

IMPROVING DECISION-MAKING FOR THE ENERGY TRANSITION

Guidance for using Strategic Environmental Assessment

CHAPTER 12

RETIREMENT OF COAL-FIRED POWER PLANTS, AND ASSOCIATED COAL MINE AND SUPPLY CHAIN CLOSURES



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CHAPTER 12

RETIREMENT OF COAL-FIRED POWER PLANTS, AND ASSOCIATED COAL MINE AND SUPPLY CHAIN CLOSURES

12.1 WHY IS SEA IMPORTANT TO COAL-FIRED POWER PLANT RETIREMENT AND COAL MINE CLOSURE

An overall rationale for why it is important to use SEA to support the energy transition is provided in the Preface to 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 and potential impacts 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 and coal mines and on supply chains.

The guidance provided in this chapter differs from that in previous chapters as the focus here is closing facilities rather than opening new renewable energy facilities or expanding existing operations. Closure can result in a loss of jobs that will ripple through regional communities, triggering a complex array of impacts, but also a suite of opportunities. Planning for such changes is made complicated by the significant role that coal can play in national and regional economies, and the potential volatility in the domestic and export coal markets due to shifts in national policy and in geopolitical relations. This brings high levels of uncertainty about timing and potential government reinvestment in affected communities. This is particularly true where there may be regional discrepancies in economic development.

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 retirement and coal mine and supply chain closure (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 early** – 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 as early as possible. This will enable key issues to be identified and verified, help build understanding and support for the energy transition and avoid future misunderstanding, economic shocks 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 principles and standards of good practice (see Chapter 1, section 1.4). They are discussed in detail in Chapters 1 and 2 and are therefore not repeated in this chapter.

12.2 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 general¹, and many other sources discussing the impacts of coal mining² 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

12.3 COAL-FIRED POWER STATIONS: INSTALLED CAPACITY

The world's coal-fired power capacity grew 2% during 2023, its highest annual increase since 2016, with China driving two-thirds of new additions, and decommissioning delays and a small increase seen for the first time since 2019 in the rest of the world.⁶ 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.⁷ This was more than four times the operational capacity of coal plants in the United States, which ranked third (Table 12.1).

Table 12.1: 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)⁸, in April 2023, there were 7,990 operating coal mines worldwide. China had by far the largest number (3,803), followed by India (783), Indonesia (642) and the USA (550) (Table 12.2).

¹ e.g. EPA Australia (1995); MNREC (2018)

² e.g. Chadwick *et al.* (1986)

³ 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=INwcJZX>

⁶ [Boom and Bust Coal 2024 - Global Energy Monitor](https://www.globalenergymonitor.org/boom-and-bust-coal-2024)

⁷ <https://www.statista.com/statistics/859266/number-of-coal-power-plants-by-country/>

⁸ 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/>).

Table 12.2: Number of operating coal mines in top 20 countriesSource: <https://globalenergymonitor.org/>

Country	No. operating mines)
World	7.990
China	3.803
India	783
Indonesia	642
USA	550
Australia	524
Russia	432
South Africa	271
Germany	161
Poland	109
Kazakhstan	107
Turkey	80
Colombia	55
Canada	55
Vietnam	46
Serbia	36
Czech Republic	43
Bulgaria	33
Mongolia	33
Czech Republic	32
Romania	22

12.4 BACKGROUND TO COAL ENERGY GENERATION

Retirement of CFPPs comprises two phases: shut down - when operational impacts cease; and decommissioning - the series of activities required (often by regulations) to remove hazards and potentially to redevelop the site. Decommissioning will typically be expected to comprise a mixture of repurposing, demolition, removal of demolition and waste material from site, land remediation and redevelopment. In the context of the Energy Transition⁹, 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 12.1 shows a generalized schematic diagram for a thermal power plant and the associated operations required to run a plant.

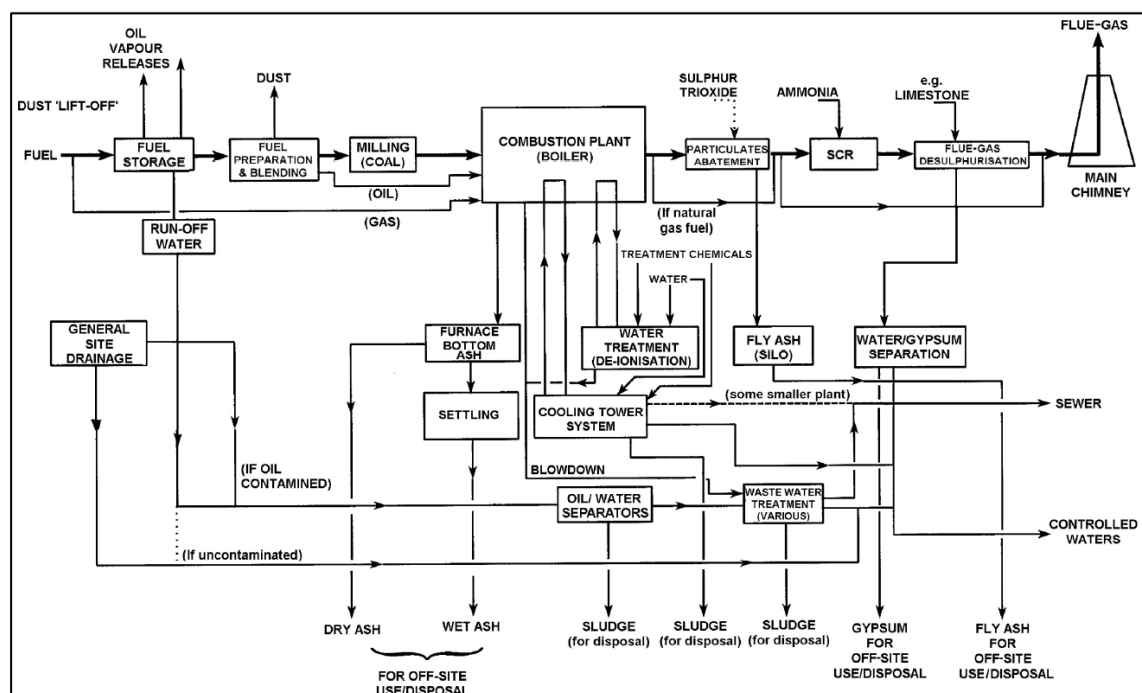
High-temperature, high-pressure steam is generated in the combustion plant (boiler) which then enters the steam turbine. At the other end of the steam turbine is the condenser, which is kept at a low temperature and pressure using a cooling agent, usually water. Through the steam condensing process, 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 (e.g., conduction to adjacent soil or air) before being used in the cooling process again. If a recirculating cooling system is used, only a relatively small amount of make-up water is required to offset the evaporative losses and cooling tower blowdown, which 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.¹⁰

⁹ 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.

