Chapter 2

Present Status

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Chapter 2
Present Status

2.1. National Energy Policies

In this section, the current status of the national energy policy in each member country is introduced. A summary of the current status of energy policy will be given in tables and narrative descriptions at the end of this section.

China

The Law of Renewable Energies of China was issued in 2006. It shows the country support development and utilisation of renewable energies, including geothermal energy.

The Programming of Renewable Energies Development of China in the 12th 5-year Plan was issued in 2012. It arranged development targets of every type of renewable energy, including geothermal energy.

China's National Energy Administration, the Ministry of Finance, the Ministry of Land and Resources, and the Ministry of Housing and Urban-Rural Development jointly issued a document 'Guidelines on Promoting Geothermal Energy Development and Utilisation' in January 2013 (NEA, 2013). It defines the guiding thought for Chinese geothermal energy development and utilisation: (1) adjusting energy structure, (2) increasing renewable energy supply, (3) reducing greenhouse gas emissions, and (4) realising sustainable development. To meet the general requirement of technology advancement, environment friendliness, and economic feasibility, reasonable and effective utilisation of geothermal resources should be comprehensively promoted. The basic principles were government guidance, market pushing forward, adjusting measures to local conditions, and pluralistic development. The main target was determined, too. Towards the end of 12th 5-year plan in 2015, ground source heat pump (GSHP) application will reach 500 million square metres; installed capacity for geothermal power generation will reach 100 megawatt electric (MW_e); and total used geothermal energy will be equivalent to 20 million tonnes standard coal. Meanwhile, the guidelines give some preferential policies, including subsidy for geothermal electricity to enter the national grid. Under the policy, the Ministry of Land and Resources increased funds exploration of geothermal resources. The policy also attracted both state-operated and private enterprises to invest in geothermal business.

On the other hand, the rapid growth of the gross domestic product (GDP), together with high consumption of coal and cars, has led to China's environmental damage. After the heavy haze in 2013, the State Council issued the Action Plan of Air Pollution Prevention. Then Beijing issued the Beijing Action Plan of Clean Air 2013–2017, which stipulated a strategy of 'creating a clean energy system with mainly electricity and natural gas with assisted geothermal and solar energies'. The actual implementation for geothermal space heating replacing conventional boiler heating will get 50 percent of the investment allowance.

In addition, the Law of Tax of Environmental Protection of the People's Republic China will be implemented in 2106. Its exposure draft was issued in June 2015. However, carbon trade has been experimentally implemented in seven cities and provinces (Beijing, Tianjin, Shanghai, Chongqing, Shenzhen, Guangdong, and Hubei) since November 2013. The price was CNY10 per tonne at the beginning and would be CNY100 per tonne for target. The present price in Beijing is about CNY40–50 per tonne.

In the face of new changes to energy supply and demand pattern, and new trends of international energy development, in order to safeguard national energy security, the China's President emphasised the need to promote an energy revolution of consumption, supply, technology, and systems. Its purpose is to devote changing the traditional coal dominant energy structure, and turn to multiple energies supply mode. It provides greater opportunity for geothermal and other renewable energies. At present, the National 13th Five-Year Plan (2016–2020) of Energy Development is formulated according to this principle.

Indonesia

The Government of Indonesia issued the new Nation Energy Policy by promulgating Government Regulation No. 74 of 2014 in October 2014, to replace the previous Government Regulation No. 5 of 2006. The policy provides guidance for energy management in order to achieve national self-sufficiency and security on energy. In the national policy, the government projected the primary energy sources from new and renewable to be about 23 percent of total national in 2025, and 31 percent in 2050. The government has set the electricity generation of 115 GW_e (gigawatt, electric) in 2025 and 430 GW_e in 2050.

The Ministry of Energy and Mineral Resources, in January 2015, released a decree concerning the agreement on Planning of Electricity Generation of the State-Owned Electricity Enterprise for 2015 to 2024, including a short-term project in 2015–2019 of an additional 35 GW_e, where geothermal energy is set to contribute.

The government also issued a new Geothermal Law No. 21 of Year 2014 in September 2014 to replace the previous Geothermal Law No. 27 of Year 2003. The ratification of the law is to provide a stronger, comprehensive, and transparent legal basis in geothermal development. Based on the new law, the government is now formulating appropriate measures and/or regulations as a basis for implementing geothermal businesses, and these are to be established by the end of 2015. The feed-in tariff (FiT) system for geothermal energy is one of the issues to be formulated, to revise the previous and ineffective FiT.

