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Geothermal Development in the Philippines: The Country Update

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ABSTRACT

The passage of the Republic Act No. 9513, otherwise known as the Renewable Energy (RE) Act of 2008, made a substantial development in the geothermal industry of the Philippines. This law provides fiscal and non-fiscal incentives to further promote and accelerate the exploration, development and utilization of renewable energy resources which include geothermal energy. Remarkable evidence is the entrance of new players, thus a total of 43 Geothermal Service/Operating Contracts has been awarded since the effect of the RE Act in 2008. From these contracts, an additional capacity of 20 MWe at Maibarara and 30 MWe at Nasulo projects are expected to be commissioned by 2014. Likewise, expansion and optimization projects are in the pipeline.

With the current installed capacity of 1,847.69 MW, the Philippines remain the 2nd largest power producer of geothermal energy in the world and continuously contribute 14% of the total electricity requirements in 2012. To sustain the growing demand and to address the issues on energy security, 75% of the existing capacity or a total of 1,465 MWe additional capacities is envisioned to be online by 2030 to provide continuous supply of cleaner energy. Furthermore, assessment on the utilization of low enthalpy geothermal resources is being undertaken to provide additional energy to the country.

1. INTRODUCTION

Even though the geothermal exploration in the country started in the late 1970's, the harnessing of this indigenous resource has been predominantly undertaken by Energy Development Corporation (formerly the PNOC-Energy Development Corporation), Chevron Geothermal Philippines Holding, Inc. (formerly Philippine Geothermal Production Company, Inc.), and the National Power Corporation (NPC) under the regulatory system, the Presidential Decree (PD) No. 1442, which governs the exploration, development and utilization of the remaining untapped geothermal potential, does not provide favorable incentives to attract private sector investments.

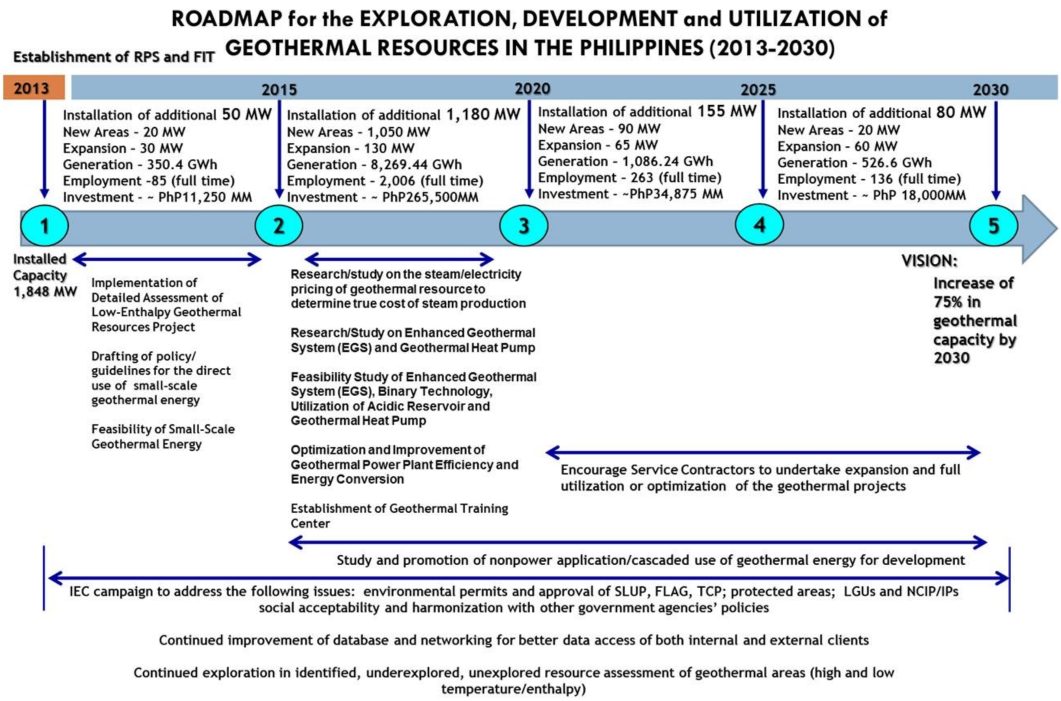

Figure 1. Geothermal Roadmap for the Exploration, Development and Utilization of Geothermal Resources in the Philippines (2013-2030)

