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Development of Indicators for Strategic Environmental Assessment (SEA) of Electric Power Development Program in Krabi Province, Southern Thailand

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Abstract

The Strategic Environmental Assessment (SEA) is a systematic process to support decision-making in the formulation of a policy, plan, or program with a focus on participation. The development of indicators is an important process in the SEA. The objectives of this study were to develop and define appropriate and comprehensive indicators for the SEA of electric power development program in Krabi Province, Southern Thailand, and to determine weights for the dimensions and indicators. This study is a mixed-methods research project that collected data from the stakeholders in the area and experts through participatory processes as well as reviewing documents from various sources. The findings reveal that 16 indicators were developed in 4 dimensions, divided into 6 indicators in the economic dimension, 2 indicators in the social dimension, 5 indicators in the environmental dimension, and 3 indicators in the energy/technology security dimension. The Analytical Hierarchy Process (AHP) was employed for weighting the dimensions and the indicators. The developed indicators were well accepted by the stakeholders in the area and relevant agencies and were able to be adopted in the impact assessment of strategic alternatives for power development in the SEA.

Keywords: indicators; Strategic Environmental Assessment; power development; Krabi Province

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1. Introduction

Southern Thailand is a world-class tourist destination, then the electrical demand in the area has trendily increased due to a steady increase in tourist numbers. Krabi is one of southern provinces that tourists come to visit at most [1, 2]. The Ministry of Energy has set a construction plan for two new power plants in the south using coal fuel, one in Krabi and another in Songkhla [3]. Krabi Province has a small old power plant that currently serves as a supplementary plant. The rationale of the plan for constructing a plant in Krabi is that the Andaman side of Southern Thailand does not have a large power plant causing risk to energy security in the area.

On one hand, the construction of a large power plant in Krabi has been strongly opposed by tourism sector, fishery groups, and local people as well as NGOs and independent scholars from outside, as they are concerned with environmental pollution and health impacts, including the impacts on the integrity of natural resources and the environment in the area. On the other hand, a large number of community leaders and local people living around the site have strongly supported the construction as they believe the plant can create prosperity in the area and provide benefits to the local communities. This has resulted in a serious conflict between these two groups. This conflict had a serious impact on the development of electric power in Krabi as the relevant agencies could not construct a new coal-fired power plant in the area, and the direction of electric power development in the area was not clear.

As a result, in a near future Krabi Province may face a shortage of power supply that would strongly affect all economic sectors as well as the people's quality of life. Hence, the Strategic Environmental Assessment (SEA) can be applied to help cope with the problems. Unlike Environmental Impact Assessment (EIA), the Strategic Environmental Assessment (SEA) is a study at the policy, plans, and programs level, while EIA is a project-level study that focus on a detailed study of the

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impacts of a project [4-7]. One of the most important steps in SEA process is development of indicators for assessing strategic alternatives of the development [8].

The development of appropriate indicators for alternatives assessment requires a comprehensive review and analysis of the data, and significantly, opinions from the stakeholders. The overall framework is consistent with strategic issues and sustainable development objectives, embracing economic, social, and environmental aspects. It must have enough information and can be continuously monitored in the long term [4, 5, 8, 9]. This study is a part of SEA for electric power development of Krabi Province. The objectives are 1) to develop and define appropriate and comprehensive indicators for impact assessment of strategic alternatives for power development of Krabi Province in the SEA study, and 2) to determine weights for the dimensions and indicators which are consistent with technical and sustainable development principles, as well as acceptable to all relevant sectors.

1.1. Literature Review

Asian Development Bank (2015) [10] defined the indicators for conducting SEA study regarding energy development under 8 security issues in line with sustainable development which are pollution, land and biodiversity, water resources and aquatic biodiversity, climate change, food security, social security, health and safety security, and economic stability. In addition, the other studies suggested SEA-related indicators for electric power development include employment, cost of electricity generation, cost of technology investment, social return on investment analysis, and problems from migrant workers, etc. [11-14]. EPPO (2018) [15] defined the indicators for PDP 2018 as 3E, consisting of energy security, economics, and ecology. This was inconsistent with the sustainable development dimensions (economic, social, and environmental). However, some social indicators were not included in the indicators for the impact assessment of the SEA, such as public acceptance which was an important indicator in gaining acceptance from the locals [7].

