

## Environmental Barriers to Geothermal Development in Eastern and South-Eastern Asia

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### ABSTRACT

Significance of environmental barriers to geothermal development has been investigated based on questionnaire result from Eastern and South-Eastern Asian countries. Among environmental barriers, there exist legally binding barriers, such as environmental laws and regulations, and legally unbinding “social” barriers such as public acceptance (PA) considering most of PA problems come from environmental concerns.

As a result of comparison of questionnaire results in different countries, a tendency was found that “the more intensive the geothermal development, the higher the environmental barrier.” This fact should be noted by the people who plan to develop geothermal energy even if there is no environmental barrier currently. Thus significance of the environmental barrier varies with the stage of geothermal development of the whole country. In addition, significance of the environmental barrier at each site varies with the development phase as: 1) Legal barrier would be highest at the beginning of concession process of the field. 2) PA barrier gradually increases with time if minor problems are left. 3) PA and sometimes legal barrier(s) drastically increase if an environmental incident occurs at any stage of development. 4) The initial PA barrier would be higher if other geothermal fields have environmental problems.

To give solutions to environmental barriers, a literature survey was conducted. In order to protect the environment and to obtain better PA, related literatures recommend to conduct strategic environmental assessment and necessary mitigation and to use appropriate public communication tools. On the other hand, for reduction of legal barriers, one solution would be a zoning of natural parks or conserved forest to enable geothermal development while keeping a balance of environmental protection and necessary development. Another solution is “one-stop-window” of the governmental authorization procedure. It is a quite helpful compromise to reduce legal barriers without changing laws and regulations if the spreading of laws and regulations over many authorities is a barrier.

### 1. INTRODUCTION

Barriers to geothermal energy utilization in countries in eastern and south-eastern Asian countries have been investigated under an ERIA geothermal project, which consists of members from China, Indonesia, Japan, Korea, Malaysia, Philippines, Thailand, and Vietnam. The whole project report is shown in Yasukawa and Anbumozhi (2018). In this project, specific barriers were nominated by project member countries and were categorized into five aspects: policy, social, legal, fiscal and technical, as shown in Table 1. Then significance of each barrier was investigated by questionnaire distributed to geothermal experts including academia, industry and government in each country (Figure 1).

**Table 1 Categorization of barriers to geothermal power generation (Yasukawa and Anbumozhi, 2018)**

Policy	National Energy Policy	Lack of Legal Incentives	
	Lack of Economic Incentives		Red Tape in Government
	Lack of R&D Funding		Other Legal Matters
	Domestic Business Protection		High Exploration Cost
	Other Policy Matters		
Social	Lack of Expert	Low Selling Price	
	Lack of Awareness		No Loan nor Support
	Lack of Knowledge		Other Fiscal Matters
	Lack of Business Model	Lack of Information/Experience	
	Other Land Uses		Exploration Technology
	Public Acceptance (PA)		Data Integration or Interpretation
Legal	Other Social Matters	Drilling	
	Environmental Matters	Scaling, Erosion, Corrosion	
	Legislation/Business Mechanism	Reservoir Management	
		Other Technical Matters	

