Power, Planning and Politics: The Contributions of SEA in Sustainable Energy Planning for Thai Power Sector

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Power, as one of the most convenient forms of energy, is always at the heart of the modern societies. It does not only bring energy for running economy and quality of life, it also consumes a lot of resources. Moreover, in the modern societies, power sector is always the main source of pollution and ecosystem disturbance. On one hand, it can lead to the improvement of people well-being. On another hand, it can also badly affect livelihoods and destinies of millions of people. Therefore, power is always one of complex and controversial issues within our societies.

Since the power sector needs well-planned long-term investment, planning is always critical for power sector management. However, because the investment in power sector can lead to several aspects of impacts and conflicts, planning in power sector is certainly complicated. It does not only need good calculation, it also requires good perspectives and, more importantly, deliberative discussion within democratic decision-making process.

Strategic Environmental Assessment (SEA) is one of the recent attempts to fulfill this demanding task. It tries to look beyond the conventional way of planning and impact assessment. In stead of coming at the end process of decision-making, SEA tries to contribute at the beginning points when most policy options is still possible and open for consideration and when various (and also different) visions and perspectives of our future can play the roles in decision-making process.

However, SEA cannot occur in vacuum. It certainly plays roles in and, concurrently, shaped by political environment within each society. Like other impact assessment, the effectiveness of SEA, thus, depends mainly on its implicit policy strategy in interacting with to decision-making process and policy arena. And this is the main idea of this paper.

This paper shows one of the recent attempts to apply SEA for long-term power planning in Thailand, one of the fast growing societies in terms of power consumption. Although the paper will cover the whole range of SEA process, the main aim is to analyze the recent policy outcomes and its lessons learnt. The paper will start by the societal needs of SEA (in part 1), then, the SEA concept and process (in part 2). The possible policy options for Thailand will be discussed in part 3

before the SEA results will be presented in part 4. Last, the main focus of this paper, i.e. recent policy outcomes and the lessons learnt, will be discussed in part 5 and part 6, respectively.

1. Impact Assessment and Thai Power Sector

1.1 Thai Power Sector

From the 1960s, Thai power system has been established based on three state-own enterprises, namely the Electricity Generation Authority of Thailand (EGAT) for generation and transmission, Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA) for distribution in the Greater Bangkok and other areas, respectively. Moreover, the supply of natural gas, main fuel sources for power generation is also controlled by another state own enterprise Petroleum Authority of Thailand (PTT).

From 1992, the private power producers have been allowed to generate power and sell power to the grid through EGAT. Presently, almost 60% of power generation are still operated by EGAT and 30% are controlled by 6 independent power producers (IPPs), of which the 2 largest IPPs are EGAT's subsidiaries. All of them rely on the centralized power and fossil fuel technology. In terms of fuel types, natural gas contributes to 70% of energy generation. Other main sources of fuel are lignite (11% of energy generation), hydro (6%), and imported coal (5%).

From the total turnover of almost 240 billion THB (6 billion USD) in 2002, these four state-own enterprises and subsidiaries absorbed more than 90% of total value-added (Figure 1). The total profit margin within the system summed up to 38% of total turnover. The high control of power and profit, combined with new trend in vertical integration, like establishing new IPPs, and capitalization in the stock exchange market, encourages them to maintain the fossil-based centralized power system. Unsurprisingly, overall utilization of renewable energy is less than 1% of total energy generation in Thai power sector.

Now, PTT and EGAT have been privatized and EGAT will be listed in the Stock Exchange of Thailand. However, EGAT still hold various authorities in terms of planning, operating, and regulation under the concept of Enhanced Single Buyer model. Although several government agencies, like Energy Policy and Planning Office (EPPO) or Department of Alternative Energy Development and Energy Conservation (DEDE), has played important roles in policy formulation, planning, and some regulations, most of the decision-making power, including long-term investment planning is still under the authorities of Thai government, Ministry of Energy (MoEn) and EGAT.

The negative impacts from power generation are quite obvious in Thailand. Mae Moh lignite power plant using domestic lignite is a good example of serious air pollution and human health impacts. Several hydropower plants also cause serious ecosystem and local livelihood changes. In the last decade, power plant projects and

relating infrastructure, like gas pipeline, have turned to be a controversial and conflicting issue in this country. Some of these conflicts lead to the violations against local people and human rights.

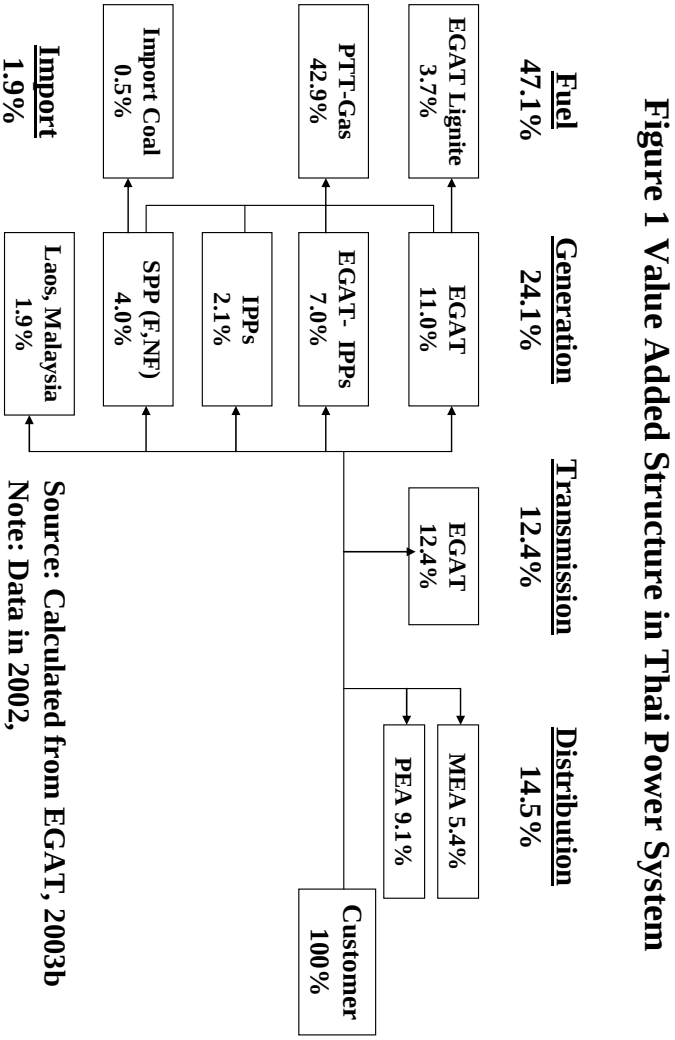

Figure 1 Value Added Structure in Thai Power System

Source: Calculated from EGAT, 2003b
Note: Data in 2002,

1.2 The Need for Strategic Impact Assessment

Along with the conflicts over the power plants, Environmental Impact Assessment (EIA), legalized by the National Environmental Quality Act since 1992, is always the issue of debate and criticism. In general, EIA in Thailand have conducted with very limited public participation and transparency. Moreover, several EIA reports of power plant projects have made obvious and serious mistake

leading to public mistrust of EIA process and its outcomes.

At the same time, since the power system needs long-term investment plan with the clear schedule of each power plant projects, EIA seems to be inadequate to facilitate public discussion, especially at the policy level. The more proactive approach of impact assessment is thus needed in strategic planning of the power sector.