Japan

The Government of Japan settled the Energy and Environment Convention in June 2011. An agreement on Innovative Energy and Environment Strategy was made in September 2011 in the convention, indicating the renewable energy target in 2030 of 30 percent of total power generation. In the process towards the agreement, dependence on nuclear power was discussed along three scenarios, where the zero-dependence scenario received 50 percent or more support in public comments from citizens.

Along with the Implementation of the Green Energy Revolution, which was declared in the Innovative Energy and Environment Strategy, the Principle Outline Plan on Green Policy was publicised in November 2012. Its basic direction is the restraint of dependence on nuclear and fossil fuels, guarantee of energy security, and adaptation of requirements towards environment-friendly systems.

The present electricity supply system in Japan is one obstacle against the promotion of renewable energy. To investigate problems of the current electricity supply system, a Specialised Committee for Electricity System Renovation was set up to discuss the separation of electric power generation and distribution.

The implementation of a FiT system for renewable electricity was agreed in Parliament in August 2011 and enacted in July 2012. Prices for geothermal power are ¥42/kWh (kilowatt-hour) for plants smaller than 15MW_e and ¥27.5/kWh for 15MW_e or larger (¥1 is nearly equal to 1 US cent). A CO_2 tax for climate change mitigation has not been adopted yet in Japan.

Geothermal energy is explicitly promoted as evidenced by FiT and other economic support provided by the Ministry of Economy, Trade, and Industry. According to the national energy plan, a goal of geothermal power capacity is 1,650 MW_e in 2030.

To promote renewable heat, a Support Programme for Accelerating Introduction of New Energy began in 2012 to give subsidies to municipals and the private sector for installation of renewable energy systems. Only a few ground coupled heat pump systems were accepted to be subsidised.

Republic of Korea

Geothermal utilisation in the Republic of Korea (henceforth, Korea) has been directly use, especially with GSHP installation, because there are no high temperature resources associated with active volcanoes or tectonic activity. GSHP installation in Korea has increased rapidly since the middle of the 2000s and total installed capacity is estimated to reach almost 800 MW_t at the end of 2014. This successful deployment has made the general public and people in the energy sector aware of what geothermal energy is, especially its nature of base-load electricity source. Information on recent stories of low temperature power generation, including enhanced geothermal systems (EGS) in Europe, Australia, and the United States (US) have caused decision-makers and industries in Korea to become interested in geothermal power generation, which led to the launch of the EGS pilot plant project at the end of 2010.

The Second National Energy Master Plan was set up in 2013 and was officially announced at the beginning of 2014. The six major tasks in this master plan are (1) transition to energy policy focused on demand management, (2) build a distributed generation system, (3) strike a balance with environmental and safety concerns, (4) enhance energy security and energy supply stability, (5) establish a stable supply system for each energy source, and (6) shape energy policy to reflect public opinion. The national plan for renewable energy was also revised in 2014 according to the master plan which led to the setting up of The 4th Basic Plan for New and Renewable Energy Technology Development, Utilisation, and Diffusion (2014–2035), and thus to fix new renewable energy R&D (research and development) and deployment policy. The new and renewable energy supply target by 2035 is 11 percent of the total primary energy consumption.

The total primary energy consumption at the end of 2013 reached around 280.29 million tonnes of oil equivalent (toe) of which renewable energy supplied 9.879 toe (3.521 percent). Geothermal energy by GSHP provided 53,995 toe which covered only 0.019 percent of the total primary energy consumption. The status and prospect of geothermal energy in the national target still does not seem significant. Fortunately, however, the government and the public acknowledge the importance of geothermal utilisation and the geothermal energy's share of market-stimulating incentives has become significant. Therefore, GSHP installation has progressed remarkably in recent years.

The main drivers of the rapid increase in GSHP installation are active government subsidy programmes and a special law for new and renewable energy (Mandatory Act). There are several subsidy programmes—Deployment Subsidy Programme, Rural Deployment Programme, and 1 Million Green Homes by 2020 Programme—through which the government subsidises 50 percent of total installation cost based on competition with a predetermined budget each year. Another powerful subsidy programme enacted from 2010 is the Greenhouse Deployment Programme for which the central government subsidises 50–60 percent and local government covers 20–30 percent, which means rural farmers pay only 20 percent of GSHP installation cost for greenhouses and aquaculture. The annual market from this special programme amounted to US$45.2 million in 2012.

