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Geothermal Energy Development: The Philippines Country Update

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ABSTRACT

The Philippines' effort to increase geothermal capacity in line with the government's thrust of energy self-reliance and environmental preservation has been the aspiration to explore and develop the remaining untapped indigenous geothermal resources through utilization of undiscovered high temperature and low to medium temperature geothermal prospect areas.

While there are many investment opportunities, the exploration and development of geothermal projects remained to be challenging. To minimize the risk in the geothermal development, the government took initiatives in conducting of comprehensive geoscientific studies through the implementation of several locally funded projects to identify and assess the viability of developing the remaining untapped geothermal areas. The enactment of Executive No. 30, creating the Energy Investment Coordinating Council in order to streamline the regulatory procedures affecting energy projects on 28 June 2017, paved the way to expedite the permitting process of all energy projects that promote energy security and resiliency.

With the current development of geothermal worldwide, the Philippines now rank as the 3rd largest power producer of geothermal energy next to United States of America and Indonesia. In the last five years, only the 12 MW Maibarara Unit 2 was commissioned in April 2018 and, as of end 2018, the total installed capacity from geothermal power plants was 1,918 MW. Nevertheless, the geothermal energy production continuously contributes 11% of the total electricity requirements in 2017. To meet the increasing demand, about 646 MW additional capacities as envisioned.

1. INTRODUCTION

The Philippines is harnessing the indigenous geothermal energy for almost half a century from the first electric bulb lit by Dr. Arturo P. Alcaraz and his team in Tiwi, Albay in 1967. From then on, the governments through the Department of Energy (DOE) continuously administer and supervise a total of 38 Geothermal Service/Operating Contracts. Of these contracts, 14 are under development stage and 18 are under pre-development or exploration stage. The Philippines's installed generating capacity from geothermal power plants stood at 1,918 MWe (Figure 1) and is about 8% of the country's total capacity of 23,815 MWe in 2018.

The latest resources estimation for geothermal energy potential in the country is 4,064 MW, of which about 50% has been developed. Most of the geothermal-based capacity is in Visayas, accounting for 49% share, followed by Luzon with 45% and Mindanao with 6%. Although there still untapped geothermal energy potential, the development and utilization of the geothermal energy has been very challenging, particularly on the permitting process which cause delay in the implementation of the project, environmental and socio-cultural acceptability of the projects.

To address the permitting issues, the government issued the Executive Order No. 30 series of 2017, creating the Energy Investment Coordinating Council in order to streamline the regulatory procedures and, subsequently, the DOE issued the Department Circular No. 2018-04-0013, the Implementing Rules and Regulations of the said Executive Order. Through this policy trust, the Developer can apply for Certificate of Energy Projects of National Significance (CEPNS) to facilitate and fast track the issuance of permits and clearances as requirements from different concerned government agencies and instrumentalities for energy projects.

Supporting the policy thrust of the government to streamline the government processing and issuance of permits and licenses, the Republic Act No. 11032 otherwise known as "Ease of Doing Business and Efficient Government Service Delivery Act of 2018" and Republic Act No. 11234 otherwise known as "Energy Virtual One-Stop Shop Act" were enacted on 28 May 2018 and 08 March 2019, respectively.

The DOE has also promulgated various policies and guidelines in the awarding of a Renewable Energy Contracts and issuance of Certificates of Registration to RE Developers. All these existing guidelines and procedures were harmonized and come-up with a Department Circular on Omnibus Guidelines Governing the Award and Administration of Renewable Energy Contracts and Registration of Renewable Energy Developers to further accelerate the promotion, development and utilization of energy projects.

To encourage investment in the Philippines, the DOE signed the Department Circular No. 2017-12-0015 or the Renewable Portfolio Standards (RPS) on Grid requiring Distribution Utilities, Electricity Suppliers, generating companies and other mandated energy sector participants to source a certain share of electricity from their Energy Mix from eligible RE resources. As of October 2019, only five (5) geothermal power plants are eligible under RPS.

