Management of the SEA process

- The SEA carried out as an integral part of the PPP-making process.
- Relevant authorities and the public concerned are consulted in ways and at times which give them an early and effective opportunity within appropriate time frames to express their opinions on the draft PPP, SEA Report and SESMP.

Source: Adapted from MONRE (2008).

A system to review, chapter-by-chapter, the content of a SEA Report is presented in Sections 2 to 8 of Annex 10:

- Section 2 of the checklist reviews the *Report Presentation* (i.e., is it complete, adequate, clear, etc.). It can support the Administrative Review of the Draft SEA Report, ensuring that the Draft SEA is of sufficient quality to be sent out to stakeholders for review.
- Sections 3 to 8 of the checklist focus on the review of various chapters of a SEA:
    - Section 3 - PPP Description;
    - Section 4 – Policy, institutional and legal framework and links;
    - Section 5 - Description of the environmental and social baseline;
    - Section 6 – Assessment of impacts, determination of impact significance and evaluation of alternatives;
    - Section 7 - Mitigation and environmental management and monitoring plan;
    - Section 8 - Consultation process.

When reviewing a *SESMP,* it will be necessary to check that the plan covers all the issues listed in Annex 16, and that it is presented in a clear and easy to use manner.

3.7 MONITORING AND EVALUATION OF THE SEA, SESMP AND PPP

Monitoring and evaluation is important to determine whether the outcomes have been achieved and have influenced the PPP (fully or in part), and to ensure quality control of the SEA process itself.

3.7.1 Monitoring and implementation of the SESMP and PPP

The PPP proponent should describe the environmental and social monitoring recommendations made in the SEA report (and amplified in a SESMP where the proponent has required such a standalone plan - the latter should, in any case, be clearly indicated in the PPP as an integral part of the PPP).

The proponent should provide periodic reports (annually or according to such other regularity as might be determined) on implementing the recommendations of the SEA and SESMP. Such reports should be submitted to the competent authority (where this is a formal requirement) and should be made available to the public for review and comment (e.g., including via the dedicated SEA website or the proponent’s website).

Information tracking systems can be used to monitor and check progress. Monitoring of cumulative effects may be appropriate for PPPs that will initiate regional-scale change in critical natural assets. Methods and indicators for this purpose need to be developed on a case-by-case basis.

3.7.2 Evaluation of the SEA and PPP

At some point during or after implementation of the PPP, a formal evaluation of the monitoring results should take place as part of the revision or renewal of the PPP. Key questions to help evaluate the performance and the development outcomes of a SEA relate to:

- The accuracy of the assumptions made during the SEA and its influence on the PPP process;
- The implementation process;
- The development goals on accountability;
- The outcome of activities.
- Any required corrective actions or next steps.

Evaluation is important to determine whether the outcomes have been achieved, fully or in part, and to ensure quality control of the SEA process itself. As a minimum, the SEA should be evaluated to determine if the PPP promoted sustainable development and what its effects were on institutional, legal, governance and capacity-building issues that highly influence the implementation process. The proponent should undertake such evaluation in consultation with the competent authority. Consultants may also be engaged to provide an independent evaluation.

3.7.2.1 Role of evaluation

Evaluation should examine whether an intervention has achieved intended outputs and outcomes. The challenge is to define clearly how to measure these achievements in an objective and robust manner. The approach can be kept relatively straightforward if it focuses on elements that can be measured more objectively than others (instead of on elements where it is difficult to determine a cause-effect relationship). Evaluating the influence of an SEA will involve examining plausible cause-effect relationships and making an informed judgment about the extent to which the SEA influenced PPP design, implementation and outcomes.

It may not be necessary to obtain absolute scientific proof, but it is necessary to engage in a reflective process to evaluate and improve on previous decisions. The aim is to learn how to continuously improve the integration of sustainability into decision-making and how to improve the use and efficiency of SEA as tool to support sustainable development. In this context, SEA evaluation can also help to:

- Improve learning on the linkages between PPP formulation, assessment, and practical outcomes;
- Achieve PPP goals by identifying ex-post adaptation requirements for those implementation mechanisms/actions that failed to deliver intended outcomes; and
- Support the accountability of decision-makers and involved stakeholders by making the results of decisions transparent.

A central element of evaluation should be the definition of appropriate indicators that reflect sustainable outcomes of implementing the PPP. Indicators are also essential to quantify the achievement of specific objectives and goals. Appropriate indicators for environmental and social quality objectives (ESQOs) should have been defined during the SEA scoping process and incorporated in the SESMP to enable the necessary data to be collected during the implementation phase. Some aspects of achieving goals and objectives are better evaluated in a qualitative manner: in that situation, a written description of the envisaged objectives can be compared with what was practically achieved.

Evaluation should lead to concrete results, for example:

- Positive recommendations on future actions;
- Ex-post adaptation of implementation measures or even the PPP decision(s) itself (e.g. in the case where serious deviations from previous assumptions endanger the achievement of specific goals); and
- Specific measures to develop capacity, tailored to help overcome implementation gaps.

The most important outcome of a good quality SEA is that it significantly influenced the achievement of positive development results and will have enhanced the effectiveness of the PPP.

A systematic approach to (monitoring and) evaluation can be supported by checklist(s). Sections 9 - 11 of Annex 10 focus on evaluation: section 9 reviews decision making; section 10 provides the IAIA SEA process review checklist; and section 11 is the SEA performance monitoring evaluation checklist.

CHAPTER 4

KEY ISSUES FOR SEA OF NATIONAL/REGIONAL ENERGY POLICIES, PLANS AND PROGRAMMES

4.1 Application of SEA to energy policies, plans and programmes

All countries face the challenges of climate change, and most have already taken steps to promote the transition away from fossil fuel consumption to enable and promote investment in renewable energy. It is reported that solar and wind are now being installed at a rate that is three times faster than all other new electricity sources combined[1].

Many countries have already, or are in the process of, reviewing, revising or developing new national energy policies, strategies and plans to reflect the need for developing renewable energy and set out how they will achieve such change. But, for most countries, the transition will be gradual (over many decades). As new renewable energy options are explored, committed to, and developed, there will still be a continuing need to rely on coal, oil, and other fossil fuels for some time to come. So, most countries will continue to rely on a mix of energy sources (both fossil fuel-based and renewables-based) and their energy policies, plans and strategies will be likely to continue to reflect this.

Countries have developed a wide range of policies, plans and programmes (PPPs) for the energy sector (Table 4.1).

Table 4.1: Examples of types of energy policies, plans and strategies

	Type	Examples
Policies	Energy policies	Nigeria 2022, Myanmar 2014
Plans	Energy productivity plans	Australia 2015
	Energy transition plans	Ghana 2022, Nigeria 2022
	Energy development plans	Estonia 2014
	Renewable Energy Action Plans and National Energy and Climate Plans	EU member states
	Energy sector plans	Samoa 2017
	Electricity plans	India 2022
	Power sector master plans	Cape Verde 2017
	Power contingency plans	Philippines 2021
Strategies	Energy strategies	Jordan 2020, EU 2022

Energy policy-making planning has traditionally focused on estimating demand and determining the types of energy sources to be used to meet it. More recently, other goals such as minimising the cost of energy while addressing environmental concerns, particularly reducing greenhouse gas emissions, have been incorporated. Such policies and plans aim to guide the future of local, national, regional systems, reflecting the needs resulting from population growth and consumption patterns.

Despite these new challenges, energy planning and policy-making remains a largely technical and economic exercise. Wider environmental and social (including cultural) factors are highly relevant to developing models for meeting future energy demands but have largely been neglected. Energy planning is often conducted within governmental organisations but may also be carried out by large energy companies such as electric utilities or oil and gas producers. It may involve input from different stakeholders drawn from government agencies, local utilities, academia, and other interest groups. Energy planning is frequently undertaken using integrated approaches that consider both the provision of energy supplies and the role of energy efficiency in reducing demands.

[1] Blakers and Ruther (2023)

Energy plans have traditionally played a strong role in setting the framework for regulations in the energy sector (e.g., concerning the type of power plants that can be built or prices that can be charged for fuels). But over the past three decades, in many countries, energy systems have been deregulated resulting in reduced energy planning and decisions have increasingly been left to the market. In the last few years, this trend has reversed following increasing concerns over the environmental impacts of energy consumption and production, particularly considering the threat of global climate change. Sustainable energy planning is particularly appropriate for communities who want to develop their own energy security, while employing best available practice in their planning processes.

As for any other SEA, its application to energy PPPs should seek to merge with and support the process of development of the PPP to achieve maximum influence on its design and content. The experience of Vietnam in applying SEA to support preparation of successive Power Development Plans (PDPs) illustrates an evolution in SEA integration (Box 4.1)

Box 4.1: Evolution in SEA integration in Vietnam's Power Development Plans

The case of Viet Nam's Power Development Plans (PDPs) illustrates how incorporating SEA into the planning process for successive PDPs ensured that they were based on a more thorough understanding of their implications for the economy, society, and environment of the country.

The first integration of SEA into the PDP was done in the preparation of the Hydropower Master Plan in the context of PDP VI. This pilot SEA considered the potential impacts of 21 large-scale hydropower schemes included in PDP VI. Five scenarios were considered: one with a base case consisting of the existing schemes included in PDP VI, and four that progressively reduced the number of hydropower schemes and replaced them with least-cost alternatives (generally thermal power) identified through the PDP process. The impacts of alternative generating sources were considered in each scenario, providing a meaningful analysis of the different options to meet the needs for generation capacity defined in PDP VI.

The lessons learned from the pilot SEA showed that changes were needed in the PDP planning process to ensure that social and environmental impacts were fully integrated into the plans for the sector. The SEA proposed a detailed model of how this was to be achieved and to inform the development of the SEA in PDP VII, which was based on the experiences and capacities developed in the execution of the pilot hydropower SEA linked to PDP VI.

The original PDP VII was prepared in 2011–2012 to guide the development of the power sector for the period 2011–2030. It analysed future electricity demand scenarios by sector, considering potential economic and social development trends. It also assessed the most effective, least-cost power generation options for meeting likely future demand patterns. The plan's SEA was done simultaneously with the preparation of the PDP. While there was close coordination at the different stages of analysis during the PDP and the SEA preparation, there were also limitations in the extent to which the SEA was fully integrated into the PDP process.

Awareness of these impacts and concerns that the demand projections were too high led to a revision of PDP VII. The preparation of the revised PDP was based on the SEA from the original plan, with the scenarios in the analysis defined in relation to impacts identified in the SEA and related to the achievement of policies on renewable energy and energy efficiency.

The latest version of Viet Nam's PDP— the revised PDP VII (RPDP VII)—is a model of good practice in integrating an SEA in the preparation of a strategic plan that is important not just for Viet Nam but for the power sector of other countries, particularly in the Greater Mekong Subregion. The SEA provided an understanding of the implications of the different development options in the PDP, leading to significant changes in the final contents of the plan, ensuring better alignment to national development policies of Viet Nam and that it more effectively reflected specific national targets in areas such as renewable energy and greenhouse gas (GHG) mitigation.

Source: ADB (2018)

Regional cooperation will be of increasing importance in developing such PPPs as there will be collective opportunities for diversifying electricity generation mixes and reducing reliance on fossil fuel resources.

4.2 Guidance and training for developing energy PPPs

It is often difficult to know whether individual governments have issued internal guidance for developing energy PPPs as this information may not be made public.

The EU has issued guidance for preparing progress reports on the implementation of National Energy and Climate Plans (NECPs) (EU 2022). It sets out setting our principles and good practice and describes how the reports should address a range of issues. But there is not specific requirement to subject the NECPs to an SEA process (EU 2022)[2] . (NECPs are discussed in section 4.3).

In the USA, guidance is available for community energy strategic planning (USDE 2013) (Box 4.2) whilst, in the UK, Energy Systems Catapult has published ***guidance on how to create a Local Area Energy Plan*** (LAEP) (Box 4.3). Both suggest a series of steps for the process.

Box 4.2: Guide to Community Energy Strategic Planning (CESP), USA

In 2013, the US Department of Energy prepared a Guide to Community Energy Strategic Planning (CESP) (USDE 2013). It offers the following 10-step process for creating a robust strategic energy plan for a local government and community that can help save money, create local jobs, and improve national security:

1: Establish and charge a leadership team;
2: Identify and engage stakeholders;
3: Develop an energy vision;
4: Assess the current energy profile;
5: Develop energy goals and strategies;
6: Identify and prioritize actions;
7: Put together a financing strategy;
8: Develop a blueprint for implementation;
9: Plan to evaluate;
10: Develop, adopt, and publicize the CESP.

The guide offers tools and tips to complete each step and highlights examples from successful planning efforts around the country. It aims to help local governments and community stakeholders to use the CESP framework to build on initial energy successes by moving from single projects and programs to a comprehensive, long-term energy strategy that delivers benefits for years to come. A CESP is seen not as a static document but rather as a long-term blueprint to focus and guide efforts and actions toward a defined energy vision. The plan articulates goals, develops strategies and actions to meet the goals, and identifies and allocates resources to assure effective completion of these strategies.

Source: USDE 2013.

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX%3A52022XC1229%2802%29%from=EN

Box 4.3: Guidance on how to create a Local Area Energy Plan (LAEP), UK

In the UK, Energy Systems Catapult has published ***guidance on how to create a Local Area Energy Plan*** (LAEP), aimed at local government organisations who are looking to create a plan to help them meet their net zero goals and climate emergency declarations[3]. A LAEP sets out the change required to transition an area's energy system to Net Zero in a given timeframe. This is achieved by exploring potential pathways that consider a range of technologies and scenarios, and when combined with stakeholder engagement leads to the identification of the most cost-effective preferred pathway and a sequenced plan of proposed actions to achieving an area's Net Zero goal.

The Guidance provides a detailed description of a 7-stage end-to-end process:

1. Preparation
2. Stakeholder Identification and Engagement
3. Understanding and Representing the Current Local Energy System
4. Modelling Options for the Future
5. Scenario Refinement and Selection
6. Actions, Priorities, and Decisions
7. Create the Plan

Source: https://es.catapult.org.uk/guide/guidance-on-creating-a-local-area-energy-plan/

Training

The International Renewable Energy Agency (IRENA) provides capacity building support to countries for developing or updating national energy masterplans through its Masterplan Development Support Programme[4]. The programme typically spans one to two years and includes several weeks of in-country training to calibrate a system planning test model, explore energy planning scenarios, and develop a national energy masterplan document. In-country sessions are complemented by online training and other meetings.

4.3 Status of SEA practice in the energy sector

Despite repeated calls to advance more strategic forms of impact assessment in energy planning, decisions about renewable energy development are still predominantly approached on a project-by-project basis[5]. Nevertheless, energy plans, programs, and sometimes policies are subject to strategic environmental assessment (SEA) in many parts of the world**.** In Europe, for example, energy plans are explicitly listed in the SEA Directive (2001/42/EC) while in low and middle-income countries energy is, next to transport, the most important sector in which SEAs are required to be undertaken.

A study by Geissler *et al*. (2021) provides an overview of the current state of research on and practice of SEA in the energy sector. A key message is that SEAs for energy plans, programs and policies have similar shortcomings to SEAs in other sectors. In particular, the assessment of cumulative effects and the consideration of alternatives are currently done poorly. The authors observe that, almost without exception, plan alternatives instead of strategic alternatives are developed and assessed in practice. Based on detailed case reviews, they identify meaningful energy alternatives from policy to programme levels (Table 4.2)

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[3] See: https://es.catapult.org.uk/guide/guidance-on-creating-a-local-area-energy-plan/
[4] see: www.irena.org
[5] Nwanakezi *et al*. (2022)

Table 4.2: PPP levels and energy alternatives
Source Gessler *et al.* (2021)

Level	Characteristic	Alternatives	Energy alternatives	Methodology
Policy	Federal course and guidance	• System alternatives; • Strategic options	• Alternative energy concepts; • Variations in energy mix; • Renewable sources; • Distribution options.	Broad-brush, qualitative (e.g. scenario analysis)
Plan	Strategy for a spatial or sectoral planning section	• Development strategies within the sector, plan variations	• Energy supply strategies; • Broad spatial alternatives; • Degree of exploitation; • Infrastructure options.	Quantitative and qualitative methods (e.g. impact matrices)
Programme	Schedule of activities in a specific area	• Alternatives to proposed actions (site, scope, mode)	• Site alternatives (bundle of projects); • Degree of exploitation; • Restriction options.	Quantitative (e.g. MCA, CBA)

The study involved an internet search for SEAs undertaken for the energy sector. It identified 83 SEAs from 28 countries with environmental reports (ERs) published between 2001 and 2019 for which access to the ER or at least to the non-technical summary was given[6].

But only a limited number of countries (20) have been identified as having applied an SEA process to the development of their national energy PPPs (see Table 4.3). Early examples are the SEAs for energy policies in the Czech and Slovak Republics (Box 4.4. Another is the from the UK where the Department for Business, Energy & Industrial Strategy (BEIS) (formerly DTI, BERR and DECC) has undertaken a sequence of Offshore Energy SEAs (OSEA) focused on oil and gas since 2001 (Box 4.5).

A recent case study used renewable energy transitions in Saskatchewan, Canada, to demonstrate how a transitions-based SEA framework can be applied to explore the capacity needs, opportunities, risks, and obstacles in existing institutions and governance arrangements for low-carbon transitions (Box 4.6).

[6] It is possible that earlier SEAs were not found as they might no longer be available online or never have been made available online in the first place.

Box 4.4: SEA of energy policy in Czech and Slovak Republics

SEA of Czech Energy Policy (1997): This identified objectives and measures for the development of the entire sector (electricity, coal and gas) including future privatisation and use of economic instruments. It also addressed the future use of nuclear power, including specific project issues:

- whether to stop or proceed with a second nuclear power plant already approved and partly built; and
- whether to change the limits for open-cast coal mining, which would result in the destruction of additional villages in North Bohemian and North Moravia.

The SEA process focused mainly on the elaboration of the report. Extensive scoping included a national public hearing to comment on the draft policy and the proposed assessment methodology. The scoping process initiated the development of three distinct scenarios of energy mixes. These could be achieved by the use of available administrative, and legal and economic instruments to regulate behaviour of companies and individuals. The scenarios were extensively modelled and assessed against set of 16 categories of environmental, social and economic impacts. A public review of the draft SEA report was held in the main chamber of the Czech Senate.

SEA of the Slovak Updated Energy Policy (EP 1997): This comprised a number of steps:

- provision of information to the public about preparation of the EP;
- expert review, including presentation of opinions for public discussion;
- public forum on the EP with participation from state and professional bodies, industry, universities and research institutions, non-governmental organisations and the media;
- statement by the Ministry of Environment (MoE) on the basis of expert opinion, other comments and public discussion;
- conclusion of the public discussion, with the Statement of MoE and the Statement of the Ministry of Economics sent to all participants; and
- submission of a new version of the proposed EP to the Slovak government – subsequently approved.

The SEA process had a number of positive features, notably with regard to public consultation and input. But NGO representatives strongly criticised the shortcomings of EP-1997 and weaknesses in the policy development process itself which lacked adequate environmental, health and socioeconomic assessments.

Source: Dusik (2003 a, b)

Box 4.5: Offshore energy SEAs in the UK

Since 2001, the UK has undertaken a series of Offshore Energy SEAs (OSEA) considering various areas of the UK continental shelf (SEA areas 1-8), in addition to an SEA for Round 2 wind leasing. The more recent Offshore Energy SEAs (OSEA, OSEA2, OSEA3 AND OSEA4) incorporated the entire UK continental shelf (with the exception of Northern Ireland and Scottish territorial waters for renewable energy, and Scottish territorial waters for carbon dioxide transport and storage), for technologies including oil and gas exploration and production, gas storage and offloading including carbon dioxide transport and storage, renewable energy (including wind, wave and tidal power), and offshore hydrogen production and transport.

As these SEAs have been carried out, the process has evolved and continues to improve. It includes consultation with the public, environmental authorities, and other bodies, together with such neighbouring states as may be potentially affected. The process is guided by a Steering Group comprising departmental representatives, conservation and other agencies, NGOs, industry representatives and independent experts. The diverse members' role is to act as technical peers, guiding the selection of SEA methods and identifying the right information sources.

Source: https://www.gov.uk/government/collections/offshore-energy-strategic-environmental-assessments

Box 4.6: SEA for energy transitions

A study showed how applying SEA to renewable energy transitions in Saskatchewan, Canada, identified significant benefits, opportunities, and risks in renewable energy transitions. Opportunities existed to address energy security concerns and promote distributed generation, but perceived risks included the immediate economic impacts of transitioning away from a fossil-based economy, reliability risks owing to the intermittent nature of renewables, and political uncertainty about the future electricity landscape. The results showed the need for clear transition goals and implementation strategies, including full commitment to the transition agenda. For transitions-based SEA, results highlighted the need for transparency and accountability to ensure effective implementation and the difficulty in establishing new assessment regimes. The lessons of this study appear broadly relevant for addressing low-carbon transition challenges and opportunities in other jurisdictions.

Source: Nwanakezie et al. (2022)

Table 4.3 Examples of SEA applied to the energy sector policies, plans and strategies

Source: A.Kolhoff, Netherlands NCEA

Cases (with hyperlink to documents if available)		Country	Scale / Basin	Year / status	Subject of SEA	Level of influence
1	SEA or Energy Policy.	Slovak Republic (Box 4.1)	National	1997 and 2000	Energy policy	Moderate
2	SEA for Energy Policy.	Czech Republic (Box .1)	National	2002	Energy policy	No
3	Strategic/Sectoral, Social and Environmental Assessment of Power Development Options in The Nile Equatorial Lakes Region .	Nile Equatorial Lakes Region	International	2007	Energy policy	Low
4	SEA for National Energy Policy. SEA case description available.	Ghana	National	2008	National energy Policy	Low
5	SEA for Power Development Plan VII. SEA report available: https://gms-eoc.org/resources/two-seas-on-power-development-planning-in-viet-nam	Viet Nam	National	2011	Power development plan VII (ex-ante)	High
6	SEA for Saskatchewan electricity planning. .	Canada	State / province	2012	Electricity supply plan	Unknown
7	SEA for National Energy Development Strategy by 2030. Summary and review of SEA available: http://www.greenhome.co.me/fajlovi/greenhome/attach_fajlovi/eng/main-pages/2013/07/pdf/Review_Of_The_SEA_For_The_Draft_Energy_Development_Strategy_In_Montenegro_By_2030.pdf	Montenegro	National	2013	Energy strategy	Unknown
8	SEA for Revised Power Development Plan VII. SEA report not available.	Viet Nam	National	2014	Revised power development plan VII	High
9	SEA for Energy Sector Development Strategy. SEA report available: https://mingor.gov.hr/UserDocsImages/UPRAVA-ZA-PROCJENU-UTJECAJA-NA-OKOLIS-ODRZIVO-GOSPODARENJE-OTPADOM/Spuo/29_08_2017_SPU_POS_Strategija_RS.pdf	Serbia	National	2015	Energy strategy	Low
10	SEA for GMS power planning	Greater Mekong subregion 6 countries	International	2015	Power development plan	Unknown
11	SEA for National Energy Sector Policy	Rwanda	National	2015	Energy sector policy	Unknown
12	SEA for National Power Policy*. .	Taiwan	National	2015	National power plan	Moderate
13	SEA for National Strategy of Renewable Energy. Summary of SEA report available:	Azerbaijan	National	2016	Nat. renewable energy strategy incl. hydropower	Unknown

	Cases (with hyperlink to documents if available)	Country	Scale / Basin	Year / status	Subject of SEA	Level of influence
	https://unece.org/fileadmin/DAM/env/greeneconomy/Lea/EaP/SEA_Azerbaijan.pdf					
14	SEA for Power Development Master Plan. .	Angola	National	2018	Power development master plan	Unknown
15	SEA for Master Plan Study on National Power system development. SEA report available as part of master plan. https://africa-energy-portal.org/sites/default/files/2019-07/Master%20Plan%20Study%20for%20Power%20Sector%20System%20Development%20in%20Nigeria.pdf	Nigeria	National	2019	Power development master plan	Unknown
16	SEA for National Power Power System Master Plan 2040. SEA report available as part of master plan. https://openjicareport.jica.go.jp/pdf/12326856_01.pdf	Bhutan	National	2019	Power development master plan	Unknown
17	SEA of National Energy and Climate Plan	Slovenia	National	2019	Energy & climate plan	
18	SEA for National Power Plan.	Cambodia	National	On-going	Power development plan	…
19	SEA for Power Development Plan VIII.	Viet Nam	National	Ongoing	Power Development Plan VIII	…
20	Offshore Energy SEA – a series of SEAs since 2001	United Kingdom	National	Ongoing	Oil & gas	

4.4 EU requirements for energy plans

4.4.1 EU member states

The European Commission require EU member states to submit a National Renewable Energy Action Plan (NREAP) outlining commitments and initiatives to develop renewable energy by 30 June 2010. NREAPs provided a detailed road map of how each member state expected to reach its legally binding 2020 target for the share of renewable energy in its total energy consumption, as required by article 4 of the Renewable Energy Directive (2009/28/EC). The plans set out sectoral targets, the technology mix expected to be used, the trajectory to be followed, and the measures and reforms to be undertaken to overcome the barriers to developing renewable energy.

Each NREAP report provided details of the expected share of energy provided by renewable sources up to and including 2020. The overall target for EU countries is to obtain 20% of their energy usage from renewable energy sources although targets for each country vary considerably. In addition, targets are broken down further by each energy use sector including transport, electricity, and the heating and cooling sectors.

In the European Union, a Regulation on the Governance of the Energy Union and Climate Action (EU)2018/1999 entered into force on 24 December 2018 as part of the Clean Energy for all Europeans package. Under rules in this regulation, all member states were required to prepare a draft (by 2020) of a10-year integrated national energy and climate plans (NECP) (Box 4.7) for the period from 2021 to 2030 charting how they aim to meet the EU's energy and climate targets for 2030. The NECPs outline how EU countries intend to address: energy efficiency; renewables; greenhouse gas emissions reductions; interconnections; and research and innovation. Each Member State is required to ensure that the public is given early and effective opportunities to participate in the preparation of the draft integrated national energy and climate plan.

Box 4.7: Integrated national energy and climate plans

The integrated national energy and climate plans (NECP) provide an overview of the current energy system and policy situation. They set out national objectives for each of the five dimensions of the Energy Union and corresponding policies and measures to meet those objectives. A socially acceptable and just transition to a sustainable low-carbon economy requires changes in investment behaviour, as regards both public and private investment, and incentives across the entire policy spectrum. The plans should be stable to ensure the transparency and predictability of national policies and measures to ensure investment certainty.

The draft plans offer a common, solid, and comparable platform to actively engage and discuss in a synchronized way across Europe with civil society, business and local governments on the EU's common challenges and long-term priorities in the field of energy and climate.

Source: https://energy-ec-europa-eu/system/files/2019-06/national_energy-and_climate-plans_v4_0.pdf

According to Chapter 2, Article 3 of the Regulation, integrated national energy and climate plans shall consist of the following main sections:

a) An overview of the process followed for establishing the plan consisting of an executive summary, a description of the public consultation and involvement of stakeholders and their results, and of regional cooperation with other Member States in preparing the plan;
b) A description of national objectives, targets and contributions relating to the dimensions of the Energy Union;
c) A description of the planned policies and measures in relation to the corresponding objectives, targets and contributions set out under point (b) as well as a general overview of the investment needed to meet the corresponding objectives, targets and contributions;
d) A description of the current situation of the five dimensions of the Energy Union, including with regard to the energy system and greenhouse gas emissions and removals as well as projections with regard to the objectives referred to in point (b) with already existing policies and measures;

e) Where applicable, a description of the regulatory and non-regulatory barriers and hurdles to delivering the objectives, targets or contributions related to renewable energy and energy efficiency;
f) An ***assessment of the impacts of the planned policies and measures*** to meet the objectives referred to in point (b), including their consistency with the long-term greenhouse gas emission reduction objectives under the Paris Agreement and the long-term strategies;
g) A ***general assessment of the impacts of the planned policies and measures on competitiveness*** linked to the five dimensions of the Energy Union;
h) An annex setting out the Member State's methodologies and policy measures for achieving the energy savings requirement.

Furthermore, under Article 8, Member States shall describe their assessment, at national and, where applicable, regional level, of:

- The ***impacts on the development of the energy system and greenhouse gas emissions*** and removals for the duration of the plan and for a period of ten years following the latest year covered by the plan, under the planned policies and measures or groups of measures, including a comparison with the projections based on existing policies and measures or groups of measures as referred to in paragraph 1;

- The ***macroeconomic and, to the extent feasible, the health, environmental, skills and social impact of the planned policies and*** measures or groups of measures ……. including a ***comparison with the projections based on existing policies and measures or groups of measures***. The methodology used to assess those impacts shall be made public;

- ***Interactions*** between existing policies and measures or groups of measures and planned policies and measures or groups of measures within a policy dimension and between existing policies and measures or groups of measures and planned policies and measures or groups of measures of different dimensions. Projections concerning security of supply, infrastructure and market integration shall be linked to robust energy efficiency scenarios;

Source: https://energy-ec-europa-eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0001.01.ENG&toc=OJ:L:2018:328:FULL

The integrated NECP approach requires a coordination of purpose across all government departments. It also provides a level of planning that aims to ease public and private investment. The fact that all EU countries are using a similar template means that they can work together to make efficiency gains across borders[7]. Each Member State must submit a progress report each two years.

The EU Regulation on the Governance of the Energy Union and Climate Action (EU 2018/1999) requires that an NECP should include an assessment of the impacts of the planned policies and measures (Box 4.5, bullet (f)); but it does not specifically state that countries undertake an SEA for the NECP.

Notably, the EU SEA Directive (2001/42/EC) (transposed into UK law) does not apply SEA to policies. But it does apply to energy plans, and NECPs are plans; and the EU Directive explicitly requires an SEA for energy plans. It does not appear that SEAs have routinely been undertaken when NECPs have been developed by EU member states. The UK did not prepare such an SEA for its draft NECP in 2020 (Box 4.8).

[7] https://energy.ec.europa.eu/topics/energy-strategy/national-energy-and-climate-plans-necps_en

Box 4.8: Environmental assessment of the UK's draft NECP

Section 5 of the report on the UK's integrated NECP (DBEIS 2020 Section 5) discusses the impact assessment of planned policies and measures. It sets out climate risks and the expected impacts (improvements) of proposed measures on air quality as well as the macroeconomic health, environmental, employment and education, skills and social impacts including just transition aspects. But these issues are described in very general terms in narrative format with some tables. It concludes that future investments will be likely to be highly sensitive to how climate change evolves over the next two to three decades. There is no indication of what impact assessment methodology was used, if any. If SEA had been applied to this plan and other NECPs, it would likely have addressed a much wider range of environmental and social concerns likely to arise when implementing the NECP.

Those member states that did undertake an SEA include Bulgaria, Ireland, and Slovenia (Box 4.9). But the 'quality' of these SEAs varies. Some were completed after the Strategic Environmental Management Plans (SEMPs (see section 3.5)started to be implemented, others are still not complete (e.g. Bulgaria). Only two of the SEAs could be judged as complying with the steps required by the EU Directive (Spain and Slovenia).

Box 4.9: SEA of NECP, Slovenia, 2019-202

Slovenia carried out a comprehensive SEA of its NECP in parallel to the plan process. It involved both internal (experts) and open scoping on effects, criteria, and measures. This involved extensive stakeholder participation, including a scoping workshop with interested ministries, organisations and NGOs as well as public discussion and a public presentation of the SEA report. The SEA addressed various key themes: mitigation and adaptation to climate change; population and health; sustainable use of natural resources; biodiversity and good ecological status of protected areas, including Natura 2000 European Ecological Network; protection of cultural heritage; landscape and stable society. The significance of likely impacts was assessed for four scenarios: existing measures; additional measures 1; additional measures 2; and an ambitious scenario with the recommendations of the European Commission 2030 with a view to 2050.

The SEA was prepared by an external team of SEA experts. The process of plan preparation was led by the Ministry of infrastructure and the SEA process by the Ministry of the Environment and Spatial Planning, which issued an opinion on the SEA Report quality and an environmental acceptability decision (after checking that environmentally accepted measures and mitigation measures were included in the plan).

Sources:

a) Vesna Kolar Planinšič, Ministry of Environment and Spatial Planning, Slovenia.
b) https://www.energetika-portal.si/dokumenti/strateski-razvojni-dokumenti/nacionalni-energetski-in-podnebni-nacrt/dokumenti/%23c96

4.4.2 EU applicant countries

Contracting parties (countries aspiring to join the EU) of the Energy Community[8] are also developing NECPs (first drafts due by June 2023, final draft by June 2024). Unlike EU member states, they are

[8] The Energy Community is an international organisation (established by treaty in 2005) which brings together the European Union and its neighbours to create an integrated pan-European energy market (www.energy-community.org).

obliged by an SEA Decision of the Community's Ministerial Council[9] and the Governance Regulation of the Community[10] for SEAs to be prepared when preparing such plans. Their preparation is monitored by the Energy Community Secretariat. To date (February 2023)[11], the following have been completed:

- Albania: the NECP was adopted before the SEA was completed. The NECP will be reviewed to reflect the SEA findings before finalisation.
- Macedonia: adopted the NECP without the (obligatory) consent of the Ministry of Environment to ensure its alignment with the SEA and that public comments have been considered. The NECP will be reviewed before finalisation.
- Georgia, Montenegro and Serbia are currently undertaking SEAs for their NECPs.
- Other countries are in the early stage of the NECP process, except for Ukraine due to martial law and the ongoing conflict with Russia.

4.5 Steps in undertaking an SEA for an energy sector PPP

As for any SEA, one carried alongside or as an integrated component of developing or reviewing an energy sector policy, plan, programme of equivalent (e.g., a strategy), should follow the basic stages and steps set out in Chapter 3.

In most countries having legislative or regulatory requirements for SEA, energy sector PPPs are specifically identified as requiring an SEA. Similarly, multilateral development banks usually require an SEA/SESA to be completed when they are providing funding for energy sector development such as initiatives to support the energy transition. Examples regarding the latter include an SEA initiated by the Asian Development Bank in Indonesia (in 2022) and scoping for a possible SEA in the Philippines (in 2023) - both linked to implementing the Energy Transition Mechanism in countries in Southeast Asia.

4.6 Key concerns that an energy PPP will need to address

The main sources of non-renewable energy of critical concern as regards climate change are carbon-based fossil fuels such as coal, oil, and natural gas. These are burned to generate energy in power stations and internal combustion (vehicle) engines.

As far as reducing reliance on fossil fuel-based energy production is concerned, this guidance focuses on the need for retirement of coal-fired power plants and the closure of associated coal mines (Chapter 11). The renewable energy sources addressed by the guidance cover: hydropower (Chapter 5), wind (Chapter 6), solar (Chapter 7), bioenergy (Chapter 8), geothermal (Chapter 9) and tidal (Chapter 10).

For all these sources, there is a relatively common set of issues for which there is potential for environmental and socio-economic impacts to arise for which management and mitigation measures need to be addressed (see Tables 4.4 and 4.5, respectively). The specifics of these likely impacts for different energy sources are addressed in subsequent chapters.

Given the challenges of climate change and international commitments concerning GHG emissions, new or revised energy PPPs need to focus on how to change the balance in energy sources to reduce emissions and to promote and invest in renewable energy options. Many countries have already made considerable progress in this transition. An SEA for a national or more local energy PPP seeking to promote this transition will need to address all these issues (as applicable).

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[9] https://www.energy-community.org/dam/jcr:33b7fa10-df38-44ae-b2bf-58c250a4a298/Decision_2016_13_MC_ENV.pdf
[10] https://www.energy-community.org/dam/jcr:c755f9db-f6e7-448c-9cf5-0a5f02113ae2/19thMCDecision14_CEPII_30112021.pdf
[11] Information provided by Energy Community Secretariat, Vienna

Table 4.4: Key environmental issues associated with closing coal-fired power plants/coal mines and developing new renewable energy facilities

Theme	CFPP	Coal Mines	Geotherm	Hydro	Solar	Tidal	Wind	Bioenergy
	Early Retirement	Closure	Development					
Integrity of habitats and preservation of biodiversity								
Integrity of protected & sensitive areas								
Delivery of ecosystem services								
Maintenance of air quality								
Fresh water use/demand								
Maintenance of water quality								
Waste (solid, gas, liquid, toxic, hazardous, spoil) & pollution)								
Land/water contamination								
Noise and vibration								
Greenhouse gas emissions								
Land degradation (erosion/sedimentation/deforestation)								
Land/marine use change								
Flooding								
Hydrological change (rivers, estuaries)								
Demand for mineral extraction								
Risk of earthquake damage								
Land drainage								
Visual impacts								

Note: Issues may be directly related to the retirement/closure of CFPPs/mines or development of RE facilities; or indirectly to the need for associated infrastructure (e.g. access roads, transmission lines) and material sourcing (e.g. minerals).

Table 4.5: Key socio-economic associated with closing coal-fired power plants/coal mines and developing new renewable energy facilities

Theme	CFPP	Coal Mines	Geotherm	Hydro	Solar	Tidal	Wind	Bioenergy
	Early Retirement	Closure	Development					
Economic growth								
Legacy socioeconomic issues								
Employment and labour conditions								
Local economy and livelihoods								
Gender and vulnerabilty								
Indigenous communities								
Food security and price								
Skilled workers								
Health and safety								
Physical and economic displacement								
Conflicts								
Migration								
Community engagement and cohesion								
Public services and infrastructure								
Cultural heritage								
Human rights								

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Note: Issues may be directly related to the retirement/closure of CFPPs/mines or development of RE facilities; or indirectly to the need for associated infrastructure (e.g. access roads, transmission lines) and material sourcing (e.g. minerals).

4.7 Designing the SEA process and challenges in implementing its recommendations

When designing the process of an SEA applied to an energy PPP, it will be important to ensure that it has the best chance of supporting and influencing the plan, i.e., to ensure that the SEA is as effective as possible. In this regard, it is critical that the government agency commissioning the SEA considers how the SEA can be integrated with the PPP process to the greatest extent possible. Section 1.5 (Chapter 1) provides a discussion of how SEA relates to the PPP development process and how *ex ante* SEA provides the best opportunity for influencing PPP preparation.

In seeking to best design the SEA process, the expert team will need to work with the relevant government agencies to clarify the process and steps involved in developing a new, or revising an existing, energy PPP. This is necessary to determine when critical steps and decisions in PPP development will be made and when products and recommendations of the SEA can best support and inform the PPP process.

At the same time, when designing the SEA process, the key actors involved in developing/revising the PPP should be identified and a strategy developed to make sure that they are informed of the SEA, understand how it can help their work, and are involved in (e.g., kept informed) of SEA progress, and receive essential information at appropriate and critical times.

A key product of an SEA will be a Strategic Environmental and Social Management Plan (SESMP) (see section 3.5 and Annex 16 which sets out the recommended content of a SESMP). The SESMP should be developed in close consultation with those government and non-government agencies and organisations that are likely to have a role in its implementation so that they are involved in agreeing its contents and recommendations, verifying that they are achievable and proportionate to identified key issues, and to ensure that roles, responsibilities are fully understood and ‘bought into’. A key challenge to implementing SESMP recommendations (e.g. for environmental or social management or for monitoring key indicators) is that there is often a lack of adequate technical skills, capacity and, equipment, and budget allocations may be insufficient. This means that the SESMP should address where capacity strengthening and/or training may be required, and it should be fully costed where possible.

Furthermore, there is sometimes a lack of clarity over institutional mandates and jurisdictions, and thus rivalries and ‘defence of turf’. This may be the result of unclear or overlapping legislation/regulations. It can lead to institutional conflicts regarding roles and responsibilities to implement SEA/SESMP recommendations. These potentials should be address and solutions found when consulting on the content of the SESMP.

Once the implementation process has been agreed to by all parties involved, it will be critical to monitor the progress of implementation and make and make any additional changes required that are needed to ensure success.

CHAPTER 5

KEY ISSUES FOR SEA IN THE HYDROPOWER SUB-SECTOR

Why is SEA important to the hydropower sub-sector

An overall rational for why it is important to use SEA to support the energy transition is provided in the preliminary sections of the guidance.

It is becoming increasingly clear that hydropower projects should be managed at a watershed or basin level. In this context, SEA can provide critical information to support better decision-making for hydropower planning and development, including identifying where there might be significant environmental and/or socio-economic risks not only at the individual project level but across the watershed. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of multiple hydropower schemes/developments. These impacts can arise:

- Along individual rivers within a country (critical to understand the impacts of multiple often uncoordinated schemes/projects);
- Along transboundary rivers that flow across country boundaries between countries (critical to anticipate potential disputes between countries);
- Along multiple rivers in a particular catchment (critical for catchment planning);
- Along multiple rivers in several catchments where inter-basin transfers are taking place; and
- Across all catchments in a country (critical for national energy and hydropower planning).

The SEA process will:

- Identify and focus on key environmental and socio-economic issues and the concerns of likely affected stakeholders, including local communities, marginalised groups, and indigenous peoples. Major issues are discussed in detail in section 5.4 and are summarised in Table 5.3.

- Identify/recommend if there are areas that should be avoided for hydropower development ('no go' areas) because of particularly high risk to the environment and/or people and local communities.

- Make subsequent project-level EIAs more efficient and cheaper by addressing the big picture upstream and downstream across the watershed and, in particular, by addressing potential cumulative impacts and identifying the broader issues that individual project EIAs should focus on in more (site-specific) detail.

- Engage stakeholders (along a river course, in a single or all catchments) – including communities, marginalised groups and indigenous peoples which can be particularly affected by hydropower developments. Stakeholders should to be informed of proposed or possible policy options or plans and they should be given opportunities to provide their perspectives and present their concerns. This will enable key issues to be identified and verified at a basin level and to help build understanding and support for hydropower development and avoid future misunderstanding and possible conflicts.

Section 5.5 discusses the benefits of SEA to the development and implementation of hydropower PPPs.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 3 and are therefore not repeated in this chapter.

5.1 EXISTING SEA GUIDANCE/GUIDELINES FOR THE HYDROPOWER SUB-SECTOR

An international survey of existing SEA guidelines conducted for the IAIA (identified only one guideline specifically focused on the hydropower sub-sector whilst there are numerous guidelines for conducting environmental impact assessments (EIA) for hydropower projects[1].

The report of the World Commission on Dams (WCD 2000) set out comprehensive guidelines for dam building. It describes an innovative framework for planning water and energy projects that is intended to protect dam-affected people and the environment and to ensure that the benefits from hydropower are more equitably distributed.

Subsequently, a broad and extensive literature has become available on hydropower development. Some selected examples include general guidelines (but not concerned with SEA) covering issues such as social impacts and risks[2,] environment and climate[3], tools[4], indigenous people[5,] health and safety[6], developers and investors[7], affected peoples and livelihoods[8] and infrastructure safety[9.] In 2010, the International Hydropower Association (IHA) published the Hydropower Sustainability Assessment Protocol (HSAP)[10] (updated 2020) which offered a way to assess the performance of a hydropower project across more than 20 sustainability topics. Subsequently the IHA launched its Hydropower Sustainability Standard which covers topics relevant to SEA in the hydropower sub-sector (Box 5.1).

Box 5.1: IHA Hydropower Sustainability Standard

The IHA Hydropower Sustainability Standard is a global certification scheme (the first of its kind for renewables), outlining sustainability expectations for hydropower projects around the world. It aims to help ensure that hydropower projects provide net benefits to the local communities and environments they interact with. The standard covers 12 environmental, social and governance (ESG) topics, including: biodiversity and invasive species, water quality, hydrological resource, cultural heritage, governance, labour and working conditions, climate change mitigation and resilience and more.

In support of the Standard, IHA has published a suite of how-to-guides offering a deep dive into specific sustainability topics such as resettlement, labour and working conditions, biodiversity and benefit-sharing. Embedded in the standard are four key project-based tools: guidelines of good industry practice; the hydropower sustainability assessment protocol (HSAP); the GRES (GHG Reservoir) tool and the hydropower sustainability ESG gap analysis tool (HESG).

All documents are available at www.hydropower.org.

[1] e.g. REMA 2008; UKEA 2009, IHA 2021c
[2] e.g. Cernea (2004); EIB (2019)
[3] EIB (2019)
[4] e.g. HSC (2020)
[5] e.g. HSC (2022); IHA (2022), IHA (2022b)
[6] e.g. IFC (2018)
[7] e.g. IFC 2015b
[8] e.g. IHA 2020)
[9] e.g. IHA (2021)
[10] Hydropower Sustainability Assessment Protocol

5.2 HYDROPOWER INSTALLED CAPACITY

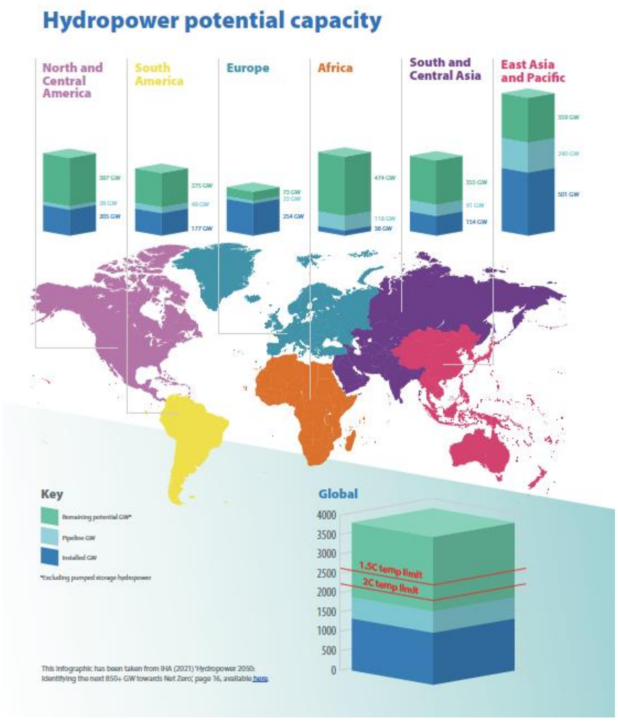
Since 1995, the hydropower sub-sector has more than doubled in size from 625 GW to over 1,300 GW, with China having, by far, the greatest installed capacity (see Table 5.1 and Figure 5.1).

Table 5.1: Hydropower installed capacity in 2021
Source: IHA (2022c)

Country	Installed Capacity (GW)	Country	Installed Capacity (GW)
China	391	Spain	20.4
Brazil	109.4	Vietnam	17.3
USA	101.9	Switzerland	16.8
Canada	82.3	Sweden	16.5
Russia	55.7	Venezuela	15.4
India	51.4	Austria	14.7
Japan	49.6	Mexico	12.6
Norway	33.4	Iran	12.2
Turkey	31.5	Colombia	11.9
France	25.5	Rest of World	268.1
Italy	22.6		
Total			***1360***

According to the International Hydropower Association[11], hydropower generated around 4,300 terawatt hours (TWh) of clean electricity worldwide in 2021; and Paraguay and Costa Rica achieved a 100% renewable electricity supply, with hydropower as the backbone. In some countries, almost all electricity generation comes from hydropower, e.g., Norway and Nepal (Figure 5.2). Global hydropower potential is shown in Figure 5.1.

Figure 5.1: Global Hydropower Potential Capacity 2022
Source: IHA (2022).



11 IHA (2022c)

Hydropower currently generates more electricity than all other renewable technologies combined and is expected to remain the world's largest source of renewable electricity generation into the 2030s. Thereafter, it will continue to play a critical role in decarbonising the power system and improving system flexibility as other renewable sources are brought on-stream[12].

5.2.1 Application of SEAs in the hydropower sub-sector

A recent international inventory identified 34 SEAs conducted for the hydropower sub-sector during the period 1995 – 2019[13] (Table 5.2). Sixteen (43%) of these were specifically focused on hydropower PPPs, whilst another sixteen (43%) addressed hydropower as part of broader PPPs for the overall energy sector. A few (5, 13%) dealt with hydropower as part of multiple PPPs covering multiple sectors.

Table 5.2: SEAs for energy sector, multi-sector and hydropower sub-sector, for regions (columns) and type of PPPs (rows) for the period 1995-2019

Source: Kolhoff and Slootweg (2021)

Type of PPPs per sector*	Asia	Africa	Europe	Americas	Total
Energy sector, including hydropower					
International	1	1			2
National**	5	4	4		13
State/provincial				1	1
Sub-total	*6*	*5*	*4*	*1*	*16*
Hydropower sub-sector					
International river basin	1				1
National**	6		1		7
State/provincial	3		1		4
River (sub-basin)	3		1		4
Sub-total	*13*		*3*		*16*
Multiple sectors, including hydropower					
International river basin		1		1	2
National river basins(s)**	2	1			3
Sub-total	2	2		1	5
Total	**21**	**7**	**7**	**2**	**37**

* Includes all SEAs applied for PPPs in the energy sector at international, national and state level have been included in the inventory. In two of these SEAs hydropower is not included as an energy source. All SEAs applied for PPPs in multi-sectoral PPPs are included, in which hydropower is considered. All SEAs applied in the hydropower sector are included in the inventory.
** Selected cases: National energy plan Viet Nam; National hydropower plan Myanmar; State level hydropower plan India and Pakistan; Multi-sector River basin plan Rwanda.

5.3 BACKGROUND TO HYDROPOWER GENERATION

There are two types of renewable energy generation: ***dispatchable*** (sources of electricity that can be dispatched on demand at the request of power grid operators) and ***variable*** (intermittent renewable energy sources (IRES) are renewable energy sources that are not dispatchable due to their fluctuating nature, such as wind power and solar power).

Large-scale hydropower projects can generate and supply large amounts of dispatchable electricity in a consistent manner. Currently. they generate around 16% of the world's electricity[14]. Pumped storage hydropower schemes can also be used as a "battery" by moving water to higher elevations during times of surplus electricity and releasing it through turbines to generate electricity at times of

[12] https://www.iea.org/energy-system/renewables/hydroelectricity
[13] Kolhoff and Slootweg (2021)
[14] IHA (2022c)

high demand. In this manner, pumped storage can support wind and solar projects which have more intermittent generation.

Hydropower projects that include a reservoir can act as a source of flood mitigation in some circumstances, as the reservoir can store peak flows and control the release of water to the downstream river course. However, hydropower projects can have many environmental and social impacts that vary in scale and significance depending on the location, size, and project design.

In addition, hydropeaking (the discontinuous release of turbined water due to peaks of energy demand) causes artificial flow fluctuations downstream of reservoirs. This can result in a series of environmental and social impacts due to flow modifications[15].

5.3.1 Installation types

Hydropower projects come in many different sizes, designs, and configurations. The nature of their environmental and social impacts is determined by how they store and use water. Broadly there are four distinct types of hydropower schemes: run-of-river, reservoir, pumped storage, and offshore hydropower:[16]

- ***Run-of-river hydropower***: a facility that channels flowing water from a river through a canal or penstock to spin a turbine. Typically, a run-of-river project will have little or no storage facility. Run-of-river provides a continuous supply of electricity (base load), with some flexibility of operation for daily fluctuations in demand through water flow that is regulated by the facility.

- ***Storage hydropower*:** typically, a large system that uses a dam to store water in a reservoir. Electricity is produced by releasing water from the reservoir through a turbine, which activates a generator. Storage hydropower provides base load as well as the ability to be shut down and started up at short notice according the demands of the system (peak load). It can offer enough storage capacity to operate independently of the hydrological inflow for many weeks or even months.

- ***Pumped storage hydropower***: provides peak-load supply, harnessing water which is cycled between a lower and upper reservoir by pumps which use surplus energy from the system at times of low demand. When electricity demand is high, water is released back to the lower reservoir through turbines to produce electricity.

- ***Offshore hydropower*:** a less established but growing group of technologies that use tidal currents or the power of waves to generate electricity from seawater (usually referred to as tidal power (discussed in Chapter 10).

Facilities can be also classified as (a) single-purpose—which are only used for hydroelectricity generation, or (b) multipurpose—which are designed and used for other purposes such as water supply, irrigation, aquaculture, or flood control. Hydropower power plants can also be classified on the basis of installed capacity, e.g.[17]:

- Very Large: 5,000 – 10,000 MW, feeding into a large grid;
- Large: exceeding 100Mw, and usually feeding into a large grid;
- Medium: 15 v- 100MW, usually feeding into a grid;
- Small: 1 – 15 MW, usually feeding into a grid;
- Mini: 100 kW – 1 MW, either isolated or feeding into a grid;
- Micro: 5 Kw – 100 kW, usually provides power for a small community or rural industry in remote areas away from the grid, and
- Pico: from a few hundred Watts up to 5 kW.

[15] Greimel *et al.* (2018)
[16] https://www.hydropower.org/iha/discover-types-of-hydropower
[17] Classification of Hydroelectric Power Plants (engineeringenotes.com)

However, classifications vary from country to country as there is currently no common consensus among countries and hydropower associations regarding the upper limit of small-scale hydropower plant capacity. For instance, some European Union countries like Portugal, Spain, Ireland, Greece, and Belgium accept 10 MW as the upper limit for small-scale hydropower installed capacity, while others place the maximum capacity from 3 to 1.5 MW. Outside the EU, this limit can be much higher, as in the USA (30 MW) and India (25 MW).

5.3.2 Hydropower installation components

The most important components of a hydropower project: dams, spillways, power stations and water ways.

Dams

Dams are the most recognizable features of hydropower facilities. They are constructed to create water storage or diversion that provide a continuous supply of water to turn the turbines. The type of dam depends on a range of factors including:

- Height (or head) of water to be stored;
- Shape and size of the valley at the proposed construction site;
- Geology and geotechnical conditions of the valley walls and floor;
- Availability, quality and cost of construction materials, and
- Availability and cost of labour and machinery.

The ability of a dam to withstand the pressure of water built up behind it depends on its weight and/or shape. The dam also needs to be made of or contain material that prevents water flowing through it.

Spillways

Dams must be designed to cope with floods. Spillways are built to provide a path for water to flow over or around the dam. On concrete dams, spillways are usually constructed to allow water to flow over the top. These are not normally appropriate for embankment dams because of the damage that floodwater can cause to loose rock on the downstream side. Spillways on embankment dams take the water around the side of the dam and away from the downstream face. Alternatively, a dam may rely on gates to release water during floods.

Power stations

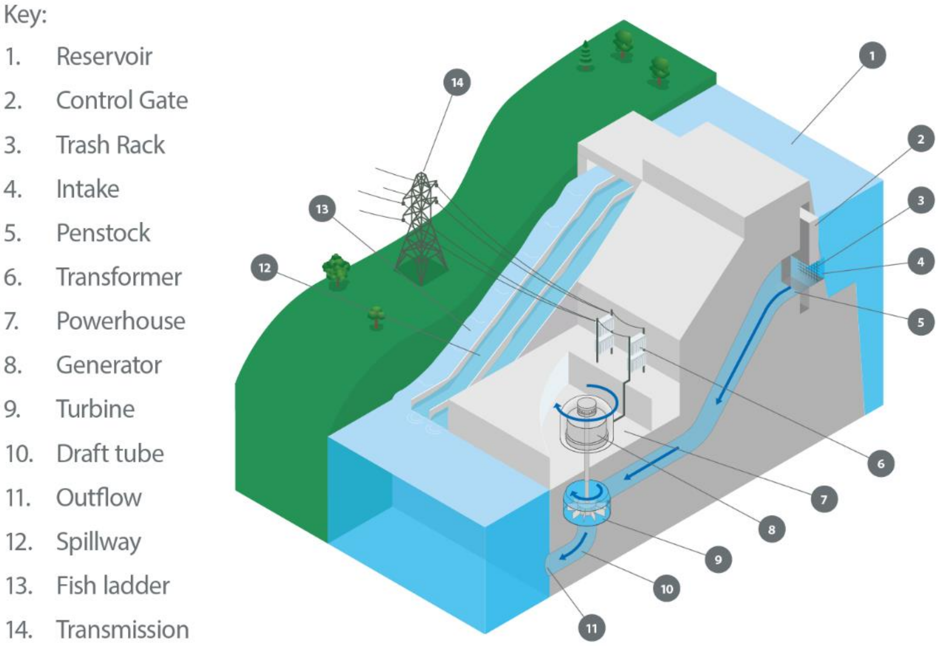
Power stations (or power houses) (see Figures 5.2 and 5.3) contain the turbines and generators that generate electricity from moving water. They may be located near the water storage or up to several kilometres away. Their location is determined by the topography and foundation conditions. The lower part of the power station houses the turbines. Water enters the station on one side, spins the turbines, and flows out the other side. The choice of turbine type will depend on the water quantity and head that it needs to accommodate. Above the turbines are the generators. They are securely fastened to solid concrete foundations. Some power stations are built underground—the decision to do so may be based on a lack of suitable surface sites, or benefits gained by creating extra height (or head) through which the water can fall, or for social or environmental reasons to minimize the impact an above-ground power station would cause.

The downstream placement of the powerhouse can also affect how much of a stretch of river is dewatered below the dam. This can be countered by having an “ecological” flow maintained from the dam to the powerhouse. This involves the flow of the river being returned after passing through and an additional powerhouse placed directly below the dam. Small amounts of electricity may also be generated by this ecological flow to supplant energy generated from the main powerhouse.

Figure 5.2: Inside a hydro powerhouse
(*Sou*rce [Inside a hydropower plant / Hydropower (alley600.eu)])

Image redacted pending securing copyright permission to use. If you have an image showing the components in a hydroelectric plant that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Figure 5.3: Major components in a hydroelectric plant
Source: The International Hydropower Association



Waterways

Water is conveyed to power stations situated near storages through intakes and down vertical shafts and inclined tunnels (penstocks). Power tunnels are often lined with concrete or steel to maximize integrity and prevent leakage of high-pressure water into the surrounding rock. A typical intake is fitted with control gates and a steel mesh trash rack that prevents rubbish such as logs, or floating trash being carried down into the turbines. Where reservoirs are situated some distance from the power station, channels need to be constructed to carry the water overland. If the topography is relatively flat, open channels are used. In rugged topography, it is cheaper to channel the water through tunnels and pipelines. Above the power station, the overland channels feed water into vertical shafts, power tunnels or high-pressure steel pipes (penstocks). Large towers (surge towers) are often built near the top of these structures and are used as a pressure neutralizer in a hydropower water systems to prevent excess pressure rise and pressure drop conditions during operations[18].

Reservoirs

The configuration of a reservoir is dependent upon the topography where the dam is situated. Reservoirs can vary from large and shallow impoundments covering thousands of square kilometers (e.g., Three Gorges, China; and Itapau, Brazil) to narrow and deep reservoirs that can be up to several hundres of meters in depth (e.g., Lianghekou hydropower station, China). The filling of a reservoir can also destabilize slopes due to the pressure of water in the impoundment, and it may take several years for the reservoir slopes to stabilize.

5.3.3 Grid stability and flexibility

Hydropower production can be adjusted instantly. This enables hydropower to act as a load frequency compensator for irregular solar and wind power, in order to balance electricity supply and demand. Pumped storage HPP systems provide additional flexibility, in particular to absorb surplus of production from renewable sources (provided the generation capacity of the facility is higher than the demand).

5.4 IMPACTS OF HYDROPOWER DEVELOPMENT

During scoping for a SEA, key environmental and social issues should be identified together with stakeholders. They will be used to focus the SEA on the most important issues and to help develop environmental and social quality objectives (ESQOs) – to be used in an “objectives-led approach” to SEA (see Chapter 3, section). The subsequent assessment phase predicts how achieving the ESQOs will either be impeded or enhanced as a result of hydropower activities.

The key issues will be identified by reviewing relevant documents (e.g., EIAs of hydropower projects and special subject reports, environmental/social profiles, sector and inter-sector strategies, donor documents, academic papers, etc.), interviews with key informants and through multiple stakeholder consultations at national to local levels. Many of the issues will be well known because of knowledge gained from implementing a large number of hydropower development projects over the past 25-30 years[19].

At the individual project-level, these issues will be the primary focus of an EIA which should recommend how to manage or mitigate impacts of hydropower project activities that might be likely to arise. Implementing a policy, plan or programme (PPP) for the hydropower sub-sector will involve multiple projects, schemes and activities, some directly concerned with the construction and operation of sites and facilities; others linked to associated infrastructure (e.g., transmission lines, access roads, borrow pits/quarries etc.).). Thus, there is a risk that the combined impacts of individual developments/projects in a cascade development scheme may become highly significant as they become cumulative. A SEA should be focus on the potential for such cumulative impacts to occur and to make recommendations for addressing them. This may include recommending thresholds for particular factors that should not be breached by an individual project in combination with other projects (and which should be addressed firstly by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it and the need for implementation of comprehensive management measures among multiple interests to mitigate cumulative impacts.

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[18] https://theconstructor.org/water-resources/surge-tank-types-function/12946/

[19] see International Commission on Large Dams (ICOLD https://www.icold-cigb.org/) and International Hydropower Association (www.iha.org).

Table 5.3 summarises the key environmental and socio-economic concerns, issues, risks, impacts and benefits often associated with individual hydropower project development. In section 5.5, the benefits of SEA for managing impacts of multiple hydroelectric projects are discussed such as:

- Integrated river basin management/coordination
- Cumulative impact mitigation and management.
- Opportunities for cascade management and optimizing hydropower generation across multiple projects and reducing cumulative E&S impacts;
- Data sharing;
- Optimizing environmental flows and opportunities for coordinated flow management, and
- Climate change mitigation and management e.g. GLOFs.

Table 5.3: List of key environmental and socio-economic issues often associated with hydropower projects

ISSUE	COMMENT
Environmental	
Loss of habitats and biodiversity (terrestrial)	• Inundation by dams and reservoirs and loss of important terrestrial habitats • Deforestation (for hydropower sites, dams, roads and transmission lines, and release of stored carbon • Fragmentation of habitats and creation of barriers to wildlife movements • Clearing for access roads and transmission lines and consequent disturbance to migration and increased road kills • Increased poaching and hunting due to increased access to areas • Disturbance to fauna from noise, vibration, and dust from blasting and other construction • Drowning of species during reservoir impoundment • Introduction of invasive species • Changes in diversity or make up of the plant and animal communities due to changes in ecosystems • Impacts on ecosystem services such as trees used for fuel • Submersion of caves used by bats • Impacts on terrestrial fauna from changes to aquatic ecosystem (e.g., loss or reduction of food sources) • Loss of riparian habitat due to erosion • Collision of birds and bats with overhead power lines leading to electrocution
Loss of habitats and biodiversity (aquatic)	• Loss of riparian habitats through inundation or changes to river flow regime • Change from lentic (fresh water) to lotic (moving water) habitat in new reservoir • Dam walls prevent migration of fish to breeding areas • Organic matter decomposition in the base of the dams over time can deplete water oxygen and kill fish and aquatic organisms • Fish killed by powerhouse turbines and/or by tail races/spillways • Increased fishing (overexploitation) due to (a) increased access (e.g., to previously inaccessible areas), via access roads and transmission lines, or as result of workforce in the area; and (b) creation of popular fishing areas where fish concentrate • Blockage of fish movements • Fragmentation of aquatic systems • Change in sediment and nutrient flows due to river flow changes can affect biodiversity, and can decrease sediment loads downstream

ISSUE	COMMENT
	• Change in riparian habitats due to hydropeaking[20] and aggressive river effects in the event of releases: loss of interface between land and the river due to riverbank erosion • Fragmentation and loss of or changes to aquatic ecosystems and connectivity in river system: animal migration, fish movements and plankton drift can be blocked both up and downstream by a dam • Loss of downstream floodplain habitat: regulation of a river by a dam and reservoir reduces the magnitude and duration of flood flows, which reduces downstream flooding and sediment transport • Introduction of invasive alien plant and animal species leading to changes in ecosystem structure and composition
Land-use changes	• Inundation of land (for reservoirs) leading to direct loss of productive land or loss of habitat • Reservoirs may also be used for irrigation, fishing, supply of water, and for recreational purposes • Changes in nutrient flows and sediment transport leading to indirect loss of agricultural land downstream • Changes in river flow regime leading to less productive agricultural land downstream (e.g., river no longer flooding crops when required) • A dam or hydropower infrastructure may alter access to an area leading to indirect changes in land use such as loss of productive land
Erosion and sedimentation	• Clearance and disturbance to vegetation and soil in areas surrounding dams and rivers, resulting in erosion and sediment runoff into the river • Landslides: ground movements such as mudflows and debris flows that occur due to project construction • Erosion and instability of riverbank or bed (and adjacent areas, e.g., following changes in river flow and geomorphology) • Erosion of rim or boundary of reservoir and increased sedimentation in reservoir • Intense rainfall on cleared land may lead to gullying and increased runoff, erosion, and sedimentation (during construction and in a reservoir catchment) • Changes in the geomorphology of river channels and increased erosional forces downstream due to sediment retention • Increased sediment runoff into rivers or streams at vehicle crossing points during construction • Sediment retention and accumulation over time (e.g., in dam bottom—reducing dam capacity, or locally in riverbeds): • Release of sediment-laden water can cause issues downstream
Land and ecosystem restoration	• Hydropower developers can maximize the adaptive benefits (regarding climate change) of watershed restoration by avoiding areas where the risks of destroying important wetlands are high, or avoiding forest clearing (e.g. around reservoirs, for access roads and transmission lines) where the risks of soil erosion are

[20] Hydropeaking refers to frequent, rapid, and short-term fluctuations in water flow and water levels downstream and upstream of hydropower stations. Such fluctuations have far-reaching effects on riverine vegetation.

ISSUE	COMMENT
	highest, reducing unnecessary sediment flows and slowing runoff in order to protect and optimize reservoir storage
Air quality	• Air pollution from machinery and vehicles (construction equipment, lorries, workers' buses, etc.) • Dust from land clearing and construction, vehicles on dirt roads • Dust from exposed areas of dam margin following drawdown operations
Water quality	• Sewage, solid waste, and polluted runoff into dams and rivers during construction (runoff from dumping of excavated materials)—can contaminate surface and groundwater • Oil or chemical spills during construction or operation • Pollution from the catchment can collect in reservoirs • Release of heavy metals from sediments • Reservoir stratification: separation of reservoir water into oxygenated and deoxygenated zones (due to organic decomposition) and unseasonal temperature water released to downstream • Change in water quality due to sedimentation during construction, and altered flows during operation – with increased turbidity: increase in the cloudiness or haziness of water caused by individual particles • Organic decomposition: decomposing of organic material during the early years of operation leading to the consumption of oxygen • Decreased air quality during drawdown operations and exposure of reservoir areas • Changes in flow regime may increase the concentration of pollutants and result in the release of nutrient-laden water, there may also be inflows of sediment, and pollution or hazardous substances from construction and from the wider catchment, and dumping of excavated materials • Contamination of surface and groundwater—particularly during construction • Impacts of degraded water quality downstream • Eutrophication due to fertilizer runoff in the catchment (nitrogen, phosphorus, and other nutrients) and enrichment in dams
Hydrology	• Flow of rivers can be changed significantly due to presence of a dam or weir • Reduced water for downstream use (e.g., irrigation, consumption). But sometimes dams/reservoirs are used to supply irrigation water. • Changes downstream: significantly reduce or alter patterns of flow between the intake and the powerhouse • Altered flow regime and sediment flows downstream of the powerhouse • Reservoirs offer opportunity to control floods and manage drought (climate adaptation and disaster-risk reduction).
Greenhouse gases	• Hydropower can reduce GHG emissions where it displaces coal as a fuel source • GHG emissions (carbon dioxide, methane, nitrous oxide) from reservoirs (particularly from decomposition of submerged vegetation) and from vehicles and fuels used in machinery and camps during construction

ISSUE	COMMENT
Noise and vibration	• Noise and vibration impacts during construction (from machinery, vehicles, blasting, drilling, machinery)
Spoil	• Significant amounts of spoil material may require disposal (where reuse is not an option) due to tunneling and excavation activities
Flooding	• Inundation of new areas to create impounded reservoir • Flash floods downstream (due to breaches, overtopping, emergency releases) • Dam break resulting in loss of life, communities, infrastructure and biodiversity, erosion • Reservoirs can be used to regulate water flow and control flooding
Socioeconomic	
Physical and economic displacement	• Physical displacement and relocation of people and their structures due to reservoir impoundment • Loss of economic and livelihood activities, such as agriculture, animal grazing, fishing • Loss of income from small business and enterprise activities
Benefits of reservoirs	• Storage of water for use in irrigation, both large- and small-scale (increasing yields, opportunities to grow range of crops), contributing to economic growth and livelihood opportunities. • Opportunities for fishing • Recreational opportunities • Flood and drought management
Cultural heritage	• Loss of (and loss of access to) religious, cultural, historical and archaeological sites, and properties submerged by dam and in downstream locations; or destroyed or damaged due to transmission lines and access roads
Employment and labour conditions	• Job opportunities with hydropower companies and their contractors • Loss of jobs with existing enterprises and public administration when people are relocated • Forced labour and child labour on hydropower projects
Health and safety	• Pollution of downstream and upstream areas • Insufficient and poor-quality water quality for worker camps—due to the water source being affected • Influx of migrant workers may lead to an increase in communicable diseases (infectious diseases such as influenza, sexually transmitted infections [STIs], and HIV/AIDS), drug and alcohol use, gender based violence and conflict • Impacts on fish and human health from methyl mercury releases from sediment into the water column and food chain • Increased road traffic accident and fatalities, particularly during construction • Accidental drowning in reservoirs • Risks of dam failure and natural disasters, land slides • Impacts on communities due to rock blasting • Electrical safety incidents

ISSUE	COMMENT
	• Fatalities at the construction site and substandard accommodation of workers. • Pressure on health services (e.g. high demand on essential drugs) during construction • Potential for increase in vectors for human transmissible disease e.g. malaria and schistosomiasis (particularly due to dams)
Migration	• Influx of people looking for work during construction • Tension between immigrants and workers • Retrenchment of construction work forces
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and indigenous communities) may be disadvantaged and at particular risk • Increased domestic and gender-based-violence due to relocation and in-migration of workers to remote areas. • Gender equity and employment opportunities on new projects • Opportunities for vulnerable groups to acquire new skills and learn new technologies • Opportunities for vulnerable groups to engage in the decision-making processes and in inclusive dialogue about hydropower development
Public services and infrastructure	• Loss and relocation of public services and infrastructure due to inundation by dams • Pressure on local pre-existing health services and infrastructure, equipment, human resources. due to projects, immigration, accidents during construction, etc. • Increased pressure on the host communities' public services when displaced people relocate • Improvement (investment) to infrastructure (e.g., roads and bridges, schools, health centers, and administrative buildings) • Heavy vehicles and transportation damage existing roads and bridges
Community cohesion and engagement	• Weakened community cohesion resulting from self-relocation and community relocation • Risk of internal conflict due to increased stress as result of lost income • Opportunities for communities to engage in the decision-making processes about hydropower development • Increased tension between the communities, NGOs, activists, and hydropower companies
Conflicts	• Conflicts over: o Lack of perceived project benefits accruing to local communities(e.g. access to power and water services): o Environmental degradation (e.g. from the reduced water quality o Loss of land or access to resources/areas used for livelihoods or cultural activities o Working conditions amongst those employed in construction or operation • Tensions between immigrants and local workers/communities • Transboundary conflict between states (e.g. over dams restricting water flow).

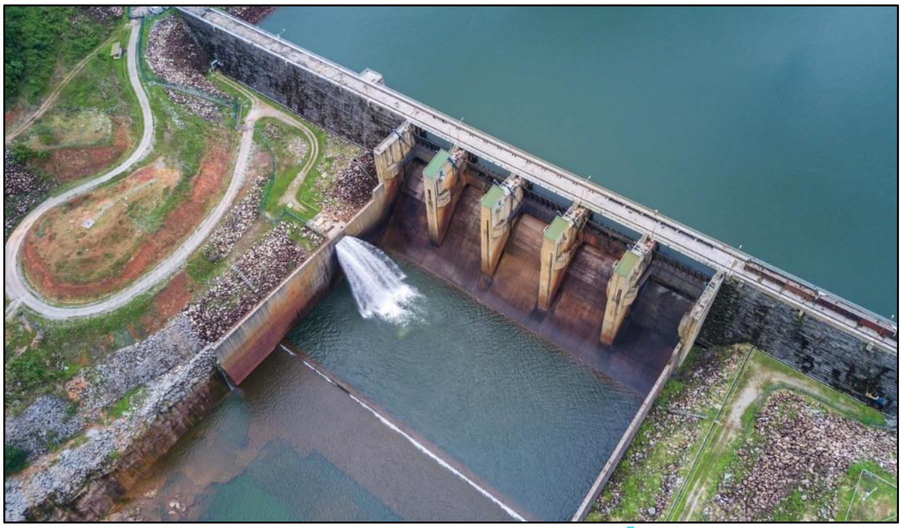
5.4.1 Environmental Issues and Impacts

Hydrology

A hydropower project will normally change the hydrological flow regime of a river. Depending on project design, this may be a significantly reduced or altered pattern of flow between the intake and the powerhouse (typical for run-of-river projects), or it may be an altered flow regime downstream of the powerhouse (typical for reservoir projects). Rivers that are already regulated by either hydropower or irrigation projects can be less sensitive to new hydrological impacts, so it is better to develop projects on rivers or tributaries that are already impacted by flow regulation[21], although multiple schemes on a river can also result in significant cumulative environmental and social impacts on habitats and species and downstream users.

Changes to a river's hydrological regime can negatively impact its aquatic ecosystem and can disrupt important environmental flows (E-flows) and associated ecological processes. The health and integrity of a river system will usually depend on a range of high, medium, and low flows. Most rivers experience natural annual low flows which reduce connectivity and limit species migration. This may be positive for native species which can often out-compete invasive species that have not adapted to low flows. So, maintaining low flows at their natural timing and level can maintain the abundance and survival rate of native species (Figure 5.4). Medium or base level flows will usually occur during most of the year. These flows maintain the hydro-geomorphology of a river which, in turn, maintains habitat, temperature, and dissolved oxygen levels to support aquatic species. Short high flow events are also important to prevent vegetation from encroaching on river channels and to move sediment and organic matter downstream. High flows can also reduce water temperature and increase dissolved oxygen, which can trigger ecological processes such as spawning and migration. Consequently, river flows altered by a hydropower project can lead to a reduction in health and integrity of the river system[22].

Figure 5.4: Dam at Nam Theun 2, Lao People's Democratic Republic, with downstream flow provision.



(Photo credit: A. Javellana/ADB)]

In some very large storage reservoirs, the filling of the reservoir may take more than one year, with a risk that downstream flows will not be adequately maintained, and this can lead to the degradation of downstream ecosystems and potential loss of habitats and biodiversity.

Dams can both contribute to and alleviate flooding and reduce disaster-risk. Large reservoirs can provide storage capacity to attenuate water flow during high rainfall events, reducing downstream

[21] Opperman *et al*. (2015)
[22] World Bank (2018).

floods. However, in the unlikely event of a dam break and inappropriate timing of a large release of water can cause downstream flooding, loss of human life and biodiversity, and damage to communities and infrastructure.

Dams/reservoirs also provide opportunities to release water to downstream areas in the event of drought as a climate adaptation response. However, this will also depend upon the availability of upstream flows to maintain reservoir integrity. [need a reference here. Can anyone suggest one?]

Water quality

There can be a range of negative impacts on water quality throughout the construction and operation phases of a hydropower project.

During construction, the main impact on surface water quality is an increase in sediment load from construction site erosion/sedimentation or from spoil heaps. This erosion increases suspended solids and turbidity of river water, which may affect aquatic biodiversity and downstream water users. Poorly managed sewage and solid waste from the construction camp can pose a risk to drinking water. Accidental spills of oils and chemicals used during construction will contaminate soil and can also enter water courses. The spillage of wet concrete into a river can cause serious depletion of dissolved oxygen and negatively impact on aquatic species (even resulting in deaths).

Run-of-river projects tend to have minimal impact on water quality during the operational phase, although they may change the erosion and sediment dynamic of the river (see next section).

Reservoir projects can have a significant impact on water quality in the operational phase. At the end of the construction phase, the reservoir area is typically cleared of vegetation. This can result in soil erosion and sedimentation of the river, reducing water quality. As a reservoir fills, pollutants in the surrounding soil (e.g., fuels, chemicals, and other substances from previous human activities in the area), can be washed into the reservoir and then the river system. Water quality in the reservoir can be further compromised from upstream contamination sources from industrial and human activity.

When the reservoir is full, the decomposition of dead vegetation is likely to cause an increase in biological and chemical oxygen demand and deplete dissolved oxygen in the water (and may lead to anaerobic conditions), which will reduce water quality, both in the reservoir and in the downstream river. It can also result in releases of methane. The water in the reservoir is likely to be deeper and retained for a longer period than in the river, and this will cause changes in temperature at different depths, with potential for thermal stratification. The latter can also lead to deoxygenated water accumulating at the bottom of reservoir. If this is released to the downstream river via a low-level outlet, it will kill fish in that reach. In the reservoir, anaerobic conditions can liberate contaminants such as sulphides, selenium, ferrous and manganese ions, and organic mercury from the sediments. These can be directly toxic to fish and can bioaccumulate and subsequently be toxic to humans consuming fish.

In some circumstances, during the first few years of operation after inundation, anaerobic conditions at lower levels (due to the breakdown of vegetation in the reservoir) can lead to the release of odorous hydrogen sulphide and methane and can generate grievances in the local community. Large amounts of hydrogen sulphide can be released if water is drawn from the lower levels in the reservoir and passed through the turbines. Water quality issues in reservoirs tend to be most problematic over the first 5–10 years of operation when most organic decomposition occurs, and a new equilibrium is found.

In some situations, water quality can be maintained in the reservoir and downstream (both short- and long-term) by removing biomass from the reservoir area before it is flooded[23]. This can improve short-term and long-term water quality in the reservoir and downstream. It can support faster stabilization of the reservoir ecosystem and improve aquatic habitat. Removing large trees improves navigation by local people and removes a risk for net fishing and development of fisheries. However, the benefits

[23] Strengthening Environment Management-Phase II. 2010. Environmental Guidelines for Biomass Removal from Hydropower Reservoirs in Lao PDR. Vientiane. http://monre.myqnapcloud.com/2017/emsp/images/doc/c2/biomassremovalfinal_6.pdf

need to be assessed on a case-by-case basis—it may not always be desirable or effective (Box 5.3)[24].

Box 5.3: Cost–benefits of removing vegetation from Nam Theun 2 Hydropower

A detailed study for the Nam Theun 2 project in the Lao People's Democratic Republic found that the cost–benefits balance of systematic vegetation clearance was an unfavourable option. The study identified several difficulties concerning the removal of vegetation:

- Only a small fraction of the rapidly degradable biomass is located in trees or bushes;
- Cutting the vegetation alone does not address the question of disposal of this biomass. Burning is the option most often considered, but it has significant impacts on air quality. Exportation of the biomass is not practically feasible;
- Clearance of large areas is technically challenging, particularly in steep terrain which is common for a hydropower project;
- The clearing operation itself has significant environmental and social impacts and poses a risk to worker safety;
- Residues from logging activity can impact operation of the powerhouse.

As such, in many contexts' removal of trees over a certain size is selected as the best compromise.

Figure 5.5: Reservoir at Nam Theun 2, Lao PDR, showing trees remaining after filling

Photo credit: Peter-John Meynell

Source: Salignat, O., Descloux, S., Chanudt, V. To clear or not to clear vegetation prior to impoundment? Feedback experience on the Nam Theun II Reservoir (Lao PDR). Conference paper. https://www.researchgate.net/publication/259640331_To_clear_or_not_to_clear_vegetation_prior_to_impoundment_Feed-back_experience_on_the_on_the_Nam_Theun_II_reservoir_Lao_PDR.

Pollution from human activity in the catchment can accumulate in reservoirs. This can lead to eutrophication due to excess nutrients (especially nitrates) from fertilizer runoff or sewage, untreated industrial waste discharges or the accumulation of solid waste from rubbish disposal upstream.

[24] HSC (2020)

When water is released from a reservoir, the river downstream will be susceptible to any reduction in water quality generated in the reservoir. Variation in temperature and oxygen levels can negatively impact on aquatic species, as can the flushing of sediment (see next section).

Impacts on groundwater tend to be of a more minor nature than those affecting surface water. Groundwater may be affected by accidental spillages of construction materials and oils, or because of poorly designed solid waste disposal facilities. A reduction in groundwater quality can impact on communities that rely on groundwater for drinking or irrigation.

Erosion and sedimentation

The clearing of and disturbance to vegetation and soil in areas surrounding dams and rivers during the development of a hydropower project usually leads to an increase in soil erosion and sedimentation of the river, mainly through the construction phase. If the local geology is unstable, landslips, mudflows and debris flows can all contribute to additional sedimentation loads of a river. During construction, earthmoving activities and road construction can increase erosion, particularly if there is inadequate attention to design and drainage. This often happens when temporary, lower cost and quality access roads are built.

In the operation phase, there is less site erosion as vegetation cover becomes established. An operational reservoir project can significantly change the sediment dynamic of a river. Dams can trap sediment, reducing sediment in the downstream reach. However, large volumes of sediment can be released to a river over a short duration, for example, if the operator needs to remove the sediment from the reservoir (e.g., to maintain storage capacity). Erosion of a reservoir rim can also occur as the water level rises and falls due to peaking operations.

Changes to the erosion and sedimentation dynamic of a river are common issues for all hydropower projects. They affect water quality and can modify the riverbed composition and geomorphology and cause the degradation or loss of habitat for fish and other aquatic organisms.

As the dam captures sediment, the sediment load in the river downstream of the reservoir is lower than it was before the dam was constructed. This means that, for an equal volume and turbulence of water, the downstream river will have greater capacity to move bed load and to pick up sediment as suspended load. In so doing, the river will erode the riverbed or banks. The water of the river may be referred to as sediment-hungry or aggressive, or the river may be said to have ***hungry-river syndrome***. The flow may erode the riverbed and banks, producing channel incision (downcutting), coarsen bed material (armouring), and remove spawning gravels used by fish. The mix of riverbed material will affect the pattern of downstream erosion: in sand-gravel mixtures (gravel bed rivers) downstream erosion will be controlled by the coarse surface armour layer, whereas in sand bed rivers the erosion will be more dynamic (IHA 2019).

Increased sediment load in the river can extend a long way downstream and can smother aquatic vegetation and habitats. This can be particularly problematic where gravel beds provide important habitat for downstream fisheries. More turbid water can also encourage fish to move to cleaner parts of the river. If sediment levels are very high, this can result in the smothering of aquatic invertebrates and can coat the gills of the fish causing death. Where significant erosion risks are likely, protection measures will be required (Figure 5.6).

Loss of habitats and biodiversity (terrestrial)

Hydropower projects can have significant negative impacts on terrestrial ecosystems and their associated flora and fauna. The impacts are greater for reservoir projects due to the loss of inundated land. During the construction phase, vegetation must be cleared for dam sites, access roads and transmission lines which leads to the destruction or alteration of terrestrial habitats. Such clearance can fragment habitats by restricting the movement of fauna and potentially their access to important feeding and breeding grounds. In turn, the changes to ecosystems can lead to changes in the diversity or composition of plant and animal communities.

Figure 5.6: Erosion protection at Nam Theun 2, Lao People's Democratic Republic

(Photo credit: G. Joren/ADB)

During construction, particularly through the displacement of soil, conditions are often created for the spread of alien species (some of which may be invasive), which can be brought in with construction equipment. Introduced invasive alien species are often able to colonize modified habitats and can out-compete and displace native species. Aquatic invasive species can also proliferate in the reservoir from upstream sources (e.g., water hyacinth).

Construction activities can cause disturbance to fauna from vibration, dust, and noise from blasting—particularly from quarrying activities. As access roads are developed in an area, there can be an increase in the number of animals killed by vehicles. Improved access can also facilitate increased poaching and hunting and overextraction of resources such as trees used for wood or fuel.

Inundation by a reservoir permanently changes the habitat. If biomass clearance is required, then trees and other vegetation will be cut down, and removed, if valuable. During impoundment, the rising water will slowly disperse fauna, but rescue may be required if animals become trapped and there is a risk that some animals may drown. Caves which provide habitat for bats can also be submerged with the habitat being permanently lost.

When a hydropower project is operational, the impacts on terrestrial fauna are much more limited. However, changes to the aquatic ecosystem may have a negative impact on terrestrial fauna when previous river food sources are lost. Similarly, riparian habitat can be lost or degraded by riverbank erosion, upstream and downstream of a hydropower project. Downstream of a dam, changes to the flow regime can lead to the loss or change of floodplain habitat. Regulation of the river by the dam and reservoir reduces the magnitude and duration of flood flows which, in turn, reduces downstream inundation of floodplain habitats.[25] Wildlife movements can also be fragmented or restricted by the presence of a large reservoir (IHA 2021).

Loss of habitats and biodiversity (aquatic)

In the construction phase of a hydropower project, aquatic flora and fauna in the immediate proximity of the site (dam site and powerhouse) will be lost as habitat is removed. Increased sediment loads as a result of site erosion can have a negative impact on fish and aquatic invertebrates.

In the operational phase, riparian habitats can be lost when a stretch of river is inundated by a new reservoir. Habitats which are important for fish breeding and spawning (e.g., deep pools, rapids, riffles, and in-channel wetland areas) can be submerged.

[25] IFC (2015b)

Changes to river flow regime can affect aquatic ecosystems and biodiversity by changing the daily or seasonal patterns of flow. This can be particularly severe if a peaking regime is used (i.e., a project only generates electricity for a few hours of the day). Run-of-river projects will often divert water around a stretch of river many kilometres long. Such a by-passed stretch can be left dry or with insufficient flow to maintain the original aquatic habitats.

Dams fragment aquatic systems and prevent the migration of fish up and downstream. This loss of aquatic connectivity in a river system can also affect plankton drift and potentially remove important spawning grounds. To some extent, fish passes (ladders) can mitigate the impact, but these may not be possible in high elevation dams.

The creation of a reservoir can result in a range of water quality issues, as described above. Of particular concern at the start of the operational phase is the decomposition of organic matter which can deplete water oxygen, release methane and kill fish and other aquatic organisms.

Opening up a previously undeveloped area with new access roads can lead to increased fishing. Fishing opportunities can be created by the creation of a reservoir; but dynamite fishing can be particularly damaging. Furthermore, exotic fish may be deliberately added to reservoirs by local people for fishing, and this can result in pressure being placed on native species. Over time, lentic species will also replace lotic species in newly created reservoirs where rivers would have originally flowed. New access roads can also enable an increase in fish poaching. This can be a particular problem where an access road is near to or passes through a protected or ecologically sensitive area.[26] [27].

Land and ecosystem restoration

As discussed above, there are significant risks associated with hydropower development with regard to potential environmental harm and degradation (e.g. unnecessary or excessive deforestation) and destruction of habitats and loss of biodiversity and ecosystem services as well as soil erosion and pollution. This will particularly arise where mitigation measures proposed by a SEA (and subsequent project-level EIAs) are inadequate, ineffective, or not undertaken. The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. Such cumulative impacts will be highly likely to occur where there are multiple hydropower developments along a river or along the different rivers of a catchment and compounded further across the entire river drainage system.

Such impacts will usually lead to demand for and need for land and ecosystem restoration (see Box 3.9). This need will also arise at sites of projects that have come to the end of their useful life (e.g., when a reservoir has silted up and no longer serves its purpose). When a dam is removed (Box 5.4), restoration can involve:

- Revegetation, which can help to restore natural ecosystem processes and minimize the presence of invasive and exotic species.
- Fisheries restoration.
- Sediment and hydrology restoration.

Hydropower developers can maximize the adaptive benefits (regarding climate change) of watershed restoration by avoiding areas where the risks of destroying important wetlands are high or avoiding forest clearing (e.g., around reservoirs, for access roads and transmission lines) where the risks of soil erosion are highest, reducing unnecessary sediment flows and slowing runoff in order to protect and optimize reservoir storage.

[26] IFC (2018)
[27] EBRD (2017)

Box 5.4: Dam removal and ecosystem restoration: the case of Elwha and Glines Canyon hydroelectric dams, USA

The removal of the Elwha and Glines Canyon hydroelectric dams in the USA, currently underway in the state of Washington's Olympic National Park, is not only the world's largest-ever dam removal but is also the second largest ecosystem restoration project in the American National Park System.

Figure **: Elwha and Glines Canyon hydroelectric dams map

Image redacted pending securing copyright permission to use. If you have an image showing the components in a hydroelectric plant that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Construction on the 105-foot Elwha Dam was completed in 1914 and led to the formation of the 267-square-mile Lake Aldwell reservoir. The 210-foot single-arch Glines Canyon Dam was built completed in 1925 several miles upstream from the first dam, and flooded the surrounding land, creating the 415-acre Lake Mills reservoir. The dams generated a combined 28 MW of electricity and provided a major boost to expanding local communities and industrial development, in and around the nearby city of Port Angeles in the early 20th century. But they have long since ceased to play a major role in meeting power supply demands.

Construction of the two dams effectively split the Elwha River in to three separate entities: the 4.9 miles of the Lower River below the Elwha Dam; the Middle River between the two dams; and the Upper River above the Glines Canyon Dam, 8.7 miles further upstream. This had profound negative impacts on the Elwha River Watershed, including sediment and silt blockage behind the dams. Construction also led to erosion of the riverbanks, impacts on protected areas, as well as adverse effects on indigenous people, such as the Lower Elwha Klallam Tribe, who previously relied on native fish populations for sustenance.

Lacking passage for migrating salmon, Glines Canyon Dam blocked access by anadromous salmonids to the upper 38 miles (61 km) of mainstem habitat and more than 30 miles (48 km) of tributary habitat. The Elwha River watershed once supported salmon runs of more than 400,000 adult returns on more than 70 miles (110 km) of river habitat. By the early 21st-century, fewer than 4,000 adult salmon returned each year.

The Elwha Restoration Act of 1992 authorised the US Federal Government to acquire the dams for decommissioning and demolition. Following the creation of a diversion channel to allow the continued flow of the river during deconstruction, the dam was fully removed by March 2012 (cost of US$26.9m) and the river was returned to its natural route. The two dams were removed in stages to prevent major disturbances caused by disrupting the many millions of cubic metres of sediment piled up above the dams, as this could potentially cause extensive damage to ecosystems further downstream. The larger Glines Canyon Dam presented greater difficulties, requiring a number of additional measures to deal with the relocation of water and sediment in Lake Mills. The first phase saw the reservoir's levels dropped gradually using an outlet pipe to transport water downstream.

Dismantling involved removing sections of the dam walls from the top down, with the concrete blocks being trucked offsite and recycled. The final stage comprised controlled blasts to clear what is left of the dam wall.

A number of other projects are helping to restore the Elwha River ecosystem, including the installation of facilities to treat water and remove sediment downstream of the dams. The area that was under Lake Mills is being revegetated and its banks secured to prevent erosion and to speed up ecological restoration.

The return of Pacific salmon to their spawning streams will be important to the region. Adult salmon bring with them marine-derived nutrients. Decomposing salmon carcasses provide nutrients that link the marine and terrestrial ecosystems. Salmon are known to benefit more than 100 other species. The return of salmon and the entire ecosystem will help to revitalise tribal culture, traditions and previously sum and old traditions age-old traditions and previously submerged sacred sites.

Source: World's biggest dam removal and restoration project (water-technology.net)

Restoration projects such as described above are a new occurrence with very few examples in place. However, as many of the world's hydropower project continue to age, dam decommissioning and restoration of affected terrestrial and aquatic ecosystems will become increasingly more common. This will require setting aside sufficients funds to cover large restoration costs.

Waste and spoil

The wastes generated by a hydropower project typically range from benign to potentially very harmful (e.g., toxic chemicals and hydrocarbons). Waste also includes excess spoil or waste rock from excavation, vegetation from clearing, and sewage and wastewater. Many jurisdictions have strict controls over the handling, transport, and storage of certain types of waste. A construction site should generally have dedicated areas that provide effective storage and transport points for wastes.

Human wastes, both solid and liquid, are a management issue at the implementation stage with respect to the large numbers of construction staff and their living quarters. Large construction camps are often developed to service the construction phase of a project. Appropriate refuse, sewage and wastewater disposal need to be planned for and managed and conform to regulatory requirements. Interactions of local fauna with refuse disposal sites (scavenging) can be an issue requiring management.

Spoil is waste material that cannot be used in construction because it is either not of the required quality or specification, or because it is surplus to requirements. Significant amounts of spoil can be generated during the construction phase of a hydropower project, particularly if there is a tunnelling operation (
Box 5.5). The spoil needs to be reused or stored near to the project site to avoid significant transport costs. It is typically used to make large, terraced piles on land which is not productive for agriculture or not important for conservation. In some cases, spoil can benefit a local community by filling in a steep area of land to make it usable. Key concerns are the gradient of slopes and suitable drainage to maintain stability and avoid erosion.

Earthmoving and quarrying activities can have an impact on soil quality in the project area. Soils can be contaminated as a result of spills of oil and fuel from vehicle operation and maintenance and fuel storage areas. Contaminated soil needs to be removed to special waste disposal sites to prevent contamination of both groundwater and soils.

Box 5.5: Karot Hydropower Project, Pakistan

One of the most significant impacts identified from the 720 MW Karot Hydropower Project in Pakistan was the generation of significant volumes of spoil from excavations and tunnelling activities. The main impacts identified were land loss due to the large amount of space required to accommodate spoil that could not be reused, and the resulting landscape and visual impacts created by the spoil heaps.

Source: Karot Hydropower Company. 2015. Environmental and Social Management Plan. Lahore. https://epaajk.gok.pk/uploadfiles/downloads/Updated%20ESIA_Karot%20HPP_%20Report2-compressed.pdf

Agriculture

The inundation of land by a reservoir can lead to direct loss of productive agricultural land. In addition, downstream agricultural land can be impacted by a reduction in nutrients carried in sediment by flood water. This occurs if the hydropower project changes the river flow regime such that it no longer provides flood water to crops when required. Flood water sediment is important for agriculture because it often carries phosphorus (dissolved and total), nitrates, and ammonium downstream. Without these nutrients, crop yields will be lower. This problem can be countered by applying fertilizers, but this can lead to further environmental problems such as inappropriate use (with associated health hazards) and pollution from fertilizer runoff.[28]

However, hydropower dams are sometimes used as reservoirs providing water for the downstream irrigation of crops and over a wider area benefitting more farmers.

Air quality

Hydropower projects do not normally have a significant impact on air quality. There is typical construction-related air pollution from materials extraction, machinery, and vehicles (trucks, workers' buses, etc.) and dust from land clearing and from vehicles moving on dirt roads.

Greenhouse gases

Some reservoirs can be a source of methane and carbon dioxide, which are greenhouse gases (GHG). It is released if the water in the bottom of a reservoir becomes anaerobic or there are low oxygen conditions, and bacteria decompose organic matter (dead vegetation left from clearing the reservoir site). One metric ton of methane in the atmosphere has about 25 times more effect on climate than one metric ton of carbon dioxide. Many reservoirs will not be significant emitters of methane, but this risk needs to be carefully checked before a project is developed.

The potential for GHG emissions can be assessed through the IHA G-Res Tool. It uses a conceptual framework that integrates up-to-date science in an online interface to estimate the GHG emissions from reservoirs. Such tools help hydropower companies and researchers estimate and report the net GHG emissions of a reservoir without the need to conduct expensive field sampling campaigns. They are especially valuable in the prefeasibility stage as a screening tool to avoid high-emitting projects.[29]

Hydropower projects do emit GHGs. However, the many myths around GHG emissions and hydropower projects have been addressed by IHA including tropical reservoirs emit more GHGs and that clearing of vegetation lowers GHG emissions. Instead GHG emissions in operating reservoirs can be reduced by implementation of operating practices such as changing operating levels, aeration, adding additional inlets above the thermocline and using methane to generate electricity. The IHA Hydropower Sustainability Standard, as well as the Guidelines on Good International Industry Practice, state that a project with low emissions should have an emissions intensity less than 100 gCO2e/kWh. This emissions level can and should guide future new hydropower development[30].

[28] IFC (2018)
[29] IHA https://www.hydropower.org/blog/carbon-emissions-from-hydropower-reservoirs-facts-and-myths
[30] https://www.hydropower.org/blog/carbon-emissions-from-hydropower-reservoirs-facts-and-myths

Climate vulnerability, and dam and community safety

Hydropower is considered highly vulnerable to climate change[31] as it is directly related to precipitation patterns, behaviour of snow-caps and glaciers, and resulting changes in (timing of) river flows. This affects both the capacity to produce electricity and the safety of dams, for example when flood gates or spillways can no longer safely evacuate increasing river discharges

The most obvious risk associated with a hydropower reservoir is dam wall failure, which can have catastrophic consequences for communities, livestock, and wildlife downstream (Box 5.6). Dam failure can be due to:

- Substandard construction materials and techniques;
- Spillway design error;
- Geological instability caused by changes to water levels during filling;
- Poor maintenance, especially of outlet pipes;
- Extreme inflow;
- Human, computer or design error;
- Earthquakes.

Dam break risk may be exacerbated by climate change. Depending on location, climate change may lead to changes to (i) annual and seasonal rainfall averages, (ii) the type and seasonal distribution of precipitation. (iii) the ranges of temperatures and precipitation, and (iv) frequency and severity of extreme weather events. Changes in these conditions will have effects on hydrological and other conditions including, for example, runoff, and seasonal patterns of runoff, glacial melt or timing of glacial melt, intensity of floods and droughts, frequency or magnitude of landslides, and sediment transport. Fortunately, dam break is relatively rare due to well-established design and maintenance standards. An emerging climate change issue for hydroelectric projects and climate change in the Himalayas is the potential for dam breach associated with an upstream glacial lake outburst flood (GLOF)[32].

A range of risks are associated with hydropower infrastructure such as electric shock, drowning, road accidents, accidents arising from community interactions with project activities.

In the preparation phase, there can be risk linked to structures used to support site investigations, e.g., access roads, buildings, test wells, helipads, etc. During project design, adherence with safety standards is an important consideration.

A significant safety risk during the construction period is the risk of flooding. Diversions are constructed to divert water from the river around the construction site. This diversion will have a capacity that can be exceeded during river flood events in which case water can inundate the construction site and the dam which is under construction can be put at risk of failure.

Other implementation safety issues include those related to construction such as increase in traffic, heavy machinery on roads and blasting activities.

During the operational stage, there will be continuing risks of electric shock, accidental drowning, and road accidents.

[31] Sixth Assessment Report — IPCC

[32] https://www.scientificamerican.com/article/glacial-lakes-threaten-himalayan-dams/

Box 5.6: Dam failure: Saddle Dam D, Lao People's Democratic Republic

On 23 July 2018, Saddle dam D on the Xe Pian-XeNamnoy hydropower project in Champassak and Attapeu provinces collapsed following heavy rain. The Government of the Lao People's Democratic Republic (Lao PDR) immediately suspended new hydropower projects and initiated safety inspections of all existing dams. The dam failure caused devastating floods in both Lao PDR and Cambodia's Stung Treng province, which lies downstream of the dam. 49 people died and 22 were missing presumed dead. The collapse displaced thousands of people, flooding homes and villages. Over 7,000 people in 19 villages in Attapeu province experienced losses and long-term damage to houses, property, and farmlands. The floodwaters extended far downstream and across the border into Cambodia, affecting an estimated 15,000 people, damaging farms, and destroying livestock and property.

Figure 5.7: Downstream flooding following the collapse of Saddle Dam D in Lao PDR.

Image redacted pending securing copyright permission to use. If you have an image showing the components in a hydroelectric plant that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Source: International Rivers. The Xe Pian-Xe Namnoy Dam Disaster: Situation Update Two Years On. https://www.internationalrivers.org/wp-content/uploads/sites/86/2020/08/ir-factsheet-2_year_xe_pian_dam_collapse_1_0.pdf.

Noise and vibration

Various activities during hydropower project construction generate noise and vibrations (truck movements, excavations, removal of vegetation, transport of workers to and from site, etc.). The use of explosives for blasting rock while preparing a dam site and in quarries will create excessive temporary noise and vibration and disturbance for nearby communities as well as wildlife. Quarries may be located at some distance from the dam site, so can increase the number of communities affected by noise. During operation, noise will be limited to generation from the power station and vehicle movements.[33]

Transboundary impacts associated with hydropower projects

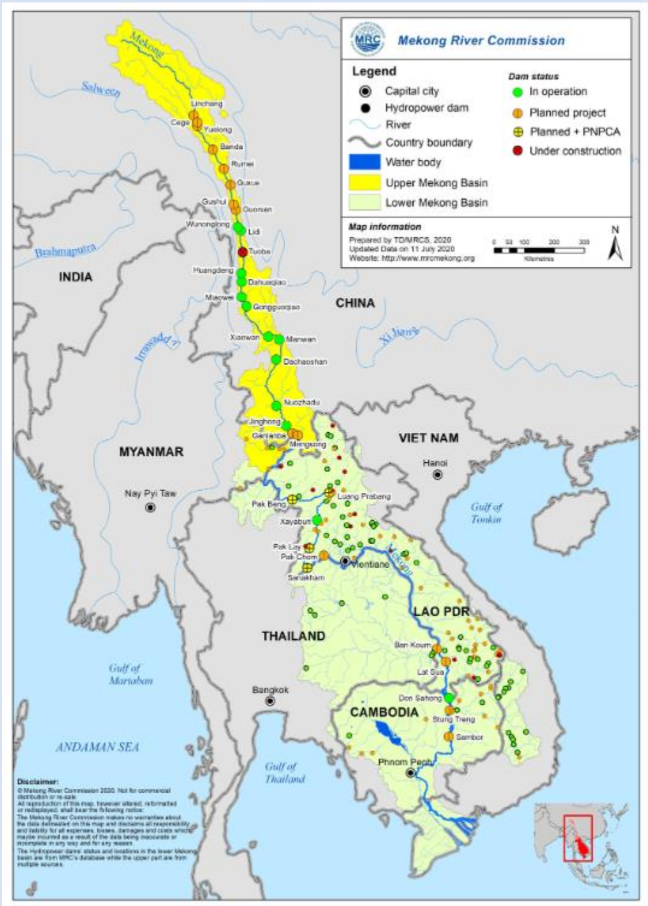
Hydropower projects can have impacts beyond national boundaries if they change the flow regime of a river that runs from one country to another. It is important that potential impacts are considered on a broad spatial and temporal scale. These can include changes to: a river's hydrological regime, its sediment dynamic, and water quality, all of which can affect aquatic ecosystems as well as associated fisheries and livelihoods. Key receptors to be considered in assessing the likely downstream impacts of a hydropower project are irrigation schemes, water supply projects, wetlands, and fisheries. This issue is particularly relevant when a river runs through several countries, e.g., the Mekong River in Southeast Asia (Box 5.8).

Dams with potential transboundary impacts, such as Xayaburi run-of-river hydroelectric dam on the Lower Mekong River (around 30 km east of Sainyabuli [Xayaburi] town in northern Lao PDR), provide lessons about how dams can cause not only ecological and environmental impacts across an international national border, but also adverse effects on the socioeconomics of the downstream riparian states and communities[34] [35].

[33] IFC (2018)
[34] IFC (2015b)
[35] Young and Ear (2021).

Box 5.8: Multiple hydropower dams on the Mekong River

The Mekong River arises in the People's Republic of China (PRC) and flows through Myanmar, the Lao People's Democratic Republic (Lao PDR), Thailand, Cambodia, and Viet Nam. In the Upper Mekong River Basin, the PRC has constructed 11 hydropower dams (of which two are large storage dams). Another 11 dams, each with production capacity exceeding 100 MW, are being planned or constructed. There are a further 89 projects in the lower basin, of which two are in Cambodia, 65 in Lao PDR, 7 in Thailand and 14 in Viet Nam. Many more dams are planned over the next 10 years, as shown in Figure 5.8.



The Mekong River Commission has been established to manage the transboundary issues associated with these projects. It is an intergovernmental organization that works directly with the governments of Cambodia, Lao PDR, Thailand, and Viet Nam to jointly manage their shared water resources and the sustainable development of the Mekong River. Its aim is to promote and coordinate sustainable management and development of water and related resources for the countries' mutual benefit and the people's well-being.

Source: Mekong River Commission gor Sustainable Development. Hydropower. https://www.mrcmekong.org/our-work/topics/hydropower/.

Location issues and cumulative impacts

Downstream dams in the main river channel are more damaging than dams in upstream river branches. Several dams located in different branches of the same river are far more damaging than a cascade of dams in one branch, if other branches remain untouched and free-flowing[36]. River basin wide analysis should be applied to find optimal locations, preferably through SEA or cumulative impact assessment.

Mini-hydropower dams are often "invisible" for EIA/ESIA (i.e.e they are below the threshold requiring such an assessment). However, potentially they can be very damaging, particularly when constructed in cascade. An EIA/ESIA for the entire cascade would be warranted , but this usually is effectively avoided by investors, by taking a one-by-one approach. A river basin management plan, and dialogue or a well-designed permit, may avoid this, informed by a basin-wide assessment of all existing and planned interventions and water uses/users, through SEA or cumulative impact assessment. This can involve several innovative planning measures such as implementing a basin wide strategic roadmap for hydropower planning, addressing baseline data gaps in biodiversity, social and cultural conditions, maintaining downstream environmental flows (E-flows), concentrating cascade hydropower projects in one area of the watershed, conducting basin wide monitoring during project operations, and providing for the continuation of intact drainages in the watershed, free of any hydropower intervention (aquatic offsets)[37] [38].

5.4.2 Socioeconomic Issues and Impacts

Physical and economic displacement

Some hydropower projects cause economic and physical displacement of riparian communities and settlements[39]. Economic displacement is defined as the loss of assets, access to assets, or income sources or means of livelihoods, which could be caused by land acquisition, changes in land use or access to land, restrictions on land use or access to natural resources, or changes in the environment leading to impacts on livelihoods.[40] Hydropower projects can also cause physical displacement from the loss of residential land and shelter. Physical displacement involves risks for both the displaced people and for the host communities receiving them when they relocate[41].

The amount of displacement will often depend on the type of hydropower project. Run-of-river schemes may cause only limited displacement. But hydropower projects that include a reservoir tend to occupy a large area of land. The land acquisition for a reservoir can affect farmland and grazing lands that are located near the river. Farmers' and villagers' incomes from farming and livestock raising will be lost or reduced when the land is flooded. Large reservoirs can also inundate residential areas and displace an entire community to a new resettlement area (Box 5.9) Business activities, whether small, medium, or large enterprises, can also be displaced, affecting their owners and workers. Furthermore, community public facilities such as schools, clinics, public meeting halls and cultural and religious sites may also be lost or need to be relocated. Often, associated infrastructure such as access roads and transmissions line can also cause physical and economic displacement[42].

Box 5.9 Displacement of people due to development of the Three Gorges project in China

Construction of the Three Gorges Dam on the Yangtze River (Chang Jiang) in Hubei province, China (Figure 5.9), was completed in 2006 – at the time, it was the largest dam structure in the world. The dam and accompanying hydroelectric plant were built in phases and over the course of

[36] Slootweg (2023)
[37] Managing Environmental and Social Impacts of Hydropower in Bhutan
[38] World Bank (2016c)
[39] Cernea, M. M. (2004).
[40] IHA (2020)
[41] WCD (2000)
[42] WCD (2000)

many years. It reached its full generating capacity in 2012. The dam allows the navigation of oceangoing freighters and generates hydroelectric power. It was also intended to provide protection from floods, but efficacy on this aim remains unclear.

While the construction of the Three Gorges Dam was an engineering feat, it has also been fraught with controversy: construction of the dam caused the displacement of about 1.4 million people. Hundreds (possible thousands) of towns and villages were evacuated and later submerged. The area surrounding the Yangtze contains some of the densest clusters of human life in the world.

Those forced to relocate were promised compensation for the value of their homes and land. But majority of relocated citizens were either given far too little in compensation or their dues were allegedly slimmed through corruption and embezzlement; many claim they received only half the land compensation they were promised[43]. This created problems for many as the cities and towns they had to move to were more expensive, driving many people deeper into poverty (Yardley 2007), landlessness, joblessness, marginalization, and food insecurity[44]. The displaced were often farmers with little formal education, if any. Many opted to return to the Yangtze region.

Figure 5.9: Three Gorges Dam, China
Source: The New Scientist

Image redacted pending securing copyright permission to use. If you have an image showing the components in a hydroelectric plant that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Flooding the reservoir has forced those farmers still in the region to migrate northwards up the mountain slopes, adding to erosion through over utilization of topsoil.

The dam also resulted in the destruction of natural features and countless rare architectural, cultural and archaeological sites. The dam's reservoir is blamed for an increase in the number of landslides and earthquakes in the region.

Sources:
https://www.britannica.com/place/China
Environmental and Social Issues of the Three Gorges Dam in China (mandalaprojects.com)
Gleick (2009)
Hvinstendahl (2008)

Displacement can impoverish the resettled people, who are often from poor communities. Without adequate mitigation measures and compensation, the livelihoods of displaced peoples can be made significantly worse.[45]

The construction of dams and weirs for both run-of-river and reservoir hydropower schemes can disrupt fishing activities which are often important income-generation activities of the riparian communities. For example, large-scale and transboundary dams along the Mekong River in Southeast Asia have led to less fish migration and lower fishing yields both downstream and upstream of the dams.[46] Hydropower projects can also displace sand mining businesses and the collecting of sand or other aggregate materials from rivers by local people.

The relocation of affected people can create pressure on the public facilities and infrastructure in the host communities, giving rise to tensions between the two groups. The losses endured by the host

[43] Hvinstendahl (2008)
[44] Gleick (2009)
[45] Cernea (2004)
[46] Young and Earl (2021).

community can lead to weakened community cohesion and an increase in domestic and gender-based violence.

Benefits of reservoirs

Although dams/reservoirs can have significant negative environmental impacts, they can also provide significant socio-economic benefits. Sometimes, they are used to supply water to downstream areas for the irrigation of crops, increasing agricultural yields and job opportunities and contributing to local and regional economies. Reservoirs generate the opportunity to establish new fishing opportunities and support local livelihoods. Reservoirs can also benefit local and more distant communities by providing a guaranteed source of fresh water to the public and industry. They are frequently used for recreational purposes (e.g. sport fishing, sailing, picnicking). Some large dams are even used for navigation and the use of locks can facilitate transport across the dam.

A challenge is to minimize contradictions/competition among multipurpose water uses of hydropower reservoirs, and to set an appropriate governance to allow coordinated/integrated water uses management. Based on twelve worldwide case studies of multipurpose hydropower reservoirs, SHARE[47] concept was developed as a framework to address such potential conflicts[48] It refers to a **S**ustainability approach for all users, **Hi**gher efficiency and equity among sectors, **A**daptability for all solutions, **R**iver basin perspectives for all, and **E**ngaging all stakeholders. As a concept for multipurpose water uses of hydropower reservoirs, it aims to help make use of hydropower reservoirs more sustainable and equitable amongst all users and uses[49].

