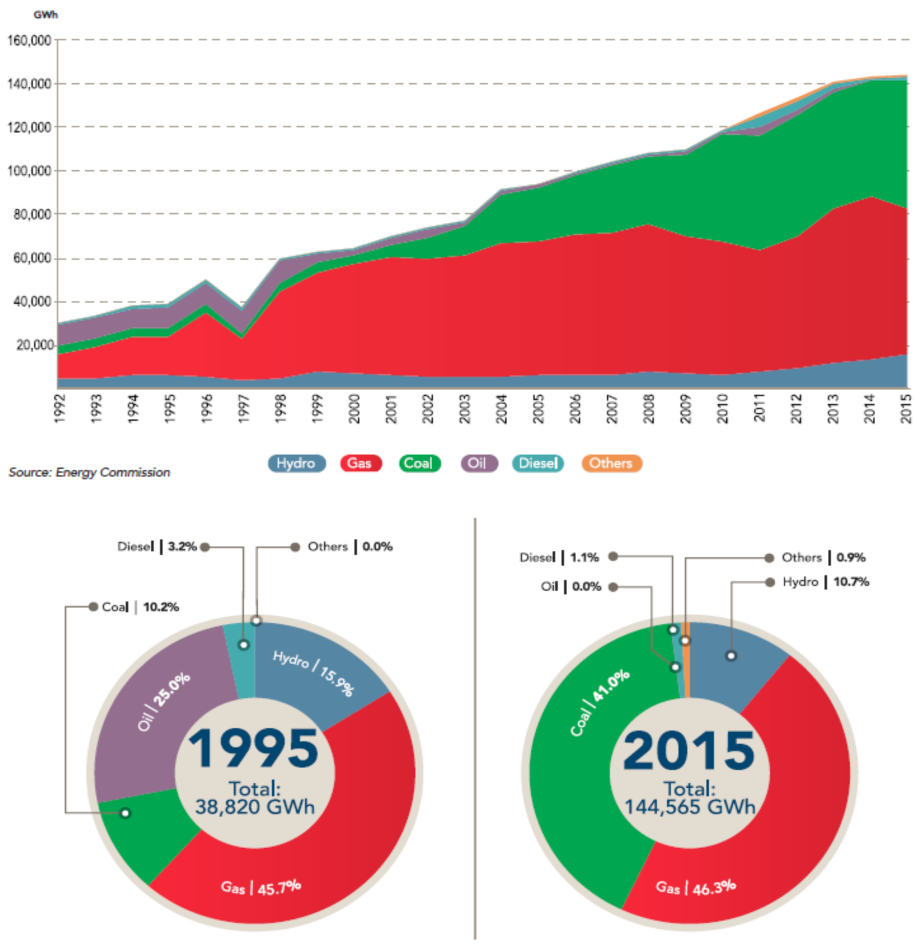
5. Malaysia

5.1 Current situation of geothermal energy use and national policy

5.1.1 Current energy policy and energy mix

Malaysia's energy sector has matured considerably in the last 30 years, from merely relying on fossil fuels to diversifying its energy mix with renewable energy. The country is working towards the new era of sustainable energy in line with the commitment expressed in its intended nationally determined contribution report to the United Nations Framework Convention on Climate Change in November 2015. The intended nationally determined contribution report stipulates Malaysia's intent to reduce its greenhouse gas emissions intensity of gross domestic product by 45% by 2030 relative to the emissions intensity of GDP in 2005. This consists of 35% on an unconditional basis and a further 10% conditional upon receipt of climate finance, technology transfer, and capacity building from developed countries. The country's electricity generation mix in 1992–2015 is shown in Figure 3.5.1-1.

Figure 3.5.1-1. Electricity Energy Mix in Malaysia, 1992–2015



GWh = gigawatt hour.

Source: Malaysia Energy Statistic Handbook, 2016.

