Renewable and Sustainable Energy Reviews xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Geothermal power generation in Indonesia, a country within the ring of fire: Current status, future development and policy

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ARTICLE INFO

Keywords:
Geothermal
Indonesia
Current status
Policy
Power plant

ABSTRACT

Indonesia has a huge of geothermal potential in the world since the location of the country is in the ring of fire in volcano line. Approximately 28.91 GW of geothermal energy potential is spread across 312 locations on several islands such as Java, Sulawesi and Sumatra, Bali, Nusa Tenggara and Sulawesi. However, the utilization ratio of this potential is small, less than 5%, generate 1533.5 MW electricity from 11 geothermal power plant such as Gunung salak, which has a capacity of 377 MW, 270 MW of darajat; 227 MW of Wayang windu, 235 MW of Kamojang, 60 MW of Dieng, 55 MW of Patuha. 165 MW of Ulubelu, 12 MW of Sibayak, 120 MW of Lahendong, and 10 MW of Ulumbu. Most of the geothermal reservoirs are water-dominated. However, two reservoirs in Gunung salak and Lahendong, are vapor-dominated. Therefore Dry steam power plant is employed in those two plant.

In the current situation, Indonesia has aggressive plans for future development geothermal power plant. In 2005 geothermal roadmap target had been released to produce 9500 MW. However, this target then evaluated to more realistic to 7000 MW in 2025. Last year in 2016 additional of the 35 MW Kamojang unit-5, 40 MW of Lahendong 2 × 20 MW and 55 MW of Ulubelu unit-3 has been inaugurated. Furthermore, five more plants will be operated in Ulubelu, Lahendong and Sarulla, Karaha bodas and Lamut balai. To promote more development of geothermal energy, government has issued laws such as Law No. 21 of 2014 represents a change from the policy of Act No. 27 of 2003. An important point of revision is that geothermal power generation is no longer classed as a mining operation. The law also describes the price of geothermal energy in three different area divisions, each with a different benchmark price.

1. Introduction

The country of Indonesia is made up of more than 17,000 islands, of which 922 are permanently inhabited. It is located in Southeast Asia, with a tropical climate, and contains many beautiful forests as well as wide diversity in plants and animals. The expanse of this beauty may disguise the frightening fact that Indonesia is located over the seismic lines of the “Ring of Fire” that stretches around the Pacific from southeast Australia to the American Southwest as shown in Fig. 1. Along with this path, frequent seismic activity occurs. As tectonic plates shift, they become triggers of earthquakes, volcanic activity, and other potential natural disasters. Therefore earthquakes come often. Once magma forms beneath the earth's crust, it will look for gaps to rise to the top because of the great pressure it is under. Over a long period, this process can form a volcano. The magma is also a source of heat to fluids trapped deep below the earth's surface called geothermal. Sometimes it heated water comes to the surface in hot springs or geysers. In any case, this heat which continually rises from the magma to water trapped under the surface is the origin of what we call geothermal energy. Therefore, Indonesia's location on the Ring of Fire makes it a storehouse of geothermal energy.

In Indonesia, total geothermal potential is estimated at 28,910 GW, drawn from 312 fields located across several islands. Unfortunately, despite having the highest geothermal potential, it draws on less than 5% of this capacity. The total installed capacity is 1533.5 MW and this shows a low utilization ratio with stand in the third rank of geothermal

Abbreviations: CIDA, Canadian International Development Agency; GFZ, German Research Centre for Geosciences; BPPT, Agency for the Assessment and Application of Technology in Indonesia; Pertamina, Indonesian state-owned oil and natural gas corporation; MEMR, Ministry of Energy Mineral Resources, Indonesia; NEDO, New Energy and Technological Development Organization; VSI, Volcanological Survey of Indonesia; GSJ, Geological Survey of Japan; PLN, State Electricity Company; PGE, Pertamina Geothermal Energy; MW, Mega Watt; GW, Giga Watt; Mwe, Mega Watt Electricity; NTT, East Nusa Tenggara; HCL, Himpurna California Energy Ltd.; JOC, Joint Operation Contract; ASL, Above Sea Level; UGI, Unoval Geothermal Indonesia; SRH, Steam Receiver Header

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http://dx.doi.org/10.1016/j.rser.2017.06.096
Received 30 April 2016; Received in revised form 10 March 2017; Accepted 23 June 2017