¹⁰ IFC (2008b)

Figure 12.1: Generalized flow diagram of a thermal power plant (coal, gas, oil) and associated operations

Source: IFC (2008b)



In many countries, CFPP sites are located on the coast and use coastal sea water for cooling in once-through cooling systems.¹¹

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 truck¹², although the majority of the CFPPs use sea-going barges to deliver coal to the plants.

The burned coal releases carbon dioxide and an array of other chemicals, and it leaves ash. To give a rough sense of scale, each tonne of coal produces 2-3 tonnes of carbon dioxide and provides about 300 kg of solid ash. For each gigawatt of electricity in capacity, a power station would use about 2-3 million tonnes of coal per year, therefore being responsible for 1 million tonnes of ash and 10 million tonnes of carbon dioxide each year. These outputs are detailed in the next section.

12.5 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 process 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.

¹¹ Suarez and Myllyvirta (2020)

¹² IFC (2008b)

Greenhouse gases

The burning of coal in CFPPs emits greenhouse gases (GHG)—predominately carbon dioxide (CO₂) with relatively minor amounts of nitrous oxide (N₂O) 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).

Table 12.3 shows the range of emission performances for a range of CFPP types.

Table 12.3: 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)	<u>Ultra-Supercritical (*1):</u> 37.6 – 42.7	676-795
	<u>Supercritical:</u> 35.9-38.3 (*1)	756-836
	39.1 (w/o CCS) (*2)	763
	24.9 (with CCS) (*2)	95
	<u>Subcritical:</u> 33.1-35.9 (*1)	807-907
	36.8 (w/o CCS) (*2)	808
	24.9 (with CCS) (*2)	102
	<u>IGCC:</u> 39.2-41.8 (*1)	654-719
	38.2–41.1 (w/o CCS) (*2)	640 – 662
	31.7–32.5 (with CCS) (*2)	68 – 86
Gas (*2)	<u>Advanced CCGT (*2):</u> 50.8 (w/o CCS)	355
	43.7 (with CCS)	39
Efficiency (% Net, LHV)		
Coal (*3)	42 (Ultra-Supercritical)	811
	40 (Supercritical)	851
	30 – 38 (Subcritical)	896-1,050
	46 (IGCC)	760
	38 (IGCC+CCS)	134
Coal and Lignite (*4, *7)	(*4) 43-47 (Coal-PC)	(*6) 725-792 (Net)
	>41(Coal-FBC)	<831 (Net)
	42-45 (Lignite-PC)	808-866 (Net)
	>40 (Lignite-FBC)	<909 (Net)
Gas (*4, *7)	(*4) 36–40 (Simple Cycle GT)	(*6) 505-561 (Net)
	38-45 (Gas Engine)	531-449 (Net)
	40-42 (Boiler)	481-505 (Net)
	54-58 (CCGT)	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)	(*6) 725
	44 (Supercritical)	774
	41-42 (Subcritical)	811-831
	47-48 (IGCC)	710-725
Oil (*5, *7)	(*5) 43 (Reciprocating Engine)	(*6) 648
	41 (Boiler)	680
Gas (*5)	(*5) 34 (Simple Cycle GT)	(*6) 594
	51 (CCGT)	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 (SO₂) produced when the sulphur in coal reacts with oxygen. In turn, the SO₂ combines with other molecules in the atmosphere (including water vapour) to form small, acidic particulates that can penetrate human and animal lungs. These particulates are the ashy grey substance in coal smoke that is linked with respiratory and pulmonary illnesses such as chronic bronchitis, aggravated asthma, lung disease, cardiovascular effects such as heart attacks, and premature death. It can also cause smog and haze 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.

Mercury and other toxic heavy metals result from coal combustion and can damage neurological, digestive and immune systems; and is a serious threat to child development.¹³

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 12.4 shows the emission standards in place in various countries.

Table 12.4: 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	NO _x	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.

Southeast Asian coal emissions were estimated to have caused 19,880 (range 11,400–28,400) excess deaths per year in 2017.¹⁴ Pollution from the current Philippines operating fleet of CFPPs is

¹³ UCS (2019)

¹⁴ UCS (2019)

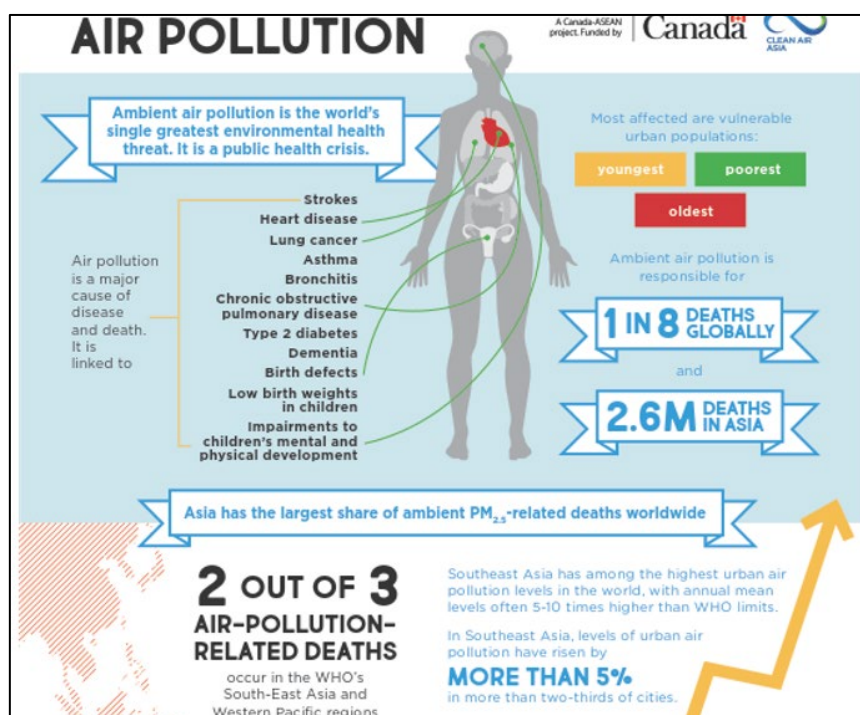
estimated as having led to 630 deaths in 2019, as well as 1,300 new cases of child asthma, 149,000 days of work absence (sick leave) and 240 pre-term births.¹⁵ Studies show that children exposed to CFPP emissions face the highest risks, resulting in significant adverse effects on paediatric neurodevelopment, birth weight and paediatric respiratory morbidity.¹⁶

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.¹⁷ 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.¹⁸ 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.¹⁹

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 12.3), with almost 70% of the burden of air pollution-related mortality borne by Asia.²⁰

Figure 12.3: Ambient air pollution



Source: Ambient Air Pollution Fact Sheet – <https://cleanairasia.org/our-resources>.