The concept of strategic impact assessment was firstly developed in Thailand in 1999, when Sustainable Energy Network for Thailand (SENT) proposed Thai government to invest in sustainable energy technologies instead of investing in a controversial coal-fired power plant project. This is because, according to SENT report, sustainable energy choice will lead to higher GDP contribution for the national economy, reduce BOP burden, create more jobs, and lower GHG emission compared to the coal-fired power plant. SENT also urged Thai government to look for broader consequences of energy investment and apply strategic impact assessment in power development planning (PDP) process.

In August 2003, Thai government has launched the National Energy Strategy, which set up quite ambitious targets for energy efficient and renewable energy development. The strategy also provided new information on the potential of renewable energy and energy efficiency as main alternative for power development in Thailand. However, this national strategy does not show the direct links between its proposal and its environmental, social, and health consequences.

Later in 2004, the alternative PDP was suggested by the National Economic and Social Advisory Council, during the public debate on government privatization policy for Thai power sector. Since one of the main forces for privatization is to release public investment and debt burden, the aim of this alternative PDP is to shows how alternative PDP, compared to formal EGAT power development plan 2004 (PDP2004) can reduce investment requirement and, thus, relax the pressure for privatization. Unfortunately, this alternative PDP did not link to other development goals and impacts.

In 2005, Health Systems Research Institute (HSRI) has developed research program on the development of Strategic Environmental Assessment (SEA), after three years of HIA development. In this research program, SEA is aim to be one of strategic planning tools to promote healthy public policy in non-health sectors and to facilitate deliberative policy discussion and decision. The long-term planning in Thai power sector has been selected to be one of the major case studies, due to its obvious impacts on human health. Since it is also used in building healthy public policy, in several cases, SEA has been also recognized as a strategic HIA, including in this case study.

With all these attempts, this SEA study is not simple an academic exercise, rather it is located on the social struggling process for more sustainable future and deliberative democracy.

1.3 SEA and Sustainable Energy Planning

SEA shares its original roots and common principles with EIA tools, which are normally applied to projects. However, instead of being used at the end of the decision-making cycle, with a limited number of feasible alternatives, the idea is to use SEA at earlier stages of the decision-making cycle when a broad range of potential alternatives can be considered. SEA focuses on a sustainability agenda and gets at sources of environmental degradation rather than focusing on a standard agenda and treats symptoms of environmental degradation. Unlike EIA, SEA uses a broad perspective with a low level of detail to provide a vision and overall framework.

Since SEA is a tool for searching for opportunities rather than just the impacts, it is certainly useful for facilitating sustainable energy policy and planning in Thailand. The Thai government has established a clear vision for sustainable development from the National development plan to the ministerial level. The critical task remaining is to bridge between this sustainable development vision and sustainable energy. One of the best ways to fulfill this task is to assess long-term environmental impacts in all aspects, aiming to promote the policy options that are best for a sustainable future.

For Thailand, a good starting point for SEA is the national vision of development. The 9th National Development Plan (2002-2006) clearly articulated the King's philosophy of "Sufficient economy" as the country's development vision. According to this sufficient economy philosophy, moderation and due consideration in all modes of conduct of the entire populace should be promoted. Concurrently, the development process should incorporate the need for sufficient protection from internal and external shocks, and lead to the development of self-support and self-reliance. It also establishes development objectives and targets, which are closely related to the development of sustainable energy. For example, the development target of (a) 1-2% surplus in the annual current account, (b) new employment of more than 230,000 jobs/year, and (c) the access to resources to achieve good health and education, are highly relevant to the aims and benefits of sustainable energy investment.

Apart from the National Development Plan, the Thai government has stated that renewable energy development is one of the three national energy strategies. The main rationales for increasing renewable energy's share are (a) to reduce the import dependence and burden; (b) to reduce environmental and social impacts from existing energy technologies; and (c) to make the best uses of national resources. Thai government also established clear targets for renewable energy, aiming to increase renewable energy's share from 0.5% to 6% in the power sector within the next 10 years. In general, the national energy strategy also aims to reduce the

increase in total energy consumption from 1.4:1 to 1:1 of national income growth.

1.4 Focusing on Power Development Plan

This SEA study will focus on the Power Development Plan (PDP). PDP is the long-term master plan of the Thai power sector. PDP determines the construction of all new power plants according to the long-term power demand forecast. The decisions on energy options will be made in the planning process and these include fuel and power plant technology, power generating capacity of each project, and potential area for construction. Accordingly, the other related energy projects, such as lignite mining, gas pipeline, as well as the expansion of the power transmission system will be developed.

Therefore, PDP will set forth the development direction of the electricity as well as the energy sector. Hence, it will determine the impacts and consequences to the society not only the emissions and other externalities but also the investment, import burden, fuel price risks, employment, technological development, etc. This is the main reason to focus on PDP as the main policy mechanism in Thai power sector in this study.

2. SEA Concept and Process

2.1 SEA Conceptual Framework

While SEA has a firm starting point in Thailand, the process must be designed with great caution to avoid the misleading of the SEA concepts and to be effective tools in the policy process. This section will explain the conceptual framework applied in this SEA case study.

The word “strategy” in SEA implies visions that look beyond existing facts. It also implies a long-term perspective, with objectives to be achieved in that time period. It identifies a roadmap or possible pathway that enables achieving these objectives within the long-range time frame. In other words, SEA, including in this case, provides an assessment of an action plan that will enable the achievement of vision and shared objectives.

Therefore, in the SEA process, it is essential to review sustainability frameworks of each case or each society, as presented in the previous section. The review of sustainability frameworks leads to a shared set of strategic objectives and goals, which are used as benchmarks in each SEA process. At this stage, all sustainable development aspects (i.e., social, economic, environmental, and health aspects) have been included and well integrated.

Since SEA aims to focus on “doing the right thing” at the strategic level, it is very important to ensure that the options are still opened and all possible options will be carefully and innovatively analyzed in a participatory and transparent basis through the SEA process.

In SEA, the decision-making at the policy level is viewed as continuing and iterative. To be effective in the policy process, SEA should be well articulated with policy-making processes, and should facilitate contribution from and communication among various stakeholders, both in terms of perspectives and preferences (or priorities). Certainly, SEA is a flexible process that enables reviewing, and altering pathways and objectives to reflect changing contextual circumstances and evolving social, economic, and political priorities.

The SEA should also include the policy action. The action is needed to facilitate the decision-making process by providing the necessary information, at the right times, and in a quick, short and easy to read format. Action also requires the determination of the chain of events and institutional frameworks necessary to promote sustainable solutions in practice.

The political commitment and policy mechanism is also critical for the SEA process design. If political commitment and the policy mechanism is lacking, public communication and education can play a crucial role in mobilizing political support and developing these essential policy mechanisms. Since there are various perspectives and preferences within Thai society, the most important consideration

is to keep the SEA process open, transparent, and communicative, so it becomes a continuous learning process within the society.

2.2 Public Policy Analysis

Since SEA needs to be well articulated with the policy-making process, the analysis of public policy process is very essential for the design of SEA process. However, policy is multi-facet concepts and activities. As a result, different people views "public policy" and "policy processes" differently. Thus, it is important to make clear about analytical perspective of "policy process" which will be applied in this paper.