In 2012, the Mandatory Public Renewable Energy Use Act was amended to state that: 'In all public buildings bigger than 1,000 square metres in area, more than 10 percent of annual energy use should be from new and renewable energy sources'. The minimum percentage is to increase annually: 11 percent in 2013, 12 percent in 2014, and so on. According to the Act, GSHP installation plans amounting to 120 megawatt thermal (MW_t) in 2012 and 135 MW_t in 2013 were reported, which would be realised two or three years after planning due to the construction period.

Although the pilot plant project of geothermal power generation started at the end of 2010 and targets 1 MW_e plants by the end of 2015, there has been no legal framework or supportive measures for geothermal power generation yet. This lack of a legal framework is the major barrier to active industry participation in the geothermal business. The government annually adjusts items in Renewable Portfolio Standard (RPS) and the Renewable Energy Certificate (REC) of each renewable energy source. Geothermal power generation was included in RPS with REC of 2.0 (highest) in 2014. Geothermal law is also expected to be set up as a part of the mining law in the near future.

A technical road map of greenhouse gas reduction technology in Korea states that there could be 200 MW_e of installed capacity with geothermal by 2030 in Korea, which is 1 percent of the technical potential of EGS geothermal power generation in the country. The outcome of the EGS pilot plant project, if successful, will be a milestone initialising the road map. This pilot plant project is expected to be scaled up to a level of 10 MW_e class by 2020.

Philippines

The thrust of the national energy programme laid out for 2013–2030 will focus on the following plans and programmes:

- Develop indigenous energy
- Expand use of natural gas
- Push sustainable fuels for transport
- Make energy efficiency a way of life
- Expand capacity and coverage of power supply
- Climate-proof energy infrastructure and facilities

At the onset of the new Aquino government in 2010, the energy sector has outlined the following three major pillars as its overall guidepost and direction: (1) ensure energy security, (2) achieve optimal energy pricing, and (3) develop a sustainable energy plan. Guided by the overall vision of providing Energy Access for More, the 2012–2030 Philippine Energy Plan (PEP) seeks to mainstream access of the larger populace to reliable and affordable energy services to fuel, most importantly, local productivity and countryside development. This energy plan is guided by President Aquino's social contract with the Filipinos, which aims to (1) alleviate corruption and promote transparency through energy contracting rounds, information, education, and communication (IEC), and public consultation activities; (2) reduce poverty by empowering the poor through electrification of rural areas; and (3) rapid, inclusive economic growth. Meanwhile, the United Nations Sustainable Energy For All Initiative Development aims for the country's transition towards to a low carbon society. PEP will also support and be at par with the ASEAN Plan of Action for Energy Cooperation, which will promote regional energy security and sustainability through aggressive implementation of action plans of the different programme components: (1) ASEAN Power Grid, (2) Trans-ASEAN Gas Pipeline, (3) Coal and Clean Coal Technology, (4) Renewable Energy, (5) Energy Efficiency and Conservation, (6) Regional Energy Policy and Planning, and (7) Civilian Nuclear Energy. The plan will also adhere to the APEC Green Growth Goals which include: (1) rationalisation and/or phase out of inefficient fossil-fuel subsidies that encourage wasteful consumption; (2) reduction of aggregate (regional) energy intensity by 25 percent in 2030 and 45 percent in 2035 (based on 2005 level) as an aspirational goal; (3) promote energy efficiency; and (4) incorporate low-emissions development strategies to economic development plans, among others.

Under the PEP are sets of specific work programmes that should contribute to the attainment of the broad policy and programme network. The Power Sector Development plans on power systems, transmission highways, distribution facilities, and missionary electrification provide the platform to put in place long-term reliable power supply to improve the country's transmission and distribution system. The Fuelling Sustainable Transport Program aims to find alternative ways to fuel the transportation sector. Specifically, this seeks to convert public and private vehicles from diesel and gasoline into compressed natural gas (CNG), liquefied petroleum gas (LPG), and electric power. More so, the Indigenous Energy Development Program plans to diversify the energy mix fuelling the Philippines by further developing the country's indigenous resources. Meanwhile, the National Renewable Energy Plan foresees the increase in renewable energy-based capacity by 2030. The Energy Efficiency and Conservation Program will look into developing energy security in the country. This aims to lay the foundation for legislation and policies to develop local energy auditors and energy managers, encourage the development of energy efficient technologies, and provide incentives for the effective promotion of efficiency initiatives in the energy market sector. The last of the major work plans included in the Philippine Energy Plan is the Natural Gas Master Plan. With technical assistance from the Japan International Cooperation Agency, and the World Bank, the Department of Energy will evaluate the opportunities, critical infrastructure, and required investments for the development of the natural gas industry.

