2. Indonesia

2.1 Current situation of geothermal energy use and national policy

By 2015, Indonesia had an installed capacity of 1,438.5 MW from 11 geothermal fields: Kamojang, Darajat, Wayang Windu, Patuha, Gunung Salak, Dieng, Ulubelu, Sibayak, Lahendong, Ulumbu, and Mataloko. These fields may still be able to generate additional power since they have bigger reserves ready for development. Moreover, additional power may be produced by private developers from geothermal fields that are at development stage or exploration stage, possibly generating about 5,800 MW_e from both probable and proven reserves by 2025 (Table 3.2.1-1).

Table 3.2.1-1. Geothermal Potential in Indonesia, as of April 2016

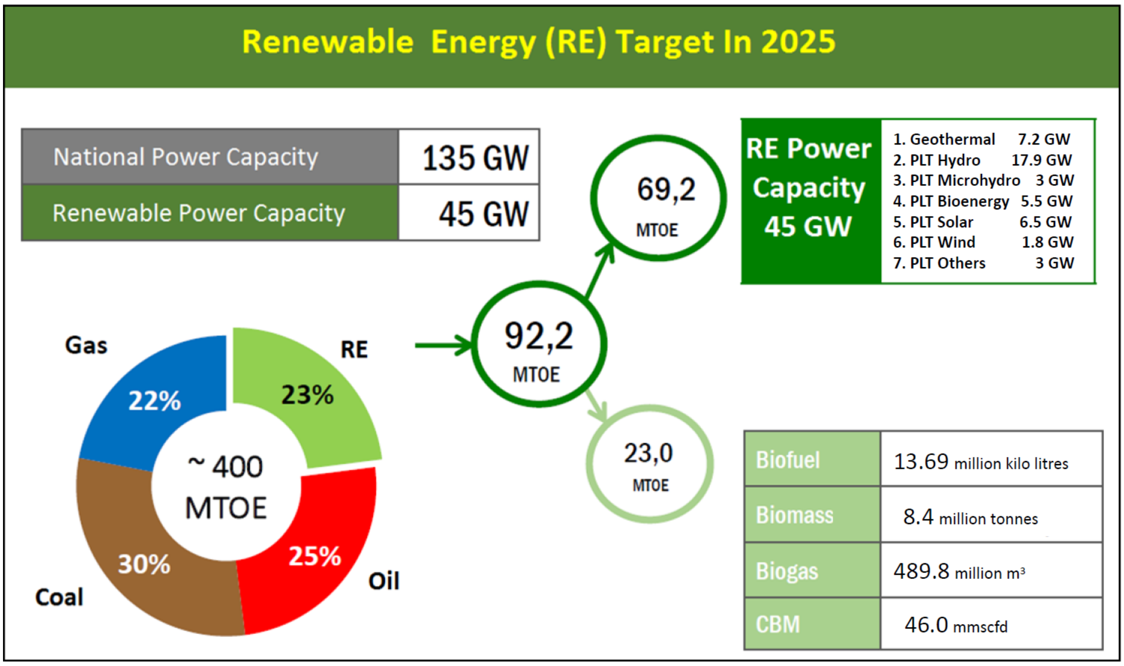
No	Island	Number of Locations	Energy (MWe)					Installed	Total
			Resources		Reserves				
			Speculative	Hypothetic	Possible	Probable	Proven		
1	Sumatra	97	3191	2205	5474	925	1127	122	12922
2	Jawa	73	1560	1739	3558	1538	1865	1224	10260
3	Bali	6	70	22	122	110	30	0	354
4	Nusa Tenggara	27	225	409	829.5	0	15	12.5	1478.5
5	Kalimantan	14	152.5	30	0	0	0	0	182.5
6	Sulawesi	77	1221	318	1441	80	140	80	3200
7	Maluku	33	560	91	770	30	0	0	1451
8	Papua	3	75	0	0	0	0	0	75
Total		330	7054.5	4814	12194.5	2683	3177	1438.5	29923
			11868.5		18054.5				
			29923						

MWe = megawatt electricity.

Source: Geothermal Department of Indonesia, 2016.

Taking into account all national potentials to fulfill energy needs and considering the barriers and the alternative solutions for them, the Indonesian government issued in 2014 a national energy plan for 2015–2050 aimed at providing a detailed programme of implementing a national energy policy. In the policy, renewable energy should contribute 23% to the energy mix in 2025 from the current 7%. For the electricity sector, the power capacity that should be achieved by utilising renewable sources is about 45 GW by 2025.