Indigenous communities

The development of a hydropower project may cause both positive and negative impacts on indigenous communities and people. The IFC's Performance Standard 7 and the ADB's SPS (2009) on Indigenous Peoples recognize that indigenous peoples can be marginalized due to their sometimes tenuous economic, social, and legal status and their limited capacity to defend their rights and interests. Indigenous peoples typically have strong spiritual, cultural, and economic relationships with their land and waterways. According to the International Hydropower Association's new guide on hydropower and indigenous peoples [50], a major negative impact can often be loss of land under traditional use. This could be land for which their jurisdiction and management may have been previously removed by national governments. Impacts on IPs other than loss of communal lands include the following:

- Reduced or variable flows that could affect the safety, irrigation, water uses, and livelihoods of communities living downstream;
- Loss of ancestral land and loss of cemeteries, or reduction of their territory, and
- Loss of access to or reduction of resources (e.g., water, fish and animal species, fertile land, and forested areas) and associated nutritional issues.

Box 5.10 provides examples of cases in which indigenous peoples have been displaced and affected by hydropower projects.

Box 5.10: Indigenous peoples affected by hydropower projects: some examples

Many indigenous groups protest against hydropower projects and denounce government approvals for projects. For example, an indigenous community on the border of Thailand and Myanmar organized a large protest against the Salween River hydropower project in 2017. [a] This unrest

[47] S: <u>S</u>ustainability approach for all users, H: <u>H</u>igher efficiency and equity among sectors, A: <u>A</u>daptability for all solutions, R: <u>R</u>iver basin perspectives for all, and E: <u>E</u>ngaging all stakeholders.
[48] Branche (2017)
[49] Branche (2017)
[50] IHA (2022)

occurred, in part, because of inadequate engagement of and consultation with affected communities, and a lack of appreciation of their ties to the land.

In Cambodia, the construction of hydropower projects, such as Lower Sesan 2 dam, have caused adverse impacts on indigenous communities (nearly 5,000 people, mostly IPs and other ethnic minorities - Bunong, Brao, Kuoy, Lao, Jarai, Kreung, Kavet, Tampuan, and Kachok - who have lived in villages along the Sesan and Srepok Rivers for generations [b]. The latter were displaced which resulted in disagreements with project proponents. [c]

In Lao PDR, where ethnicity is diverse, a number of indigenous people have been affected or displaced by hydropower projects, including the multilateral development bank-financed Nam Theun 2 project. [d]

In Indonesia, displacement of indigenous people due to hydropower development projects are often reported by media outlets. For example, a 480MW-hydropower project in South Sulawesi affected Pohoneang, Hoyyane and Amballong indigenous communities. [e]

Sources:
[a] Shah and Bloomer (2018)
[b] Human Rights Watch (2021)
[c] Young (2020)
[d] Nam Theun 2.com. NTPC Document Proforma (namtheun2.com)
[e] Rusdianto (2017)

There are also examples from Southeast Asia of renewable energy initiatives that are being driven by indigenous communities. Micro-hydro power developments in the Philippines and Malaysia are increasing access to clean energy, reducing harmful pollutants, and alleviating the work burden on women as well as providing other community benefits. Groups like 'Grupo Yansa' provide support to indigenous communities interested in developing the renewable energy potential of their land.[51] [52] In Canada, some indigenous peoples' groups are partnering with the private sector to develop and operate large energy projects [53] [54].

There are many opportunities for hydropower development to bring benefits to the indigenous communities. According to the IHA, these benefits include but are not limited to [55]:

- Increased safety by having flood control and regulated flows;
- Support to promote and enhance cultural traditions;
- Employment and business opportunities through the project life, including direct employment opportunities, subcontracting services during construction and maintenance, service provision such as food and transportation services, and indirect employment within local communities;
- Investment revenues from project partnerships with indigenous peoples' communities, and
- Training (pre-project and during construction and operation) and improved community governance capacity.

Jobs during the construction phase are varied depending on the type and size of hydropower project. The Muskrat Falls hydropower project in Canada advertised that the construction workforce would span more than 70 different types of occupations[56] . While some of the expertise may not be available in indigenous peoples' communities, the range of needs, especially in larger projects is considerable, meaning the emphasis should be on matching available local skills to needs among the contracting tiers and service providers.

[51] Shah and Bloomer (2018)
[52] UNDESA (2021)
[53] CHA (2018)
[54] https://www.amazon.ca/Aboriginal-power-energy-Canadas-peoples/dp/1927506190
[55] IHA (2022b)
[56] Muskrat Falls jobs. Nalcor Energy. Accessed October 2013.

In some countries, companies choose (for business reasons) or are regulated to offer impact benefit-sharing agreements. One report from British Columbia in Canada identifies several reasons for entering into benefit-sharing agreements with indigenous peoples including: to further social license to operate, as matter of good neighbour policy, and to provide a competitive advantage to meet consumer demand for ethically produced products[57]. The report indicates that such agreements are not a cure for all conflicts and uncertainties and will not resolve complex legal, political, cultural and historical issues; nor should one company or project be expected to bear all of the burdens of history nor share current development responsibilities. But each fairly negotiated benefit-sharing agreement is an important step forward that will help reconciliation efforts and shared hydropower project benefits with indigenous peoples.

Health and safety

Community health and safety issues are associated with hydropower development during both the construction and operational phases.[58] The IHA's guide [59] on hydropower infrastructure (2021) identifies the following issues: road safety; safety around water bodies associated with the hydropower complex; blasting, and other construction activities; electrical safety; natural hazards; underground geotechnical hazards; and pressurized conveyance hazards.

During the construction phase, the large amounts of heavy vehicle movements can also increase road traffic, affect road, and bridge conditions, and cause accidents. A major issue is the excavation of large quantities of soil and rock, drilling and creation of tunnels. Such work creates significant health and safety risks for both workers and local communities, from dust, noise, and vibrations; eutrophication; waste disposal; and the potential spread of communicable diseases.

ESIA guidance for hydropower published by the Netherlands Commission for Environmental Assessment (NCEA) identifies numerous vector-borne and tropical diseases associated with the development of reservoirs.[60] These risks are exacerbated in low-income countries in Southeast Asia where water quality regulatory enforcement remains limited. In addition to health risks, both construction and operation of hydropower plants can involve structural failure and flooding. An example is the Dhauliganga hydroelectric station in India. In June 2013, there was an unprecedented flash flood, causing massive debris accumulation and the complete submergence of the powerhouse. Damage caused electrical equipment replacement and loss of total generation capacity for more than six months[61].

The IFC hydropower guidance notes that some infectious diseases can spread around hydroelectric reservoirs, particularly in warm climates and densely populated areas. Some diseases (such as malaria and schistosomiasis) are borne by water-dependent vectors (mosquitos and aquatic snails, respectively); others (such as dysentery, cholera, and hepatitis A) are spread by contaminated water, which is frequently present in stagnant reservoirs. Hydropower development projects can also increase other communicable diseases (infectious diseases such as influenza, STIs, COVID-19 and HIV/AIDS), increased drug and alcohol use and the potential for increased crime and domestic and gender-based violence due to the immigration and large-scale influx of workers.

As the COVID-19 pandemic has shown, the large workforces often required by hydropower projects need to be managed to avoid being a spreading point for diseases, but there can be challenges, as illustrated by the experience of Karot Hydropower Project in Pakistan (Box 5.11).

Hydropower projects usually involve the use of heavy goods vehicle fleets to transport materials and staff on-site. In many cases, hydropower projects require new access roads or upgrades to existing roads and bridges to transport heavy equipment, but key risks can be neglected in policies, procedures, and monitoring programs: unsafe road design and conditions, unsafe vehicles, speeding,

[57] Woodward & Company (undated)
[58] Acakpovi and Dzamikumah (2016)
[59] IHA (2021)
[60] NCEA (2018)
[61] https://en.wikipedia.org/Dhauliganga_Dam

non-use of seatbelts and helmets, lack of driver training, driving under the influence of alcohol or drugs, inadequate post-accident care, and lack of enforcement of traffic rules. Without mitigation measures for these risks, a hydropower project can cause traffic related congestion, accidents, and fatalities.

Box 5.11: Karot Hydropower Project in Pakistan

Karot Hydropower Project is located on the Jhelum river in Pakistan and is nearing completion. The power company faced challenges over managing the spread of COVID-19 early on when no vaccine was available. Trade unions filed a complaint to the International Finance Corporation ([IFC], project funder) that the project company undermined the rights of 3,000 workers by restricting their movement, curtailing their freedom of association and collective bargaining (particularly of workers dismissed during the COVID-19 pandemic) and violated the IFC's own performance standards on workplace safety and working conditions, terms of employment, grievance mechanisms and retrenchment.

Figure 5.10: Karot Hydropower Project, Pakistan
Source: CPEC https://cpec.gov.pk/project-details/16

Source: Business and Human Rights Resource Center (2021)

Cultural heritage

Cultural heritage includes:

- Tangible forms of culture such as movable or immovable objects, property, sites, structures, or groups of structures, having archaeological (prehistoric), paleontological, historical, cultural, artistic, and religious values;
- Unique natural features or tangible objects that embody cultural values (sacred groves, rocks, lakes, and waterfalls); and
- Intangible forms of culture, such as cultural knowledge, innovations, and practices of communities embodying traditional lifestyles[62].

The Hydro Sustainability Secretariat[63], identifies that hydropower schemes can have impacts on cultural heritage at each stage of project development. The construction stage may cause direct and indirect damage to or loss of access to physical cultural resources as a result of excavation, soil compaction, blasting, vibrations, pollution, vandalism, theft, desecration of cultural objects and sites,

[62] IFC (2021)
[63] HSC (undated)

and groundwater and river flow changes. Construction activities may also be perceived to disturb spirits associated with special sites[64].

During project operation, impacts on cultural heritage may include the loss of sites inundated by a reservoir (Box 5.12). downstream damage to cultural sites (e.g., through riverbank erosion or flooding)

Box 5.12: The Bujagali hydropower project and natural heritage in Uganda

The Bujagali hydropower project in Uganda was commissioned in 2011 and is still being cited as a project that negatively impacted the culture of local people. The Bujagali Falls was a place of spiritual healing and traditional culture but was blocked and inundated by the hydropower project.

Figure 5.11: Bujagali Hydropower Project

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Source: Kabanda Umar and Francis Mwesigye. 2021. Cultural Heritage and Renewable Energy: How Bujagali Hydro-Electricity Generation Project sparked a latent conflict. https://blogs.prio.org/2021/06/cultural-heritage-and-renewable-energy-how-bujagali-hydro-electricity-generation-project-sparked-a-latent-conflict/

and interruption of ability to continue cultural traditions (e.g., in particular locations) or access specific sites due to changes arising from the project)[65].

Hydropower projects tend to be in remote areas where land is often claimed or occupied by vulnerable indigenous communities. The acquisition of land for the project can displace these communities and their cultural practices, such as sacred sites on land, in forests or in water.

From 2019 to 2021, a UNESCO World Heritage Centre initiative advocated for the protection of natural heritage in the context of renewable energy projects. Hydropower projects need to be effectively planned, evaluated, and implemented to safeguard world heritage properties.[66]

The IFC's Performance Standard on Cultural Heritage (PS8)[67] sets out good practice for addressing cultural heritage impacts. They require the protection of cultural heritage from adverse impacts, and support for preservation and equitable sharing of benefits from the use of cultural heritage. In September 2021, the International Hydropower Association announced that no new hydropower projects should be developed in World Heritage sites. It proposed a "duty of care commitment" to implement high standards of performance and transparency when affecting protected areas as well as candidate protected areas and corridors between protected areas [68].

Hydropower projects can support local communities and their cultural heritage by helping to encourage tourism to their location. It is assumed that hydropower plants and accompanying infrastructure reduce the attractiveness of the areas in which they are located for tourism, but some

[64] HSC (undated)
[65] HSC (undated)
[66] UNESCO (2021)
[67] www.ifc.org
[68] IHA Website notification September 2021. International Hydropower Association announces new commitment to World Heritage sites and protected areas - UNESCO World Heritage Centre.

tourists find them acceptable and desirable[69]. Around the world, hydropower projects organize tours and celebrate local culture, e.g., projects at Itaipu at the conjunction of Brazil, Argentina, and Paraguay, and at Niagara Falls on the border between Canada and the US.

Gender and vulnerability

A hydropower project may affect women and vulnerable groups and impair their ability to access benefits, as they often lack ownership of and rights to property, which affects their access to compensation. A sector study from India shows that[70] women are especially vulnerable when gender sensitivities are ignored or overlooked in the project design and planning phases of hydropower development. These vulnerabilities range from losing their traditional means of livelihood when they lose access to their land, which in turn affects their food security and often their access to water and sanitation as well. Women lose access to and control over resources such as land, rivers, forests, fodder, and must then deal with increasing workloads.

Many large hydropower projects have large workforces that are resident for several years with many construction camps located near to communities. Their presence (often predominantly male, although this is changing) can impact on women's safety and routine activities. World Bank guidance addresses the management of the risks of adverse impacts on communities from temporary project-induced labour influx.[71] It identifies violent and risky behaviour resulting from an increase of predominantly male construction workers for large infrastructure projects such as hydropower. Non-local workers can be drawn to the affected area and local workers can have access to relatively high incomes. This can lead to anti-social behaviours (greater alcohol and substance misuse), a heightened risk of sexual exploitation and abuse or sexual harassment[72], and long-lasting physical and mental health impacts for the community [73].

Furthermore, a lack of gender diversity within the workforce can limit access for women workers to economic opportunities created by the transition to hydropower. According to the IFC's Powered by Women initiative, which surveyed 20 hydropower companies in Nepal[74], women make up only 10% of the total number of employees, and only 5% hold technical jobs. Women are inhibited from taking up non-traditional roles in the industry due to various factors: gender stereotyping in the workplace; a lack of women taking up training in science, technology, engineering, and mathematics (STEM); a lack of access to formal finance for women-headed businesses; and deprioritizing gender mainstreaming within hydropower companies [75].

Employment and labour conditions

Globally, the numbers of workers employed in the renewable energy sector increased from 8.1 million (1.3 million in hydropower) in 2015 to 12 million in 2020 (2.2 million in hydropower) [76] [77]. The Asia and Pacific region had the greatest new hydropower capacity in 2020 (almost 14,500 MW) followed by Europe (just over 3,000 MW) and South and Central Asia (just over 1,600 MW)[78], providing significant employment. The development of a hydropower project can create job opportunities for local people

[69] Saeporsottir and Hall (2018)
[70] Shrestha *et al.* (2019)
[71] World Bank (2016)
[72] Such factors should be combined with an understanding of wider sociocultural risk factors within the country context (i.e., pervasive gender inequality, poverty and discrimination, restrictive social and gender norms) to determine the steps needed to safeguard women and girls from harm. For more guidance, see: EBRD, IFC, CDC (2021)]
[73] See World Health Organisation (2021) https://www.who.int/news/item/25-11-2021-gender-based-violence-is-a-public-health-issue-using-a-health-systems-approach [Accessed 22/03/2022]
[74] IFC (2020)
[75] IFC. Bringing Gender Equity into Hydropower Development from the Start. https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/bringing+gender+equity+into+hydropower+development+from+the+start
[76] IRENA (2021a)
[77] OECD (2017)
[78] IHA (2021b)

(Box 5.13), as well an opportunity for vulnerable groups and indigenous communities to acquire new skills through working on the project[79]. Often, there are gender gaps with women significantly underrepresented (Box 5.14).

Box 5.13: Long-term employment opportunities in the hydropower sub-sector in the Philippines

In 2021, a Japanese renewable energy developer invested in the development of a 17.4 MW hydropower project in Ifugao Province in northern Luzon, Philippines. After the completion of construction, the wider and extended portfolio of hydropower projects is expected to provide the region with clean energy and long-term employment opportunities for local communities. In the Philippines[80], the large and small hydropower sector employed close to 53,600 workers in 2021, and this number continues to rise.

Source: Rivera (2021)

Box 5.14: Gender gaps in the hydropower sub-sector

A recent study for the World Bank looked at gender gaps in the hydropower sector. It was carried out by the Energy Sector Management Assistance Program in partnership with the IHA and the Global Women's Network for the Energy Transition (GWENET) [81]. The study reports that women remain underrepresented in the sub-sector, as they are in the overall energy sector in general. It was difficult to determine the degree of underrepresentation since sex-disaggregated data and gender statistics on employment in the sub-sector are scarce. The report notes that hydropower generates almost two-thirds of renewable energy electricity, and it employs over two million people globally. Hence, the sub-sector has the potential to make a significant contribution to improving diversity and gender equality across the energy workforce.

While labour conditions may vary from one hydropower project to another, there is also a possibility that such projects can breach labour rights. It is common for construction monitoring to identify excessive use of overtime, working successive days without required days of rest, and excessive use of temporary or contract workers. The latter can create a two-tier workforce with repercussions for staff morale, workers not being paid correctly or not being correctly signed up for safety net systems.

The need to engage large workforces in remote areas (where hydropower schemes are often located) can lead to companies providing poor working conditions. In such remote areas, labour inspectors may not be able to regularly monitor projects. Some of the ILO Indicators of Forced Labour[82] were frequently breached by companies during the COVID pandemic, e.g., restriction of workers' movements, isolation, abusive working and living conditions and excessive overtime. They can also be breached by remote, large-scale construction activities such as hydroelectric projects.

One of the key elements of ensuring just renewable energy transition is ensuring that the workforce includes people from marginalized groups.

[79] HSC (2022)
[80] INFRACOASIA (2021)
[81] Energy Sector Management Assistance Program. 2021. World Bank-ESMAP Launches Survey on Gender Gaps in Hydropower Sector - As Part of New Study to Support Women's Employment in the Sector | ESMAP. 19 July.
[82] Rivera (2021)

Migration

A hydropower project may lead to an influx of migrants and skilled workers seeking business and employment opportunities. Incoming workers and followers, including job seekers and squatters, can lead to adverse socioeconomic impacts on local communities residing near hydropower projects. According to IFC guidance on project-induced in-migration[83], this may have a wide range of positive and negative impacts. Positive impacts include, among others, business opportunities, improved range of accessibility to goods and services, higher skill base and increased local tax revenue. Negative impacts include, among others, pressure on services and land, demand for and shortfalls in products and services, boom and bust cycles related to the construction phase, tensions and disputes among different groups related to benefit distribution, alteration in existing levels of communicable disease, increased incidents of social vices and increased potential for domestic and gender-based violence and sexual harrassment.

According to the IFC's guidance, the amount of in-migration can be influenced by various factors:

- Larger projects lead to a greater impact of in-migration; small projects lead to a lesser impact of in-migration;
- Low capacity leads to a greater impact of in-migration, high capacity leads to a lesser impact of in-migration;
- High concentration leads to a greater impact; low concentration leads to a lesser impact of in-migration;
- Many opportunities for compensation and benefits speculation lead to a greater impact of in-migration; few opportunities lead to a lesser impact of in-migration;
- Projects far from urban centres lead to a greater impact of in-migration; projects close to urban centres lead to a lesser impact of in-migration, and
- Migration can cause both socioeconomic and cultural tensions between the local community and migrant workers from other regions or countries; especially if there is displacement of local people, economic loss, and loss of sites and religious or cultural practice of significance due to project development.

Public services and infrastructure

Hydropower projects often fund improvements to and new local infrastructure and facilities, not least to support their own workforces (Box 5.15). They also require the construction of new access roads or upgrading of existing nearby roads to transport equipment and for the construction of transmission lines or substations as associated infrastructure. While local communities benefit from new or upgraded roads, tensions can arise when transmission lines are built, particularly since the electricity generated is not distributed locally (hydropower projects are typically permitted as generating facilities and are not allowed to distribute electricity to local communities).

Box 5.15: Hydropower Project Nam Theun 2, Lao, People's Democratic Republic: Contribution to improved public infrastructure and facilities

Before the Nam Theun 2 project began, basic infrastructure and public facilities in the remote Nakai District was lacking or inadequate. Even in the dry season it took half a day or more to travel between the district and provincial capitals. During the wet season, the Nakai Plateau was virtually inaccessible. The average distance to the nearest health facility was 11 kilometres, usually travelled on foot. Initial health surveys reported poor health conditions for both adults and children, high mortality rates for children under five (120.5 per thousand), widespread stunting and malnutrition, and remarkably high prevalence of parasite infection (59%). 63% of the population on the Nakai plateau lacked access to education, a situation that was of even greater concern for women, most of whom were illiterate. Electricity and communication services were not available to most households.

[83] IFC (2009).

> With project support, basic infrastructure and public facilities have improved. Households have access to electricity and telecommunication services, and most households own at least one mobile telephone. Traders and brokers can now access the plateau and northern villages by road to buy fish. Pigs and ducks can now be sold to collectors or at the market. The project supported the construction of new kindergartens, 14 primary and two secondary schools. 90% of the children are currently enrolled in primary school, compared to 37% before Two new dispensaries provide improved and convenient access to primary health care. In five years, child mortality of those under five decreased from 120 to 59 per thousand.
>
> *Source: Nam Theun 2 dam website. NTPC Document Proforma (namtheun2.com)*

Many hydropower projects will build permanent housing for their operational workforce. By comparison, other types of renewable energy (in particular, wind and energy) tend to have smaller operational workforces and construct much less housing, and more of it is temporary.

As indicated in the section on physical and economic displacement, the resettlement of affected people (e.g., due to the construction of a hydropower reservoir) can increase pressure on the use of the host community's public facilities (schools, clinics, hospitals) and infrastructure.

The IHA guide people/communities affected by hydropower projects[84] notes that such projects can cause permanent or temporary closures of local infrastructure and services if inundation is required. This may include schools, health centres, shops, roads, bridges, footpaths and tracks, and boat/ ferry transport, transmission and telephone lines, and pipelines. For example, in Sikkim, India, hydropower companies support local area development programs for affected areas through community development projects such as school repair, road and footpath construction, provision of electrification and water supply for villages, and livelihood skill development [85].

Community cohesion and engagement

Hydropower development projects can have both positive and negative impacts on community relations and engagement. The impacts on community cohesion can include, but are not limited to[86]:

- Impacts to or loss of community resources (e.g., roads, gardens, land, forest, fisheries) and community assets (e.g., community meeting areas, culturally significant features);
- Conflicts between the workforce and the local population and exposure to anti-social behaviour, and
- Conflicts within the local population. These can arise for a range of reasons, often relating to issues of inequity, including, for example: compensation measures (which may arise from a lack of clarity on cut-off dates), eligibility criteria or entitlement provisions (e.g., duration); access to and extent of training and support; and access to and extent of project benefits.

While the introduction of outsider culture and relationship issues are often raised in hydropower development projects, there are opportunities that projects can improve social relations and engagement (see example in
Box).

Conflicts

Conflicts can arise over a number of issues, e.g.:\.:

- o Environmental degradation (e.g. from reduced water quality

[84] IHA (2020)
[85] Chandy *et al.* (2012)
[86] IHA (2020)

- Lack of perceived project benefits accruing to local communities (e.g., access to power and water services):
- Loss of land or access to resources/areas used for livelihoods or cultural activities;
- Working conditions amongst those employed in construction or operation;
- Downstream impacts due to hydropower activities – changes in environmental flows, impacts to fisheries, water quality impacts;
- Loss of access to important spiritual or cultural sites;
- Tensions may arise between immigrants and local workers/communities, and
- There can be transboundary conflict between states (e.g. over dams restricting water flow).

Reviewers: Can you provide any case example boxes on conflicts?

5.5 HOW SEA CAN BENEFIT THE HYDROPOWER SECTOR

Section 5.4 focuses on the environmental and socio-economic issues and impacts associated with hydropower development - drawing mainly from global experience of implementing individual hydropower projects, and comments on how such impacts can effectively be managed. In addition, recommendations are made regarding higher level planning mechanisms for sustainable hydropower development at a basin level. This section summarises how SEA can address the issues and benefit three different stages in the preparation and implementation of hydropower PPPs - planning, assessment, and management.

5.5.1 Planning

SEA can have the greatest benefit at the planning phase, when PPPs for renewable energy (or specifically for hydropower) are being prepared, updated or revised, and prior to individual hydropower projects being proposed/developed. However, in reality, such synchronization is rare. Energy transition requires strategic planning and SEA can assist to make well informed decisions accepted by the public, decision makers and hydropower developers. This will be particularly important where hydropower will either supplant or support baseload generation provided by fossil fuels.
If initiated very early on in hydropower PPP preparation process, SEA offers the following benefits:

- Considers alternatives (within hydropower) and ‘to’ hydropower development – through broadscale and inclusive stakeholder consultations that allows that the most desirable alternative basin / energy development pathways to be selected, Thus, SEA helps to identify alternative water driven development pathways for socio-economic development and energy demand planning at basin level.
- Identifies locations suitable for hydropower development (e.g. particular catchments/basins) as well areas to be avoided (‘no go’ zones) in terms of risks and potential impacts), aiding subsequent selection of sites for individual hydropower projects at a basin level;
- Supporting basin/catchment planning and integrated water resource management (IWRM). In countries with hydropower potential, SEA can support river basin planning to identify the most suitable sites in terms of economic benefits and social and environmental acceptability. This is particularly important where multiple cascade hydropower developments are proposed within a single basin.
- Supports planning for energy integration whereby opportunities for hydropower and other forms of energy generation are identified and assessed (e.g. pump storage in combination with solar / wind);
  Supporting cascade development planning for siting optimization;
- Improving hydropower and energy policies pertinent to hydropower development;
- Increasing the efficiency of multi-level institutional review and coordination of sector development;
- Directing spatial planning for the optimal coordination of other land uses, and
- Identifying specific issues for stakeholder engagement planning and strategies for effective consultation and communication for the sub-sector.

5.5.2 Assessment

SEA can help inform PPP development and guide hydropower schemes/projects by assessing their environmental and social risks and impacts – as follows:

- Optimises strategic assessment of hydropower PPPs and hydroelectric development schemes (e.g. multiple hydropower projects in a particular catchment) to understand higher level environmental and social impacts and risks and their policy and planning consequences;
- Addresses cumulative effects of and impacts on other water users and uses (such as irrigation, water supply, riverine and coastal fisheries, navigation, nature conservation, recreation as well as other hydropower plants, including transboundary aspects). SEA defines and priorities water uses (including for the environment) during times of water shortages. It elaborates different water use scenarios to maximise water use outcomes that will benefit assist decisions on specific investments[87].
- Integrates consideration of climate change and sensitive areas - important factors in assessing the suitability and future viability of the proposed hydropower developments;
- Addresses how to balance or achieve trade-offs between adverse impacts; and identifies opportunities to enhance synergies (win-win outcomes) between environmental, social, economic and other concerns.
- Provides direction and streamlining of project level ESIA and approvals in the sub-sector.

5.5.3 Management

The timely and early (*ex ante*) application of SEA can offer early solutions to the management of potential risks and impacts of hydropower PPPs (and subsequent projects/scheme):

- Contributes to basin wide strategic management plans;
- Identifies where institutional capacity needs to be developed for the effective implementation of SEA and SEMP recommendations;
- Identifies opportunities for trade-offs (between environmental, social and economic considerations) for the hydropower sub-sector;
- Identifies where revised or new legislation, policies and regulations for the hydropower sub-sector may be required;
- Promotes regional cooperation mechanisms to help enhance the modalities and benefits of SEA – particularly where transboundary and regional economic considerations need to be addressed;
- Improves data collection/sharing and monitoring requirements for the sub-sector;
- Helps identify efficiency measures/options for power generation in the sub-sector;
- Develops a specific environmental and social management plan (SESMP) for the sub-sector at a national, regional or catchment level (addressing: e.g. sediment management, fisheries, navigation, biodiversity, relocation of people/communities, compensation, conflict management, etc);
- Integrates climate change adaptation and resilience into hydropower planning and development;
- Coordinates the management of cumulative and transboundary impacts between multiple proponents, agencies and interested parties;
- Enhances the credibility of hydropower development and review in the eyes of affected stakeholders, leading to smoother implementation and reduced conflict;
- Provides for easier access to funding from international development banks by examining higher level transactional and reputational risks, and
- Improves private sector involvement in addressing environmental and socio-economic concerns by providing a higher level strategic approach to managing relevant environmental and social risks beyond the project level.

[87] Slootweg (2023).

CHAPTER 6

KEY ISSUES FOR SEA IN THE WIND POWER SUB-SECTOR

Onshore and offshore wind power is addressed separately in this Chapter in sections 6.3 and 6.4.

6.1 WHY SEA IS IMPORTANT TO THE WIND POWER SUB-SECTOR

SEA can provide critical information to support better decision-making for wind energy planning and development, including identifying where there may be implications for PPPs to adequately address significant environmental and/or socio-economic risks and impacts. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of multiple wind energy schemes/developments whether alone or in combination with other renewable energy technologies (e.g., solar).

The SEA process will:

- Identify and focus on key environmental and socio-economic issues and risks and the concerns of likely affected stakeholders, including local communities, marginalised groups and indigenous peoples. Major issues are discussed in detail in sections 6.4 and 6.5 and are summarised in Tables 6.2 and 6.3.
- Identify what changes or additions are required to PPPs governing wind power development to address these risks.
- Make subsequent project-level EIAs more efficient and cheaper by addressing the big picture and upstream, downstream, and cumulative potential impacts, identifying the particular issues that enabling individual EIAs should focus on in more (site-specific) detail. This may also include spatial planning recommendations for optimal siting of wind power projects to minimize these risks and impacts.
- Engage stakeholders – including communities, marginalised groups and indigenous peoples which can be particularly affected by wind power developments - to be informed of proposed or possible policy options or plans and enable them to provide their perspectives and present their concerns. This will enable key issues to be identified and verified, help build understanding and support for wind power development, and avoid future misunderstanding and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 3 and are therefore not repeated in this chapter.

6.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE WIND POWER SUB-SECTOR

An international survey of existing SEA guidelines conducted for the IAIA was unable to identify any specifically focused on the wind power sub-sector; but a number of guidelines and papers address project-level IA for wind power developments[1]. New guidance on key environmental factors for offshore windfarm environmental impact assessment has recently been released by the Australian government[2].

6.3 INSTALLED WIND POWER CAPACITY

In 2021, global installed wind capacity was 837 GW (780 GW onshore; 57 GW offshore) (Table 6.1).

[1] e.g. Durning and Broderick M. (2018); EU (2011); GIZ (2018); GP WIND (undated); MESP (2010); MSEA (2013); Phylip-Jones and Fischer (2013); and RVO (2022)
[2] DCCEEW (2023).

6.4 ONSHORE WIND POWER GENERATION

6.4.1 Onshore installation types

Onshore wind turbines capture energy from the wind and produce electricity using long, rotating blades that drive a generator located at the top of the tower behind the blades. The longer the propellers, the more kinetic energy they can catch and 'harvest' from the wind. The current tendency in wind power development is for towers to become increasingly taller and blades to be longer to increase power generation of individual units.

Onshore wind is a developed technology, present in 115 countries around the world. The top 10 countries with the largest wind energy capacity in 2021 were China, US, Germany, India, Spain, United Kingdom, Brazil, France, Canada, and Italy[3].

Wind turbines can be tall, as much as 300 meters in height, to make the most use of available wind. To maximize power generating potential, wind farms are usually located where topography and weather patterns offer the highest potential for significant natural wind. They are often on agricultural land or on hilltops and mountains, sometimes coexisting with other land uses such as livestock grazing or cropping areas. The number of turbines at wind farm sites varies depending on the net total output required for each installation.

Land used for large-scale agricultural production (e.g., for livestock or cropping) can often be readily combined with wind turbines. In general, a relatively small portion of the productive land is utilized for a wind farm's operation, e.g., turbine siting, access roads, and other related assets such as transmission line easements, electrical substations, transformers, and meteorological masts. The landowner usually continues agricultural activities on the remaining land. Typically, there is disruption during the construction phase but only minimal disruption when the wind farm is operational, e.g., for access and maintenance[4.]

A wind turbine comprises four main parts: the base, tower, generator, and blades (or propellers). Each turbine is connected by an array of cables that connect to a substation before electricity is fed into the electricity grid. Construction of transmission lines and substations are required.

Construction activities for wind turbines typically include land clearing and levelling for site preparation and access routes; excavation, blasting and filling; transportation of supply materials and fuels; building foundations involving excavations and placement of concrete; using cranes to unload and install equipment; construction and installation of associated infrastructure; installation of overhead conductors or cable routes (above-ground and underground); and commissioning of new equipment.

As the wind turbine components (turbine blades) are large, special purpose vehicles are often used to transport them to a site. This can be a challenging in areas of steep terrain and in areas where the existing road or access infrastructure is less developed. Where access is limited, new roads and road upgrades may be required and need to be undertaken before construction.

Box 6.1 provides examples of some recent onshore wind farm projects in Southeast Asia.

[3] https://www.power-technology.com/features/wind-energy-by-country/

[4] Australian Energy Infrastructure Commissioner (AEIC). Host Landholder Matters. AEIC website (see: www.aeic.gov.au/observations-and-recommendations/chapter-1-host-landowner-negotiations)

Table 6.1: Installed wind energy capacity in 2021. Source: GWEC (2022)

Continent/country	Installed capacity (MW)	Continent/country	Installed capacity (MW)
ONSHORE		**OFFSHORE**	
Total onshore	***780,275***	***Total offshore***	***57,176***
Americas	***188,233***	***Europe***	***28,154***
USA	134,354	United Kingdom	12,522
Canada	14,255	Germany	7,728
Brazil	21,580	Belgium	2,262
Mexico	7,262	Denmark	2,308
Argentina	3,287	Netherlands	3,003
Chile	3,444	Others Europe	331
Other Americas	4,051	***Asia-Pacific***	***28,980***
Africa/Middle East	***9,085***	China	27,680
Egypt	1,702	South Korea	133
Kenya	440	Other APAC	1.167
South Africa	3,163	***Americas***	***42***
Other Africa	3,780	USA	42
Asia-Pacific	***375,161***		
China	310,629		
India	40,084		
Australia	9,041		
Pakistan	1,516		
Japan	4,523		
South Korea	1,579		
Vietnam	3,231		
Philippines	427		
Thailand	15,54		
Other APAC	2,577		
Europe	***207,796***		
Germany	56,814		
France	19,131		
Sweden	11,915		
United Kingdom	14,064		
Turkey	10,681		
Other Europe	95,191		

Box 6.1: Recent onshore wind farm projects in Southeast Asia

Sidrap Wind Farm, Indonesia. The 75 megawatt (MW) wind farm is in the Sidrap region in South Sulawesi. The project is Indonesia's first utility-scale wind farm and began providing power to the Southern Sulawesi grid in March 2018. The project uses 30 2.5 MW turbines. (Photo).

Figure 6.1: The completed Sidrap Wind farm, Indonesia. Source

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Tolo 1 Wind Farm, Indonesia. The 72 MW wind farm is located in the Jeneponto Regency area of South Sulawesi. Commissioned in 2019, it has 20 wind turbines, with each tower 134m high using 64m long blades (Photo).

Figure 6.2: Construction of a wind turbine for the Tolo 1 Wind farm, Indonesia

Source: www.venaenergy.com [permission given]

La Hoa and Hoa Dong Wind farms, Mekong Delta, Viet Nam. Currently under construction, each of the 30 MW projects are in Vinh Chau and Soc Trang, Viet Nam. Each project utilizes 8 turbines on 162-meter tall towers. Both projects include a 110 kilovolt substation and transmission line, and a total of over 17 kilometers of transmission lines.

Hanuman Wind Complex, Chaiyaphum, Thailand. The 260 MW complex consisting of five wind parks with 103 turbines is in the northeastern province of Chaiyaphum. It started operations in 2019.

6.4.2 Key environmental issues and impacts for onshore wind power

During scoping for a SEA, key issues regarding wind power development should be identified. They will be used to focus the SEA on the most important issues and to help develop environmental and social quality objectives (ESQOs) – that address these issues - to be used during the main assessment stage. The key issues will be identified by reviewing relevant documents (e.g. EIA and special subject reports, environmental/social profiles, sector and inter-sector strategies, donor documents, academic papers, other wind power development applications, wind profiles and meteorological data, etc.), interviews with key informants and during stakeholder consultations at national to local levels. Many of the issues will be well known as a result of implementing other wind power development projects.

At the individual project-level these issues will be the focus of an EIA which should recommend how to manage or mitigate project impacts associated with these issues that might be likely to arise. Ideally before individual wind projects are approved, the implementation of a policy, plan or programme (PPP) for the wind power sub-sector should be completed. This will involve the assessment of multiple projects, schemes and activities, some directly concerned with the construction and operation of sites and facilities; others linked to associated infrastructure (e.g. transmission lines, access roads). Thus, there is a risk that the impacts of individual developments/projects may become highly significant as they become cumulative. A SEA should be focus on the potential for such cumulative impacts and make recommendations for addressing them. This may include recommending thresholds for particular factors that should not be breached by an individual project (and which should be addressed by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it. Often, the timing of individual wind power applications and overarching SEA planning is not synchronized, and SEA may have to “catch-up” to the pace of individual projects rather than providing upstream (pre-project) guidance as to how wind power development should proceed.

Table 6.2 summarises the key environmental and socio-concerns concerns likely to be associated with wind power development.

Wind energy turbines can have both direct and indirect adverse impacts on the onshore environment during construction, operation and maintenance, and decommissioning.

Habitats and biodiversity

The IFC has identified potential risks to habitats and biodiversity due to onshore wind power development[5] :

- Permanent habitat loss due to land clearing for temporary project components such as site huts and worker’s accommodation, and for permanent components such as roads, turbine foundations, footings and substations;
- Fragmentation of habitats due to construction of the linear infrastructure needed for onshore wind farms, including access roads and transmission lines;
- Aquatic and terrestrial habitats can potentially be affected by various activities: widening of road sections or trimming/removal of roadside vegetation; and strengthening (or building) bridges and culverts;
- Indirect impacts on biodiversity due to the construction of new access roads in previously remote natural habitats. Increased accessibility provides more opportunities for illegal logging and poaching;
- Risk of bird, bat and insect[6] collisions and mortality with moving wind turbine blades during operation (Box 6.2);
- Permanent habitat loss due to disturbance and barrier effects on species. Operational wind turbines can disturb resident and transitory species (i.e., both terrestrial and birds/bats)—rotating turbines can cause avoidance or movement pattern changes, effectively creating “barriers” to habitats, resources, or the linkages between them. Important bird and bat migration pathways may be affected by improper siting of wind power facilities.

[5] World Bank (2015)

[6] Evidence is accumulating that insects are frequently killed by operating wind turbines, yet it is poorly understood if these fatalities cause population declines and changes in assemblage structures on various spatial scales (see: [Insect fatalities at wind turbines as biodiversity sinks | Tethys (pnnl.gov)]( ))

The creation of linear infrastructure including roads and transmission lines can often result in corridors of cleared vegetation or removed habitat. These “corridors” can cause habitat fragmentation by dividing up previously contiguous units of habitat.

Linear developments, including roads and transmission lines pose various direct threats to wildlife such as the risk of collisions and resultant mortality with vehicles and electrocutions, impeded access to resources (e.g., food), reduced genetic exchange, behavioural changes, and exposure to pollution. The impact of these corridors on arboreal mammals could be especially pronounced given their aversion to using open ground when the connectivity of the (tree) canopy is lost.

Bird and bat death associated with turbines is a significant problem where protected species are present and migratory and foraging routes are in proximity to onshore wind farms[7] [8]. There has been extensive research on the interaction between birds, bats, and wind turbines. In 2022, the US Synthesis of Environmental Effects Research prepared a briefing paper on Bat and Bird Interaction with Wind Energy Development[9].

The species that are killed by wind turbines are often long-lived, slow to reproduce, K-selected species[10], for which impacts on a few adults in the population can lead to significant population-level declines. This differs from those predominantly passerine species that are subject to collision with buildings or predation by cats, because there is much more redundancy in those populations, and they can withstand a certain level of annual mortality. This is particularly important for bats which provide significant ecosystem services, e.g.:

- Insect-eating bats have been shown to benefit? agricultural outputs by reducing pest insects[11]. Wind farm proposals in areas where the main agricultural pests are night-flying insects should take this into account.
- Insect-eating bats may reduce the number of medically important insect pests such as mosquitoes[12];
- Fruit-eating bats are important seed dispersers and pollinators and may be vital to forest regeneration[13].

[7] Thaxter *et al*. (2017)

[8] Is it possible to build wildlife-friendly windfarms? - BBC Future

[9] A table summarizing the more than 60 articles relevant to the subject is available at: https://tethys.pnnl.gov/summaries/bat-bird-interactions-offshore-wind-energy-development.

[10] K-selected species are those that reduce the number of offspring produced in order to increase their quality.

[11] e.g. Williams-Guillén *et al* (2009), Boyles *et al.* (2011), Noer *et al.* (2012).

[12] Reiskind and Wund (2009)

[13] Kunz *et al.* (2011), van Toor *et al.* (2019).

Table 6.2: List of Key Environmental and Socioeconomic Issues for onshore wind power

ISSUE	CONCERN
Environmental	
Deforestation	• Land clearing and deforestation for wind farms sites and release of stored carbon
Habitats and biodiversity, and ecosystem services	• Changes to terrestrial habitats due to land clearing and linear developments • Bird strikes or collisions (with spinning turbines) and barrier effect for local and migratory birds (including internationally listed endangered species) and bats. Often this loss is not fully recognized as predators may remove wildlife losses before they are detected. • Potential loss of bat species—information about presence and distribution of bat species are often less established or absent (i.e., relative to bird species), requiring site-specific primary surveys to adequately assess impacts. • Fragmentation of habitats by access roads and transmission lines • Changed food webs • Biodiversity impacts may also result from associated infrastructure (transmission lines, roads, and lighting), birds and bats may collide with overhead power lines leading to electrocution • Due to the typical remote nature of onshore wind turbine generators, access road required for construction (e.g., wind turbine blade transportation) and operation and maintenance can potentially open new forest areas for exploitation in terms of illegal logging and poaching • In many parts of the world bats and birds are vital to ecosystem functioning and their loss could destabilize entire ecosystems
Greenhouse gases	• Wind power can reduce GHG emissions where it displaces coal as a fuel source
Land-use changes	• Loss of agricultural and other productive land from siting of turbines and transmission lines
Protected areas	• Impact on protected areas, e.g., where wind farms are in, or nearby, protected areas or where access road and transmission lines pass through protected areas (through deforestation, disturbance to fauna, increased poaching, etc.)
Noise and vibrations	• Onshore construction noise from activities such as blasting, piling, construction of roads and turbine foundations, and the erection of the turbines themselves • Operational noise impacts of onshore wind turbines may also have ongoing impacts • Blade movement may disrupt behaviour and physiology of animals and cause physical damage (mortality to damage of hearing tissues and other organs) • Anthropogenic noise can mask detection of biologically important signals used for communication, predator avoidance, and prey detection, and can influence behaviours • Animals may move out of a noise area, potentially disrupting foraging, or breeding
Air quality	• Dust during construction • Emissions from construction plant and vehicles—potentially on nearby residences or work sites (offices, etc.). Depends on volume of traffic
Waste	• Construction waste and decommissioning waste • Wind turbine generator blades are made from unrecyclable composite materials and present a problem for disposal in most countries. However, new technology for recycling is emerging[14]
Water demand	• Water used during construction and operation—particularly an issue in arid environments

[14] https://www.energy.gov/eere/wind/articles/carbon-rivers-makes-wind-turbine-blade-recycling-and-upcycling-reality-support

ISSUE	CONCERN
Water quality	• Foundations, underground cables, roads, and infrastructure may result in increased erosion, soil compaction, increased runoff, and sedimentation of surface waters • Discharge of pollutants in water (used for plant, equipment and vehicle washing) to ground and subsequent leaching to groundwater • Release of pollutants (fuels, oils, chemicals, etc.) to groundwater during construction and decommissioning • Accidental release of liquid wastes during storage, handling, and removal, with subsequent leaching to groundwater • Accidental discharge of sanitary wastewater to ground and groundwater from the workers' domestic facilities
Metal and mineral extraction	• Overextraction of metals and minerals used for wind turbine manufacturing
Visual and aesthetic impacts	• The presence of many turbines, pylons, substations and transmission lines change landscape quality and disrupt the aesthetic value to the local communities • Shadow flicker may become a problem with sensitive receptors nearby • Wind turbines may reduce the appeal of an area for recreation and tourism
Land and ecosystem restoration	• Wind farms have a 20-30 year lifespan, after which restoration will be required, unless negotiations with landowners result in agreement to repower or upgrade the equipment and extend the wind farm's operational lifespan.
Socioeconomic	
Human rights	• Mineral mining companies (which supply wind turbine manufacturing companies) are known to violate rights of communities (e.g., rights to land, livelihood, ability to undertake traditional cultural practices) • Mineral mining companies are known employ forced and child labour
Employment and labour conditions	• Employment opportunities during construction and operation phases of wind farms • Job opportunities generated from new investment in mineral extraction for use in turbine manufacturing • Worker safety (e.g., working at heights)
Health and safety	• Failure of rotor blades • Failure and toppling of tower structures due to heavy forces of moving blades • Heavy load transportation causes traffic management/safety problems • Increased vehicular traffic during construction • Burns or electrocution from electrical shocks or arc flashes/fires
Local economy and livelihoods	• Income from agricultural land will be lost • Local communities can gain from benefit-sharing schemes • Individual land owners may receive lease payments but these may be less than those received from other sectors (e.g. oil/gas) • Concerns about liability and restoration costs of failed or terminated projects.
Shadow flicker	• Shadow flicker (which occurs when the sun passes behind a wind turbine casting a shadow) may become a problem with sensitive receptors nearby
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and indigenous communities) may be disadvantaged and at particular risk • Employment opportunities within new projects • Opportunities for vulnerable groups to acquire new skills and learn new technologies
Cultural heritage	• Risk of damaging or destroying cultural, historic and archaeological sites
Migration	• Tension between immigrants and workers • Risk of gender-based violence due to influx of predominantly male construction workers

ISSUE	CONCERN
	• Pressure on preexisting health services and infrastructure
Telecommunications and aviation	• Electromagnetic interference to telecommunications systems • Potential to impact aircraft safety with direct collision or alteration to flight paths. • Some disruptions to aviation radar may be caused by turbines such as signal distortion
Public services and infrastructure	• Wind farm companies may fund Improvements to local infrastructure • Pressure on local infrastructure due to heavy transportation of wind turbine equipment • Increased pressure on public services, including health centers • Increased local government's tax revenues generated from wind farm companies

Box 6.2: Impacts on migrating birds of large wind farm projects in Egypt near the Gulf of Suez

An SEA was undertaken covering an area of 284 km² about 5 km inland from the shores of the Gulf of Suez located north-west of Ras Ghareb in Egypt. It assessed the likely environmental and social risks and impacts of future wind farm developments in the area.

Parts of the Gulf of Suez, especially the area near Gabel el Zayt, are well known as a bottleneck for migrating birds from Europe and western Asia and there were concerns that installing large wind farms in this region may lead to significant impacts on migrating birds caused by collisions with wind turbines or - to a lower degree - by barrier effects. In addition, large wind farms might even affect roosting and local (i.e., breeding) birds by direct habitat degradation or indirect disturbance (due to avoidance behaviour of birds).

As part of the SEA, extensive monitoring on birds was conducted in accordance with the EIA guidelines and monitoring protocols for wind energy development projects in Egypt. The monitoring aimed to collect baseline data on large soaring birds (mainly storks, pelicans, and raptors ("target species")), roosting and local birds. On that basis likely impacts caused by multiple wind-farm projects in the area were identified and assessed and appropriate mitigation measures to minimize impacts were defined.

The monitoring focused on bird migration during three different periods: April- May 2016 (spring migration and breeding period); September-November 2016 (autumn migration); and February-May 2017 (spring migration and breeding period)

Though migration of target species was low during some periods, a very high migratory activity was obtained on single days (probably - at least partly - correlated with low wind speeds). Relevant numbers of "Endangered" or "Vulnerable" species occurred in the study area, in particular Steppe Eagle with 4,740 individuals in spring 2017. More than 1 % of the flyway population of ten target species was observed in the whole study area and even at single observation sites. The monitoring confirmed that the area is of high importance for large soaring birds in spring.

The SEA recommended that, to reduce collision risk for large soaring birds at an individual wind farm level during spring migration, an effective shutdown, or curtailment, program should be established. Two alternate approaches were proposed:

- Fixed shutdown - during the critical migration period in spring (March 1st to May 18th) during daytime (i.e., 1.5 hour after sunrise to 1.5 hour before sunset);

- Shutdown on-demand - turbines are stopped in times of high collision risks, i.e., during periods of high migratory activity or when large flocks approach a wind farm. At two large wind farms, four criteria for triggering the shutdown of turbines were applied:

    1. Threatened species
    2. Flocks with 10 or more large soaring birds (target species)
    3. Imminent high risk of collision
    4. Sand storm of high migratory activity or when large flocks approach a wind farm

Source: Lahmeyer and Ecoda Consultants (2018)

Not all habitat and biodiversity outcomes are negative. Research after constructing wind turbines in the Gobi Desert concluded the development was a win-win strategy that both contributed to the growth of desert vegetation with the advent of a favourable microclimate[15].

Materials used to construct wind turbines comprise of steel, fiberglass, resin or plastic, iron, copper, and aluminium. The magnets used in modern turbines are made using neodymium and dysprosium.

[15] Kang *et al*. (2019)

The supply chain and source for these materials, and the potential adverse effects to habitat and biodiversity in the locations they are mined also need to be considered.

Protected areas

Onshore wind farms and their supporting infrastructure can have negative impacts on protected areas and areas of biodiversity importance —either directly by being located within a terrestrial protected area, or indirectly by impacting on the environment near a protected area or area of Biodiversity importance.

Protected areas of local, regional or international importance may include national and international protected areas (including marine protected areas); Important Bird Areas, Key Biodiversity Areas; Alliance for Zero Extinction sites; Ramsar sites (wetlands of international importance); known congregatory sites and unique or threatened ecosystems.

These sites may be on important migration routes, particularly for birds, or for wetlands or staging, foraging, or breeding areas. They may house bat hibernation areas and roosts, or they may contain important topographical features, including ridges, river valleys, shorelines, and riparian areas[16].

Noise and vibration

Noise can be an issue during both the construction and operation of a wind farm. It can affect nearby residents and communities as well as disturb wildlife. Localized vibration impacts associated with heavy machinery movement may occur during construction but are not evident once the turbine construction is completed and operation has commenced.

<u>During Construction</u>

During the construction of an onshore wind farm noise, and in some circumstances, noise and vibration is generated by:

- The building of access roads and hardstanding (hard surfaces);
- The erection of wind turbines which includes foundation preparation, tower installation, blade assembly and electrical infrastructure works;
- Increased traffic noise from delivery and construction vehicles.

Most wind farm projects are located in remote locations away from areas sensitive to noise and vibration. As a result, in most circumstances, construction noise and vibration are limited to few sensitive receivers.

<u>During Operation</u>

Noise generation during operation is primarily from the wind turbines themselves. It is caused by aerodynamic turbulence associated with the rotating blades (creating a swishing effect that is commonly audible near each wind turbine) and mechanical noises from within the nacelle. The nacelle houses the gearbox, generator, and drive train at the back of the turbine blades atop the turbine tower (

Figure 6.3).

Wind turbine noise is often assessed for the presence of any special audible characteristics that may cause subjective annoyance and therefore increased impact on adjacent noise sensitive areas. The

[16] World Bank (2015)

characteristics that are typically assessed include tonality, amplitude modulation, intermittency, low-frequency noise, and infrasound.

Figure 6.3: Components of a wind turbine

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Ancillary power infrastructure such as transformers and substations also cause some noise, but the impact is typically localized and close to the turbines, with no sensitive receivers in immediate proximity.

Visual and aesthetic Impacts

The World Bank Group EHS Guidelines[17] note that wind farm projects can have landscape and visual aesthetic impacts on local communities and change the visual context and setting of the natural landscape.

When the sun passes behind rotating wind turbine blades, it casts a shadow causing a flickering shadow effect. Shadow flicker may become a problem when potentially sensitive receptors (e.g., residential properties, workplaces, learning and/or health care spaces/facilities) are located nearby. The problem is likely to be of more significance at high latitudes where the angle of the sun causes longer shadows (i.e., has a large radius of influence) and the magnitude and extent is dependent on the duration, timing, and presence of sensitive receptors[18].

Local communities may view wind farms as impairing the aesthetic value of their surroundings. Some tourists find wind farms attractive, while others consider that they obstruct the natural landscape[19]. More than a decade ago, wind farms were being touted in the US as a means of boosting tourism and it was found that some tourists were supportive of wind farms being developed near recreation areas[20].

There are also documented cases of opposition to wind farms because they deter tourism. For instance, research in Germany showed that wind farms were perceived to negatively affect the landscape and views in tourist areas[21]. In some low-income areas, stakeholder concerns about aesthetics are less prevalent or receive less prominence in project decision-making. In certain situations, wind farms can create conflicts between community groups having different perspectives. This can only be expected to increase as the intensity of wind power development increases on the landscape as a result of the energy transition.

Air quality

[17] World Bank (2015)
[18] Parsons Brinckerhoff (2011a and 2011b)
[19] NRC (2007)
[20] Brown (2014)
[21] Broekel and Alfken (2015)

Wind farms have negligible impacts on air quality when operational. The main issues are usually dust and vehicular emissions during the construction of access roads and excavations for the turbine towers.

Water quality

Similarly, onshore wind farms have minimal impacts on water quality. During construction, there can be localized increased turbidity in water courses due to soil erosion along access routes and at turbine construction sites. This usually arises if measures to manage soil erosion and drainage are lacking or inadequate.

There can be small-scale spills of hazardous substances such as oils or vehicle fuel during construction. These have a temporary impact on water quality.

Depending on the technology, wind turbines may require water for cooling the generator, transformer, and inverter, and occasional for blade washing to maintain efficiency. This will require abstraction for a local water resource, particularly when local rain patterns are insufficient. Supplies of water available to local communities may be reduced, particularly during dry seasons.

Subject to any additives used, each of these activities pose limited risks to catchment water quality given that only low volumes of water are used.

Waste

Overall, waste production during the construction and operation of an onshore wind farm is not significant. The tower and nacelle are usually made from recyclable steel and copper. Materials used to construct wind turbines include steel, fiberglass, resin or plastic, iron, copper, and aluminium. The magnets used in modern turbines are made using rare earths (primarily neodymium and dysprosium). Typically, 85% of a decommissioned wind farm can be recycled.

From a life cycle perspective, the blades (service life of 20–30 years) currently account for most of the nonrecyclable waste (plastic polymer and composite materials) from wind turbines when they are decommissioned at the end-of-life, or when wind farms are being upgraded in a process known as repowering. The latter involves keeping the same site and often maintaining or reusing the primary infrastructure but upgrading with larger capacity turbines. During repowering, the blades might be replaced with more modern and typically larger blades.
Wind turbine blades are significant in size and disposing them at their end-of-life of blades involves a complex value chain with several steps and stakeholders. It has been forecasted that, by 2050, the end-of-life waste stream of wind turbine generator blades (from onshore and offshore wind farms) could, cumulatively, be as much as 43 million tonnes worldwide with China possessing 40% of the waste, Europe 25%, the United States 16%, and the rest of the world 19%[22].

Decommissioning, reusing, and repurposing blades is an option (Figure 6.4), but this can be a challenge for some countries[23]. In late 2021, Siemens Gamesa Renewable Energy launched the world's first fully recyclable wind turbine blade at its manufacturing plant in Denmark.

Figure 6.4: Section of a wind turbine blade repurposed as a bike shelter in Denmark

[22] Liu and Barlow (2017)
[23] Beauson *et al.* (2022)

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

In 2023, Vestas, a wind turbine manufacturer announced that it has discovered a new chemical process which removes the need to change the design or composition of the material used for wind turbine blades to make them recyclable[24]. It breaks down epoxy-based blades into raw material that can be reused to make new wind turbine blades or to be used for other purposes. Vestas plans to scale up the newly discovered chemical disassembly process into a commercial solution in partnership with other companies. If successful, this will eliminate the need for blade redesign, or landfill disposal of epoxy-based blades when they are decommissioned.

Land and ecosystem restoration

As discussed above, there are significant risks associated with wind power development with regard to potential environmental harm and degradation, e.g., unnecessary or excessive deforestation when constructing new access roads and transmission lines, destruction of habitats and loss of biodiversity and ecosystem services as well as soil erosion and pollution. This will particularly arise where mitigation measures proposed by a SEA (and subsequent project-level EIAs) are inadequate, ineffective or not undertaken. The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. Such cumulative impacts will be highly likely to occur where there are multiple wind farm developments across landscapes.

Such impacts will usually lead to demand for and need for land and ecosystem restoration (see Box 3.9). This need will also arise at sites of projects that have come to the end of their useful operational life – usually after 20-30 years[25]. After this time, the project owner will either decommission the site, restoring the area to its previous land use, or negotiate with landowners to repower or upgrade the equipment and extend the wind farm's operational lifespan.

Scottish Natural Heritage has developed guidance for the preparation of decommissioning and restoration plans (DRP) for on-shore wind farms[26]. The guidance is focussed on the process of producing a DRP and does not provide detailed advice on methods as each site will have different environmental conditions, as well as different turbine, track and other infrastructure specifications. It is focussed on natural heritage issues and does not provide guidance on matters such as health and safety or the reuse of materials.

Given that exisiting most wind power projects were installed to supplant power generation from conventional fossil fuel sources and that they were likely to have been installed at the optimal location to maximize wind flow, it is likely that most wind projects will continue in the future with upgrades to equipment rather than decommissioning and restoration.

6.4.3 Key socio-economic issues and impacts for onshore wind power

24 [Newly Discovered Chemical Process Renders All Existing Wind Turbine Blades Recyclable - World-Energy]

[25] The average lifespan of wind turbine generators is about 20 years.

[26] Scottish Natural Heritage (2016)

Employment and labour conditions

Wind farm development projects can create job opportunities for skilled and unskilled workers in the host communities and from other places. In 2020, 1.25 million jobs were recorded in the wind industry. It is estimated that, globally, up to 7 million jobs will be generated by wind by early 2030[27] (Figure 6.5).

Figure 6.5: Global wind power jobs are in the millions and projected to increase

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

In Asia, the employment numbers are particularly high: 550,000 in the PRC and 40,000 in India. A British wind industry report[28] suggests that approximately 15%–20% of the project cost of a wind energy development is for labour, which requires skills[29] typically available from local contractors. Wind farm projects tend to create a relatively small number of employment opportunities for local workers (compared to other renewable energy technologies) during the construction phase, which is often not long (depending on size, between six and 20 months). More jobs can be created depending on the transmission line, substation, and access road requirements. The rest of the labour cost is for more complex and specialist tasks[30].

The operation and maintenance of wind farms usually requires a very small number of staff and relies on specialist skills. Some companies use drones for wind farm inspections, reducing employment opportunities[31]. Depending on their location, some wind projects will have a large regiment of security staff (normally local) to patrol large areas.

Statistics provided by IRENA[32] do not include employment opportunities in the manufacturing and supply chains of wind turbine generators and blades. As demand for wind turbines increases, there will be more investment in extraction of the metals and minerals required to manufacture wind turbines, and thus more job opportunities created along the turbine supply chain line.

All projects have potential to involve unfair treatment and/or remuneration, discrimination in labour decisions, inappropriate recruitment, and poor working conditions[33]. There can also be unsatisfactory employment arrangements, especially for projects that involve complex supply chains of materials, and various contracting tiers[34]. However, many wind projects are well-managed and mitigate such risks. The main infringement of labour rights during construction are related to requirements for excessive overtime and successive days of work without sufficient rest (see discussion of employment and labour conditions in Chapter 6). In addition, some smaller wind projects may use casual workers

[27] IRENA (2021a)
[28] CSE (2009)
[29] These include supplying and pouring concrete, laying cables and basic civil engineering tasks (such as tracks and hard-standing, foundations, trench digging for cables, basic construction for substation housing)
[30] Engineering consultancy, specialist craning, cables and sub-station equipment, and, most significantly, the manufacture and assembly of the wind turbines themselves
[31] Renewable Energy World (2017)
[32] IRENA (2021a)
[33] Rutherford, N. (2021)
[34] Actionaid (2018)

who do not have sufficient training on the environmental and social management system to meet GIIP. The sub-section on human rights discusses issues concerning the infringement of workers' rights in the supply chains of wind turbines.

Local economy and livelihoods

As with many development activities in rural areas, onshore wind projects often pose a range of risks associated with acquiring land for wind turbine generators, access roads, substations, and transmission lines. Additional land may also be required for associated facilities such as offices and storage sheds, although these are generally not large. During construction, there can be temporary land use needs for workers' accommodation, stockpiles, and laydown areas.

Land acquisition and restrictions on land use can cause both physical and economic displacement. There can be building restrictions (like transmission lines) for land closest to the wind turbine generators. Wind farms (whether linear or disparate) generally require a low amount of land-take. They can easily coexist with a range of land uses, e.g., agriculture and pastoralism[35]. Wind turbine generators typically have small footprints, so physical displacement (relocation) can often be avoided or minimized. In countries in Southeast Asia, wind farms do not appear so far to have caused controversy over land acquisition, nor to have had impacts on livelihoods. In other countries where wind farms have been developed on grazing land (e.g., Uruguay, Mexico, Kenya, and Mongolia), there has been minimal economic displacement or adverse impacts on affected people's livelihoods.

Wind farm companies frequently use leasing arrangements, entering negotiated voluntary land agreements. When a landowner is not interested, the company then modifies the micro-siting arrangements to work with others amenable to an agreement. Leasing agreements (usually for 20 to 50 years) allow companies to pay for smaller footprints (usually in acres) of wider land packages. Payments can combine installation fees for each wind turbine, including access rights plus annual payments.

Challenges can arise when a landowner makes an agreement with the wind company, but renters or neighbours are residing close enough to be affected by the noise or shadow flicker effects.
It is important that companies obtain valid land valuations. Wind projects in Central and South America have faced protests over land under communal use, including by indigenous communities, when it has emerged that the projects have negotiated leases at rates that are below actual land value. In Mexico, where landowners and users cede their property permanently or temporarily for energy projects[36], some community members have protested about previously agreed land access by erecting barriers to acquired plots during construction, causing project companies to renegotiate the land rates. The proposed scale of massive wind developments can also be problematic.

Wind farm construction generally requires a small workforce—using local workers plus some non-local workers with specialist skills for short periods of time. In most instances, the non-local workers will rent accommodation. In locations where availability of such housing is limited, rental prices can increase temporarily and a short boost to a localized economy may occur.

Benefit-sharing (including the payment of royalties) tends to be more typical for hydropower projects rather than wind. But the Windplan Groen project in Flevoland province in the Netherlands is an example where local communities are allowed to invest in the project[37].

The conditions for the construction of the wind turbines of Windplan Groen state that local residents may participate in 2.5% of the total investment. The initiators do not borrow that amount from the banks but from residents who receive an interest payment for it. With a total estimated investment of 500 million euros, the neighbourhood can therefore participate for approximately 12.5 million euros.

[35] The Dam Nai Wind Project - Vietnam (operated by the Blue Circle energy company) provides an example of combining rice cultivation and wind energy generation.
[36] Payan and Correa-Cabrera (2014)
[37] www.windplangroen.nl

Health and safety

The IFC's environmental health and safety guidelines[38] recognize that wind turbine projects can pose health and safety risks for both the local workforce and the local community.

Local workforce

Occupational health and safety hazards during the construction, operation, and decommissioning of onshore and offshore wind energy facilities are generally like those of most large industrial facilities and infrastructure projects. During construction and operation, these may include physical hazards such as working at heights and falling objects, working in confined spaces, working with rotating machinery, remote locations, electrocution or burn risk and lifting operations.

Local community

The main community health and safety impacts are blade and ice throw, aviation, electromagnetic interference and radiation, public access and abnormal (large or oversized) load transportation[39].

Blade throw is likely to occur very infrequently, often during storms or due to malfunction. Ice throw can occur in colder climates when moisture freezes to the blade surface but dislodges during operation.

An emerging safety risk is the failure and collapse of wind turbine systems. Reasons for this are being investigated and may relate to production issues or the increasing size of blades and towers.

If wind turbines need to be located near airports, military low-flying areas or known flight paths, a wind energy facility (including anemometer mast) may impact aircraft safety directly through potential collision, or indirectly by requiring alteration of flight paths. Correct site selection minimizes these risks.

Wind turbines can also cause electromagnetic interference with telecommunication systems (e.g., microwave, television, and radio). This interference could be caused by path obstruction, shadowing, reflection, scattering or re-radiation. Further information on telecommunications and aviation is provided in the ensuing paragraphs on aviation and telecommunications in this chapter.

Safety issues may arise with public access to wind turbines (e.g., unauthorized climbing of the turbine) or to the wind energy facility substation. Adequate fencing and signage minimize this risk.

One of the main challenges with respect to wind energy facilities lies with the transportation of oversized or heavy wind turbine components (blades, turbine tower sections, nacelle, and transformers) and cranes to the site. Transportation of these oversized loads pose safety risks to the community if not planned, managed, and escorted properly.

Gender and vulnerability

Areas with the highest wind power potential are remote deserts, plains, and mountain tops - often places with lower-income rural populations, marginalized groups, and indigenous people This can lead to displacement (see previous subsection) and can impact women and vulnerable groups[40].

There is considerably less physical and economic displacement associated with onshore wind projects than with other types of renewable power generation such as hydropower facilities or solar farms. There are plentiful opportunities for employment during the construction phase of onshore wind projects. It is calculated that there are 1.2 million jobs in the onshore wind power sub-sector globally, 56% of which are in the Asia region. However, only 21% of all global jobs in the sub-sector are held by

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[38] IFC (2015)
[39] IFC (2015)
[40] Differential impacts of displacement and access to any resulting benefits are explored in greater detail in the Hydropower: Gender and Vulnerability subsection in this report.

women. Existing negative perceptions of gender roles and cultural social norms are seen as major barriers to gender equality in the sub-sector[41].

Box 6.3 provides an example of a programme that aims to promote more gender-inclusive planning processes, sub-sector employment, training, and skills development within the wind energy sub-sector.

Box 6.3: Women in Wind Global Leadership Programme

The Women in Wind Global Leadership Programme was launched in 2019 by the Global Wind Energy Council (GWEC), in partnership with the Global Women's Network for the Energy Transition (GWNET). It is designed to accelerate women’s careers, support their pathway to leadership positions, and foster a global network of mentorship, knowledge-sharing, and empowerment.

Source: Global Wind Energy Council (https://gwec.net/women-in-wind/about-the-program/)

Indigenous communities

In areas where indigenous people are located, the development of wind farm projects needs to consider the potential impacts on communal land and traditional practices. Most wind farms are not fenced, and, because of their small footprints, there is usually minimal loss of access to natural and cultural resources such as sacred forests, burial grounds, and animistic sites. However, there are some high-profile cases where groups have protested about not being properly consulted and about their free prior and informed consent to wind farm projects not being sought. In Norway, the indigenous Sami people have been struggling to preserve their culture and identity as well as their main source of livelihood, reindeer husbandry, and claimed that a wind farm disturbed their reindeer husbandry[42]. In La Guajira, Colombia, indigenous Wayúu people protested wind farm companies which “grabbed” their sacred land, affecting their cultural identity and practices[43].

Members of local indigenous communities can benefit from some employment opportunities in wind farm projects, either during construction or operations. Skill development and industry participation programs for the local and indigenous communities may be provided by wind energy companies, mainly during construction since, during operation, wind farms generally have very low permanent workforces.

Cultural heritage

Wind farms and associated infrastructure such as transmission lines and access roads can cause damage to cultural, religious, historical, and archaeological sites (both tangible and intangible heritage) —mainly during construction. However, there are substantial opportunities to design and microsite the turbines to avoid adverse impacts on cultural heritage. The process of seeking free, prior, and informed consent and Broad Community Support (for ADB SPS) can help to identify such sites and avoid adverse impacts on them.

Telecommunications and aviation

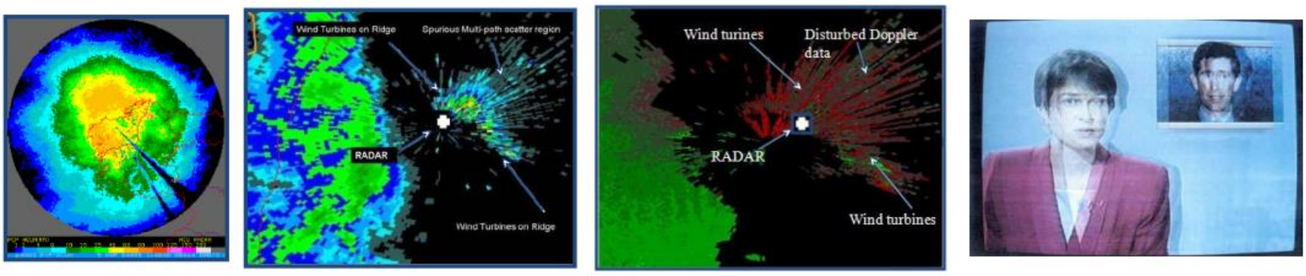
[41] IRENA (2020)
[42] aNews (2021)
[43] National Wind Watch (2021)

Wind farms can interfere with electromagnetics, radar signals and telecommunications systems, including local mobile phone coverage and quality. The operation of wind farms may also disrupt aviation radar through signal distortion – with associated safety risks. The degree and nature of the interference will depend on[44]:

- The location of the wind turbine between receiver and transmitter;
- Characteristics of the rotor blades;
- Signal frequency:
- Air traffic control radar;
- Air navigation systems, and
- The radio wave propagation in the local atmosphere.

Wind turbines are much larger signal reflectors than those actually targeted by radar systems. Their presence may hide weaker response signals from smaller targets. The rotating blades generate a Doppler shift which is also detected by radar systems. Radar systems are not designed to identify and filter out signals from wind turbines - so important information from the surroundings of a wind farm may be lost, as demonstrated in
Figure **6.6**. This can be due to the proximity of wind farms and telecommunication antennae (**Error! Reference source not found.**).

Figure 6.6: Examples of the effects of wind turbines on weather radar, air traffic control, radio, and television.
Source: Angulo et al. (2014)



[44] Wind Energy. Electromagnetic interferences (wind-energy-the-facts.org).

Figure 6.7: Wind farm and Telecommunication Antenna Installed Near Each Other

Source: https://www.ewea.org/annual2014/conference/programme/info2.php?id2=1091&id=52%20&ordre=1)

Wind turbine blade tips can be up to 200 meters tall and, in the future, may exceed this height as the technology evolves. So, if located near airports, military low-flying areas or known flight paths, a wind energy facility could create a risk of collision or require the alteration of flight paths[45]. Such impacts can be avoided and addressed through design, siting, and mitigation measures such as marking systems and signal boosting equipment.

Public services and infrastructure

Communities near wind farms can be affected by the transfer of oversized and abnormal loads carrying large and heavy wind turbine parts (blades, turbine tower sections, nacelles, and transformers) (

Box 6.4: Community development activities funded by the Lake Turkana

For the Lake Turkana Wind Power project (one of the largest wind farms in Africa), the Winds of Change (WOC) Foundation was established to disburse €10 million over the 20-year operational life. The WOC programme undertakes sustainable community development activities in the project catchment area focusing on education, health, and water.

Source: WINDS OF CHANGE – Lake Turkana Wind Power (ltwp.co.ke)

[45] FINAL_Aug+2015_Wind+Energy_EHS+Guideline.pdf (ifc.org)

Figure 6.8:). While this will be once and one way during construction, such transportation can damage existing roads. Permits from transportation authorities and often police or other escorts can be needed. In some instances, road upgrades may also be needed.

Local infrastructure and facilities can be improved by the onshore wind companies' corporate responsibility investment programs. Wind farms developers sometimes establish community investment programs commensurate with their size (**Error! Reference source not found.**6.5. These corporate responsibility activities will generally be small contributions to existing activities run by other organizations.

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Source: WINDS OF CHANGE – Lake Turkana Wind Power (ltwp.co.ke)

Figure 6.8: Land-based wind turbine blade transportation

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Human rights

There are significant human rights risks in the supply chains through which raw materials needed for wind farm equipment are sourced. The manufacture of onshore wind turbine components requires rare earth and other minerals. The process of extracting mineral resources and supplying such resources for wind turbine manufacturing can infringe the rights of both indigenous and non-indigenous communities (and there are examples where it has), including but not limited to rights to land, land ownership, natural resources, customary land uses, and adequate living standards.

6.5 OFFSHORE WIND POWER GENERATION

6.5.1 Offshore installation types

Offshore wind has been in commercial operation in parts of Europe since the early 1990s. In 2021, globally, there was 57 GW of installed offshore wind power capacity.

Offshore wind farms can be located tens of kilometres from the coastline. Construction generally involves foundation structures (e.g., piles or caissons) being installed into the seabed on which fixed wind turbines are mounted. Floating wind farms are also an option in some locations and can offer potential where there were previous technological constraints to deploying fixed wind power structures.

Large, specialized working vessels are used to undertake the foundation works and for the erection of wind turbines as well as to transport project components to offshore sites. Offshore turbines can also be built taller than those onshore, as there is opportunity to capture energy from higher and more constant winds. An intriguing opportunity is to look at converting abandoned offshore oil platforms to house offshore electrolysers for the purpose of generating green hydrogen from electricity produced from offshore wind farms.

Figure 6.9 shows the locations of mines for these materials (including from Southeast Asia). Some of the locations, including in low and middle-income countries, include places where there are conflicts or where human rights are not well-regulated or enforced.

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[46] GWEC (2022)

[47] https://www.rechargenews.com/energy-transition/worlds-first-offshore-green-hydrogen-project-on-an-oil-platform-gets-go-ahead/2-1-1043998

Figure 6.9: Producers of minerals and metals used in wind turbines

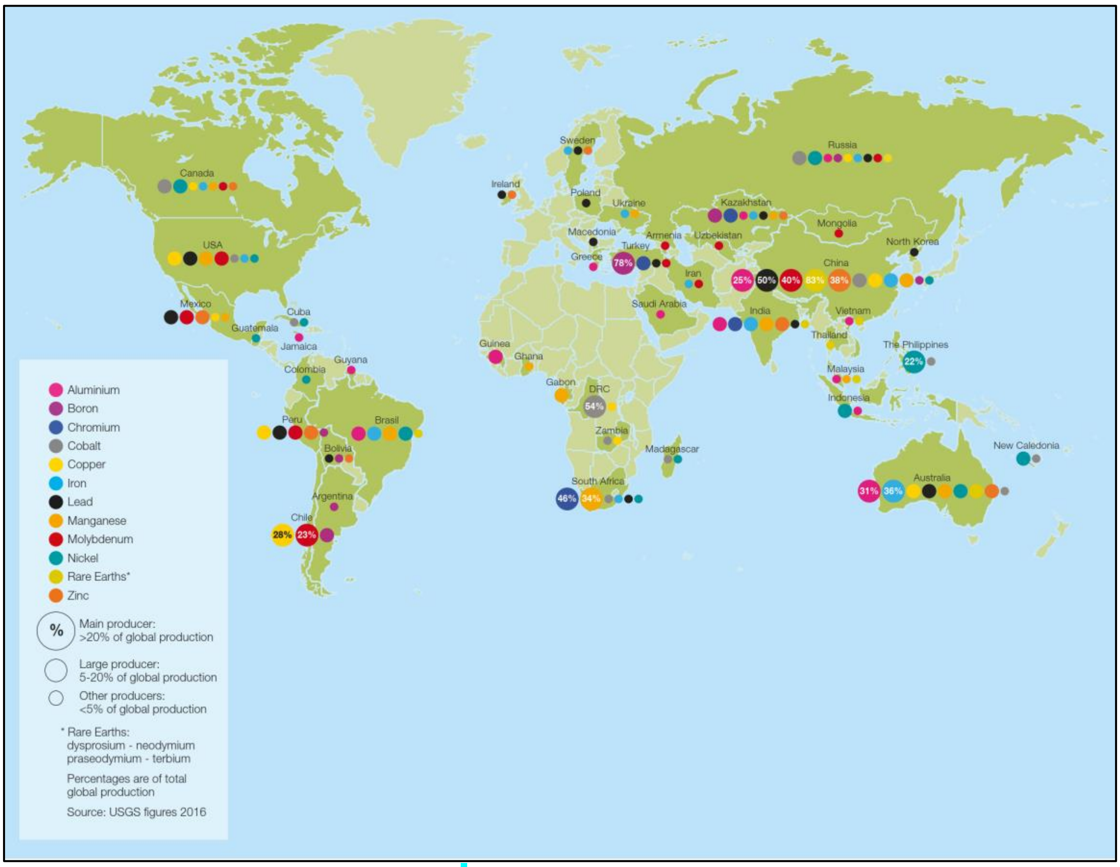

Photo credit: Action Aid (2018) and SOMO [

Each offshore wind turbine is connected via submarine inter-array cables to export the electricity generated back to land (i.e., via a submarine export cable) where it is fed into the electricity grid.

Depending on the distance offshore of the wind farm, an offshore substation might also be required in addition to the onshore transmission components such as substations and terrestrial transmission lines (**Error! Reference source not found.**).

Offshore wind farms have a high energy output per square meter (m^2) and can be built up quickly at gigawatt-scale, so they are a valuable option to provide electricity to densely populated coastal areas in a cost-effective manner. Developments in turbine technologies as well as in foundations, installation, access, operation, and system integration have made possible the move into deeper waters and farther from shore, and thus to exploit sites with greater energy potential. Over the last 5–10 years, offshore wind has reached maturity, making it the most advanced technology among offshore renewables[48].

[48] IRENA (2021b)

Figure 6.10: Offshore wind farm key components

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

The largest windfarm in the world is being developed at Dogger Bank off the coast of England (Box 6.5).

Box 6.5: Dogger Bank windfarm, England, UK

Dogger Bank Wind Farm offshore wind farm is being developed in three phases – Dogger Bank A, B and C – located between 130km and 190km from the North East coast of England at their nearest points. Collectively they will become the world's largest offshore wind farm. Each phase will have an installed generation capacity of 1.2GW. Combined, they will have an installed capacity of 3.6GW and will be capable of powering up to 6 million homes annually.

The investment in the Dogger Bank C wind farm is estimated to be £3bn ($3.99bn). Figure 6.11 shows a Voltaire jack-up installation vessel with a lifting capacity of more than 3,000t to deliver the turbines and install on foundations. The project will occupy an area of approximately 560km² and is expected to generate approximately 6TWh of clean and renewable electricity to be fed into the UK's national power grid. First power is expected in the third quarter (Q3) of 2025, while the wind farm will become fully operational in Q1 2026. Dogger Bank C will have an estimated operational life of approximately 35 years[49].

Figure 6.11: Dogger Bank C windfarm

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

6.5.2 Key environmental Issues and impacts for offshore wind power

Table 6.3 summarises the key environmental and socio-concerns concerns likely to be associated with offshore wind power development. While some potential environmental impacts (direct and indirect) of offshore wind farms during construction and operation are the same as for onshore projects, others are unique to the marine environment.

[49] Dogger Bank C Offshore Wind Farm, North Sea, UK (power-technology.com)

Table 6.3: List of Key Environmental and socioeconomic issues for offshore wind power

ISSUE	CONCERN
Environmental	
Protected areas	• Impact (incursion) on marine protected areas (MPAs)
Habitats and biodiversity	• Changes to benthic and pelagic habitats, e.g., as result of changes in water quality due to sedimentation from construction activities • Impacts on flora and fauna, e.g., bird strikes on spinning turbines for migrating and local birds (including internationally listed species) (offshore wind speeds tend to be faster and steadier than on land) • Changed food webs • Birds displaced from offshore foraging or roost sites • Offshore structures may disturb existing habitats and attract new habitat-forming species, such as shellfish, corals, and underwater vegetation. • Biodiversity impacts may also result from associated infrastructure (including underwater cables) and boat-based maintenance traffic (e.g., collisions with marine mammals). • Marine mammals and other marine fauna may be killed by construction or supply vessels • Direct loss of habitat resulting from clearing for onshore component and fragmentation of habitat from access roads and transmission lines
Noise and vibrations	• Noise and vibration from construction (on seabed) can disrupt biodiversity. Unless adequately mitigated and monitored, underwater noise generated during offshore piling could cause temporary or permanent adverse impacts to the hearing and behaviours of cetaceans (whales, dolphins, and porpoises) and pinnipeds (fin- or flipper-footed mammals) • Operational noise from offshore wind turbines can disrupt behaviours, physiology of animals and fish and cause physical damage (mortality to damage of hearing tissues and other organs) • Anthropogenic noise can mask detection of biologically important signals used for communication, predator avoidance, and prey detection, and can influence behaviours • Aquatic animals may move out of a noise area, potentially disrupting foraging, or breeding • Sound (pressure) can travel a long distance in the sea and ocean • Noise from construction traffic and use of machinery during construction of onshore component
Air quality	• Onshore dust following soil disturbance and from vehicle traffic to coastal access point site and for onshore component
Water quality	• Installation of foundations and sub-surface cables could disturb the marine floor, increase suspended sediments, and decrease water quality, which could affect marine species and commercial or recreational fisheries. • Dredging (e.g., possibly to extensive amount) could be required depending on the offshore wind turbine generator area's bathymetry, foundation type, and working vessel depth requirements. The disturbance and suspension of seabed sediment could have adverse impacts to water quality • Releasing pollutants (fuels, oils, chemicals, etc.) during construction, operation or decommissioning

ISSUE	CONCERN
	• From increased vessel traffic (to generation sites) • Release of contaminants from seabed sediments
Greenhouse gases	• Wind power can reduce GHG emissions where it displaces coal as a fuel source
Waste	• Construction and operation waste as well as waste metals and hazardous materials during decommissioning • Wind turbine generator blades are made from unrecyclable composite materials and present a problem for disposal in most countries. However, new technology for recycling is emerging
Seabed erosion	• Installation of offshore structures may result in localized seabed erosion due to changes in water movements
Mineral extraction	• Overextraction of metals and minerals used for wind turbine manufacturing
Visual and aesthetic impacts	• Turbines, pylons, and transmission lines change the landscape and disrupt the aesthetic value to the local communities • May detract appeal of area for recreation/tourism
Marine and ecosystem restoration	• Offshore wind farms have a 20-30 year lifespan, after which restoration will be required, unless agreement is reached to repower or upgrade the equipment and extend the wind farm's operational lifespan.
Socioeconomic	
Human rights	• Mineral mining companies (which supply wind turbine manufacturing companies) are known to violate the rights of communities (e.g., rights to land, livelihood, ability to undertake traditional cultural practices) • Mineral mining companies are known to employ forced and child labour
Employment and labour conditions	• Employment opportunities for construction and operational phases • Job opportunities generated by new investment in mineral extraction
Health and safety	• Hazards to beach users during transportation and construction of the wind turbines or from landfall of electrical transmission cables • Road closures or disruptions when transporting wind turbine components to site • Noise of the wind turbine and blade may disturb communities • Worker safety (e.g., working at heights, electrocution and fire risk)
Local economy and livelihoods	• Loss of income from marine fishing • Temporary and long-term loss of access to fishing areas and interference with offshore fishery rights (commonly held by communities or fishery associations) • Local communities can gain through benefit-sharing schemes
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and indigenous communities) may be disadvantaged and at particular risk • Employment opportunities on new projects • Opportunities for vulnerable groups to acquire new skills and learn new technologies
Recreation and tourism	• Interrupted and restricted access to public beaches and swimming areas due to the transportation of wind turbine components and construction of undersea cables

ISSUE	CONCERN
Marine navigation	• Interference with vessel traffic and safety, particularly when located near ports, harbors, or known shipping lanes • Interference with radar used for shipping navigation
Telecommunications and aviation	• Electromagnetic interference to telecommunications systems • Potential to affect aircraft safety with direct collision or alteration to flight paths • Some disruptions to aviation radar may be caused by turbines (e.g., signal distortion)
Public services and infrastructure	• Wind farm companies may fund improved local infrastructure • Onshore bases will be required to support offshore wind development which could lead to loss of habitat and construction and operational impacts • Pressure on local infrastructure due to heavy transportation of wind turbine equipment • Increased pressure on public services, including health centers • Increased local government tax revenues generated from wind farms
Migration	• Tension between immigrants and workers • Gender-based violence due to an influx of predominantly male construction workers • Pressure on preexisting health services and infrastructure • Onshore worker camps and accommodation cause social disruption

Habitats and biodiversity

Some potential risks to habitat and biodiversity have been identified, including those documented by the IFC[50]. These include:

- Underwater noise impacts during construction (i.e., during piling, dredging, vessel movements) and operations. This can affect the hearing, echolocation and behaviour of fish, birds, cetaceans (whales, porpoises, dolphins) and pinnipeds (e.g., seals and walruses).

- Seabed (benthic) disturbance and new structures may also impact existing habitats and attract new habitat-forming species, such as shellfish, corals, and underwater vegetation[51] to colonize the disturbed areas.

- Water quality impacts due to sediment transport of cable laying and dredging activities as well as foundation works. This has potential to increase turbidity and that affects coral or seagrass ecosystems by reducing available light.

- Potential construction and operation impacts of hydrogen pipelines from offshore electrolyser production platforms to shore may impact marine biodiversity on the sea floor.

- Working vessels colliding with cetaceans and pinnipeds during construction. This is usually addressed through raising the awareness of vessel crews about the risks and implementing a well thought out marine traffic management plan (e.g., with speed limits, using routes that avoid key habitat areas).

- Permanent habitat loss due to disturbance and barrier effects on bird species when they adjust their behaviour to avoid offshore wind farms. In turn, this may limit or alter the way in which they utilize habitats, disrupt migratory paths or their movement between roosting and feeding sites.

- Noise. Mitigation measures to minimize the effects of noise during construction are well documented.[52]

- Potential behavioural and distributional changes to wildlife resulting from construction.

Other risks include:

- Where offshore wind farms have lights, these can attract birds at night;
- Where offshore wind farms are located near seabird colonies or between their colonies and foraging grounds. Collisions are potentially more likely under adverse weather conditions at sea with poor visibility[53] [54]

Bird collisions with turbine blades (migratory and pelagic (open sea) birds and bats is one of the most common impacts of offshore wind farms, particularly as they typically have a project life of 20–30 years. As a result, even a small increase in mortality during each migratory season can result in a greater impact over time. On average, offshore wind farms have a higher risk of bird collisions than those onshore due to several factors (listed below), except where the latter are located on migratory flyways and at sites with large, less manoeuvrable species, such as those that habitually soar in thermals[55]:

[50] IFC (2015)
[51] Köller *et al*.,(2006)
[52] e.g., Scottish Natural Heritage (2019) ; German Federal Agency for Nature Conservation (2013)
[53] Hüppop *et al*. (2006)
[54] Note: it is difficult to detect collisions at sea and difficult to monitor potential collisions, especially in stormy weather (Bennun *et al.* 2021; Pellow 2017, 2019)

[55] Exo *et al*. (2003)

- Offshore wind turbines are considerably taller with longer rotor blades resulting in higher tip-speeds and turbulence;

- The hearing of birds can be hampered by background noise from waves and winds in an offshore environment;

- Seabirds and waterfowl (and many terrestrial bird species) tend to fly low above the water surface (mostly <100m), especially during foraging and short sea crossings, coinciding with the blade sweep area of offshore turbines.

There are similar risks for bats during migration and during offshore foraging of insects at sea, although these are often limited to specific regions and collisions are generally less prevalent than for migratory birds.

Offshore wind farms may be located close to coastal habitats that host congregatory and migratory bird or bat species. For example, river estuaries, wetlands or islands. They can also be located near or within important regional or global flyways—flight paths used by large numbers of birds on a regular seasonal basis during their migration between their breeding grounds and overwintering quarters.

Wind farms located offshore require less land-take than onshore projects and therefore have less land-use change consequences and associated environmental impacts.

A beneficial aspect of an offshore wind farm is that its structures can provide substrates for the growth of new artificial reefs and habitat for marine life once colonized and established.

Protected areas

Offshore wind farms and their associated infrastructure can have negative impacts on protected areas at sea, either directly by being located within a protected area or indirectly by having an impact on the environment near a protected area.

The material impacts on protected areas are generally less than those caused by onshore wind turbines. The onshore components associated with an offshore wind farm typically include a cable landing point (on the coastal shore), terrestrial cables and, if required, an onshore substation. If these onshore components are accessible by existing roads or cannot connect to existing transmission lines, new access roads and transmission lines may need to be constructed. The onshore footprint of offshore turbines is typically much smaller than that of most other power generation technologies. But there is still a potential risk (albeit of less likelihood/magnitude) of negative impacts on terrestrial protected areas if any of these components are within or close to such areas.

The density of offshore wind turbines, and their potential effects on protected areas can vary. Assumptions made in available literature about or state-of-art and prospective capacity densities for European wind farms are in the range 5.0 – 5.4 MW/km [56] . Hence, even a modestly sized 100 MW offshore wind farm could require 20km^2 of offshore area. Such a significant area could potentially encroach on marine protected areas if offshore wind farms are developed at scale around the globe. The likelihood and significance of such encroachment could be greater where fixed bottom offshore wind farms (requiring shallow water depth) are developed near coastlines or islands where there are protected marine areas.

Noise

During construction, noise can arise due to:

- Foundation works, particularly if piling methods (monopiles or jacket foundations) are used;

[56] Interreg. 2018. BalticLINes_CapacityDensityStudy_June2018-1.pdf (vasab.org).

- Dredging and backfilling activities for cable laying or preparing foundation works, and
- Offshore project activities such as vessel movements and equipment operations.

Piling causes a significant amount of noise and vibration, which can cause temporary or permanent hearing impairment in marine species, including fish, cetaceans and/or pinnipeds. Guidance developed by the United States National Marine Fisheries Services[57] provides underwater noise thresholds for peak sound pressure levels and weighted cumulative sound exposure levels. It discusses temporary threshold shifts (TTS), permanent threshold shifts (PTS) and onset thresholds for different groups of cetaceans (e.g., low-frequency, mid-frequency and high-frequency cetaceans).

Breaching such thresholds can be a particular issue if piling occurs near or at known habitats of marine animals, but particularly for cetaceans and pinnipeds species. Unmitigated underwater noise from piling can travel long distances at levels above the TTS or even PTS threshold. This risk is increasingly significant when greater hammer strength is used to install the ever-increasing large foundations for newer and bigger wind turbine generator models[58]. The impacts can be further exacerbated if piling is undertaken during a migration or breeding period, or in locations inhabited by protected species.

Dredging works and vessel movement also generate noise at levels and frequencies that depend on their nature, size, and speed. While noise from these sources is expected to have less impact than piling activities, it tends to be continuous, and the impact may be significant if they occur simultaneously.

The noise and vibration caused offshore wind turbines can have ongoing impacts on marine biodiversity. There is a risk that the behaviour and physiology of animals and fish will be impacted. The abilities of many marine species to use sound and vibrations to communicate, avoid predators and detect prey may be impaired.

Air quality

Offshore (and onshore) wind farms generally have minimal impacts on air quality as they do not produce significant emissions of pollutants during their operation. Air quality impacts are limited to the construction phase where there is a risk of dust from shore-based vehicular transport. With the limited scope of onshore components of an offshore wind farm, these air quality impacts are typically unlikely to be significant (except where new access roads and transmission lines are required).

Vehicular emissions from both onshore and offshore construction vessels and equipment have the potential to affect local air quality temporarily during construction.

Water quality

Offshore wind farms have the potential to affect marine water quality due to:

- Disturbance of the seabed for the installation of foundations and laying of sub-surface cables;
- Dredging works (including offsite dumping of dredged materials) to prepare an offshore area for foundations and vessel movements;
- Suspension of seabed sediment due to certain foundation construction methods, such as suction caisson (an inverted bucket that is embedded in the marine sediment).

These activities can all cause the temporary suspension of seabed sediment resulting in the development of a sediment plume. Due to ocean currents and flows, these sediments can become suspended, transported, and deposited to distant areas, and cause impacts such as:

[57] NOAA (2018)
[58] Bellman *et al*. (2020)

- Degradation of localized marine water quality due to an increase in total suspended solids (TSS) and decreased dissolved oxygen;
- Deposition of sediment and changes to available light for sensitive ecological receptors and areas such as corals, seagrass and coastal habitats (e.g., wetlands).

Such impacts can have both direct and indirect consequences for marine life and ecosystems.

The release of pollutants such as fuels and oils from vessels involved in construction and maintenance can also have a negative impact on sea water quality.

Waste

As with onshore wind turbines, offshore wind farm developments generate waste during repowering and during decommissioning. This will be particularly true for turbine blades that come out of service, that will need to be transported to shore for landfilling or recycling.

Seabed erosion

The foundations of offshore wind farms can cause seabed scouring[59] due to a local increase in currents and wave motions which can stir up and suspend seabed particles and transport them away from the structure, creating a pit around the structure.

Apart from affecting the geotechnical stability of the foundations of wind turbine generators (in particular, for monopiles), scouring also removes existing marine habitat and prevents new habitat creation.

Visual and aesthetic impacts

Depending on its location, a wind farm can alter the character of the natural seascape and visual setting. It may alter how local communities and visitors appreciate the seascape, especially if it is visible from or located near residential areas or tourism sites. Visual impacts associated with both onshore and offshore wind energy projects typically concern the installed and operational turbines themselves (e.g., colour, height, and the number of turbines)[60].

Key factors that determine perceptions of wind farms depend on the proximity of turbines to the viewer and the viewing angles of wind turbines. Seascape visual impacts are largely associated with the siting and layout of wind turbines and related infrastructures, such as meteorological towers, onshore access, and transmission line access tracks (if required), and substations[61].

Tourism activities may also be negatively affected through restrictions on access to public beaches, swimming areas and coastal recreational areas due to the construction of cable landing points, onshore substations, and transmission lines and easements. Careful design can often be implemented to minimize these effects.

Marine and ecosystem restoration

Currently, there is no single standard for the decommissioning and marine restoration of offshore wind farms. Regulatory standards, guidelines and best practices for offshore wind farm decommissioning are based on existing standards from the maritime conventions and other industries such as oil and gas. Project plans for decommissioning have vague procedures[62]. The unique characteristics of individual sites requires exclusive optimal solutions for each project. The basic components that need

[59] van der Tempel *et al.* (2004)
[60] Wind Energy. Offshore Impacts (wind-energy-the-facts.org)
[61] IFC (2015)
[62] Topham and McMillan (2016)

to be removed consist of: wind turbines, foundations and transition pieces, sub-sea cables (export and inter-array), meteorological masts, offshore substations and onshore elements as well as any existing scour material. It is important to know what will be done with each of these components before the operations start: if they can be re-used or recycled as a first option, or disposed as final option.

The ecological impact of removing offshore structures at the end of life is unknown and is currently not investigated nor predicted in EIAs[63].

The lifetime of an offshore wind farm is expected to be 20–25 years. By 2021, only seven offshore wind farms had been decommissioned and only a few countries have experience of executing decommissioning projects[64].

Marine spatial planning considers how existing windfarm structures can be enhanced to have a conservation benefits, and how new developments could provide opportunities for such enhancement alongside site selection. There is evidence to suggest the presence of windfarms, especially offshore, could in some cases be environmentally beneficial for certain species. e.g. providing structures/surfaces for the development of artificial reefs for marine life and potential habitat species such as oysters and mussels. Thus, leaving offshore wind farm structures in place once such reefs have developed is an issue for consideration.

Post decommissioning, there will be a need for ongoing monitoring and management of the decommissioned offshore wind site.

6.5.3 Key socio-economic Issues and impacts for offshore wind power

Employment and labour conditions

As with onshore wind farms, offshore projects also provide employment opportunities, especially during the construction phase when significant workforces are required. Such opportunities during construction are increasing but are decreasing during operation. A study of offshore wind in Denmark found that, from 2010 to 2022, the permanent labour requirements for offshore wind farms reduced from 19.0 full-time equivalent (FTE) staff per MW installed to 7.5 FTE MW installed[65].

With the increase in construction job opportunities, there is a need for employers to manage the associated occupational health and safety (OHS) risks. These are addressed in the discussion of onshore wind energy employment and labour. There are additional risks when working on offshore wind farms—working over water and transport to offshore locations by helicopter or supply vessel.

Local economy and livelihoods

Offshore wind farms affect fishing and other aquatic-based or reliant livelihoods. The presence of offshore wind farms may limit the income of fisherfolk - either directly by prohibiting access around the equipment, or indirectly by temporarily restricting access to fishing areas (e.g., if fish populations are reduced due to the impacts of a wind farm) (Box **6.6:**6.6). These impacts of offshore wind farms (e.g., creation of artificial reefs, energy landscape impacts) can occur during different project phases (Table 6.4). Offshore wind farms can also have an impact on fisherfolk's costs (e.g., when detours must be made to get fuel).

[63] Hall *et al*. (2020)
[64] Adedipe and Shafiee (2021)
[65] Danish Shipping, Wind Denmark and Danish Energy (2020)

Box 6.6: Effect of offshore wind farms on fish yields and livelihoods

Offshore wind farms can affect fish, ultimately reducing fishing yields. This can have a knock-on effect on fishmongers and other jobs reliant on the fish industry. Reduced catches have direct impacts on food supply and can reduce the income security and well-being of fisherfolk households and have negative indirect economic impacts on the local community[66].

There is also the potential for offshore wind farms to displace fishing effort. This is a major issue that SEA can consider, particularly with regard to the identification and development of leasing zones for fishing and making leases available for offshore wind development.

Table 6.4: Effects of offshore wind turbines on fisheries
Source: Gill et al. (2020)

	Construction	Operation	Decommissioning
Artificial reef effect		X	(X)
Fisheries exclusion effect	X	X	(X)
Fisheries displacement effect	X	X	(X)
Energy landscape effects*	X	X	X

*Energy landscape includes the sensory and physical energy environment
Brackets represent potential effects

Health and safety

- An offshore wind farm can cause negative impacts on community health and safety, particularly when located in an area where there is a high density of shipping movements, fishing vessels and recreational craft use[67].
- Noise and shadow flicker from offshore wind turbines tends to be limited as they are usually installed far from the coastal communities[68].
- Much of the discussion of health and safety issues related to onshore wind farms discussed earlier is applicable to offshore wind farms.

Gender and vulnerability

A recent study found that ethnic minorities and women were underrepresented in the offshore wind farm workforce in the Yorkshire and Humber region of the UK (Box 6.7). A similar situation is likely to be found in other countries where the offshore wind industry is newer.

There are a range of opportunities for local stakeholders (e.g., local governments, community cooperatives, and affected minority groups) to derive benefits from offshore wind projects through skill development and benefit-sharing models[69].

[66] Bergström *et al*. (2014)
[67] Offshore renewable energy installations: impact on shipping - GOV.UK (www.gov.uk)
[68] Offshore Impacts (wind-energy-the-facts.org)
[69] IFC (2019b)

Box 6.7: Jobs in the offshore wind industry in the Yorkshire and Humber Region, United Kingdom

A recent study predicted that the number of jobs available in the Yorkshire and Humber region would increase from 1,500 in 2017 to 9,200 by 2032. At the same time, just 4% of the current workforce is from a Black, Asian, and minority background compared to 8.5% of the available employee pool. Females made up 22% of the workforce in 2017. The prevalence of men employed in the industry makes it important to assess the potential for gender-based violence and risky behaviour resulting from an influx of predominantly male construction workers. The study recommended females and those from Black, Asian, and minority ethnic backgrounds should be encouraged into the industry.

Source: Murphy (2018)

Marine navigation

The presence of offshore wind farms can present difficulties for marine navigation. They can interrupt marine traffic, routes and activities located near ports, harbours, known shipping lanes, mooring locations, and commercial and recreational fishing grounds. If not properly managed, this can lead to marine injuries and casualties including death or loss of property—either at sea or among the onshore population[70]. Wind farm installations can also be at risk of collisions with boats (Box6.8). The disruption of navigation routes can cause economic loss due to the extra time needed for boats and cargo ships to access ports and can also delay supply chains of both non-consumable and consumable goods.

Box 6.8: Cargo ship collides with Hollandse Kust Zuid Wind Farm, The Netherlands

The Hollandse Kust Zuid wind farm consists of two sites, which are located between 18 and 36km off the Dutch coast, between The Hague and Zandvoort.

On 31 January 2022, a cargo ship and an oil tanker collided, resulting in one of them being left rudderless and later striking a platform foundation of the Hollandse Kust Zuid wind farm – two sites under construction off the Dutch coast. All personnel aboard the cargo ship were evacuated by helicopter. Reports of the accident made no mention of staff working on the foundation at the time of the collision and damage was still being assessed.

Source:
www.4coffshore.com/news/vessel-collides-with-hollandse-kust-zuid-foundation-nid24925.htm

Aviation and telecommunications

Offshore wind farms can present safety risks for low-flying aircraft, requiring the rerouting of flight paths. They can also cause signal distortion and interfere with aviation and ship radar as well as cause electromagnetic interference to telecommunications and broadcasting systems (Box6.9).

Public services and infrastructure

As with onshore wind farm projects, offshore wind companies may contribute to improving local public services and infrastructure. The construction, operation and maintenance (O&M) processes for offshore wind farms may require upgrades to public infrastructure such as roads and ports, which can generally be a net positive impact for those locations. Offshore wind farms can also contribute to

[70] Maritime and Coastguard Agency (2012)

increased revenue for local governments through taxes on offshore wind farm projects. Onshore supply bases will also be required to support offshore construction and operation of wind farms.

Box 6.9: United Kingdom's Maritime and Coastguard Agency and offshore wind farms

According to the United Kingdom's (UK) Maritime and Coastguard Agency, mariners and organizations require consistent and effective radio communications systems. If they are within close range of an offshore wind farm, they should be able to rely on marine navigation systems as much as if they were in the open sea. However, these systems may be affected by wind turbines. In the UK, to mitigate these risks, the government requires using temporary safety zones during construction, major maintenance, and decommissioning. The agency's website indicates that permanent safety zones are not expected to be established around entire wind farm groups, though for single installations this may be considered.

Source: *www.gov.uk/government/organisations/maritime-and-coastguard-agency*

Human rights

Typically, as for onshore wind farms, wind turbines (generators, towers, blades, nacelles, gearbox) require metals and minerals that mining companies may extract from countries where human rights are poorly upheld. Wind farm companies need to address this issue through due diligence, examining the activities of their wind turbine and blade suppliers, and imposing requirements on suppliers to eliminate and remedy adverse human rights impacts

Chapter 7

KEY ISSUES FOR SEA IN THE SOLAR POWER SUB-SECTOR

7.1 WHY SEA IS IMPORTANT TO THE SOLAR POWER SUB-SECTOR

SEA can provide critical information to support better decision-making for solar power planning and development, including identifying where there may be implications for PPPs to adequately address significant environmental and/or socio-economic risks and impacts. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of multiple solar power schemes/developments whether alone or in combination with other renewable energy technologies (e.g., wind energy).

The SEA process will:

- Identify and focus on key environmental and socio-economic issues and the concerns of likely affected stakeholders, including local communities, marginalised groups and indigenous peoples. Major issues are discussed in detail in section 7.5 and are summarised in Table 7.2.
- Identify/recommend if there are areas that should be avoided for solar power development ('no go' areas) because of particularly high risk to the environment, habitats/biodiversity and/or people.
- Identify what changes or additions are required to PPPs governing solar power development to address these risks.
- Make subsequent project-level EIAs more efficient and cheaper by addressing the big picture and upstream, downstream and cumulative potential impacts, and identifying the particular issues that individual solar power project EIAs should focus on in more (site-specific) detail. This may also include spatial planning recommendations for optimal siting of solar power projects to minimize these risks and impacts.
- Engage stakeholders (particularly in areas where solar power potential has been identified) including communities, marginalised groups and indigenous peoples which can be particularly affected by solar power developments - to be informed of proposed or possible policy options or plans and enable them to provide their perspectives and present their concerns. This will enable key issues to be identified and verified, help build understanding and support for solar development, and avoid future misunderstanding and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 3 and are therefore not repeated in this chapter.

7.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE SOLAR POWER SUB-SECTOR

An international survey of existing SEA guidelines conducted for the IAIA was unable to identify any guidelines specifically focused on the solar power sub-sector.

The US Department of Energy provides guidance for preparing a solar programmatic environmental impact statement (PEIS) to assess environmental impacts associated with the development and implementation of agency-specific programmes that would facilitate environmentally responsible utility-scale solar energy development in six western states[1].

A number of guidelines and papers address project-level IA for solar power developments and for large-scale solar energy development proposals[2].

[1] Arizona, California, Colorado, New Mexico, Nevada and Utah
[2] e.g. Bennun *et al.* (2021; NSW Government (2017)

7.3 SOLAR POWER INSTALLED CAPACITY

In 2021, the world had in excess of 800GW of installed capacity. By far, China had the most capacity (c. 300 GW), followed by India, Spain, Brazil, Mexico, and Chile (all <50 GW)[3]. Capacity by region is indicated in Table 7.1.

According to the International Energy Agency (IEA), solar is on track to set records for new global deployments each year after 2022, with an average of 125 GW of new capacity expected globally between 2021 and 2025[4].

Table 7.1: Installed solar power capacity by region, 2021
Source: https://ourworldindata.org

Region	Installed capacity (GW)
Africa	10.30
Asia	501.58
Australia	19.02
Europe	184.95
Middle East	7.97
North America	104.88
South & Central America	22.82
Oceania	19.07
World	843.09

The World Bank identifies photovoltaic potential by country, summarised in a global map (Figure 7.1).

7.4 BACKGROUND TO SOLAR POWER GENERATION

Solar photovoltaic (PV) technologies convert sunlight directly into electricity using photovoltaic cells.

Concentrating solar power (CSP) technologies use a mirror configuration to concentrate the sun's light energy onto a receiver and convert it into heat. The heat can then be used to create steam to either drive a turbine to produce electrical power or it can be used directly as a source of power.

Solar PV generation can be installed on rooftops ("*distributed solar*"): integrated into building designs (such as solar parking lots); or installed at utility scale on land (ground-mounted) and as "*floating" solar* (FPV) (with PV panels installed on platforms or membranes) on a body of fresh water or in a marine environment[5].

Floating PV is still considered a niche technology, but it is a growing industry with annual growth expected to be 20% per year until 2024[6]. FPV projects are being pursued in around 60 countries around the world[7], e.g. Da Mi project in Vietnam (see **Error! Reference source not found.**).

[3] https://ourworldindata.org
[4] https://nsenergybusiness.com/features/climate/energy-policy-iea/

[5] IFC (2012d)
[6] IRENA (2021b)
[7] IRENA (2021b).

Figure 7.1: Photovoltaic power potential: a global picture
Source: World Bank (2020)

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Box 7.1: Da Mi floating solar energy project, Viet Nam

The Da Mi Reservoir is Viet Nam's first floating solar farm. The project was connected to the grid in 2019. The project has a total capacity of 47.5 MW peak and power output of about 70 million kilowatt-hours per year. It comprises 143,940 solar panels on 50 hectares of the reservoir in Tanh Linh and Ham Thuan Bac districts of Binh Thuan province, approximately 220 kilometers northeast of Ho Chi Minh City. The project life cycle is expected to be 25 years. In 2018, the Asian Development Bank approved a $17.6 million loan for the project.

Figure 7.2: Da Mi Floating Solar Energy Project, Viet Nam

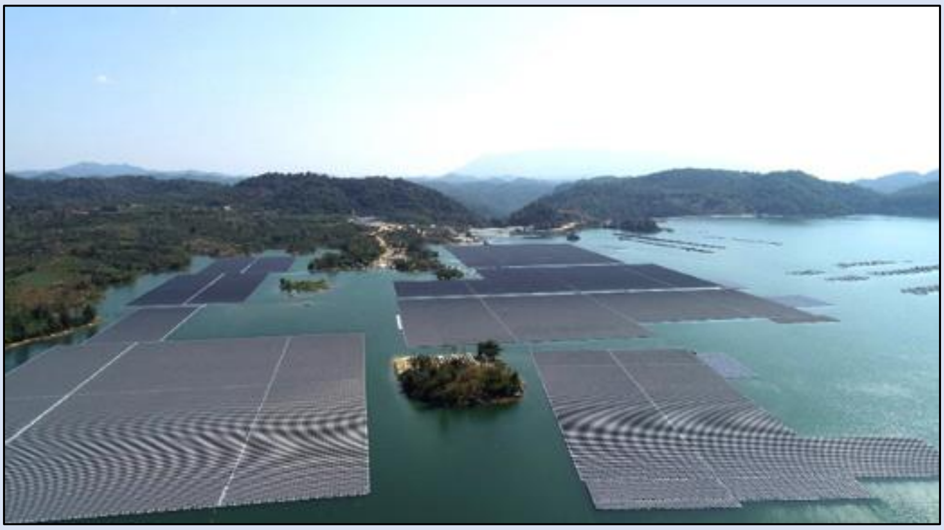

Photo: courtesy of ADB

Source: Asian Development Bank (2018). Proposed Loan and Administration of Loans Da Nhim - Ham Thuan - Da Mi Hydro Power Joint Stock Company Floating Solar Energy Project (Viet Nam). Available at: https://www.adb.org/sites/default/files/project-documents/51327/51327-001-iee-en_9.pdf

Solar generation is typically integrated with thermal or electrical energy storage systems (e.g., batteries, compressed air, green hydrogen or molten salt, which works as a medium to store solar thermal energy) that can provide power during cloudy periods or the hours of darkness. This ability to store solar energy makes solar power a flexible and dispatchable source (one that can be ramped up or shut down in a relatively short amount of time) of renewable energy. Large solar farms require a substation and connection to the electricity grid via a transmission line. Access roads are also often needed.

A solar farm requires much less maintenance during operation than other renewable energy sources, although the panels require periodic repair and cleaning. Solar cells and storage batteries have an operational lifespan of approximately 20–30 years. While panels and batteries can be recycled, the process is complex and costly, and they are often disposed to landfills. A solar farm can create large volumes of waste that are likely to be sent to landfills. The waste produced during the operation and decommissioning of CSP can more easily be recycled as the equipment and infrastructure do not involve complex manufactured parts like photovoltaic cells and storage batteries. However, CSPs do require significant quantities of thermal conducting fluid (e.g., conduction oil), which is likely to be an environmental hazard and more complex regarding its end-of-life use and disposal.