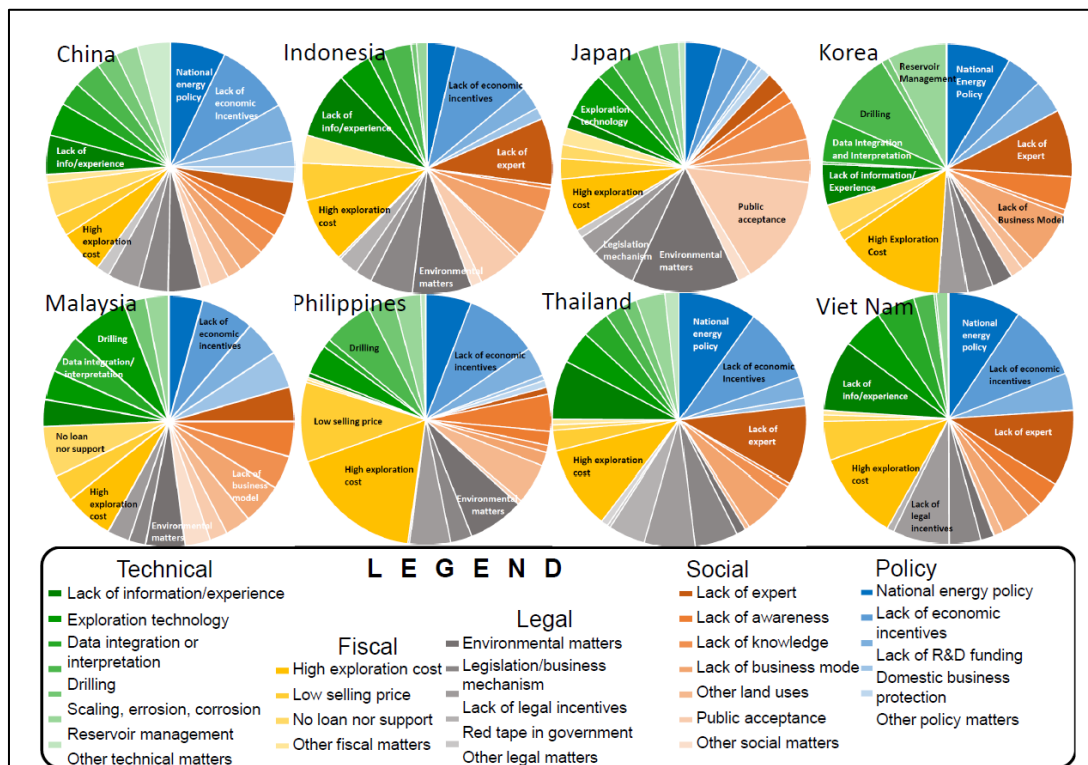


Figure 1: Significance of each barrier to geothermal power generation in each country (Yasukawa and Anbumozhi, 2018).

The project report compares significance of barriers in each country and mentions that social barriers are more prominent in countries where geothermal developments have been intensively done than the other countries where geothermal developers have not been facing the social problems yet. However the Philippines, the leading country of geothermal development in this region, is exceptional because social barriers have been already mostly solved. The report also mentions that many barriers are inter-connected so that such grouping and categorization of barriers may not be perfect.

Nevertheless, this report is quite valuable to investigate barriers from many different aspects since it includes detailed tables of each barrier with description of real situation in each country. In this paper, the authors re-analyzed the results highlighting the environmental aspects and suggest solutions to overcome these environmental problems.

## 2. EXTRACTION OF BARRIER RELATED TO ENVIRONMENTAL ASPECTS AND ITS VALIDATION

### 2.1 Extraction of Environmental Barriers

In Table 1, the environmental aspect is nominally listed only in the legal category as “environmental matters.” However, “other land uses” and “public acceptance (PA)” in the social category may be considered as environmental problems. Among “other land uses”, conflict with forestry is directly a matter of decision making from environmental policy while conflict with private land owners may be a social environmental problem. As for PA, almost all of them are coming from environmental concerns, such as noise, pollution of air, soil, or groundwater, induced seismicity, effects on surrounding natural features, etc. Even effects on local economic or social activities can be considered as concerns on economic or social “environment.” On the other hand, “environmental matters” in legal categories include restrictions and permission processes for environmental protection. Thus, in short, “other land uses” and PA are environmental barriers which are not legally binding but left as social barriers while “environmental matters” is an environmental barrier which is already legally binding.

Note that this new categorization has a merit compared to the original categorization. In Table 1, restriction in nature parks is supposed to be included in the “environmental matters” of the legal category. But as a result of the questionnaire, some answer sheets seem to include it in “other land uses” of the social category, considering the real situation in the country. Therefore, the new categorization as “environmental barriers” in this study may show the more realistic situation in each country.

Table 2 shows the significance of barriers in each country. The upper part of the table is edited from each country’s report in Yasukawa and Anbumozhi (2018), and is also depicted in Figure 1. The lower part is newly made in this paper. The environmental barriers are shown in bold letters of the upper part and summed up in the lower part of this table.