Figure 3.2.1-1. Renewable Energy Development Plan of Indonesia Until 2025



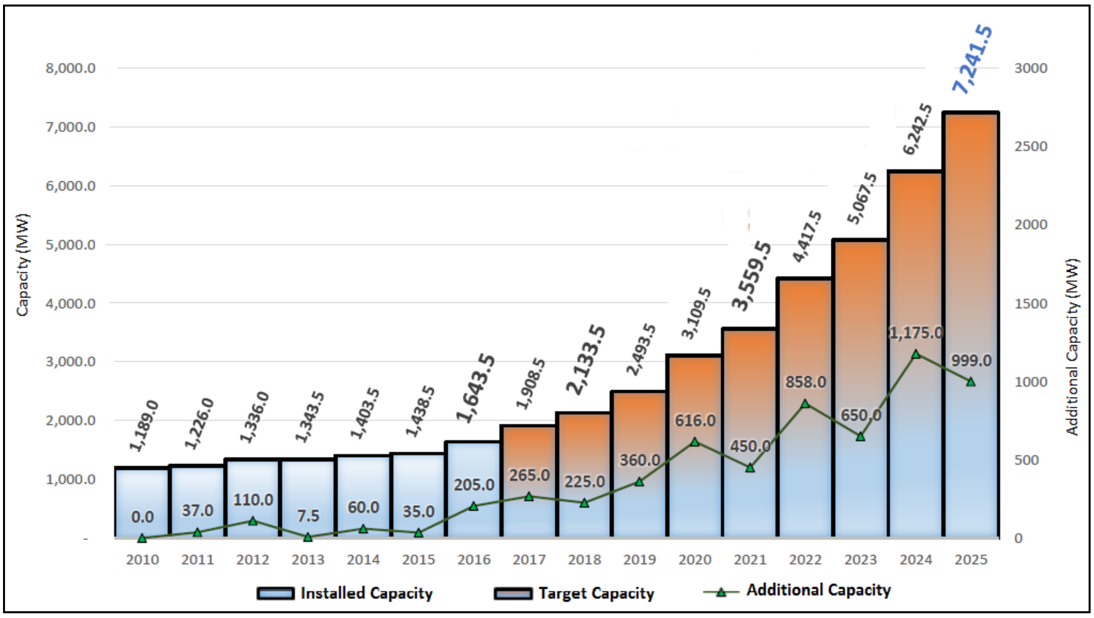
CBM = coal bed methane, GW =gigawatt, m^3 = cubic metre, mmscfd = million standard cubic feet per day, MTOE = million tonnes of oil equivalent, RE = renewable energy.

Source: Ministry of Energy and Mineral Resources, 2016.

For the geothermal energy sector, a stepwise plan has been drawn up to achieve a total installed capacity of 7,200 MW in 2025 where additional power and total power capacity for each year is indicated (Figure 3.2.1-2).

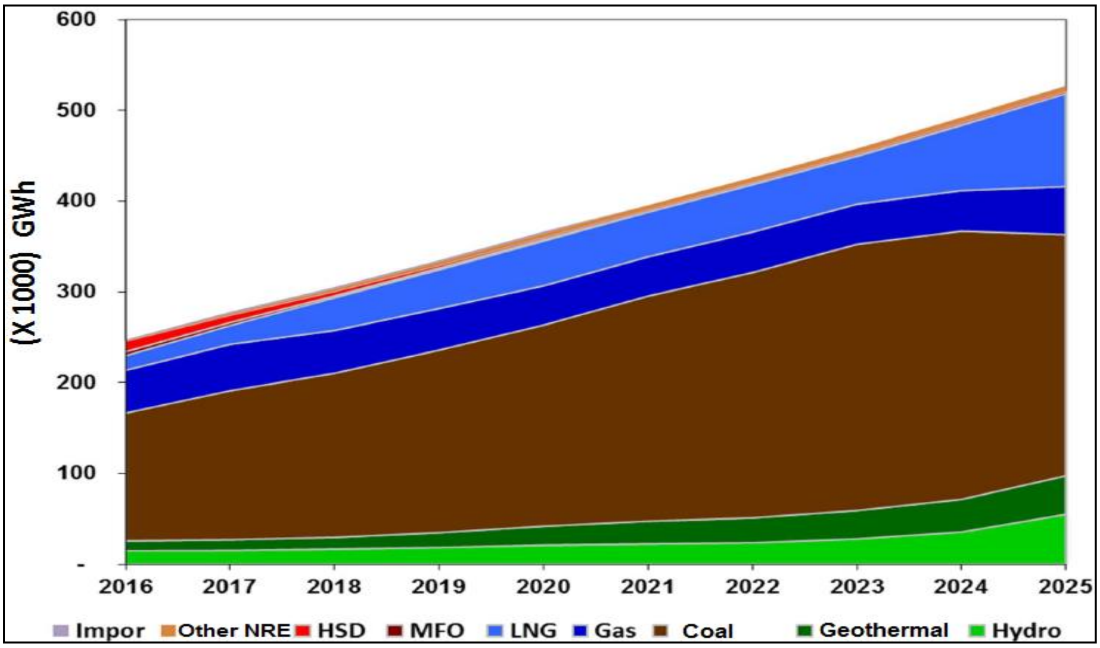
Figure 3.2.1-3 shows the contribution of geothermal power to the national electricity mix. Although coal is still a dominant source in 2025, geothermal power and hydropower will be the most significant renewable energy sources in the national electricity mix.

Figure 3.2.1-2. Geothermal Power Development Plan in Indonesia Until 2025



MW = megawatt.
Source: Ministry of Energy and Mineral Resources, 2016.