The mining of raw materials is required to produce the solar units, as well as the other equipment and infrastructure associated with a solar farm. This can result in significant environmental and social impacts given the activities and scale employed during the extraction and processing stages. Mineral extraction has direct impacts on sensitive areas if the minerals are located in such areas, e.g., impacts on biodiversity, air quality and land use, noise, overuse of water, waste generation, labour and human rights considerations. In general, a low-carbon future will be very mineral-intensive because clean energy technologies need more materials than fossil-fuel-based electricity generation technologies.

Solar PV power is one of the most mineral-intensive forms of renewable energy. The manufacturing process can involve a number of hazardous materials, including acids and other compounds such as gallium arsenide—a key chemical that can absorb relatively more energy in some solar panels, which is toxic.

Box 7.2 provides examples of other solar energy projects in Southeast Asia.

Box 7.2: Examples of solar energy projects in Southeast Asia

- The 240 megawatt (MW) B.Grimm Dau Tieng Solar Power Project occupying 270 ha of land in the Tay Ninh Province, Viet Nam. It started operation in 2019.
- The 73 MW Central Thailand Solar PV farm that has been in operation since 2012.
- The 60 MW Rooftop Solar PV project undertaken by Green Yellow Energy in Thailand. This project will see 92 Solar PV systems located on the premises of industrial buildings and facilities in Thailand.

Sources:

Asian Development Bank. Thailand: Solar Power Project. https://www.adb.org/projects/43936-014/main Asian Development Bank; Asian Development Bank. Viet Nam: B.Grimm Viet Nam Solar Power Project (Dau Tieng Project). B.Grimm Viet Nam Solar Power Project (Dau Tieng Project): Environment and Social Compliance Audit Report | Asian Development Bank (adb.org);

Asian Development Bank. Viet Nam: Floating Solar Energy Project. Available at: https://www.adb.org/projects/51327-001/main; 43936-014: Solar Power Project (adb.org);

Asian Development Bank, Green Yellow Rooftop Solar Project, Thailand, 2021 available at: Green Yellow Rooftop Solar Project: FAST Report | Asian Development Bank (adb.org).

Figure 7.3: Central Thailand PV: Solar Power Project - Thailand's First Solar Power Facility

Photo credit: Gerhard Joren/ADB

Another form of solar power generation is through solar evaporation ponds (Box 7.3).

Box 7.3: Solar evaporation ponds

A solar evaporation pond is a saltwater pool that can be used to produce and store thermal energy. Such saltwater ponds form a natural vertical "salinity gradient," known as a halocline. In these ponds, the bottom is lined with salts, as much as a few meters deep, which are then heated naturally by the sun. Because the salts are heavier than water, they remain at the bottom of the pond, while the cooler top layer of water acts as an insulator of the heat generated below. As long as the upper layer of water remains clear and free of salt, sunlight can penetrate to the bottom of the pond, Solar rays heat the water at the bottom of the pool, making it less dense than the water above it, and a process known as convection occurs naturally. Solar rays heat the water at the bottom of the pool, making it less dense than the water above it, and a process known as convection occurs naturally.

Salt is added to solar ponds to saturate the lower, warmer water which can reach temperatures up to 900C. Upper layers of low-salinity water, with much lower ambient temperature, do not mix readily with the hot, high-salinity water, which is then pumped out to be used in a turbine to generate electricity or as a source of cost-effective thermal energy. The process is relative simple and has been highly effective in generating electricity in rural areas of developing countries.

Sources:

What is a solar evaporation pond, and how does it differ from a conventional evaporation pond? (btlliners.com)
What Is a Solar Pond? Benefits and Drawbacks (treehugger.com)

Generating electricity from rooftop panels has greater flexibility in size and location than utility scale systems. However, whilst rooftop solar can supplement utility-scale solar, it cannot replace it. Nevertheless, rooftop solar provides greater resilience when considering potential hazards to the distribution system related to climate change, e.g., fires, icing events, or strong wind. Decision makers will need to consider whether utility scale or distributed (on site) systems (roof top solar) are the right choice in particular locations, or what mix of these two is appropriate. The collective benefits associated with distributed systems may outweigh the impacts and risks of utility scale power generation.

Over one third of new solar PV capacity installations worldwide are rooftop attachments. The share of rooftop solar reached a peak in 2018, when 43% of all solar panels deployed that year were fitted on residential and commercial buildings. China and the United States are expected to account for the greatest solar capacity additions in the next few years[8].

7.5 IMPACTS OF SOLAR ENERGY DEVELOPMENT

During scoping for a SEA, key issues regarding solar power development should be identified. They will be used to focus the SEA on the most important issues and to help develop environmental and social quality objectives (ESQOs) – that address these issues - to be used during the main assessment stage. The key issues will be identified by reviewing relevant documents (e.g., EIA and special subject reports, environmental/social profiles, sector and inter-sector strategies, donor documents, academic papers, other solar power development applications, solar irradiation profiles and meteorological data etc.), interviews with key informants and during stakeholder consultations at national to local levels. Many of the issues will be well known as a result of implementing existing solar power development projects.

At the individual project-level these issues will be the focus of an EIA which should recommend how to manage or mitigate project impacts associated with these issues that might be likely to arise. Ideally, before individual solar projects are approved, the implementation of a policy, plan or programme (PPP) for the wind power sub-sector should be completed. This will involve the assessment of multiple projects, schemes and activities: some directly concerned with the construction and operation of sites and facilities; others linked to associated infrastructure (e.g. transmission lines, access roads). Thus, there is a risk that the impacts of individual solar power developments/projects may become highly significant as they become cumulative. A SEA should be focus on the potential for such cumulative impacts and make recommendations for addressing them. This may include recommending thresholds for particular factors that should not be breached by an individual project (and which should be addressed by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it. Often, the timing of individual solar power applications and overarching SEA planning is not synchronized, and SEA may have to “catch-up” to the pace of individual projects rather than providing upstream (pre-project) guidance as to how they should proceed.

Table 7.2 summarises the key environmental and socio-concerns concerns likely to be associated with solar energy development.

[8] Rooftop share in solar PV deployment 2022 | Statista

Table 7.2: List of key environmental and socioeconomic issues for solar power

ISSUE	COMMENT
Environmental	
Air quality	• Soil disturbance and traffic on dirt roads creates dust • Dust generated during construction phase • Release of soil-carried pathogens and an increase in air particulate matter can contaminate water reservoirs
Greenhouse gases	• Solar power can reduce GHG emissions where it displaces coal or other fossil fuels as a fuel source
Noise and vibration	• Noise and vibration caused by construction traffic and use of machinery
Soil erosion	• Construction on vast areas of land can result in soil compaction, alteration of drainage channels and increased erosion
Water use	• Increased water demand: for cooling central towers in concentrating solar thermal plants (CSP) and cleaning of photovoltaic (PV) modules. This can be problematic, particularly in arid areas
Water quality	• Potential river or groundwater contamination through leakage of potentially hazardous chemicals used in thermal conducting fluids, semiconductors, and storage batteries
Land-use change	• Loss of productive land due to large extent of land required for developments (usually 1-2 ha per MW) • Earth movements may be required for site levelling • Displacement or destruction of existing livelihood activities and physical structures
Habitats and biodiversity	• Construction of access roads and transmission lines can result in land clearance and loss and/or fragmentation of habitat and present a collision and electrocution risk for bats and birds • Increased access to remote areas that may increase hunting/poaching and introduction of invasive alien species • Habitat below solar panels may be altered due to shade conditions • Collision and electrocution with associated infrastructure (particularly transmission lines) • Risk of incineration in concentrated solar power beams • Solar plants typically have security perimeter fencing installed, which can cause additional habitat fragmentation, especially for mammals and reptiles e.g., tortoises, and act as a barrier to movement/migration
Wastes (hazardous and non-hazardous)	• Broken or end-of-life solar panels (containing heavy metals) require recycling or disposal to landfill • Storage batteries contain hazardous substances and heavy metals and discharges can occur in the event of damage. Recycling potential for batteries varies across regions of the globe • Small scale spills of oils or other substances during construction, maintenance, and operation • Manufacturing process of PV cell includes several hazardous materials, most of which are used to clean and purify the semiconductor surface
Mineral extraction	• Overextraction of minerals used for solar PV panel and battery manufacturing
Visual and aesthetic impacts	• Solar PV reflection can damage sight and vision of community members • Solar infrastructure disrupt the aesthetic view and landscape of the host community
Land and ecosystem restoration	• Most current solar panels are designed to last for more than 25 years after which land restoration will be required, unless negotiations with landowners result in agreement to repower or upgrade the equipment and extend the solar farm's operational lifespan.

ISSUE	COMMENT
Socioeconomic	
Human rights issues	• Some mineral mining companies (which supply solar PV companies) are known to violate the rights of communities (e.g., rights to land, livelihood, ability to undertake traditional cultural practices) • Mineral mining companies are known to employ forced and child labour • Some solar companies accused of exploiting forced labour in manufacturing of solar panels and equipment
Local economy and livelihood	• Land acquisition may result in relocation of people and their structures • Increased pressure on the host communities' public services • Large amounts of land will be acquired and will displace the livelihood activities of affected communities (e.g., rice cultivation) • Loss of income from fishing activities, rice cultivation, and other farming activities • Loss of income from small business and enterprise activities due to people being displaced • Rural communities will lose access to grazing land (used on either a formal or informal basis) for cattle and livestock • Increase land value and property value within the vicinity of solar farms • Local communities can gain from benefit-sharing scheme with solar PV companies • Local access to low-cost electricity can stimulate the local economy and livelihood opportunities
Employment and labour conditions	• Job opportunities may be provided to the local communities on solar farms (mainly during construction.) • Job opportunities generated from new investment in mineral extraction
Cultural heritage	• Loss of cultural, religious, historical and archaeological sites, and properties (e.g., when land appropriated for solar farms is destroyed or damaged due to transmission lines and access roads) • Limits on access to cultural heritage sites
Health and safety	• Inhalation of silicon dust during PV cell manufacture • High-voltage electricity transmission lines from the solar PV farm can cause safety issues for the communities during construction and operation (e.g., electric shocks from touching live cables) • Solar PV reflection cause glint and glare issues for communities
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and indigenous communities) may be disadvantaged and at particular risk • Employment opportunities within new projects • Opportunities for vulnerable groups to acquire new skills and learn new technologies (i.e., solar PV)
Access to water	• Increased demand on clean water • Limited communities' access to clean underground water (when extracted for cleaning panels)
Migration	• Leads to introduced diseases, inappropriate cultural behavior, etc. • Pressure on preexisting health services and infrastructure, equipment, human resources, essential drugs, etc. due to the project • Tension between immigrants and workers • Gender-based violence due to an influx of predominantly male construction workers
Public services and infrastructure	• Loss of, or relocation of, public services and infrastructure on land acquired for solar farms • Improvement to infrastructure, including roads and bridges, schools, health centers, and administrative buildings due to community investment by solar companies • Pressure on public services and infrastructure will increase as a result of immigration • Heavy vehicles and transportation damage existing roads and bridges • Increased vehicular traffic during construction

ISSUE	COMMENT
Aviation	• Concentrating solar power systems in some circumstances could potentially cause interference with aircraft operations if reflected light beams become misdirected into aircraft pathways

7.5.1 Environmental issues and impacts

Land use change

Utility scale ground-mounted solar PV can require significant areas of land for development of an asset. A study conducted in the United States in 2013[9] found that:

- A large fixed tilt PV plant that generates 1 gigawatt-hour per year requires, on average, 2.8 acres (1.14 ha) for the solar panels. This means that a solar power plant that provides all the electricity for 1,000 homes would require 32 acres (12.9 ha) of land.
- Small single-axis PV systems require on average 2.9 acres (1.17 ha) per annual gigawatt-hour—or 3.8 acres (1.5 ha) when considering all unused area that falls inside the project boundary.
- Concentrating solar power plants require on average 2.7 acres (1.1 ha) for solar collectors and other equipment per annual gigawatt-hour; 3.5 acres (1.4 ha) for all land enclosed within the project boundary.

Solar parks require land for the panel arrays (e.g., see Box 7.2).

Box 7.4: Land required for solar panel, Benban Project, Egypt

The 1,800 MW Benban solar park is one of the largest solar projects in the world. It covers 37 square kilometers and is in the Aswan Province in southern Egypt. This project was constructed to reduce Egypt's reliance on fossil fuels and to help the country meet their carbon reduction commitments made at the nationally determined contributions under the Paris Climate Agreement. The project is expected to reduce the nation's carbon dioxide output by around 2 million tons per year.

The solar park has PV panels that vary in size from 1,200 x 600 mm to 2,000 x 1,000 mm. The project acquired land for the control centre, water supply pipeline, transmission line and substations - three substations required 15,000 m^2, and a fourth substation will require an area of 50,000 m^2 for its transformers and switchgear.

Despite the solar park being built in a desert, the scale of the project could lead to many environmental and social impacts, many cumulative, e.g., significant volumes of construction traffic leading to road safety issues, the accumulation of construction wastes and issues regarding the discharge of wastewater on such a large development. The project also provides considerable employment opportunities for local people.

Figure 7.4: Benban Solar Park, Egypt

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Floating photovoltaic or FPV has the benefit of limiting terrestrial land-use change. but there will still be some land-take associated with transmission lines and other project components that need to be located on land. The majority of FPV projects to date have been installed on artificial water sources (e.g., reservoirs), but momentum is picking up for installation of FPV in the marine environment.

Rooftop-mounted solar PV has the benefit of making use of existing rooftop space and thus does not require additional land-take. However, rooftop solar systems are small in size compared to utility-scale solar ground-mounted applications.

[9] Ong *et al*. (2013)

Agricultural lands and grasslands are most often considered for solar farm sites as they generally have suitable topography and require minimal clearing. These lands may support the livelihoods of local communities and industries or may be important for biodiversity including rare and threatened species. However, certain areas should be avoided for the development of solar farms including native grassland ecosystems, ridge tops, riparian areas and watercourses, and known wildlife corridors within the footprint of a solar power project[10].

In addition to having a socio-economic impact, the loss of agricultural land can result in a shortage in local and regional supplies of agricultural products[11] . On the other hand, there is also considerable potential to combine solar farms with agriculture. For example, there are many potential benefits from using water associated with cleaning panels for agriculture, to solar panels providing shade, to panels providing mitigation from extreme rain events and limiting soil erosion. There is also emerging use of semi-transparent panels that have the potential to improve integration with agriculture[12]. Furthermore, there are good examples of solar farms sharing the land with other uses, e.g. sheep and fish farming (Figure 7.5).

Figure 7.5 Sheep kept on solar farm, Worleston, England

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The significance of land-use changes following the development of a solar farm depends on the value of the pre-existing land-use. The siting of a solar farm on land with high value for biodiversity or to society would amplify the negative impacts of the development. Mining of raw materials and manufacturing of the units and solar farm equipment and infrastructure will also result in land-use change impacts, as land will need to be cleared if mines are expanded or new ones developed.

Increased mining demands from the uptake of renewables and their required raw materials will have implications for land-use change. Such impacts are discussed further in the section on mineral extraction.

Habitats and biodiversity

The development of a solar farm (including associated transmission and access infrastructure) will often require the clearing of vegetation. This can cause the removal of habitat for flora and fauna and cause deaths and displacement to other nearby areas—during both the construction and operational phases of PV and CSP. Where new access roads pass through forested and ecologically sensitive areas, this can result in increased traffic and road kills and can enable increased human presence which can further disturb habitats and biodiversity[13]. Solar farms typically have security perimeter fencing installed, which can cause additional habitat fragmentation, especially for mammals and reptiles e.g., tortoises, and act as a barrier to movement/migration.

There is limited evidence of bird deaths associated with the operation of solar farms, although it has been recorded more frequently at CSP sites (particularly incineration in concentrated solar power beams) than at PV power sites. Most deaths have been associated with collision with structures and transmission lines (including electrocution), with some incidences of incineration[14] . Additionally, there

[10] http://www.albertapcf.org/rsu_docs/mir_pcf_factsheet_wind-solar_jun2018_v04b.pdf
[11] Farja and Maciejczak (2021)
[12] What's agrivoltaic farming? Growing crops under solar panels | World Economic Forum (weforum.org)
[13] IUCN (2021)
[14] EC (2020)

is anecdotal evidence that birds may mistake the flat surfaces of PV panels for water bodies and fly directly into them causing injury[15].

Solar utilities can also cause habitat degradation due to changes in hydrology and water availability and quality. Pollution by dust, noise, light, vibration, solids, and liquid waste can pose some risks. Construction, decommissioning, and repowering (replacing old technology to optimize performance) can lead to dust, waste, noise, and light pollution impacts, but there are few examples of this being a significant issue for solar developments [16]. Most solar power generation technologies do not discharge pollutants into the environment, although accidental release can occur (e.g., conduction fluid). The once-through cooling systems associated with some concentrated solar power projects require the discharge of heated water into a receiving water body. This can negatively impact on the biodiversity in the waterbody which will be unlikely to be able to tolerate warmer conditions.

Where animal species are displaced (at a solar farm site or along access road and transmission line routes), this can increase pressure on food resources in the areas they relocate to and may displace and out-compete other animals and species. The introduction of alien species, carried to the site by vehicles, construction equipment and people, can also put pressure on sensitive ecosystems. The fragmentation of biodiverse habitats by solar farms, access roads, and transmission lines can lower the resilience of local populations of species by preventing their free movement and access to food resources. This can ultimately affect the ability of a species to thrive in an area.

The significance of impacts due to solar farm development will depend on the richness and abundance of existing biodiversity at the site and along access road and transmission line routes, including the presence of rare and threatened species. The development of multiple solar projects across a region would amplify the negative effects on habitats and biodiversity, potentially resulting in a significant cumulative loss, even if each individual development only causes limited impacts.

Solar evaporation ponds present a risk to wildlife and livestock as well as habitats, e.g., from drowning, poisoning, and overflow and contamination of natural waterbodies.

Soil erosion

Soil erosion can occur when land is cleared for a solar farm and for access roads and transmission lines, particularly when there is inappropriate drainage design, and the land is unsealed allowing water to flow on the land surface and wind to blow soil from exposed bare land.

Compaction of soil from construction activities (e.g., vehicle movements and civil works) can lead to reduced infiltration, increased runoff, decreased soil bioactivity and decreased soil organic matter[17]. Soil erosion can lead to sedimentation in nearby water courses and sensitive habitats and to a consequent decline in water quality and loss of biodiversity.

Water use

The water consumption of PV solar farms is highest during the manufacturing and recycling processes. Water intensive manufacturing processes include minerals processing, extraction, purification, and chemical etching[18] . Significant amounts of water are also required in the manufacturing of batteries, particularly in the extraction of lithium, which requires 500,000 gallons of water per metric ton of lithium[19].

A solar farm can have a significant impact on water resources depending on its location, the availability of water, and the technology chosen. Water is required during operation to wash the panels to maintain generation efficiency. The amount of water required depends on the size of the solar farm and the ambient levels of airborne dust. Globally, the cleaning of solar panels is estimated

[15] Horváth et al. (2009); Huso et al. (2016)
[16] Farmer (1993); McClure *et al*. (2013)
[17] DEP (2017)
[18] Tawalbeha *et al*. (2021)
[19] IER (2020)

to use more than 10 billion litres. However, new research is developing a waterless no-contact electrostatic repulsion system[20].

CSP, like all thermal electric plants, requires water for cooling. Water use depends on the plant design, plant location, and the type of cooling system. CSP plants that use wet-recirculating technology with cooling towers withdraw approximately 800 gallons of water per megawatt-hour of electricity produced[21]. An example of such a project includes the Qinghai Delingha Concentrated Solar Thermal Power Project in the PRC, which is expected to generate 199 GWh of electricity every year[22].

CSP plants with once-through cooling technology have higher levels of water withdrawal, but lower total water consumption (because water is not lost as steam). Dry-cooling technology can reduce water use at CSP plants by approximately 90%.[23] However, the trade-offs to these water savings are higher costs and lower efficiencies. In addition, dry-cooling technology is significantly less effective at temperatures above 100^0F.[24]

The demand for water can put pressure on existing local water supplies in areas where water resources are scarce, and in sensitive areas, particularly during dry seasons.

Where solar panels are installed to cover canals and reservoirs, a secondary benefit is that they keep water cooler and limit evaporation.

Wastes (hazardous and non-hazardous)

The PV cell manufacturing process includes hazardous materials, most of which are used to clean and purify the semiconductor surface. These chemicals include hydrochloric acid, sulfuric acid, nitric acid, hydrogen fluoride, 1,1,1-trichloroethane and acetone[25]. The amount and type of chemicals used depends on the type of cell, the amount of cleaning that is needed, and the size of silicon wafer. Incorrect management of the manufacturing process, including waste management, can lead to the release of hazardous and non-hazardous wastes into the environment.

Most waste generation at a solar farm will occur during the construction phase, with only limited wastes produced during operation from maintenance activities and ancillary activities (e.g., office wastes). Construction waste streams include:

- Material from packaging,
- Building materials,
- Scrap metals,
- Excess soil material,
- Plastic and masonry products,
- Vegetation clearing,
- Sanitary wastes,
- Empty chemical storage containers, and
- Concrete wash out water.

Solar cells and storage batteries have an operational lifespan of 20–30 years. Solar panels are mostly made of glass, which has low value as a recycled material. The panels also contain small amounts of valuable materials such as silicon, silver and copper, and heavy metals (cadmium, lead, etc.) that some governments classify as hazardous waste. While panels and batteries can be recycled, the process is complex and costly, and they are often disposed to landfills. Therefore, the decommissioning of a PV solar farm can create large volumes of waste that are likely to be sent to landfills where hazardous

[20] https://news.mit.edu/2022/solar-panels-dust-magnets-0311
[21] Price (2009)
[22] Asian Development Bank. *China, People's Republic of: Qinghai Delingha Concentrated Solar Thermal Power Project*.
[23] Price (2009)
[24] UCS (2013)
[25] UCS (2013)

contents may leach out and pollute soil and groundwater. Countries are still expected to bolster their policy and regulatory frameworks around PV end-of-life management[26].

The waste produced during the operation and decommissioning of CSP plants can more easily be recycled as the equipment and infrastructure do not involve complex manufactured parts like photovoltaic cells and storage batteries. However, plants do require significant quantities of thermal conducting fluid (e.g., conduction oil) that is likely to be hazardous to the environment if not managed and disposed of correctly[27].

A new technology for producing flexible and printable solar cells from perovskite offers a cheaper and alternative to the use of silicon cells and could revolutionize the future of solar cell deployment. However, the technology is not yet developed commercially, and challenges remain regarding cell longevity and use of lead in production[28].

Noise and vibration

Solar farms are generally located in areas of low population density which, in most instances, will limit the number of people impacted by noise and vibration. Wildlife in the surrounding area may be displaced by noise and vibration and/or their behavioural patterns disturbed. The scope of such impacts will be significantly greater (and possibly temporary) during construction. Solar farms do not emit significant noise nor vibration during operation.

The development of a solar farm will require civil works involving heavy machinery followed by construction work by workers and using lifting equipment. The scale and significance of the impacts will depend on the size of the installations, the flatness of the site, the proximity of sensitive receivers and the duration of construction works. Solar farms are generally relatively quick to construct, therefore any construction impacts are temporary. The total time estimated to develop a utility scale 250 MW solar (from onset to commissioning) is about 6 years, including 4 years planning and development and 2 years for construction, testing and start-up[29].

Air quality

The construction phase of solar projects can generate dust due to clearing works, vehicle movements, earthworks, stockpiling, transporting materials, road works and concrete works. Exhaust emissions will be generated by construction and workers' vehicles and machinery during construction. Air quality impacts (pollution and dust) during the operation of solar plants will be limited to vehicle movements along access roads and over unsealed land and the aerosolization of dust caused by wind. The power generation process does not release pollutants into the air.

The severity of impacts on air quality will depend on the proximity of sensitive receivers (such as dwellings) to the solar farm site.

Water quality

Where solar farms and associated infrastructure (access roads and transmission lines) are located near to rivers and lakes, construction work (excavation and stockpiling of materials and spoil, and land clearing) can cause soil erosion and lead to sedimentation of such water bodies, impairing water quality and damaging aquatic habitats. The greater risk of sedimentation is from land clearing as the exposed areas will be subject to erosion by wind and surface water flows (particularly during intense rainstorms).

[26] IEA (2016)
[27] Giaconia *et al*. (2021)
[28] https://www.energyportal.eu/news/perovskite-organic-hybrid-solar-cells-a-solution-to-the-global-energy-crisis/47715/
[29] https://www.seia.org/research-resources/development-timeline-utility-scale-solar-power-plant

Hazardous materials involved in construction can include paints, cleaning solvents and acids, concrete products, soil additives for stabilization and fuels. When used or stored improperly, these chemicals can escape from the construction site and have negative impacts on local water quality. The quantity of hazardous materials is expected to be small, so the scale of impacts will likely be localized.

The operation and management of a PV solar farm does not generally require large quantities of hazardous substances, and the potential for negative impacts on water quality is small. CSP projects use large volumes of thermal fluid, which can pollute a water course if accidentally released. Once-through CSP projects require the continuous discharge of heated water which, depending on the volume of the discharge and the size of the receiving water body, can have a significant negative impact on water quality and temperature. Discharges can also include antifouling chemicals.

The landscape design of a solar farm, extent of unsealed land and drainage strategy will influence the likelihood of sedimentation impacts on receiving waterbodies during operation because of windblown dust and surface water flows.

Mineral extraction

A low-carbon future will be very mineral-intensive because clean energy technologies require more materials than fossil-fuel-based electricity generation technologies. Solar PV power is one of the most mineral-intensive forms of renewable energy, alongside wind and geothermal. The associated infrastructure (e.g., transmission lines), battery storage solutions, and material parts needed to deliver a solar project, will further increase the need for minerals[30] to manufacture components. Current projections suggest significant increases in mineral extraction will be required to keep up with the demands[31].

The solar PV industry will need to compete for resources with other clean energy technologies as many of the minerals required are crosscutting across technologies and uses. For example, copper is a key component in both solar and wind for the conduction and connection of electricity. Together, these renewable energy technologies constitute 74.2% of all demand for copper. Other minerals are more concentrated on a single technology. For example, lithium, graphite, and cobalt are mainly associated with energy storage solutions. The recycling and reuse of minerals will play a key role in reducing demand from mining but increased mined quantities will still be required to meet the future growth in the industry.

Mining for minerals and their processing for use in the solar power industry can result in significant environmental impacts given the activities and scale employed during the extraction and processing stages. The heterogenous distribution of minerals across the globe often means their extraction has direct impacts on sensitive areas if the minerals are in such areas.

The Democratic Republic of Congo is the world leader in cobalt production, accounting for more than 70% of global output in 2019. There have been several examples of dangerous occupational safety working conditions, human rights abuses including child labour, and environmental damage associated with Congolese cobalt – prompting many major companies who rely on the country's supply chains to form initiatives aimed at promoting higher ethical standards[32].

Key environmental impacts of mineral mining include:

- Biodiversity impacts, including habitat damage and loss, disturbance and killing of species, competition from alien species, and ecosystem disruption;
- Overuse of water supplies and impacts on water quality and groundwater;
- Waste generation and pollution;
- Reduced air quality for sensitive receivers;
- Noise and vibration (including from blasting) impacts on sensitive receivers;
- Land-use change;

[30] Minerals in this context also include metals
[31] World Bank (2020b)
[32] https://www.nsenergybusiness.com/features/top-cobalt-producing-countries/

- Landscape and visual amenity degradation;

With the increase in mineral extraction expected to support the expansion of solar power generation, the cumulative impacts environmental (and social – see section on human rights in 7.3.2) systems will continue to rise even if mitigation strategies are implemented.

As mentioned previously, the use of Perovskite-Organic Hybrid Solar Cells sourced from common materials such as lead, iodine and organic materials offers a lower cost and less extractive intense alternative to silicon cells.

Visual and aesthetic impacts

The visual impact of solar installations is an issue that is frequently raised by the public, local communities, and specialist interest groups. Depending on the degree of visual impact, public opinion can strongly oppose the installation of a solar farm and significantly hinder its implementation.

The significance of a visual impact during both operation and construction typically depends on the landscape character and topography of the local area, the size of the installation, the level of screening (trees, etc.) and the number of visual receivers within the zone of influence. As many solar installations are installed in rural areas, their influence on the landscape character can be significant. This is most acute with CSP installations which can involve tall tower structures.

There is a perception that PV solar panels cause glint and glare, which can distract motorists and aircraft and cause eye damage. Solar PV modules are specifically designed to reduce reflection to minimize loss of light and convert it to electricity. Research shows that PV modules exhibit less glare than windows and snow[33] . PV modules have been installed at airports in the US, including Denver and Oakland.

There is more risk of glint and glare from CSP projects because these use mirrors to concentrate the solar rays. This can pose a potential hazard or distraction for motorists, pilots, and pedestrians[34]. The design and location of a CSP is critical in avoiding this problem.

Land and ecosystem restoration

As discussed above, there are significant risks associated with solar power development with regard to potential environmental harm and degradation, e.g., unnecessary or excessive deforestation when preparing land for solar farms, constructing new access roads and transmission lines, destruction of habitats and loss of biodiversity and ecosystem services as well as soil erosion and pollution. This will particularly arise where mitigation measures proposed by a SEA (and subsequent project-level EIAs) are inadequate, ineffective or not undertaken. The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. Such cumulative impacts will be highly likely to occur where there are multiple solar farm developments across landscapes.

From a positive perspective, in general, solar farms constructed on degraded land should enable vegetation and soil carbon to regenerate, and at least some local biodiversity to re-establish in areas from which it had previously been lost.

Environmental impacts will usually lead to demand for and need for land and ecosystem restoration (see Box 3.9). This need will also arise at sites of projects that have come to the end of their useful operational life – usually after 20-30 years[35]. After this time, the project owner will either decommission the site, restoring the area to its previous land use, or negotiate with landowners to repower or upgrade the equipment and extend the wind farm’s operational lifespan.

[33] Reach Solar Energy (2018)
[34] Ho and Kolb (2010)
[35] The average lifespan of solar panels is about 25 years.

At a minimum, land/ecological restoration after decommissioning a solar farm should involve the seeding/replanting of disturbed areas. A seed mix of species that were naturally part of the ecosystem/land prior to development of the solar farm should be used.

7.5.2 Socio-economic issues and impacts

Local economy and livelihoods

The development of solar PV farms may induce large-scale land acquisition that results in economic and physical displacement of the host communities.

This displacement can cause adverse short- and long-term impacts on livelihood activities, affecting income from rice cultivation, small businesses, and enterprise activities of the host communities. Rural communities can also lose access to grazing land (used on either a formal or informal basis). In the case of floating solar PV, the acquisition of water space can impact access to fisheries and navigation.

Land acquisition for solar parks and substations can lead to physical and economic displacement that needs to be addressed through resettlement planning. The use of marginal land or land not in high demand for other uses is preferable (e. g., the Benban project in Egypt (Box) used desert land that was vacant). This means that highly productive agricultural land required for food supplies or land assigned for other important social purposes such as residential areas will not be affected.

Some solar PV park development projects can provide opportunities including benefit-sharing schemes between the host communities and the solar PV companies (see Boxes 7.5 and 7.8) and can lead to an increase in land and property values within the vicinity of the solar farm.

Box 7.5: Joint investment in a solar farm, Dorset, United Kingdom

In Dorset in the UK, local communities benefit from joint investment in solar PV farms, often through the local Parish or Town Council. The funding may be through an annual payment over the life of the solar farm or a one-off payment once the solar farm is first commissioned. Solar farm community benefit funds totalling around UK £2m over 20 years have now been offered to twelve Dorset communities.

Source: Dorset Council. Community Renewable Energy and community benefits - Dorset Council.

Employment and labour conditions

The construction of solar farms can create jobs for neighbouring communities and skilled workers. One review found that the construction of four large-scale solar farms in the US (each 250 MW) created the FTE jobs for between 405 and 830 workers per month for a project duration of 2 to 3.5 years[36] .The average annual workforce for operations and maintenance was estimated at 68 (10 general, six engineering, 25 maintenance, 22 operations and five unskilled) (footnote 36). By comparison, it was found that 500 FTE jobs were created for half a year to construct the 25 MW Permacity PV project.

While other countries may not reach the same efficiencies and require additional labour, this information helps to show that solar projects have generally short construction phases and small operational workforces. Thus, it can be seen that the difference in job creation between construction and operation should be planned to avoid large scale retrenchment after the close of construction as found in other industries, such as hydropower.

Error! Reference source not found.IRENA (2022) reports that millions of jobs had already been created by solar PV projects by 2020 (Figure **7.6**7.6) with job opportunities having increased significantly compared to other technologies in the renewable energy sector.

[36] White *et al.* (2010)

While investing in solar PV power brings jobs to local communities, there is a need to manage associated operational health and safety risks.

Concerns regarding the extraction of mineral resources for manufacturing solar PV are discussed in the human rights section.

Figure 7.6: Number of Jobs in Each Renewable Sector and Solar Photovoltaic

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Cultural heritage

Cultural, religious, and archaeological sites can be destroyed or access to them restricted when land is acquired for solar power farms. Box cites concerns raised in the media about the impacts of a Maltese solar farm on cultural and archaeological heritage. Measures need to be put in place to manage. chance finds during construction, as per other industries that cause site disturbance.

Box 7.6: Impacts of solar farm on cultural heritage and archaeological sites in Malta

"The effects of a proposed solar farm on the rain catchment system near Ta' Ħaġrat archaeological site is of great concern for Heritage Malta. The national agency for cultural heritage said it feared the proposed solar farm in Triq San Pietru, Mġarr might negatively affect the site when heavy rainfall causes the road leading to the temples to flood. This is mainly a result of the vast development in Mġarr during the last 50 years. What is mainly worrying Heritage Malta is that the proposed project will prevent the rainwater from penetrating the soil, resulting in runoff flowing into the temples."

Source: www.newsbook.com.

Health and safety

The main risks to worker health and safety occur during the construction phase and typically include managing physical, chemical, and biological hazards[37]. In addition to working with live power lines and EMF, work on floating solar farms involves the additional risk of operating over and under water[38] . Weather conditions are a significant factor when working on outdoor solar photovoltaic installations and affects the risks to lives and working conditions.

Solar farms can also have negative impacts on community health and safety, e.g., from electric shocks when facilities are unfenced, or cables not cased. Depending on the proximity of residential areas and other community activities, the impacts of exposure to glint (momentary flashes of light) and glare (continuous, excessive brightness) from solar PV reflection may need to be modeled and mitigation measures identified. Glint and glare can affect nearby residents, road users, airplane pilots and air traffic controllers[39].

In some circumstances, CSP systems can cause interference with aircraft operations if reflected light beams become misdirected into aircraft pathways[40]. For instance, light reflection from CSP solar panels

[37] IFC (2012c)
[38] World Bank, ESMAP and Solar Energy Research Institute of Singapore (2018)
[39] DELWP (2022); SolarTech Advisor. 2021. Can Glare From Solar Panels Affect Aircrafts? | Solartechadvisor.
[40] Solar Energy Development Programmatic EIS. Solar Energy Development Environmental Considerations (anl.gov)

can distract pilots and air traffic controllers and interfere with airport equipment[41]. The adverse impacts on aircraft movements can be due to the proximity between the solar farm and their airports. Some airport companies oppose nearby solar farms. For example, Barrow/Walney Island Airport in the UK objected to a proposed solar farm, citing such concerns. Analysis of solar PV glare has been part of the impact assessment for the installation proposed at the Kuantan Airport in Malaysia.

As previously discussed, solar farms typically have small workforces only in place for short construction periods, so the influx of labour is not a substantial risk.

The impacts (positive and negative) of immigration induced by the development of solar farms are similar to those that arise for other types of renewable energy.

Gender and vulnerability

Where solar projects have negative impacts that affect livelihoods, women are often disproportionately affected. As solar farms increase in size, they may also impact on housing, health and social care services, and sociocultural quality of life (Box7.7).

Box 7.7: Gender and other impacts of the NOOR solar plant, Morocco

A study of the NOOR solar power plant development in Morocco, North Africa, showed that people living near the plant, especially women, reported decreased abilities to practice livelihood activities such as grazing goats and collecting firewood as construction ramped up. Families who did not profit from employment opportunities at the plant were left more vulnerable to economic shocks.

Construction of the NOOR plant led to an increase in migration to the area of external and foreign workers and students, which changed the social and cultural make-up of the community. It also contributed to an increased population with the potential to put a strain on public infrastructure and services like sanitation, healthcare, and education.

Source: Renewable and Sustainable Energy Reviews. 2019. Social impacts of large-scale solar thermal power plants: assessment results for the NOORO I power plant in Morocco. https://www.sciencedirect.com/science/article/abs/pii/S1364032119304678?via%3Dihub [Accessed 11/05/2022]

The underrepresentation of women in the solar energy sub-sector is another issue, and one that is also reflected across all technologies. In 2019, the IEA identified that a growing number of women are recognising that the sub-sector is a source of well-paid employment with strong opportunities for career advancement. Because solar PV technology requires a workforce for installation, sales, and operations and maintenance, IEA suggested that there is a wide range of opportunities available for women[42]. The share of women working in full-time positions in the solar PV industry is 40%. This is almost double the share in the wind industry (21%) and the oil and gas sector (22%). The solar PV industry also compares well with the 32% share across the entire renewable energy landscape[43].

Solar power projects can also create opportunities for benefit-sharing among wider community members, local government, and private investors (Box7.8) and for female-led business ventures (Box7.9).

[41] Solartechadvisor (2021)
[42] IRENA (2017)
[43] IRENA (2022c)

Box 7.8: Benefit-sharing from solar farms in the United Kingdom

Lambeth Council Community Energy Programme was part of the UK's Community Energy Initiative to reduce, purchase, manage and generate energy through collective action. The programme was a successful collaborative partnership involving Repowering London (a community-based organization), Lambeth City Council and select private local investors to co-produce three community-owned PV solar projects with a total installed capacity of 132kW through community share offers. Training and work experience was also provided to local young people from some of the poorest social housing estates in the area.

Source: UK Department of Energy and Climate Change. 2014. Community Energy Strategy: Full Report. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/275169/20140126Community_Energy_Strategy.pdf

Box 7.9: A female-led solar power company in Thailand

The SPCG Public Company Limited in Thailand is a pioneer company in solar farms and solar roof development. It is headed by a woman. SPCG owns 36 PV solar farm projects that sell electricity to Thailand's distribution grid. The company's businesses, include engineering, procurement and construction for solar farms and solar rooftops, and it manufactures steel or metal roof sheets. In 2017, the company employed more than 1,000 people.

Source: https://www.iea.org/reports/seven-women-entrepreneurs-of-solar-energy

Indigenous communities

Solar energy projects require land or bodies of water that may customarily be owned or used by indigenous peoples. There is a risk of conflict between communities and project developers if the latter do not secure the free prior and informed consent (FPIC) to projects from indigenous communities[44]. FPIC is required by various multilateral development banks and other bodies[45]. This issue is addressed in the discussion of indigenous communities in Chapter 5 (hydropower).

There are examples from many countries where stand-alone solar power systems are used to provide electricity to indigenous communities, especially to remote and/or small communities[46] (Box 7.10).

Access to water

During its operational phase, a solar project will require water to wash PV solar panels and maintain their efficiency, or to cool concentrating solar power plants. This may be accessed from underground or surface water and may decrease supplies of clean water available to the local community, particularly

[44] Free, Prior and Informed Consent (FPIC) is a specific right that pertains to indigenous peoples and is recognised in the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). It allows them to give or withhold consent to a project that may affect them or their territories. Once they have given their consent, they can withdraw it at any stage. Furthermore, FPIC enables them to negotiate the conditions under which the project will be designed, implemented, monitored and evaluated. This is also embedded within the universal right to self-determination.

[45] e.g. by the IFC under its Performance Standard 7 guideline (IFC 2012b); and by the ADB's commitment to Broad Community Support (BCS) under its Safety Policy Statement (2009).

[46] Martire (2020)

in dry areas. New cleaning technologies for solar panels, such as the use of electrostatic repulsion, offer the opportunity to substantially reduce water use for this purpose[47].

Public services and infrastructure

Solar farm projects can have negative impacts on public services and infrastructure. The movement of heavy goods vehicles and the transportation of materials and can damage existing roads and bridges and increase traffic congestion in the host communities.

But solar farms may also benefit local communities through investment programs to support local economic development, improve local infrastructure and services, and support social programs to improve community well-being (Box7.11). This can be done by project community investment programs as outlined by IFC's community investment handbook[48].

Box 7.10: Examples of solar projects serving indigenous communities

Canada

There are opportunities for indigenous peoples in Canada to own or co-own the solar projects on their lands. The largest off-grid solar project in Canada (2.2 MW) is located at Fort Chipewyan. It was projected to cost CDN$4.5 million, create 40 jobs during construction, and replace 650,000 litres of diesel fuel per year, reducing greenhouse gas emissions by 1,743 tons annually. The indigenous people in this area benefit from job opportunities during the construction and from cleaner electricity generated.

Figure 7.7: Ft. Chipewyan Solar Farm

Source: Solar Energy Moves Indigenous Communities Toward a Renewable Future (Canada) in a news release, August 2019. Solar Energy Moves Indigenous Communities Toward a Renewable Future - Canada.ca; Indigenous Business Australia, provided in Powering Indigenous communities with renewables – Renew.

Western Australia

Indigenous Business Australia (a government body) is a co-equity investor with an indigenous Noongar (an Aboriginal people in Western Australia) community partner, Bookitja in a 10 MW solar farm at Northam.

[47] https://www.renewableenergyworld.com/solar/solar-panel-cleaning-innovation-could-save-billions-of-gallons-of-water/
[48] IFC (2010)

Figure 7.8: Northam Solar Farm in Western Australia

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Box 7.11: Solar company support for community services, India

In India, Avaada (a company renewable energy company) supports a number of interventions near its solar project sites to improve health outcomes for host communities, including no-cost medical services. Specialized and general awareness camps and regular health check-ups are provided to raise awareness and help local residents lead healthier lives. In addition, Avaada is addressing sanitation challenges in rural India by building toilets and clean drinking water facilities in underserved communities.

Source: Avaada Energy. Sustainability. http://www.avaadaenergy.com/sustainability.html; International Finance Corporation. LargeScaleWindSolar.

There are many examples of covering infrastructure with solar panels (e.g., parking lots, rail systems, commercial buildings) to provide shade, help cool urban areas and provide local power sources. In France, under a new law, car parks in France with 80 or more spots will need to be equipped with overhead solar power panels[49]; and the national rail service (SNCF) plans to install some 190,000 m^2 of solar panels in 156 stations throughout the country by 2025 and 1.1 million m^2 by 2030, all with the aim to reduce energy consumption by 25%[50]. An intriguing opportunity for solar generation is to place solar panels between railway tracks throughout the rail transport system[51]

Human rights

Solar photovoltaic panels require minerals that are mined in various countries, including in low-income and conflict-affected countries where human rights are not well regulated or enforced. Key social impacts of mineral mining include:

- Child and forced labour (see Box 7.12);
- Forced resettlement, land take and violence;
- Occupational health and safety including physical and mental health.

Box 7.12: Use of forced labour in the People's Republic of China

Recently, there has been a focus on the Uyghur Region in the People's Republic of China—a major producer of solar panels. In 2021, United Kingdom (UK) academic researchers found that the region accounted for approximately 45% of the world's solar-grade polysilicon supply. The study identified 11 companies engaged in forced labour transfer, plus another four located in industrial parks, and 90 Chinese and international companies whose supply chains were affected.

49 Parking lots in France must set up solar panels (balkangreenenergynews.com)
50 France intends to cover most of its rail network with solar panels - Search (bing.com)
51 https://www.euronews.com/green/2023/03/17/solar-panels-could-be-installed-in-the-spaces-between-railway-tracks-in-world-first

In a related article in 2021, *The Guardian* newspaper reported that solar projects commissioned by the Ministry of Defence, the government's Coal Authority, United Utilities and some of the UK's biggest renewable energy developers were using panels made by Chinese solar companies accused of exploiting forced labour camps in Xinjiang province in the People's Republic of China. The newspaper article suggested that up to 40% of the UK's solar farms had panels manufactured by solar panel companies that use interned Muslim Uyghur community members in polysilicon production. Acknowledging this risk, the World Bank has recently issued guidance on measures to avoid forced labour through solar projects.

Sources:

Murphy and Elimä (2021)
The Guardian. 2021. Revealed: UK solar projects using panels from firms linked to Xinjiang forced labour. 25 April. Revealed: UK solar projects using panels from firms linked to Xinjiang forced labour | Solar power | The Guardian;
IPF Solar Procurement Bidder Declaration - Forced Labor
https://thedocs.worldbank.org/en/doc/a5d4a4a88227973aecdbab19dd58258e-0290032021/original/Forced-Labor-Solar-Declarations-and-provisions-for-Procurement-Documents-ext.docx

CHAPTER 8

KEY ISSUES FOR SEA IN THE BIOENERGY SUB-SECTOR

8.1 WHY IS SEA IMPORTANT TO THE BIOENERGY SUB-SECTOR

SEA can provide critical information to support better decision-making for bioenergy planning and development, including identifying where there may be implications for PPPs to adequately address significant environmental and/or socio-economic risks and impacts. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of multiple bioenergy schemes/developments - whether alone or in combination with other renewable energy technologies (e.g., wind or solar energy).

The SEA process will:

- Identify and focus on key environmental and socio-economic issues and the concerns of likely affected stakeholders, including local communities, marginalised groups and indigenous peoples. Major issues are discussed in detail in section 8.5 and are summarised in Table 8.2.
- Identify/recommend if there are areas that should be avoided for bioenergy development ('no go' areas) because of particularly high risk to the environment, habitats/biodiversity and/or people.
- Identify what changes or additions are required to PPPs governing bioenergy development to address these risks.
- Make subsequent project-level EIAs more efficient and cheaper by addressing the big picture and upstream, downstream and cumulative potential impacts, identifying the particular issues that individual bioenergy project EIAs should focus on in more (site-specific) detail. This may also include spatial planning recommendations for optimal siting of bioenergy projects to minimize these risks and impacts.
- Engage stakeholders – including communities, marginalised groups and indigenous peoples which can be particularly affected by bioenergy developments - to be informed of proposed or possible policy options or plans and enable them to provide their perspectives and present their concerns. This will enable key issues to be identified and verified, help build understanding and support for bioenergy development, and avoid future misunderstanding and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 3 and are therefore not repeated in this chapter.

8.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE BIOENERGY SUB-SECTOR

An international survey of existing SEA guidelines conducted for the IAIA was able to identify only one specifically focused on the bioenergy sub-sector. The OECD DAC guidelines on SEA and biofuel development (OECD DAC 2011) cover generic and specific considerations and questions to be addressed at the broad scale in a typical SEA process for biofuel PPP development at a national or sectoral level. Similarly, no EIA guidelines specific to bioenergy have been identified.

In the literature, a range of academic papers and books cover various aspects of the environmental and socio-economic impacts of biofuels (e.g. solid biofuels[1], biogas[2], in commercialization of biofuels production from feedstocks[3] , bioenergy production based on the compilation and published data[4].

8.3 BIOENERGY INSTALLED CAPACITY

According to International Energy Agency, the annual global demand for biofuels is set to grow by 28% by 2026, reaching 186 billion litres[5]. The installed capacity for bioenergy is expected to reach 220.4 GW by 2027[6].

Table 8.1 shows bioenergy installed capacity by regions in 2021.

Table 8.1: Bioenergy installed capacity in 2021
Source: IRENA (2022b)

Region	Installed capacity (MW)
World	143,371
Africa	1,785
Asia	56,917
Central America	3.047
Eurasia	3,059
Europe	41.846
European Union	33.969
Middle East	105
North America	17,054
Oceania	1.086
South America	18,473

8.4 BACKGROUND TO BIOENERGY GENERATION

Bioenergy use falls into two main categories: “traditional” and “modern”. Traditional use refers to the combustion of biomass in such forms as wood, animal waste and traditional charcoal. Modern bioenergy technologies include liquid biofuels produced from bagasse and other plants; bio-refineries; biogas produced through anaerobic digestion of residues; wood pellet heating systems; and other technologies.

Modern bioenergy[7] is the largest source of renewable energy globally, accounting for 55% of renewable energy and over 6% of global energy supply[8]. Bioenergy accounted for about 10% of total final energy consumption and 1.9% of global power generation in 2015[9].

Rural households Africa, Asia and other parts of the world use a lot of traditional biomass (e.g., wood, dried animal dung, sugarcane bagasse, crop residues) as a principal energy source (i.e., for heating and cooking). However, this chapter focuses on bioenergy sources that could potentially be used in utility-scale thermal power plants, primarily the conversion of plants (mainly high energy crops grown at large scale) or wood (from forests) to pellets to be combusted in a thermal power plant.

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[1] Christoforou and Fokaides (2019)
[2] Valerio *et al*. (2018)
[3] Arun and Dalai (2020)
[4] Wu *et al*. (2018)
[5] IEA (2021)
[6] www.mordorintelligence.com
[7] Modern bioenergy refers to biomass use alongside modern heating technologies, power generation and transport fuels as opposed to traditional wood-burning methods commonly used for heating and cooking in developing countries.
[8] Bioenergy - Fuels & Technologies - IEA
[9] Bioenergy and biofuels (irena.org)

Bioenergy energy is generated from combustion of organic matter from bio-based renewable sources such as biofuel, biogas, biomass, and other bio-organic wastes. Biomass supply comes from a variety of feedstock – wood fuel, forestry residues, charcoal, pellets, purpose-grown crops and residues, municipal and industrial waste (e.g., food, construction, and paper) biogas, biofuels, etc. Broadly, the supply can be classified into three main sectors – forestry, agriculture, and waste. It can be used in power generation, heating, and transport. To create pellets for combustion (to drive a steam turbine and create electricity), plant material is harvested, dehydrated in a processing plant, and pressed. This fuel is used instead of or as well as coal.

Box 8.1: Use of biomass in power plants in different regions

Southeast Asia

Currently, there is only limited use of biomass by power plants in Southeast Asia,[10] with some projects in Bangladesh, Indonesia, Malaysia, Myanmar, Thailand, and Viet Nam. By the end of 2018, Thailand had 3.3 GW of solid biomass capacity and Indonesia had 1.8 GW.[11] In Myanmar, companies are experimenting with generating electricity from rice husk [12].

OTHERS REGIONS TO BE ADDED
Reviewers – please provide information if you have it

Bioenergy can also be produced from waste streams such as wood chips left over from manufacturing processes or from sugar cane biomass left over from the sugar refining process. Using waste products such as these as a biofuel can reduce waste sent to landfill. But they are usually used in combustion plants alongside coal or in small-scale power plants. It is not likely that biofuels sourced from waste streams could supply electricity at scale.

Biomass has been promoted as a carbon-neutral energy, but the UK's the Guardian reports doubts about this view (Box 8.2).

Box 8.2: Biomass is promoted as a carbon neutral fuel. But is burning wood a step in the wrong direction?

Biomass has been promoted as a carbon-neutral energy source by industry, some countries and lawmakers on the basis that the emissions released by burning wood can be offset by the carbon dioxide taken up by trees grown to replace those burned. Yet there remain serious doubts among many scientists about its carbon-neutral credentials, especially when wood pellets are made by cutting down whole trees, rather than using waste wood products. It can take as much as a century for trees to grow enough to offset the carbon released.

Burning wood for energy is also inefficient – biomass has been found to release more carbon dioxide per unit of energy than coal or gas, according to a 2018 study[13] and an open letter to the EU signed by nearly 800 scientists.

This CO_2 is theoretically reabsorbed by new trees, but some scientists suggest relying on biomass could actually end up increasing emissions.

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[10] IEA (2019)
[11] *The Economic Times*. 2019. Govt hikes ethanol price to cut oil import bill by USD 1 billion. 3 September.
[12] Asian Development Bank. 2019. *Asia and the Pacific- Renewable Energy Status Report*. Manila. https://www.adb.org/sites/default/files/publication/611911/asia-pacific-renewable-energy-status.pdf
[13] Does replacing coal with wood lower CO2 emissions? Dynamic lifecycle analysis of wood bioenergy - IOPscience

Source: Biomass is promoted as a carbon neutral fuel. But is burning wood a step in the wrong direction? | Environment | The Guardian

An advantage of bioenergy is that it can provide a controllable and continuous supply of power and use waste products. Biomass and biofuel energy tend to have the lowest energy density compared to other energy sources. But they have the highest land-take of any of the renewable energy technologies. To generate 1 gigawatt-hour (GWh) of electricity, 78 ha of trees need to be harvested each year (this assumes sustainable harvesting that can be repeated each year)[14].

8.5 IMPACTS OF BIOENERGY DEVELOPMENT

During scoping for a SEA, key issues regarding bioenergy development should be identified. They will be used to focus the SEA on the most important issues and to help develop environmental and social quality objectives (ESQOs) – that address these issues - to be used during the main assessment stage. The key issues will be identified by reviewing relevant documents (e.g., EIA and special subject reports, other bioenergy development applications, environmental/social profiles, sector and inter-sector strategies, donor documents, academic papers, etc.), interviews with key informants and during stakeholder consultations at national to local levels. Many of the issues will be well known as a result of implementing other bioenergy development projects.

At the individual project-level they will be the focus of an EIA which should recommend how to manage or mitigate impacts associated with these issues that might be likely to arise. Implementing a policy, plan or programme (PPP) for the bioenergy sub-sector will involve multiple projects, schemes and activities (including dispersed individual farmers growing bioenergy crops). Activities may include: land clearing, land use change and growing bioenergy crops; construction and operation of sites and facilities; and development/expansion of associated infrastructure (e.g. transmission lines, access roads). Thus, there is a risk that the impacts of individual developments/projects may become highly significant as they become cumulative. A SEA should be focus on the potential for such cumulative impacts and make recommendations for addressing them. This may include recommending thresholds for particular factors that should not be breached by an individual project (and which should be addressed by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it. Often, the timing of individual bioenergy project applications and overarching SEA planning is not synchronized, and SEA may have to “catch-up” to the pace of individual projects rather than providing upstream (pre-project) guidance as to how they should proceed.

Table 8.2 summarises the key environmental and socio-concerns concerns likely to be associated with bioenergy development.

[14] How much land is needed for biomass power plants to generate a megawatt hour? (freeingenergy.com)

Table 8.2: List of key environmental and socioeconomic issues for solar power

ISSUE	COMMENT
Environmental	
Air quality	• Reduction in air emissions through displacement of coal, leading to improved air quality • Air quality impacts from processing and burning biofuels
Water quality	• Runoff of biocides used on energy crops
Water use	• Water consumption of bioenergy crops and conversion of land use can increase demand on water resources
Greenhouse gases	• Bioenergy can reduce GHG emissions where it displaces coal as a fuel source • Land clearing for crops can result in release of GHG (e.g., from clearing forests and release from soil) • Biofuels can be carbon neutral in some circumstances but can cause net emissions of GHG in others (i.e. CO_2 from their combustion - although less than from coal)
Land-use change	• Large areas of land required to grow crops that feed into biofuels can displace other land uses such as food crops and other agricultural practices • Forest clearance to grow energy crops will lead to habitat loss/degradation, biodiversity loss and release of carbon stores
Soil erosion and landslips	• Clearing land can lead to erosion and destabilization of areas. This can lead to landslips and sedimentation issues • Can be triggered by <u>an expansion of the area growing fuel crops (particularly corn)</u>, residue removal, and land-use change
Soil quality	• Cropping, overuse of fertilizer and inappropriate use of pesticides can lead to a reduction in soil nutrients and overall soil quality and result in polluted runoff to surrounding areas. • Soil organic carbon loss due to tillage and harvesting residues
Loss of biodiversity	• Habitat loss/fragmentation and loss of biodiversity when large areas of land are cleared to grow fuel crops • Risk of introducing invasive pests and species • Energy crops grown as a monoculture can favor some species (often pests) and displace others, leading to loss of native species
Crop waste products	• If waste products (e.g., sugar cane waste from a sugar mill) are converted to biomass pellets, this can reduce waste in the food chain
Land and ecosystem restoration	• Forest conversion to grow bioenergy monoculture crops leads to a reduction in biodiversity and resultant ecosystem degradation
Socio-economic	
Employment and labour condition	• Employment in the construction and operation phases of bioenergy projects and in associated businesses and activities • Substandard working conditions • Worker safety • Workers have opportunity to learn new skills
Health and safety	• Increased heavy truck usage to transport biofuels from agricultural areas to processing plants and then to thermal power plants, leading to air pollution congestion, noise, and safety issues • Wastes (e.g., contaminated water, particulates from biomass material burning, etc.) produced by bioenergy projects or plants could cause community health issues, including but not limited to respiratory disease
Local economy and livelihoods	• Loss of household income from agricultural land acquired by bioenergy companies • Increased opportunities for small business (e.g., selling energy-related agricultural products to bioenergy projects)

ISSUE	COMMENT
Food security and price	• Less food crops (e.g., corn) available for public sale as purchased by bioenergy companies. This will drive up the price so that poor people cannot afford to buy food • Production of energy crops may reduce volume of food crops available and lead to malnutrition in rural areas • Price of crops grown for energy production likely to increase, presenting an economic opportunity for producers • Loss of communities' grazing areas when acquired by the bioenergy projects
Land value	• When land is purchased or acquired by bioenergy companies to grow bioenergy crops, this reduces the amount of agricultural land available for cultivating food crops, and can drive up land prices, making it unaffordable to poor communities • Increased land conflict over land ownership if land price increases
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and indigenous communities) may be disadvantaged and at particular risk due to loss of arable land • Employment opportunities for vulnerable groups within new projects • Opportunities for vulnerable groups to acquire new skills and learn new technologies
Public services and infrastructure	• Loss of and relocation of public services and infrastructure on land acquired for bioenergy projects • Infrastructure (e.g., roads and bridges, schools, health centers, and administrative buildings) will be improved where there is community investment by bioenergy companies • Pressure on public services and infrastructure will increase as a result of immigration • Heavy vehicles and transportation damage existing roads and bridges • Increased vehicle traffic during construction
Access to water	• Bioenergy projects require large amounts of water (e.g., for irrigating energy crops, steaming, cleaning, etc.) reducing water available to communities
Indigenous peoples	• Acquisition of large tracts of land for bioenergy projects can cause the loss of indigenous communities' communal land

8.5.1 Environmental issues and impacts

Air quality and greenhouse gases

Bioenergy can have both positive and negative impacts on air quality. The IEA states that bioenergy can contribute to the mitigation of climate change if it is grown sustainably or if it comes from waste sources, is efficiently converted to energy products, and is used to displace GHG-intensive fuels[15]. Theoretically, net CO_2 emissions resulting from the direct use of biofuels can be less than from the utilization of fossil fuels.

However, the combustion of biomass also creates atmospheric emissions of carbon dioxide, sulphur dioxide, nitrogen oxide and particulate matter[16] . The severity of the impact on air quality of such emissions depends on the proximity of the power plant to communities, sensitivity of ecosystems, levels of pollutants released, topography and climatic conditions. Biomass combustion is generally less polluting than coal with lower emissions of NO_x and SO_x.[17]. Table 8.3 indicates the contribution of different pollutants emitted by a bioenergy plant.

Table 8.3: Air pollution from biomass energy
Source: PPFI (undated)

Emission type	Percentage contribution to combustion emissions (%)
Nitrogen oxides	0.03
Carbon monoxide	0.06
Particulate matter	0.02
Sulphur dioxide	0.02
VOCs	0.01
Hazardous air pollutants	0.00
Carbon dioxide	99.86

There are also notable indirect impacts of bioenergy as regards both increasing and decreasing CO_2 emissions[18]. For example, if there is large-scale land clearing specifically to produce biomass and to enable large-scale expansion of growing energy crops, this would release stored carbon and result in GHG emissions to the atmosphere. The carbon sink capacity of natural forests could be reduced as cleared areas may be replaced by energy source crops which may have less capacity to capture carbon than the replaced forest[19] . The volume of CO_2 emissions from bioenergy production will depend on the types of fuel crops grown and the associated management practices.

If land is to be cleared on a large scale for the growing of crops, and if this also involves the burning of forests, there will be significant negative impacts on air quality from smoke, particulate matter and other pollutants experienced over large distances. For example, forest fires in Indonesia have had major adverse impacts on air quality, which has also affected neighbouring countries such as Singapore and Malaysia[20]. The burning of crop waste products on a large scale can also have significant negative impacts on air quality.

There would also be localized negative impacts on air quality from the growing of bioenergy crops. These include dust emissions from vehicle movements and agricultural practices (such as tilling soil), vehicle emissions from the transport of crops or forest wood to the processing facility, then on to the powerplant for combustion.

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[15] IEA Bioenergy (2020)
[16] USEPA (2013)
[17] Renet *et al*. (2017)
[18] Wu *et al.* (2018)
[19] World Bank (2010)
[20] Sheldon and Sankaran (2017)

Water quality

The production of crops for biofuels can lead to a decrease in water quality due to:

- Poor agricultural practices that result in fertilizer run off into waterways, causing algal blooms and nutrient loading in waterways;
- Pesticide run off from agricultural land, leading to contaminants and biocides entering waterways;
- Land clearing and changes to vegetation cover that result in increased erosion and sedimentation of waterways; and
- Spills of fuels and oil from vehicles, agricultural machinery or machinery used in clearing forests[21].

The reduced water quality can then cause:

- Health impacts on communities as a result of using polluted water for drinking, cooking, irrigation, washing and bathing; and
- Direct loss of biodiversity and degradation of aquatic ecosystems.

Risks of climate change

The risks to bioenergy production associated with climate change are potentially significant. For instance, droughts, floods, strong winds and forest fires (due to extended droughts) will affect the cultivation of energy feedstocks (reducing or destroying energy crops), grower incomes and livelihoods, and will disrupt supply chains to power stations.[22] Power plants may be forced to run at lower utilization rates due to reduced feedstock.

There could also be a higher biomass production (and harvest) due to an increased growing season and more rainfall. Rainfall quantity could affect the moisture content of the soil or feedstock quality which, in turn, could result in lower yields and reduced feedstock inputs at the power plant.

Wind velocities can affect the dispersion characteristics of pollutant emissions (i.e., increased winds and wind variations can alter the impact of pollutants on nearby sensitive receptors).

With the increase of CO_2 concentration in the atmosphere, some (potentially less dense) quick-growing varieties of energy crops could out-compete more dense crop species, and, over time, could reduce the energy content per unit area of land[23]. The energy density of biomass can vary due to variations in photosynthetic interactions driven by CO_2 concentration changes.

Increased drought instances may limit cooling water available to power plants[24] . This risk could, at least in part, be offset by growing drought-tolerant biofuel crops. Several promising lignocellulosic crops are emerging that have no food role—fast-growing trees and grasses—but are well suited as bioenergy feedstocks, including Populus, Salix, Arundo, Miscanthus, Panicum and Sorghum[25]***.***

Water use

The majority of water used in bioenergy production is for the growing of energy crops. These are generally selected for optimal growth which can mean that they have a high-water demand (requiring irrigation). They consume more water than natural flora and many other food crops[26] . Irrigation water is drawn from either surface water sources or groundwater, which can reduce surface water yields and make groundwater wells unreliable when water sources are over extracted.

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[21] Wu *et al*. (2018)
[22] Hoover *et al*. (2019)
[23] ADB (2012)
[24] CFR (2019)
[25] Taylor *et al*. (2019)
[26] Berndes *et al*. (2011)

The extraction of underground or surface water may put pressure on existing irrigation infrastructure and reduce fresh water available to host communities and farmers for subsistence crop cultivation, drinking and sanitation, and to support environmental functioning and services. This is a particularly significant concern when water is scarce, especially during dry seasons. In Brazil (one of the world's largest sugarcane producers), there are well-documented impacts on the availability of freshwater in Sao Paulo region[27].

Land use change

Bioenergy production can lead to both direct and indirect changes to land use:

- *Direct land-use changes* relate to changing land use to produce bioenergy crops that include:
    - Changing the types of crops being grown;
    - Converting grazing land to growing biofuel crops; and
    - Removing forest or naturally vegetated areas and converting them bioenergy crops.

- *Indirect land-use changes* can occur if bioenergy crops displace food crops if forested areas are cleared to grow food crops. The overall impact would be like what has been experienced in parts of Southeast Asia because of palm oil production[28].

The conversion of land to biofuel production will likely result in the clearing of hundreds or thousands of hectares of forests and/or habitats with high biodiversity value, resulting in significant habitat and biodiversity losses. This has already occurred where other industries have been promoted, e.g., for palm oil plantations in Indonesia (Box **8.2**8.2) and the production of other agricultural products.

Review of the literature indicates that there are differences in opinion regarding bioenergy crop production and effects (positive or negative) to biodiversity.

Soil quality, erosion, and landslips

Bioenergy projects usually cause an increase in erosion and sedimentation associated with land clearing for crop production. Clearing can cause a decline in overall soil stability and health, and can lead to landslips, sedimentation of waterways and changes to the amount of water that land can hold, potentially increasing flood or landslip risks. This may also occur when there is poor crop cover, poor agricultural practices, and poor soil conservation on sloping land. Poor soil management can also lead to the loss of nutrients when existing grasslands are converted to biofuel production.

Disturbance to vegetation and soils adjacent to creeks and rivers (e.g., due to tilling soils for fuel crop production) can lead to an increase in erosion and sedimentation in the waterways. If the local geology is unstable, landslips, mudflows and debris flows can all contribute to watercourse sedimentation.

[27] IATP (2007)
[28] Berndes *et al*. (2011)

Box 8.2: Land use change from palm oil in Indonesia

Palm oil plantations in Indonesia claim roughly 50,000 hectares of land per year. The carbon footprint of the palm oil industry has two components: emissions from deforestation, and emissions from the processing of palm oil. Converting forests to palm oil plantations results in the loss of large amounts of carbon from biomass and from the disturbed soil. Studies and estimates indicate that any carbon savings associated with palm oil expansion are far outweighed by the losses. It is estimated to take between 75 and 600 years for the carbon savings of petroleum displacement by palm oil biofuel to balance the carbon lost during the growth and manufacturing of the product.

Forests are usually cleared for palm oil plantation by logging and burning. In Katapang, Indonesia, fire was the cause of 90% of deforestation between 1989 and 2008, while 20% of wildfires across Indonesia can be attributed directly to palm oil plantation practices. Burning has adverse effects on human health, as the subsequent smoke can cause respiratory and cardiovascular disease and even death.

Deforestation through these processes in Indonesia is a leading cause of biodiversity loss. There has been a significant reduction in population densities and species richness for species of birds, mammals, bees, butterflies, moths, termites, dung beetles and ants. Additionally, iconic species such as the orangutan, found only on Sumatra and Borneo, are rapidly declining due to forest loss. In Riau, Sumatra, Sumatran elephants have declined by up to 84%, from >1000 in 1984, to approximately 210 in 2007. Sumatran tiger populations declined by 70% over a similar timespan. Although these statistics on biodiversity loss in Indonesia are not entirely directly attributable to palm oil plantations, palm production has been found to reduce biodiversity more than other types of crop plantations.

When forests and other natural vegetation is cleared for biofuel production, agrochemicals associated with such cultivation can pollute both land and water and have harmful impacts on terrestrial and aquatic ecosystems and can filter into groundwater.

Sources:
Duke University (2019)
ScienceDaily. www.sciencedaily.com/releases/2019/02/190201130603.htm;
ICCT (2016)
Uryu et al. (2008).

During large-scale forest clearing, earthmoving activities and road construction can increase erosion, particularly if there is inadequate attention to access road design and drainage. This often happens when temporary, lower cost and quality roads are built.

Increased erosion and sedimentation are common issues for poorly planned and managed agricultural areas[29] . In turn, this affects water quality and can modify the riverbed composition and geomorphology and cause the degradation or loss of habitats for fish and other aquatic life. An increased sediment load can affect a river a long way downstream and can smother aquatic vegetation and habitats. Very high sediment levels can smother aquatic invertebrates, and coat the gills of fish, causing suffocation.

Impacts on the quality of soil due to biofuel crops can degrade soil quality over time, lowering soil nutrient levels or changing soil chemical composition due to the inappropriate use of fertilizers and pesticides[30] . Changes in soil quality can result in:

- Abandonment of areas of land – once land is degraded, farmers may move to new areas, abandoning farms rather than rehabilitating them;
- Making land unsuitable for future agricultural use – severe impacts on soil can prevent the land from being used for different agricultural purposes without extensive rehabilitation; and

[29] Berndes *et al*. 2011)
[30] IFC (2016)

- Additional clearing for more fertile soils –when farmers are forced to move to prepare new areas for growing crops[31].

Loss of habitats and biodiversity

Clearing of land for large-scale biofuel crop production can cause significant loss of habitat and decrease in biodiversity[32] . Fauna, including protected and threatened species, are displaced when land is cleared (forests or other natural vegetation), forcing them to seek alternative suitable habitats, where available. This has a knock-on effect as the displaced individuals may then cause increased competition for food resources when they relocate or out-compete other less dominant species.

The building of access roads in a once undeveloped and relatively inaccessible area can also lead to habitat fragmentation, an increase in illegal hunting or poaching of wildlife species, as well as an increase in illegal harvesting of timber and other forest products. Increased access may lead to further in-migration and conversion of natural habitats to agricultural practices.

The conversion of environmentally sensitive and high biodiversity value lands to biofuel crop land can result in associated negative environmental impacts. Apart from loss of biodiversity, it can also result in increased CO_2 emissions from the loss of forests, an increase in weed species, the introduction of alien species, and runoff into waterways impacting aquatic flora and fauna.

Biodiversity can also be affected or killed as a result of using pesticides and herbicides on biofuel crops, which can run off from fields and enter waterways.

The loss of biodiversity and habitats can disrupt and unbalance the overall function of ecosystems and delivery of ecosystem services.

Crop waste products

If biofuel crop waste product residues (e.g., left over leaf material, roots, and other plant parts after harvesting) are not collected and transported to power plants, or when suitable storage facilities are not available, most farmers will have no option but to openly burn the residues. This has various health risks and can significantly raises levels of pollution, particularly smoke and particulate matter. Smoke problems are commonplace in Indonesia, India,[33] and other crop producing developing countries and can have cross-border impacts on neighbouring countries[34].

The burning of crop residues has an impact on soils. When the residues are not reincorporated in the soil, nutrients are lost and cannot benefit the next crop cycle (increasing the requirement to apply fertilizers), and organic matter is also lost leading to the deterioration of soil structure.

Rice is a common crop in Asia. Once the rice grains are removed from the stalks, the rest of the plant is usually discarded. Demonstration projects in India have started creating a crop residue supply chain so that rice waste is collected, stored, and turned into briquettes and pellets, which can replace coal in power plants[35]. There can be an environmental benefit from providing an economic incentive to farmers to stop burning crop waste and increase their incomes.

Land and ecosystem restoration

Whilst bioenergy crops may be grown on existing agricultural land, areas of existing forest may also be cleared to create new land for bioenergy crops. Where these are grown as a monoculture, such conversion can lead to significant biodiversity loss land degradation as discussed above.

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[31] Wu *et al*. (2018)
[32] IFC (2016)
[33] Bhuvaneshwari et al. (2019)
[34] Sheldon and Sankaran (2017)
[35] FAO (2010)

On marginal lands, the establishment of bioenergy crops, such as perennial grasses and short-rotation woody crops, offers possibilities for both successful eco-restoration and energy production. Forest landscape restoration (FLR) is being promoted as a means for reversing land degradation while providing multiple products and services, including bioenergy. FLR using biofuel-friendly trees under climate smart agroforestry practices and utilizing fruits, nuts and biomass for energy could solve multiple issues by turning unproductive degraded lands into productive landscapes; preventing further conversion of natural vegetation for other uses; compensating for the high initial investments required for FLR; and providing multiple ecosystem services, including climate regulation[36].

8.5.2 Socio-economic issues and impacts

Employment and labour conditions

Increasingly, the deployment of renewable energy is recognized as an opportunity that helps to diversify a country's skill base and expand industrial development. Bioenergy also offers significant employment opportunities in the emerging renewable energy sector.

IRENA reports that in Southeast Asia, Indonesia, Malaysia, Thailand, and the Philippines have seen increasing employment in the biofuels sub-sector, while a national review in the Philippines indicates that the growing, collecting and marketing of biomass fuels are handled by the informal sector and are labour-intensive[37] . The same study found that fuelwood and crop residues are a significant source of income and employment, particularly in rural areas. Approximately 700,000 households are involved in commercial biomass gathering and/or production in the Philippines[38] . Similarly, Latin America has approximately two million people working in the renewable energy sector, with biofuels in the lead (with Brazil the leading producer)[39] . While employment within the biofuel sub-sector is largely benefiting rural areas of low-income countries, it also boosts employment in higher-income cities such as Stockholm, Sweden[40].

Biofuel crop production, like other agricultural practices can be associated with the unacceptable use of forced and child labour[41] (Box8.3). In 2020, a human rights coalition was working to end forced labour in the palm oil industry[42], which contributes to bioenergy. The ILO reports that, worldwide, 60% of all child labourers in the age group 5–17 years' work in agriculture, including farming, fishing, aquaculture, forestry, and livestock[43].

Box 8.3: Child Labour in the sugar cane sector in Asia

Child labour in the sugarcane sector is evidenced in three key sectoral studies conducted in the Philippines, India, and Cambodia. In 2016, the United States Department of Labour also reported the issue in Myanmar, Pakistan, and Thailand.

The evidence from Asia shows that children working in sugarcane are employed both on smallholder farms as family helpers and on larger commercial plantations.

A survey conducted by the ILO in two sugar-growing regions in Cambodia in 2015, found that the incidence of child labour was more prevalent on smallholder farms than on commercial plantations (64% compared to 26%) and that children on smallholder farms tend to be younger (12 compared to 15 years old, on average). In the Philippines in 2015, it was estimated that over

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36 An introduction to bioenergy and landscape restoration - CIFOR Knowledge
37 IRENA (2017b)
38 Remedio and Domac (2003)
39 IRENA (2017b)
40 Remedio and Domac (2003)
41 The ILO defines forced labour as situations in which persons are coerced to work through violence or intimidation or by more subtle means such as accumulated debt, retention of identity papers, or threats of denunciation to immigration authorities.
42 See for instance CGF (2020)
43 ILO (undated)

13,500 children worked in the sugarcane sector (2.5% of children working in the agricultural sector). Most were thought to be unpaid family workers.

Source: ILO (2017)

Reports indicate that ethanol production in Brazil (based on sugar growing) is associated with significant labour abuse practices, including child labour, employing children as young as seven years old[44]. While Brazil is the main producer, and Thailand, Philippines, and Indonesia are also in the top 10 sugar producing countries[45].

Among renewable energies, bioenergy is the most labour-intensive sub-sector[46]. Like other technologies, employment opportunities range from manual labour to engineering. As bioenergy production from agricultural waste increases, there will also be potential to boost employment in the sub-sector, especially managing crop residues and wastes.

Jobs are created all along the bioenergy chain, from the production of biofuels to their transportation, distribution, and marketing. Employment can be direct (resulting from operation, construction, and production phases) or indirect (resulting from expenditures related to biomass fuel cycles).

The impacts and potential benefits of employment also depend on the country context and type of biofuel used in energy production (Box 8.4).

Box 8.4: Employment in the Biofuels sub-sector in Thailand

A recent study in Thailand found that producing ethanol and biodiesel requires about 17–20 workers and 10 times more workers than gasoline and diesel per energy content, respectively. In 2022, approximately 300,000 people were engaged in ethanol production. While there are significant differences in employment characteristics in the agriculture and biofuel processing sectors, direct employment in agriculture contributes to more than 90% of total employment in Thailand.

Source: Silalertruksa et al. (2012)

Local economy and livelihoods

In addition to providing employment, bioenergy projects can impact on livelihoods and local economies in other ways. They may require large tracts of land to grow energy crops. This may result in land acquisition, leading to the physical and economic displacement and subsequent relocation of people, including indigenous communities[47]. It may also lead to loss of income, e.g., from rice cultivation or other farming activities.

A study by the United Nations Food and Agriculture Organization focused on employment and the socioeconomics of bioenergy systems found that from a macroeconomic perspective, bioenergy contributes to:

- Import substitution with direct and indirect economic effects at the national, regional and local level;
- Economic growth through business expansion; and
- Mobilizing investments for rural areas.

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[44] Teixeira and Sherfinski (2021)
[45] ILO. 2017. *Child labour in the primary production of sugarcane*. wcms_ipec_pub_29635.pdf (ilo.org).
[46] EUBIA (undated)
[47] Karekezi and Kithyoma (2006)

The study notes that the human resources required to produce biofuels is about five times more than for fossil fuels.

Increased employment opportunities in the bioenergy sub-sector could help to address adverse social and cohesion trends, such as high unemployment levels, depopulation, and out-migration, which are more prevalent in rural areas. Bioenergy production tends to be in rural locations and may be beneficial here, helping rural areas and indirectly supporting related industries and services[48].

Food security and prices

Bioenergy projects may cause both positive and negative impacts on food security and prices[49].

Bioenergy requires a large and continuous supply of energy crops. Where these are also food crops (e.g., corn), their cultivation to meet the demand as a biofuel can lead to a reduction in their availability for public sale as a food. The increase in prices can consequently make consumable energy products unaffordable to disadvantaged people and the lower socioeconomic demographic who rely on the crops for food. The production of energy crops may also reduce the volume of food crops available, leading to malnutrition in rural areas[50] . Women, who are often responsible for sourcing family food supplies, may be affected more than men. Bioenergy demand may also increase the price of biofuel products, creating more commercial opportunities for medium-scale producers or wealthy farmers.

Drawing on global data on food prices, food consumption and land-use change (especially in European countries), research by Muscat et al. (2020) shows that bioenergy projects and the increased use of biofuels causes competition for resources and lowers food crop yields[51] . This is because overall capacity to produce both biomass and food is limited to the amount of available arable land.

A balance is required between food and energy production, especially to meet the demands of the ever-increasing population and to minimize pressure on natural resources and ecosystems. Large-scale biofuel and bioenergy production also increases the demand for arable land, raising the unit cost of food production. Hasegawa et al. (2020) argue that increased population and demand for food has already led to higher food prices, reducing resource availability (such as land for agricultural cultivation) to fulfil everyone's needs[52]. This trend could cause adverse impacts on poor and vulnerable communities.

Indonesia is among the world's largest palm oil and biofuel producers. The country has seen steep increases in food prices and supply shortages from 1990 to 2013[53] and from 2020 to present, including for basic and staple ingredients and commodities. A study of the use of biofuel from agricultural crops for transportation in Indonesia showed that widespread bioenergy generation and the growing of biofuel have the potential to result in food crises, if mismanaged[54]. The study also showed that smallholder farmers in Indonesia are also more willing to sell their crops to international biofuel companies, largely driven by the higher price and income potential, adding further challenges to food security and sustainable management of resources.

Health and safety

Biofuel production can have negative health and safety impacts. Traffic levels can increase due to the transportation of fertilizers and other crop inputs, and the transport of harvested crops to processing facilities and pellets to powerplants, can lead to increased risks of accidents and localized pollution.

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[48] GNESD (2011)
[49] FAO (2012)
[50] IFPRI (2008)
[51] Muscat, A. *et al*. (2020)
[52] Hasegawa et al. (2020)
[53] DKP, KP and WFP (2015)
[54] Colbran and Eide (2008)

The increased traffic and operation of machinery can cause congestion and increase noise levels that can disturb local communities and wildlife.

Farm workers will also face health impact risks from using pesticides and fertilizers, which contain hazardous chemicals. Communities can also face health risks due to air emissions from biofuel combustion, the management of waste pesticide containers and packaging and the pollution of waterways from runoff of biocides. Such pollution can also put downstream communities and aquatic environments at risk.
For agriculture production, the IFC EHS guidelines[55] identify various OHS issues, including:

- Physical hazards (overexposure to noise vibration, and extreme or adverse weather conditions, use of machinery and vehicles, potentially confined spaces, and exposure to organic dust);
- Risk of fire and explosion from combustible dust;
- Safety when working in silos;
- Biological hazards (contact with venous animals); and
- Exposure to chemical hazards (fuels, pesticides and herbicides).

For community health and safety, the guidelines recognize that changes to land use may affect natural buffer areas and result in increased community vulnerability to manage weather patterns. There may also be exposure to potentially harmful chemicals in postharvest products and risks of vehicle or machinery injuries on roads and access routes used around local communities.

The operation of bioenergy power plants can cause bad odours that require managing and mitigation.

Health problems can arise from poorly designed bioenergy plants that produce high levels of specific emissions[56] . When biomass replaces coal in a modern power plant, there can be some reduction of the emission of sulphur dioxide or particles[57]**.**

Land value

Growing crops for biofuel production is land-intensive and can put significant pressure on the land used for conventional agriculture, forest production, and conservation. When existing arable land is converted to biofuel production, competition for land generally increases.

In Thailand, land used for sugarcane and palm oil cultivation is expected to increase significantly by 2026. Promoting sugarcane and palm oil cultivation has been a controversial policy decision due to the increasingly limited yields per area, and the conflict between crop supply and increasing demand for land for biofuel production[58].

Global analysis of biofuels and land-use change[59] has found that biofuel production will account for approximately 20% of global land-use change between 2006 and 2035. In Southeast Asian countries such as Indonesia and Malaysia, this could translate into the expansion of biofuel production and cultivation of large areas of agricultural land, and the clearance of forest land by bioenergy companies, further limiting the ability of communities to purchase and make use of land locally.

In addition, land value is also expected to climb sharply, potentially resulting in land disputes and conflict between stakeholders over licenses to operate[60]. A report in 2021 by the Carbon Disclosure Project highlights the lack of transparency by biofuel producers in Indonesia. According to Jong (2021), there is continued illegal use of land and transformation of forests and arable land to biofuel production, infringing the land rights of local communities[61] . The project claims that the Government

[55] IFC (2016)
[56] Stashwick (2016)
[57] Air Quality Expert Group (2017)
[58] Jusakulvijit, *et al*. (2021)
[59] IEA (2022b)
[60] Bruce and Boudreaux (2013)
[61] Jong (2021)

of Indonesia has committed to allocating over 4 million ha of land to support biodiesel production by 2025, with a list of Singaporean, Dutch, and Indonesian energy companies.

Gender and vulnerability

The transition to bioenergy is a land-intensive process and therefore requires access to, and availability of, large quantities of arable land. This can lead to heightened vulnerability among communities currently reliant on land access for much needed subsistence rice and crop cultivation[62]. As with other renewable technologies, there can be asymmetrical impacts on women and vulnerable groups (i.e., persons with disabilities, older people, indigenous people) associated with displacement and access to land benefits[63].

As affected households become exposed to greater economic pressures and food insecurity, the social risk factors identified in other renewable technologies are heightened, with differential impacts felt by women and vulnerable groups. For example, there are increased financial and domestic burdens on women, a risk of sexual and gender-based violence, and resulting physical and mental health issues experiences by the communities affected. Often women have the main responsibilities for sourcing food and making meals. Changes of land use that affect food availability may change (often increasing) the amount of time they need to spend on these activities.

The potential environmental risks associated with bioenergy (i.e., reduced air quality and impacts on water quality from pesticides usage[64] among others) may also decrease the resilience of rural communities and individuals to external shocks and hinder their ability to cope with climate change impacts. Women and girls in rural areas may thereby be affected by a double burden of intersecting disadvantages[65].

In 2019, IRENA conducted a survey of gender in renewables with 1440 global respondents.[66] The participating organizations and individuals rated bioenergy as the second most relevant renewable technology for their work after solar, and among the top three renewable energy types. This technology is therefore ripe with opportunity and has real potential to promote sustainable and inclusive growth for women and vulnerable communities through local employment generation, training, and skills development.

Indigenous communities

Subsistence-based indigenous peoples rely on the land and natural resources for their livelihoods and cultural practices, such as communal land use.

Bioenergy development projects can require large amounts of land to grow energy crops. The acquisition of land for these projects can cause the loss of indigenous communities' communal land and traditional use practices[67] . The development of bioenergy projects also has the potential to physically restrict access by indigenous people to their natural and cultural resources such as sacred forests, burial grounds, and animistic sites (Box 8.5).

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[62] Remedio and Domac (2003)
[63] Differential impacts of displacement and access to any resulting benefits are explored in greater detail in the Hydropower Gender and Vulnerability subsection of Chapter 5 (hydropower).
[64] McGill. 2022. *Socioeconomic and environmental impact of bioenergy*. Socioeconomic and environmental impact of bioenergy | Bioenergy Research - McGill University.
[65] Rossi and Lambrou (2008)
[66] IRENA. 2019. *Renewable Energy, A gender perspective*. Renewable energy: A gender perspective (irena.org).
[67] Zurba and Bullock (2020)

Box 8.5: Impacts of biofuel production on indigenous people of Guaraní in Mato Grosso do Sul, Brazil

In Brazil, the activities of a multinational energy corporation growing sugarcane for biofuel is alleged to have caused severe negative impacts on the indigenous Kaoiwá and Guaraní community near Dourados in the southwestern state of Guaraní in Mato Grosso do Sul. The community suffered the use of forced labour, conversion of agricultural lands to monoculture sugarcane farming and illegal land grabbing, which displaced the community from their ancestral lands and access to important cultural resources and consigned them to small reserves. After 2 years of protests, the company signed an agreement to forgo buying sugar cane grown on the indigenous communities' lands.

Sources: EJ Atlas (2017); BBC News (2012)

Public services and infrastructure

A supply-side opportunity associated with local bioenergy production is the potential for the improvement of infrastructure for the local community.

Large biofuel plantations can offer an alternative to subsistence farming for the rural poor and can provide public infrastructure and amenities for employees and their dependents, including housing, water, electricity, roads, and medical care[68] . Road networks are often built to access plantations, as well as additional public infrastructure, such as schools and hospitals for employees. Oil-palm plantations in Malaysia employ over half a million people, with the provision of infrastructure that Malaysians and foreign workers benefit from and grow dependent on[69] . Biomass companies' financial support for local communities can also be used by local authorities to enhance existing public infrastructure services, such as schools or hospitals.

However, an OECD/IEA publication in 2013 focused on bioenergy project development and biomass supply around the world, especially Australia, UK, and Norway. It identified some negative impacts as a result of improved and new access roads used for the collection and transportation of biomass. These included: higher local air pollutant emissions due to increased vehicular traffic (from exhausts), increased accidents, pedestrian safety and greater wear and tear of roads themselves[70].

Infrastructure provision may also not always happen without concrete commitments, and community infrastructure improvements require large sums of upfront investment, which can present challenges, particularly in rural low-income locations (Box8.6).

Box 8.6: Inadequate infrastructure for biofuel production in rural Myanmar

In 2005, in response to rising energy costs and protests over cuts in diesel subsidies, the government of Myanmar established a project to produce biodiesel from Jatropha (a shrub tree). Various reports estimate that the planting area ranged from 200,000–400,000 hectares (ha), with a planned expansion to 3 million ha.

Production occurred on large, centrally planned plantations, on military sites, and in rural villages. Farmers with more than 1 acre (0.4 ha) of land were directed to plant Jatropha on their landholdings and often were required to pay for the seeds. Human rights groups claimed that farmers who refused to plant Jatropha were at risk of being jailed. Other reports suggested that military rulers had confiscated land and used forced labour in some locations. Another concern

[68] Koh and Wilcove (2007)
[69] Cushion *et al*. (2010)
[70] IEA (2007)

was that the required planting of Jatropha crops displaced food production in the poor, rural areas of Myanmar.

The directive was not matched by adequate infrastructure (collection mechanisms, processing plants, distribution systems) to process the Jatropha crop. As a result, Jatropha seed production did not translate into increased fuel production. In response, on 27 February 2009, a Japanese company, the Bio Energy Development Corp (JBEDC), announced that it would establish a joint venture with a Myanmar private company for biofuel development. The new company, Japan-Myanmar Green Energy, aimed to export 5,000 metric tons (MT) of seeds in 2009 and start operating its first oil mill plant in 2010. It also planned to distribute and export Jatropha-derived fuel in addition to its seed. Globally, Jatropha has not met expected yields or investor returns.

Source: Cushion et al., (2010)

CHAPTER 9

KEY ISSUES FOR SEA IN THE GEOTHERMAL ENERGY SUB-SECTOR

9.1 WHY SEA IS IMPORTANT TO THE GEOTHERMAL ENERGY SUB-SECTOR

SEA can provide critical information to support better decision-making for geothermal energy planning and development, including identifying where there might be significant environmental and/or socio-economic risks. This information can be particularly important as regards identifying and assessing the scale and significance of the possible cumulative impacts of multiple geothermal energy schemes/developments.

The SEA process will:

- Identify and focus on key environmental and socio-economic issues and the concerns of likely affected stakeholders, including local communities, marginalised groups and indigenous peoples. Major issues are discussed in detail in section 9.5 and summarised in Table 9.3.
- Identify/recommend if there are areas that should be avoided for geothermal energy development ('no go' areas) because of particularly high risk to the environment, habitats/biodiversity and/or people.
- Make subsequent project-level EIAs more efficient and cheaper by addressing the big picture and cumulative potential impacts, identifying the particular issues that individual project EIAs should focus on in more (site-specific) detail.
- Engage stakeholders (particularly in areas where geothermal power potential has been identified) including communities, marginalised groups and indigenous peoples which can be particularly affected by geothermal energy developments - to be informed of proposed or possible policy options or plans and enable them to provide their perspectives and present their concerns. This will enable key issues to be identified and verified, help build understanding and support for geothermal energy development, and avoid future misunderstanding and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 3 and are therefore not repeated in this chapter.

9.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE GEOTHERMAL ENERGY SUB-SECTOR

An international survey of existing SEA guidelines conducted for the IAIA was unable to identify any that are specifically focused on the geothermal power sub- sector. Several recent guidelines specific to EIA for geothermal energy development projects have been identified in Australia and Europe[1],[2].

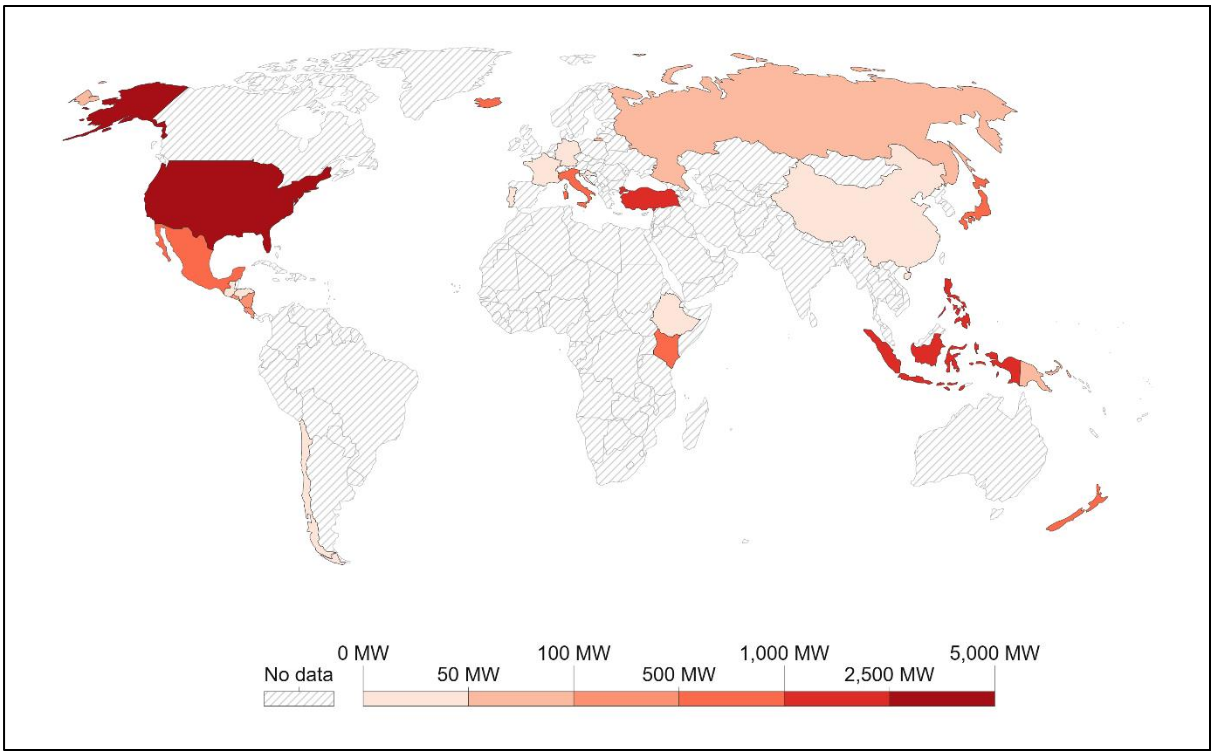
Some international agencies have produced guidance on environmental and social issues related to geothermal energy generation[3] and various sources discuss the environmental impacts of geothermal energy[4]. Whilst not a guideline, the World Bank has completed a rapid environmental and social impact assessment of geothermal energy development in Indonesia which identifies key risks and impacts typically associated with geothermal power development in forest areas [5].

[1] Guideline for the Development of Petroleum, Geothermal and Pipeline Environment Plans in Western Australia (dmp.wa.gov.au)
[2] geoenvi.eu/publications/proposal-for-a-harmonised-procedure-on-the-environmental-impact-assessment-and-licensing-guidelines-for-geothermal-development-in-europe/
[3] e.g., IFC (2007)
[4] e.g., CEI (2019); Energysage (2019); UCS (2013b); Bošnjaković *et al*. (2019)
[5] Meijaard et al. (2019)

9.3 GEOTHERMAL ENERGY INSTALLED CAPACITY

The installed capacity of geothermal energy has gradually increased worldwide over the last decade, reaching 14.075 MW in 2020[6] (Table 9.1). Figure 9.1 shows the global distribution of installed capacity. The top 10 countries in 2020 are listed in Table 9.2.

Figure 9.1: Installed geothermal energy capacity, 2020



Source: www.ourworldindata.org, based on BP (2021)

Table 9.1: Installed geothermal energy capacity, 2020
Source: www.ourworldindate.org

Region	Installed capacity (MW)
World	14,075
Africa	831
Asia-Pacific	5,650
Europe	3,265
North America	3,493
South & Central America	762

[6] www.ourworldindate.org

Table 9.2: Top 10 geothermal countries, 2020
Source: www.geothermalenergy.com

Country	Installed capacity (MW)
USA	3,714
Indonesia	2.133
Philippines	1.918
Turkey	1,688
New Zealand	1.005
Mexico	963
Italy	944
Kenya	861
Iceland	755
Japan	603
Other	1,025

9.4 BACKGROUND TO GEOTHERMAL ENERGY GENERATION

Geothermal energy is generated in countries located on or near seismically and volcanically active tectonic plate boundaries. There are four main types of geothermal power plants:

- Dry steam plants use steam directly from a geothermal reservoir to turn generator turbines.
- Flash steam plants take high-pressure hot water from deep inside the earth and convert it to steam that drives generator turbines.
- Binary-cycle power plants transfer the heat from geothermal hot water to another liquid.
- A hybrid system.

Geothermal power plants operate by extracting the Earth's heat in the form of steam or hot water which, in turn, is used to drive a steam turbine and generate electricity. There are two basic systems: open-loop systems which can require a large amount of cooling water (with potential to over exploit available water resources); and closed-loop systems return the water to the underground source.

The geothermal energy is captured through drilling production wells deep into groundwater reservoirs and then extracting and piping the hot water and steam to a power plant where it drives a turbine. This technology requires cooling towers or air-cooled condensers to cool the steam used to drive the steam turbine. Three main cooling options are used: a) surface water (once-through systems), b) wet type cooling towers, and c) dry type cooling towers[7]. Cooling with surface water yields the lowest condensing pressure and temperature and the highest conversion efficiency, followed by wet cooling towers, and then by dry cooling towers.

Steam is released to the atmosphere in this process. Wastewater effluents and gases are typically reinjected into the reservoir or its periphery to minimize the potential for groundwater contamination[8].

An example of a geothermal power plant is the 330 MW Sarulla plant geothermal power plant in Sumatra, Indonesia[9] (Figure 9.2) (see also Box 9.1).

[7] Dry cooling towers conduct heat transfer through air-cooled heat exchanger that separates the working fluid from the cooling air. Wet cooling towers expose the hot water to the ambient air, and it is cooled through the process of evaporation.
[8] IFC. 2007. *Geothermal Power Generation environmental, health and Safety Guidelines. Annex A: General Description of Industry Activities*. Washington, DC.
[9] Sarulla. Overview - Sarulla Operation Ltd. (sarullaoperations.com)

Figure 9.2: Sarulla Geothermal Plant, Indonesia

Sarulla Geothermal Plant, Indonesia
Source: Sarulla Operations Limited Home - Sarulla Operation Ltd. sarullaoperations.com

Unlike solar and wind energy, geothermal energy is constantly available. Hence, it provides both baseload power and firming power[10] for when variable renewable energies (e.g., wind or solar) are unavailable.

The environmental and social effects of geothermal energy are dependent on how and where geothermal energy is extracted. Access roads, pipelines and transmission lines are required to be constructed, often in areas that have had little or no previous development. Other infrastructure such as workers camps may be required.

During operation, freshwater may be required to cool exhaust gases (before they are passed through amine scrubbers to reclaim the amine solvents) and for cooling towers. Projects may have a wastewater treatment plant located within the production complex. Processed wastewater from exhaust gas washing and reverse osmosis plants and cooling tower wastewater are all directed to a wastewater treatment plant for treatment prior to discharge to a public sewage system, where this exists[11] . Storm water from handling areas from the production complex needs to be drained through a sedimentation trap drain to an oil and grease separator, after which it might be discharged to natural waterways[12].

9.5 IMPACTS OF GEOTHERMAL ENERGY DEVELOPMENT

During scoping for a SEA, key issues regarding geothermal energy development should be identified. They will be used to focus the SEA on the most important issues and to help develop environmental and social quality objectives (ESQOs) – that address these issues - to be used during the main assessment stage. The key issues will be identified by reviewing relevant documents (e.g., EIA and special subject reports, environmental/social profiles, sector and inter-sector strategies, donor

[10] Matek and Gawell (2015)
[11] Englande *et al*..(2015)
[12] Meland (2016)

documents, academic papers, other geothermal energy development applications etc.), interviews with key informants and during stakeholder consultations at national to local levels. Many of the issues will be well known as a result of implementing existing geothermal energy development projects.

At the individual project-level these issues will be the focus of an EIA which should recommend how to manage or mitigate project impacts associated with these issues that might be likely to arise. Ideally, before individual geothermal projects are approved, a policy, plan or programme (PPP) for the geothermal energy sub-sector should be completed and an be subjected to an SEA. This should assess the risks and impacts of multiple projects, schemes and activities likely to arise from implementing the PPP: some directly concerned with the construction and operation of sites and facilities; others linked to associated infrastructure (e.g. transmission lines, access roads). Thus, there is a risk that the impacts of individual geothermal energy developments/projects may become highly significant as they become cumulative. A SEA should be focus on the potential for such cumulative impacts and make recommendations for addressing them. This may include recommending thresholds for particular factors that should not be breached by an individual project (and which should be addressed by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it. Often, the timing of individual geothermal energy project applications and overarching SEA planning is not synchronized, and SEA may have to “catch-up” to the pace of individual projects rather than providing upstream (pre-project) guidance as to how they should proceed.

Table 9.3 summarises the key environmental and socio-concerns concerns likely to be associated with geothermal energy development.

Table 9.3: List of key environmental and socioeconomic issues for geothermal energy

ISSUE	COMMENT
Environmental	
Air quality	• Geothermal power plant emissions are negligible in comparison to fossil fuel-based power plants • Some small amounts of carbon dioxide are found in plant steam and site vents can also produce very small levels hydrogen sulphide emissions. • Well emissions in open-loop systems include sulphur dioxide, hydrogen sulphide, carbon dioxide, ammonia, methane, and boron • Some geothermal plants also produce small amounts of mercury emissions, which must be mitigated using mercury filter technology. Scrubbers can reduce air emissions, but they produce a watery sludge composed of the captured materials, including sulphur, vanadium, silica compounds, chlorides, arsenic, mercury, nickel, and other heavy metals. This toxic sludge often must be disposed of at hazardous waste sites
Greenhouse gases	• Geothermal energy can reduce GHG emissions where it displaces coal as a fuel source
Noise	• Noise from well exploration (installation, testing), construction machinery and vehicles, and maintenance activities during operation
Soil erosion	• From clearing of vegetation and construction of access roads
Water quality	• Chemical pollution of surface water and groundwaters. Hot water pumped from underground reservoirs often contains high levels of sulphur, salt, and other minerals—can affect local water quality if not a closed-loop system (water pumped directly back to geothermal reservoir after it has been used for heat or electricity production). Surface water used by geothermal plants is normally returned to the original source with some increase in heat • Fluids used during drilling activities may be water- or oil-based and may contain chemical additives. Cuttings from oil-based mud may have high oil-related contaminants in effluent • Rejected water from geothermal separators may contain heavy metals • Well blowouts can result in the release of toxic drilling additives and fluids, as well as hydrogen sulphide from underground. • Pipeline failures can result in the surface release of geothermal fluids and steam containing heavy metals, acids, mineral deposits, and other pollutants
Water use	• Geothermal plants can require between 1,700 and 4,000 gallons of water per megawatt-hour • Open-loop systems can require a large amount of water (with over exploitation of available resources); closed-loop systems return the water to the underground source
Habitats and biodiversity	• Land clearing for well pads, pipelines and access roads • Fragmentation of habitat from access roads, pipelines and transmission lines • Increased poaching and hunting due to increased access to areas and introduction of workforce into an area • Risks to birds/bats from collision with overhead power lines.
Protected areas	• Geothermal sites may be close to or within protected areas • Many geothermal sites are in remote and sensitive ecological areas • Improved access, roads, and transmission lines increase vulnerability of protected areas
Waste	• Geothermal power plants produce at a relatively minimal amount of waste. But there is potential for leaching of silica compounds, chlorides, arsenic, mercury, vanadium, nickel, and other heavy metals which may be classified as hazardous
Earthquake risk	• Hydrothermal plants are sited on geological “hot spots," which tend to have higher levels of earthquake risk

ISSUE	COMMENT
Visual and aesthetic value	• The visual amenity of the landscape will change. This may reduce appeal of the area to tourists, but may create opportunities for industrial tourism (visits to facility)
Land and ecosystem restoration	• The average lifespan for geothermal power plant is 20-25 years for the indoor components, and 50 years of more for the ground loop. If and when decommissioning takes place, restoration of the site to its former status/condition will be required.
Socioeconomic	
Local economy and livelihoods	• Relocation of people and their structures • Increased pressure on the host communities' public services • People displaced from their economic activities, such as rice cultivation • Loss of income from fishing activities, rice cultivation, and other farming activities, damage to crops from discharges • Loss of income from small business and enterprise activities due to acquisition of land by energy companies • Conflict between communities and geothermal energy companies over land ownership • Negative impact on indigenous communities and their traditional or customary land and resources • Benefits to local economy from jobs created (see: employment and labour conditions below)
Employment and labour conditions	• Employment in the construction and operation phases of projects and associated businesses and activities • Substandard working conditions • Worker safety • Workers have the opportunity to learn new skills
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and indigenous communities) may be disadvantaged and at particular risk • Gender-based violence and human trafficking resulting from an influx of predominantly male construction workers • Employment opportunities within new projects • Opportunities for vulnerable groups to acquire new skills and learn new technologies
Cultural heritage	• Loss of religious, historical and archaeological sites and properties • Cultural heritage may be destroyed or damaged due to transmission lines, pipelines and access roads • Limited access to cultural heritage sites
Health and safety	• Nearby communities may be exposed to air pollution including hydrogen sulphide gas • General hazards for local communities may include contact with hot components, equipment failures, and presence of active or abandoned wells. • Short-term disruptions such as traffic, road, influx of population, noise, vibration, odour and steam
Public services and infrastructure	• Infrastructure (e.g., roads, bridges, schools, health centers, and administrative buildings) may be improved due to community investment by geothermal energy companies • Pressure on public services and infrastructure will increase as a result of inmigration • Heavy vehicles and transportation damage existing roads and bridges • Increased vehicle traffic during construction

9.5.1 Environmental issues and impacts

Habitats and biodiversity[13]

The location of geothermal power projects is predominantly selected based on geological conditions that are suitable for the highest yield of geothermal energy. Such locations may occur in natural habitats (which can sometimes be critical habitats) such as the dense forests of Sumatra in Indonesia. Alternatively, they could be within modified habitats such as plantations or rice fields, which may still harbour significant biodiversity value. It is common that forests and vegetation need to be cleared by heavy machinery to allow for the construction of the required infrastructure such as well pads, power plants, cooling towers, pipes and pipelines, access roads, transmission lines, and other associated facilities.

Clearing results in direct loss of habitat and displaces fauna (which can include protected and threatened species) that depend on it. Animals are forced to seek alternative suitable habitats in other areas of the forest, if available. This has a knock-on effect as the displaced individuals may cause an increase in competition for resources in such other areas, or out-compete other less dominant species. There can also be road kills due to collisions with construction vehicles on access roads.

Significant long-term impacts on biodiversity typically arise from the development of access roads and transmission line easements due to habitat fragmentation. This occurs when an area of habitat that was originally “whole” before the development becomes divided into multiple areas due to partitioning. For fauna species, fragmentation creates a barrier effect by limiting or preventing their movements to areas of the habitat that they would have previously accessed for food, shelter, or breeding grounds. Arboreal species (i.e., those that almost exclusively move in the tree canopy), small mammals and slow-moving species are particularly vulnerable to habitat fragmentation.

In the long term, once forests have been permanently fragmented, the gene pool of both flora and fauna species tends to be less diverse, and more vulnerable to unpredictable and chance events such as lightning strikes and floods. The creation of access roads through a forest also introduces an ‘edge effect’, where micro-climates become permanently modified, and plant species struggle to survive when exposed to an increased amount of sunlight. Access roads also increase the risk of introducing invasive species.

Access roads constructed through a once undeveloped and relatively inaccessible area can also lead to an increase in illegal hunting or poaching of wildlife, as well as an increase in illegal harvesting of timber and other forest products.

Wildlife can also be displaced from their habitat near a geothermal development due to construction noise such as vehicles and drill rigs, but also noise from operations (vehicles and plant)[14] . Similarly, floodlighting at a geothermal power plant site can also cause the displacement of wildlife species that are not able to tolerate such changes in their environment and can force them to seek other habitats, potentially displacing less dominant species and increasing competition for resources and shelter.

Sulphur emissions from geothermal plants can hinder the growth of vegetation around the site.

Once a geothermal well pad has been established, it is usually tested for its viability and yield. More often than not, some well pads will be unviable, and more drilling than initially planned will be required. In some cases, a well pad is decommissioned or abandoned altogether. Typically, the original planned footprint of a geothermal power project will be subject to change and may increase in area with greater loss of habitat than originally envisaged.

The development of multiple geothermal projects across a region would amplify the negative effects on habitats and biodiversity, potentially resulting in a significant cumulative displacement or loss of biodiversity, even though the impacts of the individual projects may be limited.

[13] Ng et al. (2021)
[14] ADB (2017)

The loss of biodiversity and habitat, or the alteration of the ways in which species can utilize the habitat, can disrupt, and unbalance the overall function of the original ecosystem and can result in additional loss of some species and ecosystem services[15].

These issues need to be assessed and mitigation measures identified (
Box9.1).

Box 9.1: Risks to habitats and biodiversity at Sarulla geothermal power plant, Indonesia

The Sarulla Geothermal Project in Indonesia (Figure 9.2) was developed in an area of high biodiversity value. It was found to pose several risks to high value habitats and biodiversity including:

- Loss of connectivity between habitats due to the creation of access roads through habitat;
- Mortality of fauna species from collisions with vehicles;
- Increase in hunting or poaching of threatened species;
- Clearing of habitat for project components including well pads;

A Critical Habitat Assessment and Biodiversity Action Plan was developed for the project to mitigate the risks. The Biodiversity Action Plan recommended actions to be undertaken by the project company including: designing road crossing for primates, raising community and workforce awareness about the value of the habitats and species in the area, and implementing speed limits to avoid collisions with fauna species.

Source: ADB (2019); ADB (2020)

Protected areas

There is a risk that geothermal developments could be in or near protected areas such as national parks, to make the most of the available geothermal resource. In some areas, it is difficult to avoid encroaching on protected areas to create wells for a development or to construct an access road or a transmission line to export the energy to the electricity grid. The terrain on fault lines is generally steep and, in some instances, the only feasible access route to get to the geothermal resource may be to traverse a portion of a protected area.

Similarly, in some instances, routing a transmission line through a portion of a protected area may be the most cost-effective or only feasible technological solution open to a development's design.

Encroachment into protected areas results in direct habitat loss and fragmentation of habitat (see previous section). However, the impacts can be even more significant as protected areas are intended for conservation purposes and, as such, host a range of protected flora and fauna species that may not exist in significant numbers elsewhere and these species may be particularly sensitive to disturbance and human presence. Thus, encroachment into protected areas can lead to a loss of high value biodiversity. This is particularly true if these habitats are also critical habitats.

A geothermal energy development may inadvertently increase access to protected areas, even if the development or its associated infrastructure is not actually located within the protected area. This can lead to degradation of the protected area by enabling illegal take of wood or other resources from the protected area as well as increasing the opportunity for illegal poaching.

[15] IFC (2012d); ADB (2019 and 2020)

Air quality

In closed-loop geothermal energy systems, gases removed from a well are not released to the atmosphere but are injected back into the ground after giving up their heat, so air emissions are minimal. In contrast, open-loop systems emit hydrogen sulphide, CO_2, ammonia, methane, and boron[16].

Once in the atmosphere, hydrogen sulphide changes into sulphur dioxide (SO_2) which can have a strong odour when emitted in high concentrations. This contributes to the formation of small acidic particulates that can be absorbed by the bloodstream and cause heart and lung disease. At high enough levels (1,000 parts per million by volume [ppmv]), sulphur dioxide can cause death[17] . Sulphur dioxide also causes acid rain, which damages crops, forests, and soils, and acidifies lakes and streams. However, SO_2 emissions from geothermal plants are approximately 30 times lower per megawatt-hour than from CFPPs[18].

Emissions of hydrogen sulphide from geothermal power plants can cause odour annoyances among members of the exposed public - some of whom can detect this gas at concentrations as low as 0.002 parts per million by volume[19].