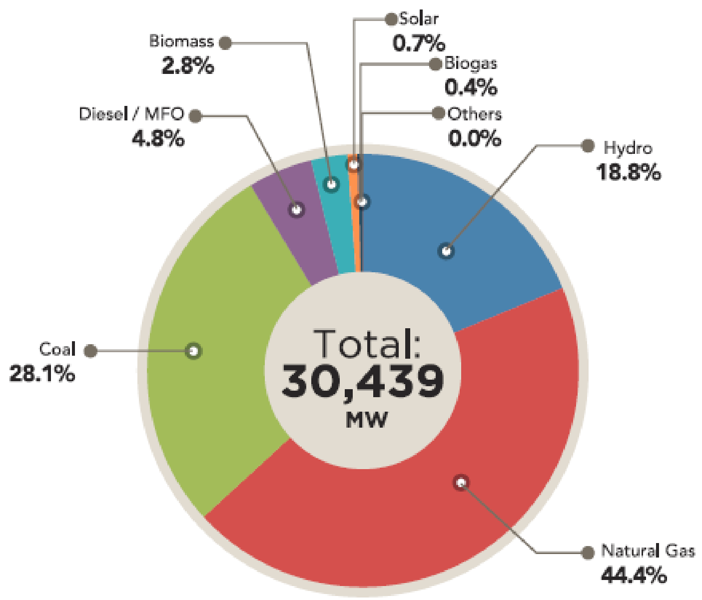
Renewable energy debuted in Malaysia in 2011 with the Renewable Energy Act, 2011 (Act

725), which provides a legal framework for feed-in tariff (FiT) to operate, and the Sustainable Energy Development Authority Act 2011 (Act 726), which provides the legal framework for the establishment of the Sustainable Energy Development Authority of Malaysia (SEDA Malaysia).

The FiT mechanism allows electricity produced from an indigenous renewable energy source to be sold to authorised power utility companies at a fixed premium price for a specific duration. The primary goal of FiT is to offer cost-based compensation to renewable energy producers, provide price certainty, and establish long-term contracts that would improve the bankability of renewable energy projects. Currently, five renewable sources are eligible for the FiT mechanism: biomass (including solid waste), biogas (including landfill gas and sewage), small hydro, solar photovoltaic, and geothermal resource.

Malaysia's total installed capacity as of the end of 2015 was 30,439 MW, an increase of 1.5% from 29,974 MW in 2014 **(**Figure 3.5.1-2). Today, the generation of electricity from renewables such as solar, biomass, and biogas has expanded in scale, attaining about 1% in the energy generation mix in 2015. Moving forward, the percentage of renewables is expected to increase gradually to address environmental and climate change concerns.

Figure 3.5.1-2. Malaysia's Installed Capacity as of 31 December 2015



MFO = marine fuel oil, MW = megawatt.

Source: National Energy Balance, 2015.

As of 31 December 2017, SEDA Malaysia approved a cumulative 12,143 feed-in tariff approval applications with a total capacity of 1,632.87 MW. Table 3.5.1-1 shows the approved projects and operational plants in Malaysia as of 31 December 2017.

Table 3.5.1-1. Approved Renewable Energy Projects in Malaysia Under FiT Mechanism as of 31 December 2017

No.	Renewable Energy Source	No. of Projects	Capacity (MW)	Percentage (%)
1	Biogas	125	220.86	13.53
2	Biomass	44	396.19	24.26
3	Small hydro	60	538.48	32.98
4	Geothermal	1	37.00	2.27
5	Solar PV	11,863	440.19	26.96
	Total	12,143	1,632.87	100.00

MW = megawatt, PV = photovoltaics.
Note: The project timeline for the approved projects is until 2019.
Source: SEDA Malaysia, 2017.

Table 3.5.1-2. Operational Plants in Malaysia Under FiT Mechanism as of 31 December 2017

No.	Renewable Energy Source	No. of Projects	Capacity (MW)
1	Biogas	30	55.83
2	Biomass	8	87.90
3	Small hydro	6	30.30
4	Geothermal	-	-
5	Solar PV	8,993	354.03
	Total	9,037	528.06

MW = megawatt, PV = photovoltaics.
Source: SEDA Malaysia, 2017.