Figure 3.2.1-3. Electricity Power Development Plan Until 2025



GWh = gigawatt hour, HSD = high speed diesel, LNG = liquefied natural gas, MFO = medium fuel oil, NRE = non-renewable energy, Impor = Imported fuels.

▲: Additional power for each year, ■: Total capacity.

Source: Department of Renewable Energy and Saving Energy, Indonesia, 2016.

To speed up geothermal energy development, the Indonesian government is conducting the following.

1) Government drilling (risk sharing by the government)

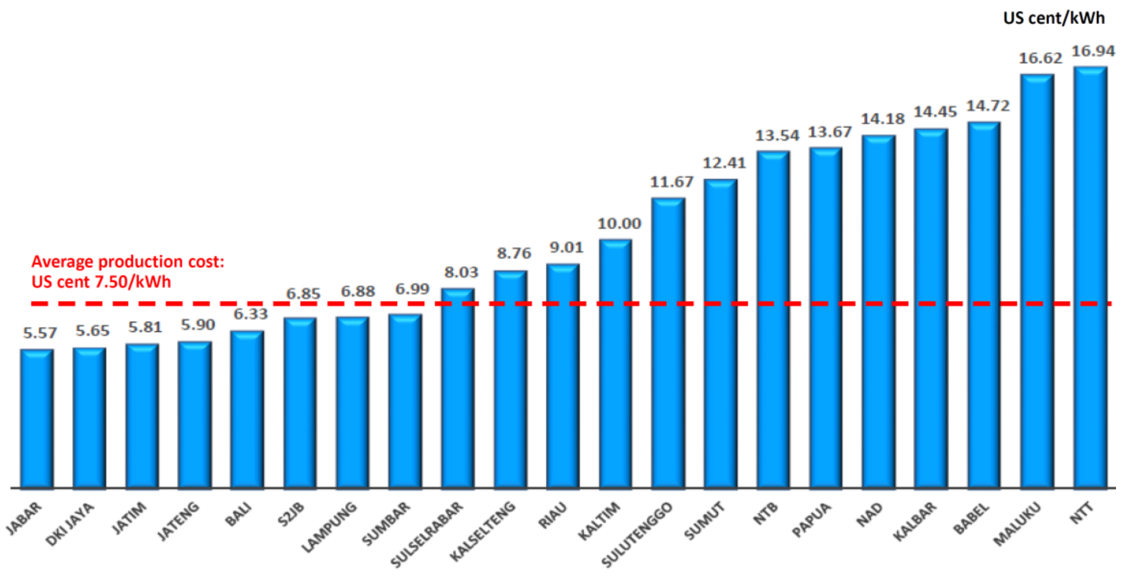
The Indonesian government has started to minimise production costs to lower electricity price. As geothermal exploration is a high-cost and risky phase, the government should take efforts to get involved in more advanced explorations. The government, however, tends to avoid use of the national budget for explorations. Thus, the government's geothermal exploration can be implemented by utilising contingent grants from international donors such as the World Bank and the Asian Development Bank. The government can also utilise the geothermal fund facility set up by the Ministry of Finance as a revolving fund for exploration. This fund, reserved in Multi Sarana Infrastruktur, a state investment company, is jointly managed by the Ministry of Energy and Mineral Resources and the Ministry of Finance. Should exploratory drilling be successful, the working area could be tendered and the winning bidder would refund the exploration cost and give a certain margin to Multi Sarana Infrastruktur. This revolving fund could be sourced from the national budget for use by government exploration institutions such as Geological Agency in conducting slimhole exploration drillings, which are much cheaper but effective tools for resource confirmation. Similar to the above fund mechanism, the tender winner should refund the government.

2) Feed-in tariff

Many developers in Indonesia are willing to spend for exploration cost for geothermal power if the return on their investment is attractive. The government has formulated a new partial feed-in tariff (FiT) for geothermal energy based on several determinants such as power capacity, regional zoning, accessibility, and power generation technology. The government, however, issued Minister of Energy and Mineral Resources Regulation No 12/2017 which states that by January 2017, geothermal price is a FiT based on *biaya pokok produksi* (regional production cost) of Perusahaan Listrik Negara (PLN) or State Electrical Power Company. Based on this regulation, price of geothermal power is a maximum 100% of *biaya pokok produksi* above the national average and the rest will be negotiated between developers and PLN.

Until now, production cost is based on the PLN production cost in 2015 (Figure 3.2.1-4). With reference to this figure, the average cost is US$7.50/kWh. The higher costs are in the eastern parts of Indonesia. Therefore, in terms of *biaya pokok produksi*, the eastern parts should be more attractive for geothermal energy investment than the western parts.