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.

¹⁵ CREA (2020)

¹⁶ Amster & Levy (2019)

¹⁷ Clean Air Asia (2020)

¹⁸ Munawer (2017)

¹⁹ Clean Air Asia (2020)

²⁰ Tong *et al.* (2021)

Mercury is one of the key contaminants resulting from the combustion of coal in CFPPs (Table 12.5), 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 12.1). 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.²¹ After mercury is emitted into the atmosphere from the stacks of CFPPs, it settles onto both water bodies and land. It is persistent in sediments, but can become bioavailable and mobilise through the food chain.

Table 12.5: 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
<i>World total</i>	<i>2220 (2000-2820)</i>	<i>100.00</i>

Box 12.1: 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)

Research has shown that Asia releases a large amount of anthropogenic mercury.²² 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.²³

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, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and many other forms of aquatic life.²⁴ 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 12.2).

²¹ <https://www.who.int/news-room/fact-sheets/detail/mercury-and-health>

²² MIT News (2015)

²³ World Economic Forum (2015)

²⁴ IFC (2008a)

Box 12.2: Thermal water pollution in Romania

A fleet of coal-fired power plants is situated along the Jiu River in Romania. 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.

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. The use of ash to replace Portland cement in concrete mixes is lauded for its contribution to reducing the significant greenhouse gas emissions created in producing cement and to divert this waste from landfills. Some countries have a very high utilisation of this ash, such as India²⁵, where the reuse rate is over 90%. Other countries, such as Australia, are struggling to boost the use of coal combustion ash. That is attributed to the cement market being dominated by a small number of large corporate players who have been portrayed as reluctant to 'rock the boat' in a buoyant market made possible by plentiful resources and extensive government investment in infrastructure that uses concrete.²⁶

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 coal-fired combustion facilities include: solid, liquid and gaseous waste-based fuels; air, 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. The failure of a surface impoundment cell at a CFPP in Kingston, Texas, led to approximately 4.1 million m³ 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).

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. The ash can leach heavy metals, including lead, arsenic and mercury, into nearby water sources.

²⁵(a) https://cea.nic.in/wp-content/uploads/tcd/2022/08/Fly_ash_Generation_and_utilisation_Report_2021_22-1.pdf

(b) Central Electricity Authority, Civil Design Division (2022). Report on Fly Ash Generation at Coal/Lignite based Thermal Power Stations and Its Utilization in the Country for the Year 2021-2022, Ministry of Power, Government of India, New Delhi.

²⁶ Review comment, Will Rifkind (23/02/2024)

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:²⁷

- **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;
- **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 handling solid fuels, additives, and solid wastes (e.g., ash). Dust may contain silica (associated with silicosis), arsenic (with skin and lung cancer), coal dust (with 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 process²⁸.

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 a 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 12.6).

²⁷ IFC (2008a) annex A.

²⁸ Markandya and Wilkinson (2007)

Table 12.6: 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

12.6 ISSUES ASSOCIATED WITH THE RETIREMENT OF COAL-FIRED POWER PLANTS

Table 11.7 summarises the range of environmental and socio-economic issues associated with the retirement of CFPPs.

During scoping, a key task is to determine which issues the SEA should focus on.

Table 11.7: Environmental and socio-economic issues associated with retiring CFPPs

ISSUE RELATING TO CFPP RETIREMENT	COMMENT
Environmental	
Reduction in greenhouse gas emissions (GHG)	<ul style="list-style-type: none"> • Early retirement of CFPPs will reduce GHG emissions - unless they are replaced by a larger capacity of power stations (i.e., for a larger population) running on natural gas or burning of municipal waste.
Improved air quality	<ul style="list-style-type: none"> • Reduction in certain emissions to air due to early retirement of CFPPs (sulphur dioxides [SO₂], nitrogen oxides [NO_x], mercury, particulates) - unless they are replaced by power stations that burn waste ineffectively, which can lead to emissions of chemicals and heavy metals.
Improved localized water quality	<ul style="list-style-type: none"> • No longer discharging cooling water to water bodies (eliminating thermal pollution), and elimination of mercury emissions contaminating water.
Water use	<ul style="list-style-type: none"> • Retiring CFPPs reduces water demand - unless they are replaced with power stations that also have significant water demands, such as facilities that generate hydrogen and then use it in fuel cells.
Generation of waste	<ul style="list-style-type: none"> • Decommissioning of power plants leading to large amounts of wastes including hazardous wastes that require disposal, including asbestos in building materials and use for insulation. • 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	<ul style="list-style-type: none"> • 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 CFPP sites to a pre-existing condition. A decommissioning plan will be required which should also prescribe safe and acceptable end land uses. • There may be associated contamination of groundwater and surface water.
Land and ecosystem restoration	<ul style="list-style-type: none"> • 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 or other desired facilities be favourable. • Large power stations often feed electricity into high voltage lines for transmission over distances up to hundreds of kilometres. In some instances, decommissioning of the power station can lead to decommissioning of the power lines, which can enable 're-wilding' of power line corridors, reversing certain effects of ecosystem fragmentation.
Socio-economic	
Legacy socioeconomic issues (crosscutting)	<ul style="list-style-type: none"> • Outstanding legacy socio-economic issues (e.g., lack of compensation for land and property loss, lost livelihoods and income, impacts on cultural practices involving the land, such as hunting and sacred sites, and historical marginalization of certain groups dating back to colonial times) linked to stand-alone mines and impacts specifically linked to individual CFPPs that have not been handled or mitigated before retirement.
Regional economy	<ul style="list-style-type: none"> • 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 the loss of employment income and loss of income tax revenues; closures of related businesses mean a loss of local tax revenue.

ISSUE RELATING TO CFPP RETIREMENT	COMMENT
	<ul style="list-style-type: none"> • Reduced reliability and security of electricity supply leading to disruption at major economic hubs and centers; possible closure of large facility electricity consumers, e.g., aluminum smelter. • Raised electricity tariffs leading to increase in commodity and food price. • Indirect losses through supply chains (transport) may affect the regional economy. • Reduced interest in investing in the region due to loss of an 'anchor tenant', its electric power, and the skilled workforce in its supply chain.
Employment and labour conditions	<ul style="list-style-type: none"> • 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. • Alternative employment options can represent under-employment in terms of hours, income and skill sets, which can lead to early departure from the workforce. • 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	<ul style="list-style-type: none"> • Reduced air and noise pollution, and dust will lead to improved public health. • 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	<ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • Disrupted belief in aspects of capitalist, growth-orientated economy as it has 'failed' locally; green, no-growth alternatives explored. • Rehabilitation and redevelopment of CFPP sites will create income- generation activities.
Gender and vulnerability	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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.