3.5.1.2 Geothermal energy potential in Malaysia

a) Peninsular Malaysia Region

The geothermal survey at Ulu Slim, Perak, conducted from January 2014 to April 2016, was a collaboration of SEDA Malaysia and Department of Mineral & Geoscience. Based on the survey, the estimated resource potential is 148 MW.

The remaining sites (hot springs) in Peninsular Malaysia that need to be further explored to determine their geothermal resource potential are Lojing in Kelantan, Ulu Langat and Batang Kali in Selangor, and Sungai Denak in Perak.

Figure 3.5.1-3. Potential Geothermal Resource in Peninsular Malaysia

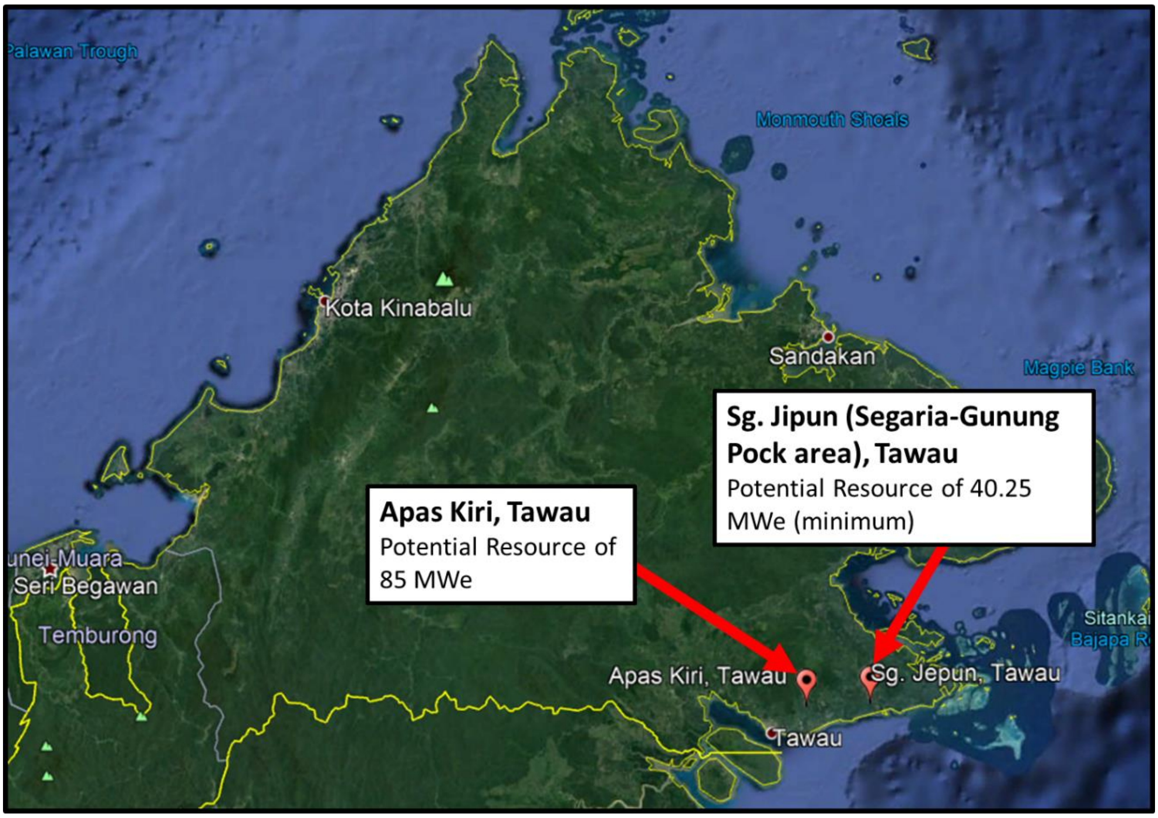
MW =megawatt
Source: Google Maps.

b) Sabah/Labuan Region

Based on a geothermal survey by Department of Mineral and Geoscience Malaysia (2009), the initial estimated resource potential in Apas Kiri, Tawau, Sabah, was 67 MW_e, but recalculated by Tawau Green Energy Sdn Bhd to be 85 MW_e (Barnett, 2010). Tawau Green Energy Sdn Bhd is developing a 37-MW geothermal power plant under SEDA Malaysia's FiT scheme, which will be operational by 2019.