In general, people look at the policy-making in two main dimensions. Conventionally, people see policy-making as a process of an authorized decision. They usually analyze the policy process in term of rules and points of decision, as well as the forces and choices of legitimate authority. In this sense, policy has been view as an authorized choice or a stated purposive course of actions, which will be (or sometime automatically) transformed into an operational rule and transmission downward into their lines of operation and enforcement. In this paper, this viewpoint will be referred as a "**vertical dimension of policy**" or "linear policy model".

Alternatively, people may look at policy-making as the arena of interaction between different players or stakeholders, who try to gear the policy direction (and mechanism) in favor of their values, interests, or beliefs. In this viewpoint, the choice and rationality of authorized decision-makers is not only the main driver for policy change (or unchanged). The interaction and relationship among policy participants in different organization becomes an important factor or condition, thus it is usually the main focus for policy analysis. We can refer to this perspective as a "**horizontal dimension of policy**".

From the horizontal dimension of policy, several interesting concepts have been developed to analyze the public policy process. The advocacy coalition network, developed by Sabatier and Jenkins-Smith is one of the approaches, looking at the policy as long-term public negotiation between different policy networks or policy communities. Another approach, like the multiple streams, may emphasize the importance of "timing" and "policy entrepreneur" in matching between societal concerns or problems, policy proposal, and political opportunities (or forces), or so-called using policy window effectively.

Recently, this horizontal dimension of policy has been developed in the ways that different interpretations of same policy issue is now recognized and being the main focus of the policy study. Since different interpretations usually lead to different languages, practices, and symbols use within the policy process (or so-

called policy discourse). Obviously, various policy outcomes are the result of the dominant policy discourse, which frames specific ways of thinking or public opinion about this policy, or so-called policy framing (i.e., Are you with us or with them?). Therefore, what is mostly needed in this concept is the interpretative policy analysis, which aims to understand the issue more deeply and promote deliberative policy discussion not only among different stakeholders but also with the communication with the whole society.

In this paper, we will look at both vertical and horizontal dimension of power. In other words, we perceive the policy-making, or PDP in this case, as the outcomes of three main policy arenas; namely an administrative "surface levels" of official agencies, a negotiation level between policy networks, and a policy interpretation and framing in the societal level.

2.3 SEA Process and Methodology

The SEA process in this case has been conducted in the seven main steps as followed;

1) **Analyzing Development Visions and Goals**. National development plan and national energy strategy have been analyzed to find an appropriate indicator for strategic impact assessment as discussed in the section 1.3.

2) **Developing Policy Options**. In this step, the three policy options will be described with the main directions and priorities of energy options for power development planning.

3) **Identifying PDP Options**. Then, all three policy options has to be readjusted to fit with the power planning criteria both in terms of 15% reserve margin and sufficient energy generations in order to ensure system reliability. After the re-adjustment, these policy options will be presented in the form of three PDP options with the investment and generation details.

4) **Calculating Strategic Impacts.** The strategic impacts of all three PDP options will be calculated based on their investment and generation plans and the coefficients of impact indicators. The coefficients of each power technology, which will be utilized in each PDP option, are shown in the Appendix 1.

5) **Preparing policy document.** After the calculation, all impact indicators of the three PDP options will be presented and compared with each other. The comparison will lead to the discussion, before

identify the most suitable options in sustainable perspective.

6) **Policy communication.** The result of this calculation, combined with relevant information on local sustainable energy potentials from sustainable energy trips and fair, has been used to stimulate public discussion on energy policy direction in each public seminar in order to gain more insightful recommendations from different perspectives.

7) Policy Recommendations and Actions. At the end, the policy recommendation will be presented to related authority and Thai public through series of policy workshops combined with some policy actions (like sustainable energy fair) to stimulate further policy discussion and policy changes.

3. Policy Options

There are three main policy options discussed and analyzed in this paper. All these three policy options will also develop into PDP options, as mentioned earlier, in this section and compare their strategic consequences in the next section.

3.1 The Existing PDP (PDP-Gas)

The present Power Development Plan (PDP2004) was approved by the Cabinet in September 2004. It was based on the power demand forecast in the beginning of 2004, which assumed the constant annual economic growth rate of 6.5 percent through out the period (2004-2015).

Consequently, 23 new power plant projects were planned in addition to the seven projects, which are called 'under construction'. These new projects can be divided into two groups by the period of construction. During 2004-2010, five new projects were decided with gas as the fuel. Some of these projects are opposed by the local people and civil society organizations, especially the Jana and the Kang Koi Gas Power Plant Projects. For 2011-2015, 18 new projects were planned with gas as the fuel for all of these projects.

It is clear that the future of Thai power sector will largely rely on natural gas, which will account for 81 percent of power generation in 2015. Moreover, it is important to emphasize that, during the negotiation process of privatizing EGAT, the government has agreed that EGAT will be responsible for half of the new projects between 2011-2015, equal to nine projects. For the other half, the government will open the bidding process. However, EGAT subsidiaries may enter the bidding and compete with private firms.

The PDP-Gas also includes the investment on renewable energy under the

renewable portfolio standard (or RPS) scheme, which means every new IPP project based on fossil fuels has to invest or buy renewable energy equal to 5% of their capacity.

3.2 EGAT's alternative PDP (PDP-Coal)

Since PDP2004 is mostly relied on gas, EGAT has expressed their concern on the energy security. Therefore, they propose that the new projects should utilize more coal to diversify the fuel-mix. However, since the discussion is still going on and thus, the proposed capacity for coal is not concluded yet. So, this study has assumed that half of the new projects or nine power plants will switch from gas to coal.

3.3 The Alternative PDP

a) Principle

The development of alternative PDP has followed four principles, which are important in Thai society. The first is the Ninth National Development Plan, which follow the King's Sufficient Economy Philosophy. The Plan emphasizes on more balance economic growth and decreasing the foreign dependence.

The second fundamental principle is the National Energy Strategy which aims to improve energy efficiency and promote renewable energy in the country, as explained earlier. Thirdly, the alternative PDP should base on the present potential of domestic energy resources and the present energy technology, which means that the alternative PDP will be pragmatic and feasible under the present resources and technology. Lastly, more realistic assumptions of the power demand forecast is crucial to prevent the over investment in the power system expansion.

b) Measures

Based on the four principles, five measures have been employed to develop the practical alternative PDP. Firstly, the power demand forecast has been adjusted to the more realistic annual economic growth rate, since in the twenty-years record, the long-term economic growth rate of this country was just around 5.6% not 6.5% as assumed in the PDP. At the same time, the forecasted demand in 2004 should be changed to the actual peak demand, which is almost 300 MW lower than forecasting. This measure is very important in preventing Thai power sector from over-investing due to over-forecasting as usually happened before.

Then, Demand Side Management (DSM) and energy saving is the first priority because of the low investment cost with low negative impacts. From overall DSM potential of around 2,000-3,000 MW, 2,400 MW of DSM in 2015 is applied in this PDP-Alternative.

Next, the high potential of various renewable energies will be exploited. The promising renewable energy in Thailand includes biomass and biogas, solar, mini-hydro, and wind. Table 1 presents the huge differences between power potential and existing install capacity and the government target to promote renewable energy. It is clear that, the PDP-Alternative is going along the same line of the government own target with small modification. Moreover, in 2015, the PDP-Alternative will

employ only less than half of the overall potential.

Furthermore, the alternative PDP also employs Co-generation System that has much higher efficiency due to the combined production of heat and power in one system. This system can be based on several industrial estates around the countries, with the overall potential of 3,000 MW of new install system.