ISSUE RELATING TO CFPP RETIREMENT	COMMENT
Public services and infrastructure	<ul style="list-style-type: none"> • Opportunities for local workers to re-skill for new opportunities in renewable energy replacement. • The early retirement of CFPPs may affect public services and infrastructure directly supported by the CFPPs (e.g., health clinics, education facilities, roads, bus services 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. • Potential loss of sponsorship funding for social infrastructure, such as libraries, town halls, parks and meeting spaces. • Potential loss of support and membership for religious organisations, and charities, reduced levels of volunteering.
Social cohesion and engagement	<ul style="list-style-type: none"> • 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 CFPPs and communities, non-government organizations (NGOs) and activists due to reclamation and rehabilitation of industrial sites formally occupied by CFPPs.

Decommissioning activities vary widely. They range from:

- A plant being abandoned 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.

Evidence suggests that there are a variety of benefits to repurposing and ensuring appropriate remediation of coal-fired power plants. A report by the World Bank²⁹ 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 of CFPP sites (Table 12.8), 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 and decommissioning needs. Repurposing allows for retaining part of the workforce for an upcoming repurposing project at the same site. This retention 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 run.³⁰

Table 12.8: 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

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 larger than gas-fired power plants.³¹ Japan is also investing in converting coal to hydrogen through gasification, supported by carbon capture and storage.³²

²⁹ World Bank (2021)

³⁰ World Bank (2021)

³¹ <https://about.bnef.com/blog/japans-ammonia-coal-co-firing-strategy-a-costly-approach-to-decarbonization-renewables-present-more-economic-alternative/>

³² <https://www.hydrogenenergysupplychain.com/about-hesc/>

Conversely, poorly planned shut down and abandoned CFPPs leave a significant legacy of environmental and social impacts which are discussed in the following sections.

12.6.1 Environmental issues associated with retiring coal-fired power plants

Greenhouse gases

A major benefit of the closure of CFPPs will be the elimination of associated GHG emissions. But benefit will not be immediate as the retirement of CFPPs may be prolonged; and there will still be relatively minor short-term GHG emissions from vehicles and mobile plant used during decommissioning activities.

Air quality

The closure of CFPPs will result in the elimination of all 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.³³

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

³³ <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 (see Box 12.3).³⁴

Box 12.3: 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 km². 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 an 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 site assessment and remediation plans covering potential contaminated land issues, to avoid leaving a legacy of contamination issues that will have long-term impacts on local communities and ecosystems. The plans should include all related facilities to the CFPPs including ponds, storage and waste disposal sites. Final suitable end-land uses for the site should be determined.

Land use 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 sites will need to be decommissioned, decontaminated and reclaimed. Any outstanding environmental and social legacy issues should be remedied. This should also include assignment of financial responsibilities for all associated liabilities.

(e.g. Box 11.5).³⁴ USEPA (undated)

12.6.2 Socio-economic issues associated with retiring coal-fired power plants

The impacts of CFPP retirement depends on the type of facility. 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.³⁵ 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.³⁶ Additionally, companies may require (depending on regulatory requirements) 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.³⁷ Energy transition can 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.³⁸

There are arguments that national politics, income from tax revenues and investment in infrastructure can cause a national economy to be 'locked in' to coal fired power generation. These conceptual 'blinkers' among decision-makers in government and industry can make it difficult to explore alternatives and plan closures with sufficient lead time. The latter is necessary to meaningfully engage – and, where necessary, to support - key stakeholder groups. Such a failure to engage with stakeholders, in turn, can result in a costly and inefficient closure process with long-term negative effects.

More specifically, 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 12.4). The closure of CFPPs may also cause import and export and trade imbalances between countries and regions.

Box 12.4: Potential economic impacts of retiring CFPPs in Indonesia

Domestically, the Indonesian electricity sector is dominated by CFPPs. In 2021, they contributed at least 5.5% to the total GDP.³⁹ 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

³⁵ 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/>.

³⁶ Roth and Lawrence (2004; Schmidt et al. (2015)

³⁷ IRENA (2020b)

³⁸ [How Indonesia can afford to cut coal-fired power – and faster | Lowy Institute](#)

³⁹ Badan Pusat Statistik ([Seri 2010)

enterprises in Indonesia rely on the state electricity company (PLN).⁴⁰ 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 demand.⁴¹ 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 that is a consequence of population growth. Without policies addressing long-term impacts in place, the rapid transition from CFPPs to renewable energy could introduce long-term issues for energy supply. Government policies need to consider which energy source(s) might replace coal in the short, medium, and long term.⁴²

Local economy and livelihoods

In localities where the economy and livelihoods of host communities are highly dependent on the operation of CFPPs, their retirement will have both direct and indirect socio-cultural and commercial consequences and could lead to socio-economic deprivation for decades.⁴³ 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.⁴⁴ 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 which can lead to them becoming part of the local culture and identity which, in turn, influences how residents envision their future options.

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 Scotland⁴⁵ and the US (in the 1970s).⁴⁶ Income from the related businesses will be reduced, increasing households' indebtedness and vulnerability to poverty, as well as reducing tax revenues due to local governments which are meant to provide support services. However, there are opportunities when the CFPPs and the adjacent areas are rehabilitated and redeveloped as recreational areas or as precincts for other uses, with new income-generating opportunities from the installation of replacement renewable energy sources.

Legacy of socio-economic issues (cross-cutting)

Currently operating 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, socio-economic and environmental legacy concerns, availability of functioning grievance mechanisms) may not have been addressed. Even if they have been addressed in some way, this is not likely to have been in line with good international industrial practices, typified by the IFC Performance Standards⁴⁷ and the World Bank Group environmental health and safety guidelines.⁴⁸

⁴⁰ Badan Pusat Statistik (undated).

⁴¹ IEA (2021b)

⁴² GRICCE (2019)

⁴³ Financial Times (2018)

⁴⁴ IEA (2021Bb)

⁴⁵ IME (2016)

⁴⁶ Baldwin *et al.* (1977)

⁴⁷ www.ifc.org

⁴⁸ <https://documents.worldbank.org/>

Coal-fired electricity generation is an industry that has long been associated with a range of human rights and environmental issues arising during the different phases of projects, including construction, operation and decommissioning.⁴⁹ 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., Philippines⁵⁰ and Indonesia⁵¹).

