QUANTIFICATION OF BARRIERS AND ADVANTAGES OF GEOTHERMAL ENERGY USE IN EAST AND SOUTHEAST ASIA

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ABSTRACT

The authors have investigated barriers to geothermal energy utilization and calculated its expected advantages in countries in East and Southeast Asia. Barriers are categorized in five aspects: policy, social, legal, fiscal and technical. The most common barriers recognized are: national energy policy, lack of economic incentives, lack of expert, environmental matters, high exploration cost, lack of information/experience, and drilling technology. The Benefits of geothermal energy use additionally to national energy security or energy savings has been investigated as a part of an ERIA geothermal project. These merits per installed capacity were roughly quantified based on literature survey of past geothermal development projects or ground source heat pump use. The advantages of geothermal energy use cover local economic effects and national CO_2 emission reduction. Finally such benefits per target new installation are calculated for each member country of the project.

Keywords: geothermal energy use, barriers, benefits, power production, ground source heat pump, CO_2 emission reduction, local economy, East and Southeast Asia

1. INTRODUCTION

Facing to the global climate change problem, many countries in East and Southeast Asia are keen to increase the utilization of geothermal resources. However, there exist various barriers that prevent smooth implementation of new geothermal projects. Therefore, a three-year project "Assessment on Necessary Innovations for Sustainable Use of Conventional and New-Type Geothermal Resources and their Benefit in East Asia" was conducted from September 2015 as a joint project of nine countries (China, Indonesia, Japan, Republic of Korea, Malaysia, New Zealand, the Philippines, Thailand and Vietnam), supported by the Economic Research Institute for ASEAN and East Asia (ERIA). The key objectives of this project are:

- to clarify major barriers and contributions of each barrier in each country, and
- to quantify benefits obtained by removal of each barrier.

We have conducted surveys on barriers and benefits of geothermal energy utilization for both geothermal power generation and direct heat use based on past experiences in member countries and literature survey as well as questionnaire surveys. The major aim of the project is to provide right insight on geothermal energy utilization especially to policy makers in Asian countries.

This paper shows the major results of this project, 1) evaluation of barriers, 2) innovative ideas to remove barriers, 3) expected geothermal energy use in each country, and 4) expected benefits of additional geothermal energy use.

2. EVALUATION OF BARRIERS

2.1 Evaluation Method

We first made a list of possible major and minor items of barriers for evaluation as follows.

- ✓ Policy barriers (national energy policy, economic incentive, R&D fund, etc.)
- ✓ Social barriers (lack of expert, lack of knowledge, lack of business model, public acceptance, etc.)
- ✓ Legal barriers (environment matters, legislation/business mechanism, lack of incentives, red tape in government, etc.)
- ✓ Fiscal barriers (high exploration cost, low selling price, loans and subsidies, etc.)
- ✓ Technical barriers (lack of information and experience, exploration technology, drilling technology, scaling problem, reservoir management, etc.)

Then, evaluation of the contribution of each barrier item has been conducted for each country by inquiry to domestic experts. The evaluation on power generation was conducted for eight Asian countries, while that on direct use and ground source heat pump (GSHP) was conducted for four countries (China, Japan, Korea and Vietnam). In each country, we tried to include inquiry answers from all sectors such as industry, academia (and research institutes) and government officers who have enough knowledge on geothermal energy. However, in some countries where geothermal energy is not commercially utilized, answers from specialists on general earth-science, engineering or renewable energy are included. The number of replies differs country by country: ranging from 13 to 77.