For the last five (5) years since 2010, the significant development in the Philippines geothermal industry focused on the policy reforms and the privatization of all the NPC generating assets. Since the 1990s several bills have been proposed in Congress for the amendment of PD 1442 and, subsequently, as the government's thrust to accelerate the promotion and development of the clean and renewable sources of energy, a new policy was introduced in the power sector. The Philippines passed the Republic Act No. 9513 (RE Law) which was signed on 16 December 2008 and took effect on 30 January 2009 to provide additional fiscal and non-fiscal incentives to further develop all renewable energy sources of energy, including geothermal. The privatization includes the sale of 112.5 MWe at Tongonan I, 192.5 MWe at Palinpinon I and II geothermal power complex to EDC in September 2009 as well as the 150 MWe Bacman Geothermal Power Plant Complex to EDC in 2010. Green Core Geothermal Inc. (GCGI), a subsidiary of EDC, operates the Tongonan I, Palinpinon I and II. The rehabilitation works for these power plants have been completed and are now in normal operation. Bacman I (110 MWe) and Bacman II Cawayan (20 MWe) plants are undergoing major rehabilitation works and expected to be on full operation by 2014.

To address the growing demand and energy security in the country, the government aims to increase the geothermal capacity by about 75% over the next 16 years (Figure 1). Out of the 1,465 MWe target, only 50 MWe additional capacity have been committed to be online. One (1) of the committed project, the 20 MWe Maibarara geothermal power project was commissioned on February 2014 which is being operating by Maibarara Geothermal Inc., and the other one is the 30 MWe Nasulo expansion project of EDC and is expected to be on commercial operations by 2014. About 255 MWe expansion projects are also in the pipeline which involves the development of additional geothermal resources located within the existing geothermal service contract. The remaining 1,160 MWe potential capacities are still undergoing exploration studies to determine if the areas are feasible for development and utilization.

The installed geothermal power capacity in the Philippines stands at 10.78% (Figure 2) of the 17,325 MWe total installed capacity and continuously contributing 14% (Table 1) of the total electricity requirement in the country. The installed capacity of geothermal decreased from 1,972.07 MWe in 2010 to 1,847.69 MWe in 2013. This was attributed to the decommissioning of 49.375 MWe Northern Negros Geothermal Power Plant, the 55 MWe Unit 3 in Tiwi Geothermal Power Plant and the 20 MWe Botong in Bacman Geothermal Power Plant.

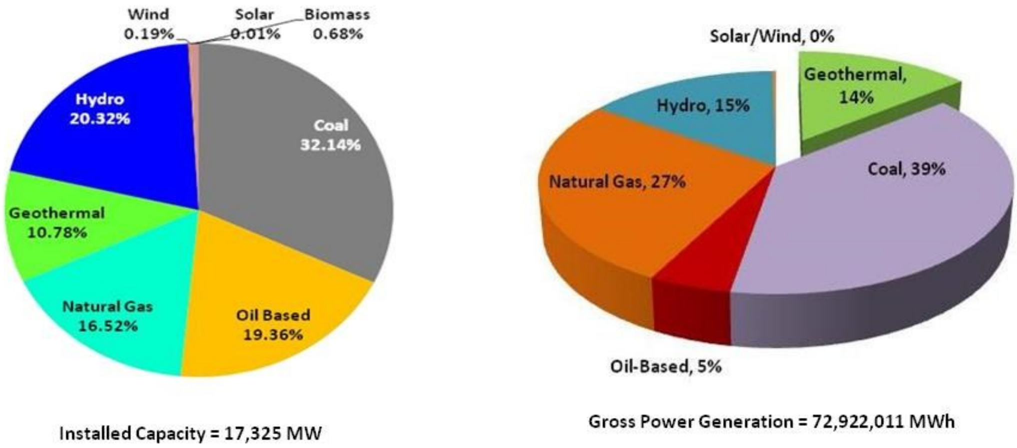

Figure 2. 2013 Installed Capacity, in MW Total Philippines (graph on the left side) and the 2012 Power Generation Mix, by Plant Type (graph on the right side)

2. REPUBLIC ACT (RA) NO. 9513 – THE RE LAW

The RE Law provides the mechanism on the awarding of a Geothermal Service Contract (GSC)/Geothermal Operating Contract (GOC) between the DOE and the interested Renewable Energy (RE) Developer. Under the new scheme, a GSC is awarded through Direct Negotiation and by Open and Competitive Selection Process or via public bidding to a local and/or foreign company who are legally, technically and financial capable to undertake operation of the geothermal power project. Still, under the RE Law, the State owns the resource and has full control and supervision over the exploration, development and utilization of the geothermal resource.