Where there are outstanding inequalities and disparities resulting from poor attention to and management of socio-economic issues linked to CFPPs that have not been dealt with or mitigated⁵², the retirement of such CFPPs could exacerbate those problems.⁵³

Experience from the rest of the world, especially in Colombia⁵⁴, 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 2019.⁵⁵

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.⁵⁶ The transition can create jobs in the renewable energy sector, but it will also reduce jobs in the non-renewable energy sector. In aggregate, there will be displacement and substitution of jobs from one sector to the other, but the full extent to which there will be a direct transfer of workers from non-renewable to renewable energy generation is uncertain. As shown in Table 12.9, energy transition is predicted to increase job opportunities globally by 0.18% in 2030 and by 0.15% in 2050, respectively.

Table 12.9: 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 have been 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 the geography of job opportunities with implications for settlement patterns.

The scale of job losses will vary from one plant to another, depending on the plant's megawatt capacity and the nature of its ownership, as the employees of large firms with renewable investments will be more likely to secure internal transfers. The larger the capacity of CFPPs, the more potential

⁴⁹ The case of Colombia suggests these legacy issues, see Wilde-Ramsing *et al.* (2021); and Haigh (2015)

⁵⁰ Valencia (2017) and World Bank (2012);

⁵¹ 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>

⁵² 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, unaddressed legacy issues and health monitoring that is deemed to be inadequate.

⁵³ Wilde-Ramsing *et al.* (2021)

⁵⁴ Wilde-Ramsing *et al.* (2021)

⁵⁵ Darmawan (2019).

⁵⁶ IRENA (2020b)

for job losses, but also the more likely that the plant will be owned by a large firm able to offer redeployment options. It is evident that significant job losses are resulting from the global trend to replace CFPPs with renewable energy, a result of international pledges to reduce carbon emission (under the Paris Agreement).⁵⁷ For example, in Poland, the employment rate in the sector declined rapidly from 1990 to mid-2015.⁵⁸ Indonesia's electricity and gas sector employed at least 0.284 million workers in 2021⁵⁹, excluding jobs associated 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 many developed countries, trade unions have secured better than average wages and conditions for the employees of CFPPs, as well as generous redundancy provisions that soften the impact of job loss.⁶⁰ Unions in such locations have identified the poorer employment conditions being offered in the renewables sector as an impediment to the direct transfer of workers to that sector and to the pace of the transition in general.⁶¹

Conversely, in countries where national regulatory enforcement is weak, CFPPs might have invoked substandard labour management. For instance, in Mexico between 2012 and 2013, it was found that some CFPPs illegally employed minors.⁶² In China, researchers reported that from 2017 to 2019, workers in CFPPs worked in hazardous, unsafe and unhealthy environments.⁶³ In jurisdictions mandating strong labour regulation in the emerging renewables sector, the closure of CFPPs might abolish substandard labour and working conditions and labour exploitation. Governments as well as 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 or mandated transition measures, where the responsibility for managing change therefore falls to exiting firms, the injustices and equity implications for the affected workers, and for households adapting to different energy sources and prices, may not be adequately redressed.⁶⁴

Therefore, it is important that, as part of the closure of CFPPs: opportunities are created for worker retraining and reskilling, ideally prior to CFPP closure, for jobs that maximise each worker's skill utilisation and earnings potential (whether in the renewable energy or other sectors); and that measures are taken to guarantee worker compensation and support for unemployed former CFPP workers, including through adequate relocation assistance.⁶⁵

Health and safety

The closure of CFPPs will end on-site occupational hazards described in sub-section on health and safety in section 12.4.1, with a consequent elimination of 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 and below the site (as described in the sub-sections above on solid waste and land/water contamination), which could contaminate drinking water, food and local

⁵⁷ an international treaty on climate change, adopted in 2015 (see: [The Paris Agreement | United Nations](#))

⁵⁸ Baran *et al.* (2018)

⁵⁹ 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&xzm n=aHR0cHM6Ly93d3cuYnBzLmdvLmIkL3B1YmXpY2F0aW9uLzlwMjlvMDIvMjUvMGEyYWZlYTRmYWI3MmE1ZDA1MmNiMzE1L3N0YXRpc3Rpay1pbmRvbmVzaWEtMjAyMi5odG1s&twoadfnorfeauf=MjAyMi0wMy0xMCAxNzoyODoxNQ%3D%3D>

⁶⁰ Snell (2018); Weller (2024).

⁶¹ ACTU (2023)

⁶² <https://www.mining.com/mexico-shuts-down-over-20-coal-pits-over-child-labour-probe-84458/>

⁶³ Wang *et al.* (2021).

⁶⁴ Piggot *et al.* (2019)

⁶⁵ Weller, 2024

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. Surrounding communities should also be informed of potential health risks from decommissioning and the measures taken to address them.

The World Bank's Environmental, Health and Safety (EHS) Guidelines provide standard requirements for coal processing power plants.⁶⁶ They outline key health and safety risks and management of health issues related to air emissions, wastewater, solid and hazardous materials and wastes, and noise as well as issues concerning occupational and community health and safety in the life cycle of coal mines. The IFC Performance Standard (PS) 2 also highlights key labour and working conditions requirements that CFPPs should comply with.⁶⁷ These include the International Labour Organization (ILO) labour conventions⁶⁸ 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 financed by the IFC or World Bank and 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, contaminant related legacies and possible food 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.⁶⁹

The closure of CFPPs is both a leading requirement for addressing the climate change narrative and for the public health of local communities proximate to where they operate. CFPPs produce sulphur dioxide (SO₂), nitrogen oxides (NO_x), mercury and invisible particulate matter (known as PM₁₀ 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.⁷⁰

A Government of Canada website for the Powering Past Coal Alliance⁷¹ indicates that there are massive health care issues (see sub-section on air quality in section 12.5) 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 the health of both humans and ecosystems.

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 ending. 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.⁷²

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

⁶⁶ IFC (2007b)

⁶⁷ IFC (2012c)

⁶⁸ 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.

⁶⁹ https://www.gem.wiki/Coal_waste

⁷⁰ World Bank (2018b)

⁷¹ [Coal phase-out: the Powering Past Coal Alliance - Canada.ca](https://www.poweringpastcoal.ca)

⁷² Kravchenko and Lyerly (2018)

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.⁷³ 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 and demands for vocational know-how would be affected by such migration.

Retraining opportunities in replacement renewable energy sources 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 communities⁷⁴

Indigenous communities⁷⁵ may be more vulnerable to the adverse impacts associated with retirement of CFPPs, e.g., through loss of identity, culture and natural resource-based livelihoods, as well as exposure to impoverishment and diseases.⁷⁶ In many countries, CFPPs are located in semi-urban and coastal areas and in remote areas where indigenous communities reside. There are documented instances of indigenous communities resisting CFPP establishment (e.g., in West Papua, Indonesia⁷⁷) 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 IEEFA⁷⁸, 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. This followed 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 CFPP 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.