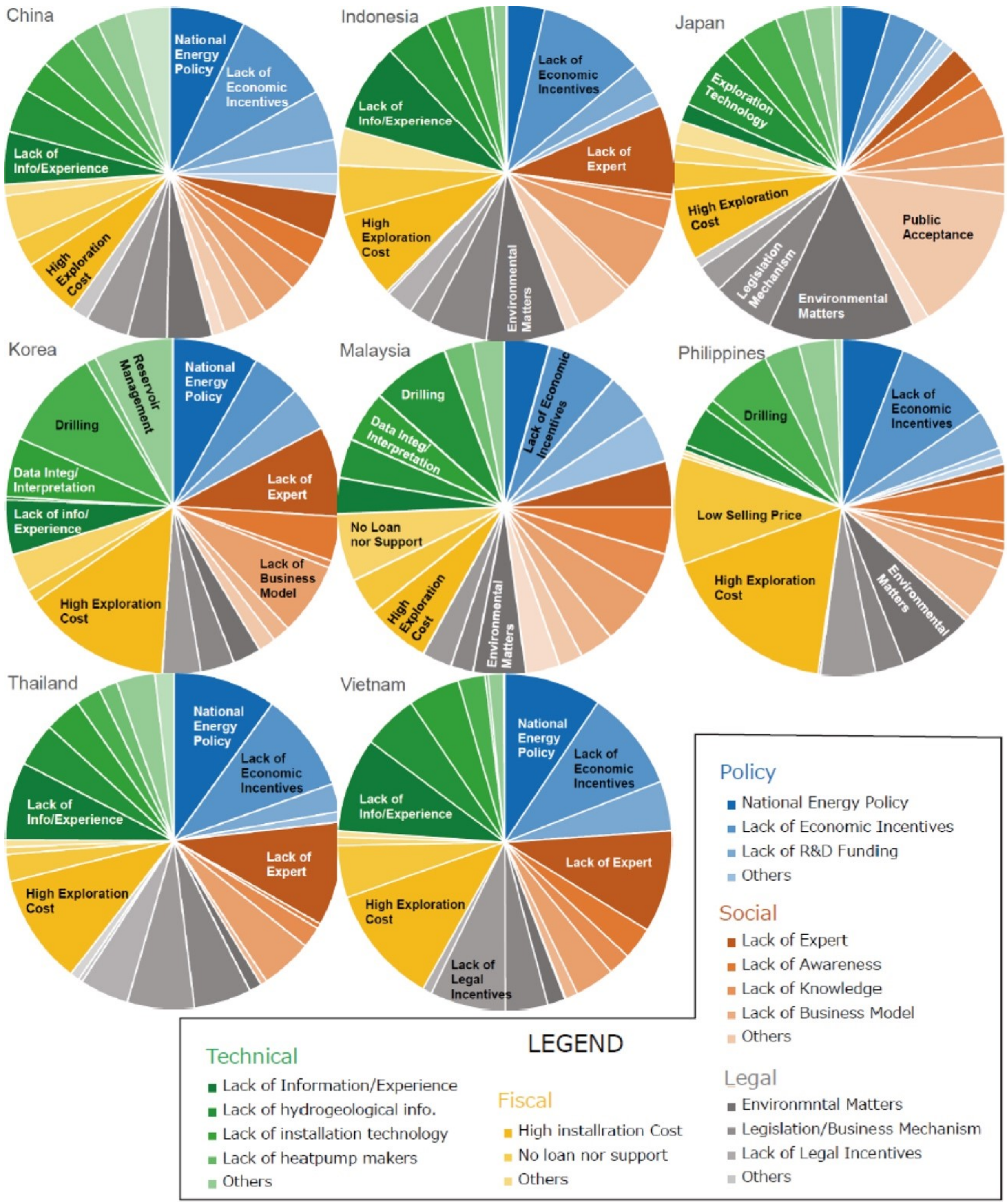

Fig. 1: Contribution of each barrier item to the development of geothermal power plant in eight countries, based on the questionnaire surveys to international experts for Indonesia and Thailand and to domestic experts for the other countries.