2. GEOLOGY BACKGROUND

The Philippines is bordered by subduction and collision zones. On the east, the island is bounded by the East Luzon Trough, an ancient subduction zone (Balce, 1979) and by the Philippine Trench where the Philippine Sea Plate subducts under the eastern Philippine Arc. This trench extends from Bicol to Leyte but becomes unclear in Mindanao. On the west, the island is bounded by the Manila Trench, Negros Trench, Cotabato Trench and the Mindoro-Panay collision zone. The oceanic crust of the South China

Sea subducts under the Luzon Arc in the Manila Trench while the oceanic crust of the Sulu Sea Basin subducts in the Negros Trench. An arc-continent collision called the Mindoro-Panay collision zone is located in between these two trenches (Aurelio and Peña, 2010). On the north, a collision zone between the Luzon Arc and Eurasian plate is present while on the south of the island, collision between two active volcanic arcs is caused by subduction of an oceanic plate in two directions (Aurelio and Peña, 2010). The subduction zones on the east and west of the island resulted in the formation of the Philippine Fault, a 1,300 km left-lateral strike-slip fault.

With this tectonic setting, the Philippines is divided into two general geologic units: the Philippine Mobile Belt and the Palawan-Mindoro microcontinent. The Palawan-Mindoro microcontinent is a continental fragment of Asian mainland that drifted toward the southeast with the opening of the South China Sea. The Philippine Mobile Belt consists of the landmasses from the sub-quatorial regions (Aurelio and Peña, 2010) and the volcanic arcs that correspond to the trenches. The geology of these units can be classified into four (4) groups: metamorphic rocks, ophiolites and ophiolitic rocks, magmatic rocks and active volcanic arcs and sedimentary basins (Aurelio and Peña, 2010). Among these groups of rocks, the Oligo-Miocene magmatic belts (ancient arcs) and the Quaternary Volcanoes and active volcanic belts which reflect the activity along the subduction zones are important to geothermal exploration.

2. GEOTHERMAL RESOURCES AND POTENTIAL

In 2000, Malapitan and Reyes presented the distribution of the geothermal resources adopted from Troncales (1979) (Figure 2). The geothermal resources of the Philippines can be found along or near the following region:

2.1 Active Volcanic Belt

These are geothermal areas confined on the base of Quaternary volcanoes with deep tectonic fissures for the trapping of magma reservoir and ascent of high temperature magma fluid. In the Philippines, the manifestations are more common in andesite-dacite volcanic terrains than in basaltic ones. These are represented by Mayon, Bulusan, Silay, Mandalagan, Kanlaon.

2.2 Non-Active Volcanic Belt

Geothermal areas in this group are concentrated along non-active Quaternary andesitic to dacitic volcanoes. The western Volcanic Front is represented byAsin, Mariveles and Montelago. The eastern Volcanic Front are Biliran, Tongonan and Anahawan, Mainit, Manat-Amacan and the southeast Volcanic Front are Lakewood, Malindang, Palinpinon.

2.3 Areas of Intermediate to Silicic Batholith

These are intra-Miocene quartz diorite bodies which occur as large to medium sized batholiths or stock forms. These diorite plutons have multiple stages of intrusions. This group is represented by the Central Cordillera Diorite Complex. Plio-Quaternary volcanic centers of andesite to dacite composition occur along the margins of these plutons.

2.4 Major Structures and other structures

There are also geothermal areas in non-active tectonic region like in the Palawan-Mindoro microcontinent. Geothermal systems in this group are characterized by deep circulating groundwater in a zone of slightly abnormal geothermal gradient due to the latent heat of an old tectonic structure. This is represented in Sta. Lucia and Tagburos, Puerto Princesa, Coron, Busuanga, Palawan.

3. GEOTHERMAL UTILIZATION

Since 2015, only the 12 MW Maibarara Unit 2 Power Plant was commissioned on April 2018, which brings the total installed capacity of geothermal in the Philippines at 1,918 MW. About 91 MW additional capacities are on the pipeline and committed to be commission from 2021 to 2026.