The Philippine Energy Sector Reforms and Programs for 2013–2030 plans to improve the indigenous options of the country by promoting more aggressive exploration of fossil fuels and development of indigenous oil and gas. Currently, the country's 16 sedimentary basins have a combined potential of 4,777 million barrels of fuel equivalent or 689.8 million tonnes of energy of oil and gas reserves. Meanwhile, the National Renewable Energy Plans and Programs aim to increase the renewable energy-based power capacity of the country to 15,304 MW_e by 2030, which is almost triple its 2010 capacity level of 5,438 MW_e. Geothermal energy is often mentioned together with other sectors under renewable energy (**Table 2.1-1**). For geothermal alone, there is a projected addition of 1,495 MW_e of installed capacity by year 2030, and this will bring the total power capacity from geothermal at close to 3,500 MW_e. Adding up the contribution of the other renewable energy sources from hydro, biomass, wind, solar and ocean, the national programme aims to increase renewable energy based power capacity to 15,300 MW_e by 2030.

Currently, there is no carbon emission tax charged to renewable energy sources, but it is targeted to be issued in 2015 in line with the establishment of the ASEAN Economic Community. It must be noted that the proposed carbon emission tax is only applicable to the oil and gas industry. It is valued at US$20 per tonne of CO_2 emissions with 10 percent efficiency gain for use of oil and coal in the country.

Table 2.1-1. Estimated Capacity Addition of 9,865 MW in the Philippines

Sector	Installed Capacity, (MW) as of 2010	Target Capacity Addition by				Total Capacity Addition (MW) 2011-2030	Total Installed Capacity by 2030
		2015	2020	2025	2030		
Geothermal	1,966.0	220.0	1,100.0	95.0	80.0	1,495.0	3,461.0
Hydro	3,400.0	341.3	3,161.0	1,891.8	0.0	5,394.1	8,724.1
Biomass	39.0	276.7	0.0	0.0	0.0	276.7	315.7
Wind	33.0	1,048.0	855.0	442.0	0.0	2,345.0	2,378.0
Solar	1.0	269.0	5.0	5.0	5.0	284.0[1]	285.0
Ocean	0.0	0.0	35.5	35.0	0.0	70.5	70.5
TOTAL	5,438.0	2,155.0	5,156.5	2,468.8	85.0	9,865.3	15,304.3

MW = megawatt.
Source: Department of Energy (DOE) (2011).

Thailand

The Thailand Energy Master Plan 2015–2035, emphasising energy security, social acceptance, and environment-friendliness (EPPO, 2014) is summarised below.

1. Promote energy, petroleum, and renewable energy industries as a new industry strategy and enable these industries to generate income from domestic demand and increase employment.
2. Promote and drive the energy sector to generate income for the country. As a strategic industry, investment in energy infrastructure will be increased to make Thailand a regional centre for the energy business, building upon the competitiveness of its strategic location.
3. Reinforce energy security through the development of the electrical power grid and exploration of new and existing energy sources, both in Thailand and abroad. Energy sources and types will also be diversified so that Thailand will be able to meet its energy needs from various sustainable energy sources.
4. Regulate energy prices to ensure fairness as well as reflect the production costs by adjusting the role of the oil fund into a fund that ensures price stability. Subsidies will be available for vulnerable groups. The use of natural gas in the transport sector will also be promoted, whereas the use of gasohol and biodiesel will be promoted for use in the household sector.
5. Support the production, use, and research and development of renewable and alternative energy sources, with the objective of replacing 25 percent of the energy generated by fossil fuels within the next decade. Comprehensive development of the energy industry will also be promoted.
6. Promote and drive energy conservation by reducing power usage in the production process by 25 percent in the next two decades. The use of energy

efficient equipment and buildings will be promoted, while clean development mechanisms will be used to reduce the emission of greenhouse gases and tackle global climate change. Systematically raise consumer awareness to use energy efficiently to conserve power in the production and transport sectors, as well as in households.

The Department of Alternative Energy Development and Efficiency (DEDE) targets to produce 1 MW_e electricity from geothermal in accordance with the 10-year Renewable and Alternative Energy Development Plan. The development of geothermal energy will emphasise joint investment between the community and the private sector to promote sustainable development and participation of local residents. It will also study renewable energy promotion measures to ensure small power producers of stable revenue streams and success of the project.

Viet Nam

Viet Nam's latest energy master plan named Energy Master Plan No. 7 for 2011–2020 considering to the period up to 2030. This master plan emphasises gradually forming and developing the competitive electricity market, and diversifying the patterns of investment and business on electricity. The government exclusively manages the national electricity networks. The sale out price of electricity follows the free markets. The national electricity production that will be produced and imported is 194 billion–210 billion kWh in 2015, 330 billion–362 billion kWh in 2020, and 659 billion–834 billion kWh in 2030.