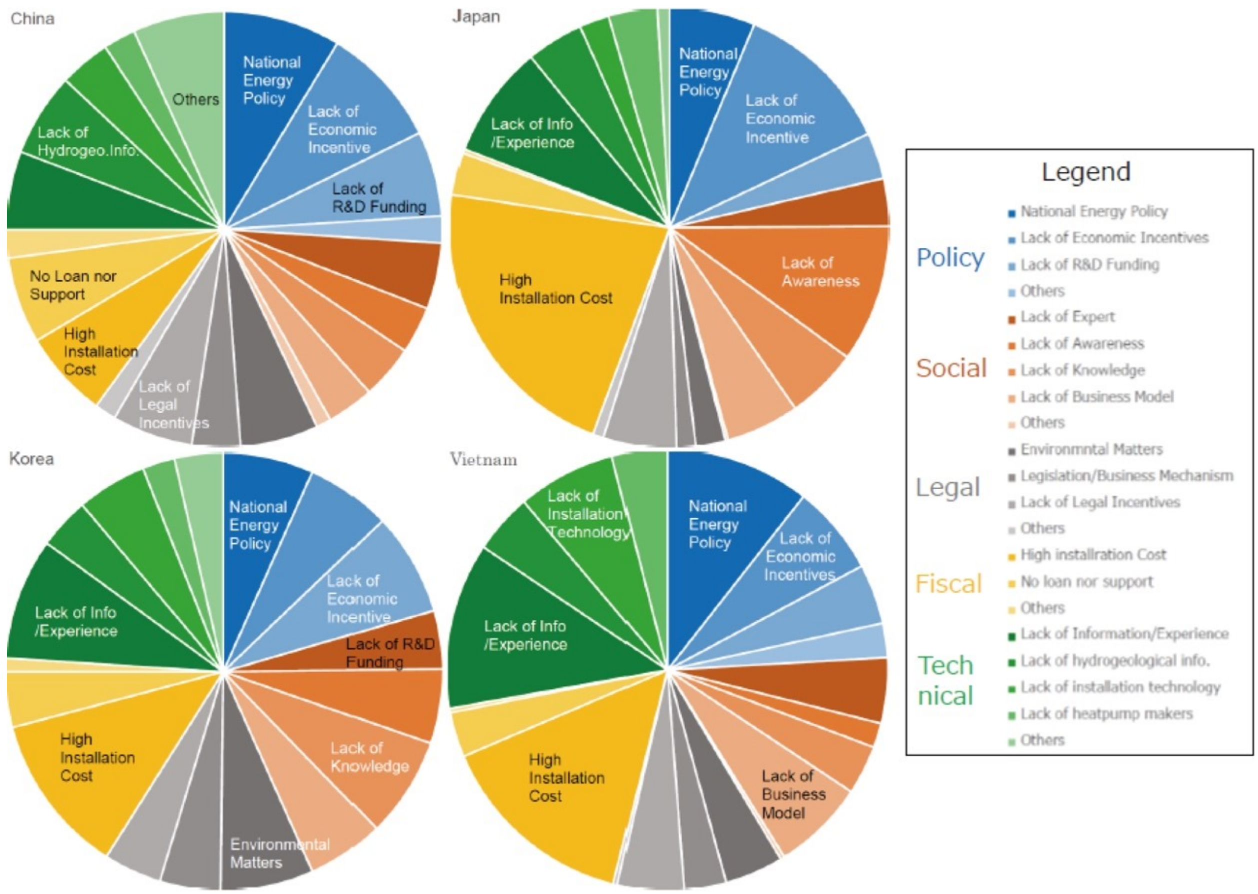

Fig. 2: Contribution of each barrier item to the geothermal direct us for China and to the development of GSHP in Japan, Korea and Vietnam, based on the questionnaire surveys to domestic experts.

2.2 Results of Barrier Evaluation

Figures 1 and 2 show the results of the evaluation on the barriers to the geothermal power generation and direct use (GSHP), respectively.

The important barriers are different country by country. It also differs for electricity generation and direct heat use in a same country. However, the most common barriers recognized are (a) national energy policy, (b) lack of economic incentives, (c) lack of expert, (d) environmental matters, (e) high exploration cost, (f) lack of information/experience, and (g) drilling technology.

3. INNOVATIVE IDEAS ON BARRIER REMOVAL

The following matters have been pointed out in the project as ideas for removal of the barriers. These include already existing ideas in some countries but new to other countries.