Another area surveyed by Department of Mineral and Geoscience Malaysia (JMG) for geothermal potential is the Segaria–Sungai Jipun–Gunung Pock area in Kunak. Based on preliminary calculation, this area has a minimum capacity of 40.25 MW_e (JMG, 2014).

Figure 3.5.1-4. Potential Resource in East Malaysia (Sabah)



MWe= megawatt electric
Note: The volume of geothermal resource potential in Peninsular Malaysia and Sabah/Labuan is based on preliminary study. Further exploration is needed to get more accurate data.
Source: Google Maps.

5.2 Target geothermal power generation in Malaysia

Table 3.5.2-1 shows geothermal potential of three regions in Malaysia.

Only the Apas Kiri, Tawau, site has obtained approval from SEDA Malaysia under the FiT scheme to build a 37-MW geothermal power plant which is scheduled to operate in 2019. Increasing the capacity to about 30 MW every 4 years is planned until the plant has reached its full resource potential.

As for the other sites, the Apas Kiri, Tawau, site is being developed and, if successful, can be a benchmark to develop other potential sites. It is assumed that by 2050, all potential geothermal resources in Malaysia could be developed once the Apas Kiri, Tawau, project becomes successful and all barriers are removed. In addition, a total of 902 new employment (estimation) may be available for the local population.

Table 3.5.2-1. Geothermal Resource Potential in Malaysia

	Potential (MW)	Achievable by 2025 (MW)	Achievable by 2050 (if all barriers are removed) (MW)
Ulu Slim, Perak (Peninsular Malaysia)	148.00	148	148.00
Apas Kiri, Tawau (Sabah)	85.00	85.00	85.00
Sg. Jipun, Tawau (Sabah)	40.25	40.25	40.25
Total	273.25	273.25	273.25

MW = megawatt.
Note: Figures are calculated based on potential reserve estimation and the assumption of zero barrier.
Source: The study team.

The values shown as 'Achievable by 2025' are considered to be achievable in the current situation. Therefore, if the existing barriers are removed, we assume that the geothermal resources ready to be developed by 2025 would be about 250 MW.

5.3 Barriers to geothermal energy use, and necessary innovations

5.3.1 Analysis of the results of inquiry on barriers

This study aims to identify barriers that hinder geothermal development in Malaysia. To determine the type of barriers, a survey was conducted among domestic experts, which include energy producers, developers, university professors, consultants, and other stakeholders.

Although 60 survey forms were distributed, only 13 people responded (21.7%). Although considered very low, the response covered a wide range of professions, which include the developers of the Apas Kiri Geothermal Resource. The other respondents include an officer of the Tenaga Nasional Berhad, a university professor, private consultants, and others.