The fifth energy measure is the re-powering of the existing EGAT's power plants, which is the construction of new power plants to replace the existing ones. This will improve the energy efficiency of the old plants and avoid the potential conflicts in new project site.

Table 1 Renewable Energy Potential, Present Install Capacity in 2004, Government Target and The Planned Capacity in PDP-Alternative.

Resources	Power Gen. Potential (MW)	Present Install Capacity (MW)	Government Target (MW)	Planned in PDP-Alternative (MW)		
			2006	2011	2011	2015
Biomass	7,000	609.5	703	1,600	1,500	2,700
Biogas	900	4.6	12	100	270	470
Solar	5,000	5.5	21	250	270	470
Wind	1,600	0.2	26	350	100	260
Micro-hydro	700	2.0	26	350	180	300
Geothermal	N/A	0.5	6	10	-	-
Total	15,200	622.3	774	2,410	2,320	4,200

Source : Decharut Sukkumnoed, 2003

After employing all five measures, it is firmly possible to cancel the new conventional projects. These include the two controversial projects, Nam Theun 2 Dam in Laos and the Jana Gas Power Plant, as well as the other 19 new gas power plant projects. Moreover, three projects can be postponed from 2009 to 2010 and 2011. In addition, the consumption of fuel oil and diesel for power generation in 2004-2006 will be reduced.

3.4 Main Differences in Three PDP Options

Table 2 presents the main differences in three PDP options. Obviously, the revising of demand forecasting and DSM can lower the power demand and consequently installed capacity and energy generation in the PDP-alternative without causing any problems for power system reliability. It is also clear that the proportions of energy generation in these three PDP options are significantly difference. PDP-Gas will push Thai power system to be based on natural gas up to 81%. PDP-Coal tries to avoid this situation by increasing coal's fuel share from 11% to 27% and reduce natural gas share down to 65%. PDP-Alternative maintains natural gas share at 72% and Coal at 13% but increase the renewable energy share from 2% up to 10% in 2015.

Table 2 Main Differences in Three PDP Options

Items	PDP-Gas	PDP-Coal	PDP-Alternative
1. Assumed Economic Growth Rate (%)	6.5	6.5	5.6
2. Power Demand in 2015 (MW)	40,978	40,978	36,253
3. Install Capacity in 2015 (MW)	47,334	47,334	41,485
4. Energy Generation in 2015 (GWh)	265,786	265,786	224,910
5. Proportion of Energy Generation in			
- Gas	81	65	72
- Lignite & Coal	11	27	13
- Oil	1	1	1
- Renewable energy	2	2	10
- Large hydro	2	2	2
- Import	3	3	2

4. The SEA Results

From the calculation, the overall strategic results are presented in Table 3 as the comparison between these three PDP options in three main aspects; namely economic environment and socio-political aspects. The result of each item is presented in terms of the overall period (2003-2015) and/or at the final point of planning term (2015), depended on its relevancy.

Table 3 Overall Comparison of Three PDP Options

Items	Unit	PDP Options	Gas-Alternative Differences			
		Gas	Coal	Alternative	Unit	%
Economic Aspect						
Investment Cost 2003-2015	Billion THB	642.4	749.5	628.1	14.3	2.22
Fuel Cost 2003-2015	Billion THB	2,973.5	2,898.5	2,599.7	373.8	12.57
Fuel Cost 2015	Billion THB	330.9	304.1	257.9	73.0	22.05
Total Cost 2003-2015	Billion THB	3,932.6	3,993.3	3,600.7	332.0	8.44
Import Burden 2003-2015	Billion THB	2,557.2	2,623.0	2,242.7	314.5	12.3
Environmental Aspect						
GHG Emission 2003-2015	Million Ton CO2 eq.	1,221.2	1,259.3	1,090.6	130.5	10.50
GHG Emission 2015	Million Ton CO2 eq.	129.9	143.6	103.0	26.9	20.72
NO2 Emission 2015	Thousand Ton	143.8	258.6	138.7	5.1	3.57
SO2 Emission 2015	Thousand Ton	187.2	297.8	170.6	16.6	8.85
TSP Emission 2015	Thousand Ton	299.1	318.0	240.9	58.3	19.5
External Cost 2003-2015	Billion THB	2,903.3	3,134.1	2,704.4	230.8	7.95
External Cost 2015	Billion THB	283.6	366.3	245.1	38.6	13.60
Socio-Political Aspects						
Concentration Ratio CR4 2015	%	57.46	57.46	57.21	0.25	
Decentralization 2015	%	6.98	6.98	22.61	-15.63	
Domestic Renewable 2015	%	1.95	1.95	9.57	-7.62	
New Large Projects 2003-2015	No.	27	27	6	21	77.7
Direct Employment 2015	Person-year	81,200	78,471	98,811	-17,611	-21.7

Source : Own Calculation

4.1 Economic Aspect

From Table 3, it can be clearly seen that, in terms of the total cost, the PDP-Gas and PDP-Coal are very close with each other. PDP-gas has its advantage in terms of lower investment burden, but PDP-coal provides the cheaper fuel cost. However, although PDP-Coal offers the cheaper fuel, its coal supply needs to be imported from other countries. As a result, in terms of balance of payment burden, PDP-Coal becomes less attractive compared to PDP-Gas. Therefore, from these results, the EGAT's proposal to increase imported coal in its fuel mix does not seem to provide significant economic benefits for Thai power sector.

Due to its adjustment for better demand forecasting and more energy efficiency investment, PDP-Alternative provides some benefit in terms of reducing investment burden (around 2.2% compared to PDP Gas). More importantly, as a result of its investment in domestic renewable resources, which is less risky in terms of fuel costs, it can reduce the overall fuel cost (2003-2015) by 12.57% and reduce the fuel costs in 2015 by 22.05%. All together, PDP-Alternative can reduce the total cost by 332.0 Billion THB (or 8.44% lower than PDP-Gas) and also reduce the import burden by 314.5 Billion THB (or 12.3% from PDP-Gas).

Therefore, for small energy-import country like Thailand This can be seen as an important benefit in providing some buffer for future oil price risk (Figure 2). It can also release economic burden both in terms of investment requirement for Thai power sector and BOP for Thai economy as a whole.

