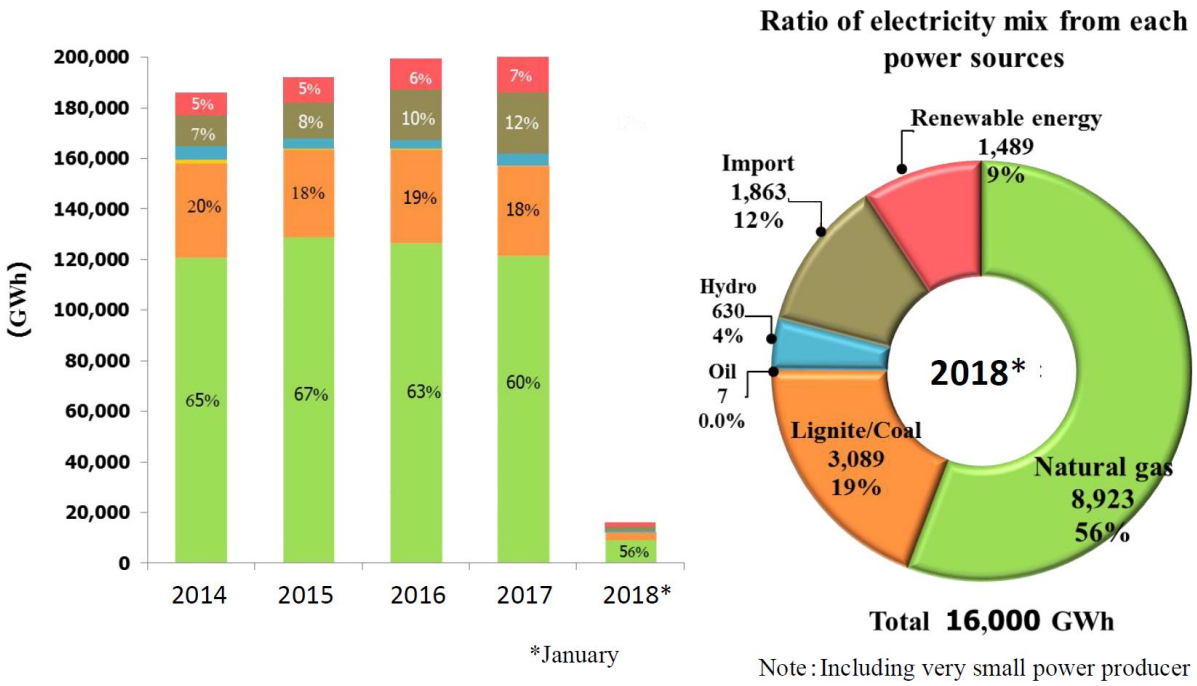
7. Thailand

7.1 Current situation of geothermal energy use and national policy

7.1.1 Current energy policy and energy mix

Thailand produces electricity from five power sources: natural gas, lignite/coal, renewable energy, hydropower, and oil. The ratio of each power source is shown in Figure 3.7.1-1 (updated: January 2018).

Figure 3.7.1-1. Ratio of Electricity Mix in Thailand



GWh = gigawatt hour.

Source: Ministry of Energy, 2018.

Thailand's renewable energy policy

Thailand's renewable energy policy started in 2006 as manifested in the 6th National Economic and Social Development Plan (Plan 6: 1987–1991) (Renewable 2011 Global Status Report). In the same year, the country introduced renewable electricity feed-in tariff (FiT). Thailand also introduced non-financial support mechanisms, including standard power purchase agreements, preferential arrangements for small generators, and information support. In 2008, Thailand, seriously concerned of the renewable energy policy of the Ministry of Energy, published the Renewable Energy Development Plan, setting targets for the deployment of renewable energy for 2008–2022. It set as main target the increase to 20% of renewable energy's share in total final energy demand in 2022 (Asia–Pacific Economic Cooperation, 2018). The Renewable Energy Development Plan targets are divided in three phases. The target for phase I is an increase of 15.6% in the renewable energy's share in the energy mix of total energy consumption in 2011. At the end of phase II (2012–2016), renewable energy is expected to represent 19.1% of total energy consumption. In the third phase (2017–2022), the share of renewables is expected to have developed to 20.3% of total final energy consumption (Olz

and Beerepoot, 2010). Table 3.7.1.-1 shows the renewable energy targets in Thailand as indicated in the Renewables 2011 Global Status Report (REN, 2011). There are no data on geothermal energy.