Figure 3.2.1-4. Production Cost of Perusahaan Listrik Negara in 2015

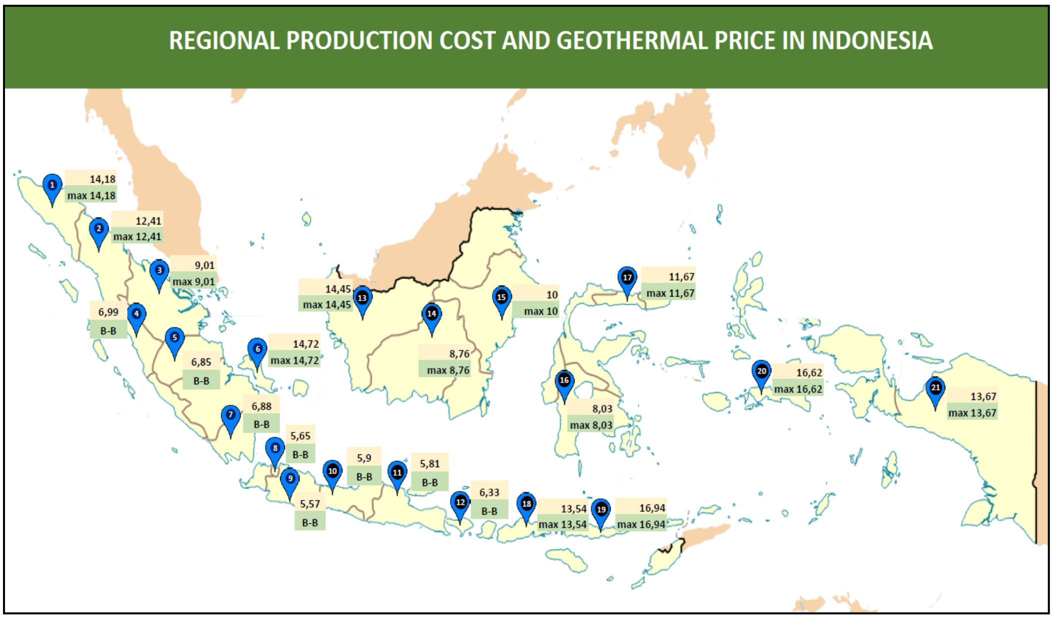


kWh = kilowatt-hour.

Note: The production cost of PLN varies based on regional zoning. The average cost is US$0.75/kWh.

Source: Ministry of Energy and Mineral Resources, 2016.

Figure 3.2.1-5. Regional Geothermal Power Price Based on Production Cost of Perusahaan Listrik Negara, 2015



max = maximum.

Source: Ministry of Energy and Mineral Resources, 2016.

2.2 Target capacity estimation for geothermal power

Indonesia is an archipelago where the population of each island is not homogenous and where economic growth rates vary, causing variations in electricity demands. The growth of electricity demand in Indonesia from 2015 to 2024 is shown in Table 3.2.2-1.

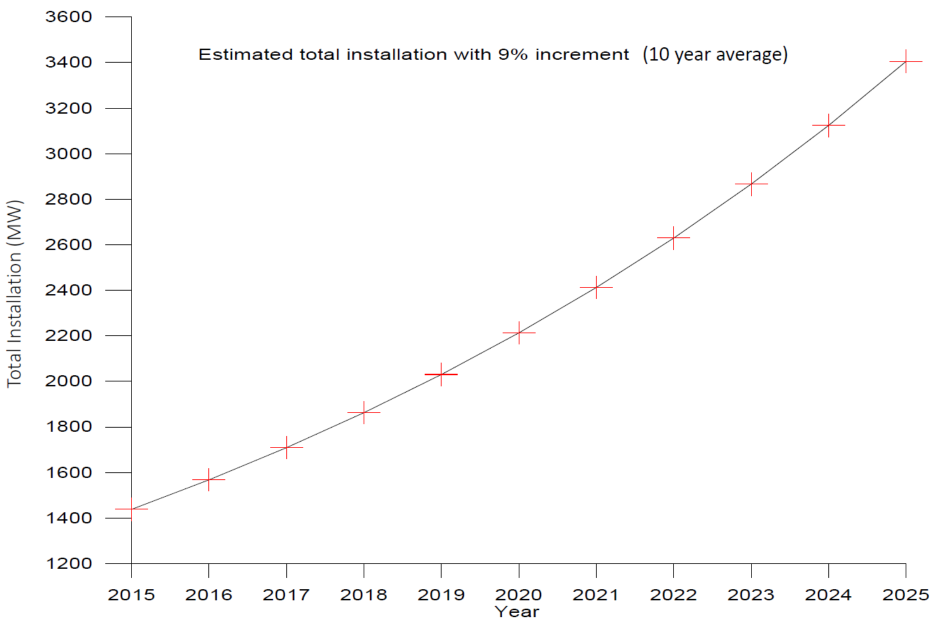
Table 3.2.2-1. Estimated Increase in Rate of Electricity Consumption in Indonesia

Area	Increase in Rate of Electricity Consumption (in %)					
	2015	2016	2018	2020	2022	2024
Indonesia	8.7	9.0	8.9	8.4	8.7	8.8
Java–Bali	7.6	7.8	7.6	7.5	7.9	7.8
Eastern Part	12.9	14.5	14.2	9.9	9.2	9.2
Sumatra	11.7	11.1	11.1	11.2	11.8	11.2

Source: PT PLN (national electric power company of Indonesia), 2014.