3.1 Makban, Laguna/Batangas

The 458.53 MW Makban Geothermal Power Plant located in Laguna and Batangas is in full operation since 1979 and operated by AP Renewables Incorporated (APRI). To maximize the available brine in Makban, APRI availed of the additional investment to rehabilitate the 6 MW Makban Binary Plant I which was on mothball status since the company acquired the assets from National Power Corporation through public bidding conducted by Power Sector Assets and Liabilities Management in 2008. The rehabilitation activities were completed on 2016. Meanwhile, the Philippine Geothermal Production Company Inc. (PGPCI) operates the geothermal field that supplies the steam requirements of Makban Geothermal Power Plants. From its commercial operation, the cumulative total electricity generated from Makban Geothermal Power Plant from 1979 to 2018 reached 82,177.91 GWh.

3.2 Tiwi, Albay

The 234 MW Tiwi Geothermal Power Plant and field is located in the Province of Tiwi, about 450 km southeast of Manila, operated by APRI and PGPCI, respectively. Since 1972 to 2018, a total of 158 wells were drilled in Tiwi Field, hence, PGPCI is taking initiative to drill additional three (3) production and one (1) reinjection wells which will commence in 2019 to augment the steam supply requirements of the power plant. For about 40 years since the plant has been on operation, the total cumulative gross generation from the power plant reached 55,270.02 GWh.

3.3 Northern Negros

The Northern Negros Geothermal Project is located at Bago City, Northern Negros. This is the first merchant project developed and operated by Energy Development Corporation. However, since the resource failed to sustain the steam requirements of the 49 MW Northern Negros Geothermal Power Plant despite drilling at the buffer zone of Mt. Kanlaon. The power plant equipment and machinery were transferred to Southern Negros Geothermal Production Field and was used for the Nasulo Geothermal Power Plant.

3.4 Palinpinon, Negros Oriental

The Palinpinon geothermal production field is operated by Energy Development Corporation (EDC) is located in southern flanks of a young volcanic complex. A total of 46 production and 29 wells have been drilled in the field since 1977. Meanwhile, GCGI operated the 112. 5 MW Palinpinon I Geothermal Power Plant which has been operational since 1993 while 80 MW Palinpinon II Geothermal Power Plants has been operational since 1994. The Palinpinon II is comprises of three (3) modular plants namely: 20 MW Okoy and 40 MWe Sogongon and 20 MW Nasuji. However, the 20 MW Nasuji Geothermal Plant is put on preservation mode after the commissioning of Nasulo Geothermal Power Plant. The combined cumulative gross generation of Palinpinon I and II reached 36,946.28 GWh of electricity since 1980.

The Department of Energy approved the Certificate of Confirmation of Commerciality for the 30 MW Nasulo Geothermal Power Plant on 25 June 2012 and the plant was officially commissioned on July 2014. Since EDC utilized the existing machine and equipment of the 49 MW Northern Negros Geothermal Power Plant for the Nasulo Plant, the 20 MW Nasuji plant was put on preservation mode to dedicate the steam for Nasulo Plant to maximize the full capacity of the said plant. Since 2014, the electricity gross generation from Nasulo is 1,593.49 GWh.

3.5 Bacon-Manito, Sorsogon/Albay

The Bacman I and II Geothermal Power Plants and steam field is operated by Bacman Geothermal Inc. and EDC, respectively. The geothermal project is located in the provinces of Sorsogon and Albay. Since 1979, a total of 69 wells have been drilled in the field and the power plants generated a cumulative gross generation of 12,770.77 GWh.

3.6 Mindanao, North Cotabato/Davao

The Mindanao geothermal production field is located on the northwest slopes of Mt. Apo in North Cotabato and Davao provinces. The EDC operated the steam field, the 108.54 MW Mindanao I and II Geothermal Power Plant. EDC has drilled a total of 39 wells in the area and, as of December 2018, the total accumulated generation of both plants were 16,886.09 GWh.