Table 3.7.1.1-1. Renewable Energy Targets in Thailand

Renewable Energy Target	2011	2016	2022
Biomass	2,800 MW	3,220 MW	3,700 MW
Wind energy	115 MW	375 MW	800 MW
Hydro	185 MW	281 MW	324 MW
Solar PV	55 MW	375 MW	800 MW

MW = megawatt, PV = photovoltaics.
Source: Renewable Energy Policy Network for the 21st Century, 2011.

In 2015, the Ministry of Energy published the Alternative Energy Development Plan, which focused on promoting energy production within the full potential of domestic renewable energy resources, and with consideration to appropriateness and benefits to the social and environmental dimensions of the community.

In the formulation of the Alternative Energy Development Plan, the final energy consumption demands from the Energy Efficiency Plan 2015 are used especially in energy intensity which is reduced by 30% in 2036 compared to the figure in 2010. This indicates that demand of final energy consumption in 2036 will be 131,000 tonnes of oil equivalent (ktoe). The electricity demand forecast from the power development plan is also used to set the target of Alternative Energy Development Plan. This power development plan indicates that in 2036, net electricity demand will be 326,119 units or equivalent to 27,789 ktoe. The heat demand forecast in 2036 will be 68,413 ktoe and the forecast demand for fuel in the transportation sector from the fuel management plan for 2036 is 34,798 ktoe. The target of other plan as shown above, including consideration of the potential of renewable energy sources that can be developed, was used to formulate the target of Alternative Energy Development Plan 2015 to replace 30% of final energy consumption (in the form of electricity, heat, and bio-fuel) by 2036 (Ministry of Energy, 2017).

Table 3.7.1.1-2. Targets of Electricity, Heat, and Bio-fuel from Renewable Energy

Energy	Share of Renewable Energy (%)		Final Energy Consumption at 2036 (tonnes of oil equivalent, ktoe)
	Status As of 2014	Target by 2036	
Electricity: Electricity	9	15– 20	27,789
Heat: Heat	17	30– 35	68,413
Bio-fuels: Fuels	12	20– 25	34,798
RE : Final Energy Consumption	**12**	**30**	**131,000**

ktoe = kilotonne of oil equivalent, RE = renewable energy.
Source: Alternative Energy Development Plan 2015.

The target electricity production from various types of renewable sources was set up using the renewable energy supply–demand matching principle. The available renewable energy resource potential will be sorted and sequenced by the merit order of renewable energy technologies in accordance with the demand for electricity in the area and the limitation of the transmission system. Going by the merit order, it seems that geothermal energy is last in the order of renewable energy technologies (Table 3.7.1.1-3).

Table 3.7.1.1-3. Merit Order of Various Types of Renewable Energy Sources for Generating Power

1	2	3	4	5	6	7	8
Municipal solid waste	Biomass	Biogas	Small hydro	Biogas (energy crop)	Wind	Solar	Geothermal

Source: Alternative Energy Development Plan 2015.

The Alternative Energy Development Plan 2015 has set a target of electricity from all renewable energy to 20% of the net electrical energy demand, which complies with the fuel diversification ratio in the power development plan for 2015–2036, indicating the proportion of electricity generated from renewables in the range of 15–20 years in 2036.