Some geothermal plants also emit small amounts of mercury, which must be mitigated using mercury filter technology such as “scrubbers” or air filters. This is generally due to the nature of the local environment, i.e., thermal waters can naturally contain mercury and arsenic. For instance, a study in West Java showed that thermal waters could naturally contain up to 2.6 ppm arsenic (As) and 6.5 ppb mercury (Hg), and the surface hydrothermal alteration could contribute up to 50 ppm As and 800 ppb Hg.

However, geothermal power plant emissions are negligible compared to those of fossil fuel combustion-based power plants or bioenergy. For example, geothermal power plants emit approximately 1% of the sulphur oxide (SOx) and nitrogen oxide (NOx), and 5% of the CO_2 emissions of a coal-fired thermal power plant of similar power generation capacity[20].

Scrubbers can reduce air emissions of mercury, but they produce a watery sludge composed of the captured materials, including sulphur, vanadium, silica compounds, chlorides, arsenic, mercury, nickel, and other heavy metals. This toxic sludge must be disposed at hazardous waste sites.

Local air quality can also be affected during construction due to emissions from construction vehicles and the creation of dust. Occupational exposure to geothermal gases (mainly hydrogen sulphide) may occur during non-routine release of geothermal fluids (e.g., due to pipeline failures) and maintenance work in confined spaces such as pipelines, turbines, and condensers. The significance of the hydrogen sulphide hazard may vary depending on the location and geological formation particular to the facility.

Water quality

Closed-loop geothermal systems have few impacts on water quality as most of the extracted water is returned to the underground source via a second well, so there are little or no discharges to the environment. However, in open-loop systems, there can be risks associated with the discharge of geothermal water to receiving water bodies. Such water (brine) extracted from underground reservoirs often contains high levels of sulphur, salt, and other minerals that can negatively affect water quality of the water body or waterway that it is discharged to and/or if there is runoff downstream. In turn, this can lead to a deterioration or alteration (even loss) of aquatic habitat as well as effects on

[16] Kagel *et al*. (2005)
[17] Layton *et al.* (1981)
[18] UCS (2013b) y
[19] Layton *et al.* (1981)
[20] Duffield and Sass (2003)

downstream users of the water. There have also been instances when steam emissions from the geothermal energy process have corroded building roofs and damaged crops of nearby communities.

Under both open- and closed-loop systems, there are risks that construction and operation activities will have a negative impact on water quality because of soil erosion and subsequent sedimentation of waterways (see section on soil erosion) or may result in accidental hazardous waste discharges (see next section).

Accidental spills of contaminants and geothermal fluids can occur during the drilling and construction stages which can have a negative impact on surface water quality[21].

If not well managed, polluted runoff from well pads and ponds, especially during rainy season floods, can also affect water quality.

Waste

The biggest source of solid waste on a geothermal project is the earthen drill cuttings material (soil, rock, mud) extracted during the drilling process. This is temporarily stored in drill pits and mud from the drilling process is stored in temporary mud pits[22]. The material then needs to be transported to landfill if an option for reuse is not available.

Other construction waste streams would include:

- Material from packaging,
- Building materials,
- Scrap metals,
- Excess soil material,
- Plastic and masonry products,
- Cleared vegetation,
- Sanitary wastes,
- Empty chemical storage containers, and
- Concrete wash out water.

These wastes can pose a risk to water and soil quality and put pressure on landfill if not managed appropriately.

Water use

Closed-loop systems recapture the steam of the geothermal water after it has driven the steam turbine, condense it back to water via a cooling process and return the water to the ground via a second well. This means that almost all the water is returned to the underground source. Nevertheless, there are some water losses (approximately 2%) from evaporation and 'blow down'[23]. However, in the less common open-loop systems, the geothermal water is not returned to source. Some is lost as steam through the cooling process, but the remainder is condensed and transferred to large-scale cooling ponds and subsequently discharged (e.g., to a marine or freshwater environment).

In the drilling stage of geothermal power plants, high volumes of surface water are required and are usually taken from nearby rivers or lakes, if accessible. In Southeast Asia, there is often sufficient surface water availability in the wet season but not in the summer dry season[24].

[21] World Bank (2017)
[22] ADB (2019)
[23] Blow down refers to a process whereby some water from the cooling system is purposely released and new cooling water added to the system to avoid a build-up of minerals such as salts in the cooling system to avoid corrosion.
[24] Alamsyah *et al*. (2020)

Similar to thermal power plants, open-loop geothermal plants also require a source of cooling water that is separate to the geothermal resource. This water could come from either a freshwater or groundwater source and typically would draw approximately 9000 litres per megawatt-hour (MWh)[25] . Depending on the availability of water resources in an area, this can lead to excess demand on local water resources which reduces freshwater available to local communities and for livestock and crops. This can be a particular problem for communities in the dry season.

The condensate from the steam cycle is used in the cooling system. Approximately 70% of the water is evaporated by the cooling tower[25]. Alternatively, air-cooled condensers may be used. These use large-scale fans to generate a flow of cool air to condense the steam to water. Such condensers do not require a water source to operate, but they create noise (see section on noise).

Soil erosion

Soil erosion can occur when land is cleared for geothermal project components, access roads, and transmission lines. Large volumes of soil can be excavated for levelling well pads and creating access roads[26]. This removal of vegetation (particularly roots) decreases soil stability.

High rainfall events are common in Southeast Asia and can cause exposed soils to wash away, leading to sedimentation of nearby waterways. This can reduce water quality and result in alteration or loss of habitat for aquatic species. Soil erosion can also lead to localized landslips, a health and safety risk for communities (see section on health and safety).

Noise and vibration

The development of a geothermal energy facility involves several construction and commissioning phases that may produce adverse levels of noise and vibration:

- Steamfield development involves drilling geothermal wells - producing noise and vibration from drilling and well-testing activities, mud pumps, compressors, hydraulic pumps, and generators;

- Purging geothermal wells to remove debris involves a vertical discharge generating a very high noise level. However, this is typically for only a few hours. Few mitigation options are available, apart from shielding the well outlet and scheduling the activity to periods with a lower risk of intrusion (such as during a weekday);

- General construction noise and vibration impacts from construction of the power plant, support infrastructure and site office buildings. The equipment transported to site can be very large, causing temporary nuisance noise and vibration in the communities through which it is transported; and

- During operation of a facility, the main sources of noise will likely include noise from high flow steam pipelines, traps installed in supply lines, steam vents, well maintenance and electricity generation plants.

Earthquake risk

Geothermal plants are in seismically active areas where earthquakes are likely to occur. In general, geothermal projects themselves are not considered to generate any significant seismic risk. However, there have been some examples of geothermal projects inducing micro-seismic events (by drilling in rock creating “shearing” or fractures) at a localized level that may be perceptible by and impact on nearby communities[27] (**Error! Reference source not found.**9.2). This risk is subject to ongoing research.

[25] USDE (2006)
[26] World Bank (2017)
[27] USDE (2007)

Box 9.2: Earthquake in Switzerland caused by a geothermal system

In 2006, a geothermal system in Switzerland caused a magnitude 3.4 earthquake in Basel, an area prone to natural earthquakes. No expert assessment had been conducted of how much the seismicity induced by the project would connect with the natural seismicity under the Basel area.

A court case seeking compensation for property damage was brought against the head of the company, Geothermal Explorer, which subsequently shut down the system.

Source: *Earthquake Concerns Shake Geothermal Energy Projects | Live Science*

Visual impacts

A gas flare, alternatively known as a flare stack, is a gas combustion device used in industrial plants such as petroleum refineries, chemical plants, natural gas processing plants as well as at oil or gas production sites having oil wells, gas wells, offshore oil and gas rigs and landfills. One of the main reasons for gas flaring is the disposal and burning of natural gas as waste, either for safety reasons, economic and technical reasons, or regulatory reasons. In some cases, for safety reasons, a geothermal project will undertake a ground flare to dispose of methane gas should the operation of engines be disrupted. Best practice is to use an enclosed ground flare. Flares would normally only be of short duration. Providing suitable technology choices are made, impacts on air quality are not expected to be significant. However, the visual amenity of the landscape will change. This may reduce the appeal of the area to tourists and local populations and could, depending on location, impact on property prices.

The development of a geothermal energy project and its associated pipelines can cause negative visual and spatial effects on the landscape (e.g., by altering vegetation and wildlife habitat[28]). In some countries, geothermal energy is often located in protected areas where and the construction of the power plants, access road, transmission lines and other facilities tend to change the natural visual landscape and, ultimately, can undermine the attractiveness of the area for tourism[29].

However, geothermal resources often coincide with natural hot springs, presenting opportunities to develop tourism (Iceland is a prime example).

Land and ecosystem restoration

As discussed above, there are significant risks associated with geothermal power development with regard to potential environmental harm and degradation, e.g., unnecessary or excessive deforestation when preparing land for geothermal plant sites, constructing new access roads, pipelines and transmission lines, destruction of habitats and loss of biodiversity and ecosystem services as well as soil erosion and pollution. This will particularly arise where mitigation measures proposed by a SEA (and subsequent project-level EIAs) are inadequate, ineffective or not undertaken. The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. Such cumulative impacts will be highly likely to occur where there are multiple geothermal power developments across landscapes.

Environmental impacts will usually lead to demand for and need for land and ecosystem restoration (see Box 3.11), particularly at sites of projects that have come to the end of their useful operational

[28] Manzella *et al*. (2018).
[29] Soltani *et al.* (2021)

life. The average lifespan for geothermal power plant is 20-25 years for the indoor components, and 50 years of more for the ground loop. If and when decommissioning takes place, restoration of the site to its former status/condition will be required. At a minimum, this should involve the revegetating of the plant area to its original state, replanting and reseeding using a mix species that were naturally part of the ecosystem/land prior to development of the geothermal power project.

9.5.2 Socio-economic issues and impacts

Local economy and livelihoods

As with many other renewable energy developments, there are opportunities for local communities as well as a range of risks and possible impacts (some associated with access to land for drill rigs, well pads, access roads, pipelines and transmission lines and other associated facilities required for geothermal energy projects).

The acquisition of land can create physical and economic displacement or both. The average area of land required for geothermal projects is smaller than for most other types of renewable energy (Box 9.3). The most land-intensive stage is the construction of well pads, power plants, and associated infrastructure. The building of access roads and storage facilities during earlier drilling stages may also cause short-term disturbances to the livelihood activities of affected communities and open-up areas with natural resources which previously were less accessible.

Because well pads generally have a small footprint, and associated infrastructure is linear or underground, often careful siting and design can help avoid or minimize physical displacement.

Land acquisition for geothermal exploration and exploitation is different from other renewable projects because there is more scope for the resource (geothermal energy) not being available. Often several wells need to be drilled to confirm presence of the geothermal resources, whereas modeling of wind and solar energy to determine sufficient yield can be undertaken through desktop work. The specific location of geothermal resources can therefore lead to more potential for disputes within communities over land ownership and sometimes over land compensation arrangements. Disputes about land ownership can cause community tension.

Conversely, geothermal projects can be built in harmony with other land uses and deliver livelihood benefits (
Box9.4).

Other than the adverse impacts, geothermal projects can induce local business opportunities. As for other renewable technologies, local communities could provide services, such as accommodation for workers, retailing and other services for the geothermal companies and contractors. In 2000, the Gunung Salak geothermal project in Indonesia, located in the middle of a protected forest, won a prestigious environmental award for its well-planned community development program and responsible environmental management[30] . In Iceland, the geothermal sub-sector provides a multitude of stakeholder benefits, such as participation in decision-making, job creation, and infrastructure upgrades, along with sustainable energy development, but there are trade-offs between pursuing an economically efficient energy system and nature conservation[31]. Iceland has been able to stimulate new unforeseen industries alongside geothermal plants (
Box9.5).

[30] Slamat and Moelyono (2000)
[31] Cook *et al*. (2022)

Box 9.3: Land required for geothermal energy projects

The US Geothermal Technologies Office estimates that an entire geothermal field uses 1-8 acres (0.4–3.2 hectares [ha]) per megawatt (MW) compared to 19 acres (7.7 ha) per MW for coal power plants.

The Asian Development Bank-financed 110MW Dieng (2) geothermal expansion project in Java, Indonesia, estimated the need for about 30.8 ha in total in various locations, mainly for the new pipelines and access road but also for the power plant and five well pads. According to the project's resettlement plan, the project will require 30.8 ha for five well pads and the power plant site. As the site is in a fertile and intensively farmed area (Figure 11.2), the acquisition of land for the project will directly impact 106 persons (29 households) and indirectly affect four lease coordinators (21 persons) livelihood, particularly smallholders, tenants, and sharecroppers in the area

Figure 9.2: Location of Dieng geothermal expansion project in Java, Indonesia

Image credit: Geothermal Technologies Office (undated); and ADB (2019b)

Box 9.4: Livelihood benefits from geothermal energy

The website of the US Geothermal Technologies Office mentions 15 geothermal plants that are producing more than 400MW in one of the most productive agricultural areas, where land around the geothermal infrastructure is used for livestock grazing, agriculture and is adjacent to a national wildlife refuge.

Source: www.energy.gov/eere/geothermal/geothermal-technologis-office.

Box 9.5: New industries connected to geothermal energy in Iceland

Iceland has leveraged geothermal energy production to stimulate new industries, including data storage, greenhouse agriculture and ecotourism. Visitors to Iceland are drawn to the famous Blue Lagoon geothermal spa located in a lava field near Gridavik.

Engineers have begun to design power plants to accommodate tourists and have established geothermal-powered greenhouses, where local farmers produce tomatoes, cucumbers, and other crops that once had to be imported.

Source: McMahon (2016)

Occupational health and safety

As for other types of renewable energy projects, geothermal energy also presents occupational risks and hazards, including[32]:

- Hazards from working in a confined space where entry by workers and the potential for accidents may vary among geothermal facilities depending on design, on-site equipment, and the presence of groundwater or geothermal fluids;
- Exposure to geothermal gases, mainly hydrogen sulphide, may occur during the non-routine release of geothermal fluids (for example, well blowout and pipeline failures) and during maintenance work in confined spaces such as pipelines, turbines, and condensers;
- Exposure to heat during construction activities and the O&M of pipes, wells, and related hot equipment.

In the case of large-scale geothermal plants, many projects will be subject to the environmental and social safeguards of multilateral development banks (MDBs) and to the environmental and social risk management guidelines and procedures of the Equator Principles. These may provide a higher standard of, and oversight of, labour and occupational health and safety management procedures than the prevailing national standard.

Community health and safety

Geothermal projects bring health and safety issues for local communities. These can be induced by the exploration, construction, and operational phases of a project. During the construction phase, communities will be exposed to short-term nuisances such as increased truck and vehicle movements, noise, vibration, and dust for those residing or working close to the project infrastructure sites as well as the influx of skilled workers, noise, and odour. Geothermal wastewater and gaseous emissions typically contain hydrogen sulphide and other non-condensable gases and may contain mercury, which can be emitted during geothermal well drilling and testing processes[33] . These emissions are typically not significant, though this is dependent on the concentration of gases and the proximity of wells to sensitive receptors. Nearby communities may be exposed to air pollution including hydrogen sulphide gas, which has an odour and can be toxic[34] . Geothermal wells need to have cement casings to prevent pollution of groundwater.

The health risks to communities include exposure to air pollution such as hydrogen sulphide gas, infrastructure safety and impacts on water resources[35] . Without proper management, the release of

[32] IFC (2007)
[33] Finster (2015)
[34] Bastaffa *et al*. (2019)
[35] IFC (2007)

wastewater from the plants can cause adverse impacts on community health (e.g., skin and respiratory diseases), sanitation and noxious odours.

Noise from gas engines, drilling, construction vehicles and power plant operation can cause disturbance and damage to local community and property (e.g., noise and traffic congestion can affect community tourism and homestays) and nearby infrastructure.

Gender and vulnerability

One of the social risk factors associated with geothermal energy development is the degradation of water quality and supply (discussed in section 9.3.1 – water quality). This may have a disproportionate impact on women and girls who tend to be the primary collectors of water for household use and may increase 'time poverty'[36] if longer travel to clean water sources is required. Other risks are associated with potential land acquisition and displacement, and resettlement planning and compensation procedures for geothermal projects. In addition, the development of geothermal projects may cause potential damage to, or restrict access to, areas of spiritual and cultural significance[37]. This can have disproportionate impacts on women and vulnerable groups, particularly those from indigenous communities, and sometimes more than for other renewable energy technologies (see section on indigenous communities).

Other risks include the potential for an increase in gender-based violence (GBV) against women, and sexual harassment, exploitation and abuse resulting from an influx of predominantly male construction workers[38] and other male presence such as the military (
Box9.6). Concerns around an increased risk of GBV during renewable energy projects have also been discussed in other technologies (see discussion of gender and vulnerability in sections on hydropower and wind power).

Box 9.6: Community opposition to the Chevron Geothermal Project, Philippines

In Kalinga, Philippines, indigenous women in Western Uma blocked development of a Chevron geothermal energy project, which caused the company to abandon the site. The women's grievances included: disregard for cultural beliefs linked to the resource; loss of tiger grass (an important cash crop for women); fear of gender-based violence (GBV) from an anticipated increase in military presence to protect assets at the project site; and unequal compensation and benefits for women, including scholarships and employment opportunities.

Source: World Bank (2019)

Furthermore, women who pursue professional careers in geothermal energy often face several barriers, such as social expectations about their roles and abilities and a lack of an inclusive workplace environment[39] . As with other technologies, factors such as a skills gap among women due to their limited access and uptake of education and training in STEM subjects (see discussion of gender and vulnerability in Chapter 5 - hydropower) can also limit their employment opportunities in the geothermal industry.

Indigenous communities

Geothermal development may have a negative impact on indigenous communities and land under traditional or customary use. Geothermal plants are often located near volcanoes or hot water - sites

[36] Time poverty is the experience or feeling of having too much to do and not enough time to do it.
[37] World Bank (2019)
[38] World Bank (2019)
[39] World Bank (2019)

that frequently have cultural, sacred, and spiritual value for local communities of indigenous people. The healing properties of the warm and sulphur-rich water are often the subject of community lore.

Potential geothermal energy development sites tend to be located in remote areas where indigenous communities often reside (e.g., Figure 9.3)

9. They may be disproportionately affected by land acquisition and by opening up access to the natural areas and resources they depend on.

Figure 9.3: Muara Laboh Geothermal Project, Indonesia

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Sections addressing other types of renewable energy have highlighted that there is potential for local indigenous communities near to renewable energy projects to benefit from employment opportunities with the project, either during construction or operations. There is a risk that such employment opportunities will not be accessible to local indigenous people, e.g., because they lack qualifications or required skills and experience.

Cultural heritage

New geothermal developments can take place in or near sites that are protected or prized for cultural significance or aesthetic aspects, threatening, or compromising the physical or visual status of the site[40]. Such risks may be more pronounced among indigenous communities who frequent geothermal sites for the sacred and healing properties they are believed to have. Such sites may also be in, or contain, fragile, or protected ecosystems with endangered species[41].

Research carried out at Olkaria geothermal fields in Kenya found that the development of geothermal projects led to a reduction in family size. This was linked to the gradual loss of community land to the project which impacted greatly on the preservation of local cultural heritage sites. Also, the local community complained about foreign cultural attitudes penetrating their culture and causing cultural conflicts because of the interaction with outsiders[42].

The preservation of cultural sites can help to increase their potential to attract tourism.

Employment and labour conditions

Geothermal energy development has the potential to offer some employment during both the construction and operations phases, providing the local community with the opportunity to acquire new skills. For instance, the ESIA for the 35 MW Casita geothermal project in Nicaragua estimated that the exploration phase (intended to be 2.5 years) would create 100 jobs for site preparation and 100 for drilling[43] . Specialist skills are required for drilling. Skills gained in fossil fuel industries are transferable to geothermal development (e.g., drilling experts and construction-related roles). Figure 9.4 **Error! Reference source not found.** shows that, in 2021, there were almost 2 million jobs in the geothermal energy sub-sector, significantly fewer than in the other renewable energy sectors discussed elsewhere in this guidance.

[40] The World Bank (2019b)
[41] World Bank (2019)
[42] Kabeyi and Olanweraju (2022)
[43] World Bank (2017)

Figure 9.4: Renewable energy employment by technology in 2021

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Public services and infrastructure

As for other renewable energy types, geothermal energy projects can bring both opportunities and risks for public services and infrastructure under the remit of local public authorities. Heavy construction vehicles and transportation may damage existing roads or buildings adjacent to roads, especially bridges. Normally, energy projects will contribute to the development, improvement, upkeep and access to overall community facilities and services in an area. This may be because the project simply requires certain infrastructure and will put this in place, or alternately through its wider corporate social responsibility (CSR) programmes. The potential for community investment has been discussed previously for other renewable energy technologies.

Geothermal energy could create alternative employment opportunities for those who may have lost jobs or are at risk of unemployment due to transition away from non-renewable energy.

CHAPTER 10

KEY ISSUES FOR SEA IN THE TIDAL ENERGY SUB-SECTOR

10.1 WHY SEA IS IMPORTANT TO THE TIDAL ENERGY SUB-SECTOR

SEA can provide critical information to support better decision-making for tidal energy planning and development, including identifying where there may be implications for a PPP to adequately address significant environmental and/or socio-economic risks and impacts. This information can be particularly important to identify and assess the scale and significance of possible cumulative impacts of of multiple tidal energy schemes/developments whether alone or in combination with other renewable energy technologies (e.g. offshore wind energy).

The SEA process will:

- Identify and focus on key environmental and socio-economic issues and the concerns of likely affected stakeholders, including local communities, marginalised groups and indigenous peoples. Major issues are discussed in detail in section 10.5 and are summarised in Table 10.2.
- Identify/recommend if there are areas that should be avoided for tidal energy development (‘no go’ areas) because of particularly high risk to the environment, habitats/biodiversity and/or people.
- Identify what changes or additions are required to PPPs governing tidal energy development to address these risks.
- Make subsequent project-level EIAs more efficient and cheaper by addressing the big picture and upstream, downstream and cumulative potential impacts, identifying the particular issues that individual project EIAs should focus on in more (site-specific) detail. This may also include spatial planning recommendations for optimal siting of tidal energy projects to minimise these risks and impacts.
- Engage stakeholders (particularly in areas where tidal energy potential has been identified) including communities, marginalised groups and indigenous peoples which can be particularly affected by tidal energy developments - to be informed of proposed or possible policy options or plans and enable them to provide their perspectives and present their concerns. This will enable key issues to be identified and verified, help build understanding and support for tidal energy development, and avoid future misunderstanding and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 3 and are therefore not repeated in this chapter.

10.2 EXISTING SEA GUIDANCE/GUIDELINES FOR THE TIDAL ENERGY SUB-SECTOR

An international survey of existing SEA guidelines conducted for the IAIA was unable to identify any that are specifically focused on the tidal energy sub-sector. Similarly, there appear to be very a few guidelines specific to EIA for tidal energy development projects. One example is from the UK[1].

Various sources discuss the environmental impacts of tidal energy[2].

[1] Environment Agency (2011)
[2] e.g., Choose Clean Power (2022); Burrows *et al*. (2009)

10.3 TIDAL ENERGY INSTALLED CAPACITY

Compared to other renewable energy technologies, tidal energy is still in development. In 2021, global installed marine/tidal energy capacity was 524 MW. The main producing regions were Asia (dominated by South Korea) and Europe (dominated by France and the UK) (Table 10.1).

Table 10.1: Marine (tidal) energy installed capacity, 2021
Source: IRENA (2022b)

Region	Installed capacity (MW)
World	524
Asia	260
South Korea	*256*
China	*5*
Eurasia	2
Russia	*2*
Europe	241
France	*212*
UK	*22*
European Union	219
North America	20
Canada	*20*
Oceania	1
South America	0
Australia	1

10.4 BACKGROUND TO TIDAL ENERGY GENERATION

Tidal power is a form of energy generation that utilizes either the tide or marine currents to generate electricity. Although not yet widely used, tidal energy has the potential for future electricity generation. Tides are more predictable than the wind and the sun.

Historically, tide mills have been used both in Europe and on the Atlantic coast of North America. The incoming water was contained in large storage ponds, and as the tide goes out, it turns waterwheels that use the mechanical power to mill grain. The earliest occurrences date from the Middle Ages, or even from Roman times. The process of using falling water and spinning turbines to create electricity was introduced in the U.S. and Europe in the 19th century.

Tidal energy is still not widely used and has had limited commercial rollout to date, partly due to:

- The high costs of development (tidal energy can be almost 10 times more expensive than other renewable technologies[3]) and the technical challenges created by the harsh nature of the marine environment and the sensitivities of estuarine areas;
- Limited availability of sites with sufficiently high tidal ranges or flow velocities;
- The potential environmental impacts and the site-specific topographical changes needed to locate and establish such schemes in environments sensitive to change.

However, many recent technological developments and improvements, both in design (e.g. dynamic tidal power, tidal lagoons) and turbine technology (e.g. new axial turbines, cross flow turbines), have helped to address some of these issues and indicate that the total availability of tidal power may be much higher than previously assumed and that economic and environmental costs may be brought down to more economically competitive levels.

Globally, there has been a tenfold increase in tidal energy production in the past decade[4].

[3] www.statista.com
[4] Largue (2020)

The world's first large-scale tidal power plant was France's Rance Tidal Power Station, which became operational in 1966. It was the largest tidal power station in terms of output until Sihwa Lake Tidal Power Station opened in South Korea in August 2011. The Sihwa station uses sea wall defense barriers complete with 10 turbines generating 254 MW.

Tidal power can be split into two subsets: tidal stream and tidal range.

10.4.1 Tidal stream power generation

Tidal stream power generation utilizes the flow of currents through a turbine. This is akin to wind turbines and converts kinetic energy in the water into electricity. The turbines are located below the surface and are generally less visible as limited surface infrastructure is required.

Tidal stream infrastructure requires placement of turbines in areas where there are high velocity marine currents. Turbines can be located individually or in an array configuration and can be either suspended on the sea surface or fixed to the seabed. Electricity is transported to an onshore substation via an undersea cable and is then exported to the electricity grid.

Some examples of tidal stream projects are provided in Box .

10.4.2 Tidal range power generation

Tidal range energy generation uses a form of barrage to impound the water at high tide, so that at low tide a difference in head is created and used to drive a turbine. This is a "reaction" type turbine that converts pressure into electricity and is based on low head hydropower technology. It is possible to generate electricity on both the ebb and flood tides.

Tidal range turbines are placed at estuarine or coastal locations and require a barrage with a low-sitting profile.

There are two types of tidal range arrangements:

- A barrage arrangement is typically located across an estuary and impounds water in the estuary;
- A lagoon arrangement is a form of barrage that encloses a body of water, either connected to the coastline or placed entirely out to sea.

In both cases, turbines are in a linear powerhouse arrangement forming part of the barrage body.

Tidal range infrastructure with barrages that incorporate turbines usually consist of:

- Embankments, constructed where there are gaps along an estuary, and to enable access;
- The barrage structure;
- Turbines, located along the barrage structure;
- Openings, fitted with control gates to enable flow at a particular time; and
- Locks - one or more to enable boat traffic (if required).

Box **10.2**10.2 provides examples of existing barrage projects. No lagoon-type projects have been taken beyond the planning stage anywhere in the world. Therefore, a lot of currently unknown risks and factors need to be expected in these environments. Planning for the Tidal Lagoon Swansea Bay in southwest Wales is well advanced and will be the world’s first purpose built tidal energy lagoon. The generating station will have a capacity of 320 MW. To deliver the project, a U-shaped 9.5 km long seawall is required, encompassing 11.5 km^2 of the seabed, foreshore, and intertidal area of Swansea Bay.

Box 10.1: Examples of Tidal Stream Projects

(A) Current projects

The MeyGen tidal energy project is located at an offshore site between Scotland's northernmost coast and the island of Stroma. Here, multiple turbines installed on sub-surface gravity turbine support structures operate in a high flow and medium water depth environment. When fully developed, it will be the world's largest tidal energy project with the option to develop a tidal stream project of up to 398MW.

Figure 10.1: MeyGen tidal energy project's sub-surface turbine during transportation prior to commissioning

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Orbital Marine Power's O2 turbine went into operation in July 2021 in the waters off Orkney in Scotland. The floating 74-meter-long turbine is anchored in the Fall of Warness, where a subsea cable connects the offshore unit to the local onshore electricity network.

Figure 10.2: A turbine at Orbital Power's 'O2' turbine in operation

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(B) Emerging tidal stream projects in Southeast Asia

Zambales, Sorsogon, Northern Samar, and Surigao del Norte provinces, Philippines. Multiple sites are at pre-development and development contract stage for projects with the capacity to generate between 5–10 megawatts (MW). These projects are being undertaken by a number of different companies[5].

Larantuka Strait, Indonesia. Nova Innovation's FLITE (Feasibility of Larantuka and Indonesian Tidal Energy) project is currently underway. It will deliver a feasibility study for Larantuka Strait which lies between the islands of Flores and Adonara and has one of the strongest tidal currents in Indonesia.

Larantuka and Boleng Straits, Indonesia. In early 2022, the UK-based energy developer SBS International Limited signed a memorandum of understanding with the state-owned Indonesia Power for the development of tidal energy projects for both the Larantuha and Boleng Straits.

Source: OES | Ocean Energy Systems - an IEA Technology Collabouration Programme (ocean-energy-systems.org).

[5] awarded_ocean_2020-12-31.pdf (doe.gov.ph)

Box 10.2: Examples of barrage projects

(A) Operational Projects

***Shiwa Lake, Gyenggi Province, South Korea*.** Construction of the 12.7 kilometer (km) tidal barrier in 1994 at Sihwa lake (c.20 km SW of Seoul) subsequently became an opportunity to commission a 260 megawatt (MW) capacity hydro project in 2010.

La Rance Tidal Power Station, France is located on the estuary of the Rance River, in Brittany. It was the world's first tidal power station, opening November 1966. The Rance Barrage is 750 meters (m) long and 13 m high, enabling a peak capacity of 240 MW to be generated by its 24 turbines.

Figure 10.2: La Rance Tidal range barrage, France

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

***Bay of Fundy, Annapolis Royal, Nova Scotia, Canada*.** This is the only barrage project in North America. The Annapolis tidal plant was commissioned in 1984 and had a generating capacity of 20 MW using a single 7.6m diameter turbine. It was decommissioned in 2019 due to equipment failure that was considered uneconomical to repair.

Each of these sites used traditional hydropower technology adapted for marine conditions. Due to the wide head range associated with the tides, these projects cannot fully exploit the potential energy available due to the limitations in operation ranges and poor efficiency at extremes of operation. A report by Sidgwick and Macrae (2016) suggested that recent developments in variable speed converter and turbine technology at the time made it possible to generate efficiently across a much wider range of heads.

An example of using this technology is the ***New Bong Escape Hydropower Project in Pakistan***. This is a low head 84MW hydro power scheme located on Bong Canal/Jhelum River basin in Azad Kashmir. Construction commenced in 2009 with commissioning in 2013, It generates power through four 21 MW low head high efficiency Kaplan turbines.

(B) Emerging Barrage Projects

***River Wyre, Fleetwood, England*.** The project is located at the mouth of the River Wyre, requiring a 600 m barrage between Fleetwood and Knott End on the Lancashire Coast. Natural Energy Wyre (NEW) has been planning the project that seeks to generate 160 MW, providing electricity for an estimated 50,000 homes.

***Derby, Western Australia, Australia*.** Tidal Energy Australia is the proponent securing approvals for the Derby Tidal Energy Project. The project proposes to generate 40 MW of electricity, with potential to supply enough to power 10,000 to 15,000 homes.

10.5 IMPACTS OF TIDAL ENERGY DEVELOPMENT

During scoping for a SEA, key issues regarding tidal energy development should be identified. They will be used to focus the SEA on the most important issues and to help develop environmental and social quality objectives (ESQOs) – that address these issues - to be used during the main assessment stage. The key issues will be identified by reviewing relevant documents (e.g., EIA and special subject reports, environmental/social profiles, sector and inter-sector strategies, donor documents, academic papers, other tidal energy development applications, interviews with key informants and during stakeholder consultations at national to local levels. Many of the issues will be well known as a result of implementing other tidal energty development projects.

At the individual project-level these issues will be the focus of an EIA which should recommend how to manage or mitigate project impacts associated with these issues that might be likely to arise. Ideally, before individual tidal energy projects are approved, the implementation of a policy, plan or programme (PPP) for tidal the sub-sector should be completed. This will involve the assessment of multiple likely projects, schemes and activities, some directly concerned with the construction and operation of sites and facilities; and others linked to associated infrastructure (e.g cables). Thus, there is a risk that the impacts of individual developments/projects may become highly significant as they become cumulative. A SEA should focus on the potential for such cumulative impacts and make recommendations for addressing them. This may include recommending thresholds for particular factors that should not be breached by an individual project (and which should be addressed by a project-level EIA). Where the risks of cumulative impacts are extremely high, this might provide the basis for the SEA report to recommend an alternative to the PPP or components of it. Often, the timing of individual tidal energy applications and overarching SEA planning is not synchronized, and SEA may have to “catch-up” to the pace of individual projects rather than providing upstream (pre-project) guidance as to how they should proceed.

Table 10.2 summarises the key environmental and socio-concerns concerns likely to be associated with tidal energy development.

Table 10.2: List of key environmental and socioeconomic issues for tidal power (tidal stream and tidal range generation)

ISSUE	COMMENT
Environmental	
Physical changes (e.g. to estuaries and river channels)	• Modified tidal and residual flows -scouring around structures • Reduced vertical mixing, leading to increase in density stratification • Reduced levels of suspended particulate matter, leading to increased light penetration • Reduced saline penetration within the basin leading to freshening (i.e., more brackish water)
Air quality	• Emissions from vehicles, barges, dust (during construction)
Water quality	• Build-up of physical and chemical contaminants due to reduced flushing rates. • For tidal range projects that include barrage infrastructure, the amount of natural vertical mixing of sea water will be reduced due to the reduced tidal flows; and there will be less re-suspension of particulate matter, leading to decreased light penetration; and reduced saline penetration within the basin leading to freshening i.e., more brackish water. • In areas of increased flows, there may be potential re-suspension of contaminated sediments—with net reduction in water quality • Toxic paints, lubricants and antifouling coatings used on offshore tidal infrastructure can affect sea water and sediment quality
Greenhouse gases	• Tidal energy can reduce GHG emissions where it displaces coal as a fuel source
Impaired land drainage	• Impaired drainage due to increase in average water level inside the basin, which could lead to a decrease in ground water flows
Loss of habitats and biodiversity	• Especially intertidal mudflats and salt marshes—important for some species of birds and can be nationally and internationally protected areas. • Benthic habitats may change due to bottom stress as a result of modified waves and currents • Migratory fish may be impeded although fish passes can be constructed • Fish and marine mammals may suffer damage by collision with the barrage and turbines. • Some estuaries may provide nurseries for breeding fish and conditions for these may no longer be suitable • An increase in primary productivity may enhance the population of filter feeders • Tidal stream infrastructure can have negative impacts on biodiversity, including disturbance and displacement, collision, and entanglement and introduction of nonnative species, and can also modify or create new habitats
Noise	• During construction and operation • Changes to ambient noise in aquatic environments can affect many types of aquatic life, including marine mammals, fish, and birds—changing their responsiveness to other stimuli, masking, temporary threshold suppression and injury, as well as interfering with communication, echolocation for navigation, spawning and shoaling behavior
Land or marine use change	• Some coastal land used for agricultural grazing or crops may be lost or more gained. • Change in access to tidal areas • Potential to impact on localized fisheries
Visual and aesthetic impacts	• Tidal infrastructure may impact on the aesthetic view and landscape of the host community • Possible impact on recreation and tourism (may deter or possibly attract tourists) • Temporary disruption or permanent loss of port, commercial, and recreational shipping activities
Marine and ecosystem restoration	• Tidal energy systems are inherently age resistant and have long lifespans. The average estimate for most tidal systems is 75-100 years of working use. After this, some components might be decommissioned and restoration of the local marine ecosystem will be

ISSUE	COMMENT
	required. Other structures might be left in situ to conserve changed (since prior to construction) ecosystems that are likely to become established.
Socioeconomic	
Local economy and livelihoods	• Diminished income of fisherfolk due to restrictions on access to mudflats • Restricted or denied access for shellfish gatherers • Disruption to fisherfolks' pier and landing areas and potential damage to fishing gear from contact with turbines • Price of land and housing near the project area may decrease • Displacement of people when land acquired for access roads and transmission lines
Gender and vulnerability	• Vulnerable groups (e.g., the poor, women, persons with disabilities, children, the elderly, and indigenous communities) may be disadvantaged and at particular risk where coastal communities are dependent on fishing. • Employment opportunities within new projects. • Opportunities for vulnerable groups to acquire new skills and learn new technologies
Cultural heritage	• Loss of religious, historical and archaeological sites and properties • Destroyed or damaged due to transmission lines and access roads • Limited access to cultural heritage sites
Employment and labour conditions	• Employment in the construction and operation phases of projects • Employment in relation to projects' associated activities • Substandard working conditions • Worker safety • Opportunities for workers to acquire or learn new skills
Health and safety	• Noise from the tidal structures can disturb beach users or nearby communities • Electricity transmission lines from the tidal power plants may be a safety issue for nearby communities during construction and operation (e.g., electric shocks from touching live cables)
Transportation	• Marine transport and navigation may be disrupted but a barrage also gives potential for road and rail crossings • Access to shoreline may be impeded
Public services and infrastructure	• Infrastructure (e.g., roads and bridges, schools, health centers, and administrative buildings) may be improved due to community investment by tidal power companies • Pressure on public services and infrastructure will increase as a result of immigration • Heavy vehicles and transportation can damage existing roads and bridges • Increased vehicle traffic during construction

10.5.1 Environmental issues and impacts

Physical changes to estuaries, river channels, terrestrial and benthic environments

Benthic habitats (those on the sea or ocean floor) can be altered, or instead can be created, by offshore tidal stream infrastructure. They are modified due to direct disturbance (e.g., seabed clearance) caused by new infrastructure introduced to either tether surface turbines, house sub-surface alternatives or deliver power back to the shore via cables[6] . Depending on the sensitivity of the local environment, structures can cause changes to bathymetry, including tidal flows, waves and currents which can have negative impacts on marine and estuarine habitats, flora, and fauna.

By retaining sea water for part of the tidal cycle, there will inevitably be some changes in an estuary basin and its channels. The tidal and residual flows will be modified, possibly leading to some local scouring around the new structures (specifically in the outflow regions of the turbines and sluices) and siltation in the basin. An increase in average water level inside the basin would lead to a decrease in ground water flows which may have impacts on land drainage[7] . The extent of these effects is dependent upon how the barrage structure is operated and will be specific to each site and each local environment.

All types of tidal power infrastructure also have the potential to have negative impacts on terrestrial environments. Where sites with strong tidal flows are in locations that do not already have access to the power transmission network, then clearing of vegetation will be required for transformers and transmission lines, and for access roads to enable construction and maintenance. This can lead to the fragmentation or loss of habitats and biodiversity, and disturbance or relocation of fauna (see discussion in section on habitats and biodiversity in Chapter 9 (section 9.3.1) for further information as the effects are similar).

A key principle of SEA is to address the cumulative impacts of multiple projects, schemes and developments that may arise when a PPP is implemented. However, it is unlikely that many tidal projects will be developed in any individual country. Assessing their cumulative impacts in an estuary will be difficult. At present, there are only a handful of commercially-operating tidal power plants worldwide. However, many new projects have been proposed or are in development with the potential environmental and social impacts of these not yet fully understood. So, given the lack of existing experience of the impacts of tidal power schemes, a precautionary approach to impact assessment is warranted. But there will be cumulative impacts arising from the combination of developing tidal power schemes and other renewable energy projects (e.g. from the construction of transmission lines), as well as from projects in other sectors and from other land uses in an estuary.

Air quality

During operation, tidal power does not normally have significant impacts on air quality. There will be impacts during construction, e.g., emissions from machinery and vehicles (trucks, workers' vehicles, generators, etc.) and dust from land clearing to construct terrestrial infrastructure (barrages, access roads, substations and transmission lines). The severity of such impacts will depend on the proximity of sensitive receivers. Once operational, the quality of the air around tidal power infrastructure will likely return to pre-construction levels since there will be only a low number of vehicle movements and few sources of dust.

Water quality

Modified flow rates or changes in mixing and settlement of particulate matter caused by tidal power turbine infrastructure (for both tidal stream and tidal range) have the potential to change the water quality and sediments. This includes mixing (both physical and chemical) of built-up contaminants in

[6] Orbital Marine Power (2021)
[7] Wolf *et al.* (2009)

areas where flows are increased. Contaminated sediments can also become re-suspended reducing water quality. This impact, coupled with increased turbidity, has the potential to affect the health of marine and estuarine life in the local area.

Toxic paints, lubricants and antifouling coatings used on offshore tidal infrastructure can also contribute to reducing sea water and sediment quality. Depending on the tidal energy technology, hazardous chemicals could be accidentally released to the marine environment during installation, operation, maintenance, and removal. This can occur due to an unplanned acute release of fluids and contaminants, or a spill of large amounts of lubricants, hydraulic fluids, vessel fuel or other petroleum-based products and gradual releases of toxic contaminants over time from antifouling coatings used on tidal devices.

Further complications could result if the contaminants bioaccumulate in the food chain, potentially affecting public health if the aquatic organisms are consumed by humans[8].

For tidal range projects that include barrage infrastructure, the amount of natural vertical mixing of sea water will be decreased due to the reduced tidal flows; and there will be less re-suspension of particulate matter, leading to increased light penetration. The reduction in mixing will also lead to an increase in density stratification. There will be reduced saline penetration within the basin, leading to freshening (i.e., more brackish water). There may be a build-up of contaminants (both physical and chemical) due to the reduced flushing rates. In areas of increased flows, there may be potential for the re-suspension of contaminated sediments which could cause a net reduction in sea water quality. An abundance of nutrients combined with increased light penetration may cause increased primary production, potentially leading to eutrophication[9] . The extent of these effects is dependent upon the how the barrage structure is operated and will be specific to the local environment.

Habitats and biodiversity

Estuarine and lagoon environments are important habitats for invertebrates, fish, and some species of birds and marine mammals, and all are susceptible to local environmental change. The uniqueness, and often remoteness, of these sites is recognized. They are often listed as nationally and internationally protected areas.

Tidal power infrastructure can lead to localized environmental changes that occur due to housing, installing, and operating the turbines. These changes are most notable with tidal range projects where water regimes (flow and depth) are affected by infrastructure installation and operating methodologies. They can result in a direct loss of habitat and biodiversity (including birdlife), particularly in estuaries and lagoons with intertidal mudflats and salt-marsh habitats that are susceptible to change. These habitats are often nurseries for breeding fish and are particularly vulnerable to the changes that would occur during construction and operation. As a result, the introduction of new infrastructure has the potential to impact on local fisheries, resulting in a reduction of local fish populations and diversity in the area and reduced access for migratory bird species. Intertidal mudflats habitats are also susceptible to change because of altered tidal flows.

Tidal barrages can impede migratory fish paths and breeding cycles. However, depending on the species of fish, the risk can be mitigated to some extent by fish ladders.

There is some understanding of the interaction between marine wildlife and tidal turbines and the potential for collision[10]. There is a low risk of marine animals colliding with underwater turbines constructed for offshore tidal steam projects. There have been only rare and isolated instances of such collisions with tidal range infrastructure involving barrages. The Annapolis Tidal Station (operating from 1984 to 2019 in the Bay of Fundy in Canada) saw two incidents involving humpback whales. In the last decade, there have been advances in methods to prevent fish and marine life

[8] Polagye *et al*. (2010)
[9] Wolf *et al*. (2009).
[10] Carlson *et al*. (2013).

mortality when passing through turbines, and deterrent devices for marine mammals are available for new infrastructure[11].

Tidal stream infrastructure can have negative impacts on biodiversity, including disturbance and displacement, collision and entanglement and introduction of non-native species, and can also modify or create new habitats[12].

Electromagnetic fields (EMF) associated with tidal power generators and underwater power cables can affect aquatic wildlife in the near-field of the device, array, or cable[13] , although the effects may be location-specific. The EMFs can be potentially sensed by fish and evoke avoidance or attraction behaviours. Some species of fish, such as sturgeon and eels, appear to be particularly sensitive to EMF, and others, such as salmon, do not appear to be as sensitive. Sharks, skates, rays, ratfishes, and other elasmobranchs can detect faint electric fields[14].

The effects of tidal power infrastructure (including cables) on fish behaviour are not clear. In situ studies of EMF effects are challenging to conduct and, often, inconclusive.

Surface structures in estuaries and at sea that require lighting for safety and navigation have the potential to affect seabirds and aquatic species, including fish.

Noise

Various activities and processes, both natural and human made, combine to form the sound profile (ambient noise) at and below the surface in estuaries, lagoons, and the open sea. Changes to ambient noise in aquatic environments can affect many types of aquatic life, primarily invertebrates, fish, but also marine mammals.

Tidal power noise sources that change existing ambient noise vary during construction and operation. The nature of these impacts will vary according to the receiving environment (whether onshore—estuaries and lagoons, or offshore—marine) and to the sensitivities of the species living on land, in intertidal areas and in the water near the tidal infrastructure.

For fish and marine mammals in particular, the observed effects of changes in ambient noise include changes in their responsiveness to other stimuli, masking temporary threshold suppression and injury, as well as interfering with communication between members of particular species, echolocation for navigation, spawning, and shoaling behaviour[15].

Short-term changes to ambient noise occur during construction for both tidal stream (during installation of rock anchors and cables) and tidal range (during barrage construction). Temporary increases in vehicle traffic, construction equipment, vessel engines, propellers, drilling, and piling contributes to the changes in noise levels.[16]

Noise from the operation of machinery and turbines housed in sub-surface structures has potential to change the ambient underwater noise (sound pressure and particle motion) for extended durations over a longer term, and this can affect marine life.

Land and marine use change

All tidal power infrastructure has the potential to change land and marine uses, both at the site of the infrastructure and along the transmission lines and access roads. Some coastal land used for agriculture and/or livestock grazing may be lost or, potentially, gained with land reclamation for

[11] Neill *et al*. (2018).
[12] Orbital Marine Power (2021)
[13] Bochert and Zettler (2006)
[14] Öhman *et al*. (2007)
[15] Michel *et al*. (2007)
[16] Gill *et al.* (2005)

infrastructure. Shellfish fisheries relying on the intertidal zone (e.g., cockles and mussels) are most susceptible to being affected by changes in water volumes. If these changes are significant, these livelihoods, and similar fisheries reliant on the existing intertidal environment may be affected if there is a change (including restriction) in access for local communities.

The development of shore-based infrastructure can cause a change in land use (and loss of livelihood for some people) and may lead to conflicts over land use and access to areas and resources—making co-location problematic or impossible.

There have been advances in the industry over the last 10–15 years in structure, design, and turbine technology that minimize the footprint extent of projects, and evolution will be ongoing as the technology develops further.

Tidal area habitats are often nurseries for breeding fish, and the introduction of new infrastructure can cause a reduction of local fish stocks. This has the potential to make fishing in the local area unviable, or force fisher folk to turn to other uses of marine and estuarine environments.

If existing access to the power network is not available for either tidal stream or tidal range infrastructure, then there will be land clearing for onshore transformers, transmission lines, substations, and access roads. This may change local access to agricultural land and conservation areas along the routes.

Visual and aesthetic impacts

The visual and aesthetic impacts of tidal power projects will depend on location. Both tidal stream and tidal range power infrastructure can result in changes to the visual appearance and aesthetics of the receiving local environment. These changes can occur at the site of the infrastructure, particularly for tidal range infrastructure and along onshore transmission lines. Subject to the local tidal environment and siting methodology, tidal stream projects are often less visible and have less aesthetic impact.

The character of an area and the landscape may be drastically changed if a tidal barrage (for tidal range sites) is constructed, but there may be pros and cons. Some people may find the visual intrusion of tidal power schemes objectionable and feel they undermine the scenic appeal of coastal areas, particularly barrage schemes. But others find tidal schemes of considerable interest[17]. The change in the speed and rise of tides resulting from tidal power schemes can be dramatic, particularly in estuarine areas, detracting markedly from the aesthetics of more inland areas of estuaries[18].

Generally, a tidal lagoon has a surface barrier marking the area. Control centres may be built into the water or on the land.

Figure 10.3 shows how a tidal project can look in open water where the visual impact is limited[19].

Figure 10.3: Tidal energy depiction in open water

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

[17] Tidal Power - Disadvantages of Tidal Power.
[18] Tidalpower (undated)
[19] https://education.nationalgeograophic.org/resource/tidal-energy

Marine and ecosystem restoration

As discussed above, there are significant risks associated with tidal power development with regard to potential environmental harm and degradation, e.g. loss of habitats and biodiversity and ecosystem services, coastal land and marine use change, unnecessary or excessive deforestation when constructing new on-shore access roads and transmission lines, This will particularly arise where mitigation measures proposed by a SEA (and subsequent project-level EIAs) are inadequate, ineffective or not undertaken. The significance and seriousness of such degradation can be compounded where the impacts are cumulative and extensive. Such cumulative impacts will be highly likely to occur where there are multiple tidal power developments across areas of sea in combination with other coastal development projects and activities.

The need and nature for land/marine and ecosystem restoration is discussed in Box 3.9. For most renewable energy developments, this need will also arise at sites of projects that have come to the end of their useful operational life. However, tidal energy systems are inherently age resistant and have long lifespans. The average estimate for most tidal systems is 75-100 years of working use. After this, some components (e.g., turbines and housings) might be decommissioned (see Box 10.2) and restoration of the local marine ecosystem will be required. Other structures (e.g., barrage walls) might be left in situ to conserve changed (since prior to construction) ecosystems that are likely to have become established.

Box 10.2: Decommisioning of Strangford Lough tidal turbine, Norther Ireland

A tidal energy turbine installed in Strangford Lough, County Down, Northern Ireland is to be removed. The SeaGen turbine was lowered into place in 2008 and generates electricity from tidal currents.Two horizontal axis turbines are anchored to the seabed and are driven by the powerful currents resulting from the tide moving in and out. The topsides and crossbeam were taken August 2018, while the remaining tower and subsea structure were removed thereafter. SeaGen's foundation structure was taken to a dry-dock in Swansea for where all recyclable materials were recycled (mainly steel) and the concrete sections were then ground down as far as possible[20].

An EIA for the decommissioning recommended mitigation for the potential environmental impacts:

- Short-term and temporary impacts upon benthic communities in Strangford Lough via loss or damage of seabed habitat through use of moored barge or jack-up vessel;
- No adverse effect on site integrity of Strangford Lough SAC and less than 0.01% will experience short-term temporary impacts via loss or damage of designated seabed habitat through use of a moored barge or jack-up vessel;
- Short-term and temporary impacts upon fish, including basking shark, pinnipeds and cetaceans, due to noise disturbance through use of DWCT or AWJ;
- Impacts on all other receptors are considered to be negligible;
- No cumulative impacts with commercial fisheries, shipping and the Minesto tidal device were expected; and
- Decommissioning of the SeaGen device is not predicted to result in any medium to long-term environmental impacts.

The EIA concluded that that, following mitigation, there would be no major adverse residual impacts either from the project alone or cumulatively with other projects on any environmental receptors within Strangford Lough[21].

[20] Pioneering SeaGen tidal power turbine decommissioned | Recharge (rechargenews.com)

[21] Decommissioning of the SeaGen Tidal Turbine in Strangford Lough, Northern Ireland: Environmental Statement | Tethys (pnnl.gov)

10.5.2 Socio-economic issues and impacts

Local economy and livelihoods

As indicated in section 10.3, there are few existing tidal power projects and so there is little direct evidence yet of their impacts on local communities. The most significant livelihood impacts from tidal energy are related to fishing and transportation.

Pollution from vessel discharges and accidental leakage of contaminants caused by tidal power projects can have a negative impact on fishing and collecting shellfish. It is reported that fish stocks in the oceans of Southeast Asia are already declining rapidly following a major expansion of regional fisheries, putting the livelihoods of up to 100 million people at risk[22] . Any additional potential impacts from tidal power development on local fisheries need careful consideration.

The rapid increase in fishing in Southeast Asia has been stimulated by increased demand for and consumption of fish due to population growth and has been accompanied by the adoption of modern fishing and aquaculture technologies, burgeoning domestic and international markets, flexible and rapidly adapting fish-supply chains, and investments in fish processing. Fishing communities' ability to access fisheries resources is critical to being able to sustain their livelihoods. Where the fish resources are depleted, larger operators continue to prosper while small-scale fishers seem to do poorly[23].

The potential effects of tidal energy generation projects on natural fish and shellfish populations (i.e., not farmed under aquaculture), which in turn could impact the livelihoods of fishermen, include:

- Release of fluid waste/contaminants;
- Light pollution;
- Excess noise and vibration;
- Increase in suspended sediments;
- Loss of spawning/nursery grounds;
- Removal/alteration of habitats;
- Barriers to fish movement; and
- Electromagnetic fields.

These effects can occur to varying degrees throughout the life cycle of a tidal power project. There could be associated impacts on shellfish gatherers if access to shellfish gathering areas is restricted or denied. Similarly, there could be a disruption to fisherfolks' pier, mooring and landing areas. There may be some short-term disruption to fishing activity during device deployment and recovery operations. However, due to the small amount of ocean energy devices, the impact from this on fishing would generally be negligible[24] . In the long term, there could be habitat changes that could create new economic activities such as new fisheries.

The supply chain supporting the development of tidal and wave energy production provides energy devices and subsystems, foundations and mooring systems, cables, installation ports, and vessels (both small and large)[25]. Expanded supply chains may provide opportunities for increased turbine production and provision of other materials. If countries are to develop tidal lagoons on a large scale, this would stimulate a supply chain. Depending on the scale, individual projects may lead to the creation of dedicated manufacturing facilities to produce turbine generator sets or other components.

The prices of land and housing near new large infrastructure may change, but for tidal projects this impact is expected to be negligible. As with all energy projects, associated infrastructure could entail some physical and or economic displacement where land needs to be acquired for access roads and transmission lines.

Some tidal projects contribute to local economic development through tourism (Box 10.3).

[22] Williams (2007)
[23] Bene (2003)
[24] Tethys. Galway Bay Test Site. https://tethys.pnnl.gov/project-sites/galway-bay-test-site
[25] Hundleby *et al.* (2015)

Box 10.3: Positive impacts of tidal energy projects on tourism and employment in the United Kingdom and France

It is suggested that 100,000 tourist visitors per year could be attracted by the proposed Swansea tidal lagoon project (320 megawatt installed capacity), which could generate new indirect employment opportunities, with associated training. The project would involve constructing a breakwater to enclose 11.5 km^2 of sea and create 2,232 construction and manufacturing jobs.

The Rance power station in France has a tidal barrage and has become a significant tourist attraction, with 70,000 visitors a year. The improvement of roads and associated infrastructure along the coastal area facilitate the access of tourists to where the tidal projects are located. In addition, some of the visitors are interested in visiting the site to understand how energy is generated. There is potential for many types of renewable energy to be more open to developing programs for such spin-off economic benefits.

Sources:
Key Statistics - Tidal Lagoon (tidallagoonpower.com); Key Statistics - Tidal Lagoon (tidallagoonpower.com);
http://www.tidallagoonpower.com/projects/swansea-bay/key-statistics/;
France - Tidal Lagoon (tidallagoonpower.com).

Employment and labour conditions

With little existing expertise globally in tidal energy project implementation, local expertise is unlikely to be available at new project sites. As the case of Tidal Lagoon Power in Wales, UK, shows (see Box 10.3), tidal energy projects can provide opportunities for training, both in terms of income-generating activities per se and for upskilling workers and increasing their chances of better paid employment going forward.

Health and safety

Renewable UK[26] has produced a health and safety guide for mitigating and avoiding OHS risks associated with wind and tidal power[27] . It identifies the risks of working near water, noting that the construction of tidal projects involves large numbers of people and vessels, working in small groups, in multiple locations. It may include vessels and offshore structures and working on a remote site for an extended period. These activities present OHS risks for the workers and marine navigation. The guide also identifies the need to address issues such as:

- Providing clear policies defining weather limits supported by effective forecasting;
- Safe practices for line handling when towing;
- Effective diver competency standards; and
- Proper equipment for recompression (when diving).

The main community health and safety risk relates to collisions and navigational safety[28] . As with other renewables, there will be a range of community and OHS issues during construction.

Indigenous communities

Tidal energy projects could have negative impacts on indigenous communities whose lives and livelihoods are primarily marine based, e.g., in Australia and the islands and coastal area throughout Indonesia and the Philippines. Indonesia has a particularly large number of indigenous communities.

[26] A membership organization involved in wind and marine renewables
[27] Renewable UK (2014)
[28] Howell and Drake (2012)

Such communities may claim traditional or customary ownership or use of coastal regions for their cultural traditions which could require BCS or FPIC for tidal power development. FPIC is usually a requirement under "lenders" (e.g., MDBs) safeguard standards to obtain financing and before a project can proceed. "The UN Declaration on the Rights of Indigenous Peoples (UNDRIP)[29] recognizes the rights of indigenous peoples in marine environments. As tidal energy projects scale up in future, the need for inclusive consultation and engagement of indigenous peoples will gain further importance.

Gender and vulnerability

The is little analysis in the literature of the impacts of tidal energy on women or vulnerable groups. As with other renewable technologies, tidal projects need to identify and manage any risks and negative impacts on women and vulnerable groups that may arise. Discussions of gender and vulnerability in sections on hydropower and offshore wind indicate that impacts could include exposure to risks of sexual exploitation and abuse and sexual harassment, pressures on social amenities from the temporary presence of construction workers from outside the local area, and disruption to travel routes.

As noted in the previous section, tidal projects can have adverse impacts on remote and/or indigenous communities in coastal areas, including potential displacement of and disruption to marine-based livelihoods. Without sufficient planning and consultation that includes women and vulnerable groups, there is a risk that projects will be rejected by the affected community. The involvement of communities in decision-making processes can ensure that any benefits derived from the project are shared equitably among community members, local governments, project developers and other private sector investors e.g., through benefit-sharing schemes and favourable project contract mechanisms that allow for the scaling-up of renewable technologies in local communities.

Cultural heritage

Many communities have an intimate cultural relationship with local aquatic and coastal environments. Land/sea acquisition for project development may affect cultural heritage sites in coastal zones, including areas with potential shipwrecks and other marine archaeological sites. It may restrict local communities' and indigenous peoples' access to sites of cultural and spiritual significance.

Some tidal energy projects can act as tourist attractions (
Box10.3). In addition to informing tourists about the technology, visitors can be made aware of local culture. In Nova Scotia, Canada, a 'visitors' centre is attached to the Fundy Ocean Research Centre for Energy (FORCE). The approximately 3,000-square foot facility houses interpretive exhibits, interactive displays, a small theatre/community room, as well as space for on-site meetings and research work[30].

Transportation

In general, shipping lanes and navigation requirements will have to be considered during the planning and design of tidal energy projects. The installation of facilities on rivers may require the installation of locks to facilitate shipping up rivers. Tidal projects may disrupt access to ports, sailing routes, navigation aids, and transportation routes in estuarine areas. Modifications may affect sea conditions, bathymetry, fishing grounds and fishing activities[31] which then influence the need for riverine transportation.

[29] See United Nations Declaration of Rights of Indigenous Peoples (www.un.org)
[30] FORCE. fundyforce.ca.
[31] https://tethys.pnnl.gov/project-sites/galway-bay-test-site

Public services and infrastructure

As with other large projects, tidal power projects can be expected to provide on-site health services during the construction phase. Construction will require the use of heavy machinery and transportation of large parts which may require changes to roads and bridges (e.g., improvements, widening), or repair work if there is damage. Increased vehicle traffic during construction may have a negative impact on existing settlements, causing accidents and air, noise, and dust pollution. It may also restrict people's movement since terrestrial access to coastal communities can be limited to the landward side. Boats and vessels are needed to support installation and their presence may affect coastal access by others.
Tidal project developers may provide financial support to improve local public facilities and infrastructure, such as schools, roads, clinics, transportation services, etc. This support is mostly included in the developers' social and EMPs or their CSR or investment.

For instance, Tidal Lagoon power (in the UK) built access roads that the public can use to access the coastal areas[32].

[32] There is a Tide? - Tidal Lagoon (tidallagoonpower.com).

CHAPTER 11

KEY ISSUES FOR SEA IN RETIREMENT OF COAL-FIRED POWER STATIONS AND ASSOCIATED COAL MINE AND SUPPLY CHAIN CLOSURES

11.1 WHY IS SEA IMPORTANT TO RETIRING COAL-FIRED POWER PLANTS AND CLOSING ASSOCIATED COAL MINES AND SUPPLY CHAINS

An overall rational for why it is important to use SEA to support the energy transition is provided in the preliminary sections of this guidance.

SEA can provide critical information to support better decision-making for the early retirement of coal-fired power plants (CFPPs) and the closure of associated coal mines and supply chains as part of the energy transition. In particular, it should identify where there might be significant environmental and/or socio-economic risks that need to be addressed. This information can be particularly important as regards identifying and assessing the scale and significance of the possible cumulative impacts of multiple retirements of CFPPs, coal mines and supply chains. The SEA process will:

- Identify and focus on key environmental and socio-economic issues and the concerns of likely affected stakeholders, including work forces and local communities. Major issues are discussed in detail in sections 11.5 and 11.6 and are summarised in Tables 11.7 and 11.10.
- Make EIAs for individual CFPP retirements and coal mine and supply chain closures (where required) more efficient and cheaper by addressing the big picture and cumulative potential impacts, identifying the particular issues that individual EIAs should focus on in more (site-specific) detail.
- Engage stakeholders – including work forces, trade unions and local communities, which can be particularly affected by such retirements/closures and enable them to provide their perspectives and present their concerns. This will enable key issues to be identified and verified, help build understanding and support for the energy transition and avoid future misunderstanding and possible conflicts.

The steps and methodologies available for use in SEA are common to all SEAs, whatever they are focused on, and reflect internationally accepted standards of good practice. They are discussed in detail in Chapters 1 and 3 and are therefore not repeated in this chapter.

11.2 EXISTING SEA GUIDANCE/GUIDELINES FOR RETIREMENT OF COAL-FIRED POWER STATIONS AND CLOSURES OF COAL MINE AND SUPPLY CHAIN

An international survey of existing SEA guidelines conducted for the IAIA was unable to identify any that are specifically focused on the retirement of coal fired power stations or associated coal mines. Similarly, no such specific EIA guidelines have been identified, although there are some for coal mining and many for mining in general[1], and many other sources discussing the impacts of coal mining[2] and coal plants in operation[3]. There are also publications focusing on managing the social impacts of mine closure[4]. Environmental, health and safety guidelines for thermal power plants are available from the World Bank Group[5].

[1] e.g. EPA Australia (1995); MNREC (2018)
[2] e.g.Chadwick *et al.* (1986)
[3] e.g. Bartan *et al*. (2017)
[4] e.g. Stanley *et al.* (2018)
[5] https://www.ifc.org/wps/wcm/connect/9ec08f40-9bc9-4c6b-9445-b3aed5c9afad/Thermal+Power+Guideline+2017+clean.pdf?MOD=AJPERES&CVID=lNwcJZX

11.3 COAL-FIRED POWER STATIONS: INSTALLED CAPACITY

China has the highest installed capacity of coal power plants in the world. As of July 2022, it operated 1,118 coal plants with a combined capacity of 1,074.1 GW[6] . This was more than four times the operational capacity of coal plants in the United States, which ranked third (Table 11.1).

Table 11.1: Countries with largest installed capacity of coal power plants worldwide (July 2022)
Source: www.statista.com

Country	Installed capacity (GW)
China	1,074.06
India	233.13
USA	217.89
Japan	50.61
South Africa	44.11
Indonesia	40.86
Russia	40.05
South Korea	38.11
Germany	37.50
Poland	30.18

According to the Global Coal Mine Tracker (GCMT)[7], in July 2022, there were 7,242 operating coal mines worldwide. China has by far the largest number (3.326), followed by Indonesia (557) and the USA (538) (Table 11.2).

Table 11.2: Number of operating coal mines in top 15 countries
Source: https://globalenergymonitor.org/

Country	No. operating mines)
World	7.242
China	3.326
Indonesia	557
USA	538
South Africa	234
Germany	140
Kazakhstan	99
Poland	95
Turkey	80
Colombia	56
Canada	49
Czech Republic	43
Vietnam	39
Bulgaria	26
North Korea	21
Ukraine	20

11.4 BACKGROUND TO COAL ENERGY GENERATION

Retirement of CFPPs comprises two phases: shut down - when operational impacts cease; and decommissioning - the series of activities required to redevelop the site. Decommissioning will

[6] https://www.statista.com/statistics/859266/number-of-coal-power-plants-by-country/
[7] The Global Coal Mine Tracker is a worldwide dataset of coal mines and proposed projects.
The most recent update – published in July 2022 – includes operating mines producing 1 million tonnes per year or more, with smaller mines included at discretion. The tracker also includes proposed coal mines and mine expansions with a designed capacity of 1 million tonnes per year or more (see: https://globalenergymonitor.org/).

typically comprise a mixture of repurposing, demolition, removal of demolition and waste material from site, land remediation and redevelopment. In the context of the Energy Transition[8], both phases are likely to take many years to complete.

CFPPs generate electricity through a series of energy conversion stages: coal is burned in boilers to convert water to high-pressure steam, which is then used to drive a steam turbine to generate electricity. Figure 11.1 shows a generalized schematic diagram for a thermal power plant and the associated operations required to run a plant.

High-temperature, high-pressure steam is generated in the combustion plant (boiler) and then enters the steam turbine. At the other end of the steam turbine is the condenser, which is kept at a low temperature and pressure using a cooling agent, usually water. Through the steam condensing process, that cooling water is warmed. If the cooling system is an open or a once-through system, this warm water is released back to the source water body (such as a river, lake, or marine environment). In a closed system, the warm water is cooled by recirculation through cooling towers, lakes, or ponds, where the heat is released into the air through evaporation and/or sensible heat transfer before being used in the cooling process again. If a recirculating cooling system is used, only a relatively small amount of makeup water is required to offset the evaporative losses and cooling tower blowdown that must be discharged periodically to control the build-up of solids. A recirculating system uses about one twentieth the water of a once-through system[9].

In many countries, CFPP sites are located on the coast and use coastal sea water for cooling in once, through cooling systems[10] (see Figure 11.2).

Coal-fired steam generation systems generally use pulverized or crushed coal. Several types of coal--fired steam generators are in use and are generally classified based on the characteristics of the coal fed to the burners and the mode of burning the coal. The coal can be transported to the powerplant by rail, barge, or truck[11], although the majority of the CFFPs in the pilot countries use sea--going barges to deliver coal to the plants.

11.5 ENVIRONMENTAL ISSUES OF OPERATIONAL COAL FIRED POWER PLANTS

It is recognized that the energy transition from coal to renewable energy sources will take some time, perhaps decades. In developing countries and economies, this could take longer, conceivably to 2050 and beyond. Therefore, in the discussion of environmental and social issues associated with coal-fired power plants (CFPPs), it is important to consider both operational as well as decommissioning and retirement phases as CFPP-related risks and impacts may continue to occur for many years to come.

Greenhouse gases

The burning of coal in CFPPs emits greenhouse gases (GHG)—predominately carbon dioxide (CO_2) with relatively minor nitrous oxide (N_2O) to the atmosphere, contributing significantly to climate change impacts. The volume of emissions from CFPPs is a function of the efficiency of the energy conversion of the plant and the fuel type (coal or lignite).

[8] Energy transition is the change in the composition or structure of primary energy supply, from fossil-based systems to renewable energy sources and electrification. It affects the energy sector and other sectors that produce energy-related emissions, such as transportation and industry.

[9] IFC (2008b)

[10] Suarez and Myllyvirta (2020)

[11] IFC (2008b)

Table 11.33 shows the range of emission performances for a range of CFPP types.

Figure 11.1: Generalized flow diagram of a thermal power plant (coal, gas, oil) and associated operations
Source: IFC (2008b)

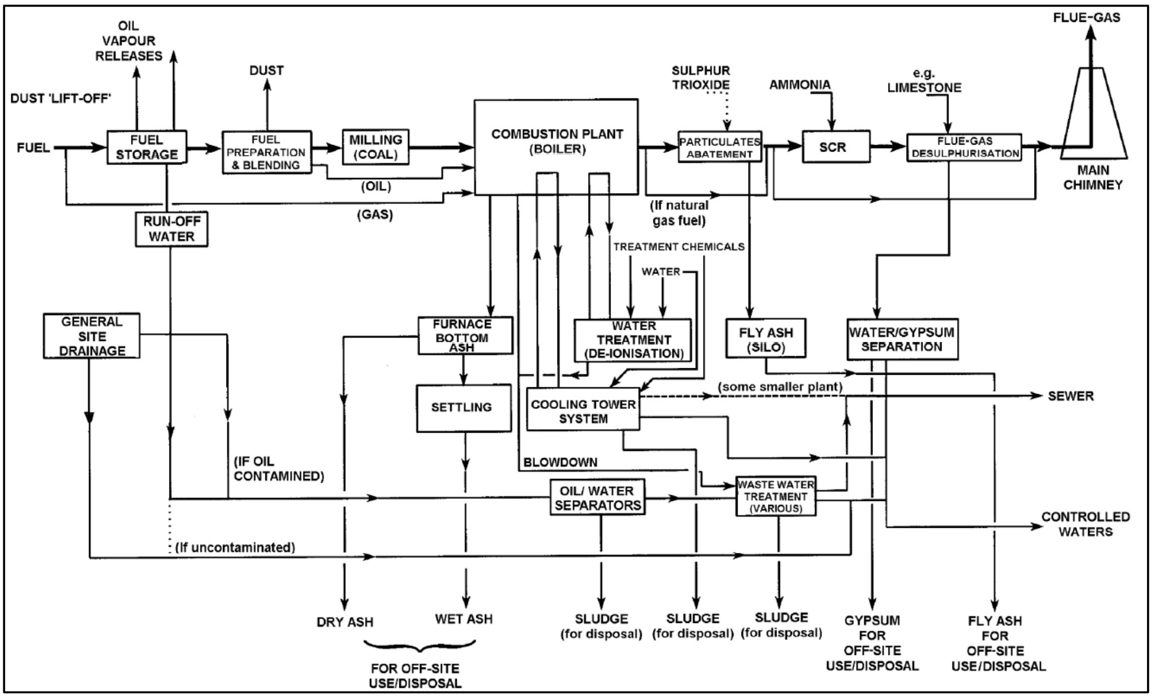


Figure 11.2: Coal-Fired Power Plant Southwest Johore, Malaysia

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Table 11.3: Typical carbon dioxide emissions performance of new thermal power plants

Source: IFC (2008A)

Fuel	Efficiency	CO_2 (gCO_2 / kWh – Gross)
Efficiency (% Net, HHV)		
Coal (*1, *2)	Ultra-Supercritical (*1): 37.6 – 42.7 Supercritical: 35.9-38.3 (*1) 39.1 (w/o CCS) (*2) 24.9 (with CCS) (*2) Subcritical: 33.1-35.9 (*1) 36.8 (w/o CCS) (*2) 24.9 (with CCS) (*2) IGCC: 39.2-41.8 (*1) 38.2–41.1 (w/o CCS) (*2) 31.7–32.5 (with CCS) (*2)	 676-795 756-836 763 95 807-907 808 102 654-719 640 – 662 68 – 86
Gas (*2)	Advanced CCGT (*2): 50.8 (w/o CCS) 43.7 (with CCS)	 355 39
Efficiency (% Net, LHV)		
Coal (*3)	42 (Ultra-Supercritical) 40 (Supercritical) 30 – 38 (Subcritical) 46 (IGCC) 38 (IGCC+CCS)	811 851 896-1,050 760 134
Coal and Lignite (*4, *7)	(*4) 43-47 (Coal-PC) >41(Coal-FBC) 42-45 (Lignite-PC) >40 (Lignite-FBC)	(*6) 725-792 (Net) <831 (Net) 808-866 (Net) <909 (Net)
Gas (*4, *7)	(*4) 36–40 (Simple Cycle GT) 38-45 (Gas Engine) 40-42 (Boiler) 54-58 (CCGT)	(*6) 505-561 (Net) 531-449 (Net) 481-505 (Net) 348-374 (Net)
Oil (*4, *7)	(*4) 40 – 45 (HFO/LFO Reciprocating Engine)	(*6) 449-505 (Net)
Efficiency (% Gross, LHV)		
Coal (*5, *7)	(*5) 47 (Ultra-supercritical) 44 (Supercritical) 41-42 (Subcritical) 47-48 (IGCC)	(*6) 725 774 811-831 710-725
Oil (*5, *7)	(*5) 43 (Reciprocating Engine) 41 (Boiler)	(*6) 648 680
Gas (*5)	(*5) 34 (Simple Cycle GT) 51 (CCGT)	(*6) 594 396
Source: (*1) US EPA 2006, (*2) US DOE/NETL 2007, (*3) World Bank, April 2006, (*4) European Commission 2006, (*5) World Bank Group, Sep 2006, (*6) World Bank Group estimates		

CGT = combined cycle gas turbine, CCS = carbon capture and storage,
FBC = fluidized-bed combustion,
GT = gas turbine,
IGCC = integrated coal gasification combine-cycle,
PC = pulverized coal.

Air quality

When coal burns, the chemical bonds holding its carbon atoms in place are broken, releasing energy. However, other chemical reactions also occur, many of which emit toxic airborne pollutants and heavy metals into the environment.

This air pollution includes sulphur dioxide (SO_2) produced when the sulphur in coal reacts with oxygen. In turn, the SO_2 combines with other molecules in the atmosphere (including water vapour) to form small, acidic particulates that can penetrate human lungs. This process is linked with asthma, bronchitis, smog, and the formation of acid rain, which damages crops and terrestrial and aquatic ecosystems.

Nitrogen oxides (NO_x) are visible as smog and irritate lung tissue, exacerbate asthma, and make people more susceptible to chronic respiratory diseases such as pneumonia and influenza.

Particulate matter is the ashy gray substance in coal smoke which can cause smog and haze, and is linked to respiratory and pulmonary illnesses, such as chronic bronchitis, aggravated asthma, lung disease, cardiovascular effects such as heart attacks, and premature death.

Mercury and other toxic heavy metals result from coal combustion, can damage neurological, digestive, and immune systems, and is a serious threat to child development[12].

Most of these emissions can be reduced by the installation of pollution control equipment (scrubbers) at the CFPPs, although many plants do not have adequate controls installed or are not monitored or maintained in line with national standards nor good international industry practice (GIIP). Table 11.4 shows the emission standards in place in various countries.

Table 11.4: Emission limits for existing coal fired power plants

CREA (undated)

Unit: mg/m3, except Hg as µg/m3, dry STP 6% oxygen.

Jurisdiction	$S0_2$	NOx	PM	Hg
EU, from 2023, hard coal	130	150	8	4
EU, from 2023, lignite	130	175	8	7
China, from 2020	35	50	10	30
EU, from 2015	200	200	20	-
USA	640	6740	23	1.6
China, all plants	200	100	30	30
South Korea	286	308	36	-
Japan	200	376	46	-
India, units installed after 2003*	200	600	50	30
Turkey	400	200	50	-
South Africa*	680	1020	68	-
India, units installed before 2003*	200	300	100	30
Indonesia	589	589	107	-
Philippines	1607	1607	214	-
Vietnam	500	1000	400	-

*Limits are technically in force but the regulator has delayed or failed to require compliance

Note: The table simplifies the complexity of regulation by only showing the emission limits applying to large (varyingly, >50MW to >500MW) plants. It also does not cover all exemptions either to individual plants or specific categories of plants which exist in many countries. The values are converted to 6% reference oxygen content, the most common basis used e.g. in the EU and China.

[12] UCS (2019)

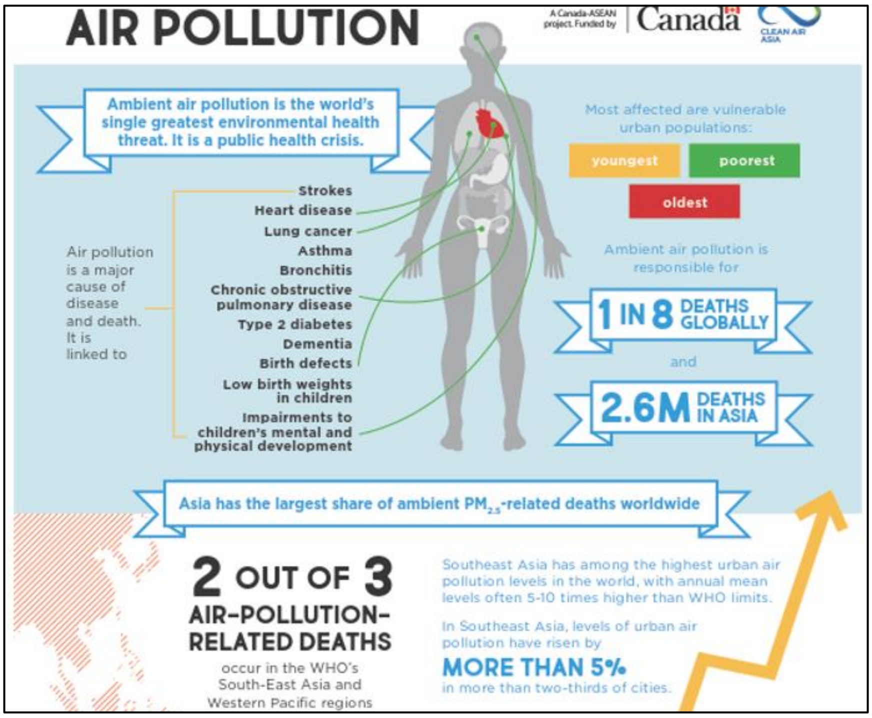
Southeast Asian coal emissions were estimated to have caused 19,880 (range 11,400−28,400) excess deaths per year in 2017[13]. Pollution from the current Philippines operating fleet of CFPPs is estimated as having led to 630 deaths in 2019, as well as 1,300 new cases of child asthma, 149,000 days of work absence (sick leave) and 240 pre-term births[14]. Studies show that children exposed to CFPP emissions face the highest risks, resulting in significant adverse effects on paediatric neurodevelopment, birth weight, and paediatric respiratory morbidity[15].

The quantum of pollutant emissions from CFPPs, their installed air pollution control devices, as well as population density, topography, and meteorology, play key roles in determining exposure risks[16]. In general, communities living nearest to CFPPs, or those with the highest exposures, face as much as five times the risk compared with those residing farther away[17]. Depending on the specific pollutants and the dominant meteorological and other atmospheric conditions, hazardous air pollutants from CFPPs can travel from 8 to 48 km from the stack unless they are deposited on the ground, chemically transformed, or removed from the air[18].

Where CFPPs are present, they contribute to ambient air pollution together with burning of other fossil fuels.

Globally, air pollution accounted for an estimated 6.67 million premature deaths in 2019 and, on average, reduces life expectancy by 1 year and 8 months (Figure 11.3), with almost 70% of the burden of air pollution-related mortality borne by Asia[19].

Figure 11.3: Ambient Air Pollution



Source: Ambient Air Pollution Fact Sheet – https://cleanairasia.org/our-resources.

[13] UCS (2019)
[14] CREA (2020)
[15] Amster & Levy (2019)
[16] Clean Air Asia (2020)
[17] Munawer (2017)
[18] Clean Air Asia (2020)
[19] Tong *et al.* (2021)

Water quality

Local coastal water quality can be impacted by both contaminants and increases in temperature (referred to as "thermal plume") and from the operations of CFPPs.

Mercury is one of the key contaminants resulting from the combustion of coal in CFPPs (Table 11.5), accounting for about 13% of global mercury emissions. Mercury is one of the most toxic elements in nature and a threat to wildlife because it accumulates and magnifies to unsafe levels in aquatic food chains (Box 11.1). Exposure to mercury in humans, even small amounts, may cause serious health problems to the nervous, digestive, respiratory and immune systems, and is a threat to the development of the child in utero and early in life[20]. After mercury is emitted into the atmosphere from the stacks of CFPPs, it settles onto both water bodies and land.

Research has shown that Asia releases a large amount of anthropogenic mercury[21]. While increased burning of coal in Asia has been known to exacerbate mercury emissions and air pollution, the research estimates that Asia could produce up to 1,770 metric tons of mercury emissions per year—more than double the mercury emissions previously estimated[22].

Table 11.5: Quantities of mercury emitted to air from anthropogenic sources in 2015, by different sectors (main sources)

Source: UNEP (2019)

Sector	Mercury emissions (range) tonnes	Sector % of total
Artisanal and small-scale gold mining	838 (675-1000)	37.70
Stationary combustion of coal (power plants)	292 (255-346)	13.10
Cement production (raw material and fuel, excluding coal)	233 (117-782)	10.50
Non-ferrous metal production (primary Al,Cu,Pb,Zn)	228 (154-338)	10.30
Waste (other waste)	147 (120-223)	6.60
Stationary combustion of coal (industrial)	126 (106-146)	5.67
Large-scale gold production	84.5 (72.3 - 97.4)	3.80
World total	*2220 (2000-2820)*	*100.00*

Box 11.1: Mercury contamination of water Case Study Thailand

Mercury concentrations were found to be above safe levels in fish tissue and hair samples taken from residents near a coal-fired power plant and a paper and pulp mill in Prachinburi's - the largest industrial area in eastern Thailand. The study concluded that the possible sources ranged from fly ash from the coal-fired power plants, coal dust from outdoor coal storage piles, ash deposits (which are spread over eucalyptus plantations in the area), as well as the possible leak of mercury-contaminated wastewater from a nearby paper and pulp mill to a public canal.

Source: Prachatai (2013)

Effluents from CFPPs include thermal discharges from the heated water emanating from the cooling systems. In some countries, where CFPPs are in coastal areas, once-through cooling systems are used that require large quantities of water that is usually drawn from the sea. Subsequently, it may be discharged at elevated temperatures, with increased brine levels and chemical contaminants (e.g., biocides, chlorine, or other additives, if used). Such discharges may affect aquatic organisms,

[20] https://www.who.int/news-room/fact-sheets/detail/mercury-and-health
[21] MIT News (2015)
[22] World Economic Forum (2015)

including phytoplankton, zooplankton, fish, crustaceans, shellfish, and many other forms of aquatic life23. Thermal pollution is the disturbance of water quality by elevated temperatures that cannot dissipate in a natural way and can result in significant degradation of aquatic ecosystems (Box).

Box 11.2: Thermal Water Pollution in Romania

A fleet of coal-fired power plants is situated along the Jiu River in Romania (Figure 11.4). They use large volumes of water from the river for their once-through cooling systems. Here, the higher temperature of the water returned to the river was found to have a significant thermal pollution impact to the downstream aquatic ecosystems in the river.

Figure 11.4: CFPP process water inlet channel to Jiu River Romania

(Photo credit:: Rosen et al. (2015)

Solid waste

CFPPs generate large volumes of solid wastes due to the relatively high percentage of ash in coal. This so-called bottom ash remains in the CFPP boiler bed after the coal has been combusted.

The coal combustion wastes (CCW) include fly ash (carried in the exhaust gases), bottom ash, boiler slag, and sludge. Fluidized-bed combustion (FBC) boilers generate fly ash and bottom ash, known as bed ash. Fly ash removed from exhaust gases makes up 60%–85% of the coal ash residue in pulverized-coal boilers and 20% in stoker boilers. Bottom ash includes slag and particles that are coarser and heavier than fly ash. Low-volume solid wastes from CFPPs include coal mill rejects and/or pyrites, cooling tower sludge, wastewater treatment sludge, and water treatment sludge.

The high-volume of CCW wastes is typically disposed in landfills or surface impoundments or, increasingly, may be used for a variety of beneficial purposes such as a component of concrete manufacturing. Low-volume wastes may also be disposed to landfills but are more frequently disposed in surface impoundments - sometimes at the CFPP site itself. Many CFPP owners manage their waste streams through relationships with third parties such as jointly owned waste management companies. The third parties are often landowners in the vicinity of the plant. Hazardous materials stored and used at combustion facilities include: solid, liquid, and gaseous waste-based fuels; air,

[23] IFC (2008a)

water, and wastewater treatment chemicals; and equipment and facility maintenance chemicals (e.g., paint, certain types of lubricants, and cleaners).

Surface impoundments storing coal ash can fail if the integrity of the containment is compromised. This can lead to very large spills to adjacent land, and potentially to water bodies, with the potential to contaminate several hundred hectares due to the volumes of waste (Box11.3).

Box 11.3: Failure of a Surface Impoundment in Kingston, Texas

The failure of a surface impoundment cell at a CFPP in Kingston Texas led to approximately 4.1 million m^3 of coal ash being released over an area extending approximately 120 ha outside of the fly ash dewatering and storage areas of the plant, and eventually spilling into the Emory River channel (Figure 11.5 below).

Figure 11.5: Failed CFPP Coal ash surface impoundment, Kingston CFPP, Texas, United States, 2009.

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Inadequate management of coal ash is a known issues in some countries. Due to high rainfall events and the dense population of coastal areas where the majority of CFPPs are located, solid waste storage is considered a significant environmental issue.

Health and safety

CFPPs are large-scale industrial facilities with a complex series of operations that have major hazards associated with materials, plants, and processes. This can lead to high numbers of workplace fatalities and injuries. The following health and safety impacts are of particular concern to workers[24] :

- Non-ionizing radiation - CFPP workers may have a higher exposure to electric and magnetic fields (EMF) than the public due to working in proximity to electric power generators, equipment, and connecting high-voltage transmission lines;
- Heat - occupational exposure to heat occurs during operation and maintenance of combustion units, pipes, and related high-temperature equipment;
- Noise - noise sources in combustion facilities include: the turbine generators and auxiliaries; boilers and auxiliaries, such as pulverizers; diesel engines; fans and ductwork; pumps; compressors; condensers; precipitators, including rappers and plate vibrators; piping and valves; motors; transformers; circuit breakers; and cooling towers;

[24] IFC (2008a) annex A.

- Confined spaces - specific areas for confined space entry may include coal ash containers, condensers, and cooling water towers;
- Electrical hazards - energized equipment and power lines can pose electrical hazards for workers at thermal power plants;
- Fire and explosion hazards - CFPPs store, transfer, and use large quantities of fuels; therefore, careful handling is necessary to mitigate fire and explosion risks. Fire and explosion hazards increase as the particle size of coal is reduced. Particle sizes of coal that can fuel a propagating explosion occur within thermal dryers, cyclones, baghouses, pulverized-fuel systems, grinding mills, and other process or conveyance equipment and at storage yards, where there is a need for regular monitoring, water sprinkling, and limitation of coal pile height;
- Chemical hazards - CFPPs utilize hazardous materials, including ammonia for NOx control systems, chlorine gas for treatment of cooling tower and boiler water and chemicals used for laboratory analyses, some of which may be classified as ozone depleting substances;
- Dust - generated in handing solid fuels, additives, and solid wastes (e.g., ash). Dust may contain silica (associated with silicosis), arsenic (skin and lung cancer), coal dust (black lung), and other potentially harmful substances;
- Operational health and safety - compared with other energy production methods, coal is significantly more dangerous than renewables and biomass as a source of energy. This is both with respect to power plants reliant on coal and the mining processes to fuel that process[25].

Historically, coal has seen the greatest number of severe accidents (leading to fatalities). Example of major incidents include:

- 21 people were killed in an explosion at a coal-fired power plant in the city of Dangyang in Hubei Province, People's Republic of China (2016);
- An explosion at a newly commissioned unit of CFPPs in northern India killed 43 people, while about 80 were injured in one of the nation's worst industrial disasters in recent years 2017);
- Six people were injured in dust explosion and fire at a CFPP in Turkey's Canakkale province (2018);
- A man died in an explosion at the Yallourn Power Station, Victoria, Australia (2018).

Coal (including brown coal) is responsible for over half of all deaths worldwide for all energy sources (Table 11.6).

Table 11.6: Mortality rate from accidents and air pollution per unit of electricity worldwide, by energy source *(death per thousand TWh)*
Source: Statistica 2023 (www.statistica.com)

Energy source	Deaths (per thousand TWh)
Brown coal	32.72
Coal	24.62
Oil	18.43
Biomass	4.63
Natural gas	2.82
Hydro	1.30
Wind	0.04
Nuclear	0.03
Solar	0.02

11.6 IMPACTS OF RETIREMENT OF COAL-FIRED POWER STATIONS

Table 11.7 summarises the key environmental and socio-economic concerns likely to be associated with the retirement of CFPPs.

[25] Markandya and Wilkinson (2007)

Table 11.7: List of key environmental and socioeconomic issues for retiring CFPPs

ISSUE RELATING TO CFPP RETIREMENT	COMMENT
Environmental	
Reduction in greenhouse gas emissions (GHG)	• Early retirement of CFPPs will reduce GHG emissions
Improved air quality	• Reduction in emissions to air due to early retirement of CFPPs closure (sulphur dioxides [SO_2], nitrogen oxides [NO_X], mercury, particulates)
Improved localized water quality	• No longer discharging cooling water to water bodies (eliminating thermal pollution), and elimination of mercury emissions contaminating water
Water use	• Retiring CFPPs reduces water demand
Generation of waste	• Decommissioning of power plants leading to large amounts of wastes including hazardous wastes that require disposal • There may be issues concerning regional cumulative impacts connected to handling and disposing of toxic waste • Failure of un-remediated surface impoundments containing waste ash, slag, and sludge. Early retirement will stop waste production but will require a waste management plan and disposal at appropriate facilities
Land and water contamination	• Decommissioning may require remediation of contaminated land (particularly with heavy metals and hazardous materials) and disposal of contaminants • It may not be possible to reclaim to a pre-existing condition. A decommissioning plan will be required • There may be associated contamination of groundwater and surface water
Land and ecosystem restoration	• CFPPs tend to occupy a small footprint and many are located in or near urban centres. After decommissioning, site restoration will be required. However, some plants/sites may be repurposed should conditions for the installation of renewable energy facilities be favourable.
Socioeconomic	
Legacy socioeconomic issues (crosscutting)	• Outstanding legacy socioeconomic issues (e.g., lack of compensation for land and property loss, lost livelihoods and income) linked to stand-alone mines and those specifically linked to individual CFPPs that have not been dealt or mitigated before retirement
Regional economy	• Early retirement of CFPPs will impact national and international coal supply chains and associated business activities (shortage of coal supplies in countries, job losses, transport, etc.) • Job losses result in loss of income tax revenues • Reduced reliability and security of electricity supply leading to disruption of major) economic hubs and centers • Raised electricity tariffs leading to increase in commodity and food price • Indirect losses through supply chains (transport) may affect the regional economy
Employment and labour conditions	• Loss of jobs (direct and indirect) in CFPPs – may require retrenchment plans • Job loss may lead to increase pressure on national welfare and social protection • Long-term opportunities for employment, improved labour standards and working conditions in CFPPs and supply chains during retirement period • Retraining and skill development will be required to take advantage of opportunities in replacement renewable energy technology.
Health and safety	• Reduced air and noise pollution, and dust will lead to improved public health

ISSUE RELATING TO CFPP RETIREMENT	COMMENT
	• Community health services may deteriorate as support to health facilities and services from CFPPs and associated businesses are reduced or lost • Hazardous waste and contaminated land may lead to contamination of groundwater supply, food crops, and local fisheries • Closure and decommissioning may result in risk of worker exposure to hazardous materials.
Local economy and livelihoods	• Reduced livelihood opportunities in the host communities (less demand for food stalls, accommodation, reduced business for small retailers) • Increased households' indebtedness and vulnerability to income losses related to individuals and businesses unable to repay their loans • Reduced revenues from renting properties and values of properties as a result of out-migration • Rehabilitation and redevelopment of CFPP sites will create income- generation activities
Gender and vulnerability	• Women and vulnerable groups, such as the poor, persons with disabilities, children, the elderly, and indigenous communities may be disadvantaged and at particular risk • Incomes will be lost following closure and competition for jobs in other sectors may well increase • Increased competition from former male workers in CFPPs may arise in women-dominated industries (such as manufacturing and garment industries) following closure • Increased domestic and gender-based-violence due to loss of income and resultant stress in the household • Increase pressure on state welfare system. • Opportunities for women and vulnerable groups to acquire new skills and learn new renewable energy technologies. • Opportunities for vulnerable groups to engage in the decision-making process and in inclusive dialogue for CFPP retirement.
Migration and loss of local skills	• Migrants attracted to work in CFPPs and associated businesses will leave the communities. • Local skilled workers and skilled migrants from CFPPs will leave communities. • Increased vulnerability of abandoned household members whose income depends on skilled migrants. • Opportunities for local workers to re-skill for new opportunities in renewable energy replacement
Public services and infrastructure	• The early retirement of CFPP may affect public services and infrastructure directly supported by the CFPPs (e.g., health clinics, education facilities, and roads, bus, and other transportation); and through reduced tax revenues due to less local government revenues generated from imposing taxes on CFPPs and associated businesses • Reduced pressure on public services and infrastructure as a result of out-migration
Social cohesion and engagement	• Weakened community cohesion resulting from out-migration of community members • Risk of internal conflict due to increased stress as income lost • Opportunities of the communities to engage in the decision-making processes • Reduced tension between the communities, nongovernment organizations (NGOs), activists, and CFPPs

Decommissioning activities vary widely. They range from:

- A plant being abandoned (Figure 11.6 and 11.7) with little advanced notice to workers, the surrounding community and authorities; and minimal works undertaken by the site operator or owner once operations cease;

to

- A carefully planned redevelopment or decommissioning plans being prepared and communicated to stakeholders years ahead of shutdown, site remediation being undertaken, and future land-use opportunities realized.

Figure 11.6: Abandoned CFPP in Shenandoah, Pennsylvania

Figure 11.7: Abandoned Market Street Power Plant, New Orleans

Figures redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Evidence suggests that there are a variety of benefits to repurposing and ensuring appropriate remediation of power plants (Figure 11.8). A report by the World Bank26 asserts that the direct benefits of repurposing such facilities in developing countries outweighs the costs of decommissioning. Such benefits may include land reutilization, equipment reuse (substations, generators, turbines), land remediation, and transmission and interconnection benefits. Beyond direct cost–benefits from decommissioning, repurposing plants provides social and grid stability benefits. There is a wide range of technology options available for repurposing (Table 11.8), e.g., solar PV (located on surface impoundments), concentrated solar power, biomass, battery energy storage systems, offshore wind and synchronous condensers. The options selected require careful consideration of multiple factors including generation requirements for renewable energy, requirements of the power systems and location. Repurposing allows for retaining part of the workforce for an upcoming repurposing project at the same site. This would partly ameliorate the socio-economic impact of potential layoffs. The repurposed plant would also continue to support local economies and the surrounding communities by providing jobs and enabling economic activities and their well-being in the long run27.

One controversial repurposing technology, proposed by Japan, is to use ammonia as a fuel with coal for co-fired power generation. But there are concerns about this technology. It may be more costly as most ammonia today is produced from fossil fuels; and emissions of nitrous oxide from the combustion process may result in a global warming potential significantly much larger than even gas-fired power plants[28].

[26] World Bank (2021)
[27] World Bank (2021)
[28] https://about.bnef.com/blog/japans-ammonia-coal-co-firing-strategy-a-costly-approach-to-decarbonization-renewables-present-more-economic-alternative/

Figure 11.8: Bankside Thermal Power Plant repurposed as Tate Modern Art Gallery, London UK

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Table 11.8: Repurposed coal-fired power plant sites and their end use

Plant name	Location	Country	End use	Status
Nanticoke	Ontario	Canada	Solar	Completed
Prosper Haniel	North Rhine Westphalia	Germany	Pumped storage, salt thermal storage	Completed
Drax	North Yorkshire	UK	Biomass	Completed
Beckjord	Ohio	USA	Battery storage	Completed
Eastlake	Ohio	USA	Synchronous condenser	Completed
Widows Creek	Alabama	USA	Data centre	Completed
Mount Tom	Massachusetts	USA	Solar & battery storage	Completed
Redbank	New South Wales	Australia	Solar, biomass	Proposed
Liddell	New South Wales	Australia	Renewable energy, battery storage, gas demand response	Proposed
Guru Nanak Dev	Punjab	India	Solar	Proposed
Breyton	New England	USA	Offshore wind	Proposed

Conversely, poorly planned shut down and abandoned CFPPs leave a significant legacy of environmental and social impacts which are discussed in the following sections.

11.6.1 Environmental Impacts of retiring coal-fired power plants

Greenhouse gases

A major benefit of the closure of CFPPs will be the elimination of associated GHG emissions. However, there will still be relatively minor short-term GHG emissions from vehicles and mobile plant used during decommissioning activities. This benefit however will not be immediate as the retirement of CFPPs may be prolonged.

Air quality

The closure of CFPPs will result in the elimination of all chimney stack emissions arising from the burning of coal. Air quality impacts from dust related to decommissioning activities will vary depending on how these activities are planned and executed. If the decommissioning of sites is not undertaken according to national and good international practice, coal ash dust from storage at CFPP sites may be an ongoing issue for local communities living in proximity (see also section below on land contamination).

Water quality

The closure of CFPPs will result in ending: (i) direct thermal emissions from the discharge of cooling waters to source water bodies, (ii) indirect impacts from contaminated dust in air emissions settling into water bodies in the vicinity of the plants and iii) groundwater contamination from ponds and leaks[29].

Water quality impacts related to decommissioning activities will vary depending on how these activities are planned and executed. If the decommissioning of sites is not undertaken according to national and good international industry practice (GIIP), coal ash waste may contaminate nearby water bodies leading to ongoing issues for local communities living in proximity (see also section below on land contamination).

Solid waste

The closure of CFPPs will stop large volumes of waste (e.g., coal ash) being generated from operations, providing a long-term benefit. However, existing fly ash stored in surface impoundments is potentially a significant environmental issue if adequate provisions are not included in the CFPP decommissioning scope of work.

Ownership of surface impoundments is frequently shared between the CFPP and other parties. If waste is left in unremediated impoundments, there will be a significant environmental risk and liability issue, deterring redevelopment of land by future owners (see also section below on land contamination).

The decommissioning phase of CFPPs will generate potentially large volumes of new waste types, both hazardous and non-hazardous—particularly if a CFPP site is demolished rather than repurposed. Waste from CFPPs can potentially have a cumulative impact. Where existing local landfills have limited capacity, they will be constrained to handle additional waste from decommissioning CFPPs, and there will be a risk of illegal dumping.

Land contamination

Coal ash generated by CFPPs can contain heavy metal contaminants such as mercury, cadmium, and arsenic. As described in the preceding section, this material is stored in either landfill or surface

[29] https://www.ucsusa.org/resources/coal-and-water-pollution

impoundments. Without proper management of ash ponds, the contaminants can be released to pollute soil, ground water, drinking water and waterways[30].(see Box 11.4).

Box 11.4: Coal ash pollution in Indonesia

The PT Indominico Mandiri coal company operates a large thermal coal surface CFPP and mine near the Bontang city, East Kalimantan, Borneo, Indonesia. The mine covers an area of 251 km^2. There have been serious issues concerning coal ash pollution:

During 2012-2013, the mine illegally piled ash near the paving block production site. In 2015, the locally community filed a report to the Ministry of Environment and Forestry (MoEF). The company then obtained a temporary permit for storage of hazardous waste and the MoEF found 3,950 tonnes illegally piled outside the ash facility. In 2016, a renewed permit was issued requiring a 44 x 60m ash shelter located 300m from the nearest residence. In December 2017, the Tenggaron District Court criminally sanctioned PT IMM and imposed a fine of IDR 2 billion (about US$ 130,000).

Source: Apriando (2018)

The PT Barat Rayon coal mine obtained permits for final disposal of coal ash from its coal-fired power plants. Nonetheless, between 2005 and 2015, the company illegally dumped 252,000 tonnes of coal ash into Rawa Kalimati, a wetland connected to the Citarum River. The local Department of Environment found out in 2011 and forced the company to sign an agreement to improve its coal ash management practices. Later, a criminal investigation revealed that despite its permit, the company had never operated a landfill facility or managed its coal ash properly. The court document estimated that the illegal disposal might have saved the company up to IDR 27.72 billion (about US$1.8 million). In 2016.Purwakarta District Court issued am IDR 1.5 billion fine (about US$100,000), and required the company to clean up the waste it dumped in the wetland. However, the clean up did not include remediation of the water that had been contaminated with various carcinogenic and toxic substances.

Source: Rising Risks: Coal Ash in Indonesia. https://bersihkanindonesia.org/

Additional hazardous materials stored and used at CFPPs include solid and liquid fuels; chemicals used for treating air, water, and wastewater; and chemicals used for equipment and facility maintenance (e.g., paints, lubricants, and cleaners). If there is poor practice in the storage and use of such hazardous materials during operations or if they are not removed from the site and properly disposed, there is a risk that they may contaminate soil and groundwater at the site. The decommissioning of CFPPs should include a site assessment and remediation plan covering potential contaminated land issues, to avoid leaving a legacy of contamination issues that will have long-term impacts on local communities and ecosystems. This should include all related facilities to the CFPP including ponds, storage, and waste disposal sites.

Land and ecological restoration

CFPPs tend to occupy a small footprint and many are located in or near urban centres. After decommissioning, site restoration will be required. However, many plants/sites are likely to be repurposed. Before this done, the CFPP site will need to be decommissioned, decontaminated and reclaimed. Any outstanding environmental and social legacy issues should be remedied.

(e.g. Box 11.5).[30] USEPA (undated)

11.6.2 Socio-economic Impacts of retiring coal-fired power plants

The impacts of CFPP retirement depends on the type of CFPPs. The latter, include stand-alone CFPPs (with coal supplied from elsewhere) and mine-mouth CFPPs where coal is supplied on-site. Regardless of the impacts from supply chains, stand-alone CFPPs tend to create less complicated adverse impacts compared to mine-mouth CFPPs. Socio-economic impacts can be contingent upon the age of the CFPPs as well as the project company's corporate reputation and relationship with the communities. A range of "true costs" are associated with the extraction and use of coal[31] . These range from the costs of health effects to atmospheric pollution. Consideration of externalities such as those related to water, air pollution, land use and others can maximize environmental conservation, protect human health, and contribute to long-term stability[32]. Additionally, companies may require a significant reserve fund for decommissioning costs at a time when plant revenues may be decreasing due to closure.

Country, regional, and global economy

At the country and regional levels, specific economic structures and their complex interactions with the energy system vary greatly[33] . Energy transition would bring substantial regional economy benefits and contribute to a country's gross domestic product (GDP). Retiring or closing CFPPs have been reviewed positively in terms of tackling the climate crisis and the need to divest from fossil fuels in the energy supply mix in regions where coal is an anchor industry. However, these costs may be too high for some national governments to assume and will require external funding from international lenders or other funding sources to finance the retirement, decommissioning and associated legacy costs.

The retirement of CFPPs is likely to pose challenges for local and national economies that have developed a dependency on CFPPs and for the industry's supply chains (e.g., Box 11.5). The closure of CFPPs may also cause import and export and trade imbalances between countries and regions.

Box 11.5: Potential economic impacts of retiring CFPPs in Indonesia

The Philippines' CFPPs import coal from Indonesia and Australia[34] and their closure could affect Indonesia's coal export economy. The Indonesian electricity sector is dominated by CFFPs. In 2021, they contributed at least 5.5% to the total GDP[35] . The potential impacts of retiring CFPPs includes regional job losses, losses for associated business activities along the coal supply chains, a rise in electricity tariffs, and increasing commodity and food prices. State revenues, from both corporate and salary taxes, could be reduced and thus decrease public funding and budgets for specific regions and provinces which host many CFPPs. The reduction of electricity supply without replacement sources being available may also adversely affect the operation of major economic hubs or centres, including shopping malls and factories, which consume more electricity than other industries. At least four million enterprises in Indonesia rely on the state electricity company (PLN)[36]. Without proper mitigation measures, the effort to retire CFPPs would cause adverse impacts on the national economy and intra-country trade (both energy and non-energy) in Southeast Asia.

However, the impact of retiring CFPPs is heavily dependent on the share of coal in each market's electricity mix, the availability of sources to replace coal, and the growth rate of the electricity

[31] True cost economics is most often applied to the production of commodities and represents the difference between the market price of a commodity and total societal cost of that commodity, such as how it may negatively affect the environment or public health (negative externalities). See more about true costs at https://truecostsinitiative.org/mission-vision/truecosts/.
[32] Roth and Lawrence (2004; Schmidt et al. (2015)
[33] IRENA (2020b)
[34] Asean Post.(2022); and DoEP (undated)
[35] Badan Pusat Statistik ([Seri 2010)
[36] Badan Pusat Statistik (undated).

demand[37]. Retiring CFPPs might increase the price of electricity (even making it unaffordable for some people), exacerbate ongoing energy supply shortages, and make it difficult to meet the ever-increasing demand for electricity in Southeast Asia that is a consequence of population growth. Without policies addressing long-term impacts in place, the rapid transition from CFPPs to renewable energy could face long-term energy supply issues. Government policies need to consider which energy source(s) might replace coal in the short, medium, and long term[38].

Local economy and livelihoods

In localities where the economy and livelihoods of host communities are highly dependent on the operation of CPPFs, their retirement will have both direct and indirect sociocultural and commercial consequences and could lead to socioeconomic deprivation for decades[39]. According to the International Energy Agency, the closure of CFPPs can have adverse socio-economic consequences and unintended distributional effects due to their highly focused value chains[40]. In most parts of the world, CFPPs can act as an anchor industry for the local area and for the livelihoods and economic development of surrounding communities. In some cases, employment at these facilities may be multi-generational.

As the CFPPs are set to retire, the associated business activities (e.g., food stalls, accommodation and renting services, retailers, small enterprises, food services, and transportation and social services) can be disrupted due to out-migration. This was the case in communities dominated by CFPPs in Scotland[41] and the US (in the 1970s)[42]. Income from the related businesses will be reduced, increasing households' indebtedness and vulnerability to poverty. However, there are opportunities when the CFPPs and the adjacent areas are rehabilitated and redeveloped as recreational areas with new income-generating opportunities.

Legacy of socio-economic issues (crosscutting)

CFPPs could have been established several years or even decades before environmental and social regulations were introduced and enforced. Those CFPPs might not meet regulatory requirements, such as addressing and managing impacts (usually these would be identified by environmental and social impact assessments) and mitigating the adverse impacts of developing and operating the power plants. Where there has been no regulatory monitoring and external audits, some of the outstanding issues (e.g., regarding workers and communities' rights, socioeconomic and environmental concerns, availability of a functioning grievance mechanism) may not have been addressed; and particularly not in line with good international industrial practices, typified by the IFC Performance Standards[43] and the World Bank's environmental health and safety guidelines[44].

Coal-fired electricity generation is an industry that has long been associated with human rights and environmental issues arising during the different phases of projects, including construction, operation, and decommissioning[45] . Disengagement from CFPPs can severely impact workers, families, and local communities that host CFPPs. Such local communities, dependent on CFPPs, may have little or no access to safety nets and social protection. Some companies do not sign everyone up to social protection schemes systematically. Some countries have relatively new social protection legislation (e.g.., Philippines[46] and Indonesia[47]).

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[37] IEA (2021b)
[38] GRICCE (2019)
[39] Financial Times (2018)
[40] IEA (2021Bb
[41] IME (2016)
[42] Baldwin *et al.* (1977)
[43] www.ifc.org
[44] https://documents.worldbank.org/
[45] The case of Colombia suggests these legacy issues, see Wilde-Ramsing *et al*. (2021); and Haigh (2015)
[46] Valencia (2017) and World Bank (2012);
[47] see: The Law of the Republic of Indonesia No. 40 of 2004 Concerning the National Security System. https://www.ilo.org/dyn/natlex/docs/MONOGRAPH/69781/93934/F1705566322/IDN69781.pdf

Where there are outstanding inequalities and disparities resulting from poor attention to and management of socioeconomic issues (e.g., lack of compensation for land and property loss, lost livelihoods and income, infringement of rights to land and associated conflict, unmet commitments for livelihood restoration entitlements) linked to CFPPs that have not been dealt with or mitigated, the retirement of such CFPPs could exacerbate those problems[48].

Experience from the rest of the world, especially in Colombia[49] illustrates this problem when stand-alone and mine-mouth CFPPs have been closed, leaving behind unresolved issues, including human rights violations in host communities. In Indonesia, since 2016, the communities in Winong village have blamed the Cilacap plant and its Jakarta-based operator for polluting their air and depleting the water table. The company did not deal with such issues until early 2019[50].

Employment and labour conditions

The transition to low-carbon economies based on accessing renewable energy will change the occupational and skills pattern in the energy sector, with both job losses and gains[51]. The transition can create jobs in the renewable energy sector, but it will also reduce jobs in the non-renewable energy sector. There will be displacement and substitution of jobs from one sector to the other. As shown in Table 11.9, energy transition is predicted to increase job opportunities globally by 0.18% in 2030 and by 0.15% in 2050, respectively.

Table 11.9: Impacts on General Employment as Result of Energy Transition (global)
Source: IRENA (2020b)

Employment (thousands)	2030	2050
Employment: Planned Energy Scenarios (PES)	4,051,588	4,238,092
Employment: Transformed Energy Scenarios (TES)	4,058,720	4,244,626
Employment changes: TES V PES	7,132	6,534
Employment changes (%) TES v PES	0.18%	0.15%

In addition to losing employment (when CFPPs are retired) and wages (which would be spent in the local economy), not all workers will have the skills or experience required to work in the renewable sector. The location of renewable energy development may in some cases be at or close to CFPP retirement sites. In other cases, they may be in other parts of the country, changing settlement patterns based on access to job opportunities.

The scale of job losses will vary from one plant to another, depending on their megawatt capacity. The larger the capacity of CFPPs, the more potential for job losses. It is evident that significant job losses are resulting from the global trend to replace CFPPs with renewable energy, a result of the international pledge to reduce carbon emission (under the Paris Agreement[52]). For example, in Poland, the employment rate in the sector declined rapidly from 1990 to mid-2015[53] . Indonesia's electricity and gas sector employed at least 0.284 million workers[54] in 2021, excluding jobs associated

[48] Wilde-Ramsing *et al*. (2021)
[49] Wilde-Ramsing *et al*. (2021)
[50] Darmawan (2019).
[51] IRENA (2020b)
[52] an international treaty on climate change, adopted in 2015 (see: The Paris Agreement | United Nations)
[53] Baran *et al*. (2018)
[54] Statistik Indonesia. 2022. *Statistical Yearbook of Indonesia 2022.* Jakarta. Statistik Indonesia. 2022. Statistical Yearbook of Indonesia 2022. Jakarta. https://www.bps.go.id/publication/download.html?nrbvfeve=MGEyYWZlYTRmYWI3MmE1ZDA1MmNiMzE1&xzmn=aHR0cHM6Ly93d3cuYnBzLmdvLmlkL3B1YmxpY2F0aW9uLzIwMjIvMDIvMjUvMGEyYWZlYTRmYWI3MmE1ZDA1MmNiMzE1L3N0YXRpc3Rpay1pbmRvbmVzaWEtMjAyMi5odG1s&twoadfnoarfeauf=MjAyMi0wMy0xMCAxNzoyODoxNQ%3D%3D

with the electricity infrastructure. If a number of CFPPs in Indonesia were to be closed around the same time without a proper mitigation plan, a very large number of direct jobs could be lost.