Under the new contract system, the law provides for development and utilization of the resource for twenty-five (25) years and renewable for not more than twenty-five (25) additional years. Provided that the total period of the RE Contract from the Pre-Development to the Development/Commercial Stage shall not exceed fifty (50) years. A new policy mechanism was adopted in 2013, that is to provide a new set of templates of all RE Contracts, including the provisions on automatic cancellation of the Geothermal Service Contract (GSC), if: (1) Failure of the RE Developer to comply with its first Annual Milestone under the approved Work Program, and (2) Failure of the RE Developer to disburse the cost equivalent of at least eighty per cent (80%) of the total financial cost of its annual Milestone which is set by the Department from the Pre-Development to the Development Stage shall result in the termination of the GSC.

To accelerate the promotion the exploration, develop and utilization of the renewable energy resources, the law provides the following incentives and benefits to all service contractors:

- 7 years Income Tax Holiday (ITH)
- 10 year Duty-free Importation of RE Machinery, Equipment and Materials
- 1.5% Special Realty Tax Rates on Equipment and Machinery

- 7 year Net Operating Loss Carry-Over
- 10% Corporate Tax Rate after ITH
- Accelerated Depreciation
- Zero Percent Value-Added Tax Rate
- Cash Incentive of Renewable Energy Developers for Missionary Electrification
- Tax Exemption of Carbon Credits
- 100% Tax Credit on Domestic Capital Equipment and Services
- Exemption from the Universal Charge
- Payment of Transmission Charge
- Hybrid and Cogeneration Systems

Table 1. PHILIPPINE GEOTHERMAL INDUSTRY PERFORMANCE

Year	Geothermal Power Plants Installed Capacity (MWe)	Philippine Power Plants (NPC+IPP) (MW)	% of Total Installed Generating Capacity	Geothermal Energy Generation (GWH)	% of Total Energy Generation	Fuel Oil Displaced (MMBFOE)	Average Oil Price in US$/ barrel	Foreign Savings in MM US$
1977	3	1,006.50	0.30	1	0.03	0.00	11.33	0.02
1978	3	2,188.60	0.14	3	0.06	0.01	12.32	0.06
1979	278	2,565.80	10.83	636.94	4.70	1.10	18.19	19.98
1980	446	3,820.80	11.67	2,044.85	13.80	3.53	29.79	105.03
1981	501	4,016.30	12.47	3,569.19	17.30	6.15	33.86	208.37
1982	559	4,459.20	12.54	3,563.86	20.60	6.14	32.80	201.54
1983	784	5,004.40	15.67	4,081.98	21.90	7.04	28.63	201.49
1984	894	5,195.40	17.21	4,531.46	24.30	7.81	27.89	217.90
1985	894	5,546.40	16.12	4,952.18	26.40	8.54	26.61	227.20
1986	894	5,787.90	15.45	4,577.30	23.80	7.89	13.06	103.07
1987	894	5,787.90	15.45	4,521.97	21.50	7.80	16.97	132.31
1988	888	5,782.40	15.36	4,845.91	21.10	8.36	13.53	113.04
1989	888	6,007.00	14.78	5,308.66	22.00	9.15	16.15	147.82
1990	888	6,035.80	14.71	5,464.76	22.06	9.42	25.00	235.55
1991	888	6,549.60	13.56	5,759.98	22.62	9.93	18.04	179.16
1992	888	6,549.60	13.56	5,696.80	22.19	9.82	18.08	177.58
1993	1018	8,796.10	11.57	5,667.25	23.92	9.77	16.00	156.34
1994	1074	9,175.00	11.71	6,319.69	20.28	10.90	15.82	172.37
1995	1194	9,630.00	12.40	6,134.52	18.47	10.58	16.60	175.57
1996	1448	10,944.00	13.23	6,538.73	17.67	11.27	18.65	210.25
1997	1819	11,635.40	15.63	7,430.88	18.70	12.81	18.27	234.07
1998	1861	12,067.02	15.42	8,951.61	21.52	15.43	12.24	188.91
1999	1909	12,335.56	15.48	10,576.69	25.53	18.24	17.45	318.21
2000	1909	13,196.30	14.47	11,317.11	25.33	19.51	27.36	533.86
2001	1931	13,459.00	14.35	10,381.03	22.14	17.90	23.48	420.25
2002	1931	14,702.06	13.13	10,248.04	21.10	17.67	25.00	441.73
2003	1931	15,124.00	12.77	9,419.02	19.10	16.24	28.00	454.71
2004	1931	15,548.00	12.42	10,280.81	18.40	17.73	35.26	625.00
2005	1978	15,619.00	12.66	9,902.49	17.50	17.07	51.16	873.47
2006	1978	15,803.00	12.51	10,460.25	18.00	18.03	63.22	1,140.17
2007	2027	15,937.00	12.72	10,256.46	18.00	17.09	71.00	1,213.68
2008	1972	15,681.00	12.58	10,586.00	18.00	17.64	96.00	1,693.76
2009	1972	15,610.00	12.63	10,024.79	16.70	16.71	88.50	1,478.66
2010	1972	16,359.00	12.05	10,279.13	14.70	17.13	78.76	1,349.31
2011	1848	16,162.00	11.43	10,494.00	14.00	17.49	108.98	1,906.08
2012	1848	17,025.00	10.85	10,249.99	14.00	17.08	108.98	1,861.76
TOTAL				**245,078.33**		**418.99**		**17,718.28**