Realistic development of geothermal electricity until 2025 should start from fields with reserves confirmed by exploration drilling, as indicated by probable reserves of about 2,600 MW_e and proven reserves of about 3,100 MW_e (Table 3.2.1). The reserves, mostly located in Java and Sumatra, are now being utilised up to 1438.5 MW_e of their capacity, with about 4,200 MW_e more for utilisation. If the reserves are developed with an assumed annual increase rate of 9%, a capacity of 3,400 MW_e can be utilised by 2025 (Figure 3.2.2-1).

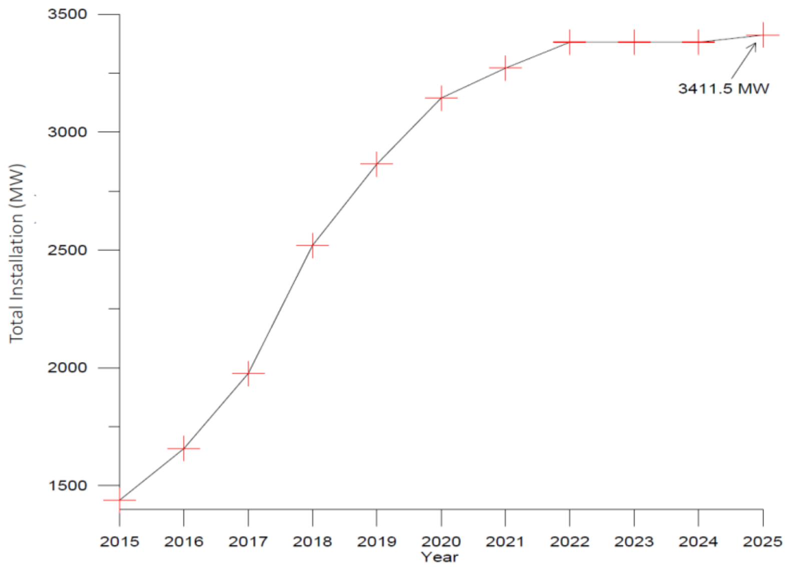
Figure 3.2.2-1. Prediction of Geothermal Electricity Development in Indonesia



Note: Prediction uses available probable and proven reserves with increase rate of 9%.
Source: Government Regulation No. 79/2014, Indonesia, 2014.

The government, however, has a policy, through Government Regulation No. 79/2014, of maximising the use of renewable energy sources, where new and renewable energy is projected to contribute 23% of the national demands (Figure 3.2.2-2).

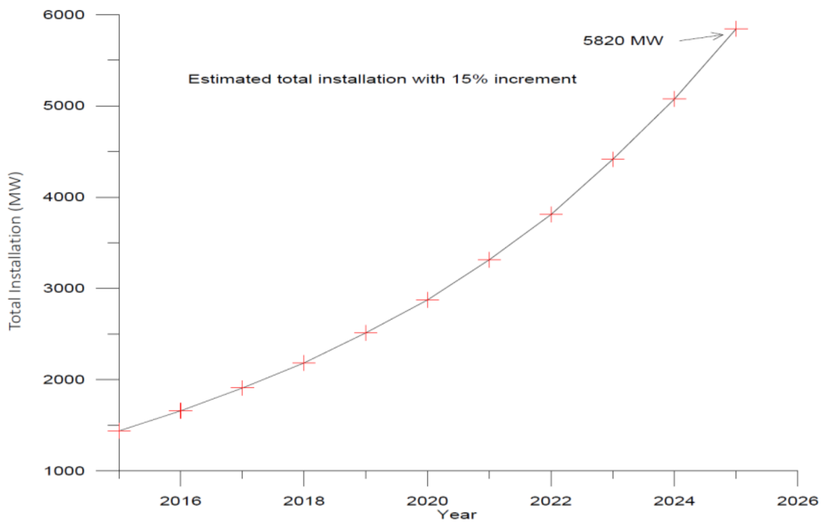
Figure 3.2.2-2. Government's Plan on Geothermal Electricity Development in Indonesia Using Available Probable and Proven Reserves



MW = megawatt.
Source: Government Regulation No. 79/2014, Indonesia, 2014.

To maximally take advantage of the available probable and proven geothermal reserves, it is necessary to increase their rate of development. With 15% increase rate, a 5,800-MW_e capacity will be available by 2025 (Figure 3.2.3).

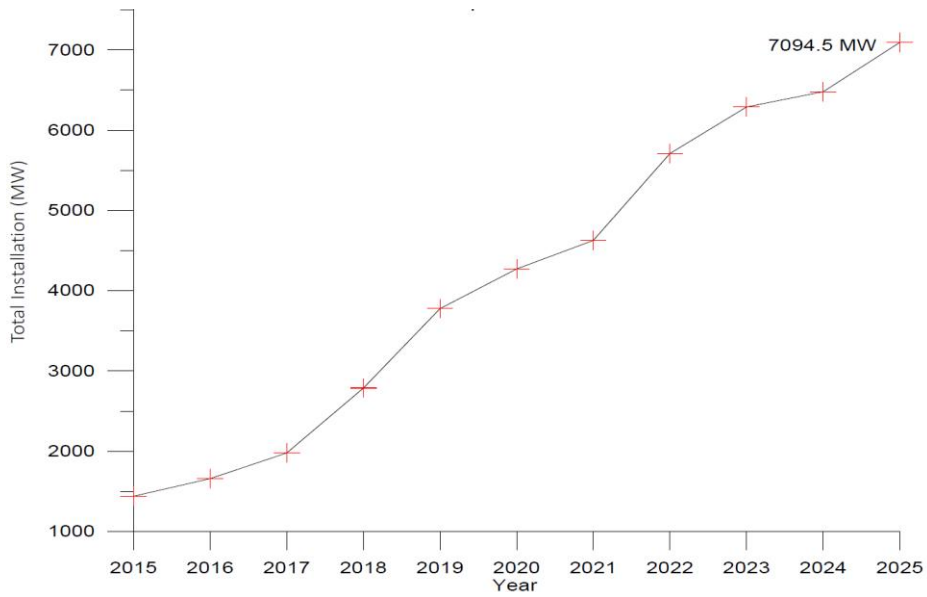
Figure 3.2.2-3. Prediction of Geothermal Electricity Development in Indonesia Using Available Probable and Proven Reserves with Increase Rate of 15%