2. Methodology

This study is a mixed-methods research. It was divided into 2 steps: the development and determination of indicators and the determination of weights of dimensions and indicators. The data were collected from key informants in the area and relevant experts.

2.1. Key informants

The key informants in this study were local leaders, representatives from tourism and fishing groups, NGOs that were active in the coal-fired power plant development project, and officers of relevant agencies, especially Krabi's electric generation office. They were derived from the stakeholder analysis and were purposively selected by the researchers. The stakeholders in the area were classified into two main groups: supporting and opposing groups of a coal-fired power plant. This is in accordance with Huailuek (2020) [16] and Sriruang (2019) [7] who studied the conflict in power plant development in Krabi Province and found that there were 2 main conflict groups in the area with very serious opposition to each other.

In addition, to help make the results of the study more accurate academically and acceptable to these 2 groups. The study additionally collected information from experts who were academics, senior government officers, and private sector who have high knowledge and experiences in the economic, social, environmental, energy, or technological field concerning power plant development.

2.2. Development and determination of indicators

The development and determination of indicators used a qualitative research method to collect primary data from the key informants, and secondary data from relevant documents. The key informants in this process of development and determination of indicators consisted of 103 local leaders and representatives of tourism and fishery groups in Krabi , NGOs, and officers of relevant agencies and 17 experts in economic, social, environmental, energy, and technological areas, totaling 120 people.

The data collection was a series of focus group discussions (3 rounds of group discussions) for the key informants and a semi-structured interview to collect data from the experts. The objectives of each round of focus group discussion are as follows:

The 1st round: To obtain the opinions of the key informants about the overall development direction of Krabi Province and their concerns towards different alternatives of power development.

The 2nd round: To let the key informants consider, criticize, and recommend the draft dimensions and indicators.

The 3rd round: To confirm the adjusted indicators by the key informants.

The data from each focus group discussion would be analyzed and synthesized based on the opinions of key informants to develop dimensions and indicators for the SEA of electric power development in Krabi Province.

2.3. Determination of weights of dimensions and indicators

The determination of weights of dimensions and indicators employed a quantitative research method by using a questionnaire to compile the opinions of key informants and applied the Analytical Hierarchy Process (AHP) in comparing weights of dimensions and indicators and summarize the weight values of the dimensions and indicators [17].

The respondents in this process were derived from representatives of stakeholders in the area who were selected by each group. For the group supporting the construction of coal-fired power plant, 9 local leaders and officers of relevant agencies were represented, while 10 local leaders, and representatives from tourism and fishery groups and NGOs were represented the opposing group. In addition, the 32 experts were also asked for weighting the dimensions and indicators.

This study used questionnaire as a tool to collect data from the key informants. The results were the weights of dimensions and indicators for the next step in the SEA of electric power development in Krabi Province.

3. Data Analysis

This study employed 2 methods of data analysis.

Part 1: the development and determination of indicators used content analysis, which are the qualitative analysis method for the data obtained from key informants and experts.

Part 2: the determination of the weights of dimensions and indicators employed the Analytical Hierarchy Process (AHP). AHP is a two-way comparison technique useful for analysts to focus on individual components or factors at a single time [18]. The pairwise comparison assigns weights between criteria in pairs by using numbers instead of values to calculating the importance scores between each criterion [17, 19]. In this study the scores are evaluated through pairwise comparison analysis of dimensions and indicators. The calculation are as presented in the Equation (1):

$$w_i = \frac{\sqrt[n]{\prod_{i=1}^{n} c_i}}{\sum^n \sqrt{\prod_{i=1}^{n} c_i}} \tag{1}$$

where w_i is the weight value of the dimension or indicator, n is the number of dimensions or indicators, C_i is the score value of the dimension or indicator, i is the order of the dimension or indicator, and is the respective product of points for each dimension or indicator.

The weights from the 3 groups were averaged to obtain the final weights for the proposed dimensions and indicators in order to draw acceptance from all groups of key informants especially the supporting and opposing groups of coal-fired power plant.