3.1 Geothermal Power Generation

On policy aspect, 1) Future target, 2) economic incentives (FiT/RPS) and 3) emphasis on capacity building and open data access are necessary items of innovation.

On social aspect, 1) good business mechanism, 2) capacity building, and 3) geothermal publicity through social media for public acceptance are necessary.

On legal aspect, 1) law or regulation for geothermal resource management and 2) one-stop-shop: simple permitting and authorization process are necessary.

On fiscal aspect, 1) risk fund or low-interest loan for geothermal exploration, 2) drilling support (subsidies or risk fund) by the government, 3) economic incentives (FiT/RPS) especially for technically difficult resources and 4) tax incentives such as environmental incentives for renewable energy are recommended.

On technical aspect, 1) government's strong support for R&D (especially demonstration projects), 2)investigation on geothermal resources and reserves in the country, 3) open data access to previous geological exploration achievements and 4) international cooperation are necessary.

3.2 GSHP and Direct Use

On policy aspect, geothermal-specific policy to drive expansion of residential applications is needed.

On social aspect, accurate monitoring schemes of load factors and system COPs for both technical and social awareness of GSHP benefits is needed.

On fiscal aspect, 1) R&D support by the government for hydrogeological surveys, case studies and long term monitoring and 2) subsidies for the new installation of GSHP system in private residential buildings are needed.

On technical aspect, compilation of suitability maps in a regional scale and optimization of GSHP system based on the local hydrogeological and thermal condition for 1) accurate design of the GSHP system (reduction of installation/running cost), 2) sustainable use of GSHP, and 3) raising awareness to GSHP, are needed.

4. EXPECTED ADDITIONAL GEOTHERMAL ENERGY USE IN EACH COUNTRY

Expected additional geothermal energy use by removal of barriers is estimated for each country. The methods and assumptions for the estimation are different for each country according to the technical and social condition of the country, but a short-term target year is set to 2025 assuming that removal of barriers takes time. A long term target, which is ultimate target of geothermal development is set to 2050.

Note that these target values are "ready to be developed (used) at the target year", not "developed (used) by the target year" since this estimation show the potential development by removal of barriers.

Table 1 Target (additional) geothermal capacity "ready to be developed (used)" at target years

Country	Short-term target at 2025		Long-term target at 2050	
	Power capacity (MWe)	Direct use capacity (MWt)	Power capacity (MWe)	Direct use capacity (MWt)
China	500	18,000 (C) 48,150 (G)	16,000 (16 GW)*	67,500 (C) 114,240 (G)
Indonesia	5,800	-	29,923	-
Japan	1,083	718 (G)	100,000 (100 GW)*	6,300 (G)
Korea	200*	3,425 (G)	800*	-
Malaysia	250	-	273.25	-
Philippines	1,371	-	-	-
Thailand	30	-	-	-
Vietnam	155	-	680	-

C: conventional, G: GSHP

*Target for China, Japan and Korea includes deep EGS

5. EXPECTED BENEFITS OF GEOTHERMAL ENERGY USE

5.1 Expected benefits

There exist direct benefits, which are automatically obtained by installation of geothermal energy use facility, and indirect benefits, which are obtained by additional projects. Direct benefits by geothermal power/heat plant are;

- Production of electricity or heat,
- National energy security (domestic energy),
- Saving fossil fuels,
- Saving energy cost (sales price of electricity or heat),
- Saving land (among renewable energy),
- CO_2 mitigation, Saving cost for CO_2 mitigation,
- Local economy: new employment, businesses with exploration/development crews,
- Development of the local region (in cases of rural areas).

Those by ground source heat pump (GSHP) are;

- Saving electricity,

- National energy security (domestic energy),
- Saving fossil fuels,
- Saving energy cost,
- Reduction of urban heat island phenomenon,
- CO_2 mitigation by replacement from heater by fossil fuels and by saving electricity.

Indirect benefits for both geothermal power/heat plant and GSHP are;

- New business such as greenhouse agriculture, fish farming, sport facility by cascade heat use or mineral extraction from geothermal fluid.