MW = megawatt.
Source: Government Regulation No. 79/2014, Indonesia, 2014.

To increase the share of geothermal energy in the national energy mix, the government plans to build a geothermal power plant using not only probable and proven reserves but also prospective possible reserves, the lowest level of reserves which can be confirmed by surface exploration without drilling. By utilising some prospective possible reserves as well, the government is projecting to develop 7,000 MW of geothermal power for electricity by 2025 (Figure 3.2.4).

Figure 3.2.2-4. Government Plan on Geothermal Electricity Development in Indonesia Using Available Probable and Proven Reserves and Some Prospective Possible Reserves



MW = megawatt.

Source: Republic of Indonesia, 2014.

2.3 Barriers to geothermal power generation, and necessary innovations

2.3.1 Barriers to geothermal power generation

Inquiry on barriers to geothermal power generation in Indonesia was made during the 11th Asian Geothermal Symposium in Chiang Mai, Thailand, in November 2016. International experts verified barriers based on a presentation by an Indonesian member of this project.

According to the results of inquiry, lack of economic incentives, high exploration cost, lack of experience in geothermal power development, lack of experts among new developers, and environmental problems are the five highest barriers to geothermal power development in Indonesia (Figure 3.2-1). Also considered as high barriers are lack of business models, lukewarm public acceptance, and existing legislation/business mechanism.

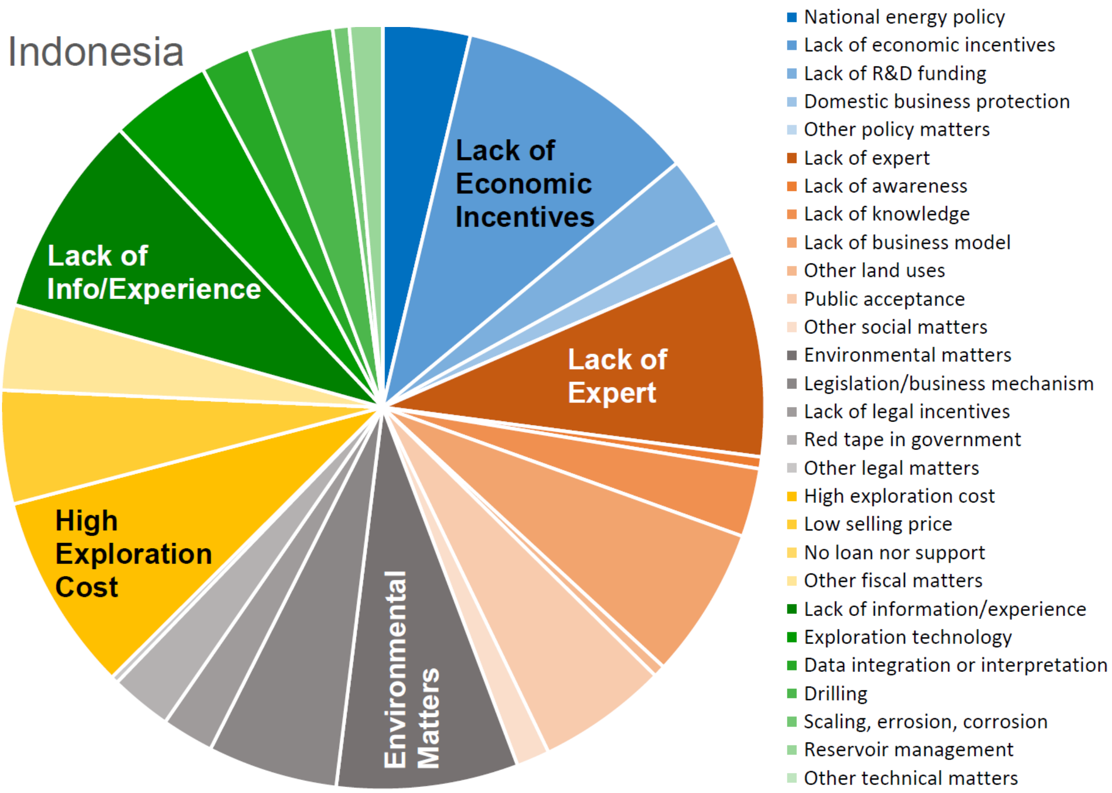
Electricity in Indonesia is mostly subsidised in all regions regardless of its source. However, even as a clean and renewable source of energy, geothermal power has no economic value. Thus, in most cases, geothermal power has to compete with cheaper fossil energy sources such as coal and natural gas, especially in major islands such as Java and Sumatra. Faced with hard competitions from cheaper sources, geothermal power needs fiscal and/or non-fiscal instruments as economic incentives.