Table 3.7.1.1-4. Status and Target of Electricity Generation by Type of Fuel

Fuel	Status by End of 2014* (MW)	Target by 2036 (MW)
1. Municipal solid waste	65.72	500
2. Industrial waste	-	50
3. Biomass	2,451.82	5,570
4. Biogas	311.5	600
5. Small hydro	142.01	376
6. Biogas (energy crop)	-	680
7. Wind	224.47	3,002
8. Solar	1,298.51	6,000
9. Large hydro	-	2,906.4**
Total installed capacity (MW)	4,494.03	19,684.40
Electrical energy (million units)	17,217	65,588.07
Total electrical energy demand (million units)	174,467	326,119.00
Share of renewable energy in electricity generation (%)	9.87	20.11

Note: * Including off-grid power generation and not including power generated from large hydro.
** The existing capacity and generation from large hydro was included in the target of AEDP2015.
MW = megawatt
Source: Alternative Energy Development Plan 2015.

For goals heat production from renewable energy targets at 68,413 ktoe in 2036 (Table 3.7.1.1-2): Demand for energy for heating is a significant portion of the energy consumption of the country, which has steadily increased and is proportional to the economic situation, such as expansion of cities and communities, tourism, industry, and agricultural sector adapting to agricultural industry.

Assessment of the potential to produce heat from renewable energy is based on four renewable energy groups (Table 3.7.1.1-5):

1) Production of heat from renewable feedstock such as residual waste, biomass, and biogas as fuel remaining after deducting the estimated potential to produce a different type of energy.

2) Production of heat from fast-growing trees.

3) Production of solar heat (solar hot water systems, solar drying system, and solar heating and cooling systems).

4) Production of heat by other sources of renewable energy. This is in the research and development of technology in the near future, such as geothermal energy, etc., that is competitive in price.

Table 3.7.1.1-5. Status and Target to Produce Heat by Type of Feedstock

Feedstock	Status by end of 2014* (ktoe)	Target by 2036 (ktoe)
1. Municipal solid waste	98.10	495.00
2. Biomass	5,144.00	22,100.00
3. Biogas	528.00	1,283.00
4. Solar	5.10	1,200.00
5. Alternatives heat source*	-	10.00
Total	5,775.20	25,088.00
Total heat demand	33,419.54	68,413.40
Share of renewable energy for heat production (%)	17.28	36.67

ktoe = kilotonne of oil equivalent.
*Geothermal, oil from tyre, etc.
Source: Alternative Energy Development Plan 2015.

7.1.2 Geothermal energy use in Thailand

According to a study by Department of Alternative Energy Development and Efficiency in 2006, 112 hot brine sources are found in regions of Thailand except in the northeastern part. Water temperatures on the surface level ranged 40°C–100°C and most of the hot springs originated from granite, especially along the fault line in the northern provinces such as Mae Chan in Chiang Rai and Fang in Chiang Mai.

The Department of Mineral Resources, in collaboration with Chiang Mai University and Electricity Generating Authority of Thailand, was reported to have test-run a 300-kW production from a geothermal project at Fang in Chiang Mai. The production cost of the project was eight times cheaper than the production cost of fossil fuel, and its maintenance is of longer durability while its cost is several times cheaper.

However, unlike in other countries, the geothermal energy potential in Thailand remains doubtful due to lack of expertise in assessing it. The Department of Alternative Energy Development and Efficiency states that the key success factors of geothermal resource development in Thailand include geothermal exploration, drilling cost, borehole characteristics, fluid collection and transmission, and geothermal by products.