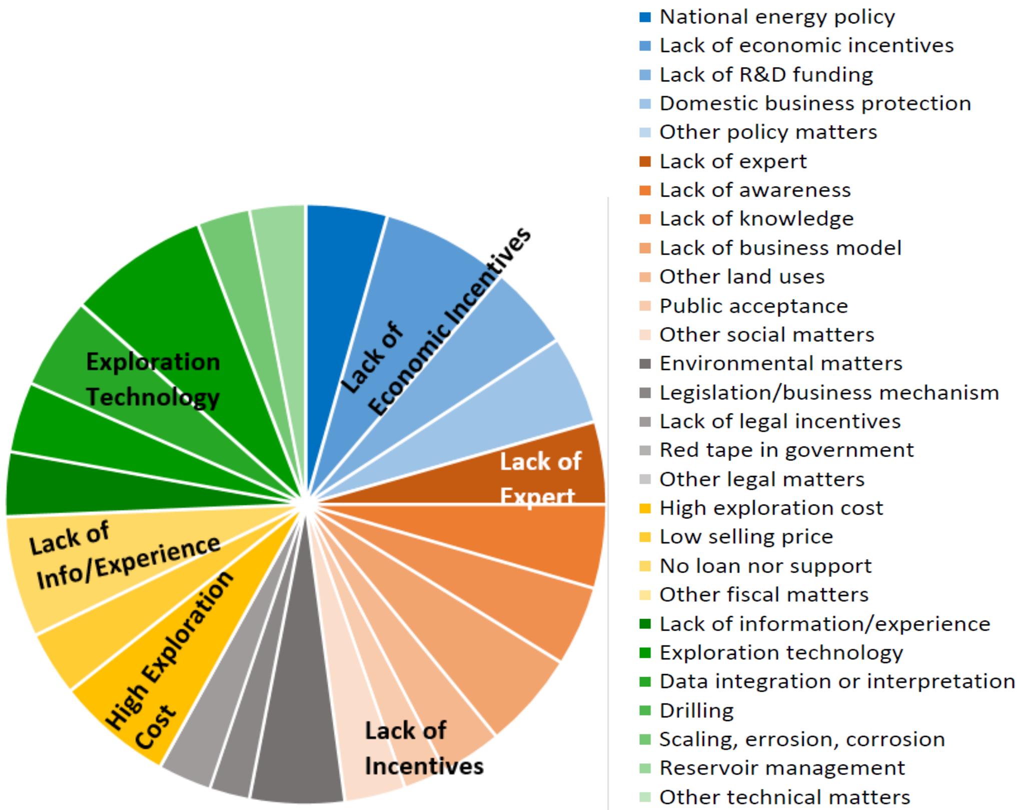
Table 3.5.3-1 shows the results of inquiry among domestic experts on barriers to geothermal power generation in Malaysia. Based on the results, all barriers are similar in percentages. Nonetheless, the greatest barriers are drilling, lack of economic incentives, no loan nor support, high exploration cost, and lack of business models (Figure 3.5.3-1). This indicates that all the relevant barriers have been considered and there is a need to address the problems.

Table 3.5.3-1. Results of Inquiry to Domestic Experts and Stakeholders in Malaysia

Barrier Category	Percentage	Barriers	Result
Policy	19%	National energy policy	6.7%
		Lack of economic incentives	10.5%
		Lack of R&D funding	6.9%
		Domestic business protection	7.3%
		Other policy matters	0.0%
Social	25%	Lack of experts	6.8%
		Lack of awareness	6.9%
		Lack of knowledge	6.6%
		Lack of business models	8.0%
		Other land uses	5.0%
		Public acceptance	3.5%
		Other social matters	5.0%
Legal	11%	Environmental matters	7.8%
		Legislation/Business mechanism	3.3%
		Lack of legal incentives	4.4%
		Red tape in government	0.0%
		Other legal matters	0.0%
Fiscal	17%	High exploration cost	9.6%
		Low selling price	5.3%
		No loan nor support	10.0%
		Other fiscal matters	0.0%
Technical	28%	Lack of information/experience	5.3%
		Exploration technology	5.8%
		Data integration or interpretation	7.6%
		Drilling	11.6%
		Scaling, erosion, corrosion	4.3%
		Reservoir management	4.6%
		Other technical matters	0.0%
TOTAL	100%		100.0%

Source: Authors.

Figure 3.5.3-1. Results of Inquiry to Domestic Experts on Barriers to Geothermal Power Generation in Malaysia



Source: Original figure of this project.

Of the inquiries, selections of samples were carefully made. The survey was developed with inputs from geothermal developers, exploration consultants, policymakers, investment authorities, energy-related personnel, university lecturers, and scientists. The results obtained reflect the current situation in Malaysia.