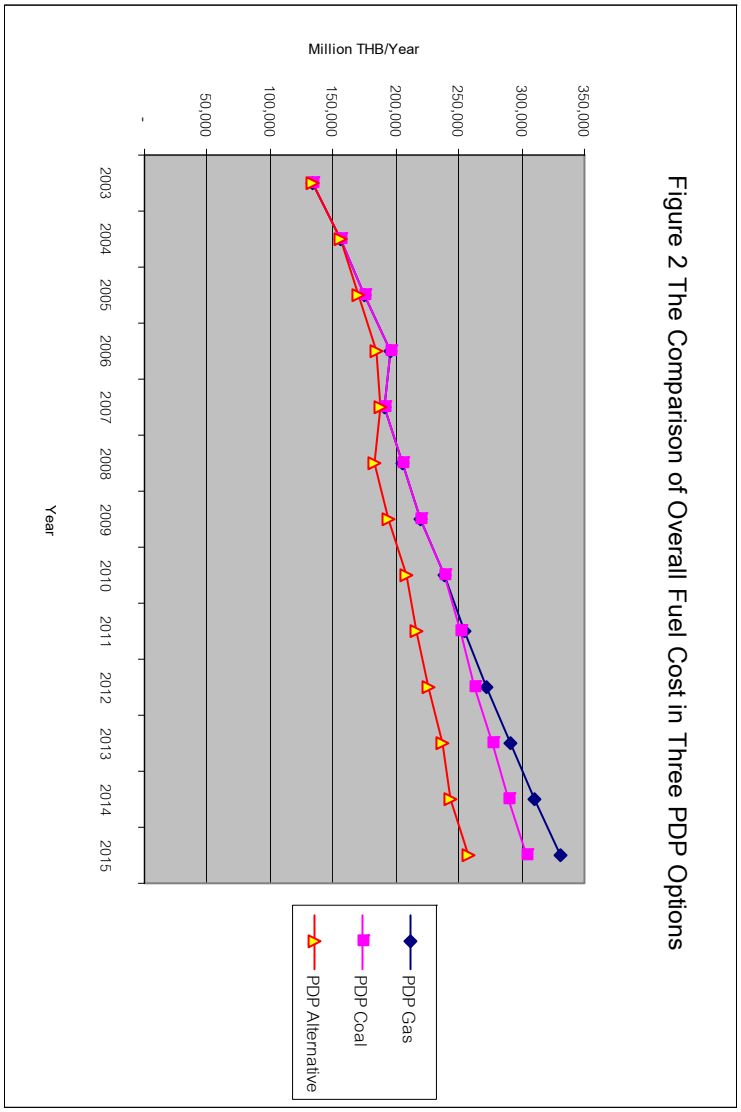

Figure 2 The Comparison of Overall Fuel Cost in Three PDP Options

4.2 Environmental Aspect

Unsurprisingly, PDP-Coal, which has the highest proportion of imported coal in the fuel mix will lead to the most negative impacts in all items. It will increase NO2, SO2, TSP and Greenhouse Gas Emission. As a result, its external cost is highest among all three PDP options. Obviously, PDP-Coal is not a healthy option at all.

PDP-Alternative provides the best PDP option from environmental perspective. It can reduce overall Greenhouse Gas Emission from the existing PDP (PDP-Gas) by 10.5%, but, if we focus on the year 2015, its annual reduction is up to 20.7% (Figure 3). Furthermore, in 2015, it can also reduce NO2, SO2, and TSP from

PDP-Gas by 3.57%, 8.85%, and 19.5% respectively. In monetary terms, it can reduce overall external costs (2003-2015) by 230.8 billion THB (7.95%) from PDP-Gas and in 2015 the external cost reduction is equal to 13.6%. This can be expected that the environmental benefits of PDP-Alternative will increasingly show in the longer term.

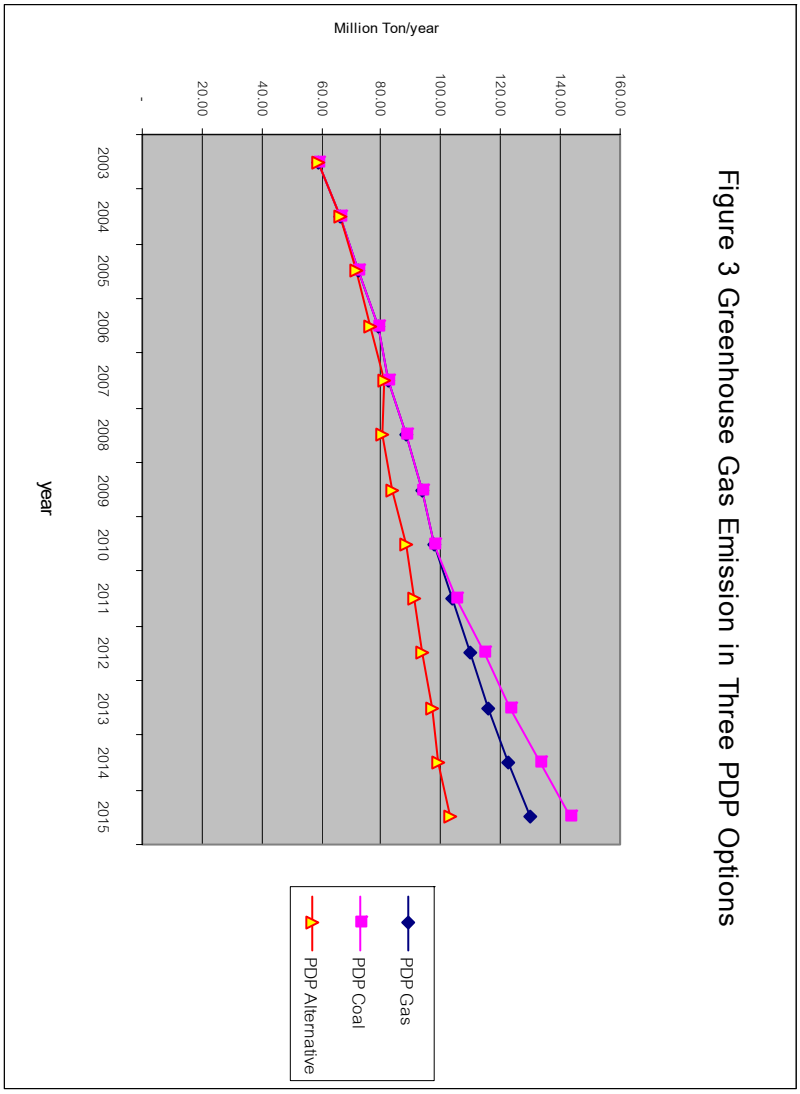

Figure 3 Greenhouse Gas Emission in Three PDP Options

4.3 Socio-political Aspect

Although all three PDP options do not provide any differences in term of concentration ratio, they can lead to completely different picture in term of decentralization and the utilization of domestic renewable resources in the power

sector. While both PDP-Gas and PDP-Coal provide so little rooms for decentralized power systems (around 7% of total energy generation) and renewable energy (around 2% of energy generation), PDP-Alternative can expand the share of decentralized power systems up to 22.6% and the share of domestic renewable energy by 9.6% in 2015. This can provide broader opportunity for Thais to actively participate and control over their power system.

At the same time, since its relies on small-scale renewable power generation, PDP-Alternative can also reduce the number of new large project from 27 in both PDP-Gas and PDP-Coal to only 7 projects, which consequently reduces the tension of future social conflicts from power plant projects in several places around Thailand. Furthermore, PDP-Alternative also increases overall direct job of 17,611 person-year or 21.7% increasing compared to the PDP-Gas. Thus, from this perspective, PDP-Alternative should be the most preferable policy choice.

4.4 Achieving Government Targets

Another important aspect for strategic comparison is how these three PDP-options will help Thai power sector to achieve the government target. As mentioned earlier, the two important target for power sector are a) to lower the energy intensity from 1.4:1 (energy generation expansion : GDP growth) to 1:1 and b) to increase the share of renewable energy generation from 0.8% to 6.0% by 2011.

Table 4 shows that neither PDP-Gas nor PDP-Coal can provide satisfactory results in reaching both targets. Both PDP options can lower energy intensity down to 1.1:1 (not 1:1 as planned by Thai government) and increase renewable energy proportion up to 1.26% (not 6% as wished). Only PDP-Alternative can hopefully make the target become the reality, with 1:1 energy intensity and 6.4% renewable energy in 2011.