**Table 2. Significance of barriers, sum of environmental barriers and installed GPP capacity in each country.**

		China	Indonesia	Japan	Korea	Malaysia	Philippines	Thailand	Vietnam
Policy	National Energy Policy	7.2%	3.7%	4.7%	8.3%	6.7%	5.9%	9.9%	9.4%
	Lack of Economic Incentives	9.6%	10.3%	3.7%	4.7%	10.5%	9.5%	9.6%	9.7%
	Lack of R&D Funding	4.9%	3.0%	1.5%	4.3%	6.9%	3.8%	2.7%	4.8%
	Domestic Business Protection	3.3%	1.5%	0.5%	0.0%	7.3%	0.7%	1.0%	0.0%
	Other policy matters	2.0%	0.0%	1.3%	0.0%	0.0%	0.9%	0.0%	0.0%
Social	Lack of Expert	4.4%	8.6%	2.7%	8.7%	6.8%	0.9%	10.0%	9.8%
	Lack of Awareness	2.9%	0.5%	1.8%	4.3%	6.9%	4.8%	0.5%	3.1%
	Lack of Knowledge	2.7%	2.9%	5.1%	0.7%	6.6%	1.8%	2.0%	2.2%
	Lack of Business Model	3.4%	6.4%	2.7%	7.0%	8.0%	0.9%	5.0%	3.8%
	Other Land Uses	1.9%	0.5%	2.9%	1.7%	5.0%	1.8%	0.6%	1.2%
	Public Acceptance (PA)	2.5%	5.5%	14.3%	1.7%	3.5%	5.3%	1.2%	0.1%
	Other social matters	1.2%	1.4%	1.7%	0.0%	5.0%	0.6%	0.0%	0.0%
Legal	<b>Environmental Matters</b>	<b>4.3%</b>	<b>7.7%</b>	<b>14.0%</b>	<b>2.7%</b>	<b>7.8%</b>	<b>7.2%</b>	<b>5.5%</b>	<b>1.7%</b>
	Legislation/Business	3.8%	5.5%	6.0%	3.3%	3.3%	2.8%	6.4%	4.1%
	Lack of Legal Incentives	4.2%	2.2%	2.6%	3.7%	4.4%	5.3%	4.7%	7.3%
	Red tape in government	0.0%	2.6%	0.0%	0.0%	0.0%	0.2%	0.4%	0.9%
	Other legal matters	1.7%	0.3%	1.1%	0.0%	0.0%	0.0%	0.9%	0.0%
Fiscal	High Exploration Cost	5.8%	8.4%	6.9%	14.3%	9.6%	17.3%	10.6%	11.5%
	Low Selling Price	2.7%	4.8%	2.6%	1.3%	5.3%	10.3%	2.6%	5.0%
	No Loan nor Support	4.4%	0.0%	1.8%	3.7%	10.0%	0.3%	0.7%	0.8%
	Other fiscal matters	1.1%	3.6%	2.2%	0.0%	0.0%	0.3%	0.7%	0.6%
Technical	Lack of Information/Experience	5.1%	8.6%	1.8%	5.3%	5.3%	0.6%	7.5%	9.1%
	Exploration technology	4.3%	4.3%	6.0%	0.3%	5.8%	3.8%	4.2%	5.3%
	Data integration or	3.1%	2.1%	2.3%	5.7%	7.6%	1.1%	3.5%	5.0%
	Drilling	3.6%	3.6%	3.6%	9.7%	11.6%	6.4%	2.4%	2.6%
	Scaling, Erosion, Corrosion	2.7%	0.7%	2.8%	1.0%	4.3%	3.4%	1.8%	0.3%
	Reservoir Management	2.9%	1.4%	2.6%	7.7%	4.6%	3.5%	3.7%	1.5%
	Other technical matters	4.3%	0.0%	0.9%	0.0%	0.0%	0.7%	1.8%	0.1%
<b>Sum of Environmental Barriers</b>		<b>8.7%</b>	<b>13.7%</b>	<b>31.2%</b>	<b>6.1%</b>	<b>16.3%</b>	<b>14.3%</b>	<b>7.3%</b>	<b>3.0%</b>
Installed GPP Capacity as of 2015 (MW) <sup>1)</sup>		27	1,340	519	0	0	1,870	0.3	0
Exploration and Development Updates <sup>2)</sup>					Deep drilling in Pohang	Development in Tawau		Several explorations	An exploration drilling

“Sum of Environmental Barriers” is newly calculated based on a Yasukawa and Anbumozhi (2018) as shown in bold text. Other information sources: 1) Bertani (2015), 2) Yasukawa and Anbumozhi (2018).

## 2.2 Comparison of Environmental Barriers in Each Country

The result is clear that contribution of environmental barriers is 13% or higher in Indonesia, Japan, and the Philippines, where geothermal developments have been intensively done. Among them, Japan has highest environmental barriers of 31% of total barriers. This may be because of its highly industrialized society in densely populated lands. The specific problems in Japan are 1) the difficulty in SA by the concerns of hot spring inn owners and 2) time consuming environmental assessment. Additional to these three countries, Malaysia has the second highest environmental barriers of 16%. In Sabah Malaysia, a geothermal development by a private sector has just started and is confronting real problems socially and legally that are related to environment. In the other countries, environmental barriers are less than 10 %.