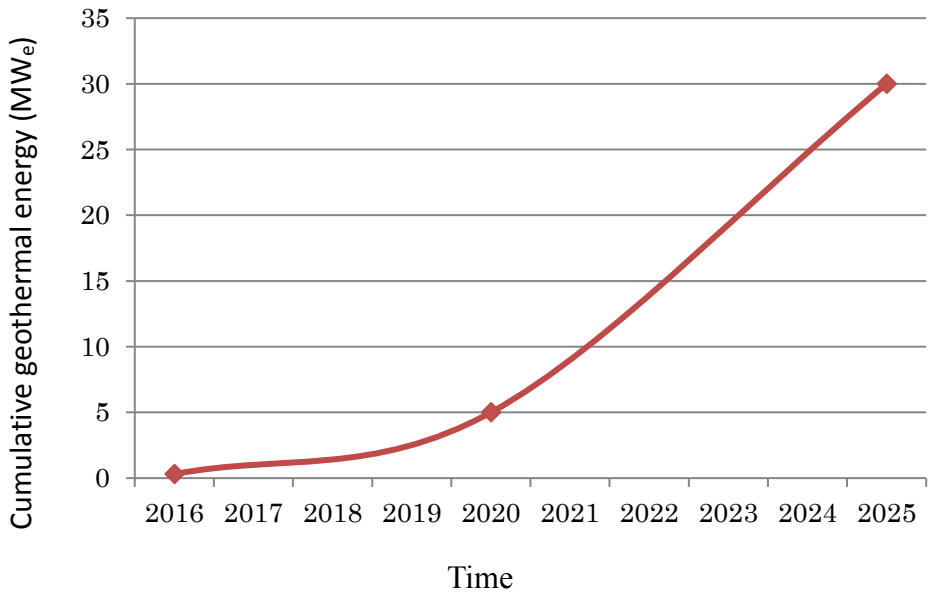
Aside from technical barriers, policy and legal barriers also hinder geothermal development in Thailand. Despite the many positive results of geothermal power utilisation, e.g. green energy, durability, etc., promoting geothermal energy development in Thailand is difficult because of the uncertainty of its potential, thus making policy and legal framework on its development equally difficult. At the moment, no specific legislation for geothermal development exists in Thailand.

7.2 Geothermal projects and target by 2025

In 2011, four memorandums of understanding on geothermal exploration, potential assessment, and development were signed among PTT Public Company Limited; Department of Groundwater Resources and Department of Groundwater Resources and Department of Mineral Resources, both of the Ministry of Natural Resources and Environment; and Department of Alternative Energy Development and Efficiency of the Ministry of Energy.

Figure 3.7.2 shows the target of geothermal energy development project as contained in the memorandums of understanding. The current power production from geothermal energy in the binary system is 0.3 MW_e. In the next 15 years, the project is set to produce up to 5 MW_e. If the project can produce the target volume, Thailand can produce up to 30 MW_e in 2025.

Figure 3.7.2. Expected Cumulative Geothermal Energy in Thailand



MW = megawatt.
Source: Authors.

If barriers are not removed, the generated geothermal power in Thailand will be 0.3 MW_e.