3.7 Tongonan, Leyte

The Tongonan 1 and Unified Leyte Geothermal Power Plants are operated by Green Core Geothermal Inc. (GCGI) and EDC, respectively. The steam field operated by EDC suffered major damaged due to the occurrence of Tropical Storm Urduja (or Kai-tak) which struck the Visayas region on December 2017 that has affected the operations of the field and power plants. The restoration activities, replacement of temporary infrastructure, and geohazard mitigation activities are undertaken and implemented in 2019

EDC has drilled about 233 wells since 1979. For the combined total cumulative gross generation of Tongonan I is about 21, 242.64 GWh since 1977 and Unified Leyte reached a total of 79,322.34 GWh.

3.8 Maibarara, Batangas

The 20 MWeMaibarara1 Geothermal Power Plant started its commercial operation in 2014 and operated by Maibarara Geothermal Inc. (MGI). In 2018, MGI successfully synchronized to Luzon Grid its 12 MWe Maibarara Unit 2 power plant. The 20 MW Maibarara was recognized as the Best Renewable Energy Project in the National Grid Category by in the ASEAN Energy Awards 2017 and the only project from the Philippines to win an award. To date, MGI has drilled a total of six (6) well and the total accumulated gross generation from the said project since 2014 reached 872 GWh.

3. GEOTHERMAL DIRECT USE UTILIZATION

The Department of Energy (DOE) is currently implementing the locally project entitled: "Philippine Geothermal Resource Inventory and Assessment", in which the primary objective is to identify and study the potential of the country's indigenous geothermal resources for both power and non-power application.

Harnessing the potential for the utilization of geothermal resource is still in the infancy stage as compared to other countries. There are two (2) crop drying facilities such as Palinpinon Agro-Industrial Plant and the Manito Lowland Drying Plant with a combined total installed thermal capacity of 1.63 MWt. The recorded annual energy used of 17.34 TJ/year and 9.59 TJ/year for Palinpinon and Manito Lowland, respectively. The drying plant in Palinpinon and Manito Lowland were decommissioned in 1997 and 1998, respectively (Ulgado and Gular, 2005).

The Philippines has a vast potential in utilizing geothermal energy directly for bathing, swimming and balneology purposes. In line with this, the DOE has conducted inventory of hot spring resorts and pools utilizing hot natural water from the foot of Mt. Makiling in Laguna. Part of the roadmap of the DOE is to conduct of study and promotion of direct use in the country.

4. CONCLUSION

An aggressive move to harmonize all the government policy is needed to address the challenges faced by the geothermal developer in the development and utilization of the indigenous geothermal energy resources. Through the enactment of Executive Order No. 30, Republic Act No. 11032 and Republic Act 11234, can help out in fast tracking the permitting process needed in the implementation of geothermal energy projects and, eventually, more projects will come in and start commercial operations. To minimize the risk of the developer and to have a data package that can be offered to private investors, the government is continuously conducting inventory and assessment of remaining unexplored area and low-to-medium geothermal potential areas.

The DOE through the Geothermal Energy Management Division is currently focused on the conduct of inventory and assessment of geothermal energy resource for power and non-power or direct use. Upon completion of this project, it is envisioned that the DOE can offer the identified areas to the private sector for investments. A policy guideline will also be formulated to attract private sector participation in the development and utilization of non-power or direct use of geothermal resources.

REFERENCES

Malapitan, R, T., and Reyes, A. N.: *Thermal Areas of the Philippines*. World Geothermal Congress (2000).

Troncales, A. C.: *Regional Geologic Setting of Philippine Geothermal Areas*. Geo-Energy Conference sponsored by the Philippine Geological Society (1986).

Philippines Department of Energy: *List of Existing Power Plants as of December 2018*

Philippines Department of Energy: *Private Sector Initiated Power Projects as of August 2019*

Ulgado, F. A., and Gular, M. T. M: *Status of Direct Use of Geothermal Energy in the Philippines*. Proceedings World Geothermal Congress (2005).