Table 4 The Comparison of Three PDP Options in Achieving Government Targets

Items	Government Target	PDP-Gas	PDP-Coal	PDP-Alternative
Assumed GDP Growth (%)		6.5	6.5	5.6
Growth in energy generation (%)		7.1	7.1	5.6
Energy Intensity 2015	**1 : 1**	**1.1 : 1**	**1.1 : 1**	**1 : 1**
Renewable Energy Share 2011 (%)	**6.0**	**1.95**	**1.95**	**6.4**

Source : Own Calculation

4.5 Public Discussions

These strategic results together with the relevant experiences on sustainable energy development at regional and local levels have been presented to stimulate public discussions about strategic directions of Thai power sector. These following points are the short summary of what have been publicly discussed and concerned during this SEA study.

- Thai people are fully **aware of environmental and health consequences** from power generation including new power plant projects, therefore, they are interested in learning and discussing about policy alternatives.

- The **sustainable energy trips and fair** are very useful in bridging the more abstract strategic choices at the national level and **the actual potential and reference cases at the regional and local levels**, and thus, stimulating more insightful public discussions.

- Another important benefit for PDP-Alternative in local people viewpoint, which have not been included in the calculation, is **adding value for their agricultural by-products and wastes**. This can be an important benefit for the agricultural society, like Thailand.

- In general, the **PDP-Alternative is highly welcome**, mainly due to its economic and environmental health benefits. The PDP-Coal is much less attractive for local people due to its limited local economic benefits and its negative environmental and health consequences.

- Although, in general, renewable energy provides significant benefits on health, but in practice, several renewable projects have also hurt local environment and people's health. Thus, the **environmental and health protection mechanism** with appropriate public participation process is certainly required, even in the case of distributed renewable energy power plant project.

- In some places, local people are highly interested and **active in developing their own local and regional energy plan** in order to reach its own potentials for sustainable energy development with good governance structure.

- During the sustainable energy trips and policy discussion, **several unflavored and unfair regulations for sustainable energy development have been identified**. This includes the problems in connecting to the grid, pricing system, discrimination of import tax, and unclear policy direction and mechanism.

- To support PDP-Alternative, the **new policy mechanism and institutional arrangement** are also needed. However, the public discussion on this issue does not seem fruitful due to its technical complications.

4.6 Policy Recommendations

Based on the SEA analysis and various policy discussions, the five main policy recommendations have been identified and present in the policy workshops in July 2005, as mentioned below;

1) **The reconsideration and revising of PDP2004** is needed to meet the real world situations and open for broader alternatives for more sustainable solutions, regarding to wider national development goals, government own targets, and available domestic resources.

2) By combining the different sources of renewable energy, energy efficiency, and improving demand forecasting, an alternative path is technically and economically feasible and more environmental friendly, as seen in PDP-Alternative. However, it needs the different ways of organizing and regulating the power system that is the "**decentralized power system" or "distributed generation", which should be promoted** through the government policy and new regulations in the power sector.

3) The Renewable Portfolio Standard (RPS) mechanism, proposed by Thai government will lock the growth of renewable energy generation with the expansion fossil fuel power plants; thus, it cannot be applied to support the PDP-Alternative. At the same time, it cannot lead to the achievement of government targets. Therefore, **more open market and policy mechanisms, such as feed-in tariff, are required** to support the development of renewable energy and sustainable energy solutions.

4) **Local and regional energy planning is very fruitful** in elaborating this PDP-alternative into action plans and deepening sustainable development concepts into different levels of public actions. Therefore, it should be supported by both Thai government and civil society.

5) Although, in general, the renewable energy technologies are highly recommended in the PDP-Alternative, it does not imply that there are no negative impacts on the local communities. Therefore, **further development in environmental and health protection mechanisms, public participation and good governance structure is still essential**.

5. Recent Policy Outcomes

5.1 Responses from Agencies and Government

Table 5 summarizes the recent responses from the authorized agencies, like EGAT, EPPO, DEDE and the relating government decisions. It is clear that the SEA efforts seem to have only little impact on the policy change, both in terms of response from the agencies and the decisions by the government. The first two recommendations, which are the core of the whole PDP-Alternative, receive negative responses from EGAT and Thai government. Although some recommendations are quite coherent with some governmental agencies' action plans and activities, the synergy between SEA recommendations and agencies' actions is still limited and excluded from the PDP process. Therefore, from the viewpoint of seeking authorized decision or so-called the vertical dimension of policy, this SEA cannot be regarded as a successful case. Perhaps, in practice, it may need more time for policy initiatives to be in the policy decision-making process.

Table 5 The Responses from the Authorized Agencies and Political Decisions from the Government until August 2005.

SEA Policy Recommendations	Agencies' Responses	Political Decisions from the Government
1. Reconsider and revise PDP 2004	In July 2005, EGAT denied to revise PDP2004 and mentioned that it should be done by the interim regulator.	No decision to revise PDP2004 and the interim regulator has not been establish yet.
2. Promotion of decentralized power system	No direct response, but some agencies, like EPPO and DEDE are working on the policy supports for very small power producer issue, even though, it is not directly included in PDP.	Decide to privatize EGAT with more centralized and monopolized model, i.e., enhanced single buyer model.
3. Revise the RPS mechanism and promote more open market mechanism	No direct response, but EPPO agree to unlock renewable energy development from the fossil fuel power plant by separation mechanisms.	No recent decision, thus, the RPS mechanism is still the main policy mechanism.
4. Local and regional energy planning	DEDE and some NGOs are now working on this issue, but it is not included in PDP	No decision.
5. Develop mechanism for public protection and participation and governance system for sustainable energy development	No direct response, but EPPO is working on the Tri-parties committee as a main mechanism for project level.	No decision

5.2 Policy Progresses

Although, in general, this SEA cannot lead to a favorite political decision, along the SEA process, this SEA study has contributed some progresses to the development of sustainable energy policy in Thailand. The progresses can be seen in three main components.

1) **Understanding the formal planning process and its policy back-up**.

Formally, the formal planning process, or PDP, just likes the technical black box for Thai public. Although it can determine the direction of Thai power sector as well as the destinies of many communities, very few people have a chance to look inside of and raise questions about its methodology, data, and assumption. Through the analysis of this SEA study, four weak points of the existing PDP process are clearly identified;

- There is no space for public participation or consultation within the existing PDP process. Although there are several steps of considerations within the process, they are only for related authorized officials to discuss and decide.

- There are no other development objectives, except power system reliability and utilities' financial conditions, playing roles in the planning process, both in terms of target variables and impact analysis. Therefore, from the PDP report, no one can see the environmental and socio-economic consequences of PDP and its policy options (if any).

- There is no actual option analysis since several government energy policies predetermined the choices in the planning process. For example, EGAT privatization policy with the Enhance Single Buyer model locks 50% of new install capacity for EGAT without any least cost analyses. Renewable energy has also locked into the 5% Renewable Portfolio Standard mechanism without considering the chances of moving beyond the 5% of energy contribution and of being independent options rather than fixed with the new fossil fuel-based power plant projects.

- Several unrealistic assumptions on demand and costs have been made within this PDP. The expected long-term economic growth of 6.5%, which are beyond economic records of Thai economy is one of obvious example. The prediction of long-term declining in oil prices in all of three scenarios is also obviously unreliable, though the prediction was made just in July 2003 when the rise of the world oil price has already occurred.

2) **Building relationship for the policy network.**

Through sustainable energy trips, exhibition and fair, as well as policy workshops within this SEA process, the nets of people who have shared concerns and interests have been developed in several approaches and levels. Certainly, the result of SEA has stimulated and connected the policy communications among these groups of people in addressing their concerns and interests. In general, four groups of shared concerned people can be observed during this SEA process.