Interestingly in most countries the level of legally binding (legal) and un-binding (social) environmental barriers are nearly the same except for Thailand. Currently Thailand is in a phase of intensive geothermal exploration led by the government, and the private sector has not got involved yet so the social problem is so low, while private sector is intensively involved in the other countries.

Note that this questionnaire was conducted from late 2016 to early 2017 and in its result the environmental barrier is quite low in Korea. However after a felt earthquake occurred in November 2017 near the Pohang EGS site, the possibility of induced (triggered) seismicity by geothermal injection was pointed out (Grigoli et al., 2018) which caused a serious problem of PA. Therefore if the questionnaire would be conducted after this incident, the shape of Figure 1 and Table 2 might be changed drastically.

Thus significance of each barrier varies with the stage of geothermal development of a field and of the whole country. Figure 2 shows a schematic image of environmental barrier change with development phases, obtained by comparison and reconsideration of each country's situation in Table 2. Legal barrier would be highest at the beginning of concession process, while PA barrier gradually increases towards starting of power plant operation. PA barrier may decrease after plant opening if there is no problem, but in many cases it increases due to minor problems left. PA (and sometimes legal) barrier may drastically increase if an environmental incident occurs in any stage of development. Note that it shows a case of single geothermal site but the barrier of PA would be largely affected by other geothermal development. The initial PA barrier would be higher if already existing geothermal power plants have environmental problems. Therefore a general tendency that “the more intensive geothermal development, the higher environmental barrier” should be noted by the countries and regions which plan to develop geothermal power in the future. Although environmental barriers are not visible at the beginning, it will be more serious when developments progress further. Therefore the government and developers should be aware of these potential barriers in the beginning.

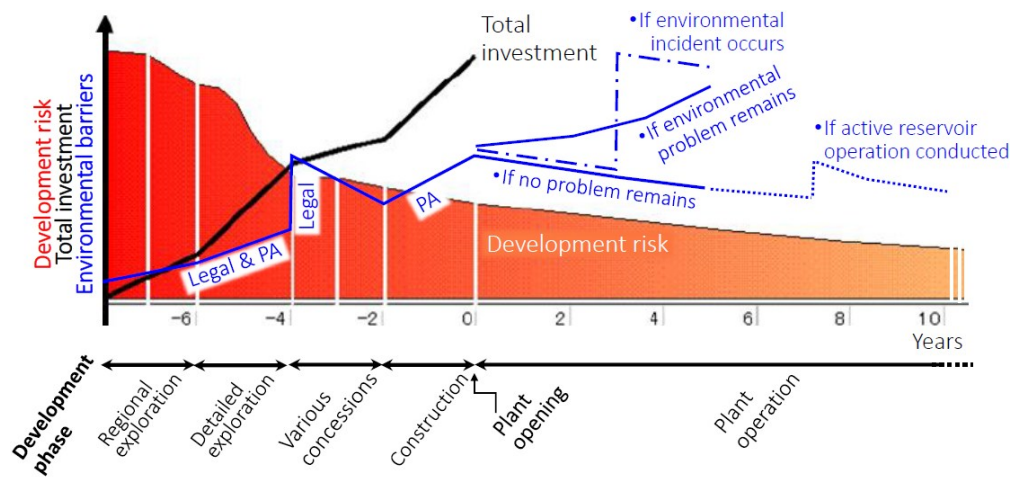


Figure 2. Schematic image of environmental barrier change with development phase of a field.

### 3. POSSIBLE SOLUTION TO ENVIRONMENTAL BARRIERS

To give solutions to environmental barriers, a literature survey was conducted using IGA's database of WGC proceedings which are fully open to public. The general tendency "the more intensive geothermal development, the higher environmental barrier" can be also identified by the recent increasing number of papers treating environmental aspect especially from regions where geothermal development have done intensively.

#### 3.1 PA activities

Public acceptance is a key of geothermal development. Although most of potential environmental problems may be solved by careful technical approach, people's concern cannot be erased without careful social approach. The key issues discussed in related papers are as follows:

- Status of public (social) acceptance should be measured (Leucht et al., 2010, Pellizzone et al., 2015, Kubota, 2015) and improved (Wallquist, 2015) by social scientific approach.
- To increase PA, reforestation (Paje et al., 2010) and eco-tourism (Roy, 2010) may be effective tools.
- Positive aspect of geothermal development such as local employment should be explained for PA (Rodríguez-Alvarez and Vallejos-Ruiz, 2010).