Since the enactment of the RE Law, a total of 43 Geothermal Service/Operating Contracts were signed and awarded. Five (5) of which are producing fields and two (2) under exploration stage under PD 1442 which was converted to RA 9513; seven (7) service contracts awarded through the 2009 Open and Competitive Selection Process (OCSP); twenty-one (21) service contracts were awarded through direct negotiation; five (5) operating contracts were awarded for the operation of privatized power plants of NPC; and there are two (2) remaining service contract still under PD 1442 (Figure 3 and 4).

3. PHILIPPINE GEOTHERMAL SITUATION

3.1 Makban, Laguna/Batangas/Quezon

The Makban geothermal power project is located in the Province of Laguna, about 70 km southeast of Manila in the island of Luzon. The Makban steam field is operated by Philippine Geothermal Production Company, Inc. (PGPC), a joint venture between Allfirst Equity Holdings, Inc. and Chevron Geothermal Philippines Holdings, Inc. In compliance with the provision of the 2003 Comprise Agreement and the RE Law, the PGPC and DOE executed a Geothermal Service Contract on 25 April 2013 to operate the geothermal steam field in the Makban. Meanwhile, the AP Renewables Inc. (APRI) acquired a Geothermal Operating Contract in 2009 for the operation of the Makban Geothermal Power Plant. A total of 132 wells have been drilled in the field since 1975. From its commercial operation in 1979, cumulative total electricity generated from Makban Geothermal Power Plant from 1979 to 2013 stood at 72,860.90 GWh.

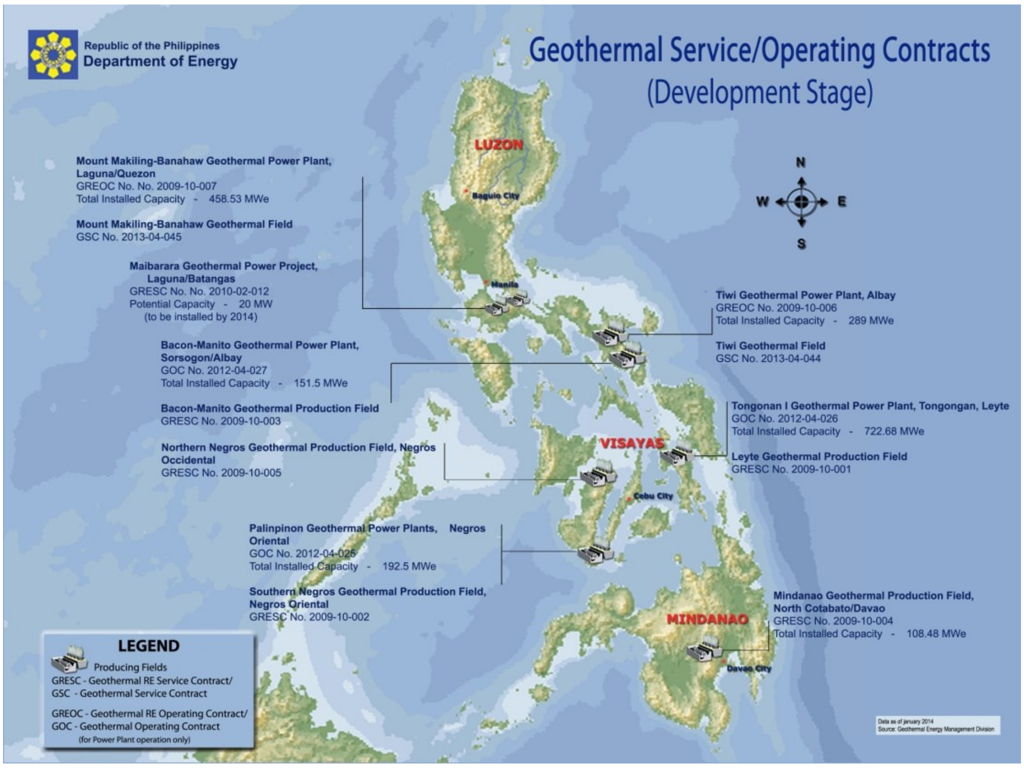

Figure 3. Map showing the Geothermal Service/Operating Contracts under Development Stage (producing fields)