- *Affected communities*, who have shared concerns over the impacts of existing and planned power plants in the PDP and the options, both in project and policy levels to avoid undesirable impacts on their communities.

- *Local Knowledge and Technological Development*, who are interested in improving, transferring, and developing new technologies and knowledge mainly for their local energy systems.

- *Local and Regional Energy Planning*, which consists of some persons from the first two networks plus some scholars who are interested in regional policy issues. Their main focus is to develop and establish local and regional energy plan in order to gain more control over their own energy systems.

- *Policy Analysts and Policy Activists*, who have specific interests in national energy and power policy issues, including the EGAT privatization and restructuring of power sector, which certainly have strong interactive effects with the PDP.

The formation of these groups can be seen as the expansion of policy network and strengthening policy-oriented learning. The expansion is not only in the number of people, but also the wider fields of expertise, which can be and should be applied for energy policy process in general and the PDP process in specific. Apart from authority and political power, expertise can be another way of entering or including more people and perspectives into the policy arena. However, it should be note that, at present, this policy network is still loosely organized and cannot reach a powerful or influential positions, therefore, it cannot works as a strong negotiation or interest groups yet.

3) **Forming policy discourse and policy framing.**

SEA analysis can contribute to the formulation of specific policy discourses, which can be used as a shared policy interpretation, language, and symbols within policy discussions and, then in many cases, framing public attentions and interpretations over specific policy issues. In this case, the messages from this SEA analysis certainly go in line with the concepts of decentralization, sustainable development, healthy public policy and local initiatives, raised during the policy workshops in this SEA process. The SEA analysis also strengthens these concepts

and practices by presenting a possible alternative future of Thai power sectors and its preferable consequences. Although these concepts may be coherence with other international and local movements, in general, they have very limited roles and less influential in Thai energy policy arena, especially compared to "system reliability" or "national champion". Therefore, in principle, this contribution from SEA process can be seen as a progress, but, in political world, it is still inadequacy for stimulating policy changes.

5.3 Unsuccessful Aspects

As mentioned earlier, although the SEA process can lead to some policy progresses, the political outcome of this SEA study seems to be quite unsatisfactory. Most of five main policy recommendations from this SEA process do not receive positive responses from the policy officials and authorized bodies. Especially on EGAT privatization and power systems restructuring policy, Thai government has made the opposite decision in favor of centralized power systems, instead of decentralized power system. From the self-reflective evaluation, there are a number of factor or condition leading to this unsuccessful political outcome.

1) **Authorized control of PDP process**.

As mentioned earlier, the PDP process in Thailand is totally under the control of authorities, especially EGAT and MoEn. The whole PDP process never starts up without the approval and the control of these authorities or the strong political signal from the government. Although it is quite clear in the mid of 2005 that the demand forecasting is overestimation and the several assumptions do not fit with the real economic conditions, EGAT still denies to reconsider and revise its own PDP. Since this existing PDP was already approved by the cabinet in 2004 and costs of over-investment and increasing fuel prices can be easily push to consumer throgh the automatic adjustment tariff mechanism (or Ft), there is no pressure for EGAT to start up the PDP process again. EGAT also stresses that after power sector restructuring, the adjustment of PDP should be the responsibility of the independent regulatory body. However, the independent regulatory is not yet established in Thailand, but several investment decisions, including the approval of new EGAT power plants and power purchasing agreements are still going on based on this PDP. This situation can certainly be referred to the "agenda setting" power, introduced by Steven Lukes. With its own agenda setting power and the policy situation, EGAT can simply push the issues of PDP reconsideration from "the policy in decision-making" into "non-decision" or "non-action" policy. This means, without strong political intervention from the government or external shock within the economy, EGAT can maintain its own favorite PDP at least in the near future.

2) **Ineffective Policy Framing**.

To reopen the PDP process, it needs strong political intervention and to achieve strong political action from the government, huge public concerns and critical political mobilization are required. However, within the situations of high oil price and economic decline, both Thai government and general Thai public seem to

pay much less attention to the power sector. For the government, the main policy interests in power sector is to privatize EGAT and strengthening EGAT as the national champion in order to boost the investment in Thailand Stock Exchange Market and, hopefully, Thai economy. Moreover, this SEA process has failed to create the clear and sharp policy message, which can be used as the alternative policy framing to urge more public concerns and attentions. Therefore, it is less attractive for public media and, consequently, less possible for general Thai public to call and mobilize for policy changes. Therefore, ongoing tasks in formulating clear and sharp policy framing(s) are required through deliberative policy analysis, further policy discussions, strengthening policy networks, and further SEA analysis.

3) **Lacks of Clear Policy Mechanism**.

Policy is not only about the visions, options, and future impacts, in practice, policy is also about seeking order to stabilize the underlying system and constitute the behaviors of stakeholders. Therefore, introducing new policy is not only about the choices, but also about creating the new order or reformulating the old one. Normally, authorized organization has its own perspectives, values, and interests on the policy issue, and, as a result, creates its own order for operating and maintaining its system. Certainly, it is not easy to challenge the authority's assumption and working practices. This is why several policy initiatives are struck at the stage of "interesting ideas", without moving into actual large-scale operation. Although this SEA case can provide the clearer picture of future impacts from different policy visions, it hardly deals with policy and operational mechanisms. Within the situation of strong authorized control and no political pressure, the lack of clear policy mechanism and operational system can certainly inhibit the development of new policy initiatives into actual practices and even into deliberative discussions with authorities. Therefore, to establish a new order for a new initiative, more detail analyses on future energy system and effective policy mechanism are required in further SEA study as well as the interactive communications with the authority and other stakeholders.

4) **Less Influential Policy Network.**

Although this SEA process can stimulate the expansion of sustainable energy policy network, it still cannot reach the influential players, like independent renewable energy producers, more academicians, or progressive politicians. Moreover, this network still organizes very loosely within limited resources. The four groups of people within the network also have clear differences in their philosophical cores as well as in their policy strategies. The communication channels within and outside the network are still limited, leading to ineffective policy movement. Therefore, building policy network in this SEA practice is still far from being effective within Thai power sector. Perhaps, it need more times and efforts to develop and expand the network.

5) **Problematic Governance Structure.**

From this experience, it seems that SEA exercise can stimulate policy discussions and activities involving in the horizontal policy dimension, but it cannot change much in the vertical dimension of the policy. Probably, there are two ways of looking at this situation. First, we need to put more effort on the horizontal dimension and find right strategy or tactic to enter into authorized vertical dimension of the policy, for example, by inviting EGAT to be advisory committee and sponsor of the whole SEA process. Alternatively, we can ask critically about the governance structure, or the structural relationship between horizontal and vertical dimension of the policy. In other words, how the authorized agency can make the decision with or without participating of other stakeholders in the horizontal dimension or in which levels and ways of participation, and how the agency will take responsibility and accountability for the decision made. Certainly, this SEA did not deal with the second questions. Like several SEA studies, SEA in this case pays much more attention to what the decision should be made rather than how the decision should be made.

However, in context of PDP process, the governance structure of the Thai power system can be problematic indeed. This is, firstly, because PDP and several recent policy decisions, like EGAT privatization and National Energy Strategy, have been made with very limited rooms for public participation. Secondly, there is no clear corrective mechanism within the PDP process. No one can know when and how this existing PDP should be reconsidered and revised. Thirdly and more importantly, there is no means of accountability. The overrun costs both due to over-estimation of demand and higher fuel costs can totally be pushed into the burden of Thai customers. Lastly, there is an obvious conflict of roles and responsibilities within Thai power system, since EGAT hold the authorities all in terms of planning, operations, and some regulations. This situation may be worse after EGAT will be listed in the stock market aiming for more profit without actual independent regulator.