#### 3.2 Environmental impact assessment

In order to communicate with local stakeholders for better PA, opening of geo-scientific data and environmental assessment data are essential. For environmental aspect, the key issues are as follows:

- Environmental impact should be estimated beforehand and monitored/managed during operation (Yousefi et al., 2010, González et al., 2015, Dereinda and Greenwood, 2015, Sequeira, 2015, Daysh et al., 2015, Mutia and Simboyi, 2015)
- Environmental impact peculiar to the specific field such as CO<sub>2</sub> and/or H<sub>2</sub>S emission (Yuniarto et al., 2010, Olafsdottira, 2015, Bierre, and Fullerton, 2015, Mutia et al., 2015, Juliusson et al., 2015, Ndeti, 2015, Aksoy, 2015), subsidence (Bromley et al., 2015) and seismicity should be investigated and appropriate measures should be done.
- Development plan with consideration in conservation of bio-diversity and local vegetation is necessary (Quinlivan, 2010, Willoughby et al., 2015, Beadel et al., 2015, Smalel and Wiser, 2015).

#### 3.2 Consideration on laws and regulations

Since laws and regulations related to environmental protection is essential for conservation of the nature and people's health, it is hard to change. Nevertheless, in many cases there remains some ways to change such rules, considering importance of renewable energy use to mitigate climate change. For example, zoning of natural parks or conserved forest from environmental aspect to enable geothermal development in such region would be a compromise. For the case of Japan, 80% of geothermal resources are seated inside national parks and development had been strictly forbidden. However recent promotion of renewable energy has enabled to use part of national parks for geothermal development if environmental consideration is taken account. As result half of geothermal resources in national parks are released for geothermal development.

Another problem with environmental laws and regulation is, in many cases, they spread over many different authorities, which delays authorization of geothermal development. In the Philippines, environmental laws spread over many agencies and Presidential Decrees (Campen, 2015). In Japan, the permission authority for each step of development spread from local government to agencies/ministries of the federal government including their local branches, such as Ministry of Environment, Ministry of Economy, Trade and Industry, Ministry of Land, Infrastructure and Transport, etc. Again, changing laws and regulation is hard, especially when such rules spread

over plural authorities. In such a situation, “one-stop-window” is a very helpful compromise to reduce legal barrier without changing laws and regulations.

#### 4. CONCLUSION

- Significance of environmental barriers to geothermal development has been investigated based on questionnaire result from Eastern and South-Eastern Asian countries.
- Among environmental barriers, there exist legally binding barriers (environmental laws and regulations) and social barriers (PA and other land uses) considering most of PA problems come from environmental concerns.
- Comparison of questionnaire results in different countries shows a tendency that “the more intensive geothermal development, the higher environmental barrier.”
- Significance of environmental barrier varies with the stage of geothermal development of the whole country.
- Significance of environmental barrier at each site varies with development phase as follows:
  - Legal barrier would be highest at the beginning of concession process of the field.
  - PA barrier gradually increases with time if minor problems left.
  - PA (and sometimes legal) barrier drastically increases if an environmental incident occurs at any stage of development.
  - The initial PA barrier would be higher if other geothermal field have environmental problems.
- Such general tendency should be noted by the countries and regions which plan to develop geothermal power even if there is no environmental barrier currently.
- For better PA, related literatures suggest that:
  - Environmental impact should be estimated beforehand and monitored/managed during operation and all the related scientific data should be opened to public.
  - Environmental impact peculiar to the specific field such as CO<sub>2</sub> and/or H<sub>2</sub>S emission, subsidence, and seismicity should be investigated and appropriate measures should be done.
  - Development plan with consideration in conservation of bio-diversity and local vegetation is necessary.
  - Status of public acceptance should be measured and improved by social scientific approach.
  - To increase PA, reforestation and eco-tourism, etc. may be effective tools.
  - Positive aspect of geothermal development such as local employment should be explained for PA.

For reduction of legal barriers, followings are suggested:

- Zoning of natural parks or conserved forest to enable geothermal development in such region would be a compromise for environmental protection and new development.
- “One-stop-window” is a quite helpful compromise to reduce legal barrier without changing laws and regulations if the spreading of laws and regulations over many authorities is a barrier.

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