The outputs of these 2 parts were the developed indicators and weights of dimension and indicators for the impact assessment of strategic alternatives of electric power development program in Krabi Province.

4. Results

From the analysis of primary and secondary data described above, the key findings of this study can be divided into 4 parts as follows:

Part 1: Key issues from focus group discussions

The group opposing the construction of the coal-fired power plant suggested key issues related to the development direction of Krabi Province which are: 1) the environmentally-friendly development should be a main concept for Krabi Province development since the area has a high potential for development based on its natural resources and can link to sustainable development. The development of industry is possible but there should not be a large factory in the area as it can pose the adverse impact on the environment and local people. Moreover, the province development should be linked to the context of the area, especially tourism and fishery which are consistent with the local resources. 2) The electric power development in Krabi should focus on alternative energy since various sources of raw materials can be obtained from the area especially biomass. In addition, the alternative energy can help minimize environmental and health impacts from production of power. Meanwhile, the coal-fired supporting group expressed their concern that renewable energy, such as solar energy, is not stable that can significantly affect the energy security. Moreover, if there is a high proportion of electricity production from renewable energy, it will affect the price of electricity. They also believed that modern technology of coal-fired power plant can control the impact on the environment and can retain the price of electricity. However, both groups agreed that base-load plant was still necessary for energy security, although the opposing group accepted only a gas power plant not a coal-fired power plant.

Part 2: Key issues from the experts

From the interviews, several experts suggested that since the development direction of Krabi Province is focused on tourism and services, the area needs a stable electric power supply. In addition, the development of power plant in Krabi has to consider 3 principles: 1) sufficiency and continuity of the power supply, 2) suitability of electricity price, and 3) low pollution and low impact on the environment and local people. The development of renewable energy has limitations such as the availability and price of raw materials and the stability of power especially solar power, etc. Hence, Krabi electric power development is still necessary to have a base-load power plant using fossil fuel with modern technology to control pollution. However, some of the experts mentioned about the significance of international agreement on climate change in which the power production sector is one of the main focuses of the carbon reduction policy. Hence, the development of power supply in the area should be in line with this agreement by moving towards the alternative energy not fossil fuel. In conclusion, according to the experts' opinions, the development of electric power in Krabi should be in accordance with the 4E principles: Economic, Environmental, Energy security, and Engineering.

Part 3: Dimension and indicators for alternatives assessment

Based on the content analysis of the data from key informants and reviews of related documents, this study developed and defined dimensions and indicators for the SEA's alternatives assessment of power development in Krabi as follows:

Four dimensions were established. The first 3 dimensions are in accordance with the sustainable development principles, consisting of 1) economic, 2) social, and 3) environmental dimension. In addition, the 4th dimension, which is another important issue in power development, is energy/technology security dimension.

Sixteen indicators were developed and determined under the 4 dimensions. Six indicators are of economic dimension: employment, tourism, fishery, agriculture, revenue from selling raw materials/fuel, and electricity price per unit. Two indicators are of social dimension: acceptance of people towards generation of electricity and change in health status of local people. Five indicators are of the environmental dimension: water quality, air quality, solid waste, aquatic biodiversity, and greenhouse gas emissions. Lastly, three indicators are in dimension of energy/technology security: fuel/energy sufficiency, power distribution ability, and efficiency of pollution treatment technology. Details of the dimensions and indicators as well as their references are shown in Table 1.

The draft of dimensions and indicators for the assessment process developed from reviewing related document and the opinions of key informants and experts were brought into a final focus group discussion of key informants in Krabi Province. Though there were some questions from the participants, after discussions and explanations from the researchers, the majority of key informants accepted that these dimensions and indicators were suitable with the context of power development in Krabi and could be used for the impact assessment process in the SEA process. Thus, the study can proceed to the next step of determining the weight score of these dimensions and indicators.

Part 4: Weights of dimension and indicators

Determination of the weights of dimensions and indicators was carried out by using the Analytical Hierarchy Process (AHP). The data were collected from key informants as respondents. The total number of respondents were 51 people from 3 groups—the supporting group, the opposing group, and the experts. To draw the acceptance from the 2 groups in the area, the study gave importance to all groups equally. The primary weights of dimensions and indicators from each group were then averaged to conclude the final weights which would be used in the assessment. The final weights were revealed to all respondents. The details are shown in Table 2.