CFPP 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 (Box 12.5).⁷⁹

⁷³ See: Global Energy Monitor (undated)

⁷⁴ The United Nations describes Indigenous peoples as inheritors and practitioners of unique cultures and ways of relating to people and the environment. [Addressing Global Challenges with Indigenous Knowledge | United Nations](#)

⁷⁵ see definition in Annex 19

⁷⁶ IFC (2012b)

⁷⁷ Asia Pacific Solidarity Network (2020)

⁷⁸ IEEFA (2021)

⁷⁹ 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

Box 12.5: 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.⁸⁰ The W.K. Kellogg Foundation has \$3 million program-related investment in support of Navajo Power.⁸¹

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.⁸² These impacts can take the form of:⁸³

- Greater gender inequality in workforce demographics and wage equality;
- 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.⁸⁴

While CFPP closure may result in direct job losses for both men and women, women are likely to bear the increased burden of social care and domestic responsibilities⁸⁵ 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".⁸⁶ 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. Closure of a CFPP that predominantly employs men, particularly when the men are from other communities, can lead to greater fears of women over their safety where they live. Where the work environment in the CFPP is strongly hierarchical or marginalises staff from certain backgrounds, closure can reduce tensions within households by reducing instances of 'oppressed group behaviour', where employees who feel oppressed take out workplace frustrations on family members.

Public services and infrastructure

The early retirement of CFPPs may also affect public services and infrastructure such as transportation, health, and education facilities. Other forms of social infrastructure might lose sponsorship, e.g., libraries, town halls, parks and meeting spaces, as well as social and sporting facilities and religious buildings (e.g., churches and mosques). Retirement will reduce dust, air and noise pollution, leading to improved public health. However, overall community health may deteriorate

UNESCAP. 2018. *Inequality of Opportunity in Asia and the Pacific: Clean Energy*. Bangkok. [Inequality of Opportunity in Asia and the Pacific: Clean Energy \(unescap.org\)](https://www.unescap.org/publications/inequality-of-opportunity-in-asia-and-the-pacific-clean-energy)

as support from CFPPs and associated businesses is reduced or eliminated (including through lost tax revenue generation to local authorities) for health facilities and other services (e.g., education facilities, roads, bus services and other transportation). 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.⁸⁷
- 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 12.6), and so will be impacted when education or health facilities are downsized or stagnate following CFPP closure.

Box 12.6: 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)

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.⁸⁸

Community cohesion and engagement

In some cases, the existence of 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.⁸⁹ 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.⁹⁰

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.

⁸⁷ McCarter and English (2016)

⁸⁸ Resosudarmo *et al.* (2009)

⁸⁹ <https://www.asiasentinel.com/p/anti-coal-movement-philippines?s=r>

⁹⁰ Darmawan (2019)

12.7 ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES ASSOCIATED WITH CLOSING COAL MINES

The previous section discusses 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 12.10 summarises the range of environmental and socio-economic issues associated with closing coal mines.

During scoping, a key task is to determine which issues the SEA should focus on.

Table 12.10: Environmental and socio-economic issues associated with coal mine closure

ISSUE	COMMENT
Environmental	
GHG emissions	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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; or can lead to impacts on downstream salinity, which can be an issue in agricultural areas as salinity can affect crop productivity by reducing the availability of soil water to plants. Spills and leaks (from vehicles and their cargoes) during closing of mine site can pollute groundwater and surface water. Alternative facilities built on a reclaimed mine site (e.g. a manufacturing plant to take advantage of the ready access to high capacity power lines and rail lines) might generate their own water quality impacts, such as effluent.
Water use	<ul style="list-style-type: none"> Closing coal mines reduces water demand for use at the coal mine. Options to turn open pit mines into lakes for water supply can lead to concerns about the cleanliness/safety of the water – since surface flows (potentially contaminated) will accumulate in the pit. Pit lakes present a large surface area, leading to high rates of evaporation in sunnier areas (such as Australia).
Noise	<ul style="list-style-type: none"> Long-term elimination of mine noise following closure/decommissioning. Short-term impacts on local communities from vehicles on-site and using local roads during decommissioning. Alternative uses for a mine site can create noise on site or via truck traffic.
Contaminated land and groundwater	<ul style="list-style-type: none"> Discharges from abandoned mines - as a consequence of groundwater rebound (commonly acidic), which 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	<ul style="list-style-type: none"> 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 and in situ coal burning, leading to increases in particulates.
Waste	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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 and habitats. Conversely, abandoned mine sites may render the site as a liability.
Land degradation	<ul style="list-style-type: none"> Slumpage and geotechnical instability from collapse of underground works may make the site unsuitable for other uses and pose a public safety risk. 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	<ul style="list-style-type: none"> 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

ISSUE	COMMENT
	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 socio-economic issues	<ul style="list-style-type: none"> • Outstanding socio-economic issues of coal mines and mine mouth CFPPs that have not been dealt with or mitigated before closure. • Particular issues relate to the negative effects on indigenous peoples and traditional societies of Western style industrialisation since colonisation.
Regional economy	<ul style="list-style-type: none"> • 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. • Infringement of international trade agreements on coal supply. • Increased electricity and fuel prices, impacting commodity and food prices. • Coal may be exported to other countries resulting in carbon leakage. • Opportunities to diversify the economy that do not rely on coal. • Impacts on coal supply transport such as truckers, shipping fleets, etc.
Illegal mining	<ul style="list-style-type: none"> • Increased illegal mining as investment in managed and regulated coal mines is reduced. • Reduced government capacity to enforce regulations as resources at the local and national level are focused on other aspects of the energy transition.
Employment and labour conditions	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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 of geotechnical risks (filling/capping mine shafts, fencing-off, etc.) leading to community 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	<ul style="list-style-type: none"> • 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. • Reduced investment in a region by outsiders as it is seen as unattractive due to closures. • Potential economic opportunities induced by the rehabilitation and redevelopment of coal mines and pits will create income-generation activities.
Gender and vulnerability	<ul style="list-style-type: none"> • 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.

ISSUE	COMMENT
Migration	<ul style="list-style-type: none"> • Opportunities for vulnerable groups to engage in the decision-making process and in inclusive dialogue for coal mine closure. • Local skilled workers and migrants attracted to work in mines and associated businesses will leave the communities. • Increased vulnerability of abandoned household members whose income depends on skilled migrants. • Opportunities for local workers to re-skill for new opportunities such as replacement renewable energy industries.
Public services and infrastructure	<ul style="list-style-type: none"> • CFPP/mine closure may affect the public services and infrastructure supported by mining companies (e.g., health clinics, education facilities, roads, bus services 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. • Increased pressure on public services when empty housing is rented by the government to house families in need from other regions . • Potential loss of sponsorship funding for social infrastructure, such as libraries, town halls, parks and meeting spaces. • Potential loss of support and membership for religious organisations and reduced levels of volunteering.
Community cohesion and engagement	<ul style="list-style-type: none"> • Weakened community cohesion due to out-migration. • Risk of internal conflict due to increased stress as result of lost income. • Opportunities for communities to engage in the decision-making processes about mine closure. • Reduced tension between the communities, NGOs, activists and mining companies; but tension can increase if they are unable to agree on overcoming past distrust and future steps - this may be influenced by how stakeholders and authorities deal with change and transition.