5.2 Quantification of the benefits

(1) Local economy

Direct benefit for local economy may be estimated based on accommodation and consumptions by operation and maintenance staff, and local tax payment from power generation profit. Significance of indirect benefit is indicated by some examples: Prawn park in New Zealand, provided extra hot water from Taupo geothermal power plant, has annual profit of NZ$400,000 (Lund and Klein, 1995) in 1995 when the capacity of the power plant was 161 MW_e. The Blue Lagoon Spa Resort in Iceland, provided hot water from Svartsengi geothermal combined plant (75MW_e and 150MW_t), has posted profits of €15.8 million annually (Nature and Travel, 2016). Since the case of the Blue Lagoon Spa Resort is a super successful case which may not be achieved by everybody, we hire the case of Prawn Park, a modest successful case, to estimate the expected annual profit by additional business using excess heat from geothermal plant, that is NZ$2,482/$MW_e$ (approximately USD1,740/MW_e, for 1NZ$ = 0.70 USD).

(2) Local employment

Life cycle employment of geothermal power generation calculated based on an extended input output model (Hienuki et al., 2015) shows good match with the data from actual power station in Japan (Soma et al., 2015). The local employment intensity of the former is 4.12 person/MW for a 50 MW plant while the latter is 5.2 person/MW in for a plant with running capacity of approximately 30 MW. Example from Costa Rica (Rodriguez-Alvarezz and Vallejos-Ruiz, 2010) is shows that of 3.1 person/MW for a 163MW plant. More cases are needed for better analysis, but a larger plant may need less labor intensity. For these three cases, power plant capacity (x) and the number of new employment (y) shows quite good linear relationship of $y = 2.71x+73$. Therefore, we use this equation for calculation of expected local employment for geothermal power plant.

(3) CO_2 mitigation

CO_2 mitigation effect is calculated for each country based on the current energy mix and CO_2 emission coefficients of energy sources of each country. This approach, using original data from each country, enables to estimate the possible CO_2 mitigation in the region more precisely.

1. CONCLUSION

Benefits of geothermal energy use in East and South-Eastern Asia is studied. The benefits per installed capacity were roughly quantified based on literature survey. The advantages of geothermal energy use cover local economic effects and national CO_2 emission reduction in addition to national energy security and energy savings. Finally such benefits per target new installation are calculated for each country.

ACKNOWLEDGEMENT

This study was a research project managed by Economic Research Institute for ASEAN and East Asia (ERIA). The budget of this project was supplied by Ministry of Economy, Trade and Industry, Japan. Institutes of the project members offered human resources and their time for this project. The authors appreciate the supports of all these organizations. Special thanks are given to Brian Carey and Greg Bignall, GNS Science and Venkatachalam Anbumozhi, ERIA for their invaluable input to the project.

References

Yasukawa, K. (2018): "Assessment on Necessary Innovations for Sustainable Use of Conventional and New-Type Geothermal Resources and their Benefit in East Asia" 2015-2016 Report, ERIA project report, 187 p.

Lund, J. W. and Klein, R. (1995): Prawn park - Taupo, New Zealand, Geo-Heat Center Quarterly Bulletin, **16**, No. 4, 27-29.

Nature and Travel, (2016): Profits at Iceland's Blue Lagoon up over 36%, available at: http://icelandmonitor.mbl.is/news/nature_and_travel/2016/09/27/profits_at_iceland_s_blue_lagoon_up_over_36_prosent/)

Hienuki et al.(2015): Life cycle employment effect of geothermal power generation using an extended input-output model: the case of Japan", Journal of Cleaner Production, 93, 203-212.

Soma, N et al. (2015): Conceptual study of Overall System Design of geothermal energy systems for achieving universal use in Japanese social condition, Proc., World Geothermal Congress 2015, 02033.

Rodriguez-Alvarezz, J. and Vallejos-Ruiz, O. (2010): Geothermal energy: development opportunities for the Miravalles area, Costa Rica, Proc., World Geothermal Congress 2010, 022.