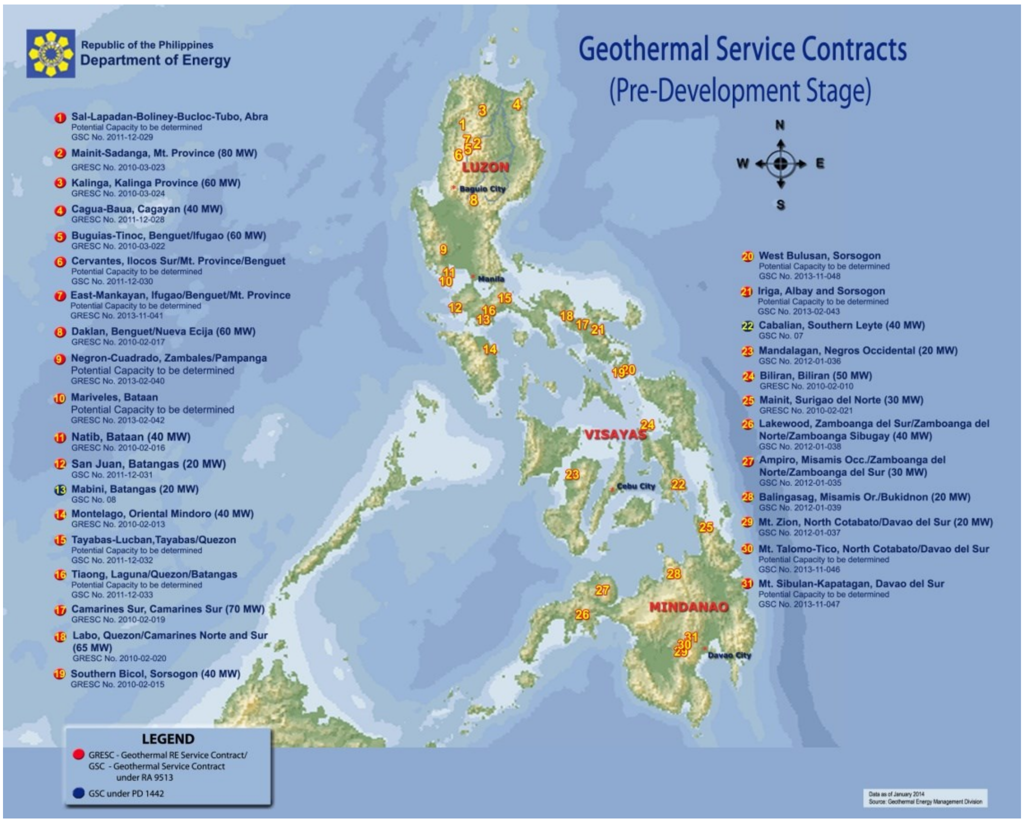

Figure 4. Map showing the Geothermal Service Contracts under Pre-Development Stage (exploration stage)

3.2 Tiwi, Albay

The Tiwi geothermal power project is located in the Province of Tiwi, about 450 km southeast of Manila. It was the first of the six (6) geothermal fields developed in the Philippines for large scale power generation. The Tiwi steam field is operated by PGPC, while the power plant is operated by APRI. With a total 158 wells drilled since 1972, moreover, since 1979 the field has generated a total of 50,285.87 GWh of electricity from 1979 to 2013. Since the plants has been operational for about 34 years and due to the typhoon damages suffered by Units 3 and 4, the NPC decided to decommission the plant, hence, the total installed capacity of the plant decrease from 344 MWe to 234 MWe.

3.3 Northern Negros, Negros Occidental

The Northern Negros Geothermal Project (NNGP) is located on the north western part of Mt. Kanla-on, approximately 60 km from Bacolod City, Negros Occidental. The field and power plant was developed and operated by EDC as the first merchant project with a 49.375 MWe installed capacity which was commissioned in 2007, however, since 2011 the plant is on shutdown due to insufficient steam resources in the area. Although several studies conducted in the field, including reservoir rehabilitation works of all existing wells and drilling of M & R, it showed that the resource cannot sustain the steam supply requirements of the power plants. To further determine the viability of the project, optimization test was conducted to assess the size of the plant turbine that should match the amount steam that can be produced from the field. As a result, NNGP resource can sustainably support a flow rate of 16-18 kg/s which can generate 5-8 MWe.