7.3 Barriers to geothermal energy use, and necessary innovations

7.3.1 Barrier to geothermal energy use in Thailand

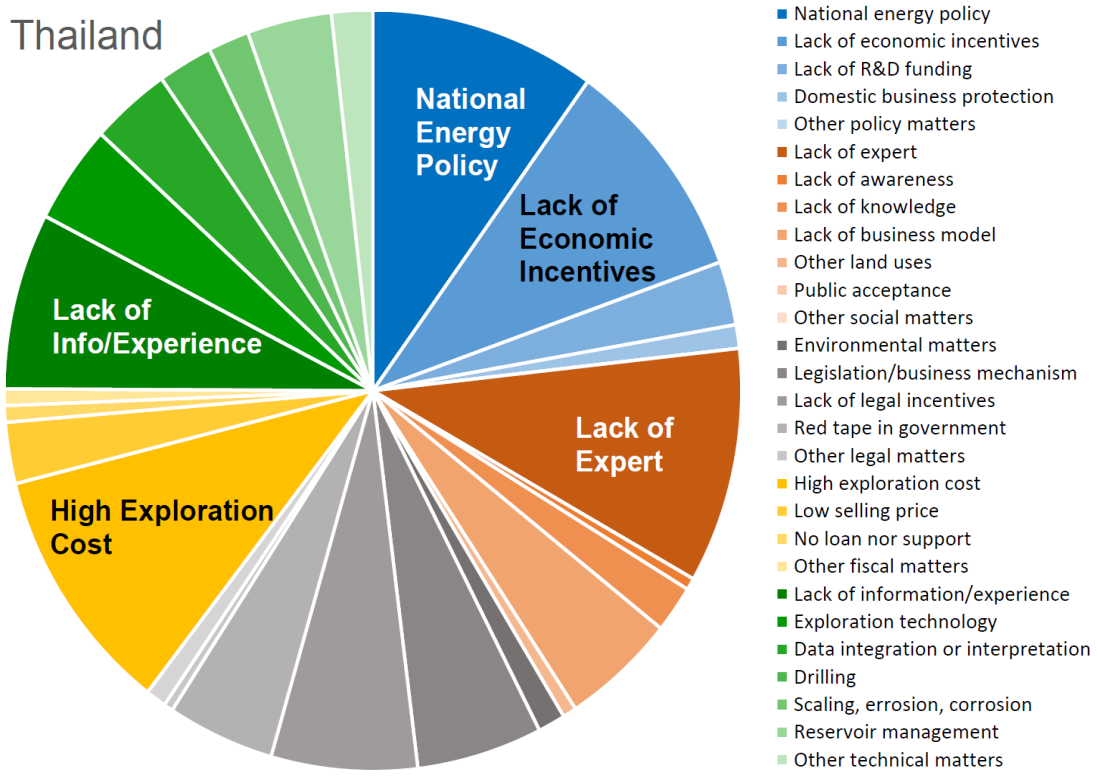
Table 3.7.3-1 and Figure 3.7.3-1 show the results of inquiry to domestic and foreign experts on barriers to geothermal power generation in Thailand, as presented by an ERIA working group member from Thailand at the 11th Asian Geothermal Symposium in Chiang Mai, Thailand, in November 2016.

Table 3.7.3-1. Results of Inquiry on Barriers to Geothermal Power Generation in Thailand, as Obtained at the 11th Asian Geothermal Symposium

Policy	23%	National energy policy	9.9%
		Lack of economic incentives	9.6%
		Lack of R&D funding	2.7%
		Domestic business protection	1.0%
		Other policy matters	0.0%
Social	19%	Lack of experts	10.0%
		Lack of awareness	0.5%
		Lack of knowledge	2.0%
		Lack of business models	5.0%
		Other land uses	0.6%
		Public acceptance	1.2%
		Other social matters	0.0%
Legal	18%	Environmental matters	5.5%
		Legislation/Business mechanism	6.4%
		Lack of legal incentives	4.7%
		Red tape in government	0.4%
		Other legal matters	0.9%
Fiscal	15%	High exploration cost	10.6%
		Low selling price	2.6%
		No loan nor support	0.7%
		Other fiscal matters	0.7%
Technical	25%	Lack of information/experience	7.5%
		Exploration technology	4.2%
		Data integration or interpretation	3.5%
		Drilling	2.4%
		Scaling, erosion, corrosion	1.8%
		Reservoir management	3.7%
		Other technical matters	1.8%
TOTAL (%)	100%		100.0%

Source: Authors.

Figure 3.7.3-1. Results of Inquiry to Experts from Foreign Countries on Barriers to Geothermal Power Production in Thailand



Source: Authors.

Based on results, the major barriers to geothermal power generation in Thailand are high exploration costs, lack of experts, lack of economic incentives, lack of information/experience, national energy policy, and legislation/business mechanism.

7.3.2 Innovative ideas to remove barriers in Thailand

Based on the study, the main barriers to geothermal energy use in Thailand are commonly legal and technical.

1) Legal barriers

The Thai government does not support renewable energy researches because no legislation promoting them has been made. Thus, there is a dearth of knowledge related to the development of renewable energy. The government should be compelled to enact laws on renewable energy so proper guidelines can be made for setting standard for production and preservation of renewable energy.