One of the targets of the master plan is to prioritise the development of renewable energy sources, develop these rapidly, and increase the proportion of electricity from the renewable sources gradually. The proportion of renewable energy that is 3.5 percent of the total in 2010 would be 4.5 percent in 2020 and 6 percent in 2030.

According to the Energy Master Plan No. 7 of Viet Nam, the government will invest to construct the national electric network or to construct the in situ electric power plants such as small hydroelectric power plants, solar cells, wind power, and diesel engines to supply electricity to the rural areas. In 2011–2015, the Government invested to expand the national electric network to supply 500,000 households in rural areas; the electricity generated from renewable energy sources would supply 377,000 households in rural areas. In 2016–2020, 200,000 households in rural areas would be supplied electricity from the national network whereas 231,000 households in rural areas would be supplied from renewable energy sources.

The current status of all member countries is summarised in **Tables 2.1-2** to **2.1-5**, based on the answers to the questionnaire given to each member country. Questions on current status are as follows:

- What is the national energy master plan in your country?
- Is CO_2 tax already issued?
- Is there priority to indigenous and renewable options?
- Is geothermal energy explicitly mentioned?

Table 2.1-2. National Energy Master Plan

Country	What is the national energy master plan in your country?
China	12^{th} Five-Year-Plan of Energy Development of the People's Republic of China
Indonesia	Master plans for 2006–2005: Presidential Decree No. 5 Year 2006 concerning National Energy Policy. Followed by blueprint on National Energy Management issued by Ministry of Energy and Mineral Resources (MEMR)
Japan	Energy plan: 1, 650 MW_e of geothermal power plant in 2030 in 'Law on promotion of development and production of energy-environment suitable goods'
Republic of Korea	The Second National Energy Master Plan (2014): 11% of primary energy supply with renewables by 2035
Philippines	2012–2030 Philippine Energy Plan: (a) Ensure energy security, (b) Achieve optimal energy pricing, (c) Develop a sustainable energy plan
Thailand	Government promoted renewable energy as a national master plan
Viet Nam	Energy Master Plan No. 7 – prioritise the development of renewable energy sources

MW_e = megawatt electric.
Source: Compiled by authors.

Table 2.1-3. CO_2 Tax

Country	Is CO_2 tax already issued?
China	Law of Tax of Environmental Protection of PRC (Exposure Draft) was issued in June 2015. But CO_2 trade had been experimentally implemented in 7 cities and provinces since November 2013, with price of CNY20–50 per tonne recently.
Indonesia	No CO_2 tax issued yet
Japan	No CO_2 tax issued yet
Republic of Korea	No CO_2 tax issued yet
Philippines	No CO_2 tax implemented yet, but is targeted to be issued in 2015
Thailand	No CO_2 tax issued yet
Viet Nam	No CO_2 tax issued yet

Source: Compiled by authors.

Table 2.1-4. Priority to Indigenous and Renewable Options

	Priority to indigenous and renewable options?
China	Indigenous resources with coal in the near future. Proposed 'roof limitation for fossil fuel' is to be installed.
Indonesia	RE sources are set to contribute ~17 percent of national energy mix in 2025.
Japan	Yes, country gives priority to indigenous and renewable options.
Republic of Korea	RE is supported through RPS and various subsidy measures.
Philippines	Yes. The National Renewable Energy Plans and Programs (PESRP) plans to improve indigenous options of the country. National Renewable Energy Program (NREPP) aims to increase RE-based power capacity to 15,304 MW by 2030.
Thailand	Priority to indigenous and renewable options, especially to solar and wind energies.
Viet Nam	EMP No. 7 - invest to construct the national electric network, to construct in-situ electric power plants (small hydro-electric, solar cells, wind power, and diesel engine to supply electricity for the rural areas).

MW = megawatt, RE = renewable energy, RPS = renewable portfolio standard.
Source: Compiled by authors.

Table 2.1-5. Status of Geothermal Energy

	Is geothermal energy (GE) explicitly mentioned?
China	GE is mentioned as one of renewable energies in the Law of Renewable Energy of the PRC.
Indonesia	GE is mentioned as one of renewables.
Japan	GE is explicitly promoted as evidenced by FiT and other economic support provided by Ministry of Economy, Trade, and Industry.
Republic of Korea	GE is mentioned as one type of renewable energy.
Philippines	GE is mentioned as one of the renewables.
Thailand	One of energy.
Viet Nam	GE is mentioned as one type of renewable energy.