Aligan, M. E.: *Opportunities for Direct Use of Geothermal Resources in the Bicol Region, Philippines*. Proceedings World Geothermal Congress (2010).

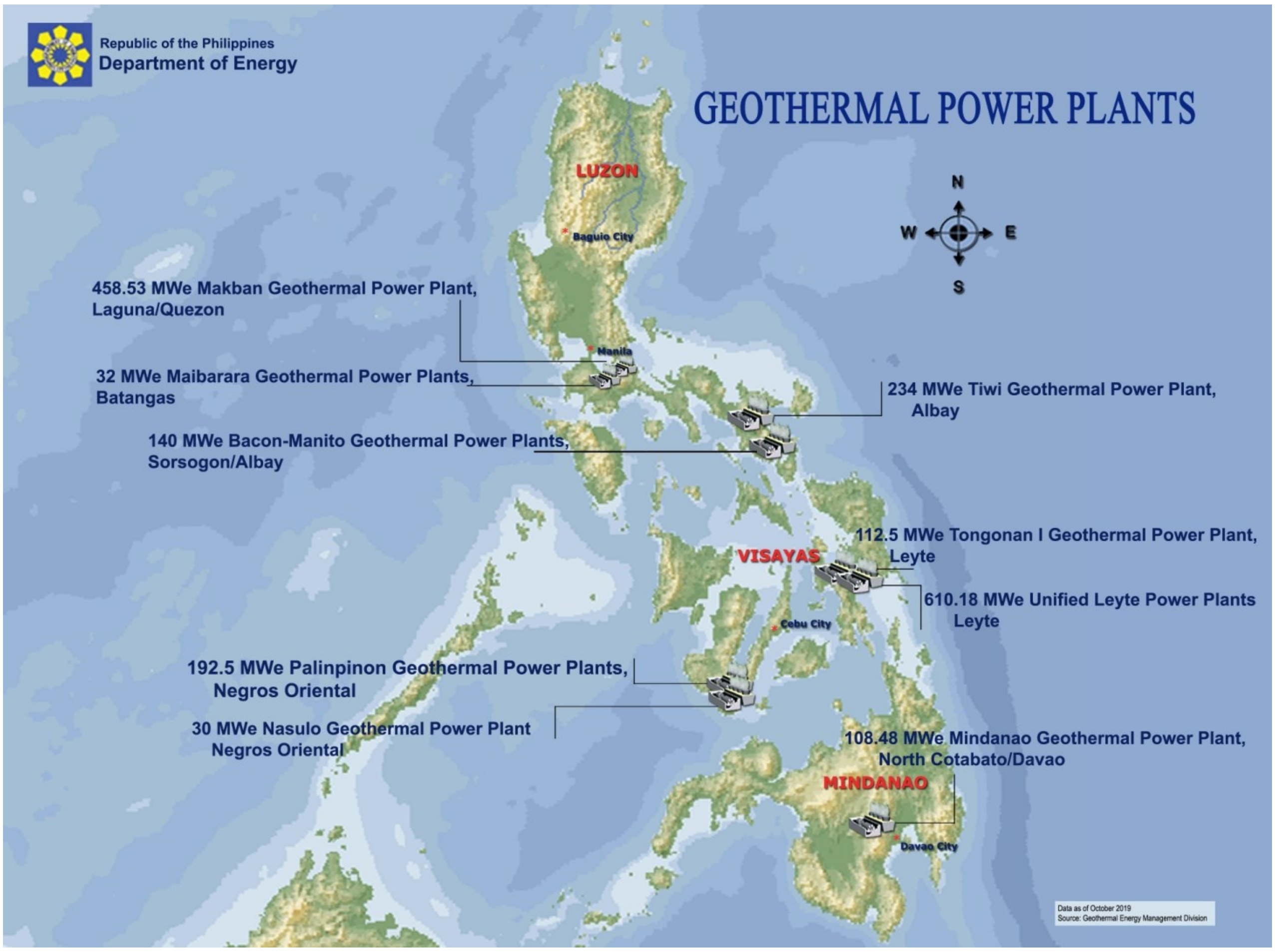

Figure 1: Location map of existing geothermal power plants.