With EDC's plan to tap and develop the excess steam within the existing Palinpinon II steam field in Southern Negros, the company decided to transfer the Northern Negros Geothermal Power Plant (NNGPP) electro-mechanical equipment to the Southern Negros Geothermal Project.

3.4 Palinpinon, Negros Oriental

The Palinpinon geothermal production field is located in Southern Negros and is operated by EDC. A total of 81 wells have been drilled in the field since 1976. On 2009, GCGI assumes the operations of the power plants from the NPC. The Palinpinon I has an installed capacity of 112.5 MWe and operational since 1993. The Palinpinon II has three (3) modular plants, namely, 20 MWe Okoy, 20 MWe Nasuji and 40 MWe Sogongon. As of December 2013, the combined cumulative gross generation of all the plants reached 30,202.92 GWh of electricity since 1980.

The 30 MWe Nasulo Expansion Project is located in the southeast part of Negros Oriental. Sumitomo Corporation entered into a contract with EDC for the relocation of the existing machine and equipment of the NNGPP to the site of the Nasulo Power Project in December 2012. The civil works, including the construction of the power house was conducted by EDC's affiliate First Balfour Inc. prior to Sumitomo's contract.

3.5 Bacman, Sorsogon

The Bacman geothermal production field is located in the provinces of Sorsogon and Albay in the Bicol Peninsula and is operated by EDC. The PSALM officially turn-overed the Bacman power plant to Bacman Geothermal Inc., one of the subsidiaries of EDC, in 2010 after winning in the auction conducted by the latter. Since 1979, a total of 66 wells have been drilled in the field. The total cumulative electricity gross generation reached 7,617.11 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 steam field and power plants is also operated by EDC. Since 1987, a total of 40 wells have been drilled to supply the steam requirements of the plants. The 54.24 MWe Mindanao I was commissioned in 1996 and the 54.24 MWe Mindanao II was commissioned in 1999. As of December 2013, a total accumulated generation of both plants was 12,761.27 GWh of electricity.

3.7 Tongonan, Leyte

The Tongonan geothermal production field is the largest steam field in the Philippines and is operated by EDC. The 112.5 MWe Tongonan I and Unified Leyte Geothermal Power Plant facilities were among the power infrastructure damaged when the super typhoon "Yolanda" (International Name: Haiyan) hit Eastern Visayas and nearby areas in November 2013. The cooling towers of the 232.5 MWe Malitbog, 180 MWe Mahanagdong and 112.5 MWe Tongonan I geothermal power plants were inoperable due to the damage sustained from the Typhon Yolanda while part of the cooling system of the 125 MWe Upper Mahiao Power Plant was also damaged. By first quarter of 2014, the power plants damaged by the typhoon Yolanda were restored and back in normal operations.

Since the start of commercial operation of Tongonan I and Unified Leyte, EDC drilled a total of 196 wells. As of December 2013, the total accumulated gross generation of Tongonan I is about 17,591.28 GWh since 1977 and Unified Leyte reached a gross generation of 62,791.15 GWh since 1996.

3.8 Maibarara, Batangas

The 20 MWe Maibarara Geothermal Power Project (MGPP) is located adjacent to the Makban project. The power plant started commercial operations on 08 February 2014 making the project the 1st integrated geothermal facility under President Benigno S. Aquino's term and the latest in the country since 2007. The facility is being operated by MGI, which is a joint venture between PetroEnergy Resources Corp. (65%), Trans Asia Oil and Energy Development Corp. (25%) and Philippine National Oil Co. – Renewables Corp. (10%). As of April 2014, the power facility has generated a total energy of 33,782 MWh using a steam rate of 2.05 kg/s/MW.

4. GOVERNMENT INITIATED PROJECT: ASSESSMENT OF LOW ENTHALPY GEOTHERMAL RESOURCES

The DOE has been implementing the locally-funded project entitled "Detailed Assessment of Selected Low Enthalpy Geothermal Resources in the Philippines" since 2011. The primary objective of the project is to accelerate the development of low to medium enthalpy geothermal resource area, with a temperature ranging from 90°C to 150°C, mainly for power generation. Subsequently, the secondary objectives of the project includes: (1) the assessment and realization of the economic feasibility of small scale geothermal power projects for local power needs, and (2) the preparation of a comprehensive data package that will showcase this type of geothermal resource for future private investor participations.