Based on the results, technical and social barriers are highest. Note that two barriers in fiscal barriers – high exploration cost and no load nor support – are biggest barriers although the fiscal barriers category is not dominant.

Barriers in the technical category include lack of information, lack of experience, lack of exploration technology, lack of data integration or interpretation, and cost of drilling. Barriers under the social category include lack of experts, lack of awareness, lack of knowledge and, most importantly, lack of business models.

5.3.2 Innovative ideas to remove barriers

Based on the analyses of barriers, the top four barriers fall under different categories as follows:

a) Technical: Drilling

b) Policy: Lack of economic incentives

c) Fiscal: No loan nor support

d) Social: Lack of business models

In offering an innovative economic support system for geothermal power generation business, the government can adopt a method used in Japan. To remove or offset the high drilling costs, the Japanese government gives drilling incentives, low-interest loans, feed-in tariff, and tax-reduction incentives to investors to encourage them to develop geothermal energy sources. Japan also initiates preliminary model/good data capture, which is sufficient for investors to decide on whether a geothermal resource reservoir is worth investing in. Other than that, technical expertise and technology transfer are needed for capacity building and attaining independence in the development of geothermal energy resource in the country.

a) <u>Drilling incentives</u>

Drilling incentives from the government may encourage investors to participate in the development of geothermal plants in the country. These may be given from the exploration stage and up to the development and power generation stages.

The government should take some of the risks by co-funding drilling activities. In the event of failed wells, the government absorbs the losses. In the case of successful wells, the developer pays its portion of the drilling costs.

JMG may assist investors with technical know-how during the initial stages of exploration such as geophysical surveys, water samplings, and analyses. As JMG has the capabilities, it is worth for investors to use JMG expertise to help reduce drilling costs.

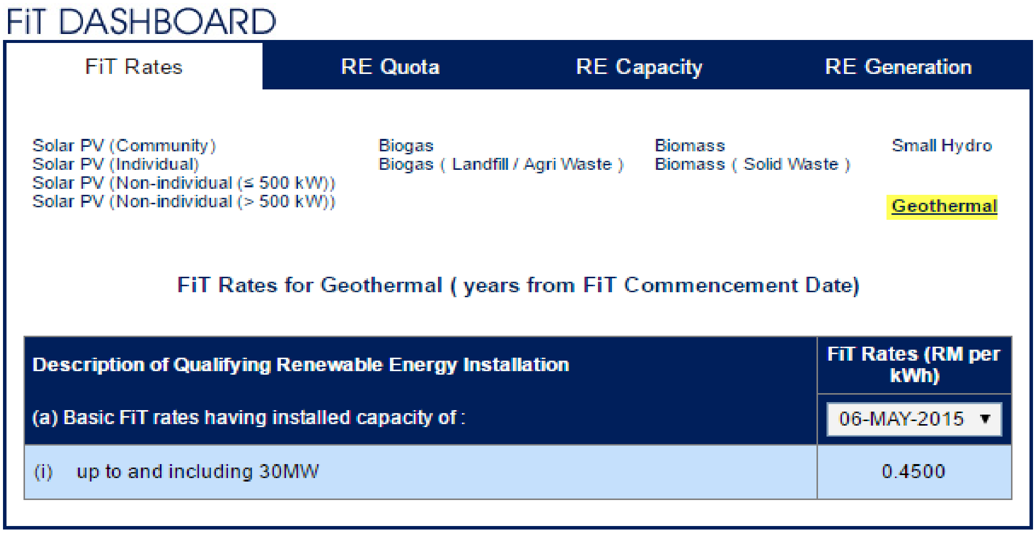
b) <u>Low-interest loans</u>

With the government's support and assurance, low-interest loans should be provided by local banks to help the development of geothermal power plants. In turn, should the project be successful, banks will benefit by recovering their loans plus additional cumulative interests. The outcome of more renewable energy supplies is a country that will benefit in energy security and environmental preservation.

c) <u>Feed-in tariff for geothermal power</u>

The FiT mechanism obliges distribution licensees to buy renewable energy from feed-in approval holders via the Renewable Energy Power Purchase Agreement. The rates to be paid are as set out in the schedule of the Renewable Energy Act 2011. The FiT rate for geothermal energy is RM0.45/kWh (approximately US$0.12) (Figure 3.5-5).