Consequently, when determining the weights of dimension and indicators for the assessment process in the SEA, it was found that the environmental dimension was the highest weighted dimension at 0.331. Indicator 2.1 Acceptance of residents towards the electricity generation was with a weight of 0.117, followed by Indicator 2.2 Change in health status of local residents, and Indicator 4.3 Efficiency of pollution treatment technology with a weight of 0.104 and 0.888, respectively. The indicator with the least weight was Indicator 1.1. Employment with a weight of 0.028.

5. Discussions

The results of this study determined sixteen indicators for alternatives assessment in the SEA study of power development in Krabi Province. They are divided into 4 dimensions: economic, social, environmental, and energy/technology security which are in accordance with the sustainable development principle and the studies of the Office of Natural Resources and Environmental Policy and Planning (ONEP) (2007) [24] and Poboon (2013) [14]. These indicators can be applied in the SEA of the electric power development program in Krabi which have been accepted by all sectors.

In sum, it can be seen from the weighting scores of dimensions that the environment (0.331) is the most important dimension in alternatives assessment of the power plant development, followed by economy (0.276), society (0.221), and energy/technology security (0.172), respectively. This is consistent with the results of the study of Poboon (2013) [14] and Takamol et al. (2021) [25]. However, this is not consistent with Abdul, Wenqi, and Tanveer (2021) [26] who prioritized renewable energy sources for electricity generation through the AHP-VIKOR integrated approach in Pakistan, which found that the highest rated dimension was the economic dimension, followed by environment, energy quality, with the political and social dimensions having the least weight.

Moreover, the weighting score of the indicators with the highest value is acceptance of people towards electricity generation (0.117), followed by change in health status of local people (0.102), both of which are the social dimension indicators. The third highest score indicator is efficiency of pollution treatment technology (0.088). These results indicate that power development in Krabi must have minimal impact on the environment and local people and must be accepted by all sectors in the area [14]. The fourth highest score indicator is electricity price per unit (0.077), indicating that the price of electricity is important as the higher price can put a burden to business and all groups of the local people [15, 20]. On the other hand, the lowest score indicator is employment (0.028). This