Below is the brief description on the three (3) identified low enthalpy areas located in Banton Island in Romblon, Balut Island in Davao del Sur and Maricaban Island in Batangas. FEDS Resources and Development Services, Inc., who won on the public bidding for the contract-out services, conducted the geoscientific studies of these islands.

4.1 Banton Island, Romblon

Banton Island is located in the most northerly island in the province of Romblon. The island is part of the Pleistocene-Quaternary volcanic chain that comprises the West Luzon volcanic arc. Geographically, it is part of the Romblon Island Group (RIG) but geologically the underlying rock sequences may differ from the rest of the island group with the exception of Simary Island which is part of the volcanic chain. The Banton Volcanic Complex (BVC) is composed of intercalated lava flows and pyroclastic rocks. Based on the rock petrography, the exposed volcanic rocks in Banton Island possibly belong to a single volcanic suite of andesitic composition, active during the Pliocene period. The BVC age would seem to suggest that the West Luzon volcanic arc has had no direct influence on Banton Island volcanism within the Pleistocene age.

Based on the latest work conducted on the island in 2013, it was concluded that there is no geothermal system active or relic. Hot water can be expected in the immediate vicinity of the springs only, and not upstream of the sub-tidal hot springs. Although the hot water temperature are usable for direct uses (i.e., drying, recreation and leisure, etc.), the very low flow rates of the thermal springs suggest either low permeability, very small localized reservoirs, or both. Development of the hot water for whatever purpose, therefore, is highly unlikely.

4.2 Balut Island, Davao del Sur

Balut Island is located in the westernmost of the Sarangani Islands and about 13 km from the mainland Mindanao. The Balut Island is an emergent submarine volcano located south of Mindanao Island. Together with other Mindanao volcanic centers, Balut Island Volcano (BIV) has a complex history as it is also probably related to the northeastward subduction of the Celebes Sea Plate along the Cotabato Trench. Thermal springs in the island are results of mixing between shallow groundwater and seawater, with elevated temperatures due to the outflow of hot, deep fluid. West of the upflow region, the presence of a shallow “gas cap” is invoked, resulting in higher temperatures, higher SO_4 content, and much lower pH of the thermal springs. This influence of the ‘gas cap’ is observed from Cayupi hot springs to the south, Sabang Emerald Pool to the north, and the Gumtago solfatara to the east. The western edge is undetermined. The presence of a near-surface gas cap requires that a deep, hot liquid reservoir exists in the system. This deep geothermal reservoir fluid has an estimated minimum temperature of 175-200^{o}C based on gas geothermometry. Subsequently, based on the current study conducted in the Balut prospect, the size of the possible exploitable resource is estimated at 4-9 km^2 with the power density assumption of 5 MWe/km^2, which translates to a power potential of 20-45 MWe for the Balut prospect.

4.3 Maricaban Island, Batangas

Based from the available data and of the results of the reconnaissance geological mapping done in Maricaban Island, the island is basically underlain by lava flows, volcanic breccias, tuff, dykes and limestone formation. The lava flows were noted along Tingloy pier and Brgy. Maricaban (PNOC-EDC, 1981) while volcanic breccias were seen in Brgy. San Jose and Recodo as costal exposures. On the other hand, almost flat lying to slightly dipping layered tuff was noted in Tingloy Poblacion and along the narrow trail in between San Juan and Papaya while dykes were noted in some places in Brgys. Papaya, Gamao, and San Jose intruding the tuff sequence.

The heat source for this system is most likely related to the volcanism on the island. The location and center of the reworked seawater aquifers is unknown at this point in time. It is however possible that the integrated exploration assessment of the study area will be able to better define the location and geometry of this aquifer. Deep fluid temperature estimates give a range of 100-240^{o}C based on several geothermometers although the overall appearance of the thermal springs and the lack of impressive thermal manifestations would suggested that the reworked seawater temperature is closer perhaps to 150^{o}C rather than 200^{o}C.

5. FUTURE PROGRAMS AND PLANS

The DOE formulated the National Renewable Energy Plans and Program (NREP). In support of the NREP, the government is pushing for the development of the 1,465 MWe geothermal additional capacities. By increasing to 75% in the geothermal capacity by 2030, it is envisioned that the installed capacity from geothermal will reach the level of 3,313 MWe. These targets can be attained by providing assistance to the service contractors in harmonizing other government policies and regulations under the Republic Act No. 7586 or the “National Integrated Protected Areas System (NIPAS) of 1992” and the Republic Act No. 8371 or the “Indigenous People’s Rights Act (IPRA) of 1997” to address the environmental and social-cultural concerns. The harmonization of these policies is very vital in the exploration, development and utilization of geothermal resources especially those located in protected areas. Moreover, included in the plans and programs are the research of the geothermal emerging technologies to fully utilize the geothermal potential in the country such as acidic reservoir and low permeability resource. To maximize the use of geothermal energy, the government is pursuing not only the large-scale geothermal development, but is taking initiatives to develop the small-scale power and non-power application.