Figure 3.5.3-2. FiT Dashboard by SEDA Malaysia



FiT = feed-in-tariff, RE = renewable energy, PV = photovoltaics, MW = megawatt, kWh = kilowatt-hour.

Source: Sustainable Energy Development Authority Malaysia, 2018.

d) Tax reduction

Import duty exemptions for geothermal power projects should be introduced as most of the equipment and materials for drilling and power plants will be imported.

e) Technical expertise and technology transfer

To reduce technical barriers, various methods can be explored such as:

- Providing scholarships or research grants on geothermal energy to graduates (either local or abroad).
- Setting up geothermal centres of excellence or research centres in local universities to encourage collaboration with other universities (local and abroad) on research and development of geothermal energy.
- Encouraging the government to collaborate with other governments (Japan, USA, Philippines, etc.) and other international agencies that are well versed in geothermal energy regarding transfer of technology and policymaking

5.4. Benefits of geothermal use in Malaysia

5.4.1 Positive aspects of geothermal power

Geothermal power has positive aspects such as:

○ Relatively high capital expenditures (65%) but low operating expenses (35%) compared to fossil-fuel generated energy (e.g. CAPEX = 35%; OPEX = 65%);

○ Baseload generation with capacity factor averaging 90%

(Cf. nuclear = 90%, coal = 71%, hydro = 35%, solar = 20%);

○ Very small carbon footprint @ 0.09 kg CO_2/kWh

(Cf. coal=1.13 kg, fuel oils = 0.895 kg, natural gas = 0.60kg);

○ Readily coexists with natural habitat.

In Tawau, Sabah, a 37-MW_e electrical generation is equivalent to a 56 million tonnes of carbon equivalent eliminated annually, 13.5 trillion trees planted annually, and 45 million cars off the roads annually (refer to website portal of Tawau Green Energy (TGE) Sdn. Bhd. at www.tge.com.my).

5.4.2 CO_2 emission reduction

A study by Malaysia Green Technology Corporation entitled 'Study on Grid Connected Electricity Baselines in Malaysia (Year 2012, 2013 & 2014)' assessed the overall average emission factor for Peninsular Malaysia, Sabah, and Wilayah Persekutuan Labuan. CO_2 emission factor is calculated by year through energy production (MWh) baseline (Table 3.5.4-1).

Table 3.5.4-1. Overall Average Emission Factor for Peninsular Malaysia and Sabah

Year	Peninsular Malaysia (tCO_2/MWh)	Sabah/Labuan (tCO_2/MWh)
2012	0.741	0.546
2013	0.742	0.533
2014	0.694	0.536

MWh = megawatt hour, tCO_2 = total carbon dioxide.
Source: Malaysian Green Technology Corporation, 2014.

Based on CO_2 emission factor in the Peninsular Malaysia and Sabah/Labuan regions, CO_2 mitigation by geothermal power was calculated as follows.

Peninsular Malaysia Region

The estimated resource potential at Ulu Slim, Perak, is 148 MW. The annual power generation at this area can be calculated (assuming an 85% capacity factor) as follows:

148MW x 24h x 365d x 0.85 = 1,102,008 MWh

Considering the 0.013 tCO_2/MWh geothermal power plant emission factor (based on Japan studies), the emission factor for the Peninsular Malaysia region is 0.694 tCO_2/MWh. Hence,

(0.694 tCO_2/MWh - 0.013 tCO_2/MWh) x 1,102,008 MWh = 750,467.4 tonne-CO_2.