Table 1. Dimensions, indicators and their references

Dimensions/ Indicators	Definitions	References
	Economic	
Employment	Increase in employment as a result of power development, including employment to carry out various activities in the power plant.	[10, 12, 20], experts' opinions and focus group discussions
Tourism	Potential changes in tourism business in the area, both positive and negative, caused by power development, especially number of entrepreneurs and income from tourism.	[14, 20], experts' opinions and focus group discussions
Tourism	Potential changes in tourism business in the area, both positive and negative, caused by power development, especially number of entrepreneurs and income from tourism.	[14, 20], experts' opinions and focus group discussions
Fishery	Potential changes in fishery, especially local fishery if different types of electric power generation are developed.	[20], experts' opinions and focus group discussions
Agriculture	Potential changes in agriculture caused by power development, which can be both positive and negative, such as changes in agricultural productivity, change in farmland.	Experts' opinions and focus group discussions
Revenue from selling raw materials/fuel	Increase in people's income as a result of power development especially income from sales of raw materials/fuels such as rubber wood, other biomass, and energy crops, etc.	[10, 13, 20, 21], experts' opinions and focus group discussions
Electricity price per unit	Price per unit of electricity generated by different technologies/fuels, including transmission and distribution costs, and other costs.	[15, 20], experts' opinions and focus group discussions
	Social	
Acceptance of people towards generation of electricity	People accept or oppose the power generation project in the area. This is mainly due to the level of confidence in the pollution control process and the expected benefit or negative impact on the area and their communities.	[14], experts' opinions and focus group discussions
Change in health status of local people	Changes in both positive and negative determinants of health from power generation, including availability and quality of medical services, environmental quality, risk of accident, etc.	[10-12, 22], experts' opinions and focus group discussions
	Environmental	
Water quality	Changes in surface water and coastal seawater quality due to power generation processes, with important parameters such as water temperature, dissolved oxygen content and heavy metal content, etc.	[10-12, 14, 22-24], experts' opinions and focus group discussions
Air quality	Amount of primary air pollution emissions, including sulfur dioxide (SO2), nitrogen oxides (NOx) and particulate matter smaller than 2.5 microns (PM2.5), which are generated and released into the atmosphere from power generation.	[10-12, 14, 22-24], experts' opinions and focus group discussions
Solid Waste	Solid wastes from the power generation process such as bottom ash, fly ash and the other wastes which can have negative impact on the environment and local people. In addition, the ability to manage or recycle such wastes are considered.	[10-12, 14, 22], experts' opinions and focus group discussions
Aquatic biodiversity	Changes in the abundance of larvae of important aquatic fauna caused by power generation activities and related activities such as fuel transportation, etc.	[10, 12, 14, 15, 24] and experts' opinions
Greenhouse gas emissions	Amount of greenhouse gas emissions from power generations calculated in the form of carbon dioxide equivalence.	[10, 12, 14, 15] and experts' opinions
	Energy/technology security	
Fuel/energy sufficiency	Availability of the amount of fuel/energy that can be used to generate electricity to meet the electricity demand with the continuous stability of power generation.	[10, 15], experts' opinions and focus group discussions
Power distribution ability	Ability of power generation technologies to provide electrical power to meet the demand of various sectors in terms of quantity and quality without problems of power supply interruption, power outages, etc.,	[10, 15], experts' opinions and focus group discussions
Efficiency of pollution treatment technology	Efficiency of technology for treatment of pollution from power generation, such as air pollution, water pollution and waste, etc.	[10, 15], experts' opinions and focus group discussions

Table 2. Weights of dimensions and indicators

Indicators	supporting	opposing	experts	Total*	Adjusted**	Ranking
Economic (0.276)						
Employment	0.042	0.010	0.050	0.102	0.028	15
Tourism	0.025	0.044	0.061	0.130	0.036	14
Fishery	0.025	0.049	0.057	0.131	0.036	14
Agriculture	0.029	0.082	0.054	0.165	0.045	11
Revenue from selling raw materials/fuel	0.041	0.111	0.043	0.195	0.054	10
Electricity price per unit	0.171	0.038	0.069	0.278	0.077	4
Social (0.221)						
Acceptance of people towards generation of electricity	0.180	0.155	0.192	0.528	0.117	1
Change in health status of local people	0.153	0.178	0.142	0.472	0.104	2
Environmental (0.331)						
Water quality	0.081	0.069	0.060	0.210	0.070	7
Air quality	0.085	0.063	0.081	0.228	0.076	5
Solid Waste	0.070	0.058	0.050	0.17	0.059	8
Aquatic biodiversity	0.063	0.080	0.074	0.218	0.071	6
Greenhouse gas emissions	0.034	0.062	0.070	0.167	0.055	9
Energy/technology security (0.172)						
Fuel/energy sufficiency	0.093	0.046	0.098	0.236	0.041	13
Power distribution ability	0.104	0.050	0.095	0.249	0.043	12
Efficiency of pollution treatment technology	0.137	0.237	0.142	0.515	0.088	3

* The sum of the weight for each indicator was divided by 3 as it gave equal importance to the 3 groups.
**Adjusted is the weight of each indicator multiplied by the dimension weight.

is likely because the stakeholders see that changes in employment are not solely the result of the development of electric power, but are the consequences of various economic activities such as tourism and other occupations in the area [16].

6. Conclusion and Recommendations

Key findings of this study are the indicators that were accepted by all stakeholders and can be used for the SEA study of electric power development program of Krabi Province. In addition, they could be applied in relevant energy development studies or the other SEA studies. However, as the other studies certainly have different context, the indicators should be modified to be consistent with their study objectives and arising issues. Moreover, the most important step in development of the indicators is public participation. Hence, any SEA studies that expect to obtain appropriate and acceptable indicators must pay the highest attention in stakeholder analysis and involvement of the stakeholders throughout the process to ensure acceptable results.

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