6. CONCLUSIONS

The need to harness the indigenous resources in the country has been the aspiration of the government to minimize the reliance on imported oil wherein the price is continuously volatile in the world market. Thus, the policy reforms in the Philippines on the power sector have successfully attracted private sectors participation in the exploration, development and utilization of all RE energy source, including geothermal. A total of 42 contracts have awarded since the implementation of the RE Law. With these new geothermal projects, the government envisioned having more investments to come in and more jobs can be created. Moreover, it will also uplift the economy of the country, especially the host Local Government, from the royalty earnings from the projects and other benefits.

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Table 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2013

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) Data for 2014 if available, otherwise for 2013. Please specify which.

Locality	Power Plant Name	Year Comissioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2013[3)] GWh/yr	Total under Constr. or Planned MWe
Mak-Ban (Laguna)	Plant A	1979	63.20 x 2			126.40	126.40	771	
	Plant B	1980	63.20 x 2			126.40	126.40	707	
	Plant C	1984	55.00 x 2			110.00	110.00	25	
Mak-Ban Modular (Laguna)									
	Plant D	1995	20.00 x 2			40.00	40.00	260	
	Plant E	1995	20.00 x 2			40.00	40.00	168	
Mak-Ban Binary (Laguna)	Binary I	1994	3.00 x 2	N		6.00	-	-	
	Binary II	1994	3.00 x 2	N		6.00	-	-	
	Binary III	1994	3.00 x 1	N		3.00	-	-	
			0.73 x 1	N		1.00	-	-	
Tiwi (Albay)	Plant A	1979	60.00 x 2		1F	120	120	255	
	Plant B	1980	55.00 x 2	R	1F		-	-	
	Plant C	1982	57.00 x 2		1F	114	114	875	
Albay-Sorsogon	Bacman I	1993	55.00 x 2		1F	110	110	238	
	Bacman II								
	Cawayan	1994	20.00 x 1		1F	20.00	20	84.92	
	Botong	1998	20.00 x 1	R	1F	-	-	-	-
	Manito-Lowland	1998	1.50 x 1		1F	1.50	-		
Tongonan (Leyte)	Tongonan I	1983	37.50 x 3			112.50	112.5	744.84	
	Upper Mahiao							817.41	
	GCCU** (Main Plant)	1996	34.12 x 4			136.48	138.48		
	OEC*** (Brine Plant)	1996	5.50 x 1			5.50	5.5		
	Malitbog	1997	77.50 x 3			232.50	232.5	1403.87	
	Mahanagdong	1997	60.00 x 3			180.00	180	841.81	
	Optimization Plants							223.62	
	Tongonan 1 - Topping	1997	6.50 x 3			19.50	19.5		
	Mahanagdong A - Topping	1997	6.50 x 2			13.00	13		
	Mahanagdong B - Topping	1997	6.50 x 1			6.50	6.5		
	Malitbong - Bottoming	1997	16.70 x 1			16.70	16.7		
Southern Negros	Palinpinon I	1983	37.50 x 3		1F	112.50	112.5	837.22	
	Palinpinon II							651.5	
	Okoy 5	1994	20.00 x 1		1F	20.00	20		
	Nasuji	1994	20.00 x 1		1F	20.00	20		
	Sogongon	1995	20.00 x 2		1F	40.00	40		
Northern Negros	NNGP	2007	49.753 x 1	R	2F	-	-	-	-
Mindanao	Mindanao I	1996	54.24 x 1		1F	54.24	54.24	320.33	
	Mindanao II	1999	54.24 x 1		2F	54.24	54.24	422.66	
Laguna/Batangas	Maibarara	2014							20
Southern Negros	Nasulo								30
Total						**1847.96**		**9647.18**	

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

Table 3. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2013

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)
since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

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**	

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

Table 4. WELLS DRILLED FOR ELECTRICAL, DIRECT, AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2010 TO DECEMBER 31, 2013 (excluding heat pump wells)

1) Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1]	(all)	4	-	-	-	9.57
Production	>150° C	50	-	-	-	123.70
	150-100° C					
	<100° C					
Injection	(all)	7	-	-	-	17.73
Total		61				151.00

Table 5. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Prograı
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010	10					
2011	11					
2012	10					
2013	11					
2014	11					
Total	53					