In countries where national regulatory enforcement is weak, CFPPs might have practiced substandard labour management. For instance, in Mexico between 2012 and 2013, it was found that some CFPPs illegally employed minors[55]. In China, researchers reported that from 2017 to 2019, workers in CFPPs worked in hazardous, unsafe, and unhealthy environments[56] . In some cases, the closure of CFPPs would abolish substandard labour and working conditions and labour exploitation. Lenders and financial institutions could require that labour and working conditions in CFPPs be improved before financing the decommissioning of such assets.

In countries where governments have not established transition measures, this could result in the coal industry not addressing injustices or equity implications for the workers or for households adapting to different energy sources and prices[57].

Therefore, it is important that as part of the closure of CFPPs, opportunities are created for worker retraining and reskilling (e.g., to work in the renewable energy or other sectors), and measures are taken to guarantee worker compensation and relocation support for unemployed former CFPP workers, as required by international financial institutions and national regulations.

Health and safety

The closure of CFPPs will end on-site occupational hazards described in sub-section on health and safety in section 11.4.1, with a consequent reduction in severe accidents and fatalities to workers on-site. There will be limited short-term health and safety issues for those workers involved in decommissioning activities. However, these are unlikely to be significant if the process is well-planned and delivered.

The decommissioning phase of CFPPs, if not undertaken to good international industry practice (GIIP), may leave hazardous waste on the site (as described in the sub-sections above on solid waste and land contamination), which could contaminate drinking water, food, and local fisheries, and cause long-term health impacts. Workers involved in decommissioning activities should be provided with protective equipment to minimize their risk to exposure to site contaminants.

The World Bank's Environmental, Health and Safety (EHS) Guidelines provide standard requirements for coal processing power plants[58]. They outline key health and safety risks and management of health issues related to air emissions, wastewater, hazardous materials, wastes, and noise as well as issues concerning occupational and community health and safety in the life cycle of coal mines. IFC Performance Standard (PS) 2[59] also highlights the key labour and working conditions requirements that CFPPs should comply with. These include the International Labour Organization (ILO) labour conventions[60] for, among other issues, rights of workers, forced labour and child labour. The Guidelines and PS can be adopted by private investors and companies for activities that are not IFC or World Bank-financed in situations where national regulatory requirements are lower than international standards.

If closure and the remediation of land are not planned carefully, there is a risk of community exposure to hazardous waste, contaminated land, and open ponds, leading to disease and possible food

[55] https://www.mining.com/mexico-shuts-down-over-20-coal-pits-over-child-labour-probe-84458 /
[56] Wang *et al.* (2021).
[57] Piggot *et al.* (2019)
[58] IFC (2007b)
[59] IFC (2012c)
[60] ILO Conventions include: ILO Convention 87 on Freedom of Association and Protection of the Right to Organize, ILO Convention 98 on the Right to Organize and Collective Bargaining, ILO Convention 29 on Forced Labour, ILO Convention 105 on the Abolition of Forced Labour, ILO Convention 138 on Minimum Age (of Employment), ILO Convention 182 on the Worst Forms of Child Labour, ILO Convention 100 on Equal Remuneration, ILO Convention 111 on Discrimination (Employment and Occupation), UN Convention on the Rights of the Child, Article 32.1, UN Convention on the Protection of the Rights of all Migrant Workers and Members of their Families.

insecurity. This was experienced in the US when a coal power plant that operated for 40 years was reported to have left behind 9.6 million tons of toxic waste[61].

The closure of CFPPs is both a leading requirement for the global climate change narrative and for the public health of local communities proximate to where they operate. CFPPs produce sulphur dioxide ($S0_2$), nitrogen oxides (NOx) and invisible particulate matter (known as PM_{10} or $PM_{2.5}$), which are all harmful pollutants and can contribute to chronic health conditions such as asthma and lung diseases. Children and elderly groups are particularly vulnerable to health impacts, and therefore may disproportionately benefit in the long-term from the closure of CFPPs[62].

A Government of Canada website for the Powering Past Coal Alliance identifies air pollution impacts from burning coal include smog, asthma, respiratory diseases, and premature deaths[63]. The website indicates that there are massive health care and economic costs due to lost worker productivity. It also states that a recent analysis found that more than 800,000 people around the world die each year from the pollution generated by burning coal. A phase out of coal will mean real improvements in air quality and human health.

As mentioned in the section on public services and infrastructure, the closure of the CFPPs may reduce financial support to community health systems and facilities provided by their operating companies, possibly through their corporate social responsibility funding. Noise pollution and dust from CFPPs are common community complaints. Some communities may therefore welcome the ending of such impacts as a result of CFPP early retirement[64].

Migration and loss of local skills

CFPPs should normally invest in developing local skills and capacities to support their functioning. However, migrant workers from other places are also often employed, bringing their skills to the host communities. Some of these migrant workers will have settled permanently in communities around CFPPs, adding to their social capital. As CFPPs are retired, skilled local and migrant workers may leave host communities to seek employment elsewhere and in other sectors. In the UK, depending on the plant's size, a coal power station typically employs around 100–500 workers directly with a similar number of people employed on a contractual basis. In the US, in 1997, a 300-MW CFPP would typically employ 54 people in operation and maintenance on an ongoing basis[65]. These employment numbers may not be as large compared to other industrial sectors, but they need to be evaluated at each individual plant level.

Migrant workers and local workers trained by the CFPPs could leave their families behind or move with their families for long-term employment in other places. Social networks, skills concentration, demands for vocational know-how would be affected by such migration.

Retraining opportunities may arise from efforts to retire CFPPs. Lenders and national regulatory institutions/bodies (such as ministries responsible for manpower or labour and employment) could require the CFPPs to compensate the workers affected by the closures and to offer a reskilling and upskilling programme to equip them for job opportunities in the renewable energy and other sectors. A well developed and implemented retrenchment plan can support such transition.

Indigenous communities

Indigenous communities may be more vulnerable to the adverse impacts associated with retirement of CFFPs, e.g., through loss of identity, culture, and natural resource-based livelihoods; as well as exposure to impoverishment and diseases[66]. In many countries, CFPPs are located in semi-urban and coastal areas and in remote areas where indigenous communities reside. There are documented

[61] https://www.gem.wiki/Coal_waste
[62] World Bank (2018b)
[63] Coal phase-out: the Powering Past Coal Alliance - Canada.ca
[64] Kravchenko and Lyerly (2018)
[65] See: Global Energy Monitor (undated)
[66] IFC (2012b)

instances of indigenous communities resisting CFPP establishment (e.g., in West Papua, Indonesia[67]), or being required to give up land for CFPPs in exchange for jobs, associated business activities, and community development.

The experience of indigenous peoples in the southwestern US provides useful lessons regarding CFPP closures. The Native American peoples' lands of this region are home to large coal reserves, coal mining and coal plants. Many Native American reserves are in remote territories with high rates of unemployment and poverty. According to IEEFA[68], the residing indigenous population is disproportionately impacted by environmental and health hazards associated with the coal industry. To date, communities including the Navajo Nation and Hopi Tribe have seen the loss of hundreds of high-paying power plant and mining jobs and millions of dollars in revenue, following the closure, in 2019, of the Navajo Generating Station near Page and the Kayenta coal mine that supplied it since the 1970s . In the face of CFFP closures, indigenous communities risk losing access to ancestral land (due to redevelopment of the CFPP sites) that may play an integral role in their way of life, providing subsistence and income, plus a spiritual, sacred landscape that contributes to individual and collective identities.

CFFP closure can also provide several benefits for indigenous communities. The transition to cleaner energy sources can end or offset negative environmental and health conditions. Often, geographic isolation and historical dispossession of ancestral lands makes energy access among indigenous groups particularly difficult, encouraging the use of highly polluting biomass and biofuels. The closure of CFPPs and coal mines, and a move toward clean energy, may help to undo long-standing trends that trap indigenous peoples in an unsustainable and damaging cycle of energy inequality[69] (Box 11.6).

Box 11.6: Delivering clean energy to Navajo tribal lands, USA

In the Southern United States, Navajo Power, a majority indigenous-owned Public Benefit Corporation is developing utility-scale clean energy projects on Tribal lands. Navajo Power's mission is to develop more than $3 billion of clean energy infrastructure in Tribal communities by 2030. Over the next decade, Navajo Power aims to deliver billions of clean energy infrastructure assets to power major markets across the U.S., with emphasis on the Southwest. A subset of this work includes bringing electricity to Navajo Nation households, where 15,000 families lack access to electricity. Navajo Power has launched a separate company, Navajo Power Home, to focus on this work of bringing power to Navajo families directly[70]. The W.K. Foundation has $3 million program-related investment in support of Navajo Power[71].

Gender and vulnerability

CFPP closures may have gender specific impacts. Gender often intersects with age, disability, income, race and/or class and indigenous status to compound social inequalities. In the context of Southeast Asia, vulnerability to the transition away from coal is ever more pervasive in rural areas, especially when women and girls (particularly indigenous women) are disproportionately impacted due to their relative isolation and more entrenched traditional gender roles[72]. These impacts can take the form of[73]:

- Greater gender inequality in workforce demographics and wage equality;

[67] Asia Pacific Solidarity Network *(*2020)
[68] IEEFA (2021)
[69] UNESCAP. 2018. *Inequality of Opportunity in Asia and the Pacific: Clean Energy*. Bangkok. https://www.unescap.org/sites/default/d8files/knowledge-products/Clean_Energy_Report_20190129.pdf
[70] https://everychildthrives.com/providing-energy-with-an-indigenous-lens/
[71] https://www.navajopower.com/
[72] EmPower (2020)
[73] Foot (2019)

- Increased social, health access and personal safety issues for women and girls;
- Education and health disadvantages that are acutely gendered;
- Where land is customarily owned by women, post-closure land distribution or withholding of customary land by the state as part of energy transitions can snatch these rights from women, and thus further diminish their economic, social, and cultural status[74].

While CFPP closure may result in direct job losses for both men and women, women are likely to feel the increased burden of social care and domestic responsibilities[75] and can be forced to take on more (often insecure and exploitative) paid work to support families—shouldering what is known as the "triple burden"[76]). Loss of livelihoods among male workers can prompt a shift in traditional gender roles at the household and societal level, heightening instances of intra-household tension, sexual and gender-based violence, and psychological distress. In pursuit of more secure economic opportunities, male workers impacted by closure may look to migrate out of affected communities and/or gain entry to so-called women-dominated sectors (i.e., garment factories), increasing competition that will seek only to heighten existing gendered disparities within the workforce.

Public services and infrastructure

The early retirement of CFPPs may also affect public services and infrastructure such as transportation, health, and education facilities. Retirement will reduce dust, air, and noise pollution, leading to improved public health. However, overall community health may deteriorate as support to health facilities and other services (e.g., education facilities, roads, bus, and other transportation) from CFPPs and associated businesses (including through tax revenue generation) is reduced or eliminated. Local communities reliant on a CFPP may also lose charitable contributions:

- Local community members impacted by a plant's closing are often most in need of the services of local charities, but the charities themselves may lose a major source of contributions - based on money donated by both the plant and the plant's wage-earning employees and the employees' contributions of time[77.]
- However, pressure on the public services and infrastructure could also be reduced as a result of out-migration of workers and their families.
- Local communities are often tied to the local services provided by CFPPs (Box), and so will be impacted when education or health facilities are downsized or stagnate following CFPP closure.

In countries which supply coal to many neighbouring countries (e.g., Indonesia), the closing of CFPPs can create more complex and serious problems than in developed countries[78]

Box 11.7: Community Dependence on Coal-Fired Power Plants and Coal Mines in Betul District, Madhya Pradesh, India

Betul District in Madhya Pradesh, India, experienced a boom in business and public infrastructure in the 1960s with the development of both coal-fired power plants and coal mines. Housing and community facilities grew, including schools, hospitals, roads, and banks. The coal industry also financed schools and medical services. It set up schools primarily for the children of its regular employees. There was a hospital only accessible to employees and dependents of the Satpura Thermal Power Station, while the rest of the community travelled to the district hospital at Betul. The communities became reliant on the facilities financed by the coal industry. Indeed. communities emerged as power plants were developed as their socioeconomic centres.

Source: Gupta (2021)

[74] Lahiri-Dutt (2021)
[75] World Bank (2018b)
[76] Lahiri-Dutt (2021)
[77] McCarter and English (2016)
[78] Resosudarmo *et al*. (2009)

Community cohesion and engagement

In some cases, the existence of particular CFPPs has been a long-standing issue of contention for local communities, often raising tensions between community members, activists, environmental NGOs, and the CFPP companies and government. In the Philippines, the anti-coal power plant movement has been growing significantly[79] . Filipino environmental NGOs such as Greenpeace, as well as trade unions, have actively advocated against new CFPPs. In Central Java, Indonesia, communities have staged protests against long-running air pollution problems caused by ash from a CFPP[80]. Stakeholder dialogue and citizen engagement (including with community representatives, CSO and trade union representatives) can provide meaningful mechanisms for addressing the concerns of coal industry workers, and for wider community members dependent on CFPP activity.

CFPP closure can have a negative impact on community cohesion and increase the risk of conflict within affected communities from groups of people who lose their jobs and incomes earlier compared to those who lose them later, and between groups of people who adapt more quickly and those who adapt more slowly. Being non-discriminatory regarding who loses jobs and when can help prevent conflict among worker groups, which may manifest further into the community.

11.7 IMPACTS OF CLOSING COAL MINES

The previous section has described environmental and social risks and impact associated with the operation and closure/decommissioning of coal-fired power plants. This section continues this discussion but for the closure of associated coal mines and supply chains. Table 11.10 summarises the key environmental and socio-economic concerns likely to be associated with closing coal mines.

[79] https://www.asiasentinel.com/p/anti-coal-movement-philippines?s=r
[80] Darmawan (2019)

Table 11.10: List of key environmental and socioeconomic issues for closing coal mines

ISSUE	COMMENT
Environmental	
GHG emissions	• Reduction in GHG emissions from stopping operating plant and pit, and shaft closure reducing methane emissions from coal seams • Uncontrolled mine abandonment may leave a legacy of methane leaks from open shafts, boreholes, fissures, and pits
Water quality	• Improved water quality following stopping dewatering (pumping water from mine) and land disturbance (tailings dams, etc.) / sediment runoff • Conversely, uncontrolled mine abandonment can leave a legacy of contamination on-site (e.g., old heaps, chemicals, etc.), which can contaminate downstream rivers, surface water bodies and groundwater • Spills and leaks (from vehicles and their cargoes) during closing of mine site can pollute groundwater and surface water
Water use	• Closing coal mines reduces water demand for use at the coal mine
Noise	• Long-term elimination of mine noise following closure/decommissioning • Short-term impacts from vehicles on-site and using local roads during decommissioning—impact on local communities
Contaminated land and groundwater	• Discharges from abandoned mines—as consequence of groundwater rebound, commonly acidic, and may contain high concentrations of heavy metals • Contamination of land and groundwater from abandoned mines due to undisposed chemicals, hazardous materials, mine dumps, and tailings
Air quality	• Stopping operations will reduce emissions of dust and particulate matter, NOx and SOx, but mine decommissioning activities may cause a short-term increase in such emissions • Fires may occur with uncontrolled mine abandonment, leading to increases in particulates
Waste	• Redundant infrastructure, equipment, and hazardous substances can contaminate soil groundwater and surface water • Improper disposal of potentially toxic overburden can cause land and water contamination
Land-use change	• Impacts related to future development. Sites that have managed decommissioning and carried out land-use planning can provide significant ecological benefits through revegetation and reinstatement of ecosystems services • Conversely, abandoned mine sites may render the site as a liability
Land degradation	• Slumpage and geotechnical instability from collapse of underground works may make the site unsuitable for other uses • Failure of mine walls, tailings dams, and stockpiles • Soil erosion on un-reinstated de-vegetated slopes • Waterlogging caused by artificial land contours and drainage patterns • Underground fires lead to ground slumpage and instability
Land and ecosystem restoration	• Developing and operating coal mines involves changes in land use and usually has a negative effect on local ecosystem functions, such as nutrient cycling and carbon sequestration. When a mine is closed, it is important to rejuvenate mine degraded land and restore ecosystem functioning similar to that of undisturbed sites. Restoration to original land uses may not be possible and final land uses should be decided well in advance as part of closure and decommissioning planning.
Socio-economic	
Legacy socioeconomic issues	• Outstanding socioeconomic issues of coal mines and mine mouth CFPPs that have not been dealt with or mitigated before closure
Regional economy	• Early retirement of CFPPs will impact on national and international coal supply chains • Increased coal price • Reduced imports and exports, leading to imbalance in national economies

ISSUE	COMMENT
	• Infringement of international trade agreements on coal supply • Increased electricity and fuel prices, impacting commodity and food prices • Opportunities to diversify the economy that do not rely on coal • Impacts to the coal supply train such as truckers, shipping fleets, etc.
Illegal mining	• Increased illegal mining as investment in managed and regulated coal mine is reduced
Employment and labour conditions	• Loss of jobs (direct and indirect employment) in coal mines • Long-term opportunities for employment, improved labour standards and working conditions in CFPPs and supply chains during the retirement period • Increased pressure on national welfare and social protection system
Health and safety	• Reduced occupational hazards and fatalities resulting from coal mining • Reduced chronic health impacts associated with coal mining, particularly underground • Improved health due to reduction of air and noise pollution and dust • Mine abandonment without remediation (filling/capping mine shafts, fencing-off, etc.) leading to safety risks • Hazardous waste and contaminated land, and mine pits left without remediation, leading to adverse impact on community health, including children's high exposure • Reduced traffic incidence
Local economy and livelihoods	• Decreased livelihood opportunities in the host communities. • Increased households' indebtedness and vulnerability to income loss and poverty. • Reduced revenues from renting properties and values of properties as a result of out-migration • Potential economic opportunities induced by the rehabilitation and redevelopment of coal mines and pits will create income-generation activities
Gender and vulnerability	• Women and vulnerable groups (e.g., the poor, persons with disabilities, children, the elderly, and indigenous communities) may be disadvantaged and at particular risk • Increased domestic and gender-based-violence due to loss of income • Increased competition from former male mine workers may arise in women-dominated industries (such as manufacturing and garment industries) following closure • Opportunities for women and vulnerable groups to acquire new skills and learn technologies • Opportunities for vulnerable groups to engage in the decision-making process and in inclusive dialogue for coal mine closure
Migration	• Local skilled workers and migrants attracted to work in mines and associated businesses will leave the communities • Increases vulnerability of abandoned household members whose income depends on skilled migrants • Opportunities for local workers to re-skill for new opportunities
Public services and infrastructure	• CFPP/mine closure may affect the public services and infrastructure supported by mining companies (e.g., health clinics, education facilities, roads, bus, and other transportation) • Decreased local government tax revenues from CFPPs and associated businesses • Reduced pressure on public services and infrastructure as a result of out-migration
Community cohesion and engagement	• Weakened community cohesion due to out-migration • Risk of internal conflict due to increased stress as result of income lost • Opportunities for communities to engage in the decision-making processes about mine closure • Reduced tension between the communities, NGOs, activists, and mining companies

11.7.1 Environmental issues and impacts of closing coal mines

Coal mine closures will occur as part of the transition away from fossil fuels toward cleaner energy. They will have a range of environmental and social risks and opportunities, as described below.

Until recently, it was not common for governments to require mine decommissioning and closure. So there are many mines that have been closed poorly or abandoned and left derelict or in some cases without ownership, creating legacy issues for governments and communities.

There is a risk that coal mines no longer supplying retired coal-fired power plants may continue coal production, selling to other markets and resulting in carbon leakage elsewhere.

Greenhouse gas emissions and air quality

Coal mining and mine closure have the potential to release coal bed methane through disturbance of the coal rock strata. Methane is released from underground mining activity through ventilation systems and degasification. Although surface mines release less methane than underground mines, the sheer volume of coal mined in surface mines allows for large volumes of methane to be released. Abandoned and closed mines release methane from diffuse vents, boreholes and fissures in the ground. Methane is a GHG with high global warming potential and can cause explosions leading to fires.

The release of methane from a mine will depend on the coal formation and the closure process, so it is difficult to quantify. Closing coal mines will have the benefit of reducing the amount of methane that would have been emitted if the coal mine had continued to operate. However, there is also a risk that in closing the operating plant, the open pit and mine shafts may continue to leak methane from the disturbed coal seam. There is potential to capture and use the methane from some larger mines. However, the small and irregular quantities of methane production from some mines makes this unviable. The volume of methane from abandoned mines around the world, although not quantified, is expected to be very high. Although the decrease in coal production would decrease methane release, it does not stop methane release altogether, and therefore, there is a need to manage methane from closed mines.

Fires may occur in abandoned mines where the methane and/or coal ignites. Such fires cause the release of airborne pollutants, which can impact the health of residents in nearby communities and cause a reduction in localized air quality. Particulate matter can also enter waterways leading to a reduction in water quality.

Coal mining can also impact on air quality due to general operational activities, e.g., dust from blasting and drilling, exhaust emissions form hauling and truck movements, and particulate matter arising from coal storage piles or the significant amounts of waste spoil generated.

Closing a coal mine and subsequent rehabilitation activities at the mine site may result in a temporary increase in trucks and machinery at the site that will cause localized air emissions from vehicle exhausts and the creation of dust. Mine closure can also lead to longer-term improvements in air quality around mining sites as a result of ceasing operational activities, and due to site rehabilitation (e.g., through revegetation), which will reduce the amount of particulate matter released to the local environment and avoid polluting waterways.

Water quality

Water management is one of the main environmental issues associated with an operational mine. It remains an ongoing concern when a mine is closed, when there is a need to address issues such as dewatering (pumping out water) of pits and mine shafts, coal washing, runoff and any water diversions that caused environmental impacts during operation. Many of these issues can be resolved and properly managed through effective site closure planning. In some cases, there will be a need for ongoing management and monitoring of water in pits and mine shafts.

Potential water quality impacts caused from mismanaged mining operations include acid mine drainage, algal blooms, and heavy metal pollution. These can impact nearby waterways, rendering the water unfit for human consumption and irrigation and impacting aquatic ecology. During mine closure, a specific water management plan should be developed, and measures implemented to prevent such potential impacts, and to ensure that stockpiles, pits, and other disturbed areas are rehabilitated and revegetated to reduce the potential for contaminated runoff.

Acid mine drainage issues associated with coal are commonplace around the world, often as a result of dam failure at abandoned mines (Box11.8). Impacts from a number of smaller abandoned mines may also have an impact.

Box 11.8: Residual Problems of Closed Coal Mines: The case of the Sewanee Coal Seam in East Tennessee, United States

In the Sewanee Coal Seam in East Tennessee in the United States, there are 300 abandoned coal mines. The Sewanee coal seam is surrounded by high levels of pyrite, an iron sulfide, that when exposed to water and air, creates acid mine drainage. Although these mines are no longer operational, due to this chemistry, there is no known method of preventing acid mine drainage runoff, which is highly toxic to humans, flora, and fauna, and has polluted the waterways and had impacts on communities. Although the water quality is being treated, the runoff still impacts aquatic flora and fauna and downstream users of this waterway.

Source: Frankenberg Veal (2012)

Subsidence during operation or closure can have an impact on streams and result in other environmental consequences. Fracturing of rockbars and dilution and cracking of bedrock can reduce the flow and water levels of streams. Subsidence may also result in soil erosion or scouring of waterways, increasing turbidity, changing water quality, and impacting on aquatic flora and fauna. These risks should be addressed through a plan for landform management and site rehabilitation.

Not only can coal mining have an impact on the quality of water but in some locations, may have an impact on surface and groundwater quantities and runoff (e.g., by blocking or diverting water courses). The reduction in volume of available water may affect nearby communities, farming, and aquatic environments. Closing of a coal mine provides an opportunity to enable surface waters to go back into water courses and groundwater systems for use by communities and to improve environmental flows.

Noise

Closure of coal mines will reduce the level of noise experienced by communities as equipment used for mining operations will cease operating (e.g., haulage equipment, truck movements, cutting and drilling machines, blasting, crushing, conveyors, fans, loaders, etc.). However, there may be a temporary increase in noise impacts when a mine site is being rehabilitated when trucks and machinery such as excavators will be required to operate.

Contaminated land and groundwater

If there is inadequate water management at abandoned or closed mines, this can result in significant pollution and contamination of surface water (Figure 11.9) or seeping into groundwater due to the discharge of mine water containing heavy metals and other pollutants[81]. Such pollutants can be carried by rivers away from the immediate mine site and impact communities many kilometres away from the mine, polluting water used for drinking and growing food.

[81] Johnston *et al*. (2008)

Figure 11.9: Seepage of Iron Oxyhydroxide Precipitates at the Friar Tuck site near Dugger, Indiana, United States.

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

With the closure of a coal mine, there is the opportunity for groundwater recharge, which can have positive and negative impacts. Reducing the use of water in the mining process reduces demand on the groundwater in the vicinity of the mine and allows the groundwater source to be replenished. However, both land and groundwater can become contaminated if there are undisposed or untreated chemicals or hazardous material abandoned in the mine on closure.

The land on which mining operations occur can become highly contaminated during mining activities due to accidents and/or the careless use and storage of chemicals, fuels, and hazardous material (e.g., sulphuric acid, nitric acid and solvents, fuels and oils and heavy metals).

Remediation of the land upon closure of a mine is vital to ensure that the land can be utilized for other uses post-mining, e.g., for agriculture, grazing, or residential estates.

Untreated land and water contamination—and long-term exposure to contaminants—can lead to health impacts for people and animals. Contamination can also have an impact on soil fertility, affecting the future use of the area. However, remediating mine sites to mitigate the risks of contamination is a costly exercise and there is a risk that mining operators may simply abandon sites.

Waste

Waste from coal mine closure also needs to be managed appropriately. It includes redundant infrastructure, overburden, equipment, and hazardous substances no longer required for mining that have the potential to contaminate soil groundwater and surface water.

Overburden (also called spoil or waste) is the soil and rock removed to access the coal. Open pit coal mining produces large volumes of overburden that may contain heavy metals, acid producing rock[82] and sulphur. Overburden should be managed from the commencement of a mining operation (i.e., the vegetation should be removed, and the topsoil taken away and stockpiled separately to the overburden).

During mine closure, the environmental impact can be reduced through engineered surface water and groundwater controls, movement of overburden, reinstatement of the topsoil layer, and revegetation. During closure, the movement of the overburden has potential to expose rocks containing sulphur (a source of acid generation) and toxic metals, which may leak into the environment and impact on soils, waterways, and groundwater. This, in turn, can impact on downstream environments and lead to ecological degradation. Intake of toxic metals by humans and animals can have severe health impacts which may not show for many years.

The disposal of potential toxic overburden to areas of the mine site where contamination can be contained is recommended in areas where management on-site and rehabilitation cannot occur. Management of toxic overburden volumes within mine sites, rehabilitation, or proper disposal of surplus wastes (subject to risk, if permitted) is often a legal requirement. Planning, measures, and actions to manage overburden is routinely documented in mine site closure plans.

[82] E.g. rocks containing iron sulphide minerals, such as pyrite

Land degradation

Land degradation is a key concern for coal mines due to activities such as land clearing, pit formation, underground shafts, subsidence, and erosion. It can lead to the loss of terrestrial habitats and loss of aquatic and terrestrial biodiversity, and reduced water quality. A key requirement in the successful rehabilitation of land post mine closure is to ensure that native vegetation is established over the site to stabilize the land and reduce erosion. Mine closure plans seek to restore water flow and quality to pre-mining levels and to create topography/landform that is consistent with the surrounding areas. This also aims to allow habitats to establish and biodiversity to return to previously cleared areas.

Mine closure plans are routinely prepared in consultation with the relevant government agencies, and in accordance with the relevant rehabilitation and mine closure guidelines for the local state and/or country. Mandated minimum durations for monitoring and evaluation are often required and are often varied by way of extension when site risks and the receiving environment are more sensitive.

The content of each mine closure plan reflects the land use being reinstated. For example, for rehabilitation to be successful for agriculture, drainage, revegetation, soil establishment and erosion control will be required to support this type of land use (e.g., Box 11.9).

Land use change

Land-use changes following mine closure require careful consideration and coordination to ensure that lands are repurposed, and environmental impacts are minimized and mitigated. As described above, soils and landform need to be rehabilitated to pre-mine conditions, if the former land use is to be reinstated. If the land use is to change, the extent of remediation needs to be sufficient to enable that end land use to occur. It is important for land to be rehabilitated to meet future use options in consultation with local communities.

In North America, former mines have been converted into wildlife centres, education, and research facilities, creating job opportunities in tourism and conservation (Box 11.10). Future land use may not be as complex as a wildlife centre, and rehabilitation may simply be for agriculture or grazing, or it may also make way for other industries and opportunities for new roads and water infrastructure.

Mine reclamation, and land and ecosystem restoration

As discussed in the preceding sections, developing and operating coal mines involves changes in land use and usually has an adverse effect on local ecosystem functions, such as nutrient cycling and carbon sequestration When a mine is closed, it is important to rejuvenate mine degraded land and restore ecosystem functioning similar to that of undisturbed sites.

The planning of mine reclamation/restoration activities should occur prior to a mine being permitted or started. It can help restore the lost carbon sink by promoting plant growth and enriching the mine spoil, which helps sequester atmospheric carbon. The most common techniques for mine restoration include afforestation, agriculture and grassland development. This may result in a land condition not necessarily the same as surrounding lands.

Box 1.9: Rehabilitation of Canyon Mine, New South Wales, Australia

Canyon Mine in New South Wales, Australia, was an open-cut coal mine and was extensively rehabilitated to pasture land after closure in 2009 due to exhaustion of the resource. Rehabilitation included reshaping of the final void and overburden emplacements, topsoil placement, installation of water management control measures, establishment of a cover crop, planting of tube stock, and monitoring and maintenance of rehabilitated areas. The land continues to rehabilitate to pre-mining vegetation communities, including pastoral, woodland, and forest. Figure 11.10 shows the site before and after rehabilitation when an initial cover crop was established. The image also shows water retention and management post-closure. As part of the closure plan and original development approval, a water management plan documented the quarterly water monitoring data results over the 5 years post-closure (i.e., October 2010 to October 2015). At this site, largely due to the absence of contaminated materials, the results were positive, with only one discharge point requiring subsequent 6-month monitoring for a further 2 years.

Figure 11.10: Canyon open-cut coal mine before and after rehabilitation

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

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Source: Whitehaven Coal

Box 11.10: Rehabilitation former coal mines: some examples

Former East Germany was a coal mining powerhouse, but the industry collapsed after the fall of the Berlin Wall. Soon after, 25 open-pit lignite mines in the Lusatia region were transformed into recreational lakes. Spanning the states of Brandenburg and Saxony, water was fed into the former mines from several major rivers, including the Spree and Black Elster. Some 30,000 animal and plant species have since been drawn to the region, leading to an increase in biodiversity. Lake Geierswalde and Lake Partwitz in particular have since become holiday hot spots.

In West Virginia, USA, the Appalachian Botanical Company is growing lavender in the poor soils of former strip coal mines. The drought-tolerant herb is processed to produce a fragrant oil for cosmetic and culinary products. Lavender rejuvenation is labour-intensive and provides jobs for coal industry workers made redundant amid the energy transition.

Source (Braun 2013)

Mine reclamation creates useful landscapes that meet a variety of goals ranging from the restoration of productive ecosystems to the creation of industrial and municipal resources, and development of alternative land uses (including solar farms). The operator should restore the land to its approximate original contour (AOC) or leave the land graded and suitable for a “higher and better” post-mining land use (PMLU) that has been approved as part of the original mining permit application. Exceptions are provided when a community or surface owner is in need of flat or gently rolling terrain. Acceptable post-mining land uses include commercial, residential, recreational, agricultural or public facility improvements.

Establishing a long-term sustainable ecosystem at a close coal mine site will depend on the adaptations of species to newly formed site conditions. The main element of the reconstructed terrestrial ecosystem is reclaimed mine soils, which are characterized by large spatial variability and consequently changeable habitat conditions. Thus, soil reconstruction and revegetation require ecological engineering tools and knowledge about species selection and their adaptation to post-mining sites. Larger landscape scale reclamation requirements, such as the restoration of wildlife movement corridors, should also be taken into account with preparation of site closure plans.

11.7.2 Socio-economic issues and impacts of closing coal mines

Country, regional, and global economy

Coal mining is an important contributor to many national economies (Box 11.11). The closure of coal mines will affect the coal supply chain at both national and international levels, resulting in increased

Box 11.11: Coal mining and economies

"Coal makes a significant economic contribution to our societies, and economies, particularly at a local level. Coal mining is still a contributor to many economies, especially in developing countries. Around seven million people worldwide work in coal mining, processing, and delivery[83].

Much of the coal industry in developing countries is export oriented and is a major source of foreign hard currency. Emerging economies continue to see coal as a good option for future development, but the contribution of coal is not limited to developing nations, as advanced economies benefit significantly from coal industry operations, both directly and indirectly.

In Queensland, Australia, 20,000 people were employed by the coal industry creating A$20 billion of income (2018 figures). Coal exports raised A$1 billion in royalties, providing a significant source of necessary funding for public services. Whilst in Europe, despite the significant reduction in coal production in recent years, the coal market in Germany and Poland still supports over 160,000 jobs in the form of direct and indirect employment."

Source: *https://www.worldcoal.org/*

Indonesia is the second-largest coal exporter in Asia and the Pacific. In 2021, coal mining contributed 8.89% to the Indonesian GDP[84]. The closure of coal mines would affect Indonesian economic growth. Between 1992–2009, Indonesia earned at least $9.3 billion in taxes from coal mine extraction[85]. The Philippines imports coal from Indonesia, Australia, the PRC, and Viet Nam. Annually, the Philippines imports coal to supply its CFPPs—about 12–15 million tons of oil equivalent. Change in coal supply in Indonesia would affect international trade patterns and importing and exporting countries' economies.

Note to reviewers: We would be grateful to have additional text (data) inserted for other countries

coal prices and reduced imports and exports, According to IRENA (2020) which analysed the global socio-economic and economic impacts of coal retirement, "An increase in imports, or reduction in exports [of coal], has a negative impact on GDP, while a decrease in imports or increase in exports has the reverse effect" [86].

Closing coal mines is a politically and socially complex issue, due to the involvement of multiple stakeholders including government (particularly energy ministries), local economic development agencies, investment associations, companies, NGOs and communities. The phasing out of coal mines requires early planning, due diligence, and active social dialogue with affected stakeholders. In Indonesia, closures of mine activities are already known to create complex and severe problems, especially since many of Indonesia's mining areas and local governments lack capacity. The sudden closure of coal mines can initially hit the local and regional economy adversely. Mass redundancies, reductions in economic output and, in more extreme cases, economic crisis, can fuel deprivation, extreme inflation and social unrest (Box 11.12).

[83] How Many People Work in the Coal Industry? (investopedia.com)
[84] Badan Pusat Statistik [Seri 2010]
[85] ASEAN Today (2021)
[86] IRENA (2020b)

Box 11.12: Mine Closure Conflicts in Indonesia

In Indonesia, since the 2000s, the closure of coal mines has resulted in substantial and ongoing tensions between communities, conservationists, mining companies, the Ministry of Forestry, and the Ministry of Energy and Mineral Resources. Local people receive only limited revenues, while mining operators make high profits from coal extraction When the mineral supply is depleted, mining operators abandon the area with limited alternative revenue options for local communities.

Mining operators, the government, and local communities have debated how to address this issue and the extent of environmental reclamation required prior to the closure of the mining operation. PT Kelian Equatorial Mining (KEM), one of the few mining companies in Indonesia, closed its operation in 2004. KEM had tried to implement its corporate social responsibility programs well in advance of its closure and had taken an integrated social and environmental approach to the mine closure process. Nevertheless, conflicts occurred as the compensation, environmental mitigation and employment opportunities could not be established in an appropriate and timely manner.

Source: Resosudarmo (2009b)

Local economy and livelihoods

As with the retirement of CFPPs, the risks associated with coal mine closures also include negative impacts on livelihoods, employment and the well-being of local skilled workers, migrant workers, and associated businesses within the existing coal supply chains. The loss of income from jobs in coal mining would substantially reduce income flows, affecting the economy of host communities (Box11.13). It would affect retail, accommodation services, food services, other dependent sectors, and social services. There is clear evidence that decades after coal mines have been shut down, many coal-dependent regions continue to lag socially and economically[87]. For instance, as workers leave communities, the price of properties and of land can decline, and local government tax revenue can also decrease. It cannot be expected that renewable energy technologies will replace these revenue losses in a timely manner. Careful planning is needed when considering the shift to cleaner energy generation. Unfortunately. in many cases. this does not happen.

Box 11.13: Local economy and community dependence on coal mines

Shanxi Province in Northern People’s Republic of China provides an example of an economy dependent on the coal industry. Recent declines in the coal market and the government’s environmental commitments resulted in closures of coal mines in Shanxi in the early 2000s. This has hit the province with reduced revenues for the state-owned enterprises and tax revenue reductions for the local government.88 Countries in Eastern Europe such as Poland, Ukraine, and Romania had programs to restructure their coal sectors in the 1990s. These resulted in the mass closure of mines, which were often located in communities where the coal sector was a dominant source of income and economic development. Mining enterprises not only mined coal, but also provided houses and socioeconomic benefits to the workers, their communities, and towns. Communities throughout Romania, Ukraine, and Poland faced further social problems after mine closure, e.g., increased substance abuse, prostitution, and child abandonment.

Evidence from Australia shows that the emotional dimension of the mining sector and community utility associated with the coal sector can be characterized as their “cultural asset” and identity. Towns hosting coal mines are usually coal industry-driven, without many alternatives to sustain economic and social make up.

Sources: World Bank (2003); and Della Bosca and Gillespie (2018)

[87] World Bank (2018b)
88 ADB. 2006. Technical Assistance Consultant's Report: Poverty Reduction in Coal Mine Areas. Manila. https://www.adb.org/sites/default/files/project-document/66626/37616-prc-tacr.pdf

However, the rehabilitation of coal mining sites can create income-generation opportunities. For example, in Nord-Pas-de-Calais in northern France, former coal mines were rehabilitated to provide playgrounds, museums, hiking trails, cycling routes, artificial ski slopes, etc.[89] . Open mine pits can also be redeveloped as reservoirs or pumped-storage hydroelectricity projects, as in the state of North-Rhine Westphalia, Western Germany [90]. Such repurposing creates economic activities for the local communities.

Many coal-dependent economies lack the incentives and resources needed to protect workers and their communities. A study of 1,000 coal mine closures from around the world between 1981 and 2009, found that 75% of all closures were unplanned[91].

Legacy of socio-economic Issues

As with the retirement of CFPPs, closing coal mines could exacerbate prolonged unresolved (i.e., not mitigated previously by coal mine companies) socioeconomic impacts, including outstanding land conflicts, contamination and land degradation, lack of compensation payments for land and property loss, lost livelihoods, and income. Such issues could be induced by the lack of enforcement of national regulations, inadequate impact assessments, and mitigation measures not following good international industrial practices (e.g., the IFC performance standards[92]). An assessment report[93] found that, In the Cesar department in the north of Colombia:

“There is no evidence that any activities by either [mining] company mitigated the impacts to any degree. The high degree of severity of the forced displacements continued unmitigated well into the mining companies’ timespan of operations, and those impacts remain fully unmitigated and remediated to this day”.

Such legacy issues can also be found in the Southeast Asian mining sector. Sumatra (Indonesia’s second coal-richest region) is both blessed and cursed by coal. At the beginning of 2022, the government revoked more than 2000 mining business licenses (including 1,776 mineral licenses and 302 coal licenses) because of failures to comply with requirements under national laws. The *government plans to transfer the areas covered by the licenses to local entities and potential investors[94].*

Health and safety

The closure of coal mines can provide opportunities for reducing the health and associated safety risks to communities (e.g., chronic health impacts associated with coal mining, particularly underground), and for improving local water and air quality. Mine closure and land reclamation requirements should be embedded in the overall mine planning and permitting process from the outset. Good practice examples are available from Ukraine, Poland, and Romania where dedicated coal mine closure companies effectively manage the efficient and safe physical closure of mines.

A priority for mine closure needs to be the health and safety of people and communities during the closure and rehabilitation phases, both within and adjacent to the mine site. Compliance with safety standards is important to protect infrastructure and prevent hazardous events and incidents from occurring.

Health and safety risks arise when a mine is not properly decommissioned. This can include land instability, subsidence, or potential land and water contamination from tailings dams and mine spoil areas. These risks, in conjunction with inadequate monitoring and water management, can lead to

[89] National Geographic (2022)
[90] Agerholm (2017)
[91] Strambo *et al.* (2019)
[92] www.ifc.org
[93] Wilde-Ramsing *et al*. (2021)
[94] Zuhal (2022)

water logging, soil slumpage, slope failure and contamination within and adjacent to the closed mine site.

The closure of coal mines can benefit the health and safety of local communities. Mine closures often help improve air quality and eliminate or reduce dust at the mine site—two key public health issues associated with coal mines.

In addition, closure eliminates fatalities resulting from road accidents involving heavy vehicles transporting coal (Box11.14).

Box 11.14: Road accidents involving coal trucks in Sumatra, Indonesia

It is reported that in Sumatra, in 2022, thousands of overloaded coal trucks used the main roads each day infuriating local communities. The trucks caused traffic congestion for kilometres, and those living along the main road had no option but to breathe dust and thick diesel fumes every day. Coal truck drivers, some of them reckless, inexperienced, and unlicensed, regularly caused traffic accidents with dozens of fatalities. During 2017–2019, more than 30 residents were killed, and, in 2021 alone, the number of deaths reached 34.

Source: Saputra, M. B. 2022. In Indonesia, Sumatra's coal brings more harm than good. New Mandala. 19 January. https://www.newmandala.org/in-indonesia-sumatras-coal-brings-more-harm-than-good/.

There may also be public health issues risks if hazardous waste is left behind in coal mine areas. Mine abandonment without remediation (filling/capping mine shafts, fencing-off, etc.) and the absence of long-term monitoring will create safety risks. For instance, animal and child drownings have been reported at abandoned mines in Australia and in Indonesia's Borneo region (Box 11.15).

Box 11.15: Lack of post-closure remediation in abandoned coal mines in Borneo

It is reported that the owners of hundreds of abandoned coal mine pits in Borneo failed to undertake post-closure remediation, and, in some cases, local governments did not fully ensure that owners complied with regulations. As a result, the surrounding communities are at risk of short- and long-term environmental and health risks.

Source: Apriando and Esterman (2017)

Closed mine sites are one of the most significant pollution risks in many countries, including the UK. It is important from a public health perspective to have mitigation measures in place when decommissioning. If not planned for or mitigated, heavy metals and other pollutants may be discharged into the water. According to environmental and coal authorities in the UK, some mines are filling up with groundwater and may discharge the liquid in the future, posing large-scale health and safety risks. Legislation and policy in the UK, including the Environmental Permitting Regulations (2010), National Planning Policies and the EU Mining Waste Directive (Directive 2006/21/EC) aim to protect human health. Other countries, including those in the Southeast Asia region, may lack such national regulations or may have less robust requirements that focus on health and safety when mine sites are closed.

Illegal mining

In countries where regulatory enforcement is weak due to inadequate institutional support, coal mining may be carried out by artisanal, illegal and unlicensed companies or individuals. Such illegal mines are reported in many low-income countries, both small- and large-scale[95] [96] and can have significant consequences (Box 11.16).

Coal mine closure can increase pressure on the capacity of local and central governments to manage the remaining coal resources. For many reasons, government capacity may be limited by insufficient public budget allocations by the central government. In such situations, opportunistic mining (individuals or entities) may find loopholes to extract coal illegally.

Employment and labour conditions

Phasing out coal mining is a complex process and will affect local workers. This is particularly true for regions highly dependent on coal-related activities. It is expected that the direct decline in coal-related jobs seen over the past decade will continue, largely driven by the environmental agreements and transformation into alternative renewable energy resources. According to the International Energy Agency (IEA), by 2030, 30% fewer people are expected to work in coal-related sectors compared to 2019. Almost a third of this decline is expected in coal mining. According to the World Bank, the closure of coal mines can exacerbate the existing socio-economic and employment impacts, given the geographic isolation, disparity in wages and the distinct culture of coal mining towns. These factors are expected to pose further challenges to the recovery efforts regarding employment and labour conditions[97].

Employment in coal mines varies from one site to another due to the size and accessibility of the coal deposit. However, coal mining sites tend to employ more workers than CFPPs. The closure of coal mines tends to create significant adverse job loss impacts. In Poland, efforts to close coal mines reduced jobs drastically from around 390,000 in 1989 to about 150,000 workers in 1999 (Figure12).

Figure 11.12: Employment in Coal Mines in Poland

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

[95] Soelistijo (2011); and Nasir *et al*. (2022).
[96] MCSA (undated)
[97] World Bank (2018b)

Box 11.16: The consequences of illegal coal mining in Indonesia

Following the Asian financial crisis[98] and unemployment in Indonesia, illegal coal mining activities significantly increased from 1998 onwards. Further expansion of such illegal mining was also fuelled by the decentralization of the coal sector aimed at boosting the economy and energy supply. Lenient sanctions and corruption in granting mining permits resulted in inconsistencies in mining regulation and policies, which led to local resistance to the government[99]. The Government of Indonesia used to tackle only symptomatic cases of illegal mining activity. This led to illegal and complex networks of coal mining operations increasingly funded and backed by foreign investors to avoid tax and other regulatory commitments. As a result, businesses in neighbouring countries and overseas used Indonesia's illegal mining sector without having to internalize and address deep socioeconomic and environmental externalities and repercussions[100] . Although illegal mining temporarily supported local and regional economic development, it also resulted in long-term and deep inter-communal conflict and social unrest. For example, in Pongkor region (West Java), the opportunities to engage in illegal mining led to the development of rebel groups and increased fighting over mining territories.

Large companies' mining operations and extraction activities in the region resulted in continued violence and an increase in sex-workers, child labour, and fatal occupational accidents[101].

In Indonesia, workers were killed at illegal mining sites due to improper health and safety measures (Figure 11.11). In 2006, illegal mining sites in Kalimantan were found to involve child labour with about 10% of workers reported as being under 17 years old. In Sumatra, non-transparent coal mining concessions increased rapidly from 750 in 2001 to 10,900 in 2022. Over 1,000 of these mining permits were revoked by President Joko Widodo because the mining had harmed both social fabric and environment of the communities. Such situations could worsen when the state's budget allocation for managing the coal mining resources diminishes as the need for coal for coal-fired power plants gradually declines.

Figure 11.11: Workers searching for people killed in a landslide at an illegal coal mine, landslide, Indonesia, October 2021

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Sources: Cronin and Pandya (2009); Resosudarmo et al (2009b); Saputra (2022); and Wijaya (2020)

According to the Indonesian Bureau of Statistics, the mining and extraction industry employed 1,443,422 Indonesians in August 2021. If the coal mines close, many workers will be affected. As such, community protests closures can be expected in areas neighbouring mines. This will be particularly important when announcing how the energy transition will occur in areas facing coal mine closure or CFPP retirement.

[98] A sequence of currency devaluations and other events that began in the summer of 1997 and spread through many Asian markets.
[99] Resosudarmo *et al*. (2009b)
[100] Resosudarmo *et al*. (2009b)
[101] Resosudarmo *et al*. (2009b

Coal mine work is characterized by the International Labour Organisation (ILO) as difficult, dangerous, and rarely associated with good labour relations[102]. There is plenty of evidence of coal mines operating without proper health and safety standard. In Sumatra, up to 34 residents were killed by road accidents caused by a coal mine transportation truck[103]. As with retiring CFPPs, the process of closing mines could reduce or eliminate the use of forced labour, child labour and/or subject to substandard working conditions through introducing or changing existing laws to make such practices illegal, and by ensuring systems are in place to enforce laws and regulations. Lending and financing institutions (e.g., the MDBs) could make such practices unacceptable through imposing lending requirements for safeguard implementation.

There are opportunities that some or all workers who lose jobs in coal mines could be retrained and upskilled for job placement programs, and to pursue employment opportunities in renewable energy projects or other sectors. For instance, evidence from job placement programs in the UK and Canada (both coal-exiting economies) shows that opportunities for former miners were largely limited to part-time and short-term positions, which did not replace the long-term security and benefits provided by full-time coal mining jobs. Part-time workers generally receive low wages, have limited advancement opportunities and unpredictable working hours, lack of pension contributions, and face undesirable working and living conditions, all limiting their career prospects[104].

Indigenous communities

When coal mines close, adjacent indigenous communities face similar issues to those highlighted during CFPP retirement (Chapter 6). However, when coal mines are to shut down, the indigenous communities can face both challenges and opportunities. Challenges include difficulties to assert their rights to reclaim natural resources, cultural sites, and places to practice cultural traditions, and their ability to participate in redevelopment projects[105]. Indigenous communities, or specific groups within them, are often already considered to be vulnerable. Where indigenous communities rely on coal mines for their livelihoods, the closure of such mines can increase their vulnerability and force them further into poverty.

Energy transition involving coal mine closure can cause unintended and complex social challenges, universally overlooked in policy making. Many cases of coal mine closure in the southwestern regions of the US demonstrate these challenges. As mentioned in Chapter 6, there are many Native American peoples' lands in the US with large coal reserves exploited by mining. Indigenous communities occupying these lands are therefore disproportionately impacted as host communities. In the face of mine closures, indigenous communities will need to agree how they want the land reclaimed, considering that their past, current, and future identity are closely aligned with the physical, cultural, and spiritual representation of the land[106].

There are also several benefits to indigenous communities from coal mine closure, not least a transition to cleaner energy sources that can offset negative environmental and health conditions. Closure may create an opportunity for such communities to reclaim land, natural resources and revive their customary land-use practices and culture, as in East Kalimantan, Indonesia[107].

Gender and vulnerability

As with CFPP retirement, the social risks and issues associated with mine closure, particularly those related to employment, livelihoods, and well-being, are felt differently by women and men, challenging and changing gender roles, relations and identities (Box). Mine closure can compound social inequalities faced by women and the most vulnerable, particularly those from protected characteristic groups such as indigenous peoples).

[102] ILO (2004)
[103] Saputra (2022)
[104] Aassve et al. (2006)
[105] IFC (2012b)
[106] University of New Mexico (2017)
[107] The Asia Foundation (2016)

Box 11.17: Gender difference in employment in coal mines in Kalimantan, Indonesia

For the indigenous peoples of Kalimantan in Indonesia, coal extraction predominantly offers income for men of the region, while women search for more precarious (and possibly informal) work. The coal industry here serves to solidify gendered divisions of labour, with the closure of the industry likely to expose such vulnerabilities further.

Source: Lahiri-Dutt (2012)

The risks and issues associated with gender and vulnerable groups highlighted in section 11.5.2 subsection on gender and vulnerability) apply equally to coal mine closure, and include:

- Greater financial and domestic burdens placed on women resulting from sudden job losses;
- A shift in traditional gender roles - heightening instances of intra-household tension, sexual and gender-based violence and psychological distress.

Migration

Mine closure can cause unintended and complex social challenges such as migration, which is universally overlooked in policy making[108]. Out-migration of the mining labour force (particularly skilled workers) can lead to significant demographic change. Evidence shows that extended out-migration can also put a strain on local businesses, tax revenues and the associated delivery of public services, as experienced in Yorkshire and Wales, UK[109].

Depending on the size of the coal mine, out-migration can be small or large. In most cases, the closure of coal mines can cause large-scale out-migration, especially from mining areas that operate for years or decades. Over time, skilled workers become a significant local resource for the communities in the mining area and, when they leave, this creates a skills vacuum. Similarly, those who had settled in the mining areas to work in small businesses associated with the mining activities may leave for other opportunities.

Opportunities may also arise when coal mines are closed early. These could be created by requirements of financing organizations that coal mine companies compensate workers affected by mine closure and provide a programme for reskilling and upskilling workers so that they can pursue job opportunities in renewable energy and other sectors. However, such reskilling will not occur quickly and must be adequately planned for.

Public services and infrastructure

As for the early retirement of CFPPs, the closure of coal mines can affect public services and infrastructure such as transportation, and health and education facilities in areas where the mining companies are present and where they have large corporate responsibility budgets. The ability of local governments to spend tax revenues on maintaining public facilities may also be reduced.

Indonesia is Southeast Asia's largest exporter of coal, supplying many neighbouring countries. In the coming years, it could face the same experience as Yorkshire and South Wales in the UK, where mine closures created social tensions due to the loss of community services such as hospitals and schools. Local communities are often dependent on services provided or financed by mines (e.g., literacy, and health and education services). Problems arise when these cease or are no longer

[108] Mayer (2021)
[109] Merrill and Kitson (2017)

funded as a casualty of mine closure[110]. In Southeast Asia, especially in the Philippines and Indonesia, the closing of mine activities can create more complex problems than in higher-income countries.

The existence of mining projects in Indonesia has often been regarded as a catalyst for accelerating development of infrastructure and increasing community well-being in many areas. This is particularly true for many districts (Kabupaten) where local governments generally lack the capacity to provide public services[111].

Section 11.4.2 discusses how communities may become dependent on public services and infrastructure provided and/or financed by CFPPs and coal mines (e.g., in Betul District, Madhya Pradesh, India[112], see Box11.7). However, the lack of financial support from mining companies could be offset by the reduced pressure on the public services and infrastructure due to out-migration; and even by the reduction of heavy vehicle movements which would then require less public expenditure on road infrastructure repair and rehabilitation.

Community cohesion and engagement

The social risk posed by rapid coal mine closures, compounded by the variations in coal mine ownership, points to the important leadership and communication roles required of governments to plan and prepare for such closures. Those planning coal mine closure must consider how best to mitigate impacts on people and communities.

Avoidance of conflict and protests is a critical measure of success in coal mine closure programs as successfully demonstrated by several coal sector reform programs in Poland and Romania (Box11.18).

Box 11.18: Engagement with coal mine workers and communities over mine closure

Extensive dialogue channels were established with trade unions in Poland, facilitating a mechanism for reform acceptance and implementation, supported by the continued engagement with mine workers.

In Romania, community representatives were involved in capacity building and identifying direct employment opportunities as part of the coal mine decommissioning process, and discussions on the repurposing of infrastructure and other assets, which guided realistic expectations. This engagement with mine workers and community representatives not only contributed to the acceptance of mine closures but also contributed greatly to the design of social and labour support measures for workers, their families, and communities.

In Ukraine and the United Kingdom, there was a lack of significant stakeholder engagement with regard to closure of coal-fired power plants and mines. In Ukraine, reforms were blocked. In the United Kingdom, reforms were achieved but there were protracted conflicts with unions and mine workers over a two-decade period after 1984.

Sources: Gupta (2021); World Bank (2018b)

[110] Merrill and Kitson (2017)
[111] Resosudarmo *et al.* (2009b)
[112] Gupta (2021)

CHAPTER 12

Guidance for Institutions

This chapter provides guidance and suggestions for those government institutions and other organisations likely to commission or undertake SEAs for national energy plans or PPPs, particularly as part of the energy transition away from generating power from fossil fuels to the use of renewable energy sources.

Usually, it will be national government departments (particularly those responsible for energy) that will commission or undertake such SEAs. But funding agencies (particularly multilateral development banks, MDBs) may also be required to carry out SEAs to comply with their safeguard policies when providing financial support for national energy transition activities.

An important factor is that achieving the energy transition will involve multiple government ministries and agencies and require the involvement of private sector energy companies and investors as well as the public. This makes it a complex process with a wide array of participants with different political and economic interests, each of which have their own agendas, policies and responsibilities. An SEA will have to navigate potentially challenging ‘institutional waters’. This makes it very important to establish a Steering Committee (or equivalent body) to oversee the SEA process (see below). It can act as a high-level platform or space to build support and involvement in the SEA, agree on its focus, and discuss concerns (which may be divergent) about energy transition. The Steering Committee should be established at the earliest point possible in the SEA process. Ideally, the Steering Committee should be chaired by the lead institutional responsible for the SEA.

12.1 A simple introduction to SEA

Chapter 1 provides a background to SEA and Chapter 3 sets out the key steps, stages, and approaches. The information in these chapters and the rest of this guidance is likely to be of particular relevance and utility to SEA practitioners and reviewers. For non-technical people working in government as policy-makers and planners, who may have to be involved in commissioning an SEA for a policy, plan or programme, or may find themselves involved in an SEA process, Box 12.1 provides a short guide to SEA .

Box 12.1: A short guide to SEA

Strategic environmental assessment is now in use around the world and is a formal requirement in over 100 countries. The following is a summary of key questions that arise at the onset of SEA.

What is SEA and how is it helpful?

- ***SEA is a high-level process*** – it is undertaken for policies, plans and programmes (PPPs) – not for individual projects or actions. Such PPPs can be over-arching (multi-sector) or for particular sectors or may be for particular geographic areas.

- ***SEA promotes sustainable development*** – it helps governments and others to ensure that environmental and socio-economic concerns are considered in a balanced way when developing and implementing PPPs.

- ***SEA is a key tool to address the challenges of climate change and the energy transition* –** it provides a mechanism to assess how a PPP might enhance or impede efforts to combat the challenges of climate change and ensure a just transition to a low carbon energy transition.

- ***Every SEA is different*** - each one needs to be tailor-made and designed to address the specific circumstances and needs. This should be made clear in the SEA terms of reference.

- ***SEA is done by experts*** – is usually undertaken by a team of experts commissioned by a government (and sometimes by a multi-lateral development banks or other funding agency).

- ***SEA is a transparent and inclusive process*** **-** that involves broad stakeholder involvement (at all levels: from national to local) throughout the process.

- ***SEA identifies issues of concern*** **-** the key environmental and socio-economic issues associated with the PPP being assessed (carried out during a scoping phase) and assembles ***baseline data*** for these issues. SEA normally uses existing and available (secondary) data but fieldwork or research may also be undertaken to collect new (primary) data.

- ***SEA Identifies benefits and impacts*** - it assesses both the potential environmental and socio-economic benefits and impacts of implementing the PPP (and alternatives to the PPP). Many of the benefits and negative impacts will be cumulative – the collective consequence of many individual actions and development projects.

- ***SEA recommends how to deal with outcomes*** **-** the success of an SEA will ultimately depend upon implementation of its recommendations in a timely manner. So, SEA results in a report on the above and a management plan (strategic environmental and social management plan, or SESMP) that recommends how potential benefits can be enhanced, how negative impacts can be avoided and mitigated, and who needs to do what to implement the SEA recommendations and undertake monitoring and follow-up.

- ***SEA provides critical information*** to policy-makers, planners and decision-takers at key stages of developing policies, plans and programmes.

How long does it take?

Usually, an SEA will take between 6 and 12 months to complete, but sometimes longer if seasonally considerations need to be addressed and where it is closely integrated with the PPP process with a longer development timetable.

Cost

The cost will vary due to the length of the process and the complexity of the chosen design: from as little as US$ 20,000 to 50,000 (e.g., for a rapid (two to three month), desk-based SEA) to US$1 to 2 million (for a full SEA of a complex PPP over say an entire year).

12.2 All institutions

The following considerations apply to all institutions involved in the SEA process:

- Follow the suggested contents provided in Annex 2 when preparing ***terms of reference*** for SEAs for PPPs concerned with energy transition and renewable energy sub-sectors.

- Engage with consultants appointed to undertake an SEA to understand any concerns or uncertainties they may have regarding the ***terms of reference*** for the SEA and clarify (modify if necessary) the terms of reference. Key discussions will be required regarding timelines and costs.

- Ensure that the terms of reference clearly set out the ***SEA process*** to be followed (having regard to the steps discussed in Chapter 3) and provide for an ***appropriate timeframe***. A short timeframe for the SEA will limit its ability to be useful and contribute effectively to decision-making. It may also prevent adequate scoping and a meaningful assessment of the likely impacts of the PPP and alternatives concerning key environmental and socio-economic issues. It will also restrict the level of stakeholder participation and affect their confidence in the SEA process. As a rule of thumb, an SEA for renewable energy is likely to require 6-12 months to undertake, assuming it is based on existing and available (secondary) data. If new data needs to be gathered, or further research needs to be undertaken, a longer timeframe will be required.

- When appointing consultants, it is advisable that the team be dominantly composed of ***national experts***. Only such experts will have thorough experience and understanding of national and more local environment and socio-economic issues, and familiarity with national cultural norms.

- In countries where SEA experience is limited or practice still in its infancy, it may be necessary to engage very experienced ***international consultants*** who have a knowledge of the SEA process. Such international consultants should be able to demonstrate SEA work experience and knowledge of the country or region concerned. They will also be available to advise, and if necessary, help coordinate the national consultant team.

- It is advisable to establish a ***Steering Committee*** (or equivalent body) to lead and direct the SEA. It should comprise representatives from key government ministries/agencies, the private sector involved in energy development, and civil society (e.g., NGOs, trade unions, academics, etc.). Funding agencies supporting the SEA (e.g., MDBs) should also be represented. Such a Steering Committee should be limited in number (e.g., 15-20 individuals) so that it can operate effectively. Its main role will be to oversee and smooth the way for the SEA process, provide guidance where required, provide a standing platform for high-level stakeholder interaction and consensus-building, and advocate for support for the process. The Steering Committee should be convened by the responsible government agency initiating the SEA. An appropriate Chairperson will be required. It will also be important to identify a key "point of contact" (e.g., the Chairperson or official Convenor) for the SEA team to interact with, as necessary. The Steering Committee should coordinate the stakeholder engagement process together with the SEA consultant. Minutes of all Steering Committee meetings should be kept.

- ***Stakeholder engagement*** is critical to ensure that an SEA is able address all legitimate concerns. It is also vital to ensure support for the goals of the PPP concerned and to enhance its successful implementation. The terms of reference should set out the minimum requirements for stakeholder engagement at national to local levels. The consultants should develop a stakeholder engagement plan as soon as possible, and discuss this with the client. Stakeholder engagement should begin early and continue throughout the SEA process. It will be very important to elicit feedback from stakeholders regarding key aspects of the SEA (e.g., focus and key issues to be addressed, findings) and respond to all comments and concerns to garner trust from all participants and to ensure that are voices are heard and listened to.

- Ensure that the critical steps in developing and approving the PPP are identified and communicated to the SEA consultants so that they can design the SEA process to ensure that ***critical information from the SEA*** is delivered to the PPP process at the most appropriate time and to the relevant individuals/agencies responsible for PPP decision-making.

- Ensure that relevant baseline environmental and socio-economic data sets and legal, governance and institutional information sources for the SEA are readily available to the SEA team.

- Require that the SEA team engages with the client and other agencies likely to have a role in implementing the Strategic Environmental and Social Management Plan (SESMP) when preparing its contents. Agreement/consensus should be sought on what plan components are realistic and able to be undertaken, and on roles, responsibilities and recommendations - particularly as regards monitoring functions. In this way, the SESMP will be designed and 'owned' by its likely implementers rather than being a mere proposal of the consultant team.

- The SESMP should indicate the frequency for monitoring and follow-up of implementation of SESA recommendations. Some indicators may require regular and frequent monitoring (e.g. quarterly); others might need less frequent monitoring (e.g. annual or biannual). The selection of these indicators is important and must be done carefully to ensure the successful measuring of SEA recommendations. Monitoring is key to signalling where corrective actions are required.

- Depending on capacity of the implementing institution, a third-party consultant may be hired to serve as a SESMP Management Office (SMO) to help set up the implementation framework and to train and develop capacity of the responsible government institution and prepare them as to how the SEA actions should be achieved.

12.3 Government institutions

The following considerations apply to government institutions involved in the SEA process:

- Check ***with national legislation and regulations*** to determine if they require that an SEA be undertaken for a national energy plan or PPP for a renewable energy sub-sector. If so, ensure that the terms of reference for the SEA comply with all stipulated requirements.
- Ensure that all ***relevant ministries/departments/agencies*** are aware of the SEA process and can engage with it. An SEA for renewable energy PPPs will likely identify issues and challenges for a range of other sectors (e.g., economy, transport, labour, health, etc.) which will have to be considered. These agencies may also have key roles to play in implementing a ***Strategic Environmental and Social Management Plan*** (including monitoring functions). So, their involvement throughout the process is advisable.
- Because many government institutions operate in a siloed fashion without mechanisms in place for effective inter-institutional coordination and cooperation, it will be important to set-up a multi-stakeholder SEA Steering Committee or an Advisory Committee responsible for overseeing the SEA and its recommendations and for overseeing implementation of the SESMP. This should be coordinated by the agency or institution responsible for the SEA.
- Ensure that the SEA is tiered with and guides subsequent project-level ***environmental and social impact assessments (ESIAs)*** carried out for individual projects/assets when the PPP is implemented. Reference to the SEA and its key findings should be referenced in the terms of reference for the preparation of project-level ESIAs.

12.4 Funding agencies

The following considerations apply to funding agencies involved in the SEA process:

- Check what requirements there may be for an SEA to be undertaken under national legislation or regulations. Ensure that the terms of reference comply with any such national requirements.
- Engage with the government body having jurisdiction over any national legal or regulatory requirements for SEA and ensure that the terms of reference are acceptable to the government (or are jointly developed).
- Determine if other funding organisations are also engaged in supporting renewable energy development or supporting the energy transition in the country. They may also have safeguard requirements that an SEA be undertaken. Ensure that a single SEA is carried out that is acceptable to all interested parties and secure agreement on its terms of reference.
- Ensure that adequate funds are provided for completing the SESA. This should include both funds for the SEA consultants and the stakeholder consultation process.
- Ensure that consultation requirements comply with lender safeguard requirements. Often, national requirements for consultation in the SEA do not meet what funding agencies require.
- Ensure that reporting requirements and responsibility for review, editing and approval of SEA recommendations are clearly defined with the SEA consultant, including timelines for both delivery and review of reports.

12.5 Renewable Energy Developers

Institutions and funding agencies may interact with private sector renewable energy proponents during the course of SEA execution. The following are some considerations as to how they should be engaged.

- Normally, developers of individual renewable energy projects are not involved in preparation of a SEA. However, the recommendations of an SEA will be of great interest in providing a reference framework as to how renewable sector energy development will occur.
- The private sector often forms an important group of stakeholders and renewable energy developers should seek to part of the consultation process.
  -
- Similarly, developers may also wish to be involved in the review of the draft SEA and offer comments and suggestions that may be relevant to their individual project.
- Developers may also wish to seek representation on an SEA steering committee to be informed of policy or planning decisions that might affect renewable energy sub-sector development, including how individual planned or future projects might be affected.

12.6 Stakeholder engagement

Reference can be made to Chapter 3 concerning how stakeholder engagement should be carried out. A key issue is that stakeholders should include all those with a legitimate interest in the energy transition PPP and SEA, whether they are likely to be directly or indirectly affected by its implementation. A stakeholder engagement plan should be prepared to ensure that an adequate and representative suite of events are organized at all levels: national, sub-national (e.g. relevant regions, provinces and districts) and local (e.g. communities) as well as for interest groups (e.g. farmers, fisherfolk, resource users, coal plant and mine workers, etc.). Stakeholder consultations should not be focused just at the national level. This will alienate many people and miss key concerns and information. It is important that the consultation budget consider this multi-level requirement for consultation. Often it is not.

12.7 SEA and Just transition

12.7.1 Uptake of the Just Transition concept

Just transition (JT) is a requirement of the energy transition. The concept was first used in the 1980s by US trade unions to protect workers affected by new water and air pollution regulations. The trade union movement developed JT as a framework to encompass a wide range of social interventions needed to secure workers' rights and livelihoods for those economies shifting to sustainable production, primarily combating climate change and protecting biodiversity. In recent years, the concept has gained traction with reference to meeting climate goals by ensuring the whole of society – all communities, all workers, all social groups – are brought along in the pivot to a net-zero future and that no one is left out of it[1]. It is highly relevant to the energy sector, as the shift from fossil fuels to renewable and low-carbon energy will entail loss of jobs in some sectors and creation of jobs in others.

The International Labour Organization (ILO) defines JT as: “Greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind.”[2]

[1] What is just transition? And why is it important? | Climate Promise (undp.org)

[2] Frequently Asked Questions on just transition (ilo.org)

JT often seeks to unite social and climate justice, for example, for coal workers in coal-dependent developing regions who lack employment opportunities beyond coal when transitioning to other forms of renewable energy.

A number of organizations have used the concept of a JTJT with respect to environmental and/or climate justice.

With regards to climate change mitigation, the IPCC defines JT as: "A set of principles, processes and practices that aim to ensure that no people, workers, places, sectors, countries or regions are left behind in the transition from a high-carbon to a low carbon economy."[3]

Language regarding JT and the creation of decent work is included in the Preamble to the UN Paris Agreement agreed at the UN Climate Change Conference in 2015 (COP21). The importance of JT was subsequently highlighted in the Solidarity and Just Transition Silesia Declaration adopted at the 2018 UN Climate Change Conference in Katowice, Poland (COP24). The Declaration encourages all relevant UN agencies to proceed with its implementation and consider the issue of JT when drafting and implementing parties' nationally determined contributions, or NDCs.

At COP26 in Glasgow, the European Investment Bank announced a set of JT common principles agreed upon with multilateral development banks, aligning with the Paris Agreement. The principles refer to focusing financing on the transition to net zero carbon economies, while keeping socio-economic effects in mind, along with policy engagement and plans for inclusion and gender equality, all aiming to deliver long-term economic transformation.

A number of multi-lateral development banks have vowed to uphold the principles of climate change mitigation and a JT.[4]

12.7.2 What is the relationship between SEA and the Just Transition?

SEA and JT goal can be seen as having parallel and complementary aims. They both seek to address the impacts and opportunities brought about by the energy transition, but with differences in focus. SEA is concerned with the environmental and socio-economic effects of PPPs, whilst JT mainly emphasises social concerns (employment, livelihoods, health, and safety) largely at the asset level.

SEA is not specific to the energy transition. It is a process that supports policy-making and strategic planning across many sectors where the environmental and socio-economic benefits, risks and impacts of development decisions need to be assessed.

As applied to the energy transition and to individual (sometimes multiple) sectors. SEA provides a high-level assessment of government energy-related policies, plans or programmes (PPPs). It is not concerned with individual energy asset or projects. Those are the focus of project-level environmental and social impact assessment (ESIA). SEA aims to identify the potential environmental and socio-economic benefits and the negative risks and impacts of the energy transition; and identifies the potential opportunities to promote sustainable development through the energy transition. The SEA produces an Environmental and Social Management Plan (SESMP) recommending how the opportunities, risks and impacts of the energy transition can be managed by the responsible implementing agencies and others.

However, JT is specific to the energy transition. It can have both a strategic as well as an asset/project-level focus. Its focus is on the process of transitioning to a low-carbon and sustainable economy in a way that is fair and equitable for all stakeholders, including workers, communities, and vulnerable populations. It involves ensuring that the benefits and costs of the transition are distributed fairly, and that workers in industries that are being phased out are not left behind or worse off. The outputs of assessments concerned with JT identify specific social interventions required to minimize social, economic, labour and health and safety risks of the energy transition at both a strategic and

[3] IPCC (2022)
[4] Source: Just transition - Wikipedia

asset level. There have been calls for the JT to also include more consideration of environmental risks[5].

While these analyses are different with regard to their outputs, the data and information derived from both JT and the SEA processes should be mutually supportive. The findings of the JT can also help inform the SEA process for the energy transition.

The relationship between JT and SEA lies in their shared goal of promoting sustainable development and ensuring that the benefits, risks and impacts of decisions about energy distribution are distributed fairly amongst all parties. SEA can be used to assess the potential benefits and impacts of a JT plan, and to identify ways to ensure that the transition is fair and equitable for all stakeholders. Similarly, assessments for JT in a country can inform the development of SEA by highlighting the needs and interests of workers, communities, and vulnerable populations.

In short, both JT and SEA are important vehicles for promoting sustainable development and ensuring that the benefits, risks and impacts of decisions regarding the energy transition are distributed fairly amongst all those involved.

[5] e.g. Abram *et al*., 2022).

CHAPTER 13

INFRASTRUCTURE ASSOCIATED WITH RENEWABLE ENERGY

This chapter focuses on infrastructure that is associated with the energy transition, particularly new infrastructure required to support the development of renewable energy such as transmission lines (trunk lines, new connections), access roads and the development of smart grids with energy storage systems/facilities. The chapters in this guidance concerned with types of renewable energy (chapters 5-10) all highlight that the construction of transmission lines and access roads are amongst the main causes of environmental and social impacts.

13.1 EXISTING SEA GUIDANCE/GUIDELINES FOR INFRASTRUCTURE ASSOCIATED WITH THE ENERGY TRANSITION

An international survey of existing SEA guidelines conducted for the IAIA was unable to identify any guidelines specifically focused on infrastructure specifically associated with the energy transition and specifically with the development of renewable energy. However, many EIA and some SEA guidelines refer to the general impacts of roads, transmission lines, and ports, harbours and terminals.

Roads

The Mekong River Commission has produced guidelines for the integrated planning and design of economically sound and environmentally friendly roads in the Mekong River floodplains[1].

Transmission lines

EIA and SEA guidelines for transmission lines have been published for several countries: Germany, Southern Africa, Surinam, and the USA. Marshall and Fischer (2006) discuss regional electricity transmission planning and tiered SEA in Scotland[2]. The International Finance Corporation's *Environmental, Health and Safety Guidelines for Electric Power Transmission and Distribution* are a very useful reference document with general and industry specific examples of good international industry practice[3].

Ports, harbours and terminals

With regard to the energy transition, ports, harbours and terminals are likely to be developed or upgraded/expanded mainly in connection with exporting green hydrogen and ammonia. The International Finance Corporation's *Environmental, Health and Safety Guidelines for Ports, Harbours and Terminals* provide a useful reference source with general and industry specific examples of good international industry practice[4].

13.2 TYPES OF TRANSMISSION LINES AND POWER GRIDS

A transmission line is the long conductor (either overground supported by pylons (Figure 13.1), or underground/sub-marine) with special design (bundled) to carry bulk amount of generated power at very high voltage from one station to another as per variation of the voltage level. Design must take account of key factors including voltage drop, transmission efficiency, line loss, etc. These values are

[1] MRC (2011)

[2] Bundesnetzagentur (2021) EnvSC (1999); Bundesnetzagentur (2021) MRC (2011); NIMOS (2005); USAID/CCAD/EPA (2011a.b.c); and Marshall & Fischer (2006).

[3] IFC (2007c)

[4] IFC (2017)

affected by line parameters R, L and C[5] of the transmission line. There are three types of transmission line length (Table 13.1)

Figure 13.1: High voltage transmission line crossing conifer forest land, Oregon, USA

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Table 13.1: Lengths categories of transmission lines
(Source: www.electrical4u.com)

Type of transmission line	Features
Short line	• A length less than 80km (50 miles) • Voltage level less than 69 kV • Capacitance effect is negligible • Only resistance and inductance are taken in calculation capacitance is neglected.
Medium line	• A length more than 80 km (50 miles) but less than 250 km (150 miles) • Operational voltage level is from 69 kV to approx 133 kV • Capacitance effect is present • Distributed capacitance form is used for calculation purpose.
Long line	• A length more than 250 km (150 miles) • Voltage level is above 133 kV • Line constants are considered as distributed over the length of the line

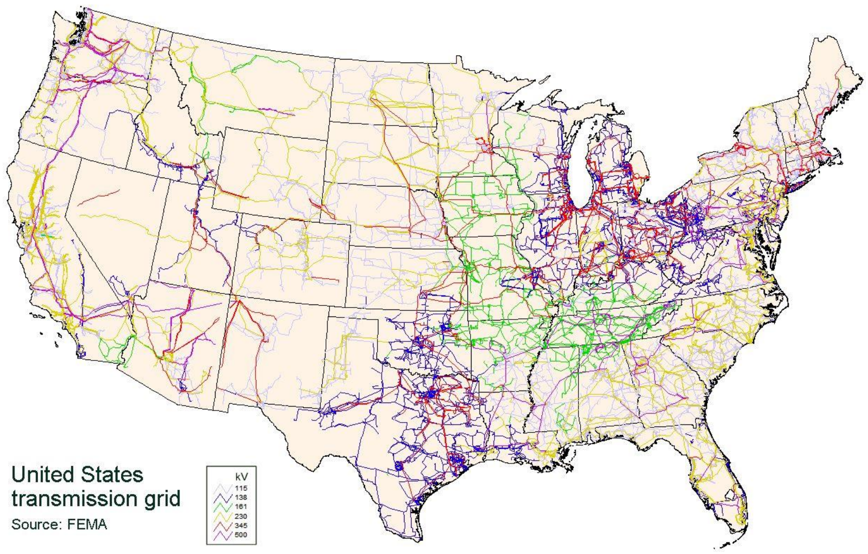
A ***power grid*** is a country's network of power generation, transmission and delivery, conducting electricity from power plants to homes and businesses across a country (e.g., Figures 13.2 (China) and 13.3 (USA)). It includes energy utility companies and energy suppliers and the infrastructure to generate and distribute power. The grid may be a single national network, or several regional grids that may be interconnected.

Figure 13.2: China's power grid

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

[5] A transmission line is modelled with a resistance (R) and inductance (L) in series with a capacitance (C) and conductance (G) in parallel. The resistance and conductance contribute to the loss in a transmission line.

Figure 13.3: USA power grid
Source: Source: Federal Emergency Management Agency (FEMA), USA (available at: https://commons.wikimedia.org/wiki/File:UnitedStatesPowerGrid.jpg



A grid ensures best practice use of energy resources, provides greater power supply capacity, and makes power system operations more economical and reliable. The generating stations are interconnected to reduce the reserve generation capacity, known as a spinning reserve, in each area.

A ***smart grid*** is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users. Smart grids coordinate the needs and capabilities of all generators, grid operators, end users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimising costs and environmental impacts while maximising system reliability, resilience, flexibility and stability.

Despite some recovery from the economic disruption caused by the Covid-19 pandemic, investment in smart grids need to more than double through to 2030 to get on track with the Net Zero Emissions by 2050 Scenario, especially in emerging market and developing economies[6].

According to analysis of available data[7], the total length of transmission circuits worldwide is estimated at 4.7 million kilometres, and the length of distribution grids between 88 and 104 million km. China accounts for 41% of the expansion of global transmission grids, and 32% of the expansion of distribution grids since 1980. In 2017, China's electricity grids were approximately as large as the grids of all western industrialized countries combined. The globally installed capacity of transformers is estimated between 36 and 45 Teravolt-Ampere, with transmission and distribution transformers accounting for above 40% each, and generator step-up transformers for the rest.

In 2023, worldwide, there were 7 million circuit Km[8] of power transmission lines and 110 million Km of power distribution lines[9]. As a 'rule of thumb' each TWH pa of electricity use globally is supported by 225 km of power transmission lines (interquartile range of 175-275 km per TWH pa). Another 'rule of

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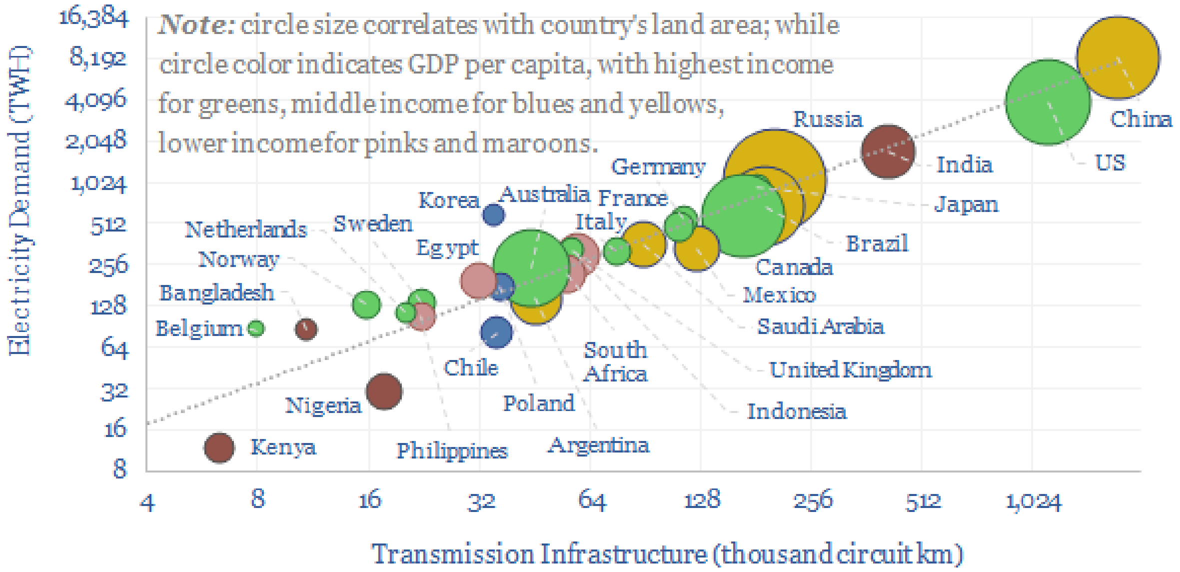
[6] Smart Grids – Analysis - IEA
[7] Kalt *et al*. (2021)
[8] *What are circuit kilometres?* One 'network kilometre' of power transmission lines may carry one circuit kilometre, two circuit kilometres or sometimes (rarely) three circuit kilometres, suspended from the same towers. In turn, each circuit kilometre may contain two large conductors (e.g., a high voltage direct current, HVDC), three conductors (3-phase AC) or sometimes (rarely) six conductors where the 3-phase AC is disaggregated to promote transmission efficiency. This makes the 'length' of a transmission line a somewhat debatable concept.
[9] Power transmission and distribution kilometers by country? - TSE (thundersaidenergy.com)

thumb' is that each TWH pa of electricity use is supported by almost 4,000 km of distribution lines. The cut-off between transmission and distribution is a little bit blurry but ,generally,100kV lines can be considered as transmission lines and <50kV lines as distribution lines. Globally, on average, countries have 16 km of distribution lines per km of transmission lines[10]. Generally, large, developed countries tend to have a higher share of large-scale transmission, due to greater availability of financing for larger and more efficient grid infrastructure. Countries tend to have longer power transmission networks per unit of delivered electricity when (a) population density is lower (b) GDP per capita is lower and (c) average voltages of the transmission system are lower.

Using the above rules of thumb above, Thunder Said Energy (a research consultancy for energy technologies) estimates that each 1 GW of new, utility-scale renewables might warrant constructing or upgrading around 500 km of transmission lines and 8,000 km of distribution infrastructure. However, the requirements will clearly vary case by case and depend on regional backlogs. A far-offshore wind project clearly has different network impacts from rooftop solar[11].

Figure 13.4 shows power transmission and distribution Km by country across 30 key countries which comprise 80% of global electricity use.

Figure 13.4: Transmission infrastructure and electricity demand for a range of countries
Source: [Power transmission and distribution kilometers by country? - TSE (thundersaidenergy.com)]



To achieve the energy transition, most electricity transmission systems around the world will need massive expansion, upgrades, shifts in technology used, and accommodation to the type of electricity that is transmitted (for instance high voltage dc). Investments in the types of transmissions systems taking place now may limit future options. There may be issues for projects to connect to electricity grids (so that they are on-grid or grid-tied) that are designed for larger utility scale projects. Also, the potential for grid connections between countries could have huge benefits (financial, environmental, social) if done properly. There are already examples of essentially 'stranded' renewable energy projects that cannot get their energy to markets due to grid constraints. After 20 years of effort, the USA has only recently finalised the first decision on a grid expansion.

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[10] Power transmission and distribution kilometers by country? - TSE (thundersaidenergy.com)

[11] Power transmission and distribution kilometers by country? - TSE (thundersaidenergy.com)

13.3 ACCESS ROADS

All renewable energy developments are likely to require access roads (including bridges), particularly in the preparatory stage, e.g. to bring in equipment (e.g. drilling rigs for geological investigation of selected sites, earth-moving equipment and construction materials), to transport labour to sites and for maintenance purposes (Figure 13.5). In an inhabited area, existing roads may be capable of being used, but may require upgrading (e.g., to accommodate wide or heavy loads). But there may be a need to extend the existing road network. In many cases, new renewable energy facilities may be located in remote areas, requiring the construction of new access roads. Such roads may require to be constructed across difficult terrain (e.g., mountainous land) and it may not be possible to avoid traversing sensitive and protected areas.

There are no internationally agreed specifications for such access roads. But they certainly can lead to serious environmental and socio-economic impacts (discussed in section 13.6) which need to be mitigated and managed. But it must also be recognised that access roads can also bring benefits to local populations and communities.

Some authorities (national or local) may set out specifications for such access roads (e.g., national standard specifications in South Africa[12], and specifications set by county councils in the UK[13]) setting out requirements covering, for example, design issues, management of materials (e.g. for blasting), safety, fences and barriers, drainage, earthworks, surfacing, footways, traffic signs, lighting, etc.).

Figure 13.5: Constructing access road to Amethyst hydropower scheme, New Zealand

Source: Amethyst Hydro Access Road | Earthworks, Rock Supply and Placement, Roading - MBD Contracting

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

13.4 ENERGY STORAGE FACILITIES

An electric power grid operates based on a delicate balance between supply (generation) and demand (consumer use). One way to achieve this balance is to store electricity during periods of relatively high production and low demand, then release it back to the electric power grid during periods of lower production or higher demand. In some cases, storage may provide economic, reliability, and environmental benefits. Depending on the extent to which it is deployed, electricity storage can help the utility grid to operate more efficiently, reduce the likelihood of drops in voltage in the electrical power supply system (brownouts) during peak demand, and allow for more renewable resources to be built and used.

The need for storage is a particular concern with regard to solar and wind power. When the electric grid has all the energy it needs at a given time, but it's a sunny or windy day and solar and wind energy systems are still generating electricity, it makes sense to store the surplus. Then, when the sun has set and the wind isn't blowing, that stored surplus energy can be discharged to continue supporting power needs.

Energy can be stored in a variety of ways, including:

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[12] COTO Standard Specification - Department-of-Transport

[13] Specification for highway works for new developments (leicestershire.gov.uk)

- ***Pumped hydroelectric*** (currently the most widely used technology with significant additional potential in several regions) Electricity is used to pump water up to a reservoir. When water is released from the reservoir, it flows down through a turbine to generate electricity.
- ***Compressed air*.** Electricity is used to compress air at up to 1,000 pounds per square inch and store it, often in underground caverns. When electricity demand is high, the pressurized air is released to generate electricity through an expansion turbine generator.
- ***Flywheels*.** Electricity is used to accelerate a flywheel (a type of rotor) through which the energy is conserved as kinetic rotational energy. When the energy is needed, the spinning force of the flywheel is used to turn a generator. Some flywheels use magnetic bearings, operate in a vacuum to reduce drag, and can attain rotational speeds up to 60,000 revolutions per minute.
- ***Batteries*** (the most scalable type of grid-scale storage and the market has seen strong growth in recent years). Similar to common rechargeable batteries, very large batteries can store electricity until it is needed (Figure 13.6). These systems can use lithium ion, lead acid, lithium iron or other battery technologies (see Box 13.1).
- ***Thermal energy storage*.** Electricity can be used to produce thermal energy, which can be stored until it is needed. For example, electricity can be used to produce chilled water or ice during times of low demand and later used for cooling during periods of peak electricity consumption.
- ***Others***: In addition to these technologies, new technologies are currently under development, such as flow batteries, supercapacitors, superconducting magnetic energy storage, molten salt[14] and hydrogen (discussed separately in Chapter 14).

Figure 13.6: Hornsdale Power Reserve (a Tesla facility), South Australia

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Box 13.1: Batteries

The most common type of battery used in grid energy storage systems are lithium-ion batteries. Lithium-ion batteries include five components:

- an anode (typically graphite coated onto aluminium foil);
- a cathode (either nickel-magnesium-cobalt or nickel-cobalt-aluminum; lithium-iron-phosphate; and blended onto copper foil);
- a separate barrier between the anode and cathode;
- an electrolyte solution to transport lithium ions; and
- current collectors made of copper and aluminium that connect the battery to wires.

An additional advantage of batteries is their use in “mini-grids,” which can help individuals and communities keep the lights on for extra hours when the grid falls temporarily offline due to blackouts or natural disasters.

In some countries (e.g. USA), instead of batteries, fossil fuel-powered “peaker plants” are often used to supply energy during high-demand periods. Despite being used infrequently, these plants are inefficient and highly polluting, and contribute greatly to carbon emissions.

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[14] Molten Salt Storage for Power Generation - Bauer - 2021 - Chemie Ingenieur Technik - Wiley Online Library

By 2023, the USA is predicted to have deployed 20.5 GwH of energy storage capacity between 2013 and 2023, followed by China (10 GwH) and Japan (8.3 GwH) (see Table 13.2).

Table 3.2: Projected energy storage deployment between 2013 and 2023
(Source: Energy storage deployment forecast by country 2023 | Statista)

Country	Projected capacity (GwH)
USA	20.5
China	10
Japan	8.3
Australia	6.6
Germany	4.3
UK	2.6
India	2
South Korea	1.5
Canada	1.3
Rest of World	8.1

According to the U.S. Department of Energy, the USA had more than 25 gigawatts of electrical energy storage capacity as of March 2018. Of that total, 94% was in the form of pumped hydroelectric storage, and most of the latter capacity was installed in the 1970s. The 6% of other storage capacity was in the form of battery, thermal storage, compressed air, and flywheel[15].

13.5 PORTS, HARBOURS AND TERMINALS

The energy transition will involve reducing (and ideally eliminating) our dependence on fossil fuels as energy sources. Coal, oil, and gas need to be transported from where they are extracted to where they are consumed – within countries or internationally - by road, rail, sea and pipelines. Where fossil fuels are exported or imported by sea, this involves ports, harbours and terminals. Sometimes these are dedicated stand-alone facilities, e.g., Richard Bay coal terminal in South Africa (Box 13.2); in other cases they are part of general ports that handle a wide range of other cargoes.

As regards fossils fuels, this guidance focuses only on retiring coal-fired power plants and the closure of associated coal mines and the cessation of use of ports, harbours and terminals for coal transport.

[15] Electricity Storage | US EPA

Box 13.2: Richards Bay Coal Terminal, South Africa

Richards Bay Coal Terminal (RBCT) in South Africa is one of the leading coal export terminals in the world. RBCT was established in 1976 with an original capacity of 12 million tons per annum (Mt/a). It has since expanded to an advanced 24-hour operation with a design capacity of 91 Mt/a, and handles coal from 65 collieries and brought by rail. RBCT is positioned at one of the world's deep seaports and handles large volumes of coal and vessels. The 276 ha site currently 2.2 km long, 6 berths and 4 shiploaders, with a stockyard capacity of 8.2 Mt. It is currently visited by more than 900 vessels per year.

Source: Global Markets: Richards Bay Coal Terminal to export 74M tons of coal this year (mozambiqueminingpost.com)

Figure 13.7: Richards Bay coal terminal, South Africa

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

Source: Who We Are – Richards Bay Coal Terminal (rbct.co.za)

13.6 IMPACTS OF TRANSMISSION LINES AND ACCESS ROADS

The environmental and socio-economic impacts of both transmission lines and access roads are discussed in detail for different types of renewable energy development in chapters 5 (hydropower), 6 (wind), 7(solar), 8 (bioenergy), 9 (geothermal) and 10 (tidal).

13.6.1 Environmental and socio-economic impacts of transmission lines and access roads

Tables 3.3 and 3.4 summarise, respectively, the main environmental and socio-economic impacts associated with transmission lines and access roads.

Table 13.3: Key environmental impacts associated with transmission lines and access roads.

Issue	Impacts	Applies mainly to transmission lines and/or access roads
Land clearing - deforestation	• Soil erosion • Landslips • Sedimentation of rivers • Loss of and fragmentation of habitats, and loss of biodiversity • Loss of services (terrestrial and aquatic)	• Both • Roads • Roads • Both • Roads
Biodiversity	• Fragmentation of habitats caused my single and multiple linear disturbances. Often transmission lines and roads occur together • Increased access to protected areas • Poaching and wildlife trafficking	• Both
Quarries and borrow-pits	• Digging for rock or gravel can also release pollutants other harmful substances into the surrounding environment (particularly surface and ground water) • Land degradation and loss of vegetation • Noise from blasting and crushing • Dust • Waste from unwanted materials • Lack of restoration to prevailing conditions	• Both
Marine habitat disturbance	• Seabed and marine habitat disturbance/scouring and water quality impacts (when constructing underwater cable foundations associated with offshore wind	• Offshore transmission line
Wildlife deaths	• Collisions with vehicles • Collisions with power lines and electrocutions • Increased access leading to poaching	• Roads • Transmission lines • Both
Waste	• Waste soil and rock (spoil) from excavation/routing works and levelling transmission pylon sites	• Both
Noise	• Noise (during road and line construction (including underwater and due to vessel movement in case of off-shore wind); • Vibration and dust during construction	• Both • Roads
Visual and aesthetic impacts	• Impacts on landscape	• Transmission lines
Herbicide use	• Impacts of herbicides used to control vegetation on the right-of-way	• Transmission lines but can be used on road margins

Table 13.4: Key socio-economic impacts associated with transmission lines and access roads.

Issue	Impacts	Applies mainly to transmission lines and/or access roads
Land use	• Limitations/restrictions on land use along easement routes and beneath transmission lines (e.g., no agriculture, tree planting or buildings). For indigenous peoples, this can include impeded access to spiritual, cultural, and economic relationships with their land.	• Transmission lines
Fishing	• Affects on fishing (e.g., reduced yields/catches) and other aquatic-based activities or reliant livelihoods (for offshore wind transmission cables	• Offshore transmission cables
Health and safety	• Health and safety issues related to high overhead voltage cables, during construction of lines or underground/underwater cables; and due to roads, quarries and borrow-pits (accidents due to increased presence of vehicles – particularly during construction, and operation of equipment) • Health effects associated with electromagnetic fields (EMF)	• Both • Transmission lines
Jobs	• Job opportunities for local people • Opportunity for vulnerable groups and indigenous communities to acquire new skills through working on transmission line construction and road building. • There may be gender gaps with women where they are under-represented	• Both
Labour rights	• Infringement of labour rights during transmission line and road construction, mainly where there is a demand to undertake excessive overtime and successive days of work without sufficient rest	• Both
Tensions and conflicts	• Tensions can arise when transmission lines are built—particularly since the electricity generated is not distributed locally (hydropower projects are typically permitted as generating facilities and are not allowed to distribute electricity to local communities). • Conflicts between the workforce and the local population and exposure to anti-social behaviour; • Conflicts within the local population can arise for a range of reasons, often relating to issues of inequity, including, for example: compensation measures (which may arise from a lack of clarity on cut-off dates), eligibility criteria or entitlement provisions (e.g., duration); access to and extent of training and support; and access to and extent of project benefits. • There is a risk of conflict between communities and project developers if the latter do not secure the free prior and informed consent (FPIC) to projects and	• Transmission lines • Both • Both • Both

Issue	Impacts	Applies mainly to transmission lines and/or access roads
	their associated transmission lines from indigenous communities	
Community cohesion and engagement	• Impacts to or loss of community resources (e.g., gardens, land, forest, fisheries) and community assets (e.g., community meeting areas, culturally significant features);	• Both
Land acquisition risks	• Associated with acquiring land for roads, substations, and transmission lines	• Both
Cultural	• Cultural, religious, and archaeological sites can be destroyed or access to them restricted when land is acquired for transmission lines	• Both

Box 13.1 discusses some of the challenges associated with transmission lines in Nepal.

Box 13.1: Challenges of constructing transmission lines in Nepal, and the case of the New Butwal – Lamahi 400 kV transmission line

(contributed by Ajay Mathema (SchEMS, Nepal)

Transition lines prioritized. The Government of Nepal (GoN) has prioritised the construction of transmission lines to 'evacuate' or transport electricity generated by hydropower projects across the country. Environmental requirements for transmission line projects have been eased. The Environmental Protection Regulations 2020 now require only an Initial Environmental Examination (IEE) rather than a full EIA for all sizes and scales of transmission line.

Land acquisition (for Rights of Way, RoW) across private land is a major challenge. Electricity Rules require both vertical and horizontal clearance beneath and adjacent to conductor wires to ensure safety and smooth operation of transmission lines. A right-of-way (RoW) is negotiated with the landowner that imposes restrictions on the use of land (e.g., on the height of vegetation and buildings that can be constructed) and offers compensation (typically 15 – 25% of the land's value) to landowners. The restrictions significantly depress the value of the land and financial institutions will not accept such land as collateral, further limiting its financial potential. As a result, many landowners are reluctant to have the transmission line pass through their land and transmission line projects have faced strong resistance from the public, significantly delaying construction and leading to uncertainties in the overall energy infrastructure development. Land is purchased from landowners for towers and substations.

Routing transmission lines through forest areas. This alternative has given rise to a new set of concerns and trade-offs, particularly related to the environment, the integrity of forest ecosystems (through land clearing) and loss of habitats and biodiversity – as exemplified by the proposed New Butwal – Landhi 400 kV transmission line – see below. Many animal species rely on forested areas for shelter, food, and breeding, and their displacement and habitat fragmentation due to the transmission line can disturb the delicate ecological balance.

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The proposed 400 kV New Butwal – Lamahi transmission line project in Lumbini Province.

This 160 km transmission line is estimated to require the clearing of about 180,000 trees along its corridor. Nearly 97% of the transmission line alignment passes through the forests on the foothills of the Churiya Hill range. Traditionally, transmission line projects in Nepal clear the vegetation along the RoW to comply with the Electricity Rule 1003 and to ensure the safe and efficient operation of the transmission land while minimizing potential hazards (e.g. fire) and disruption caused by encroachments or incompatible constructions.

The project intends to minimize impacts on the forest by avoiding removal of ground vegetation as well as minimizing the clearance or trimming of trees (to only those above 20m) - by increasing the height of the towers to 90m. Forest sampling showed that 20% out of the 180,000 trees along the transmission line corridor are taller than 20m and will require either removal or trimming.

The project also aims to minimize vegetation removal for tower construction and stringing operations. Drones will be used for stringing. Vegetation clearance will be limited to a 200m stretch of the RoW at every 4 km, requiring 40 clearance sites which will cover a combined area of 36.8 ha. Taking all factors into account, including trees above 20m, construction work, stringing, and substation sites, the total number of trees expected to be removed along the corridor will be approximately 45,000 (25% of all trees). Most of the trees to be persevered are Sal - a protected species. This approach will also minimise disturbance to forest habitats and the delicate, erosion-prone geology of Churiya hill range.

It is estimated that the proposed taller towers and using advance construction technology will increase project costs by 40%, making it one of the most expensive transmission line projects. This significant increase in expenses may not be feasible for the GoN.

13.7 IMPACTS OF ELECTRICITY STORAGE

Storing electricity can provide indirect benefits. For example, electricity storage can be used to help integrate more renewable energy into the electricity grid. Electricity storage can also help generation facilities to operate at optimal levels and reduce use of less efficient generating units that would otherwise run only at peak times. Further, the added capacity provided by electricity storage can delay or avoid the need to build additional power plants, transmission and distribution infrastructure, or access road - which have associated environmental impacts.

Potential negative impacts of electricity storage will depend on the type and efficiency of storage technology. For example, batteries use raw materials such as lithium and lead, and they can present environmental hazards if they are not disposed of or recycled properly. In addition, some electricity is wasted during the storage process. Plus, demand for these rare metals in batteries is leading to a boom in their mining and the associated environmental impacts associated with such mining.

From a social perspective, mining for rare metals is often associated with violations of the human rights of communities (e.g., rights to land, livelihood, ability to undertake traditional cultural practices, forced and child labour).

13.8 IMPACTS OF PORTS, HARBOURS AND TERMINALS ASSOCIATED WITH THE ENERGY TRANSITION

With regard to the energy transition, new ports, harbours and terminals are likely to be developed or existing ones upgraded/expanded mainly in connection with exporting green hydrogen and ammonia. Liquid natural gas (LNG) terminals are also being built for the transport of natural gas as a transition fuel for electricity generation, away from coal and diesel. But, as pressure and commitments increase to retire coal-fired coal plants and as associated coal mines are closed, existing coal terminals are likely to be closed, possibly repurposed (e.g., to export green hydrogen), or may have potential to convert to other purposes (e.g. as leisure marinas or industrial tourism sites). See also IFC EHS Guidelines for Ports, Harbours and Terminals[16].

There are two main types of environmental and social impacts associated with ports and harbours that may affect the port area itself and/or the surrounding area: those arising from construction when developing or upgrading/expanding facilities; and those linked to operating the facilities.

[16] Environmental, Health, and Safety Guidelines for Ports, Harbors, and Terminals (ifc.org)

Environmental impacts can include:

- Local air and water pollution (e.g. spillages and discharges from ships)
- Noise from ships engines and machinery used to load/unload cargoes; and from vehicles/trains delivering to the port;
- Underwater noise and vibration and blasting during construction;
- Dredging required to deepen access to the port and disposal of dredged materials;
- Biodiversity impacts to sensitive marine and terrestrial habitats (e.g., mangroves. Seagrass, coral) and protected areas such as important bird areas (IBAs);
- Water quality impacts;
- Hydrology impacts and changes to coastal geomorphology and sedimentation dynamics;
- Waste management – ballast water, slops, wastewater, hazardous materials;
- Air pollution; exhausts of greenhouse gases and particles, CO_2, NO_x and SO_2 from the ship's main and auxiliary engines; and from trains/vehicles
- Traffic congestion in and around the port and feeder roads
- Widespread contamination of sediments;
- Vulnerability to climate change impacts – increased storms, sea level rise;
- Health and safety impacts during construction and operations;
- Impacts at sea due to:
  - Ships wash;
  - Collisions between vessels and marine animals;
  - Noise from ships engines and propellors;
  - Marine accidents;
  - Anchoring and mooring.

From a social perspective, ports, harbours and terminals can support and benefit local, regional and national economies through their role in creating jobs and transporting goods. Their operators/owners can also partner with communities to offer workforce development programmes, protect the environment and coordinate on land use planning to incorporate community amenities.

However, ports can also create potential challenges for near-port communities who are disproportionately impacted by port operations and related transportation systems. Construction may involve an influx of workers from elsewhere which carries with it the potential for conflict with local communities. In addition, while ports are major economic engines for local, regional, and national economies, these economic benefits may not be equitably distributed. The near-port communities may not receive a fair share of the economic benefits that flowing to the region or national economy.

Ports may also require acquisition of land, often from nearby communities and this must be done in a fair and equitable manner consistent with best international practices (e.g., IFC Performance Standard 5). Ports can also cause conflicts with local fishing communities regarding access and landing points. Transport congestion can arise during port construction and persist throughout the life of the port.

Ports can also impact important terrestrial and marine areas important to indigenous peoples and their use of those lands. In recognition of indigenous rights and the need for respect, cooperation, partnership and the need for establishing meaningful dialogue for better informed port decisions, the Government of Canada is amending the Canada Marine Act to recognize indigenous groups alongside port users and communities and to establish new advisory bodies and governance mechanisms to assure environmental and social sustainability of port infrastructure and operations[17]

Where existing coal ports, harbours and terminals are closed, this may offer opportunities to restore sites to their former ecological status. Or they may be repurposed for other commercial use or for leisure/tourism.

Closure will inevitably have impacts on the local or regional economy and on jobs and livelihoods. Repurposing may offer new economic and job opportunities – but different skills are likely to be

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[17] Proposed legislative changes to support building stronger supply chains - Canada.ca

required. It should recognsied that port closures related to coal transport and coal mining are still in their infancy and many new initiatives are under development to reinvent ports to become “ports of the future” and energy hubs for green hydrogen and ammonia[18].

[18] How ports can be transformed into energy hubs of the future | World Economic Forum (weforum.org)

Chapter 14

KEY ISSUES FOR SEA IN THE PRODUCTION OF GREEN HYDROGEN AND AMMONIA

Put simply, ***green hydrogen*** is produced by splitting water into hydrogen and oxygen using renewable energy. When burned, only water is emitted, but creating hydrogen can be costly. ***Green ammonia*** is made from green hydrogen with the process powered by renewable energy as well. The production of green hydrogen and ammonia has both positive and negative environmental and social impacts.

Green hydrogen (see Table 14.1) is seen as a critical enabler of the global transition to sustainable energy and net zero emissions economies. Momentum is growing to develop green hydrogen as a clean energy solution. It is emerging as a leading option for storing energy (see also Chapter 13 for other energy storage options) from renewables with hydrogen-based fuels potentially being transported over long distances – from regions with abundant energy resources, to energy-hungry areas thousands of kilometres away. As a liquid fuel, green ammonia, sourced from green hydrogen, offers a number of advantages as a transport medium.

Green hydrogen featured in a number of emissions reduction pledges at the UN Climate Conference, COP26, as a means to decarbonize heavy industry and its applicability as a fuel for long haul freight, shipping, and aviation. Governments and industry have both acknowledged hydrogen as an important pillar of a net zero economy[1].

The 'Green Hydrogen Catapult', a United Nations initiative to bring down the cost of green hydrogen, announced that it is almost doubling its goal for green electrolysers from 25 GW set in 2020, to 45 GW by 2027. The European Commission has adopted a set of legislative proposals to decarbonize the EU gas market by facilitating the uptake of renewable and low carbon gases, including hydrogen, and to ensure energy security for all European citizens. The United Arab Emirates' new hydrogen strategy aims to hold a quarter of the global low-carbon hydrogen market by 2030 and, recently, Japan announced that it will invest $3.4 billion from its green innovation fund to accelerate research and development and promotion of green? hydrogen use over the next 10 years[2].

It is predicted that green or low-carbon hydrogen will become cost-competitive by 2040, given increased scale and lower costs of renewables, along with higher costs for producing brown, grey and blue hydrogen[3]. Pink hydrogen, derived from nuclear power, is another option for future hydrogen production[4].

The production of green ammonia is promoted as an additional option in the transition to net-zero carbon dioxide emissions. Its' uses in this regard include:

- ***Energy storage*** – ammonia is easily stored in bulk as a liquid at modest pressures (10-15 bar) or refrigerated to -33°C. This makes it an ideal chemical store for renewable energy. There is an existing distribution network, in which ammonia is stored in large, refrigerated tanks and transported around the world by pipes, road tankers and ships.
- ***Zero-carbon fuel*** – ammonia can be burnt in an engine or used in a fuel cell to produce electricity. When used, ammonia's only by-products are water and nitrogen. The maritime industry is likely to be an early adopter, replacing the use of fuel oil in marine engines. However, its use as a clean energy fuel currently remains nascent.

- ***Hydrogen carrier*** – there are applications where hydrogen gas is used (e.g. in PEM fuel cells). However, hydrogen is difficult and expensive to store in bulk (needing cryogenic tanks or high-pressure cylinders). As a liquid, ammonia is easier and cheaper to store, to transport

[1] What is green hydrogen? An expert explains its benefits | World Economic Forum (weforum.org)
[2] Japan Sets Aside $3.4B for Hydrogen R&D (oedigital.com)
[3] Hydrogen production costs to 2040: Is a tipping point on the horizon? | Wood Mackenzie
[4] Explained: Pink Hydrogen, The Future of Clean Energy (iamrenew.com)

and it can be readily “cracked” and purified to give hydrogen gas when required. However, there are conversion losses in the transformation process.

14.1. EXISTING SEA GUIDANCE/GUIDELINES FOR THE PRODUCTUION OF GREEN HYDROGEN AND AMMONIA

An international survey of existing SEA guidelines conducted for the IAIA was unable to identify any guidelines specifically focused on infrastructure specifically associated with the production of green hydrogen or ammonia.

14.2 TECHNOLOGIES FOR THE PRODUCTION OF GREEN HYDROGEN AND AMMONIA

Power-to-X, also known as P2X or PtX, refers to a bundle of pathways for the conversion, storage, and reconversion of electric power, especially that generated by renewable energy. It is an “umbrella” term, where X can be heat or chemicals including hydrogen, syngas, synthetic fuels. and many more[5].

Hydrogen

Initiatives potentially included in the green hydrogen value chain are very diverse and may include, for example:

- Greenfield integrated developments, potentially including renewables farms, transmission lines, electrolysers, conversion unit to ammonia/methanol, and shipping facilities
- Large- or medium-size brownfield developments in existing industrial areas, most often where GH (and eventually the by-product, oxygen) is utilized in existing units for power generation, or steel or ammonia/fertilizer production
- Medium-/small-size projects or distributed projects to produce hydrogen for mobility
- Projects that include hydrogen transmission pipelines or distribution systems.

Hydrogen can be produced using various technologies and various terms are in use reflecting the technology used, e.g. ‘brown’ grey’, ‘blue’, and ‘green’ (Table 14.1), and sometimes even ‘pink’, ‘yellow’ or ‘turquoise’ .

Table 14.1: Main types of hydrogen

Hydrogen type	Manufacturing process
Brown hydrogen	• Created through coal gasification
Grey hydrogen	• Produced from natural gas but generates carbon dioxide waste. Producing and piping natural gas is a major source of climate-warming methane leaks.
Blue hydrogen	• Captures and stores the carbon dioxide produced in the creation of grey hydrogen
Green hydrogen	• Involves the use of an electrolyser - a device that uses electricity and water and has an anode and a cathode separated by an electrolyte (see Box 14.1). Heat is generated as by-product of the process. The process is energy intensive and, where possible, that energy is derived from renewables. There are no greenhouse gas emissions, unlike other methods that use natural gas and steam. Electrolysis can also help to balance the electricity grid by adjusting the demand for electricity. • A new generation of polymer electrolyte membrane (PEM) electrolysers are being developed and used that are more efficient and less material-intensive compared to the more mature alkaline electrolysers.

[55] Power-to-X: Lighting the Path to a Net-Zero-Emission Future | ACS Sustainable Chemistry & Engineering

Box 14.1: Electrolyser levels

An electrolyser consists of three different levels (see Figure 14.1):

- The cell. The cell is the core of the electrolyser, and it is where the electrochemical process occurs. At the electrode, water is split into oxygen and hydrogen, with ions (typically H+ or OH-) crossing through a liquid or solid membrane electrolyte. The membrane or diaphragm between both electrodes is also responsible for keeping the produced gases (i.e., hydrogen and oxygen) separate and avoiding their mixture.
- The stack. The stack level includes multiple cells connected in series and related frames (providing mechanical support) and ancillary items.
- The system (or balance of plant). It goes beyond the stack to include equipment for processing hydrogen, treating water supplied to the electrolyser, and auxiliary activities.