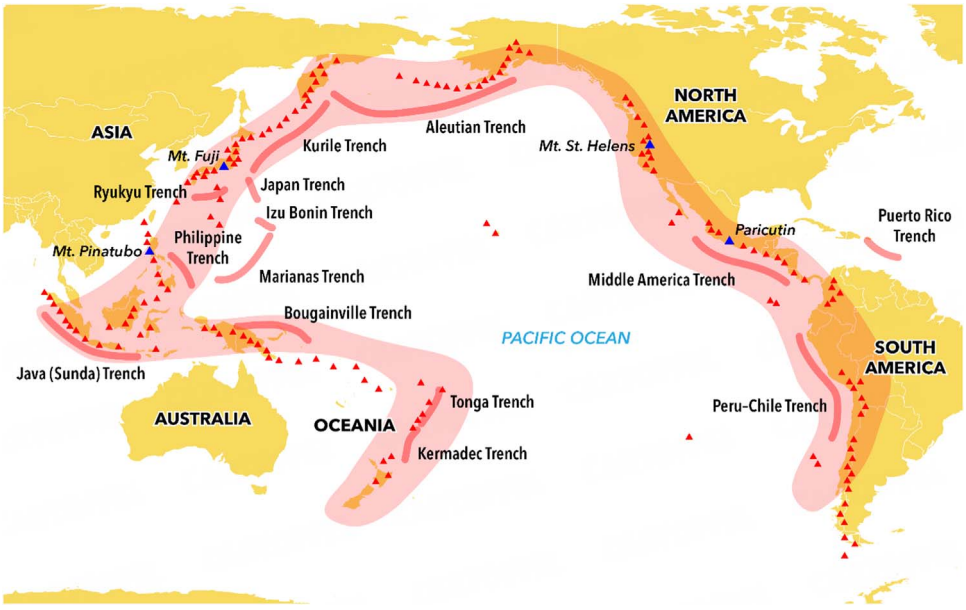

Fig. 1. The circum-pasific "ring of fire" [1].

Table 1
Installed capacity, potential, utilization ratio and power generation share.

Country	Update capacity 2016 (MW)	Estimation hydrothermal Potential	Utilization ratio %	Power generation share (%)
USA	3700 [2]	16,457 [3]	20.9	0.42 [4]
Philiphine	1870 [5]	4335 [6]	45	14 [7]
Indonesia	1533.5	28,910	5.3	2.15 [8]
Mexico	1058 [5]	2310 [9]	45.8	
New Zealand	1005 [5]	No data	No data	22 [10]
Japan	519 [5]	23,400	2.2	0.2

power produced. Indonesia still relies on fossil energy resources, which has a very large share in total primary energy supply. Definitely this is a critical situation for energy security in the future. As shown in Table 1, the installed capacity, resources potential, utilization ratio and power generation share is presented to give an overview how the development geothermal energy in each country. USA has a dominated of geothermal energy utilization with their huge capacity of 3700 MW from 24,000 its resources potential and the utilization ratio is 15.8. However, in USA this total capacity is very low in power generation share at about 0.42%. In Philiphine furthermore, the utilization of geothermal power is better by developing 1970 MW from its 4335 MW resources potential. This is the highest utilization ratio from those six countries and this geothermal energy support 14.2 power generation mix. However with a huge potential since the location in the ring of fire, is not utilize the resources optimally since the utilization ratio is about 4.97% and the share of power generation is only about 2.15%.

There are a lot of issues which makes geothermal development is challenging such as government policy, regulation, human resources, incentive infrastructure. However other countries are also facing this situation in developing of electricity from geothermal. In Japan however within lowest utilization at 2.2% has several issues such as the location of the most geothermal field is within the conservation park and Japanese hot spring bathing business interest. This paper will discuss the current situation of geothermal power generation in Indonesia, including the latest update of the geothermal capacity in 11 plants and future development of several fields which are in the processing stage of development, and the tariff subsidies policy as well as geothermal laws. The first binary geothermal power plant which is developed in Lahendong will also be covered in this paper.

2. Current situation of geothermal power generation

Geothermal development in Indonesia is small if compared to potential resources and utilization ratio. The capacity of the Geothermal power plants increased by only 193 MW since 2009 [11]. In the Table 2, Field location, number, potential, total and installed

Table 2
Field location, number, potential of current situation of geothermal energy In Indonesia [15].

Field location	Number	Potential (MWe)					Total (MWe)	Installed (MWe)
		Resources		Reserve				
		Speculatif	Hypothetic	Possible	Probable	Proven		
Sumatra	93	3183	2469	6790	15	380	12,837	122
Jawa	71	1672	1826	3786	658	1815	9575	1264
Bali-Nusa Tenggara	33	427	417	1013	0	15	1872	12,5
Kalimantan	12	145	0	0	0	0	145	0
Sulawesi	70	1330	221	1374	150	78	3153	80
Maluku	30	545	76	450	0	0	1071	0
Sulawesi	3	75	0	0	0	0	75	0
Total	312	7377	5009	13,413	823	2288	28,910	1478.5
		12,386		16,524				
		28,910 MWe potential in total						