12.7.1 Environmental issues associated with coal mine closure

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 (orphan mines), 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. 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.

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. There can also be dust from the significant amounts of waste spoil on site, and particulate matter arising from still existing coal storage piles,

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 and there is a need to address issues such as dewatering (pumping out water) of pits and mine shafts, coal washing, runoff, groundwater contamination 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 mineshafts.

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 (Box12.7). Impacts from a number of smaller abandoned mines may also have an impact.

Box 12.7: 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 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. It is highly toxic to humans, flora and fauna, and has polluted the waterways and had impacts on communities. Although the water 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, it 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 and 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.

A reduction in noise can be accompanied by a reduction in vibration and reduced use of lighting at night, reduced smells from vehicle exhaust, reduced traffic and declines in other annoyances, which are sometimes referred to by environmental toxicologists as 'non-chemical stressors'. Assessments of such stressors indicate that certain types of persistent, penetrating and/or unwelcome noise have been associated with increases in stress. In turn, this can lead to health impacts such as increased prevalence of cardiovascular disease. So, cessation of coal mine operations and the associated noise can have a ripple effect reducing health impacts.

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 or seeping into groundwater due to the

discharge of mine water containing heavy metals and other pollutants.⁹¹ 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.

With the closure of a coal mine, there is the opportunity for groundwater recharge and this can have both 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 materials (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, leading to legacy impacts.

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 and sulphur.⁹² 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, removal 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.

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 and drainage systems that are consistent with

⁹¹ Johnston *et al.* (2008)

⁹² E.g. rocks containing iron sulphide minerals, such as pyrite

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 12.8).

Box 1.8: 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 pastureland 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. 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 monitoring every 6 months for a further 2 years.

Source: Whitehaven Coal Mine (known as Canyon Coal Mine) Closure Mining Operations Plan (whitehavencoal.com.au)

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 12.9). 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.

Box 12.9: Rehabilitation former coal mines: some examples

The 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)

Discussions and planning for land use change can also have impacts on communities. Decision-making processes that are inclusive (i.e., where marginalisation is reduced, where government and industry are seen to be listening and to be trustworthy – in providing information and in following through) can boost a community's sense of meaningful engagement in and ownership of decision-making. This can lead to more positive social and economic outcomes following mine closure.

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.

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 closed 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 considered with preparation of site closure plans.

12.7.2 Socio-economic issues associated with closing coal mines

Country, regional and global economies

Coal mining is an important contributor to many national economies (Box 12.10). The closure of coal mines will affect the coal supply chain at both national and international levels, resulting in increased coal prices and reduced imports and exports. According to an analysis of the global socio-economic and economic impacts of coal retirement⁹³, “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”.⁹⁴

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 (where they exist), investment associations, companies, NGOs and local communities. The phasing out of coal mines requires early planning, due diligence and active and inclusive dialogue with affected stakeholders.

In Indonesia, closures of mine activities are already known to create complex and severe problems, especially since the local economy in many of the country's mining areas and the local governments

⁹³ IRENA (2020)

⁹⁴ IRENA (2020b)

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 12.11).

Box 12.10: 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.⁹⁵

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 8.9% to the Indonesian GDP.⁹⁶ The closure of coal mines will affect Indonesian economic growth. Between 1992–2009, Indonesia earned at least \$9.3 billion in taxes from coal mine extraction.⁹⁷ 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.

The volume of export and import of coal – and associated monetary flows - are affected by geopolitics. So, coal represents not just an important revenue stream for certain countries but also a source of potential economic instability. For example, China (PRC) dramatically reduced its purchases of Australian coal, and other commodities, as the Chinese government cited its unhappiness with Australian commentary on human rights in China and the Australian government's support for Taiwan. Further tension is due to the two countries acting as rivals in providing support for island nations in the Asia Pacific, such as Samoa.

Box 12.11: 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 Environment and 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 programmes 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

⁹⁵ [How Many People Work in the Coal Industry? \(investopedia.com\)](https://www.investopedia.com)

⁹⁶ Badan Pusat Statistik [Seri 2010]

⁹⁷ ASEAN Today (2021)

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 (Box12.12). It would affect retail, accommodation services, food services, other dependent sectors and social and emergency services. There is clear evidence that decades after coal mines have been shut down, many coal-dependent regions continue to lag socially and economically.⁹⁸ 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, planning often lacks foresight, detail and input from a range of affected parties.

Box 12.12: Local economy and community dependence on coal mines

Shanxi Province in the north of the 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. These closures have hit the province with reduced revenues for the state-owned enterprises and tax revenue reductions for the local government.⁹⁹

Countries in Eastern Europe such as Poland, Ukraine and Romania had programmes to restructure their coal sectors in the 1990s. These programmes 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 they also provided houses and socio-economic 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 utilities 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. Additionally, there are a number of communities in Australia where coal mine workers are engaged in a fly-in/fly-out or drive-in/drive-out basis. So, the affected communities are both where the mines are located, and sometimes at a great distance away where the coal miners live in the weeks when they are not rostered on to work. Similar dynamics would occur in other countries where workers are temporary migrants to the mining region.

Sources: World Bank (2003); and Della Bosca and Gillespie (2018)

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 and artificial ski slopes, etc.¹⁰⁰ Open mine pits can also be redeveloped as reservoirs or pumped-storage hydroelectricity projects, as in the state of North-

⁹⁸ World Bank (2018b)

⁹⁹ 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>

¹⁰⁰ National Geographic (2022)

Rhine Westphalia, Western Germany.¹⁰¹ 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 them were unplanned.¹⁰²

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) socio-economic and related environmental impacts, including outstanding land conflicts, land degradation and contamination, lack of compensation payments for land and property loss, lost livelihoods and income, and exacerbation of historical cultural and economic marginalisation. 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).¹⁰³ An assessment report 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”*.¹⁰⁴

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 2,000 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.¹⁰⁵

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 the 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. Problems 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 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.