Ammonia

The process of making most of the ammonia consumed in the world is currently not a "green" process. It is most commonly made from methane, water and air, using steam methane reforming (SMR) (to produce the hydrogen) and the Haber (or Haber-Bosch) process[6]. Approximately 90% of the carbon dioxide produced is from the SMR process. This process consumes a large amount of energy and produces around 1.8% of global carbon dioxide emissions[7].

The process for obtaining hydrogen is denoted by a colour (see Table 14.1). Even though ammonia is always a clear, colourless but pungent gas[8], it is also denoted by a colour prefix dependent on the hydrogen source. In the USA, 92% of ammonia produced is from natural gas, or "Grey", generating millions of tons of carbon emissions each year.

One way of making green ammonia is by using hydrogen from water electrolysis and nitrogen separated from the air. These are then fed into the Haber-Bosch process, all powered by sustainable electricity. Blue ammonia uses blue hydrogen and is used as a way to reduce carbon dioxide emissions through carbon sequestration.

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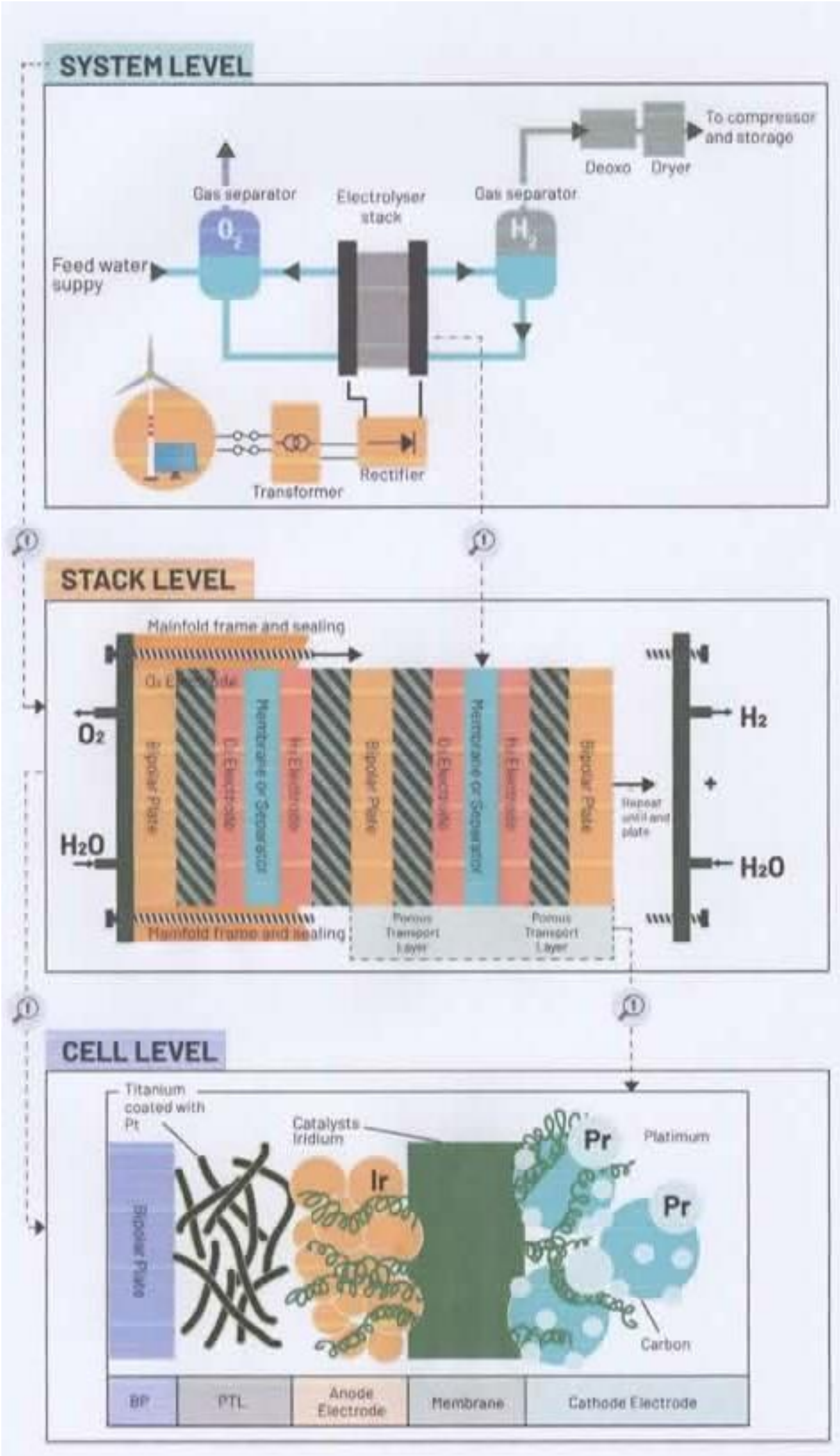
[6] The process converts atmospheric nitrogen (N_2) to ammonia (NH_3) by a reaction with hydrogen (H_2) using a metal catalyst under high temperatures and pressures.

[7] Power-to-X: Lighting the Path to a Net-Zero-Emission Future | ACS Sustainable Chemistry & Engineering

[8] About 70% of ammonia is used to make fertilisers while the remainder is used for various industrial applications, such as plastics, explosives and synthetic fibres.

Figure 14.1: The green hydrogen process
(Source: Signoria and Barlettani, 2023



14.2 GLOBAL PRODUCTION OF HYDROGEN AND AMMONIA, AND STORAGE

Hydrogen

Green hydrogen projects span from distributed and small-size production facilities to huge projects. Both greenfield and brownfield initiatives are under development, with different implications in terms of potential environmental and social aspects. Huge greenfield developments may change the socioeconomic characteristics of a vast area, while other projects, such as those related to initiatives for distributed hydrogen production for mobility, have a completely different socioeconomic pattern[9].

The Global Hydrogen Review (2022) is the second edition of a new annual publication by the International Energy Agency to track progress in hydrogen production and demand, as well as in other critical areas such as policy, regulation, investments, innovation, and infrastructure development.

Key points of the review are set out in Box 14.2.

Box 14.2: Key points from the Global Hydrogen Review, 2022[10]

Hydrogen demand reached 94 million tonnes (Mt) in 2021, recovering to above pre-pandemic levels (91 Mt in 2019), and containing energy equal to about 2.5% of global final energy consumption.

The first fleet of hydrogen fuel cell trains started operating in Germany. There are also more than 100 pilot and demonstration projects for using hydrogen and its derivatives in shipping, and major companies are already signing strategic partnerships to secure the supply of these fuels. In the power sector, the use of hydrogen and ammonia is attracting more attention; announced projects account for almost 3.5 GW of potential capacity by 2030.

The review estimates that hydrogen demand could reach 115 Mt by 2030, although less than 2 Mt would come from new uses. This compares with the 130 Mt (25% from new uses) that would be needed to meet existing climate pledges put forward by governments around the world so far, and with nearly 200 Mt needed by 2030 to be on track for net zero emissions by 2050.

If all projects currently in the pipeline were realised, by 2030 the production of low-emission hydrogen could reach 16-24 Mt per year, with 9-14 Mt based on electrolysis and 7-10 Mt on fossil fuels with CCUS (carbon capture, utilisation and storage). In the case of electrolysis, the realisation of all the projects in the pipeline could lead to an installed electrolyser capacity of 134- 240 GW by 2030, with the lower end of the range similar to total installed renewable capacity in Germany and at the upper end in all of Latin America. Meeting governments' climate pledges would require 34 Mt of low-emission hydrogen production per year by 2030 and a path compatible with reaching net zero emissions by 2050 globally would require around 100 Mt of production by 2030.

Electrolyser manufacturing capacity sits at nearly 8 GW/yr. Based on industry announcements, it could exceed 60 GW/yr by 2030.

With today's fossil energy prices, renewable hydrogen could already compete with hydrogen from fossil fuels in many regions, especially those with good renewable resources and that must import fossil fuels to meet demand for hydrogen production.

The world's first shipment of liquefied hydrogen from Australia to Japan took place in February 2022, a key milestone in the development of an international hydrogen market. Based on the export-oriented projects under development, an estimated 12 Mt of hydrogen could be exported annually by 2030, with 2.6 Mt/yr planned to come online by 2026. However, off-take and importing arrangements lag behind the scale of planned exports: only 2 Mt H_2/yr has secured a customer or potential customer. Project developers and investors are facing high uncertainty in a nascent market for hydrogen and many governments have yet to implement specific hydrogen trade policies, which are necessary for the successful development of projects.

[9] Signoria and Barlettani, 2023

[10] [Global Hydrogen Review 2022 (windows.net)](#)

There are projects under development to repurpose thousands of kilometres of natural gas pipelines to 100% hydrogen. Governments, particularly in Europe, are considering repurposing liquified natural gas (LNG) terminals, though the opportunities depend on whether they will ultimately receive hydrogen or ammonia.

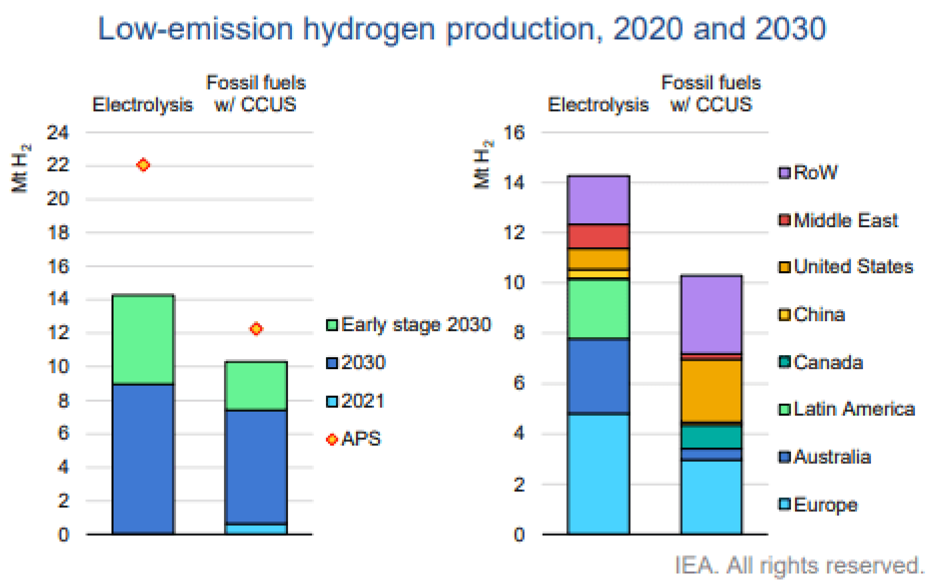
Governments continue to consider hydrogen a pillar of their future energy sector strategies: nine new national strategies have been adopted since September 2021, bringing the total number to 26. Some countries are moving to the next step by implementing concrete policies, with a particular focus to support commercial scale projects for low-emission hydrogen production and infrastructure (e.g., the EU Important Projects of Common European Interest, the US Inflation Reduction Act and the German H2Global Initiative). However, there is still not enough policy activity for creating hydrogen demand, which is critical to secure off-take agreements.

There are only eleven plants to produce low-emission hydrogen: seven are facilities retrofitted with CO_2 capture and four use electrolysers. They produced around 260 kt of low-emission hydrogen in 2021 (around 0.7% of hydrogen demand in refining), a slight increase from the 230 kt used in refineries in 2020.

Figure 14.2 shows low-emission hydrogen production data for 2020 and a projection for 2030.

Figure 14.2: Low-emission hydrogen production, 2020 and 2030

Source: IEA (2022c)



Notes: RoW = rest of world; APS = Announced Pledges Scenario. In the left figure, the blue columns for 2020 and 2030 refer to projects at advanced planning stages. The right figure includes both projects at advanced planning and early planning stages. Only projects with a disclosed start year for operation are included.
Source: IEA, Hydrogen Projects Database (2022).

Ammonia

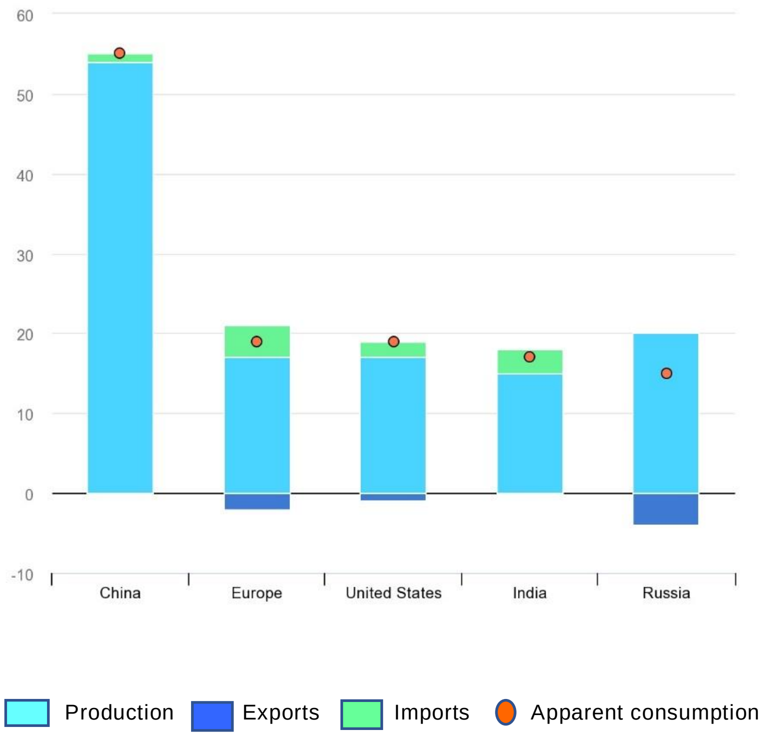
The biggest producer of ammonia in 2022 was China, followed by Russia and the USA (see Table 14.2). Almost all of this production is from natural gas sources.

Table 14.2: Ammonia production worldwide in 2022, by country
(Source: Global ammonia production by country 2022 | Statista)

Country	**Production** (1000 metric tonnes)		**Country**	**Production** (1000 metric tonnes)
China	42,000		Qatar	3,300
Russia	16,000		Algeria	2,600
USA	13,000		Poland	2,100
Other countries	13,000		Germany	2,000
India	12,000		Netherlands	2,000
Indonesia	6,000		Ukraine	2,000
Saudi Arabia	4,300		Oman	1,700
Trinidad & Tobago	4,200		Australia	1,700
Egypt	4,000		Malaysia	1,400
Iran	4,000		Vietnam	1,200
Canada	3,800		Nigeria	1,100
Pakistan	3,400		Uzbekistan	1,100

Production, consumption and trade statistics for ammonia for 2022 are shown in Figure 14.3.

Figure 14.3: Production, consumption and trade of ammonia in selected countries and regions, 2020
(Source: IEA: Production, consumption and trade of ammonia in selected countries and regions, 2020 – Charts – Data & Statistics - IEA)



According to IEA, existing and announced projects totalling nearly 8 Mt of near-zero-emission ammonia production capacity are scheduled to come online by 2030, equivalent to 3% of total capacity in 2020[11].

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[11] Executive Summary – Ammonia Technology Roadmap – Analysis - IEA

It is reported that, in 2026, South Africa will start operations of the World's largest green ammonia plant at Mandela Bay in the Eastern Cape at a cost of US$4.6 billion and creating at least 20,000 jobs[12]. It will be powered by a nearby solar farm extending over thousands of hectares and will get its water — of which vast amounts are needed to make ammonia — from a local table salt factory that desalinates seawater.

Storage of hydrogen

Hydrogen can be stored in steel or composite tanks, or in underground geological formations. Tanks of various sizes and pressures are already used in the industry. Underground storage is possible in different types of reservoirs, but the most feasible are salt caverns, which are also used for natural gas storage. Underground storage is more suited to large volumes and long timeframes (weeks to seasons).

However, storing hydrogen is not easy and leakage may occur. It is more "corrosive" and, due to its small molecule size, it is more prone to leakage. Hydrogen leakage is thus an important consideration in the context of climate change. Though hydrogen molecules do not directly trap heat, they have an indirect global warming effect by extending the lifetime of other GHGs. Certain GHGs (e.g. methane and ozone) are gradually neutralized by reacting with hydroxide radicals (OH) in the atmosphere. When hydrogen gas is released to the atmosphere, it react with OH radicals, depleting atmospheric OH levels and delaying the neutralization of GHGs. This effectively increases the lifetime of these GHGs in the atmosphere. A recent p study modelled continuous emissions of hydrogen and estimated that, over a 10-year period, hydrogen has an approximately 100 times stronger warming effect than carbon dioxide (CO_2)[13]

The relationships between green hydrogen production, conversion and end uses are shown in Figure 14.4.

12

13 https://www.energypolicy.columbia.edu/wp-content/uploads/2022/07/HydrogenLeakageRegulations_CGEP_Commentary_063022.pdf

Figure 14.4: Green hydrogen production, conversion, and end uses across the energy system
(Source: IRENA 2020)

Figure redacted pending securing copyright permission to use. If you have an image showing this spatial distribution that you can provide (with permission to use – please indicate the credit to cite) we would be delighted if you can send it.

13.5 ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IMPACTS OF PRODUCING HYDROGEN AND AMMONIA

The production of green hydrogen, and green ammonia in turn, is based on the use of large amounts of electricity derived from renewable sources. Most often, it is assumed that this will come from wind and solar power. The environmental and socio-economic impacts of wind and solar power are discussed elsewhere in Chapters 6 and 7, respectively. But the generation, storage and transport of green hydrogen and ammonia will also result in direct and indirect environmental and socio-economic impacts (Table 14.3.)

Table 14.3. Environmental and socio-economic risks and opportunities associated with green hydrogen and ammonia
(Sources: Hurwitz et al, 2023; Signoria and Barlettani, 2023)

Issue	Green hydrogen	Green ammonia
Environmental		
Transport-related issues	Transportation of hydrogen and ammonia by trucks or ships (including to homeowners) adds emissions of pollutants	
Water	• Large amounts of water are needed to produce hydrogen (approximately 9L per 1 kg of hydrogen). This has the potential to make water (a critical requirement in production) scarce – especially to local communities and particularly where it is already limited – exacerbating ***water shortages, causing conflicts with food production*** and threatening lives and livelihoods. • The use of deionized water produced by desalination plants may reduce freshwater demand, but it generates a need to ***discharge brine*** into water sources and soils (see Box 14.3). This can increase the salinity and density of the receiving water, which may lead to higher water stratification and reduced oxygen exchange in the water column. Desalination also requires significant amounts of energy which will have to be generated by renewable sources. • ***Eutrophication*** due to phosphate enrichment if polyphosphates and organic cleaning solutions are added to the brine. • ***Discoloration of receiving waters***, due to high concentration of ferric substances, also with high-suspended solids and turbidity. • Increased salinity can ***impact on the composition and distribution of biota***. • ***Biodiversity can be affected*** by impacts to water resources, (whether freshwater or seawater) receiving brine discharge from desalination plants - particularly if dilution (e.g., using a diffuser) is inadequate.	Ammonia and methanol generate waste and production often involves the use of catalysts and other ***chemicals that can be toxic or harmful to the environment***, potentially contaminating water sources and soils during production and transportation, if not handled properly. In case of continuous discharge or leaks into water bodies, this may represent an immediate danger to aquatic life, with subsequent impacts on the livelihood of communities depending on it.
Land use/land cover change	• Large amounts of land required for associated wind or solar production, This could lead to the ***conversion of natural habitats or agricultural land***, which could have negative impacts on biodiversity, ecosystem services and food security. • Such changes can lead to ***deforestation, land degradation and habitat fragmentation***, invasive alien species, over-exploitation, hydrological changes, nutrient loading, and pollution, • Such loss may involve ***loss of natural buffer areas*** such as wetlands, mangroves, and upland forests that mitigate the effects of natural hazards such as flooding, landslides, and fire; these may result in increased vulnerability and community safety-related and health-related risks and impacts. • Production plants and associated infrastructure (e.g. transport pipelines, transmission lines, port facilities, access roads) will also involve land use change with similar impacts. This will also result in increased human access to less developed areas.	

Issue	Green hydrogen	Green ammonia
	• The presence of hydrogen related infrastructure may also cause visual and aesthetic impacts.	
Waste	• ***General waste, sludge and wastewater*** from (fresh) water purification for electrolysis requires careful management to avoid pollution of water courses and groundwater. The quantity of sludge will depend on the level of contaminants originally present in the raw water, and on the purity of water required by the specific electrolysis process adopted. • ***Electric and electronic waste and hazardous substances*** as a result of the decommissioning of electrolysers and plants. • Risk of ***abandonment*** of the facilities at the end of their lives (probably 20-30 years).	
Pollution	From ***spills and leakage of fuels and chemicals*** stored and used on plant sites – which can enter water courses and groundwater.	
Socio-economic		
Transport accidents	Risk of ***accidents*** (on roads and at start/end sites.	
Occupational health and safety	• Hydrogen is ***highly flammable***. If not handled properly, it can pose a significant risk to workers' safety during production, transportation, and storage (explosions and fires). • Production process involves the operation of complex and potentially dangerous ***high-pressure equipment*** (containers and pipelines) and the handling of ***hazardous chemical***s, which can lead to accidents and injuries. • Workers may also be exposed to ***intense electromagnetic fields*** within the electrolyser building, to ***toxins*** (including methanol and ammonia) in conversion and storage units, and to ***cold surfaces*** in cryogenic storage units.	
Labour risks and working conditions	• Risk of ***poor/unacceptable working conditions*** (including lack of training or protective equipment) at production sites and associated infrastructure. • Catalyzers involves the use of rare earth elements such as iridium, which can present ***labour risks in the primary supply chain*** if not sourced responsibly – including the risk of ***forced and child labour***.	
Influx of workers	Significant influx of workers, both unskilled and skilled, is likely. Impacts include: • ***Induced pressure on land, natural resources, and availability and price of goods and services*** at the local level as the influx of newcomers in the area will likely increase demand for food, fuel, housing, and land. Such pressure may exert greatest impact on the most vulnerable in the location, as well as on those communities whose livelihoods are highly or even exclusively resource-based, in particular those depending on subsistence agriculture. • A great influx of labour from outside may stretch beyond capacity the local level's ***social service infrastructure*** due to increased demand in housing services, schools, and health care, as well as generating additional pressure on waste management, sanitation, water, power, and transportation services. • Influx of labour may cause communities to experience ***significant boosts to the local econom***y associated with the start of projects, followed by ***sharp declines*** once construction works have concluded. • External worker influx may pose ***threats to the health and safety of local communities***, provoking higher rates of violence, injuries, alcohol and drug	

Issue	Green hydrogen	Green ammonia
	consumption, and communicable diseases (including sexually transmitted diseases) in the local population. • ***Conflicts*** between local community members and workers from outside the community may arise with respect to employment opportunities, wages, and demand and pressure on natural resources. • A large influx of external male workers may lead to an increase of ***gender-based violence.***	
Job opportunities	Potential for significant ***new jobs*** but this will need to be balanced by the requirements of training of workers in new renewable energy technologies.	
Associated livelihood opportunities	Potential for ***new livelihoods*** servicing production plants and associated infrastructure (eg shops, stalls).	
Improved local services	Potential for developers to invest in/provide ***new and improved local services*** (e.g schools, clinics, bus services)	
Cultural heritage	There is a risk that ***cultural, religious and archaeological sites*** may be disturbed or destroyed as a result of developing hydrogen production sites or associated infrastructure, or access to such sites may be restricted or denied	
Land rights	• There are risks that acquisition of land for plants and associated infrastructure will undermine, restrict or limit ***local community rights to access*** particular areas of cultural or livelihood importance; lead to ownership conflicts – particularly as regards agricultural lands.	
Gender issues	• The is always the potential that ***gender inequalities*** may arise during the construction and operation of plants and associated infrastructure, These can interact with other inequalities (e.g. socioeconomic, ethnic, racial, disability) and exacerbate barriers to accessing project benefits, limit the ability to deal with negative project impacts, and create other vulnerabilities. • ***Women may be discriminated*** against or subject to sexual harassment or abuse in the workplace, due to gender and/or sexual identity and orientation. • Land fragmentation and land take may ***affect women disproportionately***, also taking into consideration that land acquisition processes occur within a framework of inequalities rooted in all dimensions of land rights: i.e., ownership, management, transfer, and economic rights, in particular those associated with agricultural lands. • A large influx of external male workers may lead to an increase of ***gender-based violence*** against women and young girls, particularly in socio-economic settings where there is an existing gender differentiation in terms of power and norms. • If green hydrogen/ammonia developments induce additional water stress, women (particularly in indigenous communities) will likely bear a ***disproportionate impact of lack of access to safe water*** for drinking, sanitation, and other purposes. Without safe access at home and/or in work and study places, it is significantly harder for women and girls to lead safe, productive, and healthy lives. • Alongside other disadvantaged groups and minorities, women risk being ***left out of and/or underrepresented*** within consultation processes and activities of stakeholder engagement. Conversely this may also provide opportunities for women owned and operated renewable energy companies[14].	
Indigenous communities	Indigenous peoples may be particularly and disproportionately affected by many of the above socio-economic issues. However, opportunities may arise for development of indigenous owned companies producing green hydrogen and ammonia.	
Economic	New green hydrogen and ammonia development will provide an economic boost to a country and to the local economy.	

[14] Women of Renewable Industries and Sustainable Energy WRISE - WRISE (wrisenergy.org)

Box 14.3: Options for managing brine from desalination for hydrogen production

- Deep well injection
- Evaporation ponds
- Discharge into surface water bodies
- Disposal into municipal sewers
- Concentration into solid salts (e.g., salt harvesting and on-site generation of sodium hypochlorite)
- Irrigation of plants tolerant to high salinity
- Reusing the brine
- Zero liquid discharge
- Aquaculture
- Application in soils

Potential impact can be minimized and regulated by treatment and recycling technologies, by limiting concentration values of brine at the discharge point, as well as by imposing concentration values within a prescribed circular mixing zone in coastal waters via outfall design.

The increase in salinity or temperature, or the reduction in dissolved oxygen, in the water bodies receiving brine discharge from electrolysers or cooling systems can be modelled with available software tools[15]. The selection of the most appropriate models will depends on various factors:

- Complexity of shoreline topography
- Presence of streams within receiving bodies
- Possibility of water recirculation (for example, within bays with strong tidal streams), with pollutant accumulation
- Sensitivity of local ecosystems to average and/or peak pollutant concentrations
- Discharge geometry (along the shoreline, under water level, single or multiple discharge, etc.)
- Distance to discharge point at which the respect of a limit is requested (point of compliance).

Source: Signoria and Barlettan (2023)

[15] The US Environmental Protection Agency (EPA) maintains and updates a specific page (currently available at https://www.epa.gov/ceam/surface-water-models- assess-exposures) with a list of commercial software and freeware tools, with recommendations for their use in different situations.

REFERENCES

Aassve A., Burgess S., Propper C. and Dickson M. (2006) Employment, family union and childbearing decisions in Great Britain. *Journal of the Royal Statistical Society Series A-Statistics in Society*. 169 (4). pp. 781–804.

Abram S., Atkins E., Dietzel A., Jenkins K. *et al*. (2022) Just Transition: A whole-systems approach to decarbonisation. *Climate Policy*, 22, 8, 1033-1049.

Acakpovi A and Dzamikumah L. (2016) An Investigation of Health and Safety Measures in a Hydroelectric Power Plant. *Saf Health Work* 7(4). pp. 331–339. (doi: 10.1016/j.shaw.2016.04.006. Epub 2016 Apr 30. PMID: 27924237)

ACEC (2015) *Wind Farm Guide for Communities. 2015. What you can expect, Who You Can Talk To*. Australian Clean Energy Council (available at: www.cleanenergycouncil.org.au)

Actionaid (2018) *Human rights in wind turbine supply chains. Towards a truly sustainable energy transition*. Actionaid, Amsterdam, Jan 2018.

Adedipe T. and Shafiee M. (2021) An economic assessment framework for decommissioning of offshore wind farms using a cost breakdown structure. *International Journal of Lifecycle Assessment*, 26. 344-370

Agerholm H, (2017) Germany converting a huge coal mine into giant renewable battery, *The Independent*, London, 24 March (available at: Germany converting a huge coal mine into giant renewable battery | The Independent | The Independent)

Alamsyah D., Mukt, A. W., Rachmadani A., Adityatama D.W., Purba D. and Nugraha R P. (2020) *Water Supply for Big Bore Geothermal Well Drilling: A Case Study in Indonesia*. Proceedings, 45th Workshop on Geothermal Reservoir Engineering Stanford University, Stanford, California, February 10-12, 2020 SGP-TR-216

aNews (2021) *Indigenous community in Norway battles 'wind turbine threat'.* 17 November. (available at: www.anew.com.tr)

ADB (2012) *Climate Risk and Adaptation in the Electric Power Sector*. Asian Development Bank, Manila. (available at: https://www.adb.org/sites/default/files/publication/29889/climate-risks-adaptation-power-sector.pdf)

ADB (2015) *Muara Laboh Geothermal Power Project: Addendum Environmental Impact Assessment*. Asian Development Bank, Manila (available at: www.adb.org)

ADB (2017) *Draft Biodiversity Action Plan (BAP) and Critical Habitat Assessment (CHA) Rantau Dedap Geothermal Power Project.* Asian Development Bank, Manila (available at: www.adb.org)

ADB (2018) *Integrating Strategic Environmental Assessment into Power Development Planning in Vietnam*. Asian Development Bank, Manila, December (available at: www.adb.org)

ADB (2019) *Sarulla Geothermal Power Development Project Biodiversity Action Plan,* Asian Development Bank, Manila, March (available at: www.adb.org)

ADB (2019b) *Geothermal Power Generation Project- Dieng Geothermal Plant Expansion Sub-Project). Resettlement Plan.* Asian Development Bank, Manila. *https://www.adb.org/sites/default/files/linked-documents/52282-001-rpab.pdf*

ADB (2020) *Sarulla Geothermal Power Development Project Offset Management Plan*. Asian Development Bank, Manila, October (available at www.adb.org)

ADB (2022) *Regional Scoping Report: Strategic Environmental and Social Assessment Applied to the Energy Transition Mechanism in Southeast Asia*, Asian Development Bank, Manila.

Air Quality Expert Group (2017) *The Potential Air Quality Impacts from Biomass Combustion*. Report of UK Department for Environment, Food and Rural Affairs, Scottish Government, and Welsh Government; and Department of the Environment in Northern Ireland (available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat11/1708081027_170807_AQEG_Biomass_report.pdf)

Amster E. and Levy C.L. (2019) Impact of Coal-fired Power Plant Emissions on Children's Health: A Systematic Review of Epidemiological Literature. *International Journal of Environmental Research and Public Health*

Angulo, I., De La Vega, D., Cascón, I., Cañizo, J., Wu, Y., Guerra, D., & Angueira, P. (2014). Impact analysis of wind farms on telecommunication services. *Renewable and Sustainable Energy,* Elsevier, vol. 32(C), pages 84-99.

Annandale, D. and Hagler Bailly Pakistan (Pvt) Ltd. (2014) *Strategic Environmental Assessment for Hydropower Sector Planning – Guidance Material.* Islamabad: IUCN Pakistan. 34 pp

Apriando T. (2018) Coal company fined 2 billion rupiah for illegal waste dumping in Borneo, Mongabay, 12 April (available at: https://news.mongabay.com/)

Apriando T. and Esterman I. (2017) Who's responsible for Indonesia's deadly abandoned coal mines? *Eco-Business*. 31 May. https://www.eco-business.com/news/whos-responsible-for-indonesias-deadly-abandoned-coal-mines/)

Arun N. and Dalai A.K. (2020) Environmental and socioeconomic impact assessment of biofuels from lignocellulosic biomass, Chapter 9. pp 283-299 Yousuf A, Pirozzi D. and Sannino F. (2020) *Lignocellulosic Biomass to Liquid Biofuels,* ScienceDirect (https://www.sciencedirect.com/)

Asean Post (2022) *Why Is The Philippines So Focused On Coal?* 4 August. (available at*: www.the aseanpost.com)*

ASEAN Today (2021). Indonesia pushes coal in West Papua despite conflict and past rights abuses. 21 May (available at: www.aseantoday.com)

Asia Foundation (2016) *Reclaiming Mined Land In East Kalimantan* (available at: Case study reclaiming-mined-land-in-east-kalimantan (slideshare.net))

Asia Pacific Solidarity Network (2020) *Indonesia pushes coal in West Papua despite conflict and past rights abuses*. 27 April. https://www.asia-pacific-solidarity.net/news/2020-04-27/indonesia-pushes-coal-west-papua-despite-conflict-and-past-rights-abuses.html

Badan Pusat Statistik ([Seri 2010) 2010 Series GDP Growth Rate (Percent), 2022 (Laju Pertumbuhan PDB Seri 2010 (Persen), 2022 (available at: *https://www.bps.go.id/indicator/11/104/1/-2010-version-growth-rate-of-gdp-2010-version.html*

Badan Pusat Statistik (Undated) *State Electricity Company Customers: 2018-2020* (Pelanggan Perusahaan Listrik Negara 2018–2020). https://www.bps.go.id/indicator/7/317/1/customers-of-electricity-state-company.html.

Baldwin T.E., Metzger J.E. and Stenejhem E.J. (1977) *Local socioeconomic impacts of coal development in the Midwest.* United States Department of Energy (available at: https://www.osti.gov/servlets/purl/5054136)

Baran J., Lewandowski P., Szpor A. and Witajewski-Baltvilks J. (2018) *Coal Transition in Poland*. Paris: IDDRI and Climate Strategies (available at: https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Rapport/20180609_ReportCOAL_Poland-def.pdf)

Bartan A., Kukucali S. and Ar I. (2017) *Environmental impact assessment of coal power plants in operation* E3S Web Conf., Volume 22, January. International Conference on Advances in Energy Systems and Environmental Engineering (ASEE17) (available at: www.e3s-conferences.org)

Bastaffa E. *et al*. (2019) The health of communities living in proximity of geothermal plants generating heat and electricity: a review. *Elsevier.*

BBC News (2012) *Brazil biofuel: Shell axes 'illegal' sugar cane plan*. BBC News, Latin America, 14 June. (available at: www.bbc.co.uk)

Beauson, J. *et al*. (2022) The Complex End-Of-Life of Wind Turbine Blades: A Review of the European Context. *Renewable and Sustainable Energy Reviews*. 155 (March). 111847.

Bellman, M., Adrian, M., Wendt, T., Gerlach, S., Remmers, P., Brinkmann, J. (2020) *Underwater noise during percussive pile driving: Influencing factors on pile-driving noise and technical possibilities to comply with noise mitigation values*. available at: https://tethys.pnnl.gov)

Bene C. (2003) When fishery rhymes with poverty: a first step beyond the old paradigm of poverty in small scale fisheries. *World development,* Elsevier, vol. 31 (6), 040-975

Bennun, L., van Bochove, J., Ng, C., Fletcher, C., Wilson, D., Phair, N., Carbone, G. (2021). *Mitigating biodiversity impacts associated with solar and wind energy development. Guidelines for project developers*. Gland, Switzerland: IUCN and Cambridge, UK: The Biodiversity Consultancy.

Bergström, L., L. Kautsky, T. Malm, R. Rosenberg, M. Wahlberg, N.Å. Capetillo, and D. Wilhelmsson. (2014) Effects of offshore wind farms on marine wildlife - A generalized impact assessment. *Environmental Research Letters* 9(3).

Berndes G, Bird N, and Cowie A. (2011) *Bioenergy, land use change and climate change mitigation*. IEA Bioenergy: ExCo 2011:04

Bhuvaneshwari S., Hettiarachchi H., and Meegoda J.N. (2019) Crop Residue Burning in India: Policy Challenges and Potential Solutions. *Int J Environ Res Public Health*. 16 (5) : pp. 832. doi:10.3390/ijerph16050832

Binedel and Brownlie (2007) Limits of Acceptable Change – How Much is Too Much? In: CSIR (2007) *Enhancing the Effectiveness of Strategic Environmental Assessment (SEA) in South Africa*. CSIR Report No. CSIR/NRE/RSBD/EXP/2007/0068/A., COUNCIL FOR Scientific and Industrial Research, Stellenbosch

Blakers A. and Ruther R. (2023) The fastest energy change in history. PV Strategy Committee, International Solar Energy Society, Article in *PV Magazine*, 25 January (available at: https://www.pv-magazine.com/)

Bochert R. and Zettler M.L. (2006). Chapter 14: Effect of Electromagnetic Fields on Marine Organisms, pp 223-234 in Koeller J., Koeppel J. and Peters W. (eds.) *Offshore Wind Energy: Research on Environmental Impacts*. Springer

Bošnjaković M., Stojkov M. and Jurjevic M. (2019) Environmental Impact of Geothermal Power Plants, *Teknicki Vjesnik*, 2(5), 1515-1522

Boyles J.G., Cryan P.M., McCracken G.F. AND Kunz T.H. (2011) Conservation. Economic importance of bats in agriculture. *Science*. Apr 1;332(6025):41-2. doi: 10.1126/science.1201366. PMID: 21454775

BP (2021*) Statistical Review of World Energy 2021*, 8 July (available at: www.bp.com)

Bragagnolo C. and Geneletti D. (2012) Addressing cumulative effects in Strategic Environmental Assessment of spatial planning, *Aestevium*, 60. Firenze University Press

Branch E, (2017) The multipurpose water uses of hydropower reservoir: The SHARE concept, *Comptes Rendus Physique*, 18, 469-478, Elsevier

Braun S. (2023) *Creating new life from dead mines*, Deutsche Welle (DW), 16 January (available at: https://www.dw.com/en/creating-new-life-from-old-and-abandoned-mines/a-64377073)

Bright J.A., Langston R.H.W., Pearce-Higgins J.W., *et al*. (2008) Map of bird sensitivities to wind farms in Scotland: A tool to aid planning and conservation*, Biological Conservation,* 141,9, pp 2342-2356

Broekel, T., and Alfken, C. (2015) Gone with the wind? The impact of wind turbines on tourism demand. *Energy Policy*, 86. pp. 506–519.

Brown A. (2014) *Tourists Flock to Wind Turbines: 14 Examples of Ecotourism*. Blog. January 2014. Southern Alliance for Clean Energy (available at: https://clenanergy.org/blog)

Brownlie S, King N, Treweek J. 2013. Biodiversity tradeoffs and offsets in impact assessment and decision making: can we stop the loss? *Impact Assessment and Project Appraisal*. 31:24–33.

Bruce J. and Boudreaux K. (2013) *Introduction: land and conflict, in* Land and Conflict: Land Disputes And Land Conflicts (available at: www.land-links.org)

Bundesnetzagentur (2021) Methods Guidance for SEA in Federal Transmission Grid Planning in Germany (*Strategische Umwelt Prufung (SUP): Die Methode der SUP sum Mundesbedarsplan*), Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen, August 2021 (available at: https://www.netzausbau.de/SharedDocs/Downloads/DE/Methodik/SUP-Methode.pdf?__blob=publicationFile)

Business and Human Rights Resource Center (2021) *Pakistan: BWI & Pakistan Federation of Building and Wood Workers lodge complaint with Ombudsman after IFC-funded Karot Hydropower Project allegedly violates labour rights of 3,000 workers*. 17 June. (available at: https://www.business-humanrights.org/)

Carlson T., Jepsen R. and Coping A. (2013) *Potential Effects of the Interaction Between Marine Mammals and Tidal Turbines – and Engineering and Biomechanical Analysis.* Paper presented at 10th European Wave and Tidal Energy Conference, Aalborg, Denmark

CEGIS/Integra (2021) *Final SEA Report prepared for the Strategic Environmental Assessment of the South West Region of Bangladesh for Conserving the Outstanding Universal Value of the Sundarbans*. Submiitted to the Bangladesh Forest Department, Dhaka.

CEI (2019) *Environmental Impacts of Geothermal Energy*, Clean Energy Ideas, October 16 (available at: www.clean-energy-ideas.com

Cernea, M. M. (2004) Social impacts and social risks in hydropower programs: Pre-emptive planning and counter-risk measures. In *Keynote address: Session on social aspects of hydropower development. United Nations Symposium on Hydropower and Sustainable Development.* Beijing,PRC.

CFR (2019) Impact of climate risk on the energy system. Council on Foreign Relations, New York, September (available at: https://cdn.cfr.org/sites/default/files/report_pdf/Impact%20of%20Climate%20Risk%20on%20the%20Energy%20System_0.pdf)

CGF (2020) *CGF Human Rights Coalition – Working to End Forced Labour*. The Consumer Goods Forum, 5 October. (available at: theconsumergoodsforum.com)

CHA (2018) *Paths Forward. Hydropower and Indigenous Relationships Across Canada*. Canadian Hydropower Association (https://waterpowercanada.ca/wp-content/uploads/2019/06/CHA-PathsForward-2018-e-web-v13.pdf)

Chadwick M.J., Highton., N.H. and Lindman N. (1986) *Environmental impacts of coal mining and utilization. A Complete Revision of Environmental Implications of Expanded Coal Utilization*, Pergamon

Chandy, T., Keenan, R. J., Petheram, R. J., and Shepherd, P. (2012). Impacts of hydropower development on rural livelihood sustainability in Sikkim, India: community perceptions. *Mountain Research and Development,* 32(2), 117-125.

Choose Clean Power (2022) Environmental Impacts of Tidal Energy, 23 July (available at: www.choosecleanpower.com)

Christoforou, E., Fokaides, P.A. (2019). *Environmental Assessment of Solid Biofuels*. In: Advances in Solid Biofuels. Green Energy and Technology. Springer, Cham. https://doi.org/10.1007/978-3-030-00862-8_6

Ciera Group and PT Hatfield Indonesia. 2023. *Strategic Environmental and Social Assessment of Energy Transition in Indonesia: Draft Scenarios Report*. Prepared for the Asian Development Bank. July 2023.

Clean Air Asia (2020) *South and Southeast Asian Countries Coal-fired Power Plan Emissions Standards*, Policy Analysis. Pasig City: Clean Air Asia (available at: https://cleanairasia.org/)

Colbran, N. and Eide, A. (2008) Biofuel, the environment, and food security: a global problem explored through a case study of Indonesia. *Sustainable Development*. Law & Policy. 9 (4).

Comer J.B. (ed) (2012) *Effects of abandoned mine land reclamation on ground and surface water quality--research and case histories from Indiana*: Indiana Geological Survey Special Report 72, 351 p., 186 figs. doi: 10.5967/dcde-5v64

Cook D., Karlsdottir I. and Minelgaite I. (2022) Enjoying the Heat? Co-Creation of Stakeholder Benefits and Sustainable Energy Development within Projects in the Geothermal Sector. *Energies*, *15*(3), 1029; (available at: https://doi.org/10.3390/en15031029)

Copping A., Grear M., Chartrand C. and Jepsen R. (2017) Understanding the Potential Risk to Marine Mammals from Collision with Tidal Turbines*. International Journal of Marine Energy*, 19, 110-123

Cotrell J., Stehly T., Johnson J., Roberts J.O., Parker Z., Scott G. and Heimiller D. (2014*) Land-Based Wind Turbine Transportation and Logistics Barriers and Their Effects on U.S. Wind Markets* (presentation to American Wind Energy Association conference, May 2014) (available at: https://www.osti.gov/biblio/1132142)

CREA (undated) Comparison of coal power plant emissions standards, Centre for Research on Energy and Clean Air, Finland (available at: https://energyandcleanair.org/)

CREA (2020) Air Quality & Health Impacts of Coal-fired Power in the Philippines

Cronin R. and Pandya A. (2009) *Exploiting Natural Resources: Growth, Instability, and Conflict in the Middle East and Asia,* Stimson, 31 January (available at: Exploiting Natural Resources: Growth, Instability, and Conflict in the Middle East and Asia • Stimson Center)

CSE (2009) Delivering Community Benefits from Wind Energy Development: A Toolkit. Delivering community benefits from wind power development. Centre for Sustainable Energy report prepared for the Renewables Advisory Board (available at www.cse.org.uk)

Cushion, E., Whiteman, A. and Dieterle, G. (2010) *Bioenergy Development. Issues and Impacts for Poverty and Natural Resource Management*. World Bank, Washington, DC (available at: https://openknowledge.worldbank.org/bitstream/handle/10986/2395/524540PUB0Bioe101Official0Use0Only1.pdf?sequence=1&isAllowed=y

Dalal-Clayton D.B. and Sadler B (2005) *Strategic Environmental Assessment: A Sourcebook and Reference Guide to International Experience*. Earthscan Publications, London

Dalal-Clayton D.B. and Sadler B (2010) *Generic SEA Quality Review Methodology*, Revised Draft. Proposal to the OECD DAC SEA Task Team, 1st April 2010.

Dalal-Clayton D.B. AND Scott-Brown M. (2022) *Inventory of existing SEA guidelines and related instruments* (available at: www.iaia.org/pdf/hot-topics/Inventory-of-SEA-guidelines.pdf)

Danish Shipping, Wind Denmark and Danish Energy (2020) Socio-economic Impacts Study of Offshore Wind. Report prepared with support from the Danish Maritime Foundation, July 2020. Available at: Socio-economic impact study of offshore wind (available at: https://winddenmark.dk)

Darmawan L. (2019) Hundreds protest pollution from coal-fired power plant in Java. *Mongabay*. 4 October. https://news.mongabay.com/2019/10/coal-power-plant-pollution-cilacap-indonesia/.

DBEIS (2020) The UK's Integrated National Energy and Climate Plan. Department for Business, Energy and Industrial Strategy, London 31 Jan 2020. (accessed on 6 Jan 2023 at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/991649/uk-integrated-national-energy-climate-plan-necp-31-january-2020.pdf).

DCCEEW (2023) *Guidance - key environmental factors for offshore windfarm environmental impact assessment under the Environment Protection and Biodiversity Conservation Act 1999*, Department of Climate Change, Energy, the Environment and Water, Canberra, July. CC BY 4.0 (available at: Key environmental factors for offshore windfarm environmental impact assessment under the EPBC Act 1999 (dcceew.gov.au))

Della Bosca H. and Gillespie J. (2018) The coal story: Generational coal mining communities and strategies of energy transition in Australia. *Energy Policy*. 120. pp. 734–740.

DELWP (2022) *Solar Energy Facilities Design and Development Guideline,* Department of Environment, Land, Water and Planning, Victoria State Government, Melbourne, October (available at: www.planning.vic.gov.au)

DEP (2017) *Solar siting analysis update*, Department of Environmental Protection, New Jersey Department of Environmental Protection, USA. (available at: https://www.nj.gov/dep/aqes/solar-siting,html)

DKP, KP and WFP (2015) *Food security and vulnerability atlas of Indonesia 2015*. Dewan Ketahanan Pangan (Food Security Council), Kementerian Pertanian (Ministry of Agriculture) and World Food Programme (WFP) (available at www.wfp.org)

DoEP (undated) *Energy mix, by fuel*, Department of Energy. Government of Philippines, Taguig City, Philippines (available at: https://www.doe.gov.ph/key-energy-statistics-dashboards/energy-mix-by-fuel.

Duffield, W.A., Sass, J.H. (2003) Geothermal Energy – Clean Power from the Earth's Heat. *U.S. Geological Survey*. Circular 1249. p. 43.

Duke University (2019) Palm oil not the only driver of forest loss in Indonesia: Wildfire and mining join plantations as threat to forests; conservation policies and practices should reflect this (available at: [Palm Oil Not the Only Driver of Forest Loss in Indonesia | Nicholas School of the Environment (duke.edu)]())

Durning B. and Broderick M. (2018) *Development of cumulative impact assessment guidelines for offshore wind farms and evaluation of use in project making*, Impact Assessment and Project Appraisal, 37:2, 124-138, DOI: 10.1080/14615517.2018.1498186 To link to this article: https://doi.org/10.1080/14615517.2018.1498186

Dusik J (2003a) SEA of the energy policies of the Slovak Republic, in *Effective SEA System and Case Studies*, Mitsubishi Research Institute for Ministry of the Environment, Government of Japan, Tokyo, pp. 101-110 (Japanese version first published in 2002)

Dusik J (2003b) SEA of Energy Policy of the Czech Republic, in *Effective SEA System and Case Studies*, Mitsubishi Research Institute for Ministry of the Environment, Government of Japan, Tokyo, pp. 95-100 (Japanese version first published in 2002)

EBRD (2017) *Environmental and Social Guidance Note for Hydropower Projects*, European Bank for Reconstruction and Development, London.

EBRD, IFC, CDC (2021) *Addressing Gender-Based Violence and Harassment. Emerging good practice for the Private Sector*. file:///C:/Users/GRE91896/Downloads/GBVH-good-practise.pdf [Accessed 22/03/2022]

EC (1996), A study on costs and benefits in EIA/SEA. European Commission. The publication is out of print, but a summary is available from http://ec.europa.eu/environment/eia/eia-studies-and-reports/eiacosts-benefit-en.htm.

EC (2020) European Commission (2020) *Potential Impacts of Solar, Geothermal and Ocean Energy on Habitats and Species Protected under the Birds and Habitats Directives*, Final Report. European Commission, Brussels (available at https://ec.europa.eu)

Ecosurv (2018) *Strategic Environmental Assessment of the Chobe Forest Reserves Management Plans.* Prepared for the Forest Association of Botswana and the Department of Forestry and Range Resources. Ecosurv Environmental Consultants, Gaborone, Botswana

Ehler C, and Douvere F. (2009) *Marine Spatial Planning: A Step-by-Step approach toward Ecosystem-based Management* (Report No. IOC/2009/MG/53). United Nations Educational, Scientific and Cultural Organistion, Paris (available at: Marine spatial planning: a step-by-step approach toward ecosystem-based management; IOC. Manuals and guides; Vol.:53; 2013 (pnnl.gov))

EIB (2019) Environmental, Climate and Social Guidelines on Hydropower Development, European Investment Bank (available at; https://www.eib.org/attachments/eib_guidelines_on_hydropower_development_en.pdf)

EJ Atlas (2017) *Agroindustry in Mato Grosso displaces the Guaraní-Kaiowá from their ancestral lands*, Brazil. Environmental Justice Atlas, 13 July. (available at: https://ejatlas.org/conflict/marinalva-manoel-murdered-brazil)

EmPower (2020) *The case for women running shift to renewables*. https://www.empowerforclimate.org/en/stories-and-gallery/stories/the-case-for-women-running-shift-to-renewables (available at: https://www.empowerforclimate.org/)

Energysage (2019) *Environmental impacts of geothermal energy*, 27 July. Energysage Inc., USA (available At: www.energhysage.com)

Englande, A. J., et al. (2015) Wastewater treatment and water reclamation, in Elias S. (ed) *Reference Module in Earth Systems and Environmental Sciences*, Elsevier.

Environment Agency (2011) *Tidal power developments: environmental impact assessment (EIA): EIA scoping guidance for power generation and transmission*. UK Environment Agency, London (available at; www.gov.uk)

EnvSC (1999) *Environmental Impact Assessment Guidelines for Transmission Lines Within the Southern African Power Pool Region*, Southern African Power Pool Environmental Subcommittee, Final Draft, August 1999

EPA Australia (1995) *Best Practice Environmental Management in Mining: Environmental Impact Assessment,* Environmental Protection Agency, Australian Federal Environment Department, Canbera

EU (2009) *Common Implementation Strategy for the Water Framework Directive* (2000/60/EC) Technical Report - 2009 – 040. European Union

EU (2011) *Wind and Energy Developments and Natura 2000: EU Guidance on wind energy development in accordance with the EU nature legislation* European Union. Publications Office, Luxembourg

EU (2022) *Commission Notice on the Guidance to Member States for the update of the 2021-2030 national energy and climate plans* (2022/C 495/02). Official Journal of the European Union (accessed on 8 Jan 2023 at: https://energy.ec.europa.eu/guidance-ms-updated-necps-2021-2030_en)

EUBIA (undated) *Renewable Energy Employment*. European Biomass Industry Association, Brussels (available at: www.eubia.org)

European Commission (2009) *River Basin Management in a Changing Climate*. Guidance document No. 24, Directorate General for Environment, European Commission, Brussels

Exo, K.-M., Huppop, O. & Garthe, S. (2003) Birds and offshore wind farms: a hot topic in marine ecology. *Wader Study Group Bull*. 100: 50-53.

FAO (2010) *Bioenergy Environmental Impact Analysis (BIAS): Analytical Framework*. Food and Agriculture Organisation of the United Nations, Rome.

FAO (2012) *Impacts of Bioenergy on Food Security: Guidance for Assessment and Response at National and Project Levels.* Bioenergy and Food Security Criteria and Indicators Project, Food and Agriculture Organization of the United Nations, Rome

FAO (2020) *Strengthening civic spaces in spatial planning processes. A technical guide on regulated spatial planning and tenure to balance societal priorities in the use of land, fisheries and forests*. Food and Agriculture Organization of the United Nations, Rome

Farja, Y.; Maciejczak, M. (2021) Economic Implications of Agricultural Land Conversion to Solar Power Production. *Energies*. 14. 6063. https://doi.org/10.3390/en14196063.

Farmer, A.M. (1993) The Effects of Dust on Vegetation—A Review, *Environmental Pollution*, 79, 63-75.

Financial Times (2018) *Coal mine closures need careful social engineering*. 29 November. https://www.ft.com/content/d820cd62-c883-11e8-86e6-19f5b7134d1c

Finster M., *et al*. 2015. Geothermal Produced Fluids: Characteristics, Treatment Technologies and Management Options. *Elsevier.* 50. pp. 952–966.

Fischer T.B. (2007) *Theory and Practice of Strategic Environmental Assessment: Towards a more systematic approach.* Annex 1: p.155–158. Routledge, London

Foot B. (2019 *Mine closure impacts on women and girls: Applying a social value approach*. Presentation at meeting of UNECE Group of Experts on Coal Mine Methane, 7-8 November, Geneva (available at: https://unece.org/

Frankenberg Veal, J. (2012) The Sewanee Coal Seam: The Dirt on East Tennessee's Toxic Coal. *The Appalachian Voice*. 21 February (available at: https://appvoices.org/)

Geothermal Technologies Office (Undated) *Geothermal Power Plants – Minimizing Land Use and Impact* (*www.energy.gov*)

German Federal Agency for Nature Conservation (2013) *Development of Noise Mitigation Measures in Offshore Wind Farm Construction*

Geissler G., Dahmen M. and Koppel J. (2021) Strategic environmental assessment in the energy sector,pp 182-202 in Fischer T.B. and Gonzalez A. (ed) *Handbook on Strategic Environmental Assessment*, Edward Elgar

Giaconia, A.; Tizzoni, A.C.;Sau, S.; Corsaro, N.; Mansi, E.;Spadoni, A.; Delise, T. (2021) Assessment and Perspectives of Heat Transfer Fluids for CSP Applications. *Energies*. 14 (7486). https://doi.org/10.3390/en14227486

Gill, A. B., Degraer, S., Lipsky, A., Mavraki, N., Methratta, E., & Brabant, R. (2020) Setting the context for offshore wind development effects on fish and fisheries. *Oceanography*, 33(4). pp. 118–127.

Gill A., Gloyne-Phillips I., Neal K. and Kimber J. (2005) *The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically* *sensitive marine organisms – a review.* Report No. COWRIE-EM-FIELD 2-06-2004. Report by Centre for Marine Studies Ltd. Report for Collavorative Offshore Wind Research into the Environment (COWRIE)

GIZ (2018) *Guidelines on Environmental and Social Impact Assessment for Wind Power Projects in Vietnam*, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn and Eschborn, Germany

Gleick P. (2009). Three Gorges Dam Project, Yangtze River, China. *World Water* (available at: http://www.worldwater.org/data20082009/WB03.pdf

Global Energy Monitor (undated) *Coal and jobs in the United States*. (available at: https://www.gem.wiki/Coal_and_jobs_in_the-United_States)

GMS (2019) *Geothermal Country Overview: Indonesia*, Geo Energy Marketing Services (available at: www.geoenergymarketing.com)

GNESD (2011). *Bioenergy: The potential for rural development and poverty alleviation*. Global Network on Energy for Sustainable Development (GNESD). Summary for policy-makers. GNESD-SPM-BET-11/2011. (available at: www.globalbioenergy.org)

González A., Therivel R., Fry J. and Foley W. (2015) *Developing and assessing alternatives in Strategic Environmental Assessment.* Prepared for the Environmental Protection Agency, Ireland, by University College Dublin, Therivel-Levett Sustainability Consultants and Girobi Environmental Service. EPA Research Report (2013-SL-DS-1), Environmental Protection Agency, Wexford, Ireland. (available at: SEA-Alternatives-157-Published_web.pdf (epa.ie))

GP WIND (undated) *Good Practice Guide* (available at: www.project=gpwind.eu)

Greimel, F. L Schülting, W. Graf, E.Bondar-Kunze, S. Auer, B. Zeiringer, and C. Hauer 2018. Hydropeaking impacts and mitigation. Chapter 5. In: S. Schmutz, J. Sendzimir (eds.), Riverine Ecosystem Management, Aquatic Ecology Series 8, https://doi.org/10.1007/978-3-319-73250-3_5

GRICCE (2019) *Is the UK doing enough to prepare for the last days of coal and the eventual phase out of oil and gas?* Grantham Research Institute on Climate Change and the Environment, London School of Economics, London (available: https://www.lse.ac.uk/)

Gupta R. (2021) *Mapping the Impact of Coal Mines and their Closure: A Case of Betul*. New Delhi: The Energy and Resources Institute (available at: https://www.teriin.org/sites/default/files/2021-03/Mapping-Impact-of-Coal-Mines-Case-of-Betul.pdf)

GWEC (2022) *Global Wind Report 2022*, Global Wind Energy Council (available at www.gwec.net)

Haigh C. (2015) *Not just transition? Coal and a Colombian miners union*. Global Justice Now (available at: https://www.globaljustice.org.uk/

Hall R., Joao E. and Knapp C.W.(2020) Environmental impacts of decommissioning: Onshore versus offshore wind farms. *Environmental Impact Assessment Review*, Vol 83

Hasegawa, T., Sands, R.D., Brunelle, T. *et al*. (2020) Food security under high bioenergy demand toward long-term climate goals. *Climatic Change*. 163. pp. 1587–1601. https://doi.org/10.1007/s10584-020-02838-8

Ho C.K. and Kolb G. (2010) Incorporating Uncertainty Into Probabilistic Performance Models of Concentrating Solar Power Plants, *Journal of Solar Engineering*, 132(3)

Hogan, B. (2020) *Is it possible to build wildlife friendly windfarms?* BBC Future Planet Article. (www.bbc.com/future/artilce/20200302-how-do-wind-farms-affect-birds-and-other-wildlife)

Hoover, A., Emerson, R., Hansen, J., Hartley, D., & Ray, A. (2019) Drought Impacts on Bioenergy Supply System Risk and Biomass Composition. In (Ed.), *Drought - Detection and Solutions*. IntechOpen. https://doi.org/10.5772/intechopen.85295

Horváth G, Kriska G, Malik P, Robertson B (2009) Polarized light pollution: a new kind of ecological photopollution. *Front Ecol Environ* 7:317–325

Howell A. and Drake C. (2012) *Scoping Study on Socio-Economic Impacts of Tidal Energy Development in Nova Scotia: A Research Synthesis & Priorities for Future Action. Report prepared for* the Nova Scotia Department of Energy & Offshore Energy Environmental Research Association, 30 January (available at: https://oera.ca/)

HSC (undated). *Cultural heritage*, Hydropower Sustainability Council (Cultural Heritage — Hydropower Sustainability Coucil (hydrosustainability.org))

HSC (2020) *Guidelines on good international practice*. Multiple tools and guidelines. Hydropower Sustainability Council. (https://www.hydrosustainability.org/)

HSC (2022) *Understanding indigenous people in hydropower*. Hydro Sustainability Council (How-to+Guide+-+Hydropower+and+Indigenous+Peoples.pdf (squarespace.com).)

Human Rights Watch (2021) *Underwater: Human Rights Impacts of a China Belt and Road Project in Cambodia* | Human Rights Watch (available at: cambodia0821_reportcover_8.5x11 (hrw.org))

Hundleby G., Valpy B. and Barnes Z. (2015) *Wave and Tidal Supply Chain Development Plan: Supply chain capability and enabling action recommendations.* Report by BVG Associates for Renewable UK. Report for Scottish Renewables (available at: https://tethys-engineering.pnnl,gov)

Hüppop O., Dierschke J., Exo K-M., Fredricj E. and Hill R. (2006) Bird migration studies and potential collision risk with offshore wind turbines. *International Journal of Avian Science*, Vol 148, issue s1, pp 90-109

Hurwitz Z., Bujak N., Tapia M. Daza E., and Gischler C. (2023) *Key aspects for managing the environmental and social risks of green hydrogen*. Blog, 6 June 2023, Inter-American Development Bank, Washington DC. (available at: Key aspects for managing the environmental and social risks of green hydrogen - Sostenibilidad (iadb.org)

Huso, M., T. Dietsch, and C. Nicolai. 2016. *Mortality monitoring design for utility-scale solar power facilities*: U.S. Geological Survey Open-File Report 2016-1087. 44 p. http://dx.doi.org/10.3133/ofr2016108

Hvinstendahl M. (2008) China's Three Gorges Dam: An Environmental Catastrophe?" *Scientific American*. http://www.scientificamerican.com/article.cfm?id=chinas-three-gorges-dam-disaster

IAIA (2002) *Strategic Environmental Assessment: Performance Criteria* (available at: Best Practices (iaia.org))

IATP (2007) *Biofuels and global water challenges*. Institute for Agriculture and Trade Policy available at: www.iatp.org)

ICCT (2016) 2016. *Ecological impacts of palm oil expansion in Indonesia*, International Council on Clean Transportation (available at: Ecological impacts of palm oil expansion in Indonesia (theicct.org))

ICEM, IIED and SchEMS (2014) *Strategic Environmental and Social Assessment of Nepal's REDD+ Strateg*y, Report to REDD Cell, Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

IEA (2007) *Good Practice Guidelines. Bioenergy Project Development Development and Biomass Supply.* International Energy Agency, Paris, June (available at: www.iea.org)

IEA (2016) *End of life management- Solar Photovoltaic Panels*, International Energy Agency, Paris

IEA (2019) International Energy Agency. 2019. *Southeast Asia Energy Outlook 2019*. https://www.iea.org/reports/southeast-asia-energy-outlook-2019

IEA (2019b), The Future of Hydrogen, IEA, Paris https://www.iea.org/reports/the-future-of-hydrogen, License: CC BY 4.0 IEA (2019), The Future of Hydrogen, IEA, Paris https://www.iea.org/reports/the-future-of-hydrogen, License: CC BY 4.0

IEA (2021) *Renewable 2021: Analysis and Forecasts to 2026*. International Energy Agency, Paris

IEA (2021b) *World Energy Outlook 2021: Phasing out coal*. Analysis. International Energy Agency, Paris

IEA (2022) *World Energy Outlook 2022*. International Energy Agency, Paris

IEA (2022b) *Biofuels*,*Fuels and Technologies*. International Energy Agency, Paris (available at www.iea.org)

IEA (2022c) *Global Hydrogen Review 2022*, International Energy Agency, Paris

IEA (2023) *Energy Technology Perspectives 2023*. International Energy Agency, Paris (www.iea.org)

IEA Bioenergy (2020) Bioenergy: A Sustainable Solution, IEA Bioenergy, 7 April (available at; www.ieabioenergy.com)

IEEFA (2021) *Navajo Nation: Hopi tribe advocates push for fair energy transition outcome in Arizona,* Institute for Energy Economics and Financial Analysis, July (available at: IEEFA: Navajo Nation, Hopi tribe advocates push for fair energy transition outcome in Arizona.

IEEFA (undated) *Coal-Mine Conversion in Germany*. Institute for Energy Economics & Financial. Institute for Energy Economics and Financial Analysis, Lakewood, Ohio, USA.. Analysis.ieefa.org.

IER (2020) *The Environmental Impact of Lithium Batteries*, Institute for Energy Research, Washington DC (available at: https://theinstituteforenergyresearch.org)

IFC (2007) *Environmental, Health, and Safety Guidelines for Geothermal Power Generation*, International Finance Corporation, Washington DC, April (available at: www.ifc.org)

IFC (2007b). *Environmental, Health, and Safety Guidelines for Coal Processing*, International Finance Corporation, Washington DC (available at: www.ifc.org)

IFC (2007c) *Environmental, Health and Safety Guidelines for Electric Power Transmission and Distribution*. International Finance Corporation (available at: Final - Electric Power Transmission & Distribution.doc (ifc.org))

IFC (2008a) *Environmental, Health and Safety Guidelines for Thermal Plants*, International Finance Corporation, Washington DC (available at: www.ifc.org)

IFC (2008b) *Thermal Power Plants Environmental Health, and Safety Guidelines Annex A General Description of Industry Activities*, International Finance Corporation, Washington DC

IFC (2009) *Projects and People: A Handbook for Addressing Project-Induced In-Migration*. International Finance Corporation, Washington, DC.

IFC (2010 *Strategic Community Investment: A Good Practice Handbook for Companies Doing Business in Emerging Markets*. International Finance Corporation, Washington DC (available at www.ifc.org)

IFC (2012) *Ecosystem services are the benefits that people, including businesses, derive from ecosystems*. PS6_English_2012.pdf (ifc.org);

IFC (2012b) *Performance Standard 7: Guidance Note: Indigenous Peoples,* January 1, 2012, International Finance Corporation, World Bank Group, Washington DC

IFC (2012b) *Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources* January 1, 2012, International Finance Corporation, World Bank Group, Washington DC

IFC (2012c). *Performance Standard 2*: *Labour and Working Conditions*, Section 1: Purpose of this Policy, International Finance Corporation, Washington DC (www.ifc.org) (www.ifc.org)

IFC (2012d) *Utility Scale Solar Power Plants: A guide for developers and investors*. International Finance Corporation, Washington DC (available at www.ifc.org)

IFC (2015) Environmental, Health and Safety (EHS) Guidelines for Wind Energy, International Finance Corporation, World Bank Group, Washington DC

IFC (2015b) *Hydroelectric Power, A Guide for Developers and Investors*, International Finance Corporation, World Bank Group, Washington DC

IFC (2016). *Environmental, Health and Safety Guidelines for Annual Crop Production,* International Finance Corporation, World Bank Group, Washington DC

IFC (2017) *Environmental, Health and Safety Guidelines for Ports, Harbours and Terminals.* International Finance Corporation, Washington D.C. (available at: Environmental, Health, and Safety Guidelines for Ports, Harbors, and Terminals (ifc.org))

IFC (2018) *Good Practice Note: Environmental, Health, and Safety Approaches for Hydropower Projects*. International Finance Corporation, Washington, DC.

IFC (2019b) *Discussion Paper, Local Benefit Sharing in Large-Scale Wind and Solar Projects*. https://www.commdev.org/wp-content/uploads/2019/06/IFC-LargeScaleWindSolar_Web.pdf. International Finance Corporation, Washington DC

IFC (2021) *Performance Standard 8: Cultural heritage* (Section 1: Purpose of this Policy. International Finance Corporation, Washington DC

IFPRI (2008) *Biofuels and Food Security: Balancing Needs for Food, Feed and Fuel*, International Food Policy Research Institute. Washington, DC.

IHA (2019). *How-to Guide: Hydropower Erosion and Sedimentation*. International Hydropower Association, London: (available from: www.hydropower.org)

IHA (2020) *Hydropower Sustainability Guidelines*. *Project Affected People and Livelihoods*. London: International Hydropower Association Limited. (Project+Affected+Communities+and+Livelihoods+Guidelines.pdf (squarespace.com))

IHA (2021) *How-to Guide: Hydropower Biodiversity and Invasive Species*. International Hydropower Association, London: (available from: www.hydropower.org

IHA (2022) *2022 Hydropower Status Report Sector Trends and Insights (available at:* https://www.hydropower.org/publications/2022-hydropower-status-report)

ILO (undated) *Child Labour in Agriculture* (available at: https://www.ilo.org/ipec/areas/Agriculture/land--en/index.htm)

ILO (2004) Coal Mining in Indonesia. International Labour Organisation, 12 July (available at: https://www.ilo.org/global/about-the-ilo/multimedia/video/video-news-releases/WCMS_074457/lang--en/index.htm)

ILO (2017) *Child labour in the primary production of sugarcane*. International Labour Organisation, 29 September (available at: https://www.ilo.org/ipec/informationresources/WCMS_IPEC_PUB_29635/lang—en.index.htm)

IME (2016) 2016. *Last standing coal plant to close down in Scotland*. Institution of Mechanical Engineer, 24 March. https://www.imeche.org/news/news-article/last-standing-coal-plant-to-close-down-in-scotland

IPCC (2022) C*limate Change 2022: Mitigation of Climate Change,* Working Group III Contribution to the IPCC Sixth Assessment Report (AR6), Section 4.5, "*Equity, including just transitions*," starts on page 4-99. Intergovernmental Panel on Climate Change, Geneva, Switzerland

IRENA (2017) *Renewable Energy Benefits: Leveraging Local Capacity for Solar PV*. International Renewable Energy Agency, Abu Dhabi, June (available at www.irena.org)

IRENA (2017b) *Renewable energy benefits: understanding the socioeconomics*. International Renewable Energy Agency, Abu Dhabi

IRENA (2020) *Renewable Energy and Jobs – Annual Review 2020*. International Renewable Energy Agency, Abu Dhabi (available at: www.irena.org)

IRENA (2020b) *Global Renewables Outlook: Energy Transformation 2050* (available at: www.irena.org)

IRENA (2020c) *Green Hydrogen: A guide to policy making*. International Renewable Energy Agency , Abu Dhabi. ISBN: 978-92-9260-286-4

IRENA (2021a) *Renewable Energy and Jobs. Annual review in 2021*. International Renewable Energy Agency, Abu Dhabi (available at: www.irena.org)

IRENA (2021b). *Offshore renewables: An action agenda for deployment*. Abu Dhabi: International Renewable Energy Agency. Abu Dhabi (available at: www.irena.org)

IRENA (2022) *Employment Time Series,* International Renewable Energy Agency. Abu Dhabi (available at: www.irena.org)

IRENA (2022b) *Renewable Capacity Statistics 2022*, International Renewable Energy Agency. Abu Dhabi (available at: www.irena.org)

IRENA (2022c) Solar PV: A Gender Perspective. International Renewable Energy Agency. Abu Dhabi (available at: www.irena.org)

Jong, H.N. (2021) Indonesia's biodiesel program fuels deforestation threat. *Mongabay.* 9 June. [Indonesia's biodiesel program fuels deforestation threat, report warns (mongabay.com).]

Johnson C.J. and Ray. J.C (2021)_The Challenge and Opportunity of Applying Ecological Thresholds to Environmental Assessment Decision Making. Chapter 9 (pp 149-157) in Blakeley J.A.E. and Franks D.M. (EDS) *Handbook of Cumulative Impact Assessment*. Edward Elgar Publishing.

Johnston, D., Potter H., Jones C. *et al*. (2008) *Abandoned mines and the water environment*. Bristol: Scottish Environment Agency and the Coal Authority, Environment Agency, Bristol, UK (available at: https://assets.publishing.service.gov.uk/)

Jusakulvijit P., Bezama A. and Thran D. (2021) Criteria prioritisation for sustainable development of second generation bioethanol in Thailand using Delphi-AHP technique. *Energy Sustain Soc*., 11.37

Kabeyi M.J.B and Olanweraju O. . 2022. Geothermal wellhead technology power plants in grid electricity generation: A review. Energy *Strategy Reviews*, 39(1). Elsevier

Kagel A., Bates D. and Gawel, K. (2005) *A Guide to Geothermal Energy and the Environment*. Geothermal Energy Association. Washington, DC

Kalt G., Thunshirn P. and Haberl H. (2021) A global inventory of electricity infrastructures from 1980 to 2017: Country-level data on power plants, grids and transformers. *Data in Brief*, 39, October 2021. (available at: [A global inventory of electricity infrastructures from 1980 to 2017: Country-level data on power plants, grids and transformers (sciencedirectassets.com)]

Karekezi, S. and Kithyoma, W. (2006) *Bioenergy and the poor*, Focus 14, Brief 11 of 12, International Food Policy Research Institute, Washington DC

Koh L.P. and Wilcove D.S. (2007) Cashing in Palm Oil for Conservation. *Nature* 448 (30): pp. 993–94.

Kolhoff A. and Slootweg R. (eds) (2021) *Strategic Environmental Assessment for More Sustainable Development of the Hydropower Sector: Five Influential Cases*. Netherlands Commission for Environmental Assessment.

Kravchenko J. and Lyerly H.K. (2018) The impact of coal-powered electrical plants and coal ash impoundments on the health of residential communities. *North Carolina Medical Journal*, 79(5), 289-300.

Kunz T.H., de Torrez E.B., Bauer D., Lobova T. and Fleming T.H. (2011) Ecosystem services provided by bats. *Annals of the New York Academy of Sciences*.1223:1-38. DOI: 10.1111/j.1749-6632.2011.06004.

Lahiri-Dutt, K. (2012) The Shifting Gender of Coal: Feminist Musings on Women's Work in Indian Collieries. South Asia: *Journal of South Asian Studies*. 35 (2). pp. 456–476.

Lahiri-Dutt K. (2021) *Gendering just transition: How coal mine closures really affect communities*. Asia and the Pacific Policy Society (available at: Gendering just transition - Policy Forum)

Lahmeyer and Ecoda Consultants (2018) *Strategic and Cumulative Environmental and Social Assessment Active Turbine Management Program (ATMP) for Wind Power Projects in the Gulf of Suez*, Final Report (D-8). Prepared by: JV Lahmeyer International GmbH and Ecoda Environmental Consultants, Germany, for the Regional Centre for Renewable Energies and Energy Efficiency (RCREEE), Cairo. March

Lambert Q., Gros R. and Bishoff A. (2022) Ecological restoration of solar park plant communities and the effect of solar panels. *Ecological Engineering*, 182,

Largue P. (2020) *Global wave and tidal stream energy production surges tenfold*, March 17, (www.powerengineeringint.com) (available at: Global wave and tidal stream energy production surges tenfold - Power Engineering International)

Layton D.W., Anspaugh L.R. abd O'Banion K.D. (1981) *Health and Environmental Effects Document on Geothermal Energy*. Lawrence Livermore National Laboratory, University of California, Livermore, CA

Liu P. and Barlow C.Y. (2017) Wind turbine blade waste in 2050. *Waste Management*, 62, 229-240.

Manzella A., Bonciani R., Allansdotti, A., Botteghi S., Donato A., Giamberini S. and Scrocca D. (2018) Environmental and social aspects of geothermal energy in Italy. *Geothermics*. *72*. pp. 232—248.

Markandya A. and Wilkinson P. (2007) Electricity generation and health. *The Lancet*, 370(9591), 979-990. Available at: http://doi.org/10.1016/S0140-6736(07)61253-7

Mariëlle L., van Toor M., O'Mara T., Abedi-Lartey M., Wikelski M., Fahr J. and Dechmann D.K.N. (2019) Linking colony size with quantitative estimates of ecosystem services of African fruit bats. *Current Biology*; 1 April

Marshall, R. & Fischer, T. B. 2006. Regional electricity transmission planning and tiered SEA in the UK – the case of ScottishPower, *Journal of Environmental Planning and Management* 49(2): 279-299.

Martire J.L. (2020) *Powering Indigenous communities with renewables,* Renew, Australia, 20 April (available at: https://renew/org.au)

Matek,B. and Gawell, K. (2015) The Benefits of Baseload Renewables: A Misunderstood Energy Technology. *The Electricity Journal*. 28 (2). pp. 101–112. https://doi.org/10.1016/j.tej.2015.02.001.
Meland S. (2016) *Management of contaminated runoff water: current practice and future research needs*. Conference of European Directors of Roads (available at: www.cedr.eu)

Mayer A. (2021) Economic Change, the Death of the Coal Industry, and Migration Intentions in Rural Colorado, USA. *Journal of Rural Social Sciences* 36(1): Article 4.https://egrove.olemiss.edu/jrss/vol36/iss1/4.

McCarter and English (2016). *Coal Plant Shutdowns: Plant Operators Should Engage Local Communities.* https://www.mccarter.com/insights/coal-plant-shutdowns-plant-operators-should-engage-local-communities/

McMahon J. (2016) *How Iceland Drilled for Renewable Energy and Struck Tourists.* Forbes*.* 3 January*(available at: www.forbes.com)*

MCSA (undated) *In the Spotlight*, Minerals Council of South Africa (available at: https://www.mineralscouncil.org.za/special-features/85-illegal-mining-on-the-rise)

Meijaard, E., Dennis, R.A., Saputra, B.K., Draugelis, G.J., Qadir, M.C.A., and Garnier, S. 2019. *Rapid Environmental and Social Assessment of Geothermal Power Development in Conservation Forest Areas of Indonesia*. PROFOR, Washington, DC (available at: https://www.profor.info/sites/profor.info/files/PROFOR_Geothermal%20Indonesia%20Report%20-%20August%202019_0.pdf)

Merrill T., and Kitson L. (2017*) The End of Coal Mining in South Wales: Lessons learned from industrial transformation.* The International Institute for Sustainable Development, Winnipeg https://www.iisd.org/system/files/publications/end-of-coal-mining-south-wales-lessons-learned.pdf

MESP (2010) *Guidelines on the Environmental Impact Assessment for Wind Farms*, Ministry of Environment and Spatial Planning, Belgrade, Serbia

Michel J., Dunagan H., Boring C., Healy E., Evans W., Dean J.M., McGillis A. and Hain J. (2007) *Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Alternative Energy Uses on the Outer Continental Shelf*. Report No, MMS 2007-038 by ICF International for the US Department of the Interior

MIT News (2015) *Better estimates of worldwide mercury pollution*. (available at: https://news.mit.edu/2015/better-estimates-of-worldwide-mercury-pollution-0812

MNREC (2018) Environmental Impact Assessment Guidelines for the Mining Sector Ministry of Natural Resources and Environmental Conservation, Myanmar (available at: https://data.opendevelopmentmyanmar.net/)

MONRE (2008) *General Technical Guidance for Strategic Environmental Assessment* [in Vietnam], Department of Environmental Impact Assessment and Appraisal, Ministry of Natural Resources and Environment, Hanoi

MRC (2011) *Roads and Floods: Best Practice Guidelines for the Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains of Cambodia and Viet Nam.* Mekong River Commission, Technical Paper No. 35 (October 2011

MSEA (2013) *Environmental Impact Assessment Guidelines for Wind Energy Developments in Egypt,* Migratory Soaring Birds Project, Ministry of State for Environmental Affairs, Environmental Affairs Agency, Cairo Egypt (available at: https://www.researchgate.net/publication/299452520_Environmental_Impact_Assessment_Guidelines_for_Wind_Energy_Developments_in_Egypt

Murphy R. (2018) *Skills and Labour Requirements of the UK Offshore Wind Industry: 2018 to 2032*. Technical Report for Energy and Utility Skills Ltd, Solihull, UK (available at: www.voced.edu.au)

Murphy, L and Elimä, N. (2021) *In Broad Daylight: Uyghur Forced Labour and Global Solar Supply Chains*. Sheffield Hallam University Helena Kennedy Centre for International Justice Sheffield, United Kingdom (available at: https://www.shu.ac.uk)

Munawer M. (2017) Human health and environmental impacts of coal combustion and post-combustion waste. *Journal of Sustainable Mining* 17 (2018) 87 - 96 Elsevier

Muscat, A., de Olde E.M., de Boer I.J.M. and Ripoll-Bosch R. (2020) The battle for biomass: a systematic review of food-feed-fuel competition. *Global Food Security*, 25, Elsevier

Nasir M., Bakker L. and van Meijl T. (2022) Coal Mining Governance in Indonesia: Legal Uncertainty and Contestation. *Australian Journal of Asian Law*. 22(1). pp. 53–67.

National Geographic (2022) *This former coal mining region now fuels green tourism,* National Geograohic, 9 March (available at: www.nationalgeographic.com)

National Wind Watch (2021) *Winds of change blow through indigenous lands in La Guajira*. 23 December. (available at: www.wind-watch.org)

NCEA (2012) *Strategic Environmental Assessment for Sustainable Development of the Hydropower Sector. Five Influential Cases - India, Myanmar, Pakistan, Rwanda and Viet Nam*. Netherlands Commission for Environmental Assessment.

NCEA (2018) *ESIA and SEA for Sustainable Hydropower Development*. The Netherlands: Netherlands Commission for Environmental Assessment. (https://www.eia.nl/documenten/00000339.pdf)

NCEA (2020) *Working Note - Costs of ESIA and SEA*, Netherlands Commission for Environmental Assessment

Neill P., Angeloudis A., Robins P., Walkington I., Ward D., et al. (2018) Tidal Range energy resource optimisation – past perspectives and future challenges. *Renewable Energy*, 127, 763-778

NEMA (2012), *National Guidelines for Strategic Environmental Assessment*, National Environmental Management Authority, Nairobi.(available at: https://www.nema.go.ke/images/Docs/Guidelines/SEA%20GUIDELINES%20FINAL%20DRAFT-feb_20_2013.pdf)

Ng C., White T., Katariya V., and Pollard E. (2021) *Geothermal power generation and biodiversity: the business case for managing risk and creating opportunity.* World Geothermal Congress 2020+1. (PDF) Geothermal power generation and biodiversity: the business case for managing risk and creating opportunity (researchgate.net)

NIMOS (2005) *Environmental Assessment Guidelines Volume V: Power Generation and Transmission Projects*, Office of Environmental and Social Assessment, Suriname

Noer C.L., Dabelsteen T., Bohmann K. and Monadjem A. (2012) Molossid Bats in an African Agro-Ecosystem Select Sugarcane Fields as Foraging Habitat, *African Zoology* 47(1), 1-11, (1 April 2012). https://doi.org/10.3377/004.047.0120

NOOA (2018) *2018 revision to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 2.0),* National Oceanic and Atmospheric Administration, Washington DC (available at: https://www.fisheries.noaa.gov/action/2018-revision-technical-guidance-assessing-effects-anthropogenic-sound-marine-mammal-hearing)

NRC (2007) *Environmental Impacts of Wind-Energy Projects*. National Research Council, Washington, DC: The National Academies Press. (https://doi.org/10.17226/11935. 4 Impacts of Wind-Energy Development on Humans | Environmental Impacts of Wind-Energy Projects, The National Academies Press (nap.edu))

NSW Government (2017) *Large Scale Solar Energy Guideline: for State Significant Development*. Government of New South Wales, Sydney, Australia (available at: www.planning.nsw.gov.au)

Nwanakezie K., Noble B. and Poelzer G. (2022) Strategic assessment for energy transitions: A case study of renewable energy development in Saskatchewan, Canada. *Environmental Impact Review*, 92, January (accessed on30 Jan 2023 at: Strategic assessment for energy transitions: A case study of renewable energy development in Saskatchewan, Canada - ScienceDirect)

ODPM (2005) *A Practical Guide to the SEA Directive, Appendix 9;* quoted *in Resource Manual to Support Application of the UNECE Protocol on Strategic Environmental Assessment.* Draft for Consultation. Office of the Deputy Prime Minister, UK, July 2006.

OECD-DAC (2006) *Good Practice Guidance on Applying Strategic Environmental Assessment in Development Cooperation*. OECD DAC Policy Guidance Document. Development Cooperation Committee, Organisation for Economic Cooperation and Development, Paris.

OECD DAC (2011) *Strategic Environmental Assessment and Biofuel Development: Advisory Note.* DAC Network on Environment and Development Co-operation (ENVIRONET), Development Assistance Committee of the Organisation for Eco nomic Cooperation and Development, Paris, April

OECD (2017) *Just Transition*. Organisation for Economic Cooperation and Development, Paris (https://www.oecd.org/environment/cc/g20-climate/collapsecontents/Just-Transition-Centre-report-just-transition.pdf)

Öhman M.C., Sigray P. and Westerberg H. (2007) Offshore Windmills and the Effects of Electromagnetic Fields on Fish. *Ambio*, 36(8), 630-633

Ong, S., Campbell, C., Denholm, P., Margoli, R., and Health, G. (2013) *Land-Use Requirements for Solar Power Plants in the United States*. National Renewable Energy Laboratory, Golden, Colorado, USA. (available at www.nre.gov)

Opperman, J., G. Grill and J. Hartmann (2015) *The Power of Rivers: Finding balance between energy and conservation in hydropower development*. Washington, DC: The Nature Conservancy. https://www.nature.org/media/freshwater/power-of-rivers-report.pdf

Orbital Marine Power (2021) *Orbital: O2.02 Tidal Turbine, Project Environmental Monitoring Program, EMEC Berth 6. Fall of Warness,* Eday, Orkney. February. Feb 2021. (available at: https://marine.gov.scot/sites/default/files/project/_environmental_monitoring_programme_2.pdf)

Parsons Brinckerhoff (2011a) *Electricity generation cost model: update by Parsons Brinckerhoff*, prepared for the UK Department of Energy and Climate Change (www.gov.uk/government/publications/electricity-generation-cost-model-update-by-parsons-brinckerhoff-2011)

Parsons Brinckerhoff (2011b) *Update of UK Shadow Flicker evidence base*. An update of the UK Shadow Flicker Evidence Base as reported for DECC by Parsons Brinckerhoff. (www.gov.uk/government/publications/update-of uk-shadow-flicker-evidence-base-2011)

Payan, T. and Correa-Cabrera, G. (2014) *Land Ownership and Use under Mexico's Energy Reform*. Issue Brief 10.29.14. 29 October. Baker Institute for Public Policy, Rice University, Houston

Pellow M.(ed) (2017) *Wildlife and Wind Farms – Conflicts and Solutions Series*: Vol 1: Onshore Potential Effects; Vol 2: Onshore Monitoring and Mitigation. Pelagic Publishing, Exeter, UK.

Pellow M.(ed) (2019) *Wildlife and Wind Farms – Conflicts and Solutions Series*: Vol 3: Offshore Potential Effects; Vol 4: Offshore Monitoring and Mitigation. Pelagic Publishing, Exeter, UK.

Phylip-Jones J. and Fischer T. (2013) *EIA for Wind Farms in the United Kingdom and Germany*, Journal of Environmental Assessment Policy and Management Vol. 15, No. 2 (April 2013)

Piggot G., Boyland M., Down A. and Torre, A. (2019) *Realizing a just and equitable transition away from fossil fuels*. Stockholm Environment Institute. http://www.jstor.com/stable/resrep22996.

Polagye B., Van Cleve B., Copping A. and Kirkendal K. (2010) Environmental Effects of Tidal Energy Development. *Proceedings of a Scientific Workshop*; Orbital Marine Power. O2.02 Tidal Turbine, Project Environmental Monitoring Program, EMEC Berth 6, Fall of Warness, Eday, Orkney. February 2021.

PPFI (undated) *Air pollution emissions from biomass*, in Biomass Energy Overview, Partnership for Policy Integrity (available at: www.pfpi.net)

Prachatai (2013) *Mercury Found in Fish and Residents near Coal Power Plant and Paper Pulp Mill*, Prachatai, Thailand, 10 January (available at: https://prachataienglish.com/)

Price T. (2009) *Dry cooling: Slaking the thirst of concentrated solar powe*r, Reuters Events / Renewables, 23 Oct 2009 (www.reutersevents.com)

Ramboll (2012) *Port of Poole Masterplan: SEA Environmental Report*. Prepared by Ramboll, Southampton, UK

Reach Solar Energy (2018) *Reflective and Illumination Glare (SLR Report).* Environmental Impact Statement (Appendix L) for Yarrabee Solar Project, Reach Solar energy, Melbourne,, Autralia (August 2018) (available at: https://majorprojects.planningportal.nsw.gov.au)

Reiskind M.H. and Wund M.A. (2009) Experimental assessment of the impacts of northern long-eared bats on ovipositing Culex (Diptera: Culicidae) mosquitoes. *J Med Entomol*. Sep;46(5):1037-44. doi: 10.1603/033.046.0510. PMID: 19769034; PMCID: PMC3749376

REMA (2008) *Sector Guidelines for Environmental Impact Assessment (EIA) for Hydropower Development Projects in Rwanda*, Rwanda Environmental Protection Agency

Remedio, E., and Domac, J. (2003) *Socio-economic analysis of bioenergy systems: a focus on employment.* United Nations Food and Agriculture Organization, Rome. (available at: http://www.globalbioenergy.org/uploads/media/0312_FAO_-_Socio-economic_analysis_of_bioenergy_systems_a_focus_on_employment.pdf)

Ren X, Sun, R, Meng X, Vorobiev N, Schiemann M, Levendis Y. (2017) Carbon, sulfur and nitrogen oxide emissions combustion of pulverised raw and torrefied biomass. *Fuel.* 188 (January). pp. 310–323.

Renewable Energy World (2017) *How Drones will Transform Wind Turbine Inspections*. 11 December. https://www.renewableenergyworld.com/storage/how-drones-will-transform-wind-turbine-inspections/

Renewable UK (2014) *Wave and Tidal Health and Safety Guide: Principles and Practice*. Renewable UK, August (available at: www.renewableuk.com)

Resosudarmo B., Nurdianto D.A. and Yusuf A. (2009) Greenhouse Gas Emission in Indonesia: The Significance of Fossil Fuel Combustion,, pp 146-159 *in Regional Development, Energy and the Environment in Indonesia*, Indonesia Regional Science Association (available at: https://www.jstor.org/stable/pdf/resrep10917.8.pdf)

Resosudarmo B., Resosudarmo I.A.P. and Sarosa W. and Subiman, N. (2009b). Socioeconomic conflicts in Indonesia's mining industry. In Richard Cronin, Amit Pandya (Ed.), *Exploiting natural resources: growth, instability, and conflict in the Middle East and Asia* (1st ed., pp. 33-46). Stimson Center. http://hdl.handle.net/1885/50556

Rivera, D. (2021). Philippines sees increase in employment in RE sector. PhilStar Global. 1 November. Philippines sees increase in employment in RE sector | Philstar.com

Rosen M.A., Bulucea C.A., Mastorakis,, N.E., Bulucea C.A., Jeles A.C. and Brindusa C.C. (2015) Evaluating the Thermal Pollution Caused by Wastewaters Discharged from a Chain of Coal-Fired Power Plants along a River. *Sustainability*, 7 (5). pp. 5920–5943.

Rossi, A. and Lambrou, Y. (2008) *Gender and equity issues in liquid biofuels production: Minimizing the risks to maximize the opportunities*. Rome: UN FAO. http://www.globalbioenergy.org/uploads/media/0804_FAO_-_Gender_and_equity_issues_in_liquid_biofuels_production.pdf

Roth I.F. and Lawrence L.A. (2004) Incorporating externalities into a full cost approach to electric power generation life-cycle costing. *Energy* 29(2004). pp. 2125–2144

Rusdianto E. (2017) In remote Indonesian villages, indigenous communities fight a hydropower dam. Mongabay. 30 March. (available at: In remote Indonesian villages, indigenous communities fight a hydropower dam (mongabay.com))

Rutherford, N. (2021) *Wind farm firms admit safety breaches over worker who froze to death*. BBC News. 25 August. (www.bbc.co.uk/news/uk-scotland-58331665)

RVO (2022) *Dutch Offshore Wind Guide Your guide to Dutch offshore wind policy, technologies and innovations*. Netherlands Eneterprise Agency and Ministry of Foreign Affairs (available at: https://www.rvo.nl/sites/default/files/2021/10/Dutch%20Offshore%20Wind%20Guide%202022.pdf

Saeporsottir, A.D., and Hall, M. (2018) Floating Away: The Impact of Hydroelectric Power Stations on Tourists' Experience in Iceland. *Sustainability*, 10(7)

Saputra M.B. (2022). In Indonesia, Sumatra's coal brings more harm than good. *New Mandala*. 19 January (available at. https://www.newmandala.org/in-indonesia-sumatras-coal-brings-more-harm-than-good/.)

Sartor O., Błachowicz A., Szpor A., Lewandowski P., Baran J. and Witajewski-Baltvilks J. (2017) *Coal Transition in Poland*. Institut du Développement Durable et des Relations Internationales (IDDRI), Paris(available at: Coal transition in Poland. Options for a fair and feasible transition for the Polish coal sector (iddri.org))

Scottish Natural Heritage (2016) Decommissioning and Restoration Plans for wind farms: Guidance, Version 2, (February 2016 (available at: Guidance (nature.scot))

Scottish Natural Heritage (2019), *A review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters*, Research Report 1070.

Shah, R. and Bloomer, P. (2018) Respecting the Rights of Indigenous Peoples as Renewable Energy Grows. *Standord Social Innovation Review*. 23 April. (available at: *https://ssir.org/articles/entry/respecting_the_rights_of_indigenous_peoples_as_renewable_energy_grows#)*

Sheldon T.L. and Sankaran C. (2017) The Impact of Indonesian Forest Fires on Singaporean Pollution and Health. *Amer. Econ. Rev*. 107(5). pp. 526–9. doi: 10.1257/aer.p20171134. PMID: 29558063.

Shmidt, A., Fitzgerald T., Lamendola D. and Schleich T. (2015) The Externalities Associated with Various Heating Sources at Bates College. *Community Engaged Research Reports*. 22. (available at: http://scarab.bates.edu/community_engaged_research/22)

Shrestha, G. Joshi, D. and Clément, F. (2019) Masculinities and hydropower in India: a feminist political ecology perspective. I*nternational Journal of the Commons*. 13(1). pp. 130–152. DOI: http://doi.org/10.18352/ijc.920.

Signoria C, and Barlettani M. (2023) *Environmental, Health, Safety, and Social Management of Green Hydrogen in Latin America and the Caribbean*: A scoping study. Technical Note; 2554, Inter-American Development, Washington DC (available at: Environmental, Health, Safety, and Social Management of Green Hydrogen in Latin America and the Caribbean | Publications (iadb.org)

Silalertruksa*, et al*. (2012) Biofuels and employment effects: implications for socio-economic development in Thailand. *Biomass and Energy.* 46 (November). pp. 409-418. 10.1016/j.biombioe.2012.07.019

Slamat U. and Moelyono D.G. (2000) Maximizing Community Benefits and Minimizing Environmental Impacts in the Gunung Salak Geothermal Project, Indonesia. *Proceedings of World Geothermal Congress* 2000. R0193.PDF (geothermal-energy.org)

Slootweg R. (2023) *Aligning Hydropower proposals to the Green Deal*. The Green Collection, European Commission

Soelistijo U.W. (2011) Control of Illegal Mining (PETI) in Indonesia: Policy and Program. *Indonesian Mining Journal*. 14(1). pp. 1–16;

Solartechadvisor (2021) *How does solar panel glare affect aircraft?,* 28 November (available at: https://solartechadvisor.com/solar-panel-glare-aircraft/)

Soltani M., Kashkooli F. M., Souri M., Rafiei B., Jabarifar M., Gharali K. and Nathwani J.S. (2021) Environmental, economic, and social impacts of geothermal energy systems. *Renewable and Sustainable Energy Reviews*. 140 (110750).

Stanley M.C., Strongman J.E., Perks R.B. *et al.* (2018) Managing Coal Mine Closure: Achieving a Just Transition for All, World Bank, Washington DC (available at: http://documents.worldbank.org/curated/en/484541544643269894/Managing-Coal-Mine-Closure-Achieving-a-Just-Transition-for-All)

Stashwick, S. (2016) *Health Groups to Congress: Burning Biomass is Bad for Health*. Natural Resources Defense Council, New York (available at: https://www.nrdc.org/experts/sasha-stashwick/health-groups-congress-burning-biomass-bad-health)

Strambo C., Thazin Aung M. and Atteridge A. (2019) *Navigating coal mining closure and societal change: learning from past cases of mining decline.* SEI Working Paper. Stockholm: Stockholm Environment Institute. (available at: https://www.sei.org/wp-content/uploads/2019/07/navigating-coal-mining-closure-and-societal-change.pdf)

Suarez I. and Myllyvirta L. (2020) *Air Quality & Health Impacts of Coal-fired Power in the Philippines.* Philippines: Center for Research on Energy and Clean Air. (available at: https://energyandcleanair.org)

Tawalbeha, M., Al-Othman, A., Kafiah, F., Abdelsalam, E., Almomanid, F., Alkasrawi, M. (2021) Environmental impacts of solar photovoltaic systems: A critical review of recent progress and future outlook . *Science Direct.* 759(143528).

Taylor G., Donnison I.S., Murphy-Bokern D. *et al*. (2019) Sustainable bioenergy for climate mitigation: developing drought-tolerant trees and grasses. *Annals of Botany*. 124(4). pp. 513–520. https://doi.org/10.1093/aob/mcz146

Teixeira F. and Sherfinski D. (2021) *Ethanol: Brazil's Sugar-based biofuel built on labour abuse*. Context, Thomas Reuters Foundation, 16 November (available at: https://www.context.news/money-power-people/long-read/ethanol-brazils-sugar-based-biofuel-based-in-labour-abuse?utm_source=news-trust&utm_medium=redirect&utm_campaign+context&utm+content=article)

Thaxter, C. B., *et al*. (2017) Bird and bat species global vulnerability to collision mortality at wind farms-based revealed through a trait based assessment. *Proc.Royal Soc*.B 284:20170829; https://royalsocietypublishing.org/doi/10.1098/rspb.2017.0829

Thérivel, R. (2005). Strategic Level Cumulative Impact Assessment. In: Schmidt, M., João, E., Albrecht, E. (eds) Implementing Strategic Environmental Assessment. Environmental Protection in the European Union, vol 2. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-27134-1_26

Therivel R. (2006) *Strategic Environmental Assessment in Action,* Quality Assurance Checklist for SEA, (adapted from Office of the Deputy Prime Minister (ODPM), UK, 2002).

Therivel R. (2010) *Strategic Environmental Assessment in Action, Second Edition,* Quality Assurance Checklists from each chapter. Routledge, London

Tidalpower (undated) *The Disadvantages of Tidal Power* (www.tidalpower.co.uk)

Tong S. *et a*l (2021) Current and future threat to human health in the Anthropocene, *Environment International* ,158, Elsevier

Topham E. and McMillan D. (2016) Sustainable decommissioning of an offshore wind farm, *Renewable Energy*, 102, Part B, 470-480

UCS (2013) *Environmental Impacts of Solar Power*, Union of Concerned Scientists, 5 March (available at: www.ucsusa.org)

UCS (2013b) Environmental Impacts of Geothermal Energy, Union of Concerned Scientists, March 5 (available at: www.ucsusa.org

UCS (2019) Coal Power Impacts. Union of Concerned Scientists, July (available at: www.ucsusa.org

UKEA (2009) *Good practice guidelines to the Environment Agency hydropower handbook - The environmental assessment of proposed low head hydropower developments*' (published August 2009), UK Environment Agency, Bristol, UK

UNDESA (2021) Challenges and Opportunities for Indigenous Peoples' Sustainability. UN Department of Economic and Social Affairs, New York https://www.un.org/development/desa/dspd/2021/04/indigenous-peoples-sustainability/

UNDP/REC (1996) *Benefits of Strategic Environmental Assessment*. Briefing Paper, The Regional Environment Centre for Central and Eastern Europe, (available at: zalomenie anglicke (unece.org)) zalomenie anglicke (unece.org)

UNECE (2008) *Spatial planning. Key Instrument for Development and Effective Governance with Special Reference to Countries in Transition*. United Nations Economic Commission for Europe

UNECE and REC (2011) *Resource Manual to Support Application of the UNECE Protocol on SEA Draft for consultation,* Prepared by United Nations Economic Commission for Europe & the Regional Environmental Center for Central & Eastern Europe, June (AVAILABLE AT: Resource Manual for SEA | UNECE)

UNEP (2019) *Global Mercury Assessment 2018*. UN Environment Programme, Nairobi (www.unep.org)

UNESCO (20201) *Renewable Energy Transition and World Heritage*. UN Educational, Scientific and Cultural Organistion / World Heritage Centre (https://whc.unesco.org/en/renewable-energy/)

University of the Basque Country (2014) Wind Farms Impact on Telecommunication Services, (Powerpoint, available at www.ehu.eus/tsr_radio/images/stories/Events/wind_turbines.pdf)

University of New Mexico (2017) *Energy Development Impacts on Indigenous Peoples*. Report of the University of New Mexico School of Law Natural Resources and Environmental Law. Prepared for the UN Special Rapporteur Victoria Tauli-Corpuz For the Rights of Indigenous Peoples. Hearing, 25 February 2107. Albuquerque, New Mexico (available at: https://lawschool.unm.edu/events/united-nations/docs/energy-development-impact-on-indigenous-peoples-final-report.pdf.)

Uryu Y., Mott C., Foead N., Yulianto K., Budiman A., Setiabudi Takakai F., Nursamsu S., Purastuti E., Fadhli N., Hutajulu C.M.B., Jaenicke J., Hatano R., Sieger, F., and Stuwe M. (2008) *Deforestation, forest degradation, biodiversity loss and CO2 emissions in Riau, Sumatra, Indonesia*. Jakarta, Indonesia: World Wildlife Fund (WWF) Indonesia Technical Report. (available at: Microsoft Word - Riau CO2 Report WWF Indonesia 22Feb08 low.doc (rackcdn.com))

USAID/EPA/CCAD (2011a) *EIA Technical Review Guidelines: Energy Generation and Transmission* Volume 1. Regional Document, prepared under the CAFTA DR Environmental Cooperation Program to Strengthen Environmental Impact Assessment (EIA) Review, United States Agency for International Development, US Environmental Protection Agency andCentral American Commission on Environment and Development (CCAD)

USAID/EPA/CCAD (2011b) *EIA Technical Review Guidelines: Energy Generation and Transmission Volume I Part 2 Example EIA Terms of Reference*. Regional Document, prepared under the CAFTA DR Environmental Cooperation Program to Strengthen Environmental Impact Assessment (EIA) Review, United States Agency for International Development, US Environmental Protection Agency andCentral American Commission on Environment and Development (CCAD)

USAID/EPA/CCAD (2011c) *EIA Technical Review Guidelines: Energy Generation and Transmission* Volume 11. Appendices. Regional Document, prepared under the CAFTA DR Environmental Cooperation Program to Strengthen Environmental Impact Assessment (EIA) Review, United States Agency for International Development, US Environmental Protection Agency andCentral American Commission on Environment and Development (CCAD)

USDE (undated) *Solar Energy Development Environmental Guidelines*. US Department of Energy. Solar Energy Development Programmatic EIS (available at: https://solareis.anl.gov/eis/index.cfm

USDE (2006) *Energy demands on water resources*: Report to Congress on the interdependency of energy and water: U.S. Department of Energy, 80p

USDE (2007) *The Future of Geothermal Energy*, US Department of Energy (available at: www.energy.gov)

USDE (2013) *Guide to Community Energy Strategic Planning*, US Department of Energy, Washington D.C. (accessed on 7 Jan 2023 at: https://www.energy.gov/eere/slsc/guide-community-energy-strategic-planning)

USEPA (undated) *Coal Ash Basics*, Environmental Protection Agency. Washington, D.C. (available at: https://www.epa.gov/coalash/coal-ash-basics)

USEPA (2018) *Biofuels and the Environment: Second Triennial Report to Congress*. United States Environmental Protection Agency. Washington, D.C.

Valencia R.G. (2017) Social Protection in the Philippines, *Economic Issue of the Day*, Vol XVII, nO. 4, Philippine Institute of Development Studies, Manila

Valerio P., Petracchini F., Segreto M., Tomassetti I., Naja N. and Cecinato A. (2018) Environmental impact of biogas: A short review of current knowledge, *Journal of Environmental Science and Health*, Part A, 53:10, 899-906, DOI: 10.1080/10934529.2018.1459076

van Schaick, J., & Klaasen, I. (2011). The Dutch layers approach to spatial planning and design: a fruitful planning tool or a temporary phenomenon?. *European Planning Studies*, 19(10), 1775-1796.

van der Tempel, J., Zaaijer, M.B., Subroto, M. (2004) *The effects of Scour on the design of Offshore Wind Turbines.* Proceedings of the 3rd International conference on marine renewable energy Marec , 7-9 July 2004. Pp 27-35, IMarEST, London

Wang X., Hu W., Kang N. *et al*. (2021) Occupational Dust Hazards and Risk Assessment of Coal-Fired Thermal Power Plants of Different Capacities — China, 2017–2019. *China CDC Weekly.* 3(43): pp. 901–905.

WCD (2000) *Dams and development: A new framework for decision-making: The report of the World Commission on Dams*. Earthscan.

White J., Mills R.S. and Kravetz A. (2010) *Workforce Needs for Renewable Energy Powerplants in Southern California*. Centre for Energy Efficiency and Renewable Technologies. Presentation to Large-scale Solar Project Workforce Needs Workshop, California Environmental Protection Agency, September 15 (available at https://ceert.org)

Whitehaven Coal Limited (2009) *Canyon Open Cut Coal Mine Closure Plan*.

Wilde-Ramsing J., Booth K., Vanpeperstraete B. and van Huijstee M. (2021) *Responsible disengagement from coal as part of a just transition*. Stichting Onderzoek Multinationale Ondernemingen (SOMO). Amsterdam

Williams M.J. (2007) Enmeshed. Australia and Southeast Asia's fisheries. *Lowy Institute Paper* 20. Lowy Institute for International Policy.

Williams-Guillén K, Perfecto I, Vandermeer J. (2008) Bats limit insects in a neotropical agroforestry system. *Science*. Apr 4;320(5872):70. doi: 10.1126/science.1152944. PMID: 18388285.

Wijaya T. (2020) 11 workers killed in landslide at illegal coal mining site in Indonesia. *Mongabay*. 3 November (available at: 11 workers killed in landslide at illegal coal mining site in Indonesia (mongabay.com))

Wolf J., Walkington I.A., Holt J. and Burrows R. (2009) Environmental impacts of tidal power schemes, *Maritime Engineering*, 162(4), 165-177.

Woodward & Company (undated) *Benefit Sharing Agreement in British Columbia: A guide for first nations, businesses and government*. Prepared for the Ecosystem-based Management Working Group. (Available at: hw03b_benefit_sharing_final_report.pdf (gov.bc.ca))

World Bank (2003) *Mine Closure and its impact on the community: Five Years After Mine Closure in Romania, Russia and Ukraine.* World Bank, Washington, DC

World Bank (2010), *Biofuels; Markets, Targets and Impacts* , Development Research Group- Environment and Energy. World Bank, Washington, DC. (available at https://openknowledge.worldbank.org)

World Bank (2011) *Strategic Environmental Assessment in Policy and Sector Reform: Conceptual Model and Operational Guidance.* World Bank, University of Gothenburg, Swedish University of Agricultural Science and Netherlands Commission for Environmental Assessment. The World Bank, Washington DC.

World Bank (2012) *Philippines - Social Protection Review and Assessment*. World Bank, Washington DC

World Bank (2016) *Managing the risks of adverse impacts on Communities from temporary project induced labour influx.* Guidance note, Environmental and Social Safeguards Advisory Team (ESSAT), World Bank, Washington DC

World Bank (2016b) *Environmental, Health and Safety Guidelines Annual Crop Production*. *Environmental, health, and safety general guidelines (English).* IFC E&S Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/157871484635724258/Environmental-health-and-safety-general-guidelines

World Bank (2016c) *Managing Environmental and Social Impacts of Hydropower in Bhutan*. Final Report. June 15, 2016. Prepared in Collaboration between the Royal Government of Bhutan and the World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/254821470402939614/managing-environmental-and-social-impacts-of-hydropower-in-bhutan

World Bank (2017) *Casita-San Cristobal Geothermal Project, Nicaragua*. Vol I Executive (Non-Technical) Summary - ESIA Exploration Phase 18 August 2017(available at: https://documents1.worldbank.org)

World Bank (2017b). *Environmental and Social Framework*. Washington, D.C. (available at: The World Bank Environmental and Social Framework)

World Bank (2018) *Good Practice Handbook: Environmental Flows for Hydropower Projects, Guidance for the Private Sector in Emerging Markets*. Washington, DC; European Bank for Reconstruction and Development. 2017. Environmental and Social Guidance Note for Hydropower Projects. London.

World Bank (2018b) *Managing Coal Mine Closure: Achieving a Just Transition for All*. World Bank, Washington, DC.

World Bank (2019) Gender Equality in the Geothermal Energy Sector: Road to Sustainability. Working Paper, *ESMAP Knowledge Series* 028/19 (available at: https//openknowledge.worldbank.org)

World Bank (2019b) *Opportunities and Challenges for Scaling up Geothermal Development in Latin America and the Caribbean*. (available at: https://openknowledge.worldbank.org)

World Bank (2020) *Solar Photovoltaic Power Potential by Country*, World Bank, Washington DC, July 23, 20202 (available at: https://www.worldbank.org/en/topic/energy/publication/solar-photovoltaic-power-potential-by-country)

World Bank (2020b) *Minerals for Climate Action.* Washington, DC: World Bank. 6062fc59ae7665175ddf19ec_MineralsforClimateActionTheMineralIntensityoftheCleanEnergyTransition-compressed.pdf (webflow.com)

World Bank (2021) *Coal Plant Repurposing for Ageing Coal Fleets in Developing Countries Technical Report 016/21*. World Bank, Washington, DC.

World Bank, ESMAP and Solar Energy Research Institute of Singapore (2018) *Where Sun Meets Water: Floating Solar Handbook for Practitioners*. 30 October (available at www.worldbank.org)

World Economic Forum (2015) *How much mercury pollution is coming from Asia* (available at: https://www.weforum.org/agenda/2015/08/how-much-mercury-pollution-is-coming-from-asia\)

Wu Y., Zhao F., Liu S., Wang L., Qiu L., Alexandrov G. and Jothiprakash V. (2018) Bioenergy production and environmental impacts, *Geoscience Letters*. Volume 5, Article number: 14

Young, S. (2020) China's belt and road initiative: Patron-client and capture in Cambodia. The Chinese *Journal of Comparative Law*. 8(2). pp. 414–434.

Young, S., and Ear, S. (2021). Transnational political economic structures: explaining transnational environmental movements against dams in the lower Mekong region. *Third World Quarterly*, 42(12), 2993-3011.

Zuhal S. (co-author) (2022). *Indonesian Government Revokes Thousands of Mining Licenses: What's Next?* JD Supra. 19 January. https://www.jdsupra.com/legalnews/indonesian-government-revokes-thousands-7529844/

Zurba, M., and Bullock, R. (2020) Bioenergy development and the implications for the social wellbeing of Indigenous peoples in Canada. *Ambio*. 49 (1). pp. 299–309.