Sabah/Labuan Region

The estimated resource potential at Apas Kiri, Tawau, Sabah, is 85 MW. The annual power generation at this area can be calculated (assuming an 85% capacity factor) as follows:

85MW x 24h x 365d x 0.85 = 632,910 MWh.

Considering the 0.013 tCO_2/MWh geothermal power plant emission factor (based on Japan studies), the emission factor for the Sabah/Labuan region is 0.536 tCO_2/MWh. Hence,

(0.536 tCO_2/MWh - 0.013 tCO_2/MWh) x 632,910 MWh = 331,011.93 tonnes-CO_2.

Therefore, annual CO_2 mitigation of 750,467.4 + 331,011.93 = 1,081,479 tonnes-CO_2.

5.4.3 Other benefits

Other benefits are calculated following the procedures 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 3.5.3-1**.** The capacity factor of 70% is used in this calculation, taking global current mode of flush type geothermal power plants, although we expect higher capacity factor in the future. 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 to be gained by barrier removal. Table 3.5.4-2 summarises the calculated benefits.

Table 3.5.4-2. Direct and (Expected) Indirect Benefits of 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		%	19	25	11	17	28	100	
Target capacity		MW	47.5	62.5	27.5	42.5	70	250	*W*
Target capacity factor		%						70%	*Cf*
a) Power generation		MWh/year	291,470	383,513	168,746	260,789	429,534	1,534,050	*W* x 24 x 365.25 x *Cf*
b) Annual fuel saving	by oil	barrel/year	368,932	485,437	213,592	330,097	543,689	1,941,748	11,096 *W x Cf*
	by LNG	kg/year	43,795,005	57,625,006	25,355,003	39,185,004	64,540,007	230,500,025	1,317,143 *W x Cf*
		Million Btu/year	2,157,250	2,838,487	1,248,934	1,930,171	3,179,105	11,353,947	0.04926 *W*
c) Saving foreign currency	by oil	US$/year	22,135,922	29,126,213	12,815,534	19,805,825	32,621,358	116,504,850	60.0 US$/Barrel
	by LNG	US$/year	10,786,250	14,192,434	6,244,671	9,650,855	15,895,526	56,769,735	5.0 US$/Btu
d) CO_2 mitigation		(tons-CO_2/yr)	205,481	270,370	118,963	183,851	302,814	1,081,479	from "CO_2" Table
e) Local employment		persons	143	188	83	128	210	751	2.71*W*+73
f) Saving lands compared to solar PV		m^2	5,297,105	6,969,875	3,066,745	4,739,515	7,806,260	27,879,500	111,518 *W*
(g) Expected profit of additional businesses		US$/year	84,953	111,780	49,183	76,010	125,194	447,120	1,788 *W*
(h) Expected local employee by additional businesses		persons	24	31	14	21	35	125	0.5 *W*
(i) Expected local economic effect of the additional		US$/year	106,210	139,750	61,490	95,030	156,520	559,000	2,236 *W*

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

5.5. Summary for policymakers

a) A total of 273.25 MW of potential geothermal resource can be developed for energy in Malaysia. A 37-MW geothermal power plant at Apas Kiri, Tawau, has been approved by SEDA Malaysia under the FiT scheme which is scheduled to operate in 2019 (expected).

b) The barriers hindering geothermal resource development in the country are identified as drilling, lack of economic incentives, no loan nor support, high exploration cost, and lack of business models.

c) Innovative ideas to tackle the barriers are drilling incentives, low-interest loans, feed-in tariff, tax reduction, technical expertise, and technology transfer.

d) The FiT mechanism has made significant contribution to two primary national issues faced by many countries: energy security and climate change mitigation. FiT also provides economic benefits such as increased employment and strengthened gross national income. Other positive impacts of FiT include improving social health, empowering and providing fairer wealth distribution, and environmental conservation.

e) It is estimated that 1,081,479.33 tonnes of CO_2 could be eliminated yearly when all the geothermal power plants are fully developed.

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