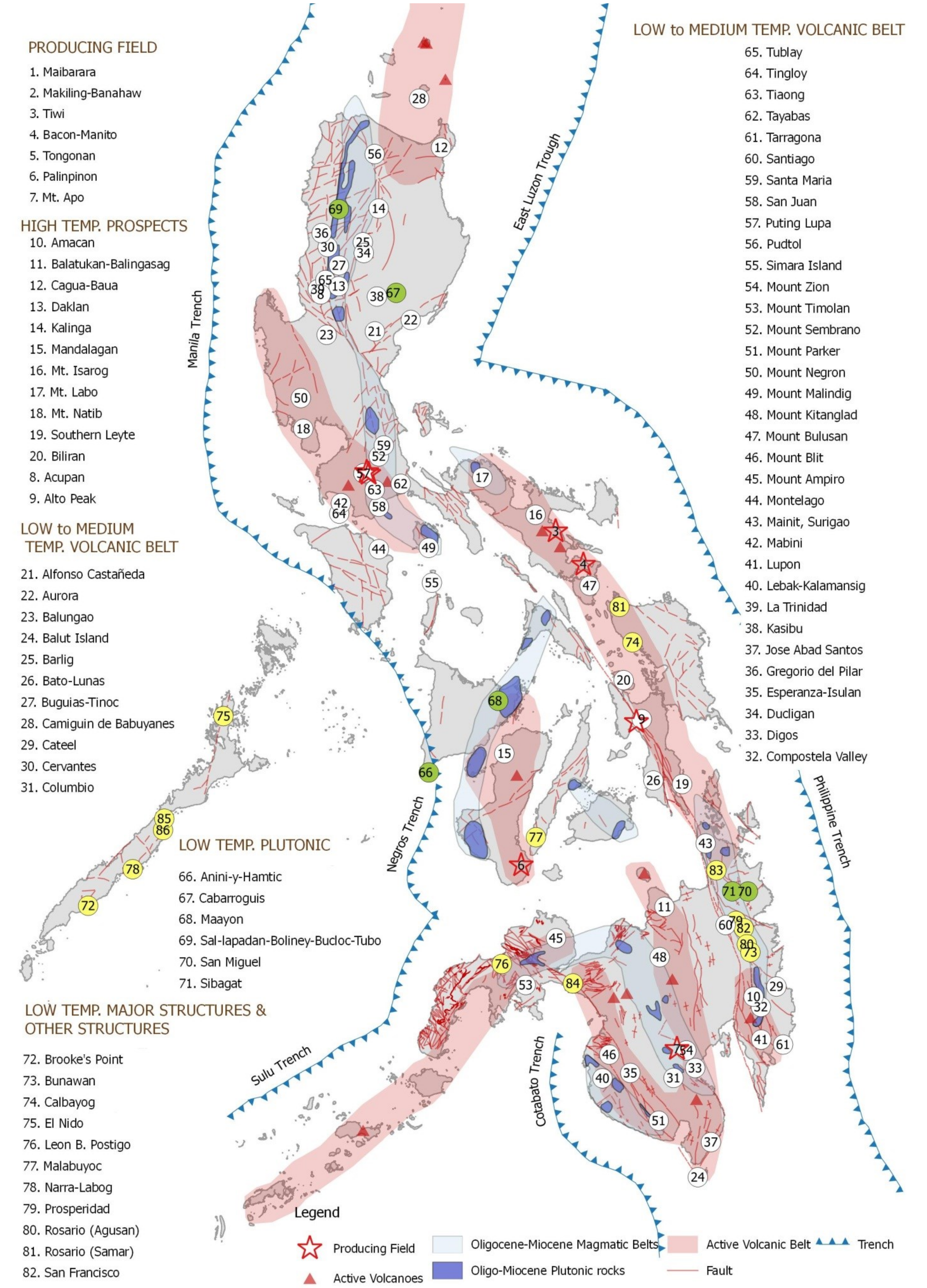

Figure 2: Location map of the distribution of the Philippines geothermal resources. The circles colored green, white and yellow represents the geothermal areas that are associated with plutonic occurrences, volcanic belt and non-active structures, respectively.