FiT = feed-in tariff, GE =geothermal energy.
Source: Compiled by authors.

Summary of the current status of energy policy

- All seven governments have a national energy programme.
- All seven countries have priority to indigenous and renewable options in their national energy programmes.
- In most countries, geothermal energy is one of the renewable energies.

Recommendation to policymakers

- National programmes should be provided **explicitly** for geothermal power generation since geothermal energy may need special care because of its uncertainty in the subsurface.
- The Philippines and Japan have national energy master plans towards year 2030, and Korea to 2035, but other countries have shorter plans. **Long-term programmes** for geothermal power generation is necessary because geothermal development takes 5–7 years.
- CO_2 tax law will be implemented in China and is forthcoming for the Philippines in 2015. All counties should issue CO_2 tax law for RE development to preserve the environment.

2.2. Present Status of Geothermal Use

The present status of geothermal use in each country is shown in **Table 2.2-1**. All seven countries use geothermal energy. PG, DU, and GSHP stand for power generation, direct use, and ground source heat pump, respectively. Power generation is dominant in the Philippines and Indonesia, whereas direct use and GSHP are dominant in China and Korea, reflecting resource base and climate. Japan has all power generation, direct use, and GSHP, but direct use is almost for bathing only. Thailand has a binary power plant and Viet Nam has direct use facilities.

Table 2.2-1. Present Status of Geothermal Use in Each Country

Country	Installed Capacity			Used (produced) Energy			Data Source
	PG (MW_e)	**DU** (MW_t)	**GSHP** (MW_t)	**PG** (GW_e-h/y)	**DU** (GW_t-h/y)	**GSHP** (GW_t-h/y)	
China	27.8	6,089	11,781	155.1	20,801	27,864	Zheng et al. (2015)
Indonesia	1,341.0	2.3	NA	9,332.32	11.8 *	NA	MEMR (2013a), Lund et al. (2010)
Japan	540.1	2,099.5	44.0	2,688.82	7138.9	NA	TNPES (2013), Lund et al. (2010)
Republic of Korea	NA	43.7	792.2	NA	164.9	580.7	Song and Lee (2015)*
Philippines	1,848.0	NA	NA	10,230.5	NA	NA	Department of Energy (2014)
Thailand	0.3	NA	NA	NA	NA	NA	DEDE (2012)
Viet Nam	0.0	30.7	NA	NA	22.36	NA	Nguyen et al. (2005)

DU = direct use, GSHP = ground source heat pump, NA = not available, PG = power generation.
Notes: *For Korea, data are estimated as of 31 December 2014; used energy of GSHP corresponds to the pure geothermal contribution (subtracting electrical energy for running the HP) of heating energy only.
Source: Compiled by authors.

2.3. Potential Survey

All seven countries have an existing geothermal energy resource assessment. A volumetric method was used for most countries, but with different bases. Since resource assessment is not a purpose of this study, we will not inspect details of these different volumetric methods, but resources assessment method should be standardised internationally. There are ongoing assessment programmes of geothermal resources and reserves under the International Energy Agency – Geothermal Implementing Agreement (IEA-GIA) and the International Geothermal Association.

Tables 2.3-1 to **2.3-7** show numerical values of geothermal energy potential and assessment methods for each country.

Table 2.3-1. Geothermal Potential of China

Category		Temperature Range (°C)	Depth Range (m)	Geothermal Potential	Source Reference
i) Power production	a) Hydrothermal	>150°C	200–3,000	2,781(MWe)	Duo (2014)
	b) EGS	>150°C	3000–8000	12.6×10^4 (EJ)	Wang et al. (2013)
ii) Direct use		>25°C	200–3,000	18×10^6 (TJ)	Wang et al. (2013)
Method of assessment	Volumetric method (National Standard of China, 2010)				

Source: Compiled by authors.