¹⁰¹ Agerholm (2017)

¹⁰² Strambo *et al.* (2019)

¹⁰³ www.ifc.org

¹⁰⁴ Wilde-Ramsing *et al.* (2021)

¹⁰⁵ Zuhail (2022)

In addition, closure eliminates fatalities resulting from road accidents involving heavy vehicles transporting coal (Box 12.13).

Box 12.13: 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 in 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/>.

Large industrial facilities, such as mines, are often serviced by improved roads to urban centres and employ staff who are relatively well paid. They can thus attract prostitution and drug dealing. So, closure can lead to improvements in reproductive health, household gender relations, physical health and mental health.

However, the departure of a large industrial employer can lead to fewer resources being put into reducing mosquito populations (leading to possible outbreaks of malaria) or to assuring health in the community through immunization programmes.

There may also be risks of public health issues 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 12.14).

Box 12.14: Lack of post-closure remediation in abandoned coal mines in Borneo

Indonesian law requires mining companies to fill in their mine pits as part of closure and prohibits mining within 500 m of houses. But these regulations are not followed. 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. In East Kalimantan, 632 water-filled mine pits have been identified, with the true number estimated as being many more.

As a result, the surrounding communities are at risk of short- and long-term environmental and health risks. Between 2011 and 2016, 27 persons, mostly children and adolescents, died in 18 abandoned mine pits in East Kalimantan, most by drowning. These pits also are an environmental hazard with the water found to be highly acidic and containing high levels of heavy metals including manganese, zinc and iron. Many of these pits provide water to nearby communities for irrigation and drinking.

In Indonesia, mining companies are required to have reclamation guarantee funds set aside for mine pit closure. Only 96 of commercial mining license holders registered in the East Kalimantan Office of Mining and Energy have deposited post-mining guarantee funds meant to restore environmental and social conditions at the mine site. As a result, hundreds of abandoned mine pits remain in East Kalimantan posing environmental, health and safety risks to adjacent communities.

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. It is important that these public health and safety concerns and issues are fully addressed and included as part of mine closure plans.

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^{106 107}, and can have significant consequences (Box 12.15).

Box 12.15: The consequences of illegal coal mining in Indonesia

Following the Asian financial crisis¹⁰⁸ 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.¹⁰⁹ The Government of Indonesia used to tackle only symptomatic cases of illegal mining activity. This selected attention 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 socio-economic and environmental externalities and repercussions.¹¹⁰ 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.¹¹¹

In Indonesia, workers were killed at illegal mining sites due to improper health and safety measures (Figure 12.11). 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 the 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.

Sources: Cronin and Pandya (2009); Resosudarmo *et al* (2009b); Saputra (2022); and Wijaya (2020)

¹⁰⁶ Soelistijo (2011); and Nasir *et al.* (2022).

¹⁰⁷ MCSA (undated)

¹⁰⁸ A sequence of currency devaluations and other events that began in the summer of 1997 and spread through many Asian markets.

¹⁰⁹ Resosudarmo *et al.* (2009b)

¹¹⁰ Resosudarmo *et al.* (2009b)

¹¹¹ Resosudarmo *et al.* (2009b)

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 impact 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, but also by increases in automation in developed settings and more efficient mechanisation in less developed countries.

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.¹¹²

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.

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.

Coal mine work is characterized by the International Labour Organisation (ILO) as difficult, dangerous and rarely associated with good labour relations.¹¹³ 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.¹¹⁴

The process of closing mines, as with retiring CFPPs, could reduce or eliminate the use of forced labour and child labour. Facilities with substandard working conditions can be addressed by 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 programmes, and to pursue employment opportunities in renewable energy projects or other sectors. However, evidence from job placement programmes 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.¹¹⁵

Indigenous communities

When coal mines close, adjacent indigenous communities face similar issues to those highlighted during CFPP retirement (see section 12.6.2). However, when coal mines are to shut down, the

¹¹² World Bank (2018b)

¹¹³ ILO (2004)

¹¹⁴ Saputra (2022)

¹¹⁵ Aassve et al. (2006)

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.¹¹⁶ 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 which are recognised in some circles to be nearly universally overlooked in policy-making. Many cases of coal mine closure in the southwestern regions of the US demonstrate these challenges. As mentioned in section 12.6.2, 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 be involved with governments and mining companies in determining how they want the land fully reclaimed, considering that their past, current and future identity are closely aligned with the physical, cultural and spiritual representation of the land.¹¹⁷

There are also 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.¹¹⁸ The benefits of closures can increase as recognition of the rights and titles of indigenous peoples increases and as policies and practices are implemented to help redress historical injustices. In other words, a changing political context in the mining sector means that closures today, and in the near future, can offer benefits that would have been less likely than closure 20 or 50 years ago.

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 12.6). Mine closure can compound social inequalities faced by women and the most vulnerable, particularly those from protected groups such as indigenous peoples).

Box 12.16: 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 12.5.2 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, harassment, sexual and gender-based violence and psychological distress.
- Opportunities for a positive shift in gender relationships within households and in communities assisted by government or industry interventions in the rare cases when closure processes are well planned and carefully executed.

¹¹⁶ IFC (2012b)

¹¹⁷ University of New Mexico (2017)

¹¹⁸ The Asia Foundation (2016)

Migration

Mine closure can cause unintended and complex social challenges such as migration. This is almost universally overlooked in policy-making.¹¹⁹ 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.¹²⁰

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 their departure 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.

This outward migration can take families from the coal mine area, which can reduce the strength of 'social capital' and community support networks which, in turn, were providing trade and staffing for small businesses in the local economy. Outward migration can also imply that one family income earner travels in search of employment while the rest of the family stays behind. This can lead to tensions within a household and can weaken support within the family for the primary caregiver in the household, the children and the elderly.

Employment opportunities may 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. Such requirements could also include mining companies providing 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 funded as a casualty of mine closure.¹²¹ In Southeast Asia, especially in the Philippines and Indonesia, the closing of mine activities - which can provide a greater proportion of a region's cash flow - 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.¹²²

Section 12.4.2 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, India¹²³, see Box12.7). 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

¹¹⁹ Mayer (2021)

¹²⁰ Merrill and Kitson (2017)

¹²¹ Merrill and Kitson (2017)

¹²² Resosudarmo *et al.* (2009b)

¹²³ Gupta (2021) <https://www.teriin.org/sites/default/files/2021-03/Mapping-Impact-of-Coal-Mines-Case-of-Betul.pdf>

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 programmes in Poland and Romania (Box12.17).

Box 12.17: 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 by government and industry 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 in discussions on the repurposing of infrastructure and other assets, which helped to guide expectations, making them more realistic. 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 the 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.

Such outcomes can be the result of other aspects of the national political context, issues with the national or global economy (such as the Global Financial Crisis) and the level of domestic corruption.

Sources: Gupta (2021); World Bank (2018b)