ANNEXES

1. Tools for stakeholder engagement and consultation
2. Outline terms of reference for an SEA
3. PPP Screening form
4. List of issues to be covered by SEA Report
5. Example review of PPPs relevant to the Preliminary SEA of Bhutan’s Road Sector Master Plan (2007-2027
6. Overview of selected analytical and decision-making tools for SEA
7. Example of objectives compatibility analysis: compatibility of objectives for Poole Port Masterplan (UK) against environmental and social quality objectives
8. SEA environmental and socio-economic quality objectives for key issues and suggested indicators developed for the ADB’s Energy Transition Mechanism.
9. Developing scenarios
10. Consolidated checklist for the quality assurance, review, and performance evaluation of a comprehensive SEA
11. Trend analysis
12. Analytical methods that can be used in SEA
13. Comapartive assessment of growth scenarios assessments in Bangladesh (rated with and without mitigation measures)
14. Checklist questions for assessing significance of impacts
15. The role of a SEMP
16. List of issues to be covered by a Strategic Environmental Management Plan (SEMP)
17. international and regional organisations concerned with renewable energy
18. Sensitivity mapping for Chobe Forest Reserve, Botswana
19. Definitions of terms

Annex 1

Tools for stakeholder engagement and consultation

Source: UNECE and REC (2011)

This following approaches are described below

- Printed material inviting comments
- Displays and Exhibits
- Information hotline/ Staffed telephone lines
- Internet/Web-based consultations
- Questionnaires and Response Sheets
- Surveys
- Public Hearings
- Workshops
- Advisory Committee

Public participation method	***Enables …***			***Key features***		
	Provision of information	Gathering of comments	Collaborative problem solving	Usual cost of application	Problem-solving ability	Ease of commenting
Range of printed material inviting comments	✓	✓		$		😐
Displays and Exhibits	✓	✓		$		😐
Staffed displays and exhibits	✓	✓	✓	$$	○	☺
Information hotline	✓	✓		$		☺
Internet/web-based consultations	✓	✓	✓	$	○	😐
Questionnaires and response sheets		✓		$$		☺
Surveys		✓		$$		☺
Public hearings	✓	✓		$		😐
Workshops	✓	✓	✓	$	○○	☺
Advisory committee	✓	✓	✓	$	○○	☺

Key:

Enables	✓	Yes
Usual cost of application	$	Lower
	$$	Higher
Problem-solving ability	○	Low

Ease of commenting	○○ 😐 ☺	High Moderate High

Method	**Printed material inviting comments**
Description	• Printed materials are the easiest ways to publicize and provide information on a draft plan or programme and the SEA, or to publicize a participation process. Popular forms of the printed materials include: *fact sheets, flyers, newsletters, brochures, issues papers, reports, surveys etc*. These can be single purpose or produced as a series (e.g. newsletters). Printed material can be handed out, made available to be picked up, or mailed out either directly to a select mailing list, or included as 'bill stuffers' with regular mail outs such as utility bills, rates notice or other regularly posted bills. • Printed materials aim to provide easily read information in words and drawings, to inform a wide range of stakeholders about the plan- or programme-making and assessment processes or documents. • Printed material, whether handed out, dropped into letterboxes, distributed by mail, or mailed out with other material, is one of the easiest and most familiar methods for increasing awareness of an issue and soliciting responses to an issue or proposal. • Available budget, and the use of other publicity methods and tools will determine just what type of printed material will best suit your need.
Advantages	• Printed materials can reach a large number of people through mailing or via free display • Information material with comment sheets or questionnaires facilitates feedback • Can facilitate the public participation process • Printed information can be a low-cost publicity means, which is easily handed out and carried away • Can be economically distributed by doubling up with existing mailing lists • Can reach a wide audience, or be targeted towards particular groups • Ongoing contact, information can be updated
Disadvantages	▪ The problem with most printed materials is the limited space available to communicate complicated concepts ▪ Needs time to design, prepare text, visuals, proofread, print and fold. ▪ There is no guarantee that the materials will be read – may be treated as junk mail ▪ If mailed, the guarantee of being read is only as good as the mailing list itself; mailing lists need regular updating ▪ Appearance of the material should be visually interesting but should avoid a 'sales' look ▪ Can be lost if included with many other flyers and bill stuffers (consider using coloured paper and bold headlines if mailing as a bill stuffer, to ensure this is not just binned without reading) ▪ Can exclude those who are not print literate unless visual elements are used ▪ Information may not be readily understood and may be misinterpreted
Examples of sources of information	International Association for Public Participation (2000) IAP2 Public Participation Toolbox, available at http://www.iap2/practitionertools/index.html/

Method	**Displays and Exhibits**
Description	These tools are events that are intended to provide project information and raise awareness about particular issues. Displays can be interactive, and can be used as part of a forum, workshop, exhibition, conference or other event. Displays and exhibits can include feedback opportunities such as blank sheets with one-line questions, and can include drawings, models, maps, posters, or other visual and audio representations illustrating an event, proposal or issue. Interactive displays can include 'post-it' idea boards, maps and flipcharts or blank posters for comments and questions. Displays and exhibits develop more concrete concepts of proposals or developments, and, where these provide options for interaction, provide public opinions and feedback that can be incorporated into the plan- or programme-making and assessment processes. Key issues to consider before, and the main steps to prepare for and carry out the methods, include: • Select a date and venue that will encourage the greatest number of participants to attend (generally weekends or public holidays/shopping centres/public spaces) • Arrange for a number of displays/exhibits to give details of the event/issue • Place the display/exhibit in a well-populated public space where those most affected by the issue/event are likely to pass by • Advertise and publicize the event with emphasis on the issue to be considered • Advertise times when display/exhibit will be open • Allow adequate time for setting up • Provide adequate staffing and consider the employment of volunteers, security and insurance issues • Provide coordinators to facilitate participation and answer questions • Collate feedback and publish results
Advantages	▪ The tool focuses public attention on an issue ▪ It can create interest from media and lead to increased coverage of the issue ▪ Allows for different levels of information sharing ▪ Provides a snapshot of opinions and community issues based on feedback ▪ People can view the displays at a convenient time and at their leisure ▪ Graphic representations, if used, can help people visualise proposals
Disadvantages	▪ The tool needs a facilitator to encourage involvement and written feedback ▪ Information may not be fully understood or misinterpreted if no staff provided to respond to questions or receive comments ▪ Public must be motivated to attend ▪ Can damage the proposal's reputation if done unprofessionally
Examples of practical application or key sources of further information	The Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (Australia) http://www.coastal.crc.org.au/toolbox/alpha-list.asp International Association for Public Participation (2000) *IAP2 Public Participation Toolbox*. http://www.iap2.org/associations/4748/files/toolbox.pdf US Dept of Transportation (1997) *Public Involvement and Techniques for Transportation Decision-Making: Transportation Fair*. Washington, (accessed 12/12/02) http://www.fhwa.dot.gov/reports/pittd/tranfair.htm Wates, N. (1999) *The Community Planning Handbook*. London, Earthscan.

Method	**Information hotline/ Staffed telephone lines**
Description	An Information Hotline offers pre-recorded information on the planning document or an issue via the telephone and/or access to SEA and planning team members who can answer questions or provide additional information and assistance. It aims to deliver accurate, consistent information over the telephone to those who wish to know about an issue or who can provide additional information. Staffed telephone lines can serve as a link between the public and the developer during the duration of the plan or programme making and assessment, making the public feel involved. Key steps in application: • Determine the information to be recorded and timetable of updates • Advertise the phone number, e.g. via stationery and flyers printed, or a sticker e.g. on outgoing printed correspondence or promotional material. Advertise the number in the media, and ensure it is on all your outreach material • Set up a hotline number for callers by recording message and hooking up to the phone line. Record information that will answer the most commonly asked questions • If staffed phone line is used, assign the person to answer the calls. The person assigned to provide information has to be briefed and trained, and has to have a pleasant telephone manner, even with difficult callers • Set up a toll free number for non-local callers • In case of pre-recorded Information Hotline, offer the option of being put through to a specific person for more details • Record calls/common complaints/concerns in telephone journal for your records and input to the participation/consultation process
Advantages	• An Information Hotline offers an inexpensive and simple device that can ensure fast, easily and efficiently information dissemination • Provides a one-stop service to the public to access information about the planning activity. Can describe ways the public can get information and provide feedback. • Offers a reasonably low-cost for set up and updates • Portrays an image of 'accessibility' for an organisation, developer or the SEA team • A convenient way of receiving comments from interested parties. Not intimidating, easy for people to participate and provide comments. Promotes a feeling of accessibility.
Disadvantages	• Must be adequately advertised to be successful • If staffed, can be time consuming and limit staff member to perform other tasks • Designated contact must have sufficient knowledge of the activity to be able to answer questions quickly, accurately and professionally
Examples of practical application or key sources of further information	Department of Public Health (Flinders University) & South Australian Community Health Research Unit. (2000) *Improving Health Services through Consumer Participation - A Resource Guide for Organisations*. Commonwealth Department of Health & Aged Care. Canberra. Available at http://www.participateinhealth.org.au/how/practical_tools.htm. RCRA. 1996. *Public Participation Manual*. Ch 5: Public participation activities. http://www.epa.gov/epaoswer/hazwaste/permit/pubpart/chp_5.pdf. US EPA (2002) *National Pollution Elimination System (NPDES) Public Involvement/Participation Hotlines*. (Accessed 11/12/02) http://cfpub.epa.gov/npdes/stormwater/menuofbmps/invol_3.cfm

Method	**Internet/Web-based consultations**
Description	The tool typically comprises a website on the Internet. It is used to provide information or invite feedback. Care should be taken to keep the information up to date. More interactive forms of participation on the Internet may also be developed, e.g. on-line forums and discussion groups. Technically, the potential tools for Internet-based consultations can be: • HTML web pages with links to documents, pictures and graphics (moving or still) and sound • Dedicated email address to which non-structured submissions can be sent • Survey forms that elicit community response on particular issues (HTML or PDF to be faxed/mailed back) • Moderated bulletin boards that allow 'threaded' discussions about a range of issues • Virtual meetings using a chat room facility on specific topics • Web-casting (i.e. audio and visual broadcasting via the web) of meetings and events The Internet can enhance traditional techniques but it cannot replace them. The purpose of the website should be clearly articulated and information should be accurate and timely. The resource implications of maintaining the site need to be carefully assessed and budgeted for before it is established. It should be decided whether the management of the website will be done in-house or outsourced, what web-based tools to be used and what staff training is needed.
Advantages	1. The most straightforward and inexpensive, resource-efficient technique to present and distribute information to those that have Internet access 2. The audience is potentially global 3. Costs are reduced as no printing or postage costs are incurred 4. Has a possibility to provide timely and accurate information about and a historical record of the planning, assessment and consultation processes 5. It is a way to invite stakeholders to comment on the specific proposals and a means of receiving feedback 6. An interactive medium allowing discussion and debate
Disadvantages	• There are significant resource implications in setting up a new website • The responses can be difficult to analyze if questions are open-ended • Because not all stakeholders will have access to the Internet, it cannot be used to replace the traditional means of consultation – alternative means of information dissemination will also be required
Examples of practical application or key sources of further information	iPlan initiative in New South Wales (Australia), http://www.iplan.nsw.gov.au/engagement/techniques/website.jsp

Method	**Questionnaires and Response Sheets**
Description	Questionnaires are a basic tool used to collect information, and are usually developed and tested to ensure that they are easily understood. Questionnaires ensure that exactly the same questions are presented to each person surveyed, and this helps with the reliability of the results. Questionnaires can be delivered via face-to-face interviews, telephone interviews, self-completed forms, mail outs or on-line. Questionnaires can be distributed by email as well as posted or faxed. Response sheets can be collected at a workshop, or can be picked up at a workshop and mailed back. These can also be mailed out in ways that reduce postage costs, when they are included in routine mail-outs such as the distribution of fact sheets or accounts. Questionnaire preparation steps**:** • Draft questions. Keep as short as possible. • Test questions with a small pilot group to determine whether they are unbiased, straightforward and not open to misinterpretation. Wording of questions has to be clear to avoid bias. • Indicate the purpose of the questionnaire at outset • Include qualitative data such as age, sex, address, education etc. to allow for further extrapolation of the results and/or inclusion into the mailing list. • Send out with questionnaires. If mailed and if the budget allows, provide free mail reply (stamped addressed envelope; freepost mailbox, etc.) to improve responses. • Document and publicize the responses.
Advantages	• Less personal if interviews or telephone surveys are not used, but anonymity can encourage more honest answers • Useful to generate both qualitative and quantitative data • Works well to reach respondents who live in a large area • Provides information from those unlikely to attend meetings and workshops • Permits expansion of the mail list • Can be used for statistical validation • Allows results to be extrapolated by subgroups • Allows the respondent to fill out at a convenient time • More economical and less labour intensive than interviews and telephone surveys as they provide larger samples for lower total costs
Disadvantages	• Low response rates can bias the results • Needs a return envelope/freepost address to encourage participation • Depends on a high degree of literacy
Examples of practical application or key sources of further information	US Department of transport (2002) *Public Involvement Techniques for Transportation Decision-Making* (accessed 13/12/02) http://ntl.bts.gov/DOCS/pubinvol.html

Method	**Surveys**
Description	Surveys are a method used to collect information from a specific population. They can be used to collect broad general information from or about a large audience or specific information from target groups. Surveys can seek information that can be quantitative (facts and figures) and/or qualitative (opinions and values). Surveys use questionnaires to collect information, and these can be delivered through face-to-face interviews, self-completion written forms, telephone surveys, or electronic surveys (see also Questionnaires and Response Sheets). For a well-conducted survey using a large, random sample, surveys are usually high cost. Small-scale surveys using opportunistic sampling and volunteers can be relatively low cost, but may not produce results that can be generalised beyond a specific group of people. Surveys are designed to collect information in relation to a particular issue or planning document. The results of the surveys provide information about the demographics and/or opinions of a specific group of people. Relevant steps in designing and carrying out a survey: ○ Find out what is already known, and what relevant surveys are being done or planned elsewhere in order to avoid duplication, and define the scope of the survey ○ Talk to developer and relevant authorities to focus the questions ○ Determine the way the information will be obtained (see Questionnaires and Response Sheets) ○ Select your target audience. How will you sample them? How will you ensure that your survey gives a representation of the ideas of the group? ○ Pilot test the survey to ensure the readability and clarity of questions ○ Carry out the survey ○ Collate and analyse the results, prepare report ○ Make the report available to those surveyed, to appropriate authorities, and to the media
Advantages	○ Provides traceable data ○ Surveys can serve an awareness raising purpose ○ When properly constructed, can reach a broad, representative public or targeted group ○ Can derive varied information from the results
Disadvantages	• Poorly constructed surveys produce poor results • Can be expensive if surveying a large audience • Care must be taken that wording of questions is unambiguous to prevent skewed results • Care is needed in sampling to make sure representative samples are taken • Surveys with tick boxes are the fastest and easiest to process, however, this limits the detail in the information collected
Examples of practical application or key sources of further information	COSLA. (1998). *Focusing on Citizens: A Guide to Approaches and Methods*. Available at: http://www.communityplanning.org.uk/documents/Engagingcommunitiesmethods.pdf RCRA. (1996). *Public Participation Manual*. Ch 5: Public participation activities. http://www.epa.gov/epaoswer/hazwaste/permit/pubpart/chp_5.pdf US Department of Transportation (1996) *Public Involvement Techniques for Transportation Decision-Making* (13/12/02) http://www.fhwa.dot.gov/reports/pittd/surveys.htm

Method	**Public Hearings**
Description	Public hearings are a formal way of presenting and exchanging information and views on a proposal. Formal public hearings generally tend to be best used in conjunction with more informal methods of engagement such as informal meetings and facilitation. http://www.iplan.nsw.gov.au/engagement/techniques/publichearing.jsp - top#top Important points to consider before organizing the event: • Clearly describe the purpose of the public meeting and the issue to be considered • Describe where in the spectrum the public hearing sits. Be particularly clear about the extent to which input provided could influence the outcome of the process. • Decide whether a public hearing is appropriate when you receive a request for one • Advertise the public hearing by public notice. • Send the notice to each person who requested a public hearing. • Carefully schedule presentations by interested parties and ensure presenters can speak for their allotted time without interruption. • Prepare a report/record of the public hearing and make it public.
Advantages	• During such events the public is allowed, by prior arrangement, to speak without rebuttal • Available evidence can be worked through systematically • Comments received can are recorded and made public • If run well, can provide a useful way of meeting other stakeholders. • Demonstrates that the responsible authority is open to all interested parties for consultations and information exchange.
Disadvantages	• It does not foster dialogue • An adversarial mood can be created • Public meetings can be intimidating and may be hijacked by interest groups or vocal individuals • Minority groups and those who do not like to speak in public are not easily included • Whilst appearing simple, can be one of the most complex and unpredictable methods • May result in no consultation only information provision
Examples of practical application or key sources of further information	

Method	**Workshops**
Description	A workshop is a structured forum where participants are invited to work together in a group (or groups) on an assessment of an issue or SEA step. The goals of a workshop are to bring participants together in a structured environment (that is, through large and small-group activities, discussions, and reflection) to resolve issues and build consensus on the assessment, rather than provide information and answer questions. Alternatively, workshops can be organised to target representatives from a particular stakeholder group, e.g. NGOs, or experts of one area. Workshops require a facilitator who is able to engage all participants in the discussion; therefore they are participatory tools that are best used with smaller numbers of participants. A variety of tools can be used within a workshop. These include many of the tools listed in this toolbox (see the CRC reference below), e.g.: focus groups and/or visioning. A report has to be prepared as on outcome of the workshop, recording opinions, suggestions or conclusions that have been collaboratively developed and agreed to by all participants, on an issue or proposal.
Advantages	• Excellent for discussion on criteria or analysis of alternatives • Fosters small group or one-on-one communication • Offers a choice of team members to answer difficult questions • Builds ownership and credibility for the outcomes • Maximizes feedback obtained from participants. Ability to draw on other team members to answer difficult questions • Maximized feedback obtained from participants • Fosters public ownership in solving the problem (see IAP2 reference below) • Can provide a more open exchange of ideas and facilitate mutual understanding. Useful for dealing with complex, technical issues and allowing more in-depth consideration. Can be targeted at particular stakeholder groups.
Disadvantages	• Hostile participants may resist what they may perceive as the 'divide and conquer' strategy of breaking into small groups • Facilitators need to know how they will use the public input before they begin the workshop • Several small group facilitators are usually needed. (IAP2) • To be most effective, only a small number of individuals can participate, therefore, full range of interests are not represented
Examples of practical application or key sources of further information	Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management (the Coastal CRC) http://www.coastal.crc.org.au/toolbox/alpha-list.asp (Australia) IAP2 – The International Association for Public Participation: http://www.iap2.org/ Ontario Public Consultation Guide 1994, www.ene.gov.on.ca/envision/gp/H5.pdf (Canada)

Method	**Advisory Committee**
Description	Advisory committees generally comprise expert groups and governmental or non-governmental institutions with expertise in a specific field or interest in the draft plan or programme. In a consultation process, they can offer advice on appropriate changes to a plan or programme or recommend the introduction of specific measures. Although similar to task forces, advisory committees function as an ongoing structure while task forces tend to be formed on a short-term basis to focus specifically on the development of a particular proposal. Advisory committees are particularly useful for involving community representatives, especially people with required expertise, in complex, controversial or significant plan- or programme-making and assessment processes. Committees are not lobby groups – they have an important public function beyond individual members' own interests. Committees are more effective if their roles and tasks are clearly established before deciding on membership. Also establish selection criteria for membership. Time and resources must be committed to supporting the committee during the life of the project or the committee. The committee has to be informed of progress, the consultation results, developer and decision-maker conclusions; policy changes/emerging issues that will influence the committee's advice/role.
Advantages	• Advisory committees offer additional advice and guidance • They can help to reduce criticism from interest groups • They demonstrate a commitment to participatory engagement and suggest to the stakeholders that they will be able to influence decisions and outcomes within certain boundaries
Disadvantages	• Manage conflicts of interest that may occur during the life of the committee • May be time and resource consuming. Care needs to be taken to establish, manage and monitor their ongoing operation. • Where there are divergent views or where members have unequal status, knowledge or expertise, facilitation may be needed
Examples of practical application or key sources of further information	Steering group for SEA of Scottish Marine Renewables (see http://www.seaenergyscotland.co.uk)

Annex 2
Outline for setting terms of reference for SEA

This outline aims to assist a proponent in preparing TOR for an SEA in circumstances where it intends to engage consultants to undertake the SEA.

Terms of reference need to thorough and clear. Research shows that many SEAs are unsatisfactory because they fail to follow basic principles and good practice. In part, the reason for this is setting of poor Terms of Reference by the PPP proponent – often because they have limited knowledge or experience of the role and nature of SEA

Below are suggested generic contents for TOR for a SEA. They will need to be customised in every case and customised to the context and focus of the PPP concerned:

List of acronyms

1 Introduction

Provide a background to the SEA, and summarise national legal, regulatory and guideline requirements for SEA. Indicate the need to comply with these and with national development philosophy of Gross National Happiness, SEA good practice and principles (listing these) – and provide summary information on these. Information can be taken from these SEA guidelines.

2 Description of the PPP

Describe the focus and aims of the PPP, why it is being promulgated and what is seeks to achieve.

3 Key treaties, accords and policies, plans and proposals to be considered, and useful reports to be consulted

List those that are particularly relevant to the focus of the PPP and SEA under the following categories to guide the SEA team to important framework commitments:

7. International treaties and accords/conventions (those ratified by Bhutan and others that may be relevant);
8. Legislation and national-level strategies and policies;
9. Other useful reports and studies (including relevant EIA/SEA reports).

4 Aims of the SEA

Set out the specific aims of the SEA under the following headings:

4.1 Technical aims

10. Provide a thorough ***review and assessment of the direct, indirect and cumulative impacts*** (positive and negative) of the PPP and development activities, projects and initiatives that may arise during its implementation. Such assessment should address impacts under several ***scenarios*** (see below)

11. Identify impacts on national ***sustainable development objectives*** (local, regional, national)

12. Identify ***synergies*** (and how these can be enhanced) and ***conflicts/antagonisms*** (and how these can be minimised, avoided or mitigated) between such activities, PPPs and downstream projects/development activities.

13. Generate ***development scenarios*** (to be identified and agreed during scoping). These may represent development meta alternatives that examine how the PPP (and downstream projects/activities that may arise during implementation) may unfold over the short-, medium- and long-term, and in different combinations (i.e. under alternative roll-out situations – for example (but not limited to) business-as-usual, low-growth, moderate growth and high growth), and their consequent meta-level impacts.

14. Identify where ***EIA*** (addressing both environmental and social concerns) may need to be undertaken for particular types of downstream projects/activities likely to arise during PPP implementation and recommend key issues that should be addressed.

15. Identify issues that will need to be addressed when preparing a ***Strategic Environmental and Social Management Plan (SESMP)*** for the PPP – if the proponent judges that one is required.

16. Prepare required reports – these should include a ***scoping report*** , an ***interim SEA report*** covering the assessment of alternative, the ***SEA report*** (focusing on the preferred alternative) and an associated ***Strategic Environmental and Social Management Plan*** (SESMP) for the PPP (if required). Both draft and final reports will be required.

The SEA report should present baseline information, assessments, analyses and information in a way that is relevant, understandable and readily usable by policy-makers, planners and decision-takers. The SEA team should liaise directly with PPP proponent and NECS on the most appropriate format for presenting such information (note: information presentation is likely to require a mix of text, maps, tables, figures and photographs, and could be organised on a GIS basis).

4.2 Capacity building objectives

Indicate that SEA is still in its infancy in Bhutan and the country is still building its experience and skill base. In this regard, the proponent may wish to consider combining the technical assessment functions of the SEA with a capacity-building component – to benefit both selected government officials as well as Bhutanese environmental/social consultants and recent graduates. In this way, the SEA could provide opportunities for such people to ***gain SEA experience on-the-job*** at different stages of the SEA process –working alongside the SEA team members, tutored by them, and undertaking appropriate technical tasks.

5 Boundaries of the SEA

Indicate the geographical boundary or extent of the SEA, eg national, sector, region, district, catchment, protected area, cross-border, etc., and provide a map where appropriate.

6 Role of other bodies

Indicate what role the NECS, SEA Task Force or other body (e.g. SEA Steering Committee. Technical Assessment Committee. Independent Expert Committee), will play in guiding and/or evaluating the SEA.

7 Scope of work to be carried out

Provide a general overview of the scope of the work to be undertaken by the SEA. Indicate what reports should be produced. The SEA report should include recommendations on how to mitigate negative environmental and social impacts and how to enhance positive ones. Indicate that the intention is for such recommendations to be incorporated the PPP and the mitigation/enhancement measures put into practice during PPP implementation

The SEA should be applied at two levels of specificity, to address environmental and social impacts arising as a result of (a) the PPP and project/initiatives arising during its implementation, and b) those impacts arising as a result of ‘external’ developments (regional, national or international (i.e. the bigger picture).

8 Major tasks to be undertaken

8.1 Initiation report

Indicate that, following appointment, the SEA team should prepare an Initiation Report for the SEA within a prescribed time period (e.g. 4 weeks of taking up the assignment), setting out the background, their approach to the SEA to comply with the TOR and the SEA guidelines, the steps to be followed, and providing a provisional timeline.

8.2 Stakeholder analysis and action plan

Indicate that the SEA team should undertake a comprehensive ***stakeholder mapping*** covering:

17. Primary stakeholders: those ultimately likely to be affected, either positively or negatively by the PPP and projects/initiatives arising during its implementation;
18. Secondary stakeholders: the ‘intermediaries’ – those persons or organizations who are indirectly affected by the PPP and projects/initiatives arising during implementation;
19. Key stakeholders: (who can also belong to the first two groups) – those persons or organisations that have significant influence upon or importance related to the PPP and/or to projects/initiatives likely to arise during implementation, or play key roles within organisations.

The SEA team should prepare a ***stakeholder participation and disclosure plan*** to set out the roles and responsibilities of different stakeholders in the SEA/SESMP processes, indicating when and how they can engage in these processes, e.g. through providing information or views, engaging in workshops, meetings, focus sessions, interviews, dialogues, etc., responding to questionnaires, participating in phone-ins or web-based information access/provision, etc.

The SEA team should set up a ***communication mechanism*** to inform stakeholders of such events (date, timing, location, etc.) and indicate how feedback on progress in the SEA will be provided, when draft reports will be available for review and how (e.g. online, from an office), how stakeholders' views comments have been addressed, etc.

All SEA documents and the SESMP (where required) should clearly reflect what stakeholder participation has been organised/facilitated to support their preparation (e.g. listing workshops and meetings with dates), and indicate who participated in events and where a record of meetings and issues raised can be found – preferably minutes of all meetings and events should be attached as appendices to the master documents.

The above tasks may be undertaken as part of, or in parallel to, scoping (see 9.3).

8.3 Scoping requirements:

Indicate that scoping should verify, deepen and extend any preliminary analysis and undertake the following:

20. a ***review of relevant literature*** including: relevant international treaties and accords/conventions; national level policies, regulations and strategies; relevant policies and plans; and EIAs and specialist studies undertaken in the SEA area;
21. ***consult with stakeholders*** as well as ***interested and affected parties*** (I&APs) (including NECS, national, local and municipal authorities, relevant parastatals, concerned groups, local communities, technical experts, etc.) – through workshops, 'focus group' meetings, interviews and electronic communications;
22. take into account ***more recent developments*** (e.g. the release of new regulations or new proposed PPPs or projects) that might have relevance to or interact with the PPP being assessed;
23. secure the ***opinions of experts***;
24. an ***analysis of Bhutan's laws, policies, regulations, strategies and action plans***, as well as permit requirements insofar as they are relevant to the issues at hand;
25. an ***analysis of Bhutan's*** guidelines insofar as they are relevant to the issues at hand (to determine their relevance and applicability to the SEA area). Where Bhutanese safeguards are not in place, then other relevant safeguards may be consulted (eg new World Bank safeguards[1]);
26. Identify and secure agreement on ***SEA objectives***
27. Identify possible ***alternatives*** to the PPP or its component that should be considered by the SEA and establish definitions for each alternative.
28. identify and secure agreement on ***scenarios*** to be developed, against which the impacts of the preferred alternative for the PPP should be assessed
29. Identify how the SEA can strengthen the existing ***institutional and practitioner capacity***

A scoping report should be prepared. Indicate that this will be circulated to lead agencies and provided to the public for comment prior to its finalisation.

Indicate that if any significant changes are made to the TOR, it may be necessary to advise stakeholders of those and seek comments before the SEA team proceeds further.

8.4 Preparation of work plan

State that this should clearly set out all activities, outputs and a timeline, and indicating which team members will be involved, and when, in particular steps.

[1] World Bank safeguards are policies that aim to ensure strong protections for the world's poorest and most vulnerable people and for the environment
(see:. http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/EXTPOLICIES/EXTSAFEPOL/0,,menuPK:584441~pagePK:64168427~piPK:64168435~theSitePK:584435,00.html

8.5 Baseline studies

Indicate the need for the SEA team to carry out (or commission where specialist studies are required) research and analysis (drawing from published and unpublished, official and unofficial sources, existing EIA reports and ongoing work) and prepare a baseline profile of the SEA area, documenting environmental, social, economic, governance and other key characteristics, and any related trends, in sufficient detail to provide a basis for subsequent assessment of impacts. These characteristics may be listed in the TOR if preliminary scoping has been undertaken prior to appointing the SEA team.

Section 3.3.7 of the SEA guidelines lists typical characteristics that should be covered. The TOR should include such a list.

8.6 Legislative and regulatory profile

Indicate that the SEA team should prepare a concise overview of relevant Bhutanese laws and regulations and internal commitments (e.g. under MEAs that are pertinent to the PPP The consultant will prepare a concise overview of relevant Bhutanese laws and regulations and internal commitments (e.g. under MEAs that are pertinent to the PPP, with specific reference to compliance requirements and constraints. This should include a description of pertinent standards governing *inter alia*, health and safety, waste discharge, noise, etc. Also, the SEA team should provide a justified opinion as to whether any of the possible development downstream projects, activities or other initiatives that may arise when implementing the PPP could be deemed illegal under Bhutanese or international law, especially (but not only) in the context of effluent discharges into water courses and air, and where developments may be located in or may affect national parks, wetland sites), or other protected areas.

The profile should also include a matrix-based, cross-comparative analysis of interactions between legal and regulatory instruments, particularly showing where any are in conflict with each other with regard to how they might influence, promote or impede development PPPs, projects or initiatives, and thus where clarification or harmonisation may be necessary.

8.7 Assessment of environmental and social impacts

Indicate that the SEA team will be required to undertake a thorough ***review and assessment of the direct, indirect and cumulative impacts*** (positive and negative) of the development and initiatives that will be likely to arise during implementation of the PPP under different scenarios (including but not limited to business as usual scenario and future low, moderate and high growth scenarios – meta alternatives). Scenarios may be generated through multi-stakeholder brainstorming workshops. The SEA should also assess the impacts of agreed alternatives identified during scoping.

The assessment should include identifying ***synergies*** (and how these can be enhanced) and ***conflicts/antagonisms*** (and how these can be minimised or mitigated) between elements of the PPPs and between different PPPs.

The assessment should identify where ***EIAs*** (addressing both environmental and social concerns) may need to be undertaken for particular projects/initiatives likely to arise during PPP implementation and recommend key issues that should be addressed.

8.8 Key themes and issues to be addressed by the SEA

Indicate any key themes, issue, existing projects, activities and developments underway and planned in the area covered by the PPP. These may have been identified during preliminary scoping and the SEA will need to focus on these. During scoping, the SEA team should verify these (through interactions with stakeholders) and identify any other issues that may need to be added, e.g.

- ***Protection and conservation of critical and sensitive areas, and fragmentation of habitats and resources***
- ***Demand on natural resources*** (current and future; legal and illegal) – forests, land, water, wildlife, minerals, etc.
- ***Land tenure, land-use (current and forecast) and land-take*** (arising from developments and infrastructure)

- ***Hydrology and drainage patterns***
-
- ***Visual impacts*** and deterioration of sense of place – as rural and urban development changes the character of NCR and its municipalities.

- ***Pollution of land, air and water*** due to effluent and waste discharges from industrial developments, pollution from accidents, other land-based pollution and physical changes as a result of the new infrastructure and new companies/industries

- ***Loss of aquatic life and altered ecological functioning*** due to pollution or other factors.

- ***Accident risks***, especially from transport trucks, chemical spillages and road traffic accidents.

- ***Biodiversity loss***, both from physical disturbance (habitat alteration) and pollutants.

- ***Strain on municipalities and communities***, eg if the PPP may stimulate an influx of job-seekers. In this case, there will be both positive and negative impacts. Specific issues of concern may be increased crime, overcrowding (with social and health consequences), and strain on physical and social infrastructure.

- ***Health risks***, because of pollution from industrial developments reaching nearby communities from all possible pathways, but especially air. Also, issues such as light pollution, noise and increased electromagnetic radiation need to be addressed.

- ***Other social issues*** such as education, skills, livelihoods, poverty, gender concerns, access to resources, migration, population change, cultural dilution, etc.

- ***Protection of cultural/religious assets and heritage sites***

- ***Settlements and settlement patterns, and urban expansion***

- ***Trans-boundary issues*** (trade, transport, tourism, management of critical resources such as water, etc.)

- ***Economic issues*,** especially the benefits of the PPP and projects arising during implementation in terms of direct and indirect jobs, import substitution, taxes and likely spin-offs.

8.9 Key elements when assessing impacts

Indicate that positive and negative impacts should be evaluated in terms of their importance at local, regional, national or inter-national level, and also with regard to their magnitude, significance, frequency of occurrence, duration and probability.

The SEA should distinguish between primary, secondary, synergistic and cumulative effects where relevant and should consider at least a 30 year time frame.

It should be indicated when impacts are likely to be irreversible or unavoidable and which ones can be mitigated – and the degree of confidence that the consultants attach to their assessment of each impact and the likelihood of avoidance/mitigation being successful.

Indicate that if the SEA team identifies any fatal flaws in relation to the PPP that require application of the precautionary principle, this should be clearly indicated and justified in the report (and communicated to the NECS and PPP proponent immediately).

The impact assessment process must include a combination of literature review, specialist studies (where needed – to be identified and budgeted for by prospective consultants in their proposals, and confirmed during scoping), expert opinion, stakeholder opinion and rigorous analysis. It is a requirement that a comprehensive public participation and disclosure process be followed.

8.10 SEA report requirements (basic contents)

Indicate that the SEA team should prepare a SEA report that is concise and focused on the significant environmental and social issues. The main text should include findings, conclusions and recommended actions, supported by summaries of the data collected and citations for any references used in interpreting those data. Detailed or un-interpreted data are not appropriate in the main text and should be presented in appendices or a separate volume. Unpublished documents used in the assessment may not be readily available and should also be assembled in an appendix. Wherever possible, data should be summarised in tables and, where relevant and appropriate, the text should be supported by figures and photographs.

The SEA report should be presented according to the outline in Annex 7 of the SEA guidelines.

8.11 Strategic Environmental (and Social) Management Plan (SESMP) (basic contents)

If required, indicate that the SEA team should prepare a Strategic Environmental and Social Management Plan (SEMP) for the PPP, setting out:

30. ***Strategies and procedures*** to implement the SESMP so as to enhance positive, and prevent, minimise or mitigate adverse environmental and social impacts associated with the PPP and projects or activities likely to arise during its implementation.
31. These procedures should include measures to ensure ***compliance with relevant safeguards*** during both preparation and implementation of the PPP and projects/initiatives that may arise during its implementation. Bhutanese safeguards should take precedence. Where Bhutanese safeguards do not exist, then reference should be made to other safeguards (eg World Bank safeguards).
32. ***Environmental and social Objectives***
33. The ***roles and responsibilities*** of different jurisdictions, authorities and actors in implementing the SESMP. As far as possible, recommendations should be institution-specific (who should do what).
34. A ***simple performance monitoring and evaluation mechanism*** for the environmental and social impacts of the PPP and development projects/initiatives likely to be implementing during its implementation, with monitoring indicators and a corresponding evaluation procedure and methodology. It should aim to signal when steps are required to enhance benefits or to remove or reduce risks and negative impacts. The proposed mechanism should take into account existing national legislation and provisions regarding EIA. The objectives monitoring are to ensure that:
35. Mitigation measures are implemented;
36. Mitigation measures are effective, i.e., have the intended result;
37. Remedial measures are undertaken where mitigation measures are inadequate or where the impacts were underestimated in the SEA study;
38. Compliance with national (and international) standards is assessed.
39. A ***stakeholder consultation procedure*** for the monitoring and evaluation mechanism.
40. ***Guidance and recommendations for project level EIAs***.

See Annex 8 of the SEA guidelines for recommended issues that should be in a SESMP.

8.12 Monitoring and review of SEA and SESMP

Indicate what monitoring, evaluation and review procedures will apply to the SEA and SESMP.

8.13 Work schedule

Indicate the time period within which the SEA and SESMP (if required) should be completed and the requirement for the SEA team to submit a detailed work plan and schedule of activities in the inception report.

8.14 Deliverables

Indicate the deliverables required, e.g.:

1. Inception report, including work plan
2. Stakeholder analysis and stakeholder engagement plan
3. Scoping report
4. Quarterly progress reports
5. Interim SEA report
6. Draft and final reports on any special studies conducted
7. Draft and final SEA report
8. Draft and final SEMP (if required separately).

Annex 3:

SEA Screening Form

Proponents reference Number: …..........……………………….**Submission date**:………………….……

Proponent's Address:
……………………………………………………………………….....…………………………………………………
………………………………………………………………………..……………………………………………………

PPP Title:
…….............................
....

PPP Sector
…………………………………………………………………………………………………….………………………
…………………………………………………………………………………

PPP area of implementation (National, Region, District, Town, trans-national)

.................…………………...………...............................
……………………………………………………………………………………………

PPP SCREENING COMMENTS:

The following comments should provide a summary – to draw the attention of the competent authority to key points in the SEA report.

A. Characteristics of the PPP itself:

- To what extent will the PPP set a framework for downstream projects and other activities (eg concerning their location, nature, size and operating conditions or by allocating resources)?
……
…………………………………………………………………………………
- Is the PPP likely to influence other PPPs – at national to local levels?
……
……………………………………………………………………………..
- To what extent will the PPP enable the integration of environmental and social considerations (and their relationship with economic concerns and drivers) and promote sustainable development?

 ……
…………………………………………………………………………………
- What are the main environmental and social problems associated with the PPP?
……
…………………………………………………………………………………
- How might the PPP provide a means to implement national legislation on the environment (for example, PPPs linked to waste management or water protection) or social conditions?
……
………………………………………………………………………………
- To what extent is the proposed PPP likely to be politically or publicly contentious?
……
…………………………………………………………………………………
- Is the PPP is unprecedented (e.g. pioneering, address new issues)?
……
…………………………………………………………………………………

B. CHARACTERISTICS OF THE EFFECTS AND OF THE AREA LIKELY TO BE AFFECTED:

41. Regarding the impacts – what is their probability, magnitude, duration, spatial extent (geographical area and size of the population likely to be affected), frequency and reversibility ?
………
…………………………………………………………………………

42. Are there any inherent uncertainties and what is the level of confidence in predicting the effects of the proposed PPP?
………
……………………………………………………………………………………

43. Are there any important information gaps, that have made it difficult to predict impacts?
………
……………………………………………………………………………………

44. What is the nature of the cumulative?, and are they likely to be significant (both additive and synergistic effects)?
………
……………………………………………………………………………………

45. Are there likely to be any trans-boundary effects (i.e., the PPP is likely to affect other municipalities, Dzongkhags, regions or countries)?
………
……………………………………………………………………………………

13. Are there any high risks to the environment, social conditions or human health (eg due to accidents), safety and/or the integrity of social or ecological systems?

………
……………………………………………………………………………………

- What social and/or ecological systems in the PPP area of influence have low resilience and high vulnerability to disturbance or impact (e.g., poor communities or sensitive ecosystems)?
………
…………………………………………………………………………

- What areas in the influence of the PPP have high value or are vulnerable and are likely to be affected by the PPP due to:
  - having unique, special, or highly valued natural or cultural elements (e.g., threatened biodiversity or sacred areas);
  - being protected areas (e.g., national parks, nature reserves, biological corridors, heritage sites, Ramsar sites) or areas of recognized local, district, national, or international importance for conservation;
  - having existing levels of environmental quality that are close to defined limits of acceptable change (i.e., there is a definite risk that limits of acceptable change will be exceeded); or environmental quality standards have been exceeded; or
  - intensive land-use.
  ………
  ……………………………………………………………………………………

- What impacts will the PPP have on areas or landscapes that have a recognised national or international protection status?
………
…………………………………………………………………………

- Will the PPP be likely to result in major changes in actions, behaviours, or decisions by individuals, businesses, NGOs, or government that could lead to:

- The stimulation of development of infrastructure or other changes in urban or rural land use;
- An increase in the transformation and development of natural habitat or of areas important to nature conservation;
- Major changes in the pattern of settlement, land occupation, and/or demographics in an area;
- Major changes in the development or use of technology that could have negative implications for health and/or safety;
- The introduction of alien and potentially invasive organisms;

- Changes in society's consumption of energy and in particular fossil fuels, and therefore, in emissions of carbon dioxide and other greenhouse gases;
- Changes in the rate of society's consumption of and/or demand on natural resources, including water.

…… ……………………………………………………………………………

Record of Decision: (tick where applicable)

1. Recommended/Not recommended for SEA …………………………………………………......

2. Recommended for EIA Study ……………………………………………………………….

Names of Reviewers:

1……………………………………........... Signature……………………………Date ………………………..

2…………………………………….......... Signature …………………………..Date …………………………

Annex 4:

List of issues to be covered by SEA Report

The list below includes issues that should be covered in an SEA report. It does not necessarily represent chapter or section headings, nor the order in which information should be provided. The contents of an individual SEA report will also need to be guided by the TOR for the SEA, the context, focus of study, and requirements set by the proponent of the PPP.

- Title of report
- Table of contents.
- Acknowledgements.
- List of acronyms and abbreviations.
- Executive Summary.
- Introduction and background (including scope of SEA).
- Brief description of policy, plan or programme
    - Objective, purpose, and rationale of the PPP;
    - Other development initiatives likely to arise during implementation; and of other project or initiatives (including at a broader scale - national or international– where these will likely influence or impact on PPP or its area.
    - Alternative policy or plan options, and strategies;
    - Areas and sectors affected;
    - Proposed activities for PPP;
    - Implementation plan and time scale of PPP.
- Methodology of SEA.
- Baseline profile and trends.
    - Baseline environmental and social conditions, especially areas potentially affected;
- Description of authorities, jurisdictions and key institutions – their roles and responsibilities.
- Policy, legal and administrative framework.
- Related PPPs
- Future development scenarios (meta alternatives) and other development alternatives.
- Assessment of significant environmental and social impacts.
- Prediction and evaluation of impacts of the PPP, including cumulative effects, compared against indicators;
- Prediction and evaluation of impacts of alternative PPP options and compared against environmental indicators;
    - A justification for the preferred alternative
- Recommended avoidance/mitigation of negative impacts and enhancement of synergies and positive impacts.
- Linkages with ongoing projects and how they fit in the proposed PPP.
- Overview of public/stakeholder engagement activities undertaken
- Summary of stakeholder concerns and expectations, and how these have been addressed (details to be provided in appendix).
- Impacts on sustainable development objectives (local, regional, national).
- Conclusion and recommendations (including recommended PPP changes and need for subsequent EIAs).
- References.
- Appendices - including:
    - List of SEA team members (with brief outline of experience).
    - Record of consultation meetings, stakeholders consulted and stakeholder opinions (an issues-response form should be used to show how stakeholder issues have been addressed in the report).
    - Relevant technical appendices

Supplementary reports should be prepared for specialist studies conducted.

Annex 5

Example review of PPPs relevant to the Preliminary SEA of Bhutan's Road Sector Master Plan (2007-2027) [Can we find an example relevant to energy/RE?]

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
POLICIES AND STRATEGIES		
Water Policy, 2007	*Vision*: Water is the most important natural, economic and life-sustaining resource and we must ensure that it is available in abundance to meet the increasing demands. Present and future generations will have assured access to adequate, safe and affordable water to maintain and enhance the quality of their lives and the integrity of natural ecosystems. Emphasis on water resources management within river basins and aquifers, including both upstream and downstream water users	• localized and seasonal water shortages for drinking and agricultural purposes • increasing sediment load in rivers is decreasing the expected output and economic life of hydropower plants • Pressure on water resources is mounting due to competing demands from different users • New demands from other sub-sectors such as hydropower and industries • Rapid urbanisation has serious impacts both on water demand & associated pollution • Increasing demand for timber, firewood and non-timber forest produce is starting to have negative impacts on watersheds • Climate change will reduce the natural river flow-regulating capacity of glaciers
Sustainable Hydropower Development Policy, 2008	• Develop hydropower projects in accelerated manner to reach installed capacity of 10,000 MW by 2020 • Projects to cover: micro/mini, small. medium, large & mega.	• Project developers required to carry out comprehensive EIAs; make suitable provisions for mitigation of adverse impacts; and implement an Environmental Management Plan and other risk management measures. • Need to protect water catchment areas by promoting sustainable agricultural/land use practices and nature conservation works; • Need for sustainable water resources management • Annual rental paid for private land acquired • Free 10,000 KWh/yr provided for every acre of private land acquired (or cash-in lieu) to the owner. • Developer must provide up to 1% of project costs to cover rehabilitation/resettlement of displaced persons; and provide employment to at least one member of every displaced family.
Cottage, Small and Medium Industry (CSMI) Policy, 2012	Provides direction for development of CSMI; preparing them for the opportunities & challenges of globalisation; ensuring they play an increasing role in fostering economic development; to generate employment & support equitable distribution of income and bring about balanced regional development	• CSMI account for 98% of all industries in Bhutan • Policy fosters job creation
Irrigation Policy, revised 2011 (draft)	Provides direction on measures to increase the irrigated area and improve irrigation water management and	• A significant proportion of arable land remains under rain-fed conditions, while c. 10% of irrigation systems is non-functional. • Irrigation technology and on-farm water management remains rudimentary.

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
	optimal utilization of national water resources for crop production.	• Decentralisation has impeded planning & design of irrigation projects. • Lack of water storage systems • Poor quality irrigation schemes that are highly prone to damage during peak monsoons and high water demand periods; and often washed away during natural calamities. • Conflicts among conjunctive water users/uses from a common source • Pollution of water by agro-chemicals not yet assessed. • Channel & on-farm water are not managed efficiently resulting in land degradation and water wastage.
Land Policy, final draft 2010	Goal: to strive for sustainable use of land through efficient and effective land management and prudent land administration for socio-economic development and conservation of the natural environment in the country. *Objectives* - to: • Coordinate and harmonize the use of land by different users; • Provide access to land for all Bhutanese citizens and juristic persons • provide secured land tenure and rights to title holders; • Generate land revenue and control land speculation; • Undertake broad zoning based on land use capability to fulfil land needs for different purposes; • Enhance equitable, sustainable and efficient use of land resources; • Ensure protection and conservation of ecology	See objectives

National Urbanisation Strategy, 2008	*Objectives:*
	Develop a pro-active approach to the country's urban growth in a sustainable and environmentally sound way that minimizes the negative effects of urbanization;
	• Ensure balanced regional growth;
	• Develop a strategy for improving the quality of life of the growing urban population in a way that embraces rather than undermines the local culture and values;
	• Develop a set of recommendations to improve local government systems in
		• Very rapid rates of urbanization
		• Limited availability of serviced land
		• In general urban centres consume prime agricultural lands in the valleys and encroach on forested hill slopes.
		• Lack of proper infrastructure and facilities for drainage, sanitation and waste disposal have cumulative adverse impacts on the environment.
		• Increased timber logging and conversion of slopes into urban uses
		• Primary environmental pressures on the urban environment arise from:
		  ○ Water supply
		  ○ Waste water collection and treatment
		  ○ Drainage and flooding

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
	• Bhutan, including municipal finance and institutional aspects.	○ Solid waste collection and disposal ○ Hill cutting and erosion • Secondary environmental issues are: ○ Electrification and street lighting ○ Noise ○ Traffic congestion ○ Air pollution ○ Pedestrian areas ○ Household fuel supply • Concerns of the poor (most of them migrants who do not own land in the town): ○ Unaffordable rentals that seem to be responsible for squatting. Housing for poor is critical ○ Housing with access to quality /effective basic and social services. ○ Livelihoods and local economic development, youth unemployment ○ Transport • Urban development related activities have the potential to negatively impact the cultural heritage structures and systems • Loss of the traditional extended family as the proportion of migrants in the urban areas increase • Household will be the major social loss. • Culture and heritage consist of a number of intangible and tangible aspects of which the traditional built environment, community spaces and places form the most important as they are mostly home to and imbibe within themselves traditional rituals, ceremonies and festivals; arts, crafts and textiles including dances, poetry/literature (folklore, myths, legends), music and religion; values and relationships; dressing and etiquette; social setup and structures.
Economic Development Policy, 2010	• *Vision* - to promote a green and self-reliant economy sustained by an IT enabled knowledge society guided by the philosophy of Gross National Happiness • Work towards achieving a minimum economic growth rate of 9% annually and strive to be a middle-income nation with economic self-reliance by 2020. • Achieve full employment (97.5%). *Strategies:*	• Economic development should take into account environment mainstreaming in a phased manner that allows for industries to grow as well as engage in cleaner production • Government to provide incentives for the promotion of green technology, micro-hydro projects, solar, wind, biomass and energy efficiency and conservation programmes. • Conservation efforts to be one of the main drivers for developing the “Brand Bhutan” theme. • Aims to protect biodiversity and genetic resources, and promote indigenous knowledge.

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
	• Diversify the economic base with minimal ecological footprint. • Harness and add value to natural resources in a sustainable manner. • Increase and diversify exports. • Promote Bhutan as an organic brand - in natural resources, tourism, culture, handicrafts, textiles and agro produce. • Promote industries that build the Brand Bhutan image. • Reduce dependency on fossil fuel especially in respect to transportation.	• Commits to use non-renewable resources (ie minerals) in a sustainable manner to diversify the economy while at the same time ensuring due environmental considerations. • Commits to pursue corporate social responsibility in the construction industry. • Organic farming will be a major focus area. • Commits to phasing out use of harmful chemical fertilizers and pesticides • Encourages bio-exploration and bio-prospecting. • Concludes that the "sensitive mountain ecology and the difficulties of building multi lane highways make tunnelling the most viable option to reduce travel time as well as increase connectivity throughout the country. The development of the road sector especially tunnels shall be in sync with the hydropower development".
Mineral Development Policy, 2011 (draft)	Objectives - to: 46. Develop the scarce mineral resources for optimum value addition so that maximum benefit accrues to the nation; 47. Allow selective & cautious development of minerals for socio-economic development while ensuring environmental sustainability & inter-generational equity in the larger interest of the country; 48. Ensure the availability of construction materials at affordable prices to all the citizens; 49. Increasingly contribute to the national economic development by enhancing generation of revenue & employment; 50. Promote human resource development & ensure that mineral development is carried out by technically qualified professionals; 51. Promote investment in the mineral sector by technically & financially competent entities; 52. Develop an integrated mineral information system in the country; 53. Ensure effective regulation, administration, management & monitoring of the mineral sector.	54. Mining sector is important catalyst to economic growth in terms of revenue and employment generation. 55. Mine reclamation & restoration. 56. Impacts on communities surrounding mines. 57. Mining companies must contribute to a community development fund to be used specifically for drinking water schemes, water source protection, social forestry schemes and renovation of religious sites belonging to the community and other schemes as may be prioritized by the community - managed by a Tshogpa appointed by the affected communities, 58. Priority for employment accorded to the local affected community.
Forestry Policy, 2010	59. *Objectives* – to:	68. Loss of forest cover due to establishment of development projects. 69. Forest fires.

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
	60. Manage Bhutan's forests for sustainable production of economic and environmental goods and services and to meet the long term needs of society 61. Manage Bhutan's production forests for sustainable supply of timber, other forest products and environmental goods and services and to meet the long term needs of society; 62. Maintain species persistence and ensure long term sustainability of Bhutan's biodiversity, ecosystem services, natural habitats and cultural heritage through a network of Protected Areas, biological corridors and management of other parts of the forest landscape for positive environmental outcomes; 63. Provide for effective and integrated watershed management, maintain and improve water and watershed conditions and contribute to sustainable livelihoods through provision of watershed services; 64. Empower rural communities manage forests sustainably for socio-economic benefits, poverty reduction and to contribute to overall sustainable forest management at national level; 65. Facilitate raising forestry crop on registered land of individuals or institutions and accrue ecological, social and economic benefits; 66. Enable an economically viable and efficient forest based industry aimed at adding value to forest products and build capacity of private sector and rural communities to utilise, process and market forest products; 67. Establish a dynamic organisational set up through institutional reforms for appropriate managerial and technical capacity to implement all policy objectives.	70. Watershed services. 71. Biodiversity. 72. Appropriate vegetation composition 73. Sustainable timber supply. 74. Illegal logging, poaching, illegal trade of wild flora and fauna 75. Human-wildlife conflict. 76. Conservation of scared/heritage sites. 77. Local community access to forest resources (timber, firewood, medicinal plants & herbs, non-wood forest products, etc.)
Renewable Energy Policy, 2011	a) Long-term objectives: • Enhance energy security and broaden the energy portfolio;	• Land acquisition for projects, and compensation

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
	• Conserve the environment and reduce greenhouse gas (GHG) emissions; • Enhance socio-economic development. b) Short-term objectives: • Support and promote research & development in renewable energy (RE) technologies (solar, wind, biomass, other) with long term objective of a viable energy resource, harness the potential of RE resources and adoption of RE technologies in the country; • Develop RE roadmap for each of the RE technologies by mapping capacity, generation potential and cost of generation by location across the Kingdom. • Design appropriate tariff for various RE technologies to offer secure and stable market to investors and project developers with guaranteed incentives provided by the Government; • Enable, encourage and facilitate both public and private sector participation for the development RE; • Enable to set realistic target for RE for the energy-mix in line with the principles of GNH; institutionalize development of national and local capacities and capabilities for enhanced and optimum utilization of RE systems; • Promote efficient and cost-effective RE systems by providing time-bound incentives; and • Establish the necessary administrative, basic physical infrastructure and institutional mechanisms to implement the provisions of this Policy. • Strengthen regulatory functions in RE sector	
(b) PLANS		
11th Five Year Plan	Introduced “green” concept – prioritises environmental management and reduction of GHG & pollution based on pro-poor, low carbon, eco-friendly, energy- & cost-efficient modalities & strategies	
Phibsoo Wildlife Sanctuary: Conservation	Main objectives:	82. Human-wildlife conflicts 83. Poaching 84. Free-range grazing in forest habitats (large numbers of cattle)

POLICY/PLAN	KEY AIMS	ENVIRONMENTAL / SOCIAL ISSUES
Management Plan (2012-2017)	79. Reduce conservation threats posed by human-wildlife conflicts, poaching, and free-range grazing; 80. Strengthen the infrastructure for effective management of PWS and implementation of planned management interventions; 81. Enhance professional and public knowledge for local biodiversity conservation and related community development.	85. Loss of cereal crops to wildlife 86. Indirect costs - loss of time, added cost of production, expenditure torches, batteries and kerosene, and construction of elevated guard shelters (machans). 87. Wildlife predation on livestock (lower scale than crop damage) 88. Proximity to regional wildlife trafficking routes 89. Spread of animal diseases – where wild and domestic animals overlap. 90. Lack of research & information 91. Limited conservation management infrastructure 92. High security risks due to insurgency in bordering India

Annex 6

Overview of selected analytical and decision-making tools for SEA

Source: OECD/DAC (2006)

1. TOOLS FOR PREDICTING ENVIRONMENTAL AND SOCIO-ECONOMIC EFFECTS

1.1 Carrying capacity analysis (CCA) determines the human population that can be 'carried' by a particular area on given consumption levels, i.e. it identifies the limits to growth. The 'capacity' concept is controversial with continued debate on what exactly it is, and how land can be managed to increase capacity. Ecological carrying capacity usually refers to the maximum population size of a species that an area can support without reducing its ability to support the same species in the future. More information at www.ilea.org/leaf/richard2002.html.

1.2 Network analysis (also called cause-effect analysis, consequence analysis, or causal chain analysis) explicitly recognises that environmental systems consist of a complex web of relationships, and that many activities' impacts occur at several stages removed from the activity itself. It aims to identify the key cause-effect links describing the causal pathway from initial action to ultimate environmental outcome. It doing so, it can also identify assumptions made in impact predictions, unintended consequences of the strategic action, and possible measures to ensure effective implementation. It is useful for identifying cumulative impacts. The technique involves, through expert judgement, drawing the direct and indirect impacts of an action as a network of boxes (activities, outcomes) and arrows (interactions). (Source: Therivel, 2004). For more information, see European Commission (1999).

1.3 Ecological (environmental) footprint analysis addresses the human impact on the Earth's ecosystems, measuring and visualising the resources required to sustain households, communities, regions and nations, converting the seemingly complex concepts of carrying capacity, resource use, waste disposal, etc. into an understandable and usable graphic form. An excellent handbook is Wackernagel and Rees (1996).

1.4 Social and economic analysis/surveys. Information on many of the key tools available for social analytical and survey work are described in the *PSIA User's Guide* for practitioners in developing countries. DFID has funded work on Tools for Institutional, Political and Social analysis of PSIA (TIPS Sourcebook) (soon to be available on the World Bank website). Most are available on the World Bank PSIA website:

http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPSIA/0,,menuPK:490139~pagePK:149018~piPK:149093~theSitePK:490130,00.html

Ministries of finance and other governmental bodies usually use general and partial equilibrium models for planning purposes. These predict how changes in the economy, due to for example fiscal reforms or exchange rate reforms, will affect demand, supply and relative prices. In general, these models can indicate changes in the use of different natural resources, such as energy use and agricultural output. In some cases, models also include effects on different forms of pollution. For more information see http://siteresources.worldbank.org/INTEEI/214584-1115794388939/20486164/ToolkitForAnalyzingEnvironmentalAspectsofPolicyLending.pdf

1.5 Expert judgement of direct and indirect impacts: relatively quick and cheap, and can be used for applications including collecting data, developing alternatives from the strategic policy level to the detailed site level, analysing and ranking them, predicting impacts, and suggesting mitigation measures. One or preferably several experts with specialist knowledge covering the range of impacts of the strategic action brainstorm/discuss/consider the relevant issue. This is sometimes formalised, e.g. through the Delphi Technique which uses consecutive cycles of questionnaires of expert participants until agreement on a subject is reached (Source: Therivel 2004).

1.6 Geographical information system (GIS): a tool to organize and present information. It combines a computerised cartography system that stores map data, and a database management system that stores attribute data. This allows links between the two data sets to be displayed. GISs are often only used to map data. However, they are also valuable analytical tools, e.g. for calculating areas and distances, identifying viewing areas from a point, constructing buffer zones around features, drawing contour lines using interpolated values between points, and superimposing maps of the above. For more information, see European Environment Agency (1998).

1.7 ***Land use partitioning analysis:*** assesses the fragmentation of land into smaller parcels that might result from linear infrastructure development. It involves comparing before and after scenarios. For more information, see European Environment Agency (1998).

1.8 ***Mapping of transmission channels:*** a component of Poverty and Social Impact Assessment that identifies the channels through which a particular policy change or other major intervention is expected to affect stakeholders. There are six main transmission channels: employment, prices - production, consumption, and wages; access to goods and services; assets - physical, natural, social, human, financial; transfers and taxes; and authority. Impacts may be direct (from changes in the policy levers altered by the reform) or indirect (from reform through other channels). The nature of impacts may also vary over time, and so will net impacts on various stakeholders. More information at

http://lnweb18.worldbank.org/ESSD/sdvext.nsf/81ByDocName/Approach3Understandingtransmissionchannels

1.9 ***Modelling (also called forecasting):*** techniques predict likely future environmental conditions with and without the strategic action. Modelling involves making a series of assumptions about future conditions under various scenarios, and calculating the resulting impacts. Models typically deal with quantifiable impacts: air pollution, noise, traffic, etc. Most models used in SEA have evolved from EIA techniques. Many are computerised. (Source: Therivel, 2004). The June 1998 issue of *Impact Assessment and Project Appraisal* (Vol 16, No.2) is devoted to modelling, though mainly in the context of EIA. See also European Commission (1999).

1.10 ***Overlay maps:*** obtained by superimposing maps of areas of constraint using transparencies (e.g. overlaying areas of importance for landscape, wildlife and groundwater protection). The overlay maps can identify areas that would be appropriate/inappropriate for development, and produce easily understandable results that can be used in public participation exercises. For more information, see European Commission (1999).

1.11 ***Participatory techniques for assessment:*** available for work with stakeholders and those likely to be directly or indirectly affected by a strategic action, so they can engage in the process of assessing impacts. They include, for example: participatory learning and action (PLA); participatory dialogues; focus groups and round tables; consensus-building, negotiations and conflict resolution. A useful guide to such techniques is Pretty *et al*. (1995). A participatory poverty assessment (PPA) collects poor people's views regarding their own analysis of poverty and the survival strategies. PPAs focus on poor people's capacity to analyse their situations and to express their priorities themselves. PPAs are an effective tool for obtaining direct feedback from the poor on a country's poverty profile and the impacts of policy reform. Guidance materials on PPA are available at www.worldbank.org/poverty).

1.12 ***Quality of life assessment (QoLA):*** aims to identify what matters and why in an area, so that the good and bad quality of life consequences (environmental, societal and economic) of strategic actions can be better considered. The technique involves identifying benefits/disbenefits that an area offers present and future generations, assessing:

- The importance of each, to whom, and why?
- Whether there will be enough of them;

93. What (if anything) could substitute for the benefits?

The answers lead to a series of management implications from which a ‘shopping list’ of things that any development/management of the area should achieve, and their relative importance. (Source: Therivel, 2004). For more information, see Countryside Agency *et al*. (2002) www.qualityoflifecapital.org.uk.

2 TOOLS FOR ANALYSING AND COMPARING OPTIONS

2.1 ***Compatibility appraisal:*** ensures that a strategic action is internally coherent and consistent with other strategic actions. This is not strictly an SEA function, more one associated with good planning. Normally two types of matrices are used:

- An internal compatibility matrix plots different components/statements of the strategic action on both axes, with compatibility/incompatibility between the actions marked in the cells with a tick or cross. It is usual to undertake a compatibility analysis between the objectives of the PPP and the SEA objectives;
- An external compatibility matrix plots the strategic actions (as a whole) against other relevant (normally higher- and equal-level) strategic actions. Matrix cells are filled by listing those statements of the strategic action that fulfil the requirements of the other strategic actions, or explaining how the evolving strategic action should take the requirements into account. When no statements in the strategic action fulfil the other’s requirements, or where they conflict, this may need to be addressed. (Source: Therivel, 2004).

2.2 Cost-benefit analysis, scenario analysis and multi-criteria analysis to identify priorities and viable alternatives:

Cost-benefit analysis (CBA): A relatively simple and widely used technique for deciding whether to make a change. The technique adds up the value of the benefits of a course of action, and subtracts the costs associated with it. Costs are either one-off, or may be ongoing. Benefits are most often received over time. The effect of time is built into the analysis by calculating a payback period - the time it takes for the benefits of a change to repay its costs. In its simple form, CBA is carried out using only financial costs and financial benefits e.g. a simple cost/benefit analysis of a road scheme would measure the cost of building the road, and subtract this from the economic benefit of improving transport links. It would not measure either the cost of environmental damage or the benefit of quicker and easier travel to work. A more sophisticated approach to CBA is to try to put a financial value on these intangible costs and benefits. Guidance on the use of CBA is available at http://www.mindtools.com/pages/article/newTED_08.htm.

Scenario analysis/sensitivity analysis: can be used to describe a range of future conditions. The impact of a strategic action can be forecast and compared for different scenarios – sensitivity analysis – to test the robustness of the strategic action to different possible futures. Forecasts based on current trends and/or scenarios representing trends outside the decision makers' control are generated and the strategic action's impacts are predicted based on these forecasts/scenarios. Sensitivity analysis measures the effect on predictions of changing one or more key input values about which there is uncertainty. The Stockholm Environment Institute has developed the Polestar Manual for scenarios http://sei.se.master.com/texis/master/search/?q=scenarios&xsubmit=Search%3A&s=SS.
Scenario planning is an example of a number of tools developed within the private sector (see e.g. Shell International 2000). It is used to evaluate future, long-term, business environments and develop strategies that serve the traditional business goals of survival, maintenance and growth in competitive markets. The intention is to develop strategies that are robust enough to be able to adapt the company to shocks and surprises in the business environment. It does this through a systematic process, usually engaging external stakeholders, to consider the nature and impact of uncertain futures and important drivers/influences on changes in technological, societal, environmental, economic, political, commercial, cultural, etc., environments.

The goal of scenario planning is to assist strategic planners and policy analysts to make more resilient choices through understanding a wide range of possible futures and designing pathways to arrive at desired positions.

Key stages in this process include:

- Agree the wide range of issues to address.
- Identify participants (lateral thinkers).
- Workshops and interviews of a 'brain storming' nature.
- Identify uncertainties and drivers of change.
- Develop matrices to describe possible combinations of critical uncertainties.
- Elaborate scenarios for each of the above combinations- again through group discussion.
- Describe requirements (PPPs) to move towards a preferred vision and constraints to be overcome in getting there.

Multi-criteria analysis (MCA): techniques can assess a variety of options according to a variety of criteria that have different units (e.g. $, tonne, km, etc). This is a significant advantage over traditional decision-aiding methods (e.g. cost-benefit analysis) where all criteria need to be converted to the same unit (e.g. dollars only). They also have the capacity to analyse both quantitative and qualitative evaluation criteria (e.g., yes/no, pluses and minuses). MCA techniques have three common components: a given set of alternatives; a set of criteria for comparing the alternatives; and a method for ranking the alternatives based on how well they satisfy the criteria. An MCA manual is available at www.cifor.cgiar.org/acm/methods/mca.html.

- ***Opinion surveys to identify priorities*:** for methods go to http://gsociology.icaap.org/methods/surveys.htm

2.4 Risk analysis or assessment: established itself as an essential tool for the management of environmental risk. An issue for environmental risk assessment is the lack of an easily defined measure of what constitutes *harm* to the environment. In some cases definitions of environmental damage are laid down in statute, but in others appropriate criteria will need to be selected on the basis of scientific and social judgements. For a comprehensive treatment of the basic principles of environmental risk assessment and management, see Calow (1998). Many sources provide guidelines for environmental risk assessment, e.g. http://www.defra.gov.uk/environment/risk/eramguide/index.htm.

2.5 Vulnerability analysis: assesses the impacts of a planned activity or different development scenarios on the vulnerability of an area. Vulnerability maps are produced showing degree of vulnerability for selected targets (e.g. people, flora and fauna, landscape). These are overlaid and 'weighted' (using GIS and multi-criteria analysis) to indicate areas of high vulnerability and then related to expected levels of impact associated with different development options (e.g. noise increase, groundwater decline) - revealing the locations of negative impacts regarding different targets, and the alternatives with the least impacts. For further information, see van Straaten (1999).

3 TOOLS FOR ENSURING FULL STAKEHOLDER ENGAGEMENT

3.1 General information, techniques, etc: many guidelines are available for effective community involvement and consultation, e.g., www.rtpi.org.uk/resources/publications/ConsultationGuidelines_web.pdf www.iap2.org/associations/4748/files/toolbox.pdf; www.unece.org/env/eia/publicpart.html.

3.2 Consensus building processes: a conflict-resolution process used mainly to settle complex, multiparty disputes. Since the 1980s, it has become widely used in the environmental and public policy arena but is useful whenever multiple parties are involved in a complex dispute or conflict. It allows them to work together to develop a mutually acceptable solution. More information is at www.beyondintractability.org/m/consensus_building.jsp.

A short guide to consensus building is available at http://web.mit.edu/publicdisputes/practice/cbh_ch1.html.

3.3 Stakeholder analysis to identify those affected and involved in the PPP decision: incorporates economics, political science, game and decision theory, and environmental sciences. Current models apply a variety of tools on both qualitative and quantitative data to understand stakeholders, their positions, influence with other groups, and their interest in a particular PPP. In addition, it provides an idea of the impact of the PPP on political and social forces, illuminates the divergent viewpoints towards proposed PPPs and the potential power struggles among groups and individuals, and helps identify potential strategies for negotiating with opposing stakeholders.
Go to http://www1.worldbank.org/publicsector/anticorrupt/PoliticalEconomy/stakeholderanalysis.htm.

SOURCES OF FURTHER INFORMATION ON SEA TOOLS

- A modular Capacity Development Manual for the Implementation of the UNECE Protocol on Strategic Environmental Assessment is being developed by UNECE. It will be available at www.unece.org.

- Therivel, R (2004) *Strategic Environmental Assessment in Action*, Earthscan: London contains an Appendix with SEA prediction and evaluation techniques. It covers expert judgement, quality of life assessment, overlay maps, land use partitioning analysis, geographical information systems, network analysis, modelling, scenario/sensitivity analysis, cost-benefit analysis, multi-criteria analysis, life cycle analysis, vulnerability analysis, carrying capacity, ecological footprint, risk assessment, and compatibility appraisal.

- Rauschmayer F. and Risse N. (2005) A Framework for the Selection of Participatory Approaches for SEA, *Environmental Impact Assessment Review*, 25(6): 650-666, covers: mediation, mediated modelling, consensus conference, citizens' juries and co-operative discourse.

- Finnveden G., Nilsson M., Johansson J., Persson A., Moberg A. and Carlsson T. (2005) Strategic Environmental Assessment methodologies - Applications within the Energy Sector. Environmental *Impact Assessment Review*, 23(1): 91-123. This paper covers: future studies, LCA, environmentally extended input/output analysis, risk assessment of chemicals and accidents, impact pathway approach, ecological impact assessment, multiple attribute analysis, environmental objectives, economic valuation, surveys, and valuation methods based on mass, energy and area.

Annex 7

Example of objectives compatibility analysis: compatibility of objectives for Poole Port Masterplan (UK) against environmental and social quality objectives

(Source: Ramboll (2012)

√ Likely compatibility
- Relationship complex (or there is more than one potential outcome, depending on the interpretation of the Masterplan objective and the way that it is met
X Likely incompatibility

Port of Poole Masterplan objectives	**To continue to operate a commercially viable port with a diversity of activities**	**To continue to promote safe use of the harbor for all**	**To continue to educate and promote amongst harbor users the sustainable use of the harbor for commerce, recreation and amenity**	**To continue to protect and maintain the special natural features of the harbour**	**To support the wider economy and community**
ESQOs					
1: To preserve, protect and enhance biodiversity on or in the vicinity of the port	-	-	√	√	-
2: To reduce accidents and incidents in the port and harbor and reduce risk/improve safety for the users of the harbour	√	√	√	-	-
3: To improve the strength of the region's economy, including through providing a diverse range of employment opportunities	√	-	-	-	√
4: To improve the accessibility of community amenities and facilities to local residents	-	-	√		-
5: To encourage the protection of water resources	-	-	-	√	-
6: To minimize the impact on soil and land resources including contamination and loss	-	-	-	√	-

7: To contribute towards improving local air quality	-	-	-	-	-
8: To contribute towards the reduction of greenhouse gas emissions	-	-	-	-	-
9: To contribute towards the protection and enhancement of sites, features and areas of historical and cultural value	-	-	-	√	-
10: To contribute towards the protection and enhancement of the landscape character of the area	-	-	-	√	-
11: To contribute towards the improvement of levels of congestion and reliability on the road networks in the vicinity of the port	-	-	-	-	√
12: To contribute towards the reduction of noise levels from activities on port land	-	-	-	-	-

Annex 8

Developing SEA environment and social objectives, indicators and targets

Environmental and social quality objectives (ESQOs) are widely used to ensure that the right level of consideration is achieved. An objective is a statement of what is intended, specifying a desired direction of change. For these Guidelines, a distinction needs to be made between three types of objectives:

- The ***objectives of the PPP*** in question: government policies and guidance increasingly require these to be based on sustainability considerations, and the development of ESQOs for a SEA may help to promote ideas for making them more environmentally friendly and sustainable.
- ***External objectives***: other objectives to which the PPP proponent needs to have regard independently from the SEA process. They may include environmental protection objectives (which, if binding, must be covered in the SEA report), but they can also be economic or social. They may also include obejecties of international conventions, treaties and regional accords to which a country is a signatory as well as the UN sustainable development goals (SDGs).
- ***SEA ESQOs***: devised to test the environmental and social effects of the PPP or to compare the effects of alternatives.

Objectives can be expressed so that they are measurable (e.g. an objective to reduce greenhouse gas emissions could be expressed as “reduce CO_2 emissions by 12.5% by 2010”). The achievement of objectives is normally measured by using indicators.

ESQOs can often be derived from environmental protection and social objectives identified in other PPPs or from a review of baseline information and environmental and social problems. Stakeholders may also suggest ESQOs for the SEA.

Some SEA ESQOs and indicators are shown in Table A8.1. They are derived froma much larger matrix of ESQOs and indicators developed during scoping for the ADB’s Energy Transition Mechanism (ETM).

These objectives and indicators can be adapted (by addition, modification or deletion) to take account of national circumstances/contexts and concerns.

Table A8.1: SESA environmental and socio-economic quality objectives for key issues, suggested indicators, and related sustainable development goals and Just Transition principles

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
Environmental					
Climate change	1	Reduce emissions of GHGs from energy generation	13	1,2	• Pre-closure emissions of CO_2 from stacks (tonnes/yr) (*to provide measure of reduction when CFPP is closed*) • CH_4 emissions (e.g. from uncapped abandoned mine shafts and dams) (tonnes/yr) in ETM-affected areas
	2	Increase resilience of the country's overall energy supply to climate change impacts	13	1, 2	• Vulnerability of energy supply to climate change impacts (low, medium, high)
Habitats, biodiversity and protected areas	3	Minimise loss of habitats, biodiversity and ecosystem(s) integrity and services	14,15		• Area of natural habitat and critical habitat (Ha) *[as per IFC PS6 definitions (IFC 2012)]* in ETM-affected areas • Population of key indicator species (to be determined at national level) in ETM affected areas (numbers) *(to measure change compared with baseline data)*
	4	Minimise deforestation	13,14		• Forest coverage in ETM affected areas (Ha)
	5	Reduce encroachment and degradation of protected and sensitive areas	15		• No of reported cases of illegal resource extraction (e.g. poaching, illegal fishing, illicit felling) in PAs • Volume of seized illegal timber (cubic m) taken from protected and sensitive areas
Air quality	6	Reduce all forms of air pollution	3,14,15		• Ambient concentration of $PM_{2.5}$ at selected sites ($\mu g/m^3$), • Ambient concentration of NO_2, at selected sites ($\mu g/m^3$), • Direct emissions of SO_2, NOx, $PM_{2.5}$, CO, heavy metals and volatile organic compounds (VOCs) (g/ kWh) at selected sites
Surface water quality	7	Reduce all form of water pollution (surface and groundwater)	3,6,14,15		• Water quality at selected sites (heavy metals, nitrate, phosphate, BOD) (mg/L) • COD/TN/TPh/TSS/Temp/T bacteria Volume of discharge (m^3 / kWh)

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
Solid waste	8	Reduce waste disposed to landfill (e.g. by increasing repurposing, recycling and reuse of assets)	3,15		• Volume waste disposed to dump sites by energy operators under ETM (tonnes) • Percentage of waste diverted from landfill by energy operators under ETM (%)
	9	Improve safe handling, storage and disposal of solid waste	3,15		• Capacity of recycling plants in country (tonnes/yr) • Number of hazardous waste treatment facilities • Capacity of hazardous waste treatment facilities
Materials use	10	Minimise use of non-renewable and toxic materials used in developing new assets	3,6,15		• % of non-renewable resources used in constructing new renewable energy assets
Land contamination	11	Maintain soil and groundwater quality and reduce land contamination	6,15		• Number of pollution incidents linked to the continuing operation of CFPPs/mines (in the period up to retirement) and after retirement/closure, and to ETM funded renewable energy projects
Noise and vibration	12	Minimise disturbance caused by noise and vibration	3		• No hrs. in which noise at selected sites exceed a set standard (to be determined) (dBA) during both operation (whilst awaiting retirement) of CFPPs/mines and during retirement/closure process; • No. hrs in which noise at selected sites excveed a set standard (to be determined) (dBA) during construction and operation of renewable energy projects
					• Average day time noise at boundary of selected projects (dBA)
Land degradation	13	Minimise soil, river bank and sea bed erosion, and sedimentation of surface water	14,15		• Extent of degraded land or impacted surface waters (Ha) in ETM-affected areas
Land use change	14	Minimise loss and degradation of productive agricultural land, forests, grazing land, and fisheries	15		• Extent of such lands lost/degraded (Ha) in ETM-affected areas
Water use	15	Minimise use of local water resources and ensure efficient use/reuse of water	3,6,11		• Net volume of water used (m^3/yr)

THEMES		**OBJECTIVE**	**RELATED SDGS**	**MDB JT PRINCIPLES**	**POTENTIAL INDICATOR(S)** (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
Visual impacts	16	Minimise extent of visual change to landscape and loss of aesthetic value	3		• Number of complaints regarding a negative aesthetic impact • Area subjected to a change in view (size of viewshed) (Ha)
Health and safety	17	Ensure population health, and safety of communities and workers	3,6,8		• Life expectancy (yrs) • Incidence of specific diseases in affected areas (number of cases reported to clinics/hospitals) (*if such data is available/accessible*) in affected areas • Number of accidents related to CFPPs/mines whilst awaiting retirement under ETM, and during retirement/closure process • Number of accident related to construction and operation of renewable energy projects under ETM
Socio-economic					
Economic growth	18	Enhance economic development and diversification, and increase in economic growth (regionally & nationally)	8	1,3	• Per capita GDP • Volume of coal exports (national) (metric tons) • Inflation rate (%) • Contribution of coal and renewable energy to GDP (%)
Employment and skills	19	Enhance and maintain opportunities for employment and decent work for all, and maintain income levels	1,8,9	1,4	• Number of people employed long-term (more than 1 year) in each type of energy project under ETM (coal power plants, mines, renewable energy projects) • Number of workers losing income from ETM projects
	20	Minimise loss of skilled workers	1,8,9	1,4	• Number of skilled jobs lost • Number of workers retrained/re-skilled
Local economy and livelihoods	21	Minimise loss of livelihoods including for vulnerable groups and indigenous peoples	1,2,10	1,4	• Number of small businesses closing due to implementation of ETM • Number of people having reduced income due to ETM implementation

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
	22	Enhance equitable opportunities for new/improved and diversified and sustainable livelihoods	1,2,10	1,4	• Number of new jobs available in non-ETM businesses in ETM affected areas
	23	Improve access to affordable and quality housing	3,11	1,4	• Average price of land and housing (rental and for sale)
	24	Minimise gender inequality and minimise vulnerable groups being disadvantaged	4,8,10	1,5	• Number of social security entitlements, benefits and / or (financial) support packages claimed under ETM, by sex, age, disability and indigenous status
					• Percentage of all job advertisements for ETM projects targeting women and vulnerable groups via positive / affirmative action (%)
					• Number employed in non-ETM businesses in ETM affected areas by sex, age, disability and indigenous status
					• Percentage of females employed in ETM facilities (%)
					• Number of females retrained/reskilled for other jobs following CFPP/mine closure under ETM
					• Number of people from indigenous communities employed in ETM facilities
					• Number of people from indgenous communities retrained/re-skilled following CFPP/mine closure under ETM ?
	25	Minimise competetition by men for jobs in sectors dominated by women	4.8,10	1,5	• Number of men in ETM affected areas employed in women-dominated sectors
Food security and price	26	Improve food security for all	2,3	1,4	• Status of food security - as measured by availability of selected communities (e.g. in shops/markets) (plentiful/moderate/scarce)
					• Price of rice, corn, meat and vegetables in selected communities
					• Food quality in selected communities (good/moderate/poor)
					• Rice production in selected communities (tons/yr)

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
					• Nutritional level in selected communities (Average Kcal/person/meal)
Physical and economic displacement	27	Minimise physical and economic displacement	3,16	1,4	• Number of housholds relocated due to ETM projects
					• Number of housholds suffering lost land due to land acquisition for ETM projects
Conflicts	28	Reduce conflicts (e,g, over use of and access to land, between migrant workers and local population, between developers and local communities)	16	1,4	• Number of reported disputes
Community cohesion and engagement	29	Minimise disruption to household relationships	11	1,4	• Number of reported cases of domestic violence linked to CFPP/mine closure or development of renewable energy projects under ETM
					• Number of divorces linked to CFPP/mine closure or development of renewable energy projects under ETM
	30	Enhance inclusive and transparent engagement by communities, interested and affected parties (CIAPs) in planning and implementation of ETM initiatives	8,16	1,5	• Number of public and private consultation events organized for ETM (overall and for individual projects?)
					• Number of submissions/comments received for ETM (overall and for individual projects)
					• Percentage of representatives from vulnerable groups attending meetings (overall and for individual projects)(%) • Percentage of consultation events that provide for representation by NGOs/CSOs/trade unions
Public services and infrastructure	31	Maintain and improve local public facilities and services	9	1,4	• Number of facilities by type in each ETM affected area
					• Number of grievances (made through designated grievance mechanism) about adequacy of particular public services and infrastructure per month/year
					• Number of doctors per 1000 head population in each ETM affected area
Human rights	32		10,16		• Reported cases of complaints about infringements of human rights linked to CFPP/mine closure under ETM

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)
		Avoid infringement of human rights of workers, communities and vulnerable groups (including in supply chains)		1,4 5	• Reported cases of complaints about infringements of human rights linked to renewable energy projects under ETM
					• Number of children reported to be working on ETM projects falling into the category of child labour
					• Number of reported cases of bonded labourers in renewable energy projects under ETM
					• Number of workers recorded to be underpaid (less than legal minimum wage for normal working hours, less than statutory overtime pay for overtime hours) in renewable energy projects under ETM
					• Number of persons reporting infringements to freedom of movement (passports withheld by renewable energy projects)
					• Number of substandard contracts identified on ETM projects
Migration	33	Minimise outmigration			• Rate of migration out of communities where CDFPP/mines closed under ETM (%)
	34	Minimise the number of unskilled immigrants competinglocal people for employment in ETM facilities		1,4	• Number and % of unskilled, semi-skilled and skilled workers by gender and origin (international, national, local and project affected persons) per ETM facility
Cultural heritage	35	Preserve heritage sites (historic buildings, archaeological and cultural sites)	3		• Number of cultural heritage sites impacted per ETM facility (including associated infrastructure)

List of Sustainable Development Goals

- ***No poverty***: End poverty in all its forms everywhere
- ***Zero hunger***: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
- ***Good health and well-being:*** Ensure healthy lives and promote well-being for all at all ages
- ***Quality education****:* Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
- ***Gender equality****:* Achieve gender equality and empower all women and girls

THEMES		OBJECTIVE	RELATED SDGS	MDB JT PRINCIPLES	POTENTIAL INDICATOR(S) (Affected areas = those affected by energy facilities and associated infrastructure under ETM)

- ***Clean water and sanitation***: Ensure availability and sustainable management of water and sanitation for all
- ***Affordable and clean energy****:* Ensure access to affordable, reliable, sustainable and modern energy for all
- ***Decent work and economic growth****:* Promote sustained and inclusive and sustainable economic growth, full and productive employment and decent work for all
- ***Industry, innovation and infrastructure***: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
- ***Reduced inequalities***: Reduce inequality within and among countries
- ***Sustainable cities and communities*****:** Make cities and human settlements inclusive, safe, resilient and sustainable
- ***Responsible consumption and production***: Ensure sustainable production and consumption patterns
- ***Climate action***: Take urgent action to combat climate change and its impacts
- ***Life below water***: Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- ***Life on the Land:*** Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
- ***Peace, justice and strong institutions***: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
- ***Partnerships for the goals***: Strengthen the means of implementation and revitalise the global partnership for sustainable development.

MDB Just Transition Principles

- MDB support for a just transition aims to deliver climate objectives while enabling socio-economic outcomes, accelerating progress towards both the Paris Agreement and the SDG
- MDB support for a just transition focuses on ***moving away from GHG emissions intensive economic activities*** through financing, policy engagement, technical advice and knowledge sharing, in line with MDB mandates and strategies, and country priorities including NDCs and long-term strategies.
- MDBs will encourage support for a just transition by building on existing MDB policies and activities, mobilising other sources of public and private finance, and enhancing coordination through strategic plans that aim to deliver ***long-term, structural economic transformation***.
- MDB support for a just transition seeks to mitigate negative socio-economic impacts and increase opportunities associated with the transition to a net zero economy, ***supporting affected workers and communitie***s, and enhancing access to ***sustainable, inclusive and resilient livelihoods*** for all.
- MDB support for a just transition encourages transparent and inclusive planning, implementation and monitoring processes that ***involve all relevant stakeholders and affected groups***, and that further ***inclusion and gender equality***.

Annex 9

Developing scenarios

Scenarios are a technique for presenting alternative views of the future. They identify some significant events, the main actors and their motivations, and they convey how the world functions. Scenario development allows us to think systematically about and understand the nature and impact of the most uncertain and important driving forces affecting our future.

The purpose of scenario development is not to imminently decide which scenario is correct; rather it is to look at each plausible future scenario and examine how prepared a country or organisation is or how robust a PPP is, for the potential change and consequences.

Scenario development helps policy-makers to anticipate hidden weaknesses and inflexibilities in organizations, methods and PPPs. Most development PPPs are fixed in that they tend to assume a self-validating future – one usually based on extrapolation or prediction that dominates decision-making (and usually termed the ***default scenario***). However, we live in world in which there are sudden changes and ***uncertainties*** (no-one predicted the COVID pandemic!) – so PPPs fail to hold up under the stream of real events – and lead us into ***shocks and surprises.***

Scenario development deals with "what if?" questions and helps clarify a vision of the way ahead, capable of modification but allowing progress.

Thus, constructing scenarios enable the feasibility and effectiveness of a proposed PPP or its alternatives to be evaluated in different future conditions. There are four main steps involved in constructing scenarios. These are:

- Identifying the strategic issues associated with the PPP (i.e. what are the critical success factors and key concerns);
- Analysing the present conditions and levels of environmental quality and social well-being;
- Identifying the most important and relatively predictable factors, or 'key drivers of change' and the uncertainties that will determine the nature of the future environment in which the proposed PPP or its alternatives will operate and link them together into a framework; and
- Deriving two to four realistic scenarios associated with the effects of these most important factors on present conditions, and determining which critical outcomes have most potential to affect the proposed PPP and particularly components of the PPP.

Table A9.1: indicates a typical scenario building process.

Table A9,1: Scenario building process

Scenario building steps & tasks	Comments
Identify scenario setting	• Identify key factors and keep focus – avoid drifting or going too broad; • Consider the appropriate time horizon for the scenario.
Identify & analyse key drivers of change	• Select macro/broad drivers, possibly global; • Drivers include social, technological, political, economic, environmental forces; • Understand forces and dynamics; • Undertake initial research and analysis; • Organise multi-stakeholder workshop and seek expert option.
Ranks drivers according to importance and uncertainty	• Identify 2/3 most important factors/trends and the most uncertain ones;

Scenario building steps & tasks	Comments
	• Focus attention on selection of the scenario logics – eg high importance/low uncertainty forces (these are the potential shapers of different futures for which longer-term planning should prepare).
Select scenario logics	• Plot selected drivers on axes (eg high- low, improving-declining) along which the scenarios can be constructed (see example in Figure A9.1); • From the different plots, select a manageable number of scenarios (about 3) that are most worthy of articulation; • Eliminate those whose combinations of logics are implausible/inconsistent.
Flesh out the scenarios	• Prepare a written description of the selected logical scenarios.
Assess the impacts of the PPP or alternative under each scenario	• Assess the environmental & social impacts of the PPP or its alternatives under each scenario and compare.

Figure A9.1: Example scenario plot for global growth
(Source: McKinsey https://www.google.co.uk/search?q=scenario+diagram&espv=2&biw=1366&bih=667&source=lnms&tbm=isch&sa=X&ved=0ahUKEwii5pzP04nOAhWkKsAKHXGBCPwQ_AUIBigB#tbm=isch&q=development+plan+scenarios+axes&imgrc=VqwJBKwkEfDjfM%3A)

The process of scenario building should raise awareness of uncertainties, risks and constraints which could be encountered in the future

In developing and assessing scenarios, the ‘worst case’ scenario should be identified. The issues and consequences of the ‘do-nothing’ (or ‘business-as-usual’) scenario should also be identified, as these two scenarios can serve as a benchmark for the evaluation.

It can also be very helpful for the SEA to examine basic ***meta scenarios*** in relation to economic growth, eg

- *Baseline scenario* (the current situation) – drawing from the baseline profile;
- *Business as usual scenario* – essentially organic growth extrapolating current plans and trends (i.e. current trends continue, developments in the pipeline are realized, but there is not much stimulation for added growth and there is little significant change to the current situation);
- *Low growth scenario* - as with business-as-usual but with a low level of stimulation to growth with some new developments (e.g. new infrastructure);
- *Moderate growth scenario* - a moderate level of stimulus for growth is provided by government, with planned expansion/improvement of infrastructure and improved production – consistent with Bhutan's objective to achieve balanced regional growth.
- *High growth scenario* –- a high level of stimulation is provided to achieve significant and rapid development.

Such scenarios can also be used as alternatives to ve assessed.

Annex 10:

CONSOLIDATED CHECKLIST FOR THE QUALITY ASSURANCE, REVIEW, AND PERFORMANCE EVALUATION OF A COMPREHENSIVE SEA

There are a number of SEA quality assurance, review, and evaluation checklists available on the internet. This *Consolidated Checklist* combines the following resources:

- EU SEA Directive-based environmental report quality review table; quoted in Fischer (2007).
- IAIA (2002)
- NEMA (2012)
- Report Review Sheet. In NEMA (2012)
- ODPM (2005).
- Therivel R. (2006).
- Therivel R. (2010).

The Consolidated Checklist provides a relatively complete and robust system to quality-assure, review, and evaluate a ***comprehensive*** SEA from start-to-end (i.e., from scoping process to development outcomes), focusing different sections of the consolidated checklist on:

- Scoping Process and TORs;
- Draft SEA Report:
- Internal/ Administrative Review
- Detailed Content Review
- SEA Outcomes.

It goes without saying that quality assurance, review, and evaluation procedures have to be modified for ***SEAs that are quick appraisals or semi-detailed.***

INTRODUCTION

Note: The checklist cannot be used in a 'cookbook' fashion. Each SEA is unique; each SEA is tied to its TORs (including any limitations imposed on it by budget, available resources, data gaps, and context). The reviewer will NOT be able to answer all the listed questions in all cases; some questions may not be relevant to a specific SEA exercise. The 'checklists' are meant to ***guide reviewers*** (and to guide those responsible for conducting SEAs and writing SEA reports)! The checklists are not a prescription and they cannot replace (context-specific) good judgment!

The checklists comprise 11 sections that will provide reviewers and practitioners some insights into what to include in a comprehensive SEA and what to look for during review. Please always bear in mind the context specific-ness of the actual SEA exercise, the SEA's tier (policy vs. program level), the SEA's administrative level (national vs. local), and the SEA TORs (especially budget and allocated resources).

Section 1 can be used to conduct quality assurance on a scoping report.

Section 2, *'General Review'* mainly reviews the Report Presentation. NECS should complete this review before the report is sent to other stakeholders for review.

Sections 3 to 8 cover a '*Detailed Content Review*', which can be used by internal and external reviewers to systematically review these important SEA report chapters:

- Section 3: PPP description;
- Section 4: Policy and legal framework and links;
- Section 5: Description of the environmental baseline;
- Section 6: Determination of impact significance and evaluation of alternatives;
- Section 7: Mitigation and Environmental Management and Monitoring Plan (EMMP);
- Section 8: Consultation process.
- ***Sections 9–11*** can be used to monitor and evaluate SEA outcomes:
- Section 9 reviews aspects of the decision-making process;
- Section 10 reviews the SEA process overall.
- Section 11 looks at certain aspects related to SEA performance.

The review of scoping, the review of the SEA report in general and in detail, and review of the SEA outcomes will occur at different times in the PPP/SEA timeline. Table A10.1 summarizes the review system.

Table A10.1: The review systems at a glance

Type of review	Topic / review section	Main (Responsible) entity
Review of SEA Scoping	1. Scoping procedure	PPP proponent / SEA consultant / & competent authority
Review of the SEA Report: General Review	 2. General Review of the SEA Report	 Mainly comptent authority
Detailed Content Review	3. PPP description 4. Policy & legal framework and links 5. Description of the environmental baseline 6. Determination of impact significance & evaluation of alternatives 7. Strategic Environmental Management Plan (SEMP) 8. Consultation process	Reviews conducted by: • Lead agencies; • Public review; • Independent Committees [Technical Advisory Committee, or Independent Expert Commission). All review comments consolidated and considered by competent authority
Review of Outcomes: SEA Implementation	9. Decision making	Competent authority
	10. IAIA SEA process review	
	11. SEA performance monitoring & evaluation	

PROPOSED REVIEW PROCEDURE

- Within a given review exercise, each reviewer would be expected to summarize his/her review comments by topic/review section (and in the case of Lead Agencies, also by mandate, e.g., energy).
- Each entity could then summarize all the comments of its reviewers by topic. For instance, in the case where external reviewers are participating (e.g., during the technical review of the SEA document), each Lead Agency could summarize the comments of all of its reviewers by topic (e.g., Environmental Baseline).
- The competent authority is the entity that would have to consolidate the review comments from all the entities involved in the review process, for its deliberations and final decision /recommendations.

1. REVIEW OF SCOPING

Was the methodology used to conduct scoping described? Was it adequate? (i.e., Did it lead to a correct identification of key issues, objectives, stakeholders, & alternatives?)

Is there a clear description of the PPP & the PPP's objectives, the scope of the strategic action, and what the PPP can and cannot do?

- Were the objectives of the PPP confirmed and clarified and are they in line with existing (environmental, social or other) objectives?
- Were the PPP objectives & targets reviewed against the national, regional, or local environmental and social action plan(s)?
- Were the links between the PPP and higher- and lower-tier strategic actions considered?

Did the scoping process describe enough baseline to identify key problems? Did the scoping process identify key sustainability issues? Does the scoping report:

- List the environmental / social/sustainability issues considered in the assessment?
- Describe how key environmental/social/sustainability issues were identified?
- Highlight what matters are more appropriately assessed at other levels or layers of decision-making?
- Provide information on existing environmental/social/sustainability problems that are relevant to the PPP, including those relating to any areas of particular importance to sustainability?
- Outline the significant issues that need to be studied during the SEA?
- Provide valid reasons for eliminating some issues from further consideration (i.e., explain why were certain issues 'scoped' out?)
- Regarding studies to be conducted during the SEA, are the baseline-data-collection requirements related to the SEA objectives?

Did the scoping process identify adequate SEA Objectives?

- Does the scoping report provide information on relevant international & national environmental protection and social objectives?
- Were the international & national environmental protection, social & sustainability issues adequately considered in selecting & developing the SEA objectives, indicators, & targets?
- Was the national policy and institutional framework adequately considered in selecting and developing SEA objectives, indicators, and targets (e.g. other development, sectoral, or poverty alleviation objectives)?
- Were the SEA objectives described & clearly defined, quantitatively where appropriate?
- Do the SEA objectives & indicators cover an appropriate range of environmental, social & sustainability topics, including relevant objectives for the biological (e.g., for biodiversity & ecosystems), physical (e.g., for soil, water, air, landscape, climate change), & socio-cultural & economic components (e.g., for health, equity, poverty, heritage, or economy)?
- Were adequate decision criteria identified for the assessment (e.g., the use of relevant standards).?
- Were the technical, procedural, & other difficulties discussed (e.g., technical deficiencies, data gaps, or lack of know-how)? Were the assumptions & uncertainties made explicit?

Did the scoping process identify reasonable / adequate alternatives? Does the scoping report:
- Consider & describe how reasonable alternatives were identified & selected for further assessment?
- Were the alternatives that were selected for further assessment appropriate to the scale (national vs. local) and level (policy, plan, or programme) of decision-making?
- Do the alternatives deal with the key issues identified in the issues analysis?
- Do the alternatives include (among others) the ‘do nothing’/‘do minimum’/‘business as usual’ alternative & the ‘most environmentally beneficial’ alternative?
- Are the alternatives in the PPP proponent’s remit (i.e., in terms of geographical scope, objectives, and legal competence)?
- Are the alternatives feasible (i.e., are the relevant resources and technology available? are the alternatives implementable)?
- Are the alternatives relevant to the decision-making process (i.e., are the alternatives for ‘real’, as opposed to made-up for the SEA exercise)?
- Were reasons given for eliminating some alternatives? (Also see: 6b: *Evaluation of alternatives & selection of preferred alternative*).

Was the stakeholder consultation process conducted during scoping relevant and adequate? (i.e., were key stakeholders identified? was the stakeholder consultation process culturally appropriate)?

Was a careful stakeholder analysis carried out to identify and characterize stakeholders?
- Was the start of the PPP planning process announced and were key stakeholders brought together to agree on the problem, objectives, and alternatives?
- Were appropriate consultation bodies (including NGOs) & relevant authorities (including environmental and health authorities) consulted in appropriate ways and at appropriate times on the content, scope, alternatives, SEA objectives, and level of information to include in the SEA report?
- Was an appropriate communication plan / stakeholder engagement plan developed for the full SEA?
- Did the scoping process identify adequate spatial & temporal boundaries for the SEA?

Terms of References for the SEA study:
- Do the SEA TORs focus on significant issues?
- Does the SEA work plan to implement the SEA study seem appropriate?
- Does the SEA budget to implement the SEA study seem appropriate?
- Is the budget sufficient to implement the work plan?
- Was a management team and a SEA coordinator appointed?
- Is the list of experts (with supporting accreditation) adequate to conduct the study?
- Are the methods of data analysis & sources of relevant information listed?

2. GENERAL REVIEW OF THE SEA REPORT

*** The reviewer may need to interview some stakeholders.*

Is the SEA report complete, acceptable, and adequate (as defined below)?
- Does the SEA contain these chapters: non-technical summary, introduction, PPP description, environmental and social analysis (baseline description, evaluation of alternatives &risks, mitigation measures, consultation), recommendations, accompanying SESMP & appendices?
- Does the ***non-technical summary*** explain the overall approach to the SEA, the objectives of the strategic action, the objectives of the SEA, the main alternatives considered, the proposed mitigation & monitoring plan, & how the SEA changed the strategic action?
- Specifically, does the ***non-technical summary*** provide a statement summarizing:

- How environmental/social/sustainability considerations (and their relationship with economic concerns and drivers) were integrated into the PPP?
- How the SEA report and the results of the consultations were taken into account?
- The reasons for choosing the selected PPP over other reasonable alternatives?

Is the SEA report:
- Clear and concise in its layout and presentation? Does it use simple, clear language?
- Adequate in scope? (i.e., Has it adopted a good time horizon? An adequate spatial scale)?
- Practical in focus? (i.e., Does it focuses on a limited number of key issues, targets, indicators)?
- Presented as an integrated whole? (e.g., Are the chapters harmonized)?
- Carried out in a professional manner? (i.e., Does it provide an impartial/balanced analysis)?
- Presented in an open manner? (i.e., Are the methods & data accessible? Are assumptions explicit)?

Does the SEA report:
- Define necessary technical terms? Does the report avoid technical jargon?
- Identify the decision-maker?
- Identify who carried out the SEA and their competences?
- Provide a declaration jointly signed by the SEA consultant and the PPP owner?
- Use maps, other illustrations, and summary tables where appropriate?
- Describe the methodology used in the SEA (i.e., methodology for scoping, impact identification, prediction, evaluation, comparison of alternatives, & stakeholder identification & analysis)?
- Were the methods used appropriate to the size and complexity of the assessment tasks?
- Were difficulties explained (e.g., technical deficiencies or lack of know-how; data uncertainties or data quality issues)?

Was the draft PPP and draft SEA made available for public consultation and review by relevant authorities in a timely manner? Does the SEA report:
- Explain who was consulted and what consultation methods were used?
- Provide proof that various stakeholders were consulted (e.g., signed statements and/or minutes) and summarize the comments received and how each comment was addressed?
- Focus on the big issues / relevant strategic issues?
- Discuss the scope of the SEA? (i.e., Is the scoping report attached?)
- Comply with the policy, legal, and administrative framework for conducting a SEA (including being in compliance with existing procedural and substantive guidelines)?
- Comply with the TORs?
- Identify all sources of information, including expert judgment& matters of opinion?
- Provide adequate information (i.e. comprehensive, rigorous, understandable, & in compliance with the TORs) from the point of view of the PPP owner? What is missing? **
- Provide adequate information from the point of view of the key stakeholders & the TORs? What is missing?

3. DESCRIPTION OF THE PROPOSAL (+ LINKS)

Does the SEA report:
- Clearly highlight the strategic action’s purpose and objective(s)?
- If the SEA procedure was simultaneous with the PPP-making process, does the SEA describe how the SEA and the PPP-making processes were integrated:
    - ***Simultaneous with integrated SEA process*** (i.e., one team): Does the report describe what inputs & how the SEA inputs were integrated? Is this well documented?
    - ***Simultaneous with parallel SEA process*** (i.e., two teams): Does the SEA report describe what inputs/how/when the SEA inputs were integrated into the various decision-making windows / opportunities)?
- Identify the degree to which the PPP sets a framework for other projects/other activities (e.g., in terms of location, size, nature and operating conditions, or resource allocation and future projects that will require EIAs)?
    - Explicitly highlight the links to project-level EIA (i.e., Does it explain what type of projects requiring EIA will follow from implementing the PPP)?
- Clearly outline the (expected) content of the PPP, including the area covered and the implementation timeframe?
    - Identify (&describe to extent possible) PPP implementation activities that could influence:
- Important ecosystem services / important ecosystem diversity;
- Areas with legal and/or international status?
    - Identify (&describe to extent possible) PPP implementation activities that could influence:
- Changes in land use or lead to the depletion of natural resources;
- The production of raw materials, chemicals, and other hazardous products;
- The generation of pollutants and wastes?

    - Identify (and describe to extent possible) PPP implementation activities that could lead to these *direct drivers of change:* (also see Section ‘Baseline’):
- Land conversion;
- Fragmentation (and isolation of important habitats);
- Extraction / use of natural resources;
- Wastes (all types);
- Disturbance of ecosystem composition, structure, or key processes;
- Introduction of alien species;
- Restoration;
- Population changes;
- Conversion or diversification of economy or land use;
- Enhanced transport, services, or access;
- Marginalization and exclusion?
    - Identify (and describe to extent possible) PPP implementation activities that could lead to *indirect drivers of change*:
- Societal changes (demographic, economic, socio-political, scientific, or changes in social values) (e.g., a new technology could result in more intensive use of a resource in the future)?
- Are the *assumptions about what the strategic action will ‘look’ like* when implemented clearly stated or, if implicit, do they make sense? (This query is repeated in Section 6)

4. POLICY AND LEGAL FRAMEWORK AND RELATIONSHIP TO OTHER PPPS

Does the SEA report:
- Clearly explain the PPP’s links to other related PPPs, including links between the strategic action and related higher- and lower-tier strategic actions?

Consistency and Compatibility Analyses:
- Does the SEA identify & describe any conflicts that exist between the SEA objectives (e.g., an internal consistency analysis on the SEA objectives)?
- Does the SEA identify & describe any conflicts that exist between the PPP’s objectives (i.e., internal consistency analysis of the PPP objectives)?
- Does the SEA identify & describe any conflicts that exist between the SEA objectives & the PPP’s objectives (compatibility analysis)?
- Does the SEA identify and describe any conflicts that exist between the PPP’s objectives & the objectives of other PPPs (compatibility analysis)?
- Where the proposed PPP, other strategic actions, or other objectives are in conflict, does the report clearly document the reasons for the conflict and does it make recommendations on how to reconcile the PPP [or how to reconcile the other PPP(s)] to promote sustainability?
    - Where identified conflicts are not reconcilable, does the SEA explicitly state which PPP, action, or objective will dominate?
- Does the report succinctly summarize all of above, highlighting the most relevant to the PPP (relevant in terms of important problems and/or tier of assessment)?

5. ENVIRONMENTAL BASELINE DESCRIPTION

Bearing in mind the likely PPP activities (identified in section 3), does the SEA report:
- Describe the relevant aspects of the current biological, physical, social-cultural, and socio-economic environment, as per TOR requirements?
- Provide a ‘trend’ analysis of relevant, important aspects (i.e., does it describe/predict the future environment *without* the PPP)?
- Describe *in detail* the environmental and social characteristics of the area likely to be significantly affected, including areas beyond the physical boundary of the PPP that are likely to be affected?
- *Specificall**y,*** does the SEA provide sufficient information / baseline information on the likely significant effects of the different options on (where relevant):

  Biological component:
- Biodiversity & ecosystem services;
- Protected areas;

  Physical component:
- Soil
- Water
- Air
- Climate & climate change

- Landscape

Social-cultural and socio-economic component:

- Population
- Human health
- Cultural heritage, including architecture and archaeology
- Material assets
- Resource use (e.g., water, land use)
- Economy

And, the (important / relevant) interrelationship between the above biological, physical, and social-cultural and socio-economic components?

- Does the baseline data cover more than just an inventory of species? Was there a focus on important ecological systems, their services, their resilience, and vulnerability, & the significance of the ecological services for human well being?

Does the report:

- Explain data sources, data gaps, and assumptions, where relevant?
- Describe the tools & methods used to complete the baseline description?

6. DETERMINATION OF IMPACT SIGNIFICANCE & EVALUATION OF ALTERNATIVES / OPTIONS

6.a Impact identification, prediction, & evaluation

- Are *assumptions about what the strategic action will 'look' like* when implemented clearly stated or, if implicit, do they make sense? (Same query seen in Section 3)
- Are *assumptions* about the likely *impacts* of the strategic action's implementation clearly stated, or if implicit, do they make sense?
- Is the area and time over which the predictions are made appropriate?
- Is an effort made to prioritize those effects that most affect sustainability?
- Is the level of detail of the predictions appropriate (is it proportional to the level of detail of the strategic action& the baseline data, and is it 'fit for purpose'? Are the predictions overly-detailed or insufficiently detailed?)
- Is the level of uncertainty regarding the predictions documented?
- For each alternative/option, are the likely significant impacts on the environment identified, described/predicted, and evaluated?
- For *each alternative*, does the SEA:
    - Identify both positive and negative effects?
    - Identify the probability, duration (short-, medium-, or long-term, permanent or temporary), frequency, and reversibility of the effects?
    - Identify the magnitude and spatial extent of the effects (geographical area and size of population affected)?
    - Identify the secondary, cumulative, and synergistic effects?
    - Identify the trans-boundary effects?
    - Identify risks to human health and to the environment (e.g. due to the risk of accidents)?
    - Are the impacts on different groups of people identified and evaluated (e.g., on those stakeholders already negatively affected by environmental impacts and risks)?
- Has impact evaluation been carried against a clearly stated and reasonable basis? e.g., evaluated against the current situation, future situation, environmental standards, SEA objectives, or environmental limits?
- In evaluating '**significance**', is the 'importance' of environmental components considered using various ways of viewing importance e.g.:
    - ***Institutional recognition*** (i.e., the attribute is acknowledged in the policy and legal framework or has relevant accepted standards, regulations, and thresholds);
    - ***Public recognition*** (i.e., the public recognizes the feature as important);
    - ***Technical recognition*** (i.e., the feature is recognized as important based on scientific or technical knowledge)?
- Were the tools/methods used to identify and evaluate impacts adequate?

6.b Evaluation of alternatives/options & recommendations on the preferred alternative/option

- Was each alternative/option evaluated against the SEA objectives or relevant baseline?
- Were the environmental, social and sustainability effects (both adverse and beneficial) of each alternative/option compared to the other alternatives/options?
- Were the residual impacts (impacts remaining after mitigation) of each alternative/option evaluated and compared?

Does the SEA report:

- Outline how the alternatives were assessed & the reasons for selecting the preferred alternative(s)?
    - Did the assessment & the procedure for comparison use credible tools/methodology?
    - Did the evaluation/comparison of alternatives involve appropriate stakeholders?
- Are credible reasons given for eliminating certain alternatives?
- Are 'trade-offs' explained and justified?
- If 'trade-offs' are necessary:
    - Are irreversible impacts avoided?
    - Are impacts that would exceed environmental thresholds or limits avoided?
    - Are sensitive areas avoided?
    - Are areas that have already been cumulatively affected avoided?
    - Is greater weight given to longer-term impacts?

7. MITIGATION AND STRATEGIC ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (SESMP)

7.a Mitigation: *Does the SEA report:*

- Document that the mitigation hierarchy of first avoidance, then mitigation, and then compensation was followed?
- Identify measures to avoid, reduce, repair, or compensate for any significant adverse effects of implementing the PPP?
- (Mainly) propose mitigation measures that are within the PPP proponent's remit or control?
- Identify measures that are likely to be effective (i.e. measures that will manage a good share of the impacts caused by the strategic action)?
- Clearly commit to measures to avoid, reduce, repair, or compensate for any significant adverse effects of implementing the PPP (e.g., is there a budget and an organizational framework for implementing impact mitigation & monitoring)?
- Identify & commit to measures to enhance positive effects of implementing the PPP?
- Where relevant, identify mitigation measures that need to be taken into account in follow-on project consents (e.g., does it identify subsequent EIAs? or the need to conduct specific types of assessments e.g., poverty impact assessment or gender impact assessment)?