Table 2.3-2. Geothermal Potential of Indonesia

Category		Temperature Range (°C)	Depth Range (m)	Geothermal Potential	Source Reference
i) Power production	a) Hydrothermal	High: >225 Med: 125–225 Low: <125	1000–3000	28,910 (MWe)	Ministry of Energy and Mineral Resources (2013b)
	b) EGS	–	–	–	
ii) Direct use		NA	NA	NA	
Method of resource assessment	Based on Indonesia National Standard (SNI 13-5012-1998): Geothermal potential is divided into two groups: resource and reserve. The resource is divided into two classes: speculative and hypothetic. The reserve is classified into three groups: possible, probable, and proven. Resource assessment is based on Indonesia National Standard (SNI 13-6171-1999 and SNI 13-6482-2000): The speculative resources estimated by using power density of the prospective area. The power density is estimated as 5, 10, and 15 MW_e/(km^2 of the area) for low, medium, and high temperatures, respectively. The hypothetic and reserve are estimated by using a volumetric method. Geothermal physical parameter value for potential estimation of the reserve is assumed based on three temperature regimes: high (>225^{o}C, medium (125–225), and low (<125) by assuming uniform/lumped heat content of reservoir. The reserves are calculated by using reservoir thickness between 10002000 m, 100% water saturated, rock porosity of 10%, heat capacity of rock 0.8–1.0 kJ/kg^{o}C, plant life 30 years, thermal to electric conversion 10%. The cut-off temperatures are 90, 120, 180^{o}C for low, medium, and high temperatures, respectively. These calculations are simulated by a statistical approach of Monte Carlo.				

Source: Compiled by authors.

Table 2.3-3. Geothermal Potential of Japan

Category		Temperature Range (℃)	Depth Range (m)	Geothermal Potential	Source Reference
i) Power production	a) Hydrothermal	150 <	3 km *	23,000 (MWe)	Muraoka et al. (2008)
	b) EGS	NA	5 km	450,000 (MWe) All Japan 45,000 (MWe) Surveyed areas	Hori (1990)
ii) Direct use convention GSHP		No data 10–25℃	No data 20–100 m	No data	
Method of resource assessment	i)-a) by volume method for the resources lying <u>shallower than the depth of basement rock</u>. NEDO's priority areas, for which resource assessment including economic analysis has been done, have 950 MWe of resources (reserve). i)-b) is based on resources analysis for HDR by CRIEPI. ii) GSHP may be used everywhere in Japan and resource assessment has not been done. However, according to the borehole heat exchange analysis based on groundwater flow and heat transfer simulation, heat extraction rate in quaternary sediment varies from 30 to 70 W/m due to groundwater speed, showing wide spatial variation.				

Source: Compiled by authors.

Table 2.3-4. Geothermal Potential of the Republic of Korea

Category		Temperature range (℃)	Depth Range (m)	Geothermal Potential	Source reference
i) Power production	a) Hydrothermal				
	b) EGS	> T_0+80, T_0 is surface temperature	3,000–10,000 for theoretical, 3,000–6,500 for technical	6,974,567 (MWe) for theoretical 19,567 (MWe) for technical	Song et al. (2011)
ii) Direct use		NA	NA	NA	
Method of assessment	Beardsmore et al. (2010) based on volumetric method				

Source: Compiled by authors.

Table 2.3-5. Geothermal Potential of the Philippines

Category		Temperature Range (°C)	Depth Range (m)	Geothermal Potential	Source Reference
i) Power production	a) Hydrothermal	>180	1,500–3,000	3,337 (MWe)	Pastor et al. (2010)
	b) EGS	NA	NA	NA	
ii) Direct use		NA	NA	NA	
Method of assessment	Volumetric reserve estimation using Australian code and minimum temperature of 180 °C.				

Source: Compiled by authors.

Table 2.3-6. Geothermal Potential of Thailand

Category		Temperature Range (°C)	Depth Range (m)	Geothermal Potential	Source Reference
i) Power production	a) Hydrothermal	130	100–500	0.3 (MWe)	Korjedee (2002)
	b) EGS	NA	NA	NA	
ii) Direct use		NA	NA	NA	
Method of assessment	No official assessment yet.				

Source: Compiled by authors.

Table 2.3-7. Geothermal Potential of Viet Nam

Category		Temperature Range (°C)	Depth Range (m)	Geothermal Potential	Source Reference
i) Power production	a) Hydrothermal	100–185	210–1000	400 (MWe) [2]	Hoang (1998)
	b) EGS	NA	NA	NA	
ii) Direct use		30–105	0–210	NA	2005
Method of resource assessment	The volume methods were used for thermal capacity basing on the surface temperatures and the flow rates of the hot springs. The predicted capacity of electric generation was assessed basing on a comparison with the capacity of existing geothermal plants in Nevada, United States of America, including Brady, Soda Lake, Steamboat, Stillwater, and San Emidio. Volume method using heat content between surface to 3 km depth using geothermal gradient map and heat capacity of rocks is just generally used in some geothermal resources in Viet Nam.				

Source: Compiled by authors.

2.4. Development Trends of Geothermal Energy Use

Table 2.4-1 shows development trends of geothermal energy use in each country. All seven countries target capacity addition within 5 years. However, the significance of the development plan differs from country to another country.