The high risk and cost of geothermal exploration stage is also a problem in Indonesia since the government still puts the risk on developers alone, except for preliminary surveys. Some domestic experts expect the government to take more risks by conducting deep exploration drillings. Others are of the opinion that developers may take the risk but should have better price of geothermal power in return.

Among domestic developers, especially newcomers, many have inadequate experience in geothermal power development. Most of those licenced for development of new geothermal areas have often failed to execute the exploration phase within the allocated period as they lack capacity or expertise to carry out the task. This is also caused by inadequate criteria set by the government in qualifying bidders for projects.

Since many prospective geothermal resource sites are located in forest areas, geothermal power projects tend to occupy protected and/or conservation areas. This is a complicated problem and may take a long way of being solved. Another major environment-related problem is public acceptance. Most communities around geothermal project areas do not understand what geothermal energy is. Any incident occurring in an oil and gas exploration area is enough to frighten people and arouse antipathy towards exploration activities.

Figure 3.2-1. Results of Inquiry to Outside Experts on Barriers to Geothermal Power Generation in Indonesia



Note: Major barriers are labelled.
Source: The study team.

2.3.2 Innovative ideas to remove barriers

The Indonesian government has already been conducting risk-sharing drillings and FiT as innovatice ideas to remove barriers (see Section 3.2.1). Results of these policies may be obtained in a few years. Additionally, the following are considered in this project as innovative ideas to remove barriers.

1) Business mechanism

In the last 10–15 years, our experience in geothermal power development tells us that a good business mechanism is very important. The lack of it produces none of best-practice developers and induces lack of expertise. The mechanism problem is now minimised by the issuance of stronger geothermal energy laws and better government regulations to assure that there would be more qualified developers with necessary expertise.

2) Education programmes to strengthen expertise

To strengthen expertise, geothermal energy educational programmes have been established in major domestic universities. Vocational training on geothermal energy development is also being advocated at a government institution under the Ministry of Energy and Mineral Resources.

3) Environmental matters

Overlapping problems between forestry areas and geothermal energy development areas have been solved by the issuance in June 2016 of environmental service regulations for geothermal projects in forestry areas. However, technical mechanisms and coordination between the Ministry of Forestry and MEMR on implementing the regulations are crucial to smoothly solve problems.

4) Public acceptance

Problems of public acceptance should be minimised by disseminating information on the benefits of geothermal energy development in communities around areas of development. Since the issuance of the Geothermal Law 21/2014, the development of geothermal power under the authority of the central government has continued. However, involving local governments in information dissemination is very important since they have wider access to communities.

2.4 Benefits of geothermal power generation in Indonesia

The benefits of geothermal power generation in Indonesia were quantitatively analysed following the procedure in Section 2.4.2.1 b).

1) CO_2 mitigation

CO_2 mitigation by an additional geothermal capacity of 5,800MW is calculated as 25,064,122,560 kg-CO_2/year (Figure 3.2.4-1).

Figure 3.2.4-1. 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	54.7%	1,000	546.90
Oil	7.0%	778	54.23
LNG	25.9%	443	114.69
Nuclear	0.0%	66	0.00
Hydro	7.9%	10	0.79
Solar PV	0.2%	32	0.08
Wind onshore	0.0%	10	0.00
Geothermal (natural system)	4.3%	13	0.56
Geothermal (HDR)	0.0%	38	0.00
Small-hydro	0.0%	13	0.00
Biomass	0.0%	25	
Total	100%	-	717

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

CO_2 mitigation by geothermal electricity per kWh is:

$$717 - 13 = 704 \text{ (g-}CO_2\text{/kWh)}$$

Target capacity: C	5,800	MW
Capacity factor: D	70%	

Total CO_2 mitigation by additional geothermal electricity is:

$$704 \times 5{,}800 \times 24 \times 365.25 \times 0.7$$

$$= 25{,}064{,}122{,}560 \quad \text{(kg-}CO_2\text{/year)}$$

CO_2 = carbon dioxide, g-CO_2 = gramme of carbon dioxide, HDR = hot dry rock, kWh = kilowatt-hour, LNG = liquefied natural gas, MW = megawatt, PV = photovoltaics.
Source: Authors. Data source for column A: PwC Indonesia, 2017; B: Benjamin K. Savacool, 2008.

2) Other benefits

Other benefits are calculated following the procedure for target capacity in Section 2.4.2.1. Expected benefits by removal of each category of barriers are calculated based on barrier contributions (Table 3.6.3-1). Note that these barriers are interrelated and removal of one barrier may stop further geothermal power development. Nevertheless, this estimation may give policymakers insights on the benefits to be gained by barrier removal. Table 3.2.4-1 summarises the calculated benefits.