Proposed action plans for geothermal energy development:

1) Sign memorandums of understanding among entities previously cited on geothermal exploration, potential assessment, development, and their affects to the environment and local population.
2) Enact geothermal energy laws upon review of similar legislation from foreign countries.
3) Set period and target for geothermal energy development and set up a mechanism for transparency and accountability in its management.
4) Define feed-in tariff.
5) Introduce tax measures, and establish and manage geothermal energy fund.
6) Determine and establish legal rights of the various sectors such as producers, buyers, consumers, and affected communities. Determine the structure and price mechanism for hydrothermal energy, business licence application, and examine the effects of energy production and consumption.
7) Ease the process of applying for permission.

2) Knowledge and technique barriers

Thailand has few research efforts and limited knowledge on geothermal energy development. For deep geothermal exploration, we need more knowledge, techniques, machineries, and materials from foreign entities that are more experienced in geothermal development and have poured huge investments into it. To remove these barriers, the following have to be considered:

a) Material

Most hot springs of high potential in Thailand are located in nature parks, which are not the best place to set up power plants. Thus, to avoid problems and conflict, the Ministry of Natural Resources and Environment should first consider gaining knowledge from geothermal energy experts from other countries, and conduct training courses on exploration, assessment, and development of geothermal sources, including the construction of power plants, before starting any research or action plans.

b) Method

Aside from geology and structure analysis, we should use geophysical exploration to define exact geology and structure of reservoirs of geothermal energy such as resistivity, transient electro magnetic, and magneto telluric methods, which are the most commonly used today to define very deep structures; and geochemistry and specific isotope technique to classify temperature and water source.

We should also change geothermal power station system from binary system to Kalina system.

c) Budget

Thailand should look for foreign funds to support research on geothermal energy development. Since the Thai government is paying more attention to the well-being of the people than supporting research and development for geothermal energy, we have to show how geothermal energy is, on the long term, useful for people.

d) Machine

We need more high-potential machines for deep reservoirs.

7.4 Benefits of geothermal energy use in Thailand

The benefits of geothermal power generation in Thailand include 1) local welfare, 2) local infrastructure, 3) local economy, 4) CO_2 emission mitigation in the power sector, and 5) energy security. Amongst them, items 3), 4), and 5) are quantified here.

1) CO_2 mitigation

CO_2 mitigation by additional geothermal capacity of 1371MW was calculated as 92,054,100 kg-CO_2/year (Figure 3.4.4-1).

Fig. 3.7.4-1. CO_2 Mitigation by Additional Geothermal Power

Power Source	Power Supply Ratio: A	Unit CO_2 Emission: B	A x B
unit		(g-CO2/kWh)	
Coal	19.9%	1,000	199.40
Oil	0.0%	778	0.00
LNG	70.6%	443	312.94
Nuclear	0.0%	66	0.00
Hydro	0.0%	10	0.00
Solar PV	0.8%	32	0.27
Wind onshore	0.0%	10	0.00
Geothermal (natural system)	0.0%	13	0.00
Geothermal (HDR)		38	0.00
Small-hydro	3.5%	13	0.46
Biomass	4.2%	25	
Total	99.2%	-	513

CO_2 mitigation by geothermal electricity per kWh is:

513 - 13 = 500 (g-CO_2/kWh)

Target capacity: C	30 MW
Capacity factor: D	70%

Total CO_2 mitigation by additional geothermal electricity is:

500 × 30 × 24 × 365.25 × 0.7

= 92,054,100 (kg-CO_2/year)

←CO_2 Emission by all electricity sources (g-CO_2/kWh)

CO2 = carbon dioxide, HDR = hot dry rock, g-CO2 = gramme of carbon dioxide, kWh = kilowatt-hour, LNG = liquefied natural gas, PV = photovoltaics.
Sources: Original of this study. Data source for column A: International Energy Agency 2016; B: Benjamin K. Savacool, 2008.