In the situation of newly privatized EGAT, it seems that further SEA study cannot go alone to reach more sustainable solution without asking and addressing question about the governance structure of Thai power system. SEA and other relating studies need to build, frame, or at least try to make better connection and integration between horizontal and vertical dimensions of policy.

6. Conclusion

Although, in this case, SEA cannot reach formal policy change, both progress and unsuccessful aspects can help us to understand multi-facets of policy process and policy actions in the read world. Table 6 shows several aspects of policy process and actions and what is addressed by this SEA study and what is not. With this overview picture, we can think about the existing and potential roles of SEA in the policy process.

In short, by analyzing and providing essential information on societal

concerns, policy visions, and future impacts, SEA can be one of the effective tools to connect and integrate horizontal and vertical dimensions of the policy across the three layers of policy process; namely formal authorized, policy networks, and societal levels. However, in the real political world, SEA cannot achieve its goal, which is the policy change, if it simply ignores the aspects of power, institutional, and governance structure within the policy arena.

Through the light of this reflection, further SEA study and other relating activities are now going on in Thailand, including;

- Continuous effort for expanding and strengthening policy networks through series of policy forum at the regional and national levels,

Table 6 Multi-Aspects of Policy Process and Actions and the Roles of SEA in this case study

Multi-Aspects of Policy Process	Addressed by SEA in this case	Recent Outcomes
1. Policy process is about shared and difference concerns.	Directly	☺
2. Policy process is about common and contested policy visions and objectives.	Directly	☺
3. Policy process is about formulation and selection of different policy options.	Directly	☺
4. Policy process is about the analysis and discussion of different future impacts.	Directly	☺
5. Policy process is about building, linking, and contesting different expertise and rationality.	Indirectly	☺
6. Policy process is about consultation and negotiation between different interest groups.	Indirectly and inadequacy	☹
7. Policy process is about public communication and deliberation.	Directly but inadequacy	☹
8. Policy process in about seeking the order or policy mechanism.	Indirectly and inadequacy	☹
9. Policy process is about authorized decision	Directly	☹
10. Policy process is about governance system over authorized decision.	Indirectly and inadequacy	☹

Note: ☺= Satisfactory, ☹ = Unsatisfactory

- Further analysis on risks and flexibility of the policy options and Thai power system in order to face with more uncertainty in energy market and to elaborate the application of the King's philosophy of sufficiency economy in energy management,

- Further study on effective policy mechanisms, based on energy system planning techniques,

- Strengthening and upgrading local and regional energy plan in order to be an actual action plan in local and regional levels and to be integrated into national planning system,

- Improving and fine-tuning policy message, policy framing, and policy communication,

- Assessing electricity governance in Thai context to seek for better practice and structure for Thai power sector both in policy and project levels.

Furthermore, very recently, EGAT has announced in its prospectus the possibility of revising the PDP2004 due to unexpected economic situations in September 2005. Recent EGAT's position change should be seen as the new opportunity for our SEA process, since the PDP process may reopen again. However, how success we can reach from the new opportunity is depended mainly on the progress of all on-going efforts listed above.

Therefore, one should not expect and evaluate SEA process as a one-shot event or activities. Rather, SEA should be recognized and, thus, evaluate as a long-term development process of changing ways of thinking about policy process, of opening the rooms for wider stakeholders and expertise, of communicating concerns and perspectives, of creating new policy solutions and mechanisms, of balancing power relationship within the policy arena, and, lastly, of deepening deliberative democracy into the structure and culture of public decision-making.

Appendix 1 Co-efficient for Each Power Technology and their Import Content.

Item	unit	Power Technology												Import	
		Lignite	Coal	Oil	Diesel	Gas	Co-gen.	Biomass	Biogas	PV	Hydro	Micro-hydro	Wind	DSM	Laos	Malaysia
Investment cost	Mil. THB / MW	45.00	42.00	27.00	55.00	25.00	36.00	42.27	48.00	190.43	23.15	61.83	50.00	5.00	-	-
Import Content	%	60	70	70	60	70	70	50	30	50	70	40	50	50	-	-
Fuel Cost	THB/kWh	0.57	0.72	1.84	3.49	1.36	1.25	0.55	0.00	0.00	0.00	0.00	0.00	0.00	1.65	1.60
Import Content	%	20	90	80	80	70	70	20	-	-	-	-	-	-	100	100
O & M Cost	THB/kWh	0.11	0.15	0.12	1.83	0.12	0.12	0.30	0.15	0.03	0.13	0.15	0.65	0.50	-	-
Import Content	%	15	15	15	15	15	15	15	15	15	15	15	15	15	-	-
Greenhouse gas Emission	g. of CO2 eq./ kWh	1,008	796	690	650	471	314	37	20	30	50	-	11	-	50	471
NO2 Emission	g/kWh	2.986	2.986	0.560	0.105	0.251	0.166	0.654	0.251	0.008	0.000	0.000	0.000	0.000	-	-
SO2 Emission	g/kWh	4.457	2.971	1.047	0.369	0.336	0.221	0.154	0.336	0.023	0.000	0.000	0.000	0.000	-	-
TSP Emission	g/kWh	1.626	1.626	0.305	0.057	1.176	0.776	0.512	1.176	0.017	0.000	0.000	0.000	0.000	-	-
External Cost	THB/kWh	4.04	2.76	2.67	2.67	0.79	0.53	0.63	0.00	0.05	0.39	0.03	0.14	0.00	0.40	0.31
Employment	Person/GWh	0.370	0.175	0.260	0.260	0.250	0.331	0.733	0.733	14.760	0.250	0.120	0.459	1.000	-	-

Source:

1. Investment cost: From EGAT, *Power Development Plan 2004* (July Edition) and the Energy for Environment Foundation, 2003. *Supportive Approach for Wind and Solar Power Generation.*
2. Investment Import Content: Own Assumption
3. Fuel Cost: Adapted from EGAT. 2003. *Power Generation Cost*, the Energy for Environment Foundation, 2003. *Supportive Approach for Wind and Solar Power Generation* and Own Calculation.
4. Fuel Cost Import Content: Own Assumption
5. O & M Cost: Adapted from EGAT. 2003. *Power Generation Cost*, the Energy for Environment Foundation, 2003. *Supportive Approach for Wind and Solar Power Generation* and Own Calculation.
6. O & M Cost Import Content: Own Assumption

7. Greenhouse Gas Emission: Holdren, J.P., and Smith K.R., 2000. "Chapter 3 Energy, the Environment, and Health" in World Energy Assessment, *Energy and Challenging of Sustainability*. UNDP.
8. NO2, SO2, and TSP Emission: Everett & Boyle, 1996. "Chapter 10 Integration" in Boyle (ed), *Renewable Energy: Power for Sustainable Future*. The Open University and Oxford University Press. And Own Assumption.
9. External Cost: the Energy for Environment Foundation, 2003. *Supportive Approach for Wind and Solar Power Generation* and Own Calculation.
10. Adapted from Goldemberg, 2004. "The Case for Renewable Energies". Thematic Background paper for International Conference on Renewable Energy 2004, Bonn, Germany