7.b SESMP: *Does the SESMP:*

- Summarize the impacts related to the PPP?
- Describe the mitigation measures envisaged to prevent, reduce, or compensate for any significant adverse effects on the environment or social conditions related to the PPP [including the need for subsequent EIAs or the need for specific designs, equipment, or operating procedures]?
- Summarize the enhancement measures related to the PPP?
- Describe the SESMP implementation framework:
    - Explain how existing monitoring arrangements may be used, where appropriate?
    - Propose monitoring measures that are clear and practicable?
    - Provide clearly defined indicators based on the baseline information and on the objectives of the PPP and the SEA?
    - Describe the measures envisaged to monitor the significant environmental and social effects of the PPP implementation?
    - Describe how monitoring will identify & manage unforeseen adverse effects in a timely manner, e.g., in the case where SEA predictions prove to be inaccurate?
    - Provide thresholds that signal the need for corrective actions?
    - Propose adequate action in response to significant adverse effects?
    - Ensure that the collected monitoring data addresses deficiencies in the SEA's baseline information?
    - Describe the institutional arrangements (responsibilities for mitigation and monitoring, &any coordination arrangements)?
    - Describe the implementation schedule (e.g., methods, sampling locations, detection limits, timing, and frequency of measurements & duration of mitigation measures)?
    - Describe reporting procedures?
    - Provide cost estimates (initial investment and recurring expenses)?
    - Provide for institutional strengthening and capacity building requirements (equipment requirements & training requirements)?
- Describe how stakeholders provided input to the mitigation and monitoring plan?
- Describe the role of the various stakeholders (including the public) during the SESMP implementation?
- Define outcome indicators?
- Provide an evaluation plan (with adequate budget and clear responsibilities)?

8. CONSULTATION PROCESS (DURING SCOPING, THE SEA STUDY, THE SEA REVIEW, AND DURING IMPLEMENTATION AND MONITORING)

- Was there an effective co-operation between the SEA team and the PPP proponent? If not, how could this be improved in the future? ***(May require interviews)***
- Was SEA consultation an integral part of the PPP-making process [in the case of a simultaneous (parallel or integrated) SEA model]?
- Was SEA consultation integrated into the SEA design and implementation (e.g., were stakeholders consulted on the SEA TORs, the baseline, the evaluation of alternatives, the identification of mitigation and monitoring measures, and the SEA review)? (Relevant to the 'separate' and the 'simultaneous' SEA model.)
- Overall, was the consultation process adequate and effective? How could it be improved in the future?
- Was there broad participation in the SEA, that is:
- Were relevant professional, technical, social, and NGOs groups represented?
- Did the decision-makers participate (to ensure adoption and endorsement)?
- Were the communication methods effective, i.e., tailor-made to the needs of the different audiences?
- Did the SEA process promote collective learning and feedback? Did the SEA process support the development of local assessment capacity?

Does the SEA report:
- Describe ***how/when*** the relevant stakeholders were ***identified*** and how their interests were ***analyzed*** (i.e., during scoping, SEA preparation, and SEA review)?
- Describe ***how/when*** the relevant authorities (including environment and health authorities), lead agencies, and the public were ***consulted*** (i.e., during scoping, SEA preparation, and SEA review)?
- Specifically, describe ***how/when*** the ***draft PPP*** and the ***draft SEA report*** were made ***available*** to relevant authorities, lead agencies, and the public and ***how/when*** they were allowed to ***express their opinions*** on the documents?
- Was an appropriate range of stakeholders consulted (i.e., was the stakeholder analysis sufficient)?
- Were these stakeholders consulted in ways and at times that gave them an early and effective opportunity with appropriate timeframes to express their opinion on the draft PPP and draft SEA report:
    - *Lead agencies and other authorities?*
    - *Environmental and health authorities*?
    - *Expert committee* (TAC, SERC, or IEC)?
    - The *public* (or more likely, the designated public representatives likely to be
    - affected by, or having an interest in the PPP)?
    - Was there an effort to *involve vulnerable stakeholders* (e.g., very poor) in the consultation? If so, was it successful? How could this be improved in the future?

Does the SEA report:
- Summarize & address all stakeholder views?
- Highlight how the consultation results were considered in decision-making?
- Provide adequate documented evidence of the consultation events?
- Outline a grievance mechanism if stakeholders feel that their opinions have not been sufficiently addressed?

OUTCOME REVIEW

9. DECISION-MAKING

- Was the SEA conducted as an integral part of the decision-making process? [i.e., In the case of a simultaneous SEA model (integrated or parallel), were SEA inputs considered during decision windows? In the case of a separate or a reactive (ex-post) SEA, were SEA inputs considered when approving, revising, or amending the strategic action]?
- Does the Final SEA Report explain how the SEA findings & stakeholder inputs were considered during decision-making?
- Was the Final SEA Report and the opinions of those consulted taken into account in finalizing and adopting the PPP?

What was the influence of the SEA on the PPP process?
- Was the SEA proactive? i.e., Did the SEA provide assessment results early enough to influence decision-making?
- Did the SEA provide useful information for those responsible for developing the PPP?
- Did the SEA identify the issues most important to *sustainable outcomes*, rather than dealing with all environmental issues?
- Did the SEA address questions & concerns not initially included in the PPP? What was appreciated most? What proved irrelevant?
- Could the SEA findings be effectively conveyed to the decision makers?
- Were decision makers willing to consider the SEA inputs and willing to integrate the findings into decision-making?

- Did the SEA actually make the PPP more environmentally sound?
- Did the PPP process make sufficient reference to the findings of the SEA?

Did the SEA build capacity and improve accountability/transparency?
- Did SEA empower weak and vulnerable stakeholders?
- Did the SEA help build capacity by training decision makers on implementation?
- Did the SEA build capacity to collect data and provide documentation?
- Did the SEA enhance the transparency of the decision–making processes and accountability of decision makers on the environmental implications of the PPP?
- Did decision makers justify/correct their decisions based on SEA findings & SEA monitoring?
- Did the SEA exercise lead to a better understanding of the potential of this approach? Did the SEA exercise encourage subsequent SEA applications (did the SEA results identify other PPPs requiring SEA? Was the SEA process fruitful and/or a positive experience, making the participants more willing to participate in the next SEA)?

** Some of the above questions may require interviews.

10. IAIA SEA PROCESS REVIEW

Was the SEA Integrated?

Did it:
- Ensure an environmental assessment/sustainability appraisal of all the PPP's strategic decisions?
- Address the interrelationships of biophysical, social, and economic aspects?

Was it:
- Tiered to policies in relevant sectors & transboundary regions and, where appropriate, to project EIA and decision-making?

Sustainability-led? Did it:
- Facilitate identification of more sustainable development options & alternatives?

Focused? Did it:
- Provide sufficient, reliable, usable information for planning & decision-making?
- Concentrate on key issues of sustainable development?
- Was it customized to the characteristics of the decision-making process?
- Was it cost- and time-effective?

Accountable? Was it:
- The responsibility of the strategic decision's lead agencies?
- Carried out with professionalism, rigor, fairness, impartiality, and balance?
- Subject to independent checks and verification?

Did it:
- Document & justify how sustainability issues were considered in decision making?

Participatory? Did it:
- Inform & involve interested and affected public and government bodies throughout the decision-making process?
- Explicitly address stakeholders' inputs & concerns in the report & in decision-making?
- Provide clear, easy-to-understand, necessary information?
- Ensure sufficient access to all relevant information?

Iterative? Did it:
- Make available the assessment results early enough to influence the decision-making process and inspire future planning?
- Provide sufficient information on a strategic decision's actual implementation impacts to judge whether the decision should be amended?

Overall comments on the SEA process:
- What is/what was the view of key stakeholders (particularly the more vulnerable) and those responsible for developing the PPP on the SEA procedure and results?
- How could it be improved in future?
- What were the most significant constraints to achieving an effective SEA?

- What were the most significant positive factors ensuring success of the SEA?
- Did the SEA address equity, social acceptability, and incorporate the precautionary principle?

** Some of the above questions may require interviews.

11. SEA PERFORMANCE REVIEW: IMPLEMENTATION, MONITORING, & EVALUATION

Did the SEA predict future outcomes correctly?

- Were the assumptions made during the SEA for modelling impacts and/or institutional and governance requirements correct?
- Were there any PPP-related unforeseen impacts? Explain.

What was the influence on the implementation process?

- Did the SEA improve the strategic action (i.e., did the SEA result in relevant amendments / modifications to the PPP? Did it identify more sustainable alternatives?)
- Did the SEA lead to more effective implementation? (e.g., Did it inform subsequent lower-tier decision-making? Did it improve monitoring and follow-up?)
- Did the SEA succeed in actually changing the PPP implementation or budget plans, or other subsequent measures, making the PPP more environmentally sound?
- Did the PPP implement measures that better reflect the goals of sustainable development?
- Were the options implemented in a more environmentally-sound manner?
- Did the recommendations of the SEA lead to:
- Institutional development (e.g., an advisory group on environment or better inter-sectoral coordination)?
- Subsequent EIA requirements?
- Improved governance (e.g., empowerment of vulnerable stakeholders)?
- More sustainable implementation / more sustainable resource use by the PPP?
- Did the different stakeholders implement their relevant SEA recommendations?
- How do the stakeholders view the SEA process and its outcomes now?

What was the influence on direct & indirect goals of sustainable development?

- Are there any indications that the SEA contributed to:
    - Achieving SDGs and /or other goals of relevance in the particular case?
    - Environmental protection and sustainability?
    - Improving conditions of environment and natural resources in the relevant
    - area?
    - Enhancing transparency, accountability, and good governance?
    - Improvements to future PPP making? (e.g. Were key environmental issues
    - identified? Were lessons learnt? Do planners have a better understanding of
    - sustainability issues?)
- Did the sustainable development benefits of the SEA outweigh the costs of conducting the SEA?

Annex 11

Trend analysis

For conducting many SEAs, trend analysis is likely to one of the most useful approaches. Trend analysis can be defined as an interpretation of changes over time without and with the proposed/revised PPP. It has several advantages:

- It can help to describe the past trends and current situation by tracing any trends or patterns in the relevant territories in time periods covered by the SEA.
- It can also help in predicting future 'baseline' trends without the proposed PPP being implemented (the so-called 'zero alternative') since some trends can be safely extrapolated based on the information about their future drivers[2]. Such analyses can open many new insights and can be useful not just for the SEA process but also for the development of the PPP as such.
- Lastly, the trend analysis can facilitate the assessment of cumulative impacts of proposed developments (including downstream projects) in the PPP on the identified future "baseline" trends.

Trend analysis can combine many different tools and it has the capacity of analyzing cause-effect relationship even in situations constrained by significant data gaps. The presentation of trends can be fairly simple, e.g.:

- Story-lines that describe the overall trends, their main drivers, their territorial dimensions and key concerns and opportunities arising from these trends;
- Maps showing spatial development patterns;
- Graphs: these can be (a) simple graphs that use available data sets to illustrate evolution of key issues and/or their drivers over time, of (b) complex graphs that provide a comprehensive overview of the correlation between the evolution of drivers over time and the corresponding (sometime delayed) changes in the issues addressed by the analysis.

Proper understanding of the current situation and trends and their likely evolution if the PPP is not implemented provides the basis for predicting environmental and social effects within the SEA. These trends may be influenced in various ways by e.g.:

- Market forces – e.g. higher prices for minerals can stimulate mining,
- Major development projects that have been already approved but not implemented yet,
- PPPs other than one being directly assessed by the SEA; and
- Changed climatic conditions

Impacts of these developments may not yet be visible or fully evident. The forward-looking analyses undertaken by an SEA should outline the expected future environmental and social trends since it is important to understand impacts of the PPP on the "future environment" in which the PPP will operate. Many environmental and social issues may improve and many may get worse in the future irrespective of the proposed PPP (e.g. some ecosystems will be lost anyway; many environmental features will become even more important; the population will grow anyway and place increased demand on land and natural resources). It is also important to consider that, in the near future, some environmental and social trends may be affected by climate changes - e.g. increasing temperatures, flash floods, landslides, forest fires, glacial retreat and glacial lake outburst floods (GLOF), water shortages, declining yields of some crops (e.g. maize and rice) and increases for others (e.g. potato), changes in pests and plant diseases as well as rainfall patterns, shifts of forest types to higher elevations, changes in the ranges of species, increased risk of water-borne diseases and spread of vector-borne diseases (e.g. malaria, dengue).

SEA requires consideration of long-term trends and the SEA team needs to present sound judgments on the ongoing environmental and social changes (which may be linked) which are relevant to the PPP. In this regard, it should be noted that the most common deficiencies in analyzing current situation and trends do not usually arise from the lack of data but rather from poorly targeted analyses that focus on irrelevant issues. This task therefore demands, especially in the case of large scale PPP, focused

[2] Oversimplified extrapolation that does not consider how the trend will evolve once it reaches a key breaking point (e.g. when carrying capacity of the surrounding environment has been reached or exceeded), or once the counter-trend becomes stronger, may be misleading.

analytical thinking, a strategic approach to data collection and qualified expert judgments.

In order to ensure that the assessment of the current situation stays focused, it is recommended to concentrate on the main environmental and social issues, objectives and guiding questions that have been identified in the preceding SEA scoping step. The SEA experts need to gather just enough information to answer the following questions:

- How good or bad is the current situation? How far is the current situation from any established thresholds or targets?
- Are particularly sensitive or important elements of the receiving environment affected, eg vulnerable social groups, non-renewable resources, protected areas, endangered species, rare habitats? Are the problems reversible or irreversible, permanent or temporary?
- What is driving these trends?
- What is the expected future continuation of these trends, if one considers impacts of other already agreed projects or PPPs and considering impacts of climate change?

Both qualitative and quantitative information can be used for this purpose. The description of the past and current trends can be made on the basis of data available from existing information sources (eg State of the Environment reports, data from other available PPPs, research projects, donor analyses), or through expert judgments (in cases where data are lacking). SEA experts should not embark on collecting raw data at this stage; unless very clear key issues are identified for which no data are available. They are required to accomplish this task while taking into account available studies and considering the key driving forces behind these trends. When maps are easily available, these analyses may be supplemented by maps showing spatial dimensions and linkages between the key environmental, social and economic issues in the study area.

The data on the current and future environmental and social trends serve not just to inform future SEA steps but may also strengthen the analysis of the overall development context during the elaboration of the PPP. In cases where the SEA process is carried out during the elaboration of the PPP, information gathered or generated during this step can be provided to the PPP planning team and may strengthen the analysis of the overall development context.

Analysis of environmental and social trends without the PPP can significantly benefit from inputs of key authorities, academia, business groups or NGOs that have the relevant information. Workshops, roundtables and formal meetings, etc. can be used for this purpose.

Tips for practice

Keep the focus when collecting information: Do not collect excessive details or use information just because it is there. Concentrate on environmental and social issues, objectives and guiding questions identified in the scoping phase and do not overburden evaluation of the situation with irrelevant information.
Set a time limit for information collection. Do not expect to be able to obtain all relevant information in the first SEA of a PPP, but make arrangements to fill any major gaps for future replacements or reviews of PPP.
Use the expertise within environmental and social authorities and key stakeholders to identify and interpret relevant data and predict trends.
When describing the past trends, try to determine the main economic or social factors that drive these trends. This information may later help you to analyze whether the PPP positively or negatively influence these driving forces.
Consider impacts of other relevant PPP and outline the likely expected evolution of environmental trends, if the proposed PPP were not to be implemented.
Consider the impacts of the expected climate changes on the future environmental and social trends as increased risk of hazards may increase vulnerability..
Where possible, supplement these analyses by maps showing spatial dimensions and linkages between the key environmental, social and economic issues.
Share and double-check this information with the planning team.

Tables A11.1 and A11.2 provide fictional examples of a trends analysis for past trends and future trends, respectively.

Table A11.1: Fictional example of past trends analysis for terrestrial biodiversity

Analysis of past trends and current situation	
Theme: Issues:	**Terrestrial biodiversity** Condition and extent of natural areas and connectivity of important ecosystems
Please describe: • An overall context of the theme addressed (i.e. original/natural potentials & constrains, etc. - basic facts such as volumes, acreage, etc. accompanied by a short commentary on their importance – international, national, provincial, local) • List issues that you have chosen to focus on within this theme and justify in 1-5 sentences for each issue why it is important – wherever possible relate it to official documents that also recognize these issues as important • For each issue, analyze its past trend (e.g. how has the situation evolved so far, whether the trend is improving or worsening, whether it reaches any critical bottom-lines or turning points, etc.) • Factors (drivers) that positively or negatively affect this trend or that limit the trend (counter-trends). When doing so, you may wish to cross-refer to any relevant national/provincial/local SPPs or major projects. • The key problems and/or the key geographic areas of specific concern (of national, provincial and local importance) • Always quote sources of data (e.g. full references in footnotes) and when necessary provide commentary on their quality and uncertainties – if you found that some critical pieces of information are missing or may be doubtful (contradictory, incomplete, etc.), state it clearly. E.g. • In 1990, the province had extensive population of XX critically endangered species (out of which XX species are endemic) and of XX endangered species (out of which XX species are endemic). Further to this, the province hosts a small population of XX species which are not protected but they play a significant role in the lifestyles of the local ethnic groups. • Valuable natural ecosystems in areas (see attached map) accounted for ZZ ha (25% of the territory of the province) in 1995. They were connected by bio-corridors KVD and HWD which played an important role for migration of XX critically endangered or endangered species. The Biodiversity Conservation Action SPP of the province (elaborated in 1994 by SWA but not yet awaiting formal approval by Provincial People's Committee) has suggested ensuring that at least 15% of the territory becomes protected to halt biodiversity decline. • Until 2006, 9% of territory of the province has received various degrees of protection. ZZZ ha in location XYZ that hosts species SSS has been declared as national park which is also classified as habitat of international importance (see ministerial meeting XSW and resolution by KWC). ZZZ ha in location UBF serves as a breeding ground for species GDE has been declared protected area, etc. Areas GBH 1-3 have been proposed as special use forests. • At the same time, ZZ ha (5% of valuable important ecosystems found in the province) have been irreversibly damaged by conversion of these natural ecosystems to mining and agriculture. The remaining valuable ecosystems that are endangered by forestry practices FFF. As overall degradation of the ecosystems regards, it should be noted that the status of existing protected areas does not entirely prevent degradation of already protected ecosystems (e.g. forestry practices GHJ cause impacts YUZ in locations DRT). • A study by FAO found out that a most important driving force for deforestation in rural areas is development of paved roads in rural areas. The pavement of new roads contributes to 85% of forest loss. Corridors along the newly paved roads (5-10 km on each side of the road) quickly become deforested due to illegal logging and subsequent small-scale illegal agricultural activities and informal settlements. So far, all government measures to tackle this problem were ineffective due to lack of enforcement. • The bio-corridor KVD has been irreversibly damaged by road developments in AA1. Migration of critically endangered species XX has stopped with the fragmentation of this bio-corridor; however some migration reportedly takes place through the bio-corridor HDW. The bio-corridor HDW thus serves as the only migration route for species XX and plays the key role the viability of these populations of these migratory species in the province, and in the country generally. + supplemented by any graphic aids to illustrate the trend - graphs, maps, pictures or boxes with local stories that provide representative examples the trend.	
Future trends without the proposed SPP	
Theme: Issues:	**Terrestrial biodiversity** Condition and extent of natural areas and connectivity of important ecosystems

Key factors that will influence these trends	Likely expected positive or negative impacts of these factors on the given trend
Outline key factors that may positively or negatively influence the future trend in this issue without the SPP. These may include: • market drivers; • new policies, laws and regulations and economic incentives, • other agreed SPPs; • major projects; and • climate change!	Explain in detail: • Character of impact (what exactly causes this impact or assumptions that form the basis for your prediction) • Probability and key uncertainties • Geographic scale - directly and indirectly affected territories • The key concerns associated with this impact All these statements need to be substantiated (calculations, examples, references to international and national literature, maps, graphs) which can be annexed to illustrate the impact.
Spatially-focused plans (Ps) for Development of Tourism for 2007-2013 (Ministry of Tourism, 2006)	10 ha of coastal ecosystems that are part of the planned protected area ZDT may be lost in next 6 years because of planned tourism projects in LKT, HWT, CZD. The scale of impact depends on the outcomes of detailed design of these Planned projects that will be also subject to EIAs.
Forestry Ps (MARD, 2005)	Natural ecosystems that could be declared protected areas are likely to decrease by approximately 5% in the next 6 years, mainly because of recently adopted changes in the forest classification and approval of logging projects at QSW and GRF.
Aquaculture projects in XYZ & ZSY (approved by the District People's Committee in 2006)	Both projects have damaged bio-corridor GJY. No plans for rehabilitation of these bio-corridors exist.

Summary of key trends in the relevant environmental issue without the implementation of the SPP
Please use the above information to outline: • How good or bad is the current situation? Do trends show that it is getting better or worse? • How far is the current situation from any established thresholds or targets? • Are particularly sensitive or important elements of the receiving environment affected, e.g. vulnerable social groups, non-renewable resources, endangered species, rare habitats? • Are these problems reversible or irreversible, permanent or temporary? • How difficult would it be to offset or remedy any damage? E.g. • Valuable natural ecosystems that could be declared as protected amount for 25% of the territory. Until now 9% of these ecosystems have been declared protected areas but the most important bio-corridors that connect them have been damaged. • Valuable natural areas are likely to decrease by approximately 5% in the next 6 years, mainly because of recently adopted Transport Development SPP and approved future projects for aquaculture and tourism. No plan for rehabilitation of bio-corridors exist.

Table A11.2: A fictional example of assessment of impacts of future environmental and social trends as influenced by the actions proposed in a PPP - for terrestrial biodiversity

<table>
<tr><th colspan="3">Analysis of future trends with the SPP</th></tr>
<tr><td>Theme:
Issues:</td><td colspan="2">Terrestrial biodiversity
Condition and extent of natural areas and connectivity of important ecosystems</td></tr>
<tr><td colspan="3">Summary of the past and future trends without the SPP
Summarize the past and future trends without the SPP – e.g. through 5-10 sentences that remind the reader of the past trends, current situation and future trends without the SPP
E.g.
Valuable natural ecosystems that could be declared as protected cover 25% of the territory. Until now 9% of these ecosystems have been declared protected areas but the most important bio-corridors that connect them have been damaged.
These areas will decrease by approximately 5% in the next 6 years, mainly because of recently adopted Forestry Policy and approved future projects for wind-farming, aquaculture and tourism. No SPPs for rehabilitation of bio-corridors exist.</td></tr>
<tr><td colspan="3">Expected direct effects of the proposed SPP on the future trend in this issues</td></tr>
<tr><td>Components of the SPP</td><td>Expected environmental risks (negative impacts) and environmental opportunities (positive impacts)</td><td>Proposed mitigation and enhancement measures</td></tr>
<tr><td>Feature or component of the SPP which cause these impacts (these may be the overall development direction pursued by the SPP, clusters of projects or individual projects proposed in the SPP).</td><td>Explain in detail:
• Character of risk/impact (what exactly causes this risk/impact or assumptions for this prediction)
• Probability and key uncertainties
• Geographic scale -directly and indirectly affected geographic areas that will become of specific concern
• Duration and reversibility
• Key concerns associated with this impact

When doing so, make sure that you judge these impacts on the basis of future trends without SPP (e.g. some important ecosystems or development opportunities may be lost as result of development trends without the SPP or some ecosystems or development opportunities may become even more important since they will provide the only remaining assets in the study area).

All these statements can be substantiated by detailed calculations, examples, and references to international and national literature and supplemented by graphic aids (maps, graphs) to illustrate the impact.</td><td>Provide your recommendations for possible changes in this proposed strategic orientation of the RDP.

You may also suggest additional ‘flanking’ measures for future management of environmental issues that you’ve identified.</td></tr>
<tr><td>Project 1.1.1.</td><td>The construction will most probably lead to fragmentation of ecosystem AXT that will form an integral part of the only remaining regional bio-corridor. This impact can be either short-term or permanent depending on the effectiveness of mitigation.</td><td>This loss of bio-corridor can be compensated by restoration of damaged ecosystems AXT after the construction.</td></tr>
<tr><td>Projects 1.2.3. and 4.4.2</td><td>….</td><td>….</td></tr>
<tr><td colspan="3">Expected future cumulative effects of the SPP on the trends for the issue</td></tr>
<tr><td colspan="3">Summarize the worst-case scenario & the best-case scenario for the future evolution of this trend if all direct and indirect impacts of relevant components of the SPP on the trend would happen.

E.g.
<u>Worst-case scenario</u>
If SPP proceeds as planned, 250 ha of natural ecosystems in location CDR, etc will be lost and 4 bio-corridors DWS, etc. of international importance will be permanently damaged. This trend will most likely lead to extinction of species FRD, GWS, etc.

<u>Best-case scenario</u>
If all recommended changes to SPP are adopted, only 50 ha of natural ecosystems in location DRT, etc. will be lost and only 2 important bio-corridors will be temporarily damaged. This damage - which will occur in any case - can be compensated by establishment of new protected areas in XXX. Species FRD, GWS will remain critically endangered and greater attention needs to be given to their protection.</td></tr>
</table>

Annex 12

Analytical methods that can be used in SEA

Source: UNECE and REC (2006)

This annex provides a menu of selected analytical tools and techniques that can be used in SEA and offers an overview of each method. In practice, the SEA experts may find it appropriate to vary their approach, for instance in combining qualitative and quantitative assessment. The following methods are described:

- Expert judgments
- SWOT
- Checklists
- Matrices
- Spatial analyses: Overlay maps and GIS
- Trends analysis/extrapolation
- Networks and flow diagrams
- Delphi technique
- Modelling
- Multi-criteria analysis

The key features of these tools can be summarized as follows:

Tools	**Application within the SEA process**				
	Identification of issues and impacts	**Analysis context and baseline**	**Contributing to development of alternatives**	**Assessment of impacts**	**Comparing key options for decision-making**
Expert judgment	✓	✓	✓	✓	✓
Checklists	✓				
SWOT	✓	✓			✓
Matrices	✓		✓	✓	✓
Networks and flow diagrams	✓	✓		✓	
Spatial analyses: Overlay maps and GIS	✓	✓	✓	✓	✓
Trends analysis/extrapolation	✓	✓	✓	✓	✓
Delphi technique	✓	✓	✓	✓	✓
Modelling	✓	✓	✓	✓	
Multi-criteria analysis			✓	✓	✓

Tool: Expert judgment	
Linkages to other tools	Matrices Delphi technique Modelling Multi-criteria analyses
Purpose	Expert judgment is a process for obtaining data directly from experts in response to a technical problem.
Description	Expert judgments are part of any SEA process. This is inevitable because SEA is an analytical process which examines the relevant trends and risks through: • identification of key strategic issues relevant for the plan (and its position in the decision-making process); • determination of spatial and temporal scale of the relevant issues; and • selection of appropriate indicators (or proxy-indicators) that simplify the evaluation and turn it into manageable assessment. Use of all analytical approaches and tools in the SEA is therefore always influenced by expert judgements. The SEA tools that most rely on the expert judgements include: Matrices - experts need to use their own judgement determine the key impacts or synergies/conflicts addressed by the matrix; • Modelling - experts need to use their own judgement to identify the specific issues and interactions that needs to be modeled; determine key assumptions and boundaries of the modeling; select suitable model and verify it, calibrate it and fine-tune it to fit the local situation and data availability; and • Multi-criteria analyses - experts need to use their own judgement to determine the assessment criteria, their relative importance (weights) and performance (scoring) of each proposed option. This summary deals with one specific form of expert judgment when the recognized 'experts' in the relevant fields directly formulate explicit and quantitative views on the probability and magnitude of the expected impacts and explain uncertainties in these predictions. Well organised expert judgments does not mean 'guessing' since the participating experts need to usually clearly explain: • Assumptions on which the judgment is based (when would the risk/impact occur and what it is caused by); • Character of the predicted risk/impact (e.g. probability of the risk/impacts, its nature and scale; and duration and reversibility) • Directly and indirectly affected geographic areas, ecosystems or persons (e.g. particularly sensitive or important elements of the receiving environment, vulnerable social groups, non-renewable resources, endangered species, etc.); • Baseline situation (e.g. the past, present and future actions which should be considered when judging this risk/impact and the relative importance of the expected risk/impact when compared with the baseline situation); • Key concerns associated with the predicted risk/impact (e.g. how far is the predicted impact from any established thresholds or targets); and • Magnitude of key uncertainties in this judgment. When these rules of good practice are expected, expert judgment can reflect a life-long experience and expertise of participating experts. Such judgments can be - especially in situations of significant data gaps - more precise than quantitative predictions based on incomplete data. Such expert judgments are best obtained through canvassing of opinions from a representative set of recognized experts in a given field and their iterative discussion. Expert judgments can be formulated through simple participatory tools such as: workshops, interviews or questionnaires with a problem-solving focus (these tools are described in the Annex 2 to this guidance) The most sophisticated means of collective expert judgement is the Delphi technique which is separately described in the annexes) The Chinese Provisional Measures for Public Involvement in EIA[3] for instance allow for the use of expert judgements through consulting expert opinions in written or other forms (Article 20) or through organising evaluation meetings with relevant experts (Articles 21-23).

3 Document No. 2006 [28] issued by the State Administration of Environmental Protection on February 14, 2006

	Consulting expert opinions in written or other forms requires that the individual experts and organizations that accept such consulting arrangements provide clear opinions on consulting matters, and reply in writing. Any written opinion should be signed by individual experts and affixed with the employer's seal. Any different opinions in collective expert consulting shall be described by the consulting organization in consulting replies. Evaluation meetings with relevant experts require determination of the major topics for review according to the scope and extent of environmental impact and the assessment factors, notification of the related organizations and individuals of the time, venue and major topics of the meeting and elaboration of the meeting record. The meeting record summarizes the different opinions based on presented facts and can be prepared in the form of the meeting minutes or the meeting conclusions. The basic rules for the use of expert judgements formulated by the US Environmental Protection Agency[4] may be also of interest. These can be summarised as follows: • At least five individuals need to be used in any expert judgment process, unless there is a lack or unavailability of experts. • The individuals involved in expert judgment have appropriate level of knowledge and experience for the questions or issues addressed. • At least two-thirds of the experts involved in expert judgment are not directly employed by the proponent. • The public and relevant authorities are provided with a reasonable opportunity to comment on the scientific and technical validity of these expert judgements.
Usual application within SEA	The expert judgment can be used at any stage of the SEA process. It is usually used when: • the key issues of concern are being identified; • periodical result or final results are prepared -- to check the results achieved; and • difficulties arise in the use of qualitative tools or when there are problems without solutions -- to collect opinions on the specific issue or to identify the solution.
Inputs and data demands	Basic information on the proposed development and affected environment, possibly complemented by a series of questions on the specific issue.
Outputs	Direct response from experts to a technical problem.
Advantages	• Expert judgment is a tool which provides quick and effective advice • It can operate in situations of significant data gaps
Disadvantages	• Quality of the outcome depends on the knowledge and competence of participating experts • The judgment will be also affected by the comprehension of the background/briefing material. If the material is not complete or include deficit, it will affect the conclusions • The outcome can be also influenced by the quality chairing of the entire process

[4] http://www.epa.gov/rpdweb00/docs/wipp/card26.pdf

<table>
<tr><th colspan="2">Tool: Analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT analysis)</th></tr>
<tr><td>Description</td><td>SWOT is used as part of diagnosis of the current situation. It highlights the key internal issues (strength and weaknesses) and the key external issues (opportunities and threats) that should be considered in the planning or in the assessment process. The following table shows logic of a SWOT analysis.
<table>
<tr><th></th><th>Positive</th><th>Negative</th></tr>
<tr><td>Internal</td><td>Strengths</td><td>Weaknesses</td></tr>
<tr><td>External</td><td>Opportunities</td><td>Threats</td></tr>
</table>

SWOT was originally developed in business management but it is increasingly used in elaboration of SPPs. Regardless of its specific application, the SWOT analysis applies the following simple sequence of tasks.

Step 1. List internal factors (what is here and now): List all strengths that exist now. Then in turn, list all weaknesses that exist now. Be realistic but avoid modesty.

Step 2 – List external factors (what is relevant for the future developments): List all opportunities that exist in the future. Then in turn, list all threats that exist in the future.

Step 3 – Review the SWOT analysis: When the analysis has been completed, a SWOT profile can be generated and used as the basis of goal setting, strategy formulation, and implementation. The completed SWOT profile is usually arranged as follows:
<table>
<tr><th>Strengths</th><th>Weaknesses</th></tr>
<tr><td>1.
2.
3.
…..</td><td>1.
2.
3.
…..</td></tr>
<tr><th>Opportunities</th><th>Threats</th></tr>
<tr><td>1.
2.
3.
…..</td><td>1.
2.
3.
…..</td></tr>
</table>

These tasks can be performed by planning teams as well as assessment teams. However, SWOT analysis offers a useful tool in participatory discussions and is generally more effective if it engages stakeholders with different viewpoints.</td></tr>
<tr><td>Usual application within SEA</td><td>• Analysis context and baseline
• Identification of constrains (risks) and opportunities (benefits)</td></tr>
<tr><td>Advantages</td><td>• SWOT reduces a large quantity into simple overview of key issues that could be considered in the planning.
• SWOT is a useful tool for obtaining various viewpoints on the current situation and can be very well used in participatory processes.
• Demand for data: Small – undertaking SWOT largely depends only on personal knowledge and insights of participants in the SWOT process.
• Cost and time requirements: Small - SWOT can be done as a quick exercise by single person or as a rapid appraisal process of current situation that involves a large number of stakeholders.
• Ability to deal with uncertainties: Medium to High. By examining future opportunities and threats SWOT highlights key future uncertainties.
• Transparency: High – SWOT is a very transparent technique.</td></tr>
<tr><td>Disadvantages</td><td>• SWOT has a tendency to oversimplify the situation.
• Analysis of current internal situation through simple presentation of strengths and weaknesses does not explain why these strengths and weaknesses occur (their root causes) and whether there are any linkages between them.
• Classification of external factors as opportunities or threats is somewhat arbitrary - the same point may feature both as a strength and as a weakness. For example, ‘increased exports’ may be presented as a strength and ‘reliance on exports’ as a weakness.</td></tr>
<tr><td>Examples of practical</td><td>Community Tool Box, a website from the United States, has an easy to follow description of</td></tr>
</table>

application or key sources of further information	how to do a SWOT analysis (http://ctb.ku.edu/tools/en/sub_section_main_1049.htm) An example of an interesting SWOT analysis that examined key trade, poverty and environmental issues and linkages in rural development programs of the European Commission DG Development can be found at: http://europa.eu.int/comm/development/body/theme/rurpol/outputs/diagnostic/html/5.htm

Tool: Formal and informal checklists	
Description	A checklist presents a catalogue of issues that might beconsidered when assessing particular types of plan or programme. Checklists may list: • Environmental, including health, concerns usually associated with certain plans and programmes • Relevant environmental, including health, objectives for various development activities • Indicators or specific guiding questions that can be asked when evaluating a plan or programme in certain fields
Usual application within SEA	• Analysis context and baseline • Identification of issues and impacts
Advantages	• Help remember all the information relevant to a task • Provide a simple way of identifying whether certain issues are relevant to a proposal and help to avoid overlooking potential issues
Disadvantages	• Do not offer a very analytical approach to analysis • Encourage neglect of any important effects that are not present in the checklist • May cloud judgement with irrelevant information • Do not specify the nature of cause-and-effect relationships – are prone to pigeon-holing impacts into certain categories whereas, in reality, an impact may be part of a complex system.

Tool: Matrices	
Linkages to other tools	Expert judgments
Purpose	Matrices enable identification or presentation of: • impacts of proposed development on various elements of the environment (matrices of impacts), or • synergies or conflicts between proposed development and the relevant environmental objectives (matrices of conflicts or synergies). Matrices visually summarize these effects in user-friendly way. As such can be used to quickly compare pros and cons of proposed development options.
Description	A simple matrix can help to identify various effects of a single intervention. More complex matrices can show cumulative effects of numerous projects on various environmental issues or objectives. Basic matrices can mark the existence of impacts or conflict/synergy using simple symbols (e.g. X, XX). More elaborate matrices use various characters, numerical scores, colours or even textual descriptions to outline the nature, scale, importance and duration or reversibility of each effect. Presented information should be easy to verify - matrices thus needs to be accompanied by a text explaining the nature of specific effects.
Usual application within SEA	Matrices belong along the most commonly used tools in SEAs in the European countries. They can be very easily used for: • Identification of effects • Presentation of effects • Comparison of alternatives
Inputs and data demands	Basic information on the proposed development - a simple list of proposed development objectives or development activities. Basic information on the local environment - a simple list of relevant environmental issues or relevant environmental objectives in the study area.
Outputs	Visual summary of impacts or conflicts/synergies
Advantages and	• Matrices help to systematically identify impacts or conflicts/synergies

disadvantages	• They can easily present outcomes of qualitative or quantitative assessments • They generally do not consider spatial issues and local territorial issues • They force users to consider many potential interactions – this may divert attention to minor impacts.
Further reading	Further information on the various uses of matrices can be found at: http://en.wikipedia.org/wiki/Matrix_methods

Tool: Spatial analyses: Overlay Mapping and Geographical Information Systems (GIS)	
Linkages to other tools	-
Purpose	To illustrate the spatial distribution of relevant issues and impacts.
Description	Spatial analyses are undertaken through a preparation of maps with different information which is relevant to the SEA. When these maps are laid over each other, they can: • Provide a composite picture of the receiving environment (e.g. sensitive areas or resources, current pressures, etc.) and resulting development opportunities and constraints • Present impacts of previous developments and show linkages between different issues (e.g. correlation between air pollution concentrations and development of transport network, correlation between water pollution and sitting of industrial facilities, etc.) • Identify potential impacts of future activities. Outline cumulative impacts of different activities on one issue (e.g. impacts of agricultural developments, new housing and new industrial zones on water quality) • Indicate spatial concentrations of different environmental impacts (e.g. map showing specific areas that will be subject to excessive air pollution, water pollution and noise pollution). Spatial analyses can be based on manual elaboration of transparent maps (overlay mapping) or elaboration and processing of electronic maps (Geographical Information Systems, GIS). While overlay mapping may be a simpler form of the analysis, it delivers only one series of maps and overlays. Elaboration of base maps for GIS is more demanding, however, once these maps have been prepared, GIS allows users to easily add further information or to flexibly amend existing maps within the GIS.
Usual application within SEA	• Analysis of context and baseline • Identification of issues and impacts, including cumulative and synergistic impacts • Development and comparison of alternatives
Inputs and data demands	• Base maps of appropriate scale (e.g. topography, land uses, etc.) • Maps indicating location of key development initiatives or spatial distribution of relevant environmental issues (e.g. air quality, water quality).
Outputs	• Maps showing spatial distribution of key issues or impacts. • These maps can be developed to visualise past, present and future situations.
Advantages and disadvantages	• Spatial analyses can consider topography and local territorial issues • If the relevant maps are not readily available, spatial analyses can be expensive and time consuming.
Further reading	British Geological Survey report (2004) on Strategic environmental assessment (SEA) and future aggregates extraction in the East Midlands Region presents a number of GIS usage methods and approaches: http://www.mineralsuk.com/britmin/CR_04_003N.pdf

Tool: Trend analysis and extrapolation	
Description	Accurate trend analysis is one of the most important aspects of any strategic assessment. In the context of SEA, it can be defined as an interpretation of environmental pressures and changes in the state of the environment, including health, over time. Trend analysis uses data sets and helps to trace any trends or patterns. Trends can be linear, exponential or cyclical and they should, where possible, be analyzed over a correct temporal scale. The presentation of trends can be fairly simple, e.g. a line graph, or quite complex, e.g. using three-dimensional graphics or video simulation. There are numerous computer programs that facilitate trend analysis (e.g. the simplest ones being computer spreadsheet software, more advanced ones including RATS, GAUSS, JMP, etc.). Trend analysis facilitates presentation of the main linkages between environmental pressures and corresponding (sometime delayed) changes in the state of the environment. As such, it can also assist predictions of future impacts. Some trends can be safely extrapolated on the assumption that the trend is going to continue in the same dynamic. When doing so, it is important to realize that virtually every trend has a corresponding counter-trend. Oversimplified extrapolation that does not consider how the trend will evolve once it reaches a key breaking point (e.g. when carrying capacity of the surrounding environment has been reached or exceeded), or once the counter-trend becomes stronger, may be misleading. Trend extrapolation can thus play an important role in medium-to-short term forecasts when no major counter-trends or breaking points are expected. Long-term trends can be precisely determined only through modelling, if at all.
Usual application within SEA	• Analysis of context and baseline • Assessment of impacts
Advantages	• Can greatly assist in the quantification of cumulative impacts in cases where environmental data are available over long periods of time
Disadvantages	• There are often situations where it is not possible to obtain relevant or sufficient data on specific environmental pressures. • In cases where there are gaps in data, it becomes important to use appropriate statistical methods to ensure the proper interpretation of trends. Such analysis may be quite cumbersome.
Examples of practical application or key sources of further information	Different examples of trend analysis are presented in the Transport Analysis Guidance on *SEA for Transport Plans and Programmes* (2004) by UK Department for Transport, available at http://www.webtag.org.uk/webdocuments/2_Project_Manager/11_SEA/2.11.pdf

Tool: Networks and Flow diagrams	
Linkages to other tools	Modelling
Purpose	Networks and flow diagrams[5] can be in SEA used to illustrate: • implications of the proposed decisions on the subsequent decisions and their knock-on effects on other developments (decision-trees); or • a gradual progression from direct immediate effects to indirect or longer-term or delayed effects (effect networks).
Description	Steps for constructing a decision tree might comprise: • List the proposed developments; • Identify effects of these proposals on other decisions or developments; • Identify secondary knock-on effects of these decisions or developments – thus illustrating their wider indirect implications. Steps for constructing an effect network might comprise: • List the proposed developments; • Identify effects of these proposed developments on the directly affected elements of the environment; • Identify secondary knock-on effects on other elements of the environment, including health – thus illustrating pathways from direct effects to indirect effects; • When doing so, determine whether any cumulative effects on the same element of

[5] sometimes also called system diagrams

	environment, including health, occur; • If appropriate consider a loop to show any feedback; • If appropriate use quantitative techniques as a simple form of modelling to evaluate the effects. This approach constitutes a simple form of modelling and allows the evaluation of effects (see more on modelling).
Usual application within SEA	• Identification of issues and effects • Assessment of effects • Development & comparison of alternatives
Inputs and data demands	• Basic information on the proposed developments. • Basic information on the local environment - a simple list of relevant elements of environment in the study area.
Outputs	• Illustration of the cause-effect relationships
Advantages	• Flow diagrams help identifying indirect and delayed effects • They clearly illustrate the interaction pathways – the mechanism of cause and effect is made explicit • Flow diagrams provide a good basis for choosing which processes could be quantified or modelled in further detail
Disadvantages	• Flow diagrams do not illustrate spatial or temporal scales of impacts • They uses a holistic approach to impact assessment, so it may require a considerable effort to complete • They can become too complex

Tool: Delphi Technique	
Linkages to other tools	Expert judgments
Purpose	Delphi Technique enables identification of prevailing judgment within a large group of experts who do not directly interact with each other.
Description	The Delphi technique represents the systematic and powerful tool for formulation of collective expert judgements. It is based on the following principles: • there is no face-to-face interaction; • each participant is given time for thought and an equal opportunity to contribute; and • in particular, disagreements are recorded used to examine different points of view and to increase understanding. The Delphi technique is based on the following key steps: • Clarify what information is needed, design the questions and determine the time line of the process. • Identify the appropriate number of experts to serve on the Delphi panel and explain the tasks. • Prepare and distribute the initial set of open-ended or closed-ended questions. • Collect and analyze the first responses and compile the responses. If open-ended questions were used extensively, analyze and present the first set of responses within an appropriate theoretical framework. • Send the same question out to the same panellists a second and third time. The process may be repeated with additional waves, if necessary. Include the responses with the question so that panellists can read the other opinions and adjust their own opinions. Respondents will read each other's ideas and answer the question again. As information is exchanged, people incorporate each others' perspectives and information into their thinking and arrive at a fairly accurate understanding of the critical issues to consider in their decision-making process. • Always prepare and distribute a final report to panellists. One of the motivations for participating in a Delphi panel, particularly for specialists, is to learn first hand, before others, what the results of the Delphi study are. It process identification of prevailing judgment within a large group of experts who do not meet and who may not even know each other's identity in order to minimize personal influences. It thus enables participation of experts from geographically dispersed locations. The approach used in the Delphi technique also defines some useful principles and steps for the formulation of expert judgement through other less time-consuming techniques (e.g. workshops, conferences, etc.).
Usual application within SEA	• Identification of effects • Assessment of effects

	• Comparison of alternatives
Inputs and data demands	• Basic information on the proposed development. • Basic information on the receiving environment.
Outputs	• Prevailing professional judgment from a large group of experts.
Advantages	• Delphi technique can deal with quite technical or complex issues. • It allows sharing of ideas and consensus in decision-making by a large number of stakeholders who do not know each other's identity and can be even geographically distanced • It is convenient to participants, as they can contribute from their own office or home.
Disadvantages	• It takes time for the organizers (can run for several months) • Participant commitment may falter if the process takes too long or they have other commitments • Large amounts of data need to be carefully assessed and distributed, so the process can be expensive to manage
Further reading	Nehiley, J. M. (2001) *How to Conduct a Delphi Study* Dick, B. (2000), *Delphi face to face*, available at http://www.uq.net.au/action_research/arp/delphi.html

Tool: Modelling	
Linkages to other tools	• Networks and flow diagrams • Spatial analyses
Purpose	Models facilitate simulation of environmental impacts.
Description	Modelling generally tends to be used in SEA only when other analytical tools would provide insufficient predictions. Models of relevance to SEA are mainly those developed to simulate specific environmental impacts. Environmental modeling typically includes the following basic steps: • define the very specific issues and interactions that need to be modeled; • define key assumptions and boundaries of the modelling; • identify the suitable model and fine-tune it to fit the local situation and data availability; • collect the basic data on the local environment (e.g. topography, wind speed & direction, flow regimes, etc.) • collect the input data for the past and current situations (e.g. emission levels) and run the model to enable its verification and calibration; • run the model for the different scenarios that are considered in the assessment (e.g. emissions from the different proposed project and from other actions which are considered during the assessment). Developing a new model is generally very costly. Established and accepted models can be used if they are carefully calibrated to ensure that the simulation fits the specific features of the study area. The most common models include: Air Quality Models can simulate the cumulative impacts of a number of projects on the local air quality. They typically consider factors such as the wind direction and speed, air quality & humidity, details of the topography of an area and location of developments that emit air pollutants. Water Quality Models can simulate dispersion of various pollutants under different flow or tidal conditions. They require data on flow regimes (and/or tidal conditions) and can typically predict changes in the dissolved oxygen, coliform bacteria, sediment or chemical concentrations. Other water quality models can simulate the behaviour of pollutants in a lake environment. These models normally consider various inputs of chemicals (e.g. discharge, inflow in rivers, and deposition from the atmosphere) and their removal factors (e.g. irreversible reaction in the water and sediment, outflow in the water, and sediment burial). They typically yield mass balance equations for the water columns and the bottom sediments, but they may also consider pollutant transfer through sediment-water exchanges (e.g. by diffusion and deposition). Soil Quality Models can calculate soil degradation (e.g. erosion, degradation of the organic matter, etc.) or leaching and accumulation of chemicals (fertilisers, pesticides, heavy

	metals) applied to soil. They typically consider physical-chemical properties of the soil and chemical's behaviour of the applied chemicals in a soil environment. Noise Models can consider the cumulative noise levels from more than one source. They typically consider details of the topography of an area and locations of noise emitters.
Usual application within SEA	• Assessment of impacts • Development and compassion of alternatives
Inputs and data demands	Use of models typically requires the following inputs data: • specific impact that needs to be modeled; • key assumptions and boundaries of the assessment; • data on the local environment (e.g. topography, wind speed & direction, flow regimes, etc.); • input data on relevant emissions from the proposed project and from other actions which are considered during the assessment.
Outputs	• Simulation that quantifies the expected impacts.
Advantages	• Model can be relatively easily manipulated through assumptions made in its design or adaptation • Model, once constructed, can simulate effects over time and in space • It can facilitate numerous simulations based on different assumptions and input data • Modelling results can be effectively combined with GIS
Disadvantages	• No model can realistically address every intricacy of the natural system. • The accuracy of a model totally relies on the quality of baseline data. • Construction or calibration and running model is usually very demanding in terms of cost, expertise and time.
Further reading	The Canadian Environmental Modelling Centre at Trent University develops, validates and disseminates mass balance models, which describe the fate of various chemicals in the environment. Their site www.trentu.ca/academic/aminss/envmodel/models/models.html offered (as of 2007) fifteen freeware models that can be freely used for basic modelling of air, water and soil quality. International Environmental Modelling and Software Society is a global not-for-profit association of persons and organizations dealing with environmental modelling. It operates a site http://www.iemss.org that offers a comprehensive information various aspects of environmental modelling, software and related topics.

Tool: Multi-criteria analysis	
Linkages to other tools	Expert judgements
Purpose	• Multi-criteria analysis numerically evaluates all alternative options against several criteria, and combines these separate evaluations into one overall evaluation. • It can be used to identify a single most preferred option, to rank options, or simply to distinguish acceptable and unacceptable options so that a limited number of options can be short-listed for a detailed appraisal.
Description	Multi-criteria analysis (MCA) helps to manage complexity in decision-making by converting the evaluation to a numerical score. All MCA approaches incorporate judgments that are expressed in weights of criteria and in performance evaluations of each option. Usual steps in a multi-criteria analysis are as follow: *1. Identify assessment criteria*, so that they can measure key consequences of proposed alternative options. The proposed set of criteria should be carefully examined to ensure that: • The set of criteria is complete (no significant criteria is missing) • There are no redundant criteria (these may include insignificant criteria or criteria where all options perform equally) • Criteria are measurable (it must be possible to assess - at least qualitatively - how well each option performs in relation to the criterion) • Criteria are mutually independent (there is no double counting) *2. Analyze relative importance of criteria (weighting).* Most MCA techniques determine relative weights of each criteria in the decision -making. Methods of weighting vary from simple techniques (e.g. comparing criteria against each other to determine their relative weight) to complex methods (e.g. sociological surveys to determine importance of each criterion in the affected community).

	3. Analyze performance (scoring). Determine what constitutes the best and the worst performance in the given context. Then, score performance of each option with regard to each assessment criteria. Scoring can be basically done through three means: • Expert judgments that assign scores to show performance of each option when it comes to each assessment criteria (e.g. 0-100 point scale) • Compare options against each other. These methods vary – from simple mutual comparison of options (e.g. on criterion 1 the option A scores best, C second and B third) to more complex comparisons (e.g. programs based on fuzzy sets that turn linguistic evaluations into numerical scores) • Performance is determined on the basis of criterion-specific curve that defines gradual progression from the worst to the best performance *4. Multiply weights and scores for each of the options and derivation of their overall scores.* Each option's performance on a criterion is multiplied by the weight of the respective criterion – this done for all the criteria. The sum yields the overall relative score for the given option. The results for all options are compared and discussed. *5. Analyze sensitivity to changes in scores or weights.* Sensitivity shows how changes in the scores or weight affect the results of MCA. Such analysis may be essential if: • There are serious uncertainties about performance of some options against selected criteria, or • If decision-makers or stakeholders argue about the relative weights of criteria used in MCA.
Usual application within SEA	• Determination of relative importance of impacts • Assessment of impacts • Comparison of alternatives
Inputs and data demands	• Carefully identified assessment criteria reflecting the key environmental consequences of all proposed alternative options • Judgments on relative importance/weights of these criteria • Judgments on performance of each option with regard to all criteria
Outputs	• Conversion of assessment into numerical scoring
Advantages	• MCA takes into account different criteria at the same time (i.e. they avoid decision-making process based on a single criterion); • MCA may be used to bring together the view of the different stakeholders in the evaluation; • MCA is transparent and explicit (the scores and weights are recorded and easy to audit); • MCA may facilitate communication with decision maker and sometimes with the wider community. • MCA reduces rational debate about various pros and cons of proposed alternative options into discussion about abstract numbers (scores and weights)
Disadvantages	• MCA cannot facilitate consensus on very controversial decisions; • By presenting quantitative information (aggregated scores) MCA may create a false impression of accuracy. This sometimes hides the fact that all MCAs heavily depend on a value judgment; • MCA may be easily manipulated by those who perform it (i.e. simple sensitivity analyses that are normally performed within MCA show criteria that best influence outcomes - this knowledge can be used to manipulate the entire analysis).
Further reading	Multi-criteria Analysis Manual of the UK Government, available at http://www.odpm.gov.uk/index.asp?id=1142251 The Journal of Multi-Criteria Decision Analysis (ISSN: 1099-1360). By subscription only. More information can be obtained from the editor val@mansci.strath.ac.uk or at http://www.interscience.wiley.com/jpages/1057-9214/ Department of the Environment, Transport and the Regions, *Review of Technical Guidance on Environmental Appraisal:* A Report by EFTEC (Economics for the Environment Consultancy) http://www.defra.gov.uk/environment/economics/rtgea/1.htm

Annex 13

20. Compartive assessment of growth scenarios assessments in Bangladesh (rated with and without mitigation measures)
21.

Source: CEGIS/Integra, 2021)

A: Without mitigation

R: Risk score: where existing environmental and social safeguard policies, regulations and guidelines are not fully or effectively implemented or enforced, and/or where no or ineffective mitigatory action is taken to avoid, minimise, restore, mitigate or offset potential impacts of development, and/or the use of clean and sustainable technologies is not compulsory.

			Low growth	Medium growth	High growth
Environmental Objectives					
Forest, Protected areas and biodiversity	1	Reduce over-exploitation/degradation of habitats, loss of biodiversity and ecosystem(s) integrity and services	-3	-2	-4
	2	Reduce illegal activities related to protected areas and biodiversity	-3	-2	-3
	3	Reduce introduction and spread of Invasive Alien Species	-3	-2	-3
Waste and pollution	4	Reduce poor management and unsafe disposal of solid and liquid waste (urban & industrial)	-4	-2	-3
	5	Reduce all forms of pollution (air, land, water, noise, light, etc.)	-4	-2	-3
	6	Minimise emissions of greenhouse gases	-3	-3	-3
Climate change and disasters	7	Reduce vulnerability to climate change and natural disasters (salinity intrusion, floods, storm surges, etc.)	-4	-3	-4
Water	8	Increase dry season freshwater flow in rivers	-3	-2	-3
	9	Reduce high/peak flows in rivers during monsoon season	0	0	-2
Land degradation	10	Minimise loss of land due to degradation (e.g erosion of river banks/water channels, soil salinity, soil erosion, etc)	-3	-2	-3
Land use change	11	Minimise conversion of agricultural land (e.g. conversion to shrimp ponds)	-2	-3	-3
Socio-Economic					
Economic growth	12	Ensure significant economic development and diversification, and increase in economic growth	-2	-2	-3
Employment	13	Enhance opportunities for employment and new/improved livelihoods (particularly for fisheries, agriculture, eco-tourism)	-2	-2	-3
Health and sanitation	14	Improve health services and health of society (eg. by reducing vulnerability to diseases)	-2	-1	-1
	15	Improve and extend water supply and sanitation services	-2	-3	-3
Education. skills and training	16	Improve access to education for all, increase attendance (by reducing drop-out rates), and improve skills development and training	-2	-1	-1

			Low growth	Medium growth	High growth
Migration	17	Reduce migration from rural (including disaster-prone and risk-prone) areas to urban areas	-2	-2	-2
Women and children	18	Improve gender equality and empowerment of women	-1	0	0
Social inclusion	19	Increase the inclusion of landless and marginal land holders in development activities in SW region	-3	-2	-2
Conflicts and security	20	Reduce conflicts over use of land	-3	-2	-3
Cultural and natural heritage sites	21	Preserve heritage sites (historic buildings, archaeological and cultural sites and enhance cultural diversity (eg language, arts, etc.) and also Sundarbans 0natural heritage sites	-3	-1	-2
Food	22	Improve food security	-2	0	0
Ag+1riculture and fisheries	23	Increase agricultural and fish production	-1	0	0
Power and energy	24	Increase uptake of renewable energy	-2	-1	-1
	25	Increase efficiency in production and consumption of energy	-2	0	0
	26	Increase access to affordable energy	-1	0	0
Tourism	27	Improve tourism management and behaviour to limit noise, pollution and other negative impacts; and to remain within the carrying capacity of the Sundarbans for tourism.	-2	-1	-1
Infrastructure, transportation and communications	28	Improve connection of communities, and improve access to infrastructure, services and facilities	-2	-1	-1
	29	Optimise the existing and future physical footprint of transport services (rail, road, waterways)	-2	-1	-1

22.

B: With Mitigation

23.

M: Mitigated score: where existing environmental and social safeguard policies, regulations and guidelines are fully and effectively implemented and enforced, and the government implements effective measures to avoid, mitigate, minimise, restore or offset potential impacts of development, and ensures the use of clean and sustainable technologies.

ENVIRONMENTAL OBJECTIVES			Low growth	Medium growth	High growth
Forest, Protected areas and biodiversity	1	Reduce over-exploitation/degradation of habitats, loss of biodiversity and ecosystem(s) integrity and services	0	+2	+4
	2	Reduce illegal activities related to protected areas and biodiversity	0	+2	+4
	3	Reduce introduction and spread of Invasive Alien Species	0	+2	+4
Waste and pollution	4	Reduce poor management and unsafe disposal of solid and liquid waste (urban & industrial)	0	+2	+4
	5	Reduce all forms of pollution (air, land, water, noise, light, etc.)	+1	+3	+4
	6	Minimise emissions of greenhouse gases	0	+2	+1
Climate change and disasters	7	Reduce vulnerability to climate change and natural disasters (salinity intrusion, floods, storm surges, etc.)	+1	+2	+4

Water	8	Increase dry season freshwater flow in rivers	0	+2	+4
	9	Reduce high/peak flows in rivers during monsoon season	0	0	+2
Land degradation	10	Minimise loss of land due to degradation (e.g erosion of river banks/water channels, soil salinity, soil erosion, etc)	0	+2	+3
Land use change	11	Minimise conversion of agricultural land (e.g. conversion to shrimp ponds)	0	0	0
SOCIO-ECONOMIC			**Low growth**	**Medium growth**	**High growth**
Economic growth	12	Ensure significant economic development and diversification, and increase in economic growth	+1	+3	+4
Employment	13	Enhance opportunities for employment and new/improved livelihoods (particularly for fisheries, agriculture, eco-tourism)	0	+2	+3
Health and sanitation	14	Improve health services and health of society (eg. by reducing vulnerability to diseases)	0	+2	+3
	15	Improve and extend water supply and sanitation services	0	+2	+4
Education. skills and training	16	Improve access to education for all, increase attendance (by reducing drop-out rates), and improve skills development and training	0	+2	+4
Migration	17	Reduce migration from rural (including disaster-prone and risk-prone) areas to urban areas	+1	+2	+4
Women and children	18	Improve gender equality and empowerment of women	+1	+2	+4
Social inclusion	19	Increase the inclusion of landless and marginal land holders in development activities in SW region	+1	+2	+3
Conflicts and security	20	Reduce conflicts over use of land	0	+2	+2
Cultural and natural heritage sites	21	Preserve heritage sites (historic buildings, archaeological and cultural sites and enhance cultural diversity (eg language, arts, etc.) and also Sundarbans natural heritage sites	0	+1	+3
Food	22	Improve food security	0	+3	+4
Agriculture and fisheries	23	Increase agricultural and fish production	+1	+2	+4
Power and energy	24	Increase uptake of renewable energy	0	+2	+3
	25	Increase efficiency in production and consumption of energy	+1	+3	+4
	26	Increase access to affordable energy	+1	+3	+4
Tourism	27	Improve tourism management and behaviour to limit noise, pollution and other negative impacts; and to remain within the carrying capacity of the Sundarbans for tourism.	0	+1	+3
Infrastructure, transportation and communications	28	Improve connection of communities, and improve access to infrastructure, services and facilities	+1	+2	+3
	29	Optimise the existing and future physical footprint of transport services (rail, road, waterways)	+1	+2	+4

Annex 14

Checklist questions for assessing significance of impacts

1. What are the likely impacts (negative and positive) of the policy option on the environment and social conditions (ESC)
2. Is the PPP in line with national strategic environmental and social goal?
3. What is the public response regarding exploitation of the environment and changes to social conditions?
4. What is the impact on ownership of natural resources?
5. What are the costs and financial benefits regarding natural resources, the environment and social conditions?
6. How will the financial benefits be used for improved livelihoods, environment conservation and management?
7. Are the production processes environmentally sustainable and socially acceptable?
8. What are the costs of the economic gains in terms of damage to environment and natural resources or negative impact on social conditions?
9. Do the economic gains promote further damage to the environment or deterioration of social conditions ?
10. Will the PPP require the movement of people that will cause concentration in other areas and need for other facilities such as waste management facilities?
11. Will the PPP cause the relocation of human and financial resources away from environmental management or provision of social services?
12. What are the trans-boundary environmental and social implications?
13. Which Multilateral Environmental Agreements (MEAs) / Protocols will be affected by the PPP?
14. Will national obligations under MEAs not be met because of implementing the PPP?
15. Will the PPP affect national or international heritage sites?
16. Will different social groups be affected in a way that will result in them causing negative impacts on the environment?
17. Will the PPP affect gender balance in terms of access, ownership and control over natural resources and benefits realized from them?
18. Is the PPP consistent with the Constitution and provisions of the relevant legislation and regulations in Bhutan?
19. Will the PPP require the enactment of new legislation on environment?
20. Does the PPP unnecessarily expose the environment to abuse or the public to risk and therefore the need for more controls and enforcement?
21. Does the PPP affect the roles and mandates of environment or social sector institutions?
22. Does the PPP have the potential to cause overlap of responsibilities and mandates?

Annex 15

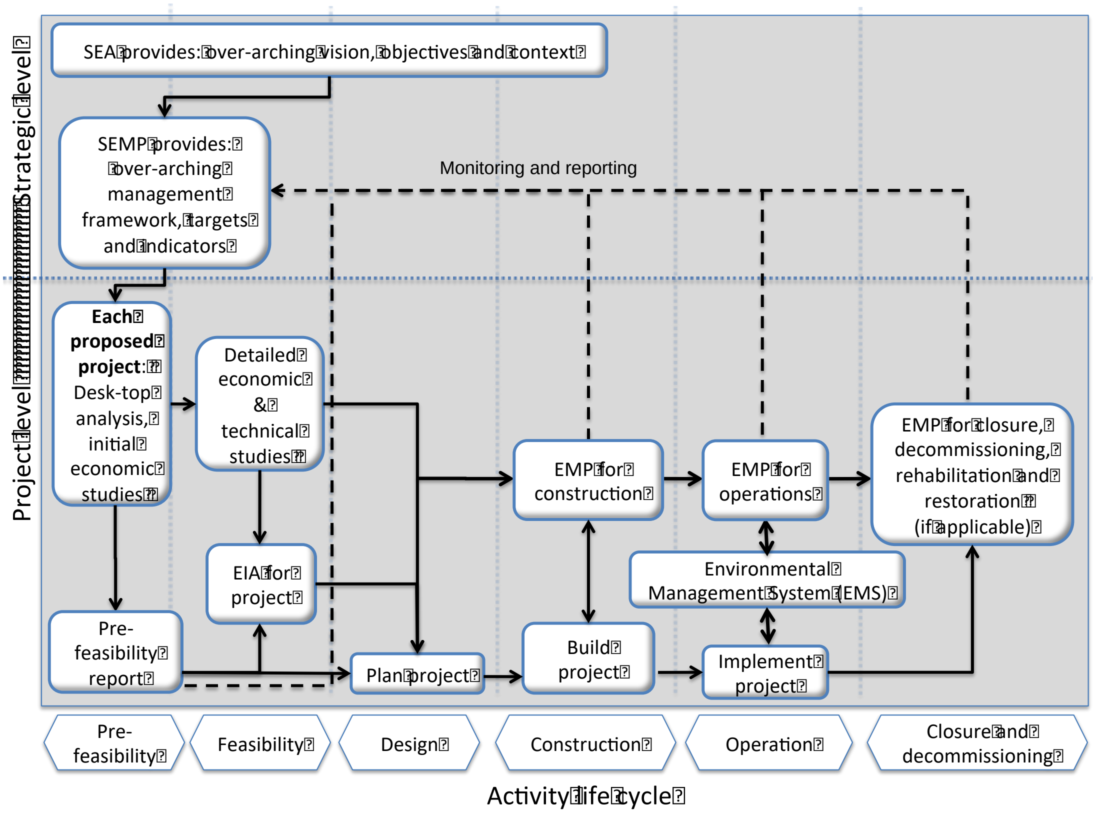
The role of a Strategic Environmental Management Plan

An SEMP should be an integral part of a PPP and act as an ***over-arching framework*** and roadmap for addressing the cumulative impacts of projects, development initiatives and activities planned to be implemented under the PPP (see Box A15.1). To fulfil this role, the SEMP should set limits of environmental and social quality (i.e. performance targets) that need to be achieved as a whole (by the concerted, collaborative oversight of relevant authorities), and, at a lower level, by the proponents of individual projects. Guided by the overall SEMP, individual Environmental Management Plans (EMPs) prepared for each individual project, will need to incorporate all relevant environmental and social management specifications. Thus, the SEMP does not remove the obligation from a developer for conducting a project-specific EIA and EMP where required by national legislations or regulations; or the need to secure required permits for development activities/projects.

Box A23.1: Relations between SEA, SESMP, ESMP AND EMS

The undertaking of the SEA will not rule out the need for subsequent project-level EIAs. Even though the SEA might set development parameters (e.g. good practice for particular development activities), individual projects with potential to cause significant environmental and social impacts will still require an EIA to address site-specific concerns and circumstances. This tiered approach means that the major, consolidated and integrated efforts made to conduct the SEA will result in the subsequent EIAs (which could be many in number) needing relatively less effort, cost and time (Figure A15.1).

Figure A15.1: The continuum between SEA, SESMP, EMP and EMS
Source: Unpublished training materials developed by the Southern Africa Institute for Environmental Assessment, 2012

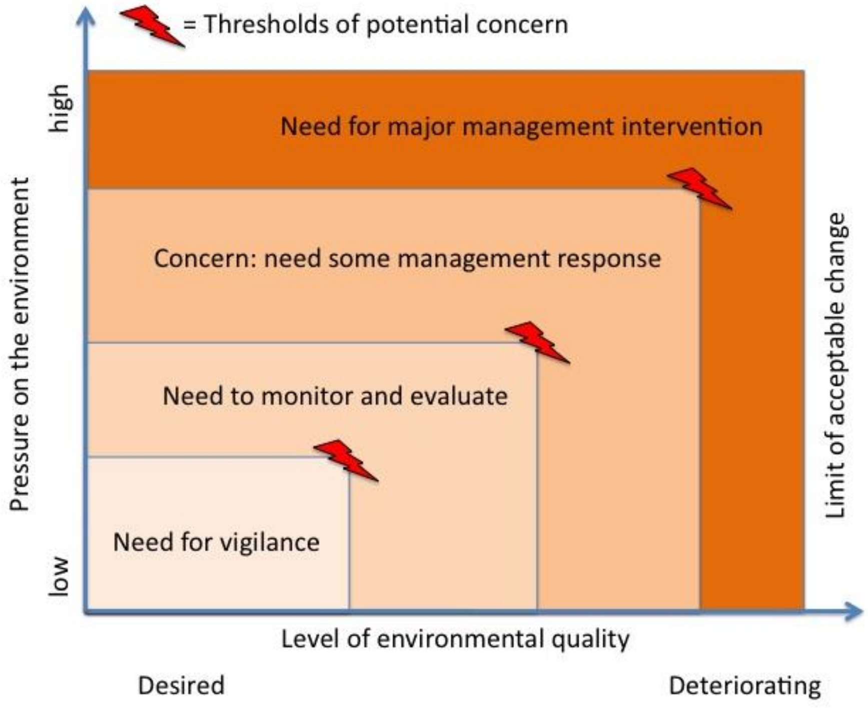


Developing environmental and social quality objectives (ESQOs) (see section 3.3.4 of these guidleines) will require a combination of public and expert opinion, scientific research and an examination of policy, ethical and legal requirements. These informants constitute the ***'input'*** into the objectives. The objectives must each articulate a specific goal, provide a context, set standards and elaborate on a small number of key indicators that need to be monitored. These will collectively make up the SEMP, which is the framework within which individual projects need to be planned and implemented and within which a number of institutions need to undertake certain actions.

The objectives must specify targets that are outcomes-based, practical, achievable, measurable and enforceable. Wherever possible, they should be acceptable to all key stakeholders.

Implicit within all environmental and social quality objectives is a minimum management objective that any changes to the environment or social conditions must be within acceptable limits (following the precautionary principle) and that pro-active intervention will be triggered by the responsible party to avoid unwanted changes that breach a specified threshold (Figure A15.2).

Figure A15.2: Environment pressure and quality, and trigger points for a management response
(Source: adapted from Binedel and Brownlie, 2007).



Through the SEMP, the information obtained during monitoring will enable the PPP proponent to prepare an annual SEMP report for the PPP.

Institutional and procedural arrangements will need to be established for the above purposes (through discussion and consensus amongst key authorities and actors) and maintained to ensure that the monitoring system runs effectively and that data from year to year are replicable, comparable and auditable.

The SEMP should also indicate any capacity-building required to ensure that the SESMP can be effectively implemented, including any institutional adjustments or procedures, recruitments or new assignments and training for national and local officials and civil society organizations.

It will be necessary to ensure that proposed implementation measures are workable. In this regard, the SEA team should review the implementation of previous SEMPs.

Annex 16

List of issues to be covered by a Strategic Environmental Management Plan (SEMP)

In some situations a stand-alone SESP may be required by the PPP proponent. The SEMP should outline the measures to be taken during PPP implementation and operation to enhance positive, and prevent, minimise or mitigate adverse environmental and social impacts associated with the PPP and projects or activities likely to arise during its implementation.

The SESMP should include:

- ***Summary of impacts***
  - The predicted negative environmental and social impacts for which mitigation is required and the positive impacts which can be enhanced, should be identified and briefly summarized. Cross-referencing to the SEA report or other documentation is recommended – so that additional detail can be readily referenced.

- ***Mitigation measures***
  - Identify feasible and cost effective measures to reduce potentially significant adverse environmental and social impacts to acceptable levels;
  - Each mitigation measure should be briefly described with reference to the impact to which it relates and the conditions under which it is required (e.g., continuously);
  - The mitigation measures should be accompanied by, or referenced to, designs, equipment descriptions, and operating procedures that elaborate on the technical aspects of implementing the various measures;
  - Where mitigation measures may result in secondary impacts, their significance should be evaluated;
  - Need for a subsequent EIA(s).

- ***Environmental and Social Quality Objectives*** (ESQOs)

- ***Environmental and Social Performance Monitoring Programme/Mechanism***

  - Provide details for a monitoring and evaluation mechanism for the environmental and social impacts of the PPP and development projects/initiatives likely to be implementing during its implementation, with monitoring indicators and a corresponding evaluation procedure and methodology. It should aim to signal when steps are required to enhance benefits or to remove or reduce risks and negative impacts. The proposed mechanism should take into account existing national legislation and provisions regarding EIA. The monitoring programme should clearly indicate:
    - The linkages between impacts identified in the SEA study;
    - Indicators to be measured;
    - Methods to be used;
    - Sampling locations;
    - Frequency of measurements;
    - Detection limits (where appropriate);
    - Definition of thresholds that will signal the need for corrective actions.

- ***Compliance:***
  - Indicate measures to ensure ***compliance with relevant safeguards*** during both preparation and implementation of the PPP and projects/initiatives that may arise during its implementation. Bhutanese safeguards should take precedence. Where Bhutanese safeguards do not exist, then reference may be made to other safeguards (World Bank safeguards).

- ***Institutional arrangements***
  - Roles and responsibilities of different jurisdictions, authorities and actors in implementing the SESMP (particularly coordination, mitigation and monitoring). As far as possible, recommendations should be institution-specific (who should do what).

- ***Implementation schedule and reporting procedures***
  - Timing, frequency, and duration of the mitigation measures;
  - Procedures to report the progress and results of mitigation and monitoring measures.

- ***Cost estimates***
  - Initial investment and recurring expenses for implementing all measures contained in the SESMP;
  - Where practicable, decisions regarding appropriate mitigation measures should be justified by an economic evaluation of potential environmental and social impacts.

- ***Institutional Strengthening/ Capacity Building***
    - Equipment requirements: Indicate type of equipment and number of units;
    - Training/study tours: Information should be provided regarding type of training, number to be trained, duration of the training, the organization providing the training and costs.

- A ***stakeholder consultation procedure*** for the monitoring and evaluation mechanism.

- ***Guidance and recommendations for project level EIAs***.

Annex 17

International and regional organisations concerned with renewable energy

Bioenergy Europe

Bioenergy Europe (https://bioenergyeurope.org/) is a non-profit, Brussels-based international organisation bringing together 40 associations and 157 companies, as well as 11 academia and research institutes from across Europe. It aims to develop a sustainable bioenergy market based on fair business conditions. Founded in 1990, Bioenergy Europe is a non-profit, Brussels-based international organisation bringing together 40 associations and 157 companies, as well as 11 academia and research institutes from across Europe.

Global Bioenergy Partnership

The Global Bioenergy Partnership (GBEP) (www.globalbioenergy.org) was founded in 2006, and now has more than 80 members. It brings together public, private and civil society stakeholders in a joint commitment to promote bioenergy for sustainable development. The Partnership focuses its activities in three strategic areas: sustainable development, climate change, and food and energy security.

Global Solar Council

The Global Solar Council (GSC) (www.globalsolarcouncil.org), founded in 2015 and based in the USA, is an international non-profit association of the national, regional, and international associations in solar energy and the world's leading corporations. With a primary goal of enabling solar energy, it offers programs in regulatory policy, trade policy, new market opening, and jobs and skills training.

Global Wind Energy Council

The Global Wind Energy Council (www.gwec.net) is the international trade association for the wind power industry. Its mandate is to communicate the benefits of wind power – to national governments, policy makers and international institutions. It provides authoritative research and analysis on the wind power industry in more than 80 countries around the world, and transparent information to governments about the benefits and potential of wind power. GWEC supports collaboration between policy-makers in different countries to help them share best practices and experiences in adding clean power to their energy mix.

Global Wind Organisation

The Global Wind Organisation (GWO) (https://www.globalwindsafety.org/) is a non-profit body founded and owned by its members - all of whom are globally leading wind turbine manufacturers and owners/operators. It promotes an injury free work environment in the wind turbine industry, setting common international standards for safety training and emergency procedures.

Hydropower Sustainability Council

The Hydropower Sustainability Council (HSC) (www.hydrosustainability.org/) is the multistakeholder governing body of the Hydropower Sustainability Standard and Tools. Its membership is open to all stakeholders involved in the development of hydropower

International Energy Agency

The International Energy Agency (IEA) (www.iea.org) was created in 1974 to help co-ordinate a collective response to major disruptions in the supply of oil. While oil security remains a key aspect of its work, the IEA has evolved and expanded significantly since its foundation to focus on all fuels and technologies, The IEA recommends policies that enhance the reliability, affordability and sustainability of energy. It examines the full spectrum issues including renewables, oil, gas and coal supply and demand, energy efficiency, clean energy technologies, electricity systems and markets, access to energy, demand-side management, and much more. Since 2015, the IEA has opened its doors to major emerging countries to expand its global impact, and deepen cooperation in energy security, data and statistics, energy policy analysis, energy efficiency, and the growing use of clean energy technologies.

International Hydropower Association

The International Hydropower Association (www.hydropower.org) is a non-profit organisation representing organisations committed to the responsible and sustainable development and operation of hydropower, and operating in over 120 countries. IHA members include leading hydropower owners and operators, developers, designers, suppliers and consultants. Around a third (450 GW) of global installed hydropower capacity is directly managed and operated by IHA's membership.

International Geothermal Association

The International Geothermal Association (IGA) (www.lovegeothermal.org) is an international non-profit, non-political, non-governmental association representing the geothermal power sector worldwide. The organisation works for the promotion and worldwide deployment of geothermal energy technology and advocates a future energy system based on renewable energy. The IGA has consultative status to the UN and special observer status to the Green Climate Fund. With partners, the IGA sets standards such as the Geothermal Sustainability Assessment Protocol (GSAP) (2021). It also maintains the geothermal power database and organises regular conferences.

International Renewable Energy Agency

The International Renewable Energy Agency (IRENA) (www.irena.org) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

IRENA's role is to seek out, establish and develops new synergies, facilitate dialogue, share best practices, promote enabling policies, build capacity and foster co-operation at the global, regional and national levels. IRENA encourages investment flows and works to strengthen technology and innovation, with diverse stakeholders contributing to these shared goals.

International Solar Energy Society

The International Solar Energy Society (ISES) (www.ises.org) is a non-profit, UN-accredited membership NGO founded in 1954. It informs and connects its diverse membership of researchers, academics, professionals, practitioners, businesses, decision-makers, and advocacies in more than a hundred countries. It promotes solar research and development, provides authoritative advice on renewable energy issues worldwide, advocates for a sustainable global solar industry, and promotes energy education for everyone at all levels.

Ocean Energy Council

The Ocean Energy Council (OEC) (www.oceanenergy council.com), based in the USA, works to improve public knowledge and acceptance of ocean energy (tidal and wind) as a viable resource. It provides a forum for presenting the considered professional recommendations of the ocean energy community to the US Department of Energy and other government bodies as well as international energy organisations. It also fosters educational advancement and growth of its members in the field of ocean energy and works to educate the public on the potential and current status of development of ocean energy.

Ocean Energy Europe

Ocean Energy Europe (OEE) (www.oceanenergy-europe.eu). launched I 2013, is the largest network of ocean energy professionals in the world. It represents over 120 organisations, including Europe's leading utilities, industrialists and research institutes.

Solar Energy International

Solar Energy International (SEI) (www.solarenergy.org) is a nonprofit educational organization. Its primary mission is to provide industry-leading technical training and expertise in renewable energy to empower people, communities, and businesses worldwide. Through its training program (Renewable Energy Education Program, REEP), SEI offers hands-on workshops and online courses in solar PV, micro-hydro, and solar hot water. Additionally, it works cooperatively with grassroots and development organizations in the Americas, Africa, Micronesia, and the Caribbean.

Solar Foundation

The Solar Foundation (www.thesolarfoundation.org), based in the USA, is a non-profit, non-partisan organization that aims to advance the use of solar worldwide, through research products, educational outreach, and leadership.

Wind Europe

WindEurope (https://windeurope.org) - formerly the European Wind Energy Association (EWEA) - promotes wind energy across Europe. It has over 400 members from across the whole value chain of wind energy: wind turbine manufacturers, component suppliers, power utilities and wind farm developers, financial institutions, research institutes and national wind energy associations. WindEurope coordinates international policy, communications, research and analysis, and provides various services to support members' requirements and needs in order to further their development, offering the best networking and learning opportunities in the sector.

WindEurope analyses, formulates and establishes policy positions for the wind industry on key strategic sectoral issues, cooperating with industry and research institutions on a number of market development and technology research projects. It also produces a large variety of information tools and manages campaigns aimed at raising awareness about the benefits of wind and enhancing social acceptance, dispelling myths about wind energy and providing easy access to credible information.
WindEurope regularly organises numerous events, ranging from conferences, exhibitions, and launches to seminars and workshops.

World Bioenergy Association

World Bioenergy Association (WBA) (www.worldbioenergy.org), based in Sweden, represents a wide range of actors in the bioenergy sector, and supports the sustainable development of bioenergy globally.

World Coal Association

The World Coal Association (www.worldcoal.org) is a global association with members across the coal value chain, committed to a transition to clean coal. Its work encompasses government advocacy, policy, media and industry representation. The WCA calls for level playing field policy and greater collaboration between industry, government and investors to advance both global economic and climate aspirations. It is committed to building a sustainable future for global coal and playing an active role in achieving our worldwide economic and environmental aspirations. WCA's activities are focussed on those markets that continue to produce and/or use coal, as it actively supports their right to choose coal. It works with industry stakeholders across the globe and uses its voice to educate and raise awareness of coal and clean coal technologies.

World Solar Thermal Electricity Association

World Solar Thermal Electricity Association (STELAWorld) (www.stelaworld.org) was formed in 2011 to work with international agencies like IEA, IRENA, UNFCCC, UN Development Program, the World Bank, and many more. It assists policy-makers and energy investors to access information on solar thermal electricity development and the value and the rapidly reducing cost of solar thermal electricity production.

Annex 18

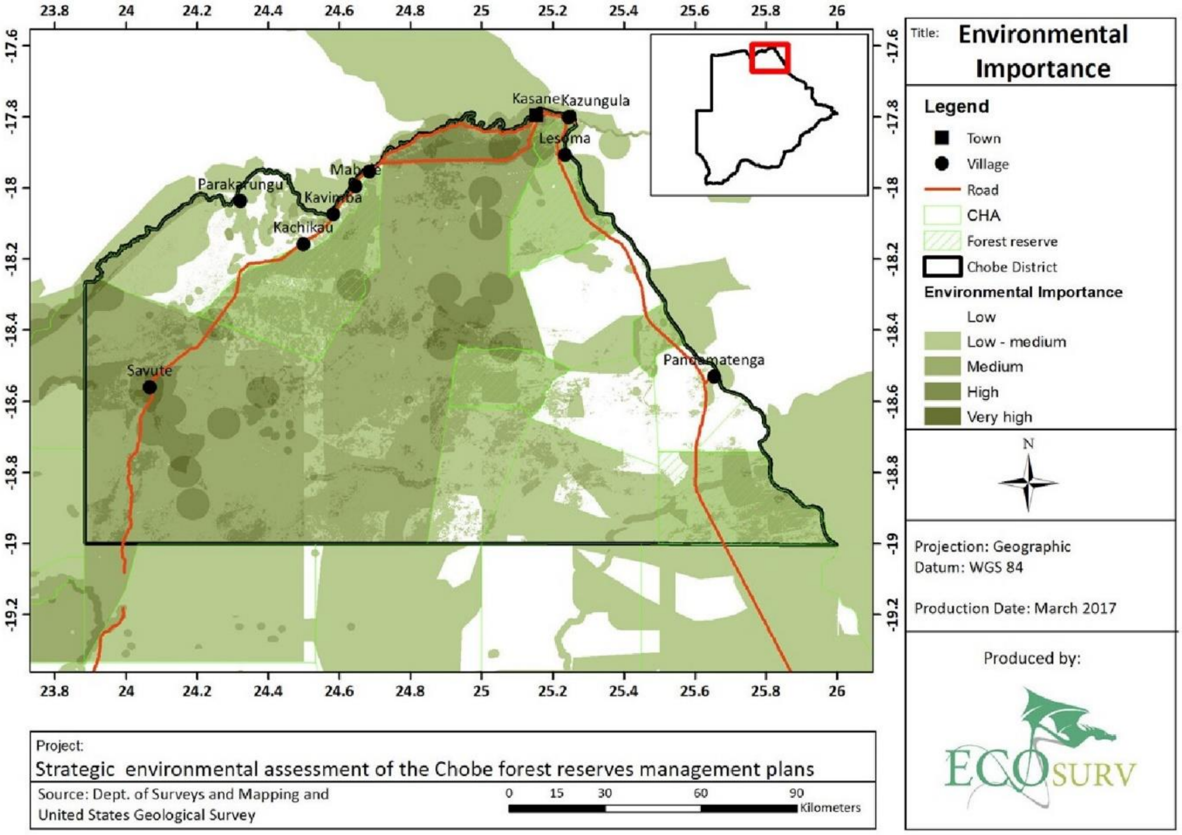
Sensitivity mapping for Chobe Forest Reserve, Botswana

Source: Ecosurv (2018)

An initial SWOT focussed an SEA of the Chobe Forest Reserve , Botswana, on the main cumulative impacts and opportunities. Each cumulative impact was placed within a resilience framework of domain (social, economic and biophysical), scale and time. This provided an understanding of where cumulative impacts were within the overall landscape and what was driving them.

GIS data was then used to generate a land use conflict matrix of the three domains. The layers were combined to provide an overview of areas of sensitivity for biophysical aspect and for socio-economic aspects, so that these can be evaluated separately. Figure A18.1 provides an example of the environmental importance of different areas of Chobe District.

Figure A8.1: Environmental importance of areas in Chobe District



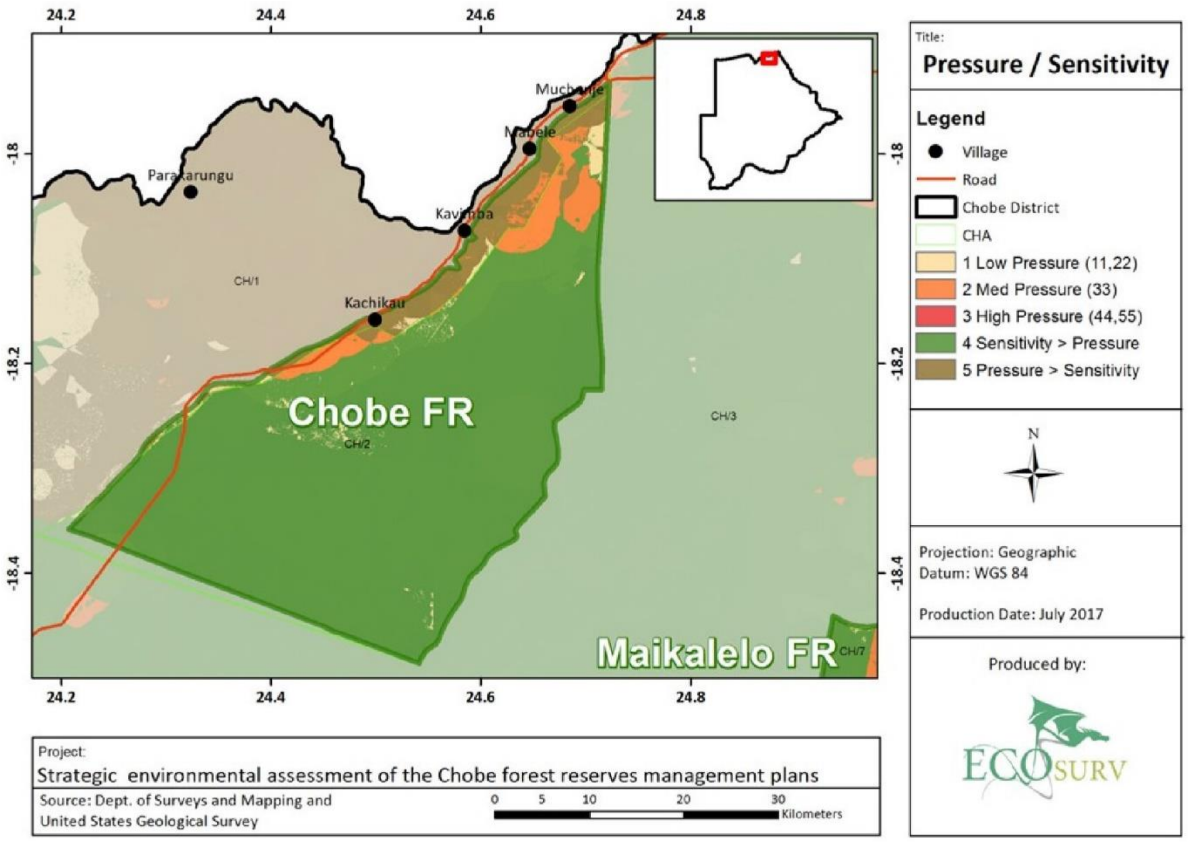
Subsequently these layers were ranked to assign a standardised value, so that they could be analysed for potential land use conflicts using the LUCIS conflict management tool. The tool combined the different inputs to identify preferences and objectives, and allowed decisions to be made on factual evidence as to what types of land use should be selected for which locations.

In the case of the SEA, the final raster GIS was a grid of cells each containing 25 possible combinations of socio-economic and biophysical values. Thus, where socio-economic values were high (as in arable agricultural areas) and biophysical were low, no conflict was identified. But where both were high, conflict occurred and required management to address.

The mapped raster values provided a framework for management planning of each forest area.

From stakeholder workshops, a number of data sets were identified that were used to prepare a description of the present state and the pressures and sensitivity maps An overlay of the two (pressure x sensitivity) was used to spatially highlight the main areas of concern. Figure A18.2 is an example of combining environmental sensitivity with pressures to identify areas of existing and potential conflict.

Figure A18.2: Pressure-sensitivity map for Chobe Game Reserve

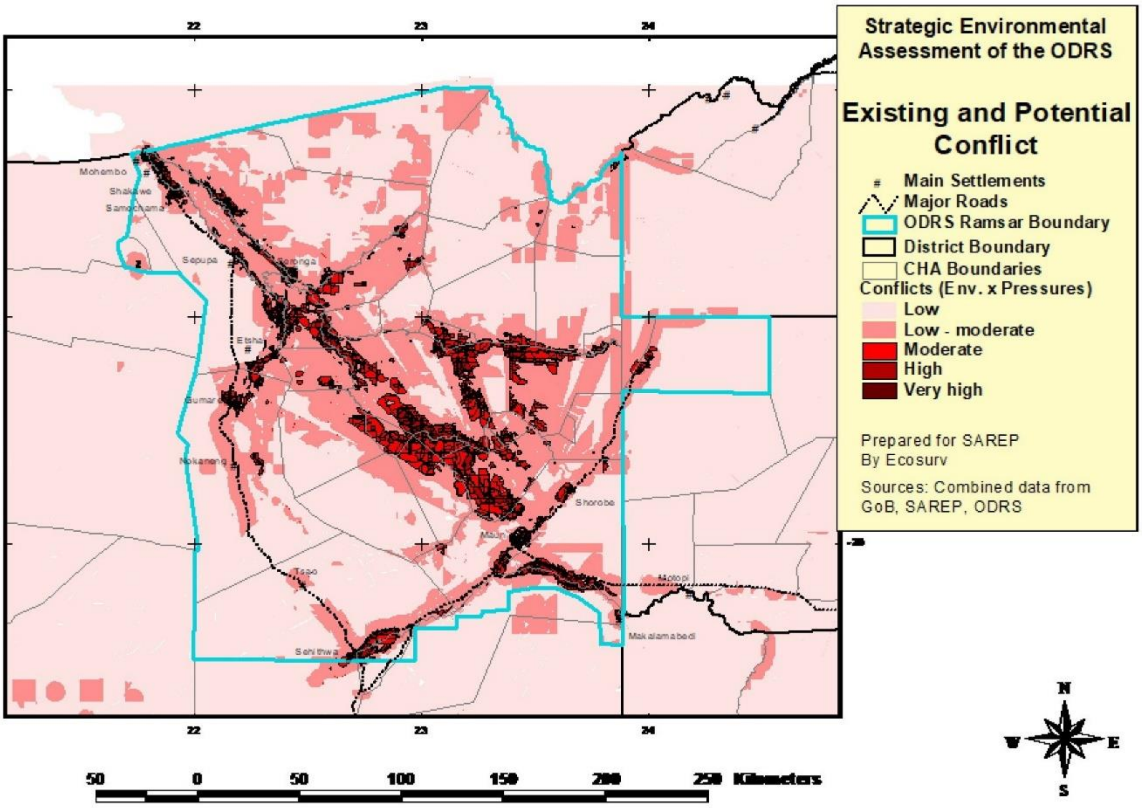


A hub type SEA was undertaken for the Okavango Delta Ramsar Site (ODRS) in 2010-2012, Because of its complexity and multiple land uses, the SEA included a wide range of specialists from different disciplines. The SEA was undertaken for the Tawana Land Board (as the owners of the ODRS and guided by the Department of Environmental Affairs (DEA) as the party responsible for the Ramsar treaty implementation.

Figure A18.3 is an example of combining environmental sensitivity with pressures to identify areas of existing and potential conflict.

The SEA influenced the review and updating of the Okavango Delta Ramsar Site (ODRS). it provided clear guidelines and targets for most of the development pressures faced by institutions such as the Tawana Land Board. Use of LUCIS (land use conflict information system) was adopted by The Land Board in planning on most conflict areas especially in the pan handle area of the Okavango Delta.

Figure A18.3: Map show areas of existing and potential conflict, Chobe Forest Reserve



Annex 19

DEFINITIONS OF TERMS

Rolling list - to be added to

Adaptive management: (Also known as adaptive resource management or adaptive environmental assessment and management). A a structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring.

Agenda 21: A comprehensive plan of action to be taken globally, nationally, and locally by organizations of the United Nations' system governments and major groups that was agreed at the United Nations Conference on Environment and Development (UNCED) in Rio de Janerio in 1992. It has effectively been replaced in the global policy sphere by subsequent international agreements such as the UN's 2030 Agenda for Sustainable Development (which includes the sustainable development goals), the Paris Agreement on Climate Change 2015, and the Sendai Framework

Alternatives: A key principle of SEA is to consider alternatives to a PPP, or elements of a PPP. This provides the opportunity to identify and explore different ways (different options, choices, or courses of action) to deliver a PPP's objectives while addressing environmental and socio-economic issues. The timely consideration of alternatives in SEA and the planning process provides an opportunity to identify and explore ways of accommodating the future development needs of an area or sector, taking into account the intrinsic environmental and socio-economic conditions[6]. Alternatives should be realistic, reasonable, viable and implementable alternatives that promote environmental and socio-economic benefits while fulfilling a PPP's objectives.

Examples of alternatives used in SEA include: PPP implementation under different economic growth regimes (e.g. high, moderate, low); use of different different technologies (e.g. hydropower power, versus solar versus wind, etc.); different geographic areas for implementation, etc.

Baseline data: Data that describe issues and conditions at the inception of the SEA. Serves as the starting point for measuring impacts, performance, etc., and is an important reference for evaluations.

Benchmark: A standard or point of reference against which things can be compared, assessed, measured or judged. Benchmarking is the process of comparing performance against that of others in an effort to identify areas of improvement.

Capacity assessment: A structured and analytical process whereby the various dimensions of capacity are assessed within a broader context of systems, as well as evaluated for specific entities and individuals within these systems.

Capacity development: The process by which individuals, groups and organisations, institutions and countries develop, enhance, and organise their systems, resources and knowledge - all reflected in their abilities, individually and collectively, to perform functions, solve problems and achieve objectives.

Civil society organisations: The multitude of associations around which society voluntarily organizes itself and which represent a wide range of interests and ties. These can include community-based organizations and non-government organisations. Sometimes indigenous peoples' organisations are erroneously lumped into CSOs. Indigenous Peoples form distinct societies, with their own laws, languages, epistemologies, ontologies, and methodologies, including in the area of Renewable Energy.

Competent authority: means the designated regulatory body charged with monitoring compliance with the national statutes and regulations regarding a country's SEA system.

Cross-boundary impacts – see Impacts

Cumulative effects/impacts – see Impacts

Decision-makers / decision-taker: Policy-making, planning and decision-making and decision-taking systems vary and the meaning depends greatly on national or agency circumstances and procedures. A decision maker or taker may be (i) an official responsible for broad-scale or sectoral development plans or (ii) an elected Councillor or Minister.

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[6] Gonzalez *et al*. (2015)

Direct impacts – see Impacts

Environment: Mostly used in an ecological sense to cover natural resources and the relationships between them. But, social aspects (including human health) are also often considered part of “the environment”. Issues relating to aesthetic properties as well as cultural and historical heritage (often in “built” environment) are frequently included.

Environmental assessment” (EA): The umbrella term for the process of examining the environmental risks and benefits of proposals prior to decisions on them being made. Interpretations of the scope of EA also vary, particularly regarding the social dimension. It is usual to consider the physical/biological impacts of development on directly affected groups (e.g., impacts on downstream water supply, displacement, and local communities or vulnerable groups). But many institutions routinely include consideration of social impacts that are mediated by the environment (such as the human impacts of water pollution). Some agencies undertake “environmental and social assessments” or separate “social assessments” to identify adverse social impacts and promote other social goals, such as social inclusion or poverty reduction. The relative importance of the different dimensions varies depending on the issue involved. In the case of a dam, for example, it is increasingly routine in EA to consider both physical/ecological and social impacts.

Environmental clearance means a decision, usually issued in writing by a competent authority, to authorise a project to proceed from an environmental and social perspective. It may include terms to ensure that the project is managed in an environmentally sound and sustainable way. Note that, ‘environmental clearance’ is a not as common in regulatory terms in UK/Europe compared to North America.

Environmental Impact Assessment (EIA or ESIA) was first introduced in the USA as a requirement of the National Environmental Protection Act (NEPA) in 1969. It is a process, applied mainly at project level, to improve decision-making and to ensure that development options under consideration are environmental and socially sound and sustainable. As a process, EIA identifies, predicts and evaluates foreseeable impacts, both beneficial and adverse, of public and private development activities, alternatives and mitigating measures, and aims to eliminate or minimise negative impacts and optimise positive impacts. In the early days of EIA application, the focus tended to be mainly on biophysical impacts. But nowadays, EIA also covers social impacts. The term Environmental and Social Impact Assessment (ESIA) is preferred by some organisations (particularly IFIs) as it specifically makes reference to ‘social’. A subset of additional processes has emerged since EIA was introduced, including social impact assessment, cumulative effects assessment, environmental health impact assessment, risk assessment, and biodiversity impact assessment.

Environmental security: A condition in which a nation or region, through sound governance, capable management, and sustainable utilization of its natural resources and environment, takes effective steps toward creating social, economic, and political stability and ensuring the welfare of its population.

Environmental and Social Impact Assessment: see Environmental impact assessment

Environmental and social quality objectives (ESQOs): are specified targets/aims agreed during an SEA for environmental and social quality (e.g. prevention of loss of biodiversity, improved job opportunities) that should be met when implementing a policy, plan or programme. ESQOs and associated indicators form the core element of the monitoring component of a strategic environmental and social management plan (SESMP).

Environmental impact statement*:* means written documentation produced after evaluating the environmental consequences, including cumulative impacts, of a proposed policy, plan or programme. It may be a separate report or part of a proposal.

Ex ante assessment: An evaluation of the environmental and social impacts of a PPP undertaken during its formulation phase, by looking at the expected or intended results of the PPP and predicting and extrapolating its potential significant impacts. It is a way of assessing whether a proposed project is feasible and leaves the opportunity to consider alternatives and adjust the plan, programme, or policy to avoid or enhance the results.

Ex post assessment: An evaluation of the environmental and social impacts of a PPP undertaken after implementation has begun- effectively examining the results of PPP implementation. It provides an opportunity to adjust a PPP to avoid, minimise or enhance the results.

Good governance: Governance is the exercise of political, economic and administrative authority necessary to manage a nation’s affairs. Good governance is characterized by participation, transparency, accountability, rule of law, effectiveness, equity, etc.

Impacts: (can be environmental and/or social)

> ***Direct impacts*** are caused as a direct consequence of the PPP or of a component of the PPP or of downstream projects during PPP implementation. For example, road building activities can give rise to land take, removal of vegetation, and severance of farmland. The removal of gravel material from a borrow

pit, for use in surfacing the road, is an obvious direct impact of road construction. In this case, the land area in which the pit site is located has been directly affected by activities associated with the road project.

Indirect impacts (also known as secondary, tertiary, and chain impacts) are usually linked closely with the PPP or with components of the PPP or downstream projects, They may have more profound consequences on the environment than direct impacts. Indirect impacts are more difficult to measure but can ultimately be more important. Over time they can affect larger geographical areas of the environment than anticipated. Examples include degradation of surface water quality by the erosion of land cleared because of a new road, and urban growth near a new road. Another common indirect impact associated with new roads is increased deforestation of an area, stemming from easier (more profitable) transportation of logs to market, or the influx of settlers. In areas where wild game is plentiful, new roads often lead to the rapid depletion of animals due to poaching.

Induced Impacts - Induced impacts (a type of indirect impacts) result from activities that occur in response to socio-economic opportunities associated with new development: e.g., as a result of: opening up access to previously remote areas and untapped resources; creating potential for employment and/or enterprises to service new settlements. Induced impacts may be attributable to a project's facilities and activities, or to "associated facilities" that are not funded by the project, but without which the project would not be viable. Induced activities are not part of the project scope, design or objectives and may not be essential for it to operate. In effect, they compound impacts from a project and associated activities and result in cumulative impacts (Source: IAIA).

Cumulative effects/impacts**:** the incremental impact of a project when added to impacts from other relevant past, present and reasonably foreseeable developments as well as unplanned but predictable activities enabled by the project that may occur later or at a different location[7].

Synergistic impacts – another term for cumulative impacts

Cross- or trans-boundary impacts – impacts which caused as a result of a PPP or its component or downstream projects and occur beyond the boundary of the area in which the PPP is focused. Boundaries can be at different scales: administrative areas at local to national level, protected areas, national borders.

Indicator: A signal that reveals progress (or lack thereof) towards objectives: provides a means of measuring what actually happens against what has been planned in terms of quantity, quality and timeliness.

Indigenous peoples: are distinct social and cultural groups that share collective ancestral ties to the lands and natural resources where they live, occupy or from which they have been displaced. The land and natural resources on which they depend are inextricably linked to their identities, cultures, livelihoods, as well as their physical and spiritual well-being. They often subscribe to their customary leaders and organizations for representation that are distinct or separate from those of the mainstream society or culture. Many Indigenous Peoples (IPs) still maintain a language distinct from the official language or languages of the country or region in which they reside; however, many have also lost their languages or on the precipice of extinction due to eviction from their lands and/or relocation to other territories[8].

Indirect impacts: – see Impacts

Irreversible Negative Impact: An impact that cannot be undone in time using reasonable means.

Iterative: The act of repeating a process usually with the aim of approaching a desired goal or target or result. Each repetition of the process is called an "iteration" and the results of one iteration are used as the starting point for the next iteration.

Lead agency: means any Government Ministry, Institution, Department, Parastatal, State Corporation or Local Authority, in which any law vests functions of control or management of any element of the environment or natural resources or social service.

Limits of acceptable change (LAC): Extremes in environmental or social quality beyond which society would find further change unacceptable. LAC relates to a level of environmental quality (usually biophysical) or social quality that is either desired or would be tolerated by society (often a qualitative value).

Mainstreaming/Up-streaming: Integrating environment into development planning processes.

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[7] World Bank (2017b)

[8] Indigenous Peoples Overview (worldbank.org)

Marine spatial planning (MSP): A public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process. Ehler and Douvere (2009) provide a clear, straightforward step-by-step approach to setting up and applying MSP (see also: spatial planning).

Mitgation: Measures to avoid, reduce, restore, and - if necessary - offset significant adverse impacts on environmental or social receptors. The sequence of mitigation follows the mitigation hierarchy (see below).

Mitigation hierarchy:A framework, or sequence of actions implemented, for managing risks and potential impacts. The hierarchy usually encompasses: to anticipate and avoid, or where avoidance is not possible, minimize, and where residual impacts remain, compensate/offset risks and impacts. ~~to workers, Affected Communities, and the environment.~~ Once a project comes to the end of its useful life, then restoration/rehabilitation of the land/ecosystem at a site is usually required.

Monitoring: At a project level, monitoring means a programme of systematic, objective and quantitative measurements, observations and reporting of projects that may have environmental and social impacts. For SEA, monitoring recommendations should be broader and include, e.g., assessing environmental and social conditions and trends, observing PPP development and implementation, and developing information for reporting to national policy-makers, planners, international forums and the public.

Non-government organization (NGO): see CSO.

Plan: A purposeful, forward-looking strategy or design, often with coordinated priorities, options, and measures that elaborate and implement policy.

Policy: A broad statement of intent that reflects and focuses the political agenda of government and initiates a decision cycle. A general course of action or proposed overall direction that a government is pursuing or intends to follow; a policy guides ongoing decision-making.

Policies, plans and programmes (PPP): have different meanings in different countries according to the political and institutional context. Also, in a particular country/jurisdiction, there may be instruments that are not labelled as a policy, plan or programme but which have a similar meaning or intent, e.g., a strategy which may be similar to a plan. These should be treated as a PPP and be subjected to SEA (if the law/regulations required this).

Policy reform is a process in which changes are made to the formal 'rules of the game' - including laws, regulations and institutions - to address a problem or achieve a goal such as economic growth, environmental protection or poverty alleviation. Usually involves a complex political process, particularly when it is perceived that the reform redistributes economic, political, or social power.

Programme: A coherent, organized agenda or schedule of commitments, proposals, instruments, and/or activities that elaborate and implement policy.

Project: A project is a set of tasks that must be completed in order to arrive at a particular goal or outcome. In terms of environmental and social assessment, it refers to a development activity or initiative (including those that involve construction). For renewable energy developments, a project might encompass the following:

- Hydropower schemes (reservoir-based, run-of-river, micro schemes);
- Wind farms (onshore or offshore)
- Solar farms;
- Geothermal power plants
- Tidal power developments
- Bioenergy production (mainly growing bioenergy crops
- Associated infrastructure may also be included (e.g. transmission lines, access roads, electricity storage facilities, ports, harbours and terminals, etc.)..

Proponent: In SEA. the proponent is the authority or organisation (often a government ministry or department) that has lead responsibility for preparing or implementing a policy, plan or programme, In EIA, the proponent is the organisation, company or individual that is proposing and developing a project.

Receptor: A receptor is a component of the environment or social fabric that could be adversely affected by the implementation of a PPP, e.g., habitats, biodiversity, land, soil, water, air and climate, material assets, cultural heritage and landscape, communities, human health, rights, etc.

Responsible authority: The organisation which prepares and/or adopts a plan or programme subject to SEA.

Scenarios: Scenarios are a technique for presenting alternative views of the future. In SEA, simple scenarios are sometimes used (e.g., low economic growth, medium economic growth or high economic growth) to compare how the impacts of an individual PPP or, in some situations, a suite of PPPs, may differ in nature/extent/severity under different possible circumstances. Modelling is sometimes used to predict how different scenarios might unfold.

For an SEA of a PPP concerned with the energy transition, it might be useful to develop scenarios of the nature of the transition (what energy resources will be developed and where) during different timeframes (e.g. near-term, medium-term or long-term).

The process of scenario planning is well developed and can involve various actors to identify significant events, drivers of change, and contrast have responses to change may differ according to actors' different motivations. Scenario development allows us to think systematically about and understand the nature and impact of the most uncertain and important driving forces affecting our future (see Annex 9).

Scoping: An early stage in SEA to review the context, extent (spatial and temporal boundaries of the SEA), identify key environmental and socio-economic issues, providing an opportunity to focus the report on the important issues to maximise its usefulness to the authorities, decision-makers and public. Scoping should identify baseline and other data requirements and initiate collection, identify any critical information gaps, and determine the relevant criteria for assessment. It should also determine the scope of the analyses needed, identify the stakeholders to be involved (and how). Furthermore, scoping should involve identifying alternatives (to the PPP or elements of the PPP) to be assessed, identifying relevant environmental and social quality objectives (ESQOs), targets, indicators. It may also involve a review of the policy, legal and institutional framework,

Sectoral guidelines: means all guidance documents, including codes of best practice, published by government ministries or agencies.

Sectoral strategy: A policy framework, for the long- and/ or medium-term, which has been adopted by a government as a plan of action for a particular area of the economy or society.

Spatial planning: Spatial planning systems refer to the methods and approaches used by the public and private sector to influence the distribution of people and activities in spaces of various scales. Spatial planning can be defined as the coordination of practices and policies affecting spatial organization[9]. Spatial planning is synonymous with the practices of urban planning in the United States but at larger scales and the term is often used in reference to planning efforts in European countries. Discrete professional disciplines which involve spatial planning include land use, urban, regional, transport and environmental planning. Other related areas are also important, including economic and community planning. Spatial planning takes place on local, regional, national and international levels and often results in the creation of a spatial plan (see also: marine spatial planning).

Stakeholder: Those who may be interested in, potentially affected by, or influence the implementation of a PPP. Stakeholders may include government (national and local), local communities, NGOs, civil society, the private sector and, in the context of development cooperation, donor agencies.

Steering committee: a broad-based, multi-stakeholder committee for the SEA to: provide oversight, advice, support and guidance; facilitate access to critical information; review reports; build ownership of the SEA process amongst key actors; and advocate for the uptake of its recommendations,

Strategic action – refers to an action taken to implement a policy, strategy, plan or programme.

Strategic environmental assessment (SEA): A systematic process for incorporating environmental and social considerations across different levels of strategic decision making – plan, program, and policy levels. It encompasses a family of approaches on a continuum from institutional assessment to impact analysis and spatial mapping. Some organisations prefer the term Strategic Environmental and Social Assessment' (SESA) (notably IFIs)

Strategic Environmental and Social Assessment (SESA): see Strategic Environmental Assessment

Strategic environmental and social management plan (SESMP) – sometimes called a Strategic Environmental Management Plan (SEMP**)**. A plan (either stand-alone or sometimes as a section of a SEA report) that presents strategies and procedures to enhance positive, and prevent, minimise, or mitigate adverse environmental and social impacts associated with a PPP and projects or activities likely to arise during implementation of a PPP. These procedures should include measures to ensure compliance with relevant safeguards. The SESMP should set out: (a) the roles and responsibilities of different jurisdictions, authorities and actors in implementing the SESMP; (b) a simple performance monitoring and evaluation mechanism for the environmental and social impacts of the PPP and subsequent development projects/initiatives, with monitoring indicators and a corresponding evaluation procedure and methodology; (c) steps required to enhance benefits or to remove or reduce risks and negative impacts; (d) a stakeholder consultation procedure for the monitoring and evaluation mechanism; and (e) guidance and recommendations for project level EIAs.

[9] spatial planning : definition of spatial planning and synonyms of spatial planning (English) (sensagent.com)

Sustainable development goals: An intergovernmental set of 17 aspiration Goals with 169 Targets - contained in UN Resolution A/RES/70/1 of 25 September 2015. They cover a broad range of sustainable development issues, including ending poverty and hunger, improving health and education, making cities more sustainable, combating climate change, and protecting oceans and forests. The SDGs replace the former Millennium Development Goals.

Synergistic impacts – see Impacts.

Target PPP: the particular policy, plan or programme that is the subject of the SEA.

Threshold: Levels that should not be exceeded; points at which irreversible or serious damage could occur, either to ecosystems and/or to social systems (health, safety, or wellbeing). The threshold concept is commonly invoked as a necessary component of environmental assessment and, more broadly, land-use decision making. Many consider thresholds as objective and finite stopping points at which a harmful activity or development trajectory should cease, because further activities will result in an unacceptable change or risk to the environment. Although ecological thresholds can play an important role in environmental assessment, they are not a simple solution to complex socio-ecological decisions, nor do they ensure objective decision-making. A threshold, even if precise, is only one component of the assessment process. In contrast to the often naive expectation of precise and definitive science-based thresholds, management or significance thresholds recognise a continuum of risk that can be weighed against socio-economic interests. That risk continuum can guide the incremental increase in monitoring and precaution that should accompany the review and implementation of individual projects or land-use change that results in cumulative effects across watersheds[10].

Tier: A layer or ranking in a hierarchy, as in policy, plan, or programme.

Tiering: addressing issues and impacts at appropriate decision-making levels (e.g. from the policy to project levels).

[10] Johnson and Ray (2021)