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2019	N/A											
Under construction in December 2019	N/A											
Funds committed, but not yet under construction in December 2019	N/A											
Estimated total projected use by 2020	N/A											

NOTE: 1. No power plant in operation or under construction in 2019
2. Still collating data. For updating.

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2019

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash
2F = Double Flash
3F = Triple Flash
D = Dry Steam
B = Binary (Rankine Cycle)
H = Hybrid (explain)
O = Other (please specify)

3) Electrical installed capacity in 2019

Electrical capacity actually up and running in 2019

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe[3)]	Total Running Capacity MWe[4)]	Annual Energy Produced 2019 GWh/yr	Total under Constr. or Planned MWe
Albay	**Tiwi**								
	Plant A	1979	2		1F	120			
	Plant B	1980	2	R			207.9		
	Plant C	1981/1982	2		1F	114			
Laguna	**Makban**								
	Plant A	1979	2		2F	126.4			
	Plant B	1980	2		2F	126.4			
	Plant C	1984	2		1F	110	420		
	Makban Modular								
	Plant D	1995	2		1F	40			
	Plant E	1996	2		1F	40			
	Makban Binary								
	Binary I	1994	2		B	6	5.4		
	Binary II	1994	2	N	B	6			
	Binary III	1994	1	N	B	3.73			
Sorsogon and Albay	**Bacman I**	1993	2		1F	120	120		
	Bacman II								
	Cawayan	1994	1		1F	20	20		
	Botong	1998	1	R	1F				
Manito, Albay	**Manito Lowland**	1998	1	R					
Leyte	**Tongonan I**	1983	3		2F	112.5	107	No data available yet. For updating.	
	Upper Mahiao								
	GCCU (Main Plant)	1996	4		O	136.48			
	OEC (Brine Plant)	1996	1		B	5.5			
	Malitbog	1996/1997	3		1F	232.5			
	Mahanagdong A	1997	2		1F	120			
	Mahanagdong B	1997	1		1F	60	538		
	Tongonan I- Topping	1997	3		O	19.5			
	Mahanagdong A - Topping	1997	2		O	13			
	Mahanagdong B - Topping	1997	1		O	6.5			
	Malitbog - Bottoming	1998	1		O	16.7			
Negros Oriental	**Palinpinon I**	1989	3		1F	112.5			
	Palinpinon II								
	Okoy 5	1993	1		1F	20	172		
	Nasuji	1995	1	N	1F				
	Sogongon	1995	2		1F	40			
	Nasulo	2014				49	47.5		
Negros Occidental	**Northern Negros**	2014	1	R					
Cotabato	**Mindanao I**	1996	1		1F	54.24	100		
	Mindanao II	1996	1		2F	54.24			
Batangas	**Maibarara**	2014	1		1F	20	20		
	Maibarara Unit 2	2018	1		1F	12	12		
Total						**1,918**	**1,770**		

O - Combined Cycle

TABLE 3. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2019

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
projects do not operate at 100% capacity all year

4) Other than heat pumps

5) Includes drying or dehydration of grains, fruits and vegetables

6) Excludes agricultural drying and dehydration

7) Includes balneology

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
Individual Space Heating[4)]			
District Heating [4)]			
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish Farming			
Animal Farming			
Agricultural Drying[5)]			
Palinpinon Drying Plant	1	17.34	0.55
Manito Drying Plant	0.63	9.59	0.48
Industrial Process Heat[6)]			
Snow Melting			
Bathing and Swimming[7)]			
Laguna Hot Springs and other resorts	1.67	12.65	0.24
Other Uses (specify)			
Subtotal	3.3	39.58	
Geothermal Heat Pumps			
TOTAL	3.3	39.58	