Table 2.4-1. Development Trends of Geothermal Energy Use in Each Country

Country	Target Capacity Addition			
	Power generation	**Direct use**	**GSHP**	**Date**
China	100 MW_e (National plan)	3,700 MW_t (National plan)	18,200 MW_t (for residential, office buildings, school, hospital, mall, etc.) (National plan)	by 2019
Indonesia	1,160 MW_e (National plan)	NA	NA	by 2019
Japan	Several small binary (50 kW_e–1 MW_e) and a 40 MW_e (by private sector with government's support)	No specific plan	GSHP at 990 units (2011) to increase for next 5 years (Estimation by related organisation)	by 2019
Korea, Republic of	Pilot plant, EGS technology (1-3 MW_e) (Estimation by institute)	No significant development	>100 MW_t new installations each year (for large office buildings, green-house, small residential houses) (Estimation by related organisation)	by 2019
Philippines	1,465 MW_e (Fronda et al., 2015) (National plan)	NA	NA	by 2030
Thailand	at least 5 MW_e (Estimation by institute)	Spa, drying system would be supported by hot springs	No application	by 2019
Viet Nam	20 MW_e (estimation by institute)	Agricultural drying, industrial process heat, bathing, swimming	Projects to find out potential and application for office buildings and residential houses	by 2019

kW = kilowatt, MWe = megawatt electric, MWt = megawatt thermal, NA = not available.
Source: Compiled by authors.

Some countries include geothermal development in national plans whereas only the private sector or institutes have plans in other countries. National plans on geothermal development may help its promotion since countries where geothermal development is advancing, such as the Philippines and Indonesia, have national plans.

Only China has a clear plan for all power production, direct use, and GSHP. No other countries have plans for direct use, whereas all countries show targets for power production. Long-term programmes for geothermal power generation are necessary because geothermal development takes five to seven years. China, Japan, and Korea, which have cold seasons, have targets for GSHP.

Recommendations to policymakers

- National development plans should be provided explicitly for geothermal power generation, in conjunction with the national programmes on fiscal and non-fiscal incentives, for example, tax exemptions, royalties, and subsidies.

2.5. Technology and Management of Geothermal Energy Use

Table 2.5-1 shows the topics of interest for sustainable use of geothermal energy pointed out by each country. These topics are listed in the order of priority (based from China, Indonesia, the Philippines, and Japan):

1. Monitoring and reservoir engineering
2. Reinjection
3. Anti-scaling
4. Anti-corrosion and anti-erosion

In Korea, the sustainable issue of geothermal power generation is not of common interest yet. They focus on sustainability of GSHP, among others. Thailand and Viet Nam have yet to develop a binary system for sustainable use of geothermal energy. The study of the second year of this project was decided based on this result.

Table 2.5-1. Topics of Interest for Sustainable Use of Geothermal Energy (marked boxes indicate higher priority for each country)

Country	a) Reinjection	b) Monitoring and Reservoir Engineering	c) Anti-corrosion and Anti-erosion	d) Anti-scaling	e) Others
China	X	X			
	a) In key cities of geothermal utilisation, the Geothermal Resources Administration stipulates that geothermal district heating has to install reinjection.				
	b) Geothermal monitoring is popularly carried out in key cities and developing areas.				
Indonesia	X	X	X	X	
Japan	X	X		X	
Republic of Korea	e) Sustainability issue of geothermal energy is not of common interest yet because no systematic deep geothermal utilisation is operating now. There are concerns about sustainability of GSHP system, especially on water level change and subsurface temperature sustainability.				X
Philippines	X	X	X	X	
Thailand	e) To develop a binary system				X
Viet Nam	e) To develop a binary system				X

GHSP = ground source heat pump.
Source: Compiled by authors.

Recommendations to policymakers

Power generation

- For geothermal power generating countries, changes in reservoir characteristics and reservoir engineering properties including injection issue is a common technology problem for reservoir management for sustainability of steam production.
  - Sharing production history and strategies for reservoir management and control of reinjection problems among power generating countries is recommended.
- Anti-erosion, corrosion to acidic fluid, and mineral scaling are also common problems for reservoir management to sustain steam production.

- Collaborative research studies with steel companies and chemical companies for finding solutions for acidity, corrosion, and mineral scaling problem are recommended.

Ground source heat pump

- Support from research institutions may be necessary for decent installation and sustainable use of GSHP system to avoid over specification, which causes high installation cost, and under specification, which causes un-sustainable use.

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