Table 3.2.4-1. Direct Benefits and (Expected) Indirect Benefits from Geothermal Power Generation by Removal of Barriers

Item		Unit	Barriers significance and benefits by removal of each barrier					Total benefit	Remarks
			Policy	Social	Legal	Fiscal	Technical		
Barrier significance		%	18	26	18	17	21	100	
Target capacity		MW	1044	1508	1044	986	1218	5,800	*W*
Target capacity factor		%						70%	*Cf*
a) Power generation		MWh/year	6,406,193	9,253,390	6,406,193	6,050,293	7,473,892	35,589,960	*W* x 24 x 365.25 x *Cf*
b) Annual fuel saving	by oil	barrel/year	8,108,738	11,712,621	8,108,738	7,658,252	9,460,194	45,048,542	11,096 *W x Cf*
	by LNG	kg/year	962,568,104	1,390,376,151	962,568,104	909,092,099	1,122,996,122	5,347,600,580	1,317,143 *W x Cf*
		Million Btu/year	47,414,082	68,487,008	47,414,082	44,779,967	55,316,430	263,411,569	0.04926 *W*
c) Saving foreign currency	by oil	US$/year	486,524,254	702,757,255	486,524,254	459,495,128	567,611,629	2,702,912,520	60.0 US$/Barrel
	by LNG	US$/year	237,070,412	342,435,040	237,070,412	223,899,834	276,582,148	1,317,057,846	5.0 US$/Btu
Electricity sales	developer's	US$/year							
d) CO_2 mitigation		(tonne-CO_2/year)	4,511,542	6,516,672	4,511,542	4,260,901	5,263,466	25,064,123	from "CO_2" Table
e) Local employment		persons	2,842	4,106	2,842	2,684	3,316	15,791	2.71*W*+73
f) Saving lands compared to solar PV		m^2	116,424,792	168,169,144	116,424,792	109,956,748	135,828,924	646,804,400	111,518 *W*
(g) Expected profit of additional businesses		US$/year	1,867,173	2,697,028	1,867,173	1,763,441	2,178,369	10,373,184	1,788 *W*
(h) Expected local employee by additional businesses		persons	522	754	522	493	609	2,900	0.5 *W*
(i) Expected local economic effect of the additional		US$/year	2,334,384	3,371,888	2,334,384	2,204,696	2,723,448	12,968,800	2,236 *W*

Btu = British thermal unit, CO_2 = carbon dioxide, LNG = liquefied natural gas, m^2 = square metre, 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.

3) Promotion of the development of eastern Indonesia

Here is another benefit that is not quantified but should be described.

Indonesia's eastern part has many volcanic islands with good quality of geothermal resources. About 1,600 MW of geothermal power is generated in Java, Sumatra, and North Sulawesi. A small portion is generated in Flores Island, one of the small volcanic islands in the eastern part.

However, despite the potential in the eastern part of Indonesia, geothermal power development is not attractive due to high tariff, small market, and inadequate infrastructure. Therefore, promoting geothermal power development in the eastern region should mean lower tariff, particularly for Flores Island and its neighbouring islands in East Nusa Tenggara, which have the highest tariff (US$16.94/kWh) in the region.

2.5 Summary of barriers to and benefits of geothermal power generation

The highest barriers to geothermal power generation in Indonesia are lack of economic incentives, high exploration cost, lack of experience and expertise of new developers, and environmental problems.

The suggested innovative ideas to remove barriers to geothermal energy use in Indonesia, including the existing ones, are as follows:

- Risk sharing by government in explorations
- Feed-in tariff
- Good business mechanism
- Education programmes to strengthen expertise
- Environmental incentives
- Public acceptance
- Future targets

Note that the benefits of geothermal energy use in Indonesia include promotion of the development of eastern Indonesia, CO_2 emission mitigation, and creation of local employment and new businesses.

References

Direktur Panas Bumi (2016), Pengembangan Panas Bumi. Presentation slides presented in the Focus Group Discussion on Geothermal Exploration by Government, Jakarta, 29 March 2016.

Ministry of Energy and Mineral Resources (2016), Republic of Indonesia, 2016 Minister Decree No. 5899K/20/MEM/2016 on the Legalization of Business Plan of PLN's RUPTL for 2016 to 2025. Ministry of Energy and Mineral Resources. Jakarta.

Ministry of Energy and Mineral Resources (2017), Republic of Indonesia, 2017 Minister Regulation No. 12 on Utilization of Renewable Energy for Electricity. Ministry of Energy and Mineral Resources. Jakarta.

PT PLN (2014): Rencana Usaha Penyediaan Tenaga Listri PT PLN (Persero) 2015–2024.

PwC Indonesia (2017): Power in Indonesia – Investment and Taxation Guide November 2017.

Republic of Indonesia (2014), Law No. 21/2014 on Geothermal, Secretary of State. Jakarta.

Republic of Indonesia (2014), Government Regulation No. 79/2014.

Republic of Indonesia (2017), Government Regulation No. 7 on Geothermal Utilization for Electricity, Secretary of State. Jakarta.