2) Other benefits

Other benefits are calculated following the procedure in Section 2.4.2.1 for the target capacity. The expected benefits by removal of each barrier category are calculated based on the barrier contributions shown in Table 3.7.3-1. Again, note that these barriers are interrelated and removal of one barrier may stop further geothermal development. Nevertheless, this estimation gives insights to policymakers on the significance of benefits by barrier removal. Table 3.6.4-1 summarises the calculated benefits.

Table 3.7.4-1. Direct Benefits and (Expected) Indirect Benefits of Geothermal Power Generation by Removal of Barriers in Thailand

Item		Unit	Barriers significance and benefits by removal of each barrier					Total benefit	Remarks
			Policy	Social	Legal	Fiscal	Technical		
Barrier significance		%	24	20	13	18	25	100	
Target capacity		MW	7.2	6	3.9	5.4	7.5	30	*W*
Target capacity factor		%						70%	*Cf*
a) Power generation		MWh/year	44,181	36,817	23,931	33,135	46,022	184,086	*W* x 24 x 365.25 x *Cf*
b) Annual fuel saving	by oil	barrel/year	55,922	46,602	30,291	41,942	58,252	233,010	11,096 *W x Cf*
	by LNG	kg/year	6,638,401	5,532,001	3,595,800	4,978,801	6,915,001	27,660,003	1,317,143 *W x Cf*
		Million Btu/year	326,994	272,495	177,122	245,245	340,618	1,362,474	0.04926 *W*
c) Saving foreign currency	by oil	US$/year	3,355,340	2,796,116	1,817,476	2,516,505	3,495,146	13,980,582	60.0 US$/Barrel
	by LNG	US$/year	1,634,968	1,362,474	885,608	1,226,226	1,703,092	6,812,368	5.0 US$/Btu
d) CO_2 mitigation		(tonne-CO_2/year)	22,093	18,411	11,967	16,570	23,014	92,054	from "CO_2" Table
e) Local employment		persons	37	31	20	28	39	154	2.71*W*+73
f) Saving lands compared to solar PV		m^2	802,930	669,108	434,920	602,197	836,385	3,345,540	111,518 *W*
(g) Expected profit of additional businesses		US$/year	12,877	10,731	6,975	9,658	13,414	53,654	1,788 *W*
(h) Expected local employee by additional businesses		persons	4	3	2	3	4	15	0.5 *W*
(i) Expected local economic effect of the additional		US$/year	16,099	13,416	8,720	12,074	16,770	67,080	2,236 *W*

Btu = British thermal unit, CO_2 = carbon dioxide, cf = coefficient factor, kg = kilogramme, LNG = liquefied natural gas, MW = megawatt, MWh = megawatt hour, PV = photovoltaics. For symbols *Cf* and *W*, please refer to equation (1) in section 2.4.2.1.
Source: Authors.

7.5 Summary of barriers to and benefits of geothermal energy use

The most significant barriers to geothermal use in Thailand are high exploration costs, legislation/business mechanism, and national energy policy, followed by lack of legal incentives and lack of drilling technology. Innovative ideas and measures to remove the barriers are as follows:

National policy should include geothermal energy in the government's master plan of energy supply.

Legal barriers, including legislation/business mechanism, should be solved by setting up the following items:

1) Legislation on geothermal energy, aided by reviews of laws on the subject from foreign countries.
2) Target period for geothermal energy development, with corresponding transparency and accountability in management.
3) Feed-in tariff.
4) Tax and management measures in the set up of geothermal energy fund.
5) Legal rights of various sectors such as producers, buyers, consumers, and affected communities. Likewise, structure and price mechanism for geothermal energy, and processing of licence for geothermal energy business.
6) Process of permit application.

Barriers to knowledge and technology should be solved by:

- Collaboration with experts such as engineers and academics from foreign countries.
- Geothermal training in New Zealand, Iceland, and Japan for Thai geothermal experts.

Technical problems need solutions such as:

- Application of geological, geochemical, and geophysical (especially electro-magnetic) exploration methods.
- Improvement of binary cycle system such as changing from Organic Rankin Cycle to Kalina cycle.

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