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Introduction to the Geothermal Energy Program in Taiwan

Tsanyao Frank Yang and Geothermal Energy Research Teams of Taiwan

Department of Geosciences, National Taiwan University, Taipei 10617, Taiwan

tyyang@ntu.edu.tw

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ABSTRACT

Located on the Pacific Rim of Fire, Taiwan possesses rich geothermal resources due to volcanic activities and plate collision. Based on available data prior to 1980, Taiwan may have about 1 GWe of potential shallow geothermal energy, which is less than 3% of the national gross power generation. Recently, one of the National Science & Technology Program (NSTP) projects has been conducting research and reevaluating the island-wide deep geothermal energy. Four hot potential sites have been recognized. They are: (1) Tatun Volcano Group of northern Taiwan; (2) I-Lan Plain of NE Taiwan; (3) Lu-Shan area of Central Taiwan; and (4) Hua-Tung area of eastern Taiwan. We found that the geothermal resource in Taiwan may be as high as 160 GWe, with 33.6 GWe of exploitable geothermal energy. The potential is great and should not be underestimated. Therefore, geothermal energy has been listed as one of major tasks of National Energy Program, Phase II (NEP-II) in Taiwan. We will conduct more detailed geothermal energy surveys on some proposed hot sites and to construct an EGS pilot geothermal plant with 1 MWe capability in a few years.

1. ENERGY SITUATION IN TAIWAN

Taiwan is characterized by a shortage of energy sources. The country mostly relies on imports of energy sources from other countries. The proportion of imports to domestic energy production is as high as 98%. In addition, the local manufacturing industry is export oriented and the energy demands of the population and the industrial sector are consistently high. A stable supply of low-price energy is therefore a basic prerequisite for the economic development of Taiwan. An analysis of the installed capacity and power generation ratio of Taiwan Power Company (TaiPower) in 2013 reveals that fossil fuel based power generation accounts for 71.8% (coal 38.4%, natural gas 31.1%, fuel oil 2.3%), while nuclear power generation and other forms of power generation (cogeneration 3.4%, renewable energy 4.5%, pumped storage 1.5%) make up 18.8% and 9.4%, respectively (Table 1 and Figure 1).

Table 1. Present and planned production of electricity in Taiwan

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (win, sloar, biomass, solid waste etc)		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 2014	0.05	0.043	30,462	162.2	4683	4.3	5,144	40.5	894	6.4	41,182	213.4
Under construction in December 2014	1	8.76					2,700					
Funds committed, but not yet under construction in December 2014	0.2	1.752					-					
Estimated total projected use by 2020	66	578.16					6,272					

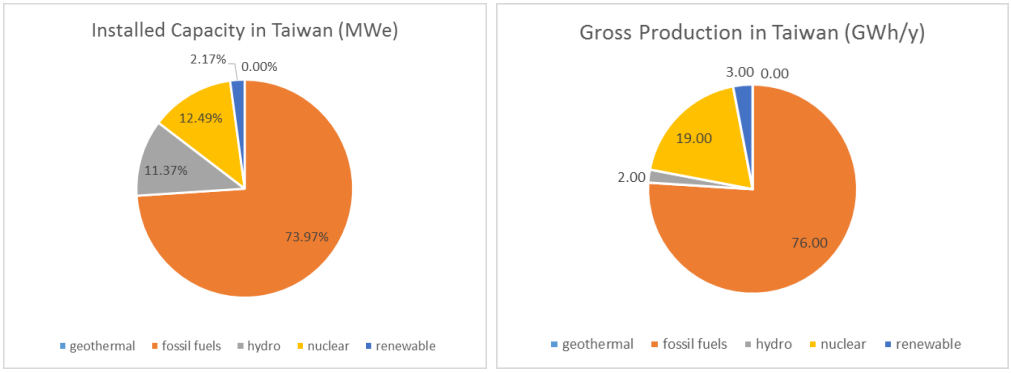

Figure 1: Present production of electricity in Taiwan (data from Taiwan Power Company)

In other words, 70% of the country's power generation still relies on thermal power plants. However, this form of power generation leads to serious pollution problems. The main culprit is coal which accounts for the largest proportion of power generation (40%). Coal-fired power plants release large amounts of CO_2 into the environment. CO_2 is considered the main factor in the worsening of the greenhouse effect in the earth's atmosphere.

A 3-MWe geothermal energy power plant was installed in Ilan Plain, NE Taiwan since 1981. However, it was shut down due to the decreasing efficiency in 1993. It was recently re-opened again due to recent new technology to overcome the problems (Table 2).

Table 2. Utilization of geothermal energy for electric power generation in Taiwan

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2014[3)] GWh/yr	Total under Constr. or Planned MWe
Ilan	Chingshui	2012	1		B	0.05	0.05	0.043	1
Ilan	Chingshui	1981	1	R	1F	3	3	0	0
Ilan	Tuchang	1985	1	R	B	0.3	0.3	0	0
Total									

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

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

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

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

2. GEOLOGICAL BACKGROUND AND HOT SITES FOR GEOTHERMAL ENERGY IN TAIWAN

Geothermal energy is clean and eco-friendly since it is derived from the inexhaustible thermal energy emitted by our planet. This represents a renewable energy form which can be used directly or converted into electricity. The area of land required is extremely small and the extraction of geothermal energy doesn't destroy the original ecology of the natural environment. Geothermal energy can serve as base-load electricity and as a substitute for fossil fuels.

Located on the Pacific Rim of Fire, Taiwan possesses rich geothermal resources due to volcanic activities and plate collision. Taiwan is located at a plate boundary and geothermal activity can be observed all over the island which has rich geothermal reserves. Initial exploration and development of these reserves was carried out earlier, but exploration work has already been suspended for many years. Based on available data prior to 1980, Taiwan may have about 1 GWe of potential shallow geothermal energy, which is less than 3% of the national gross power generation.

A recently released planning report on the NSTP specifies that geothermal energy is an important type of renewable energy. It is expected that geothermal energy will eventually have an installed power capacity of 7.15 GWe, which is equivalent to 14.65% of the national installed capacity which currently amounts to 48.8 GWe.

The project of geothermal energy research in the Chingshui Area in Ilan County, sponsored by NSTP, has adopted the concept of EGS to reassess the amount of geothermal energy present in deep strata all over the island over the past year and a half. The results show that geothermal resources present in Taiwan equal 159.6 GWe (the exploitable quantity amounts estimated up to 33.6 GWe, Table 3).

Table 3. Estimated power generating capacity of geothermal reserves with geothermal temperatures in excess of 175℃ in the four major geothermal areas of Taiwan

Area	Covered total area (km^2)	Power generating capacity (MWe)	Ratio (%)	Power generating capacity of geothermal reserves at different depths (MWe) (development restricted or unrestricted by natural conditions)				
				＞2000m	1500-2000m	1000-1500m	500-1000m	＜500m
Ilan plain	532	36,923	23.13%	30,219	13	456	2,100	4,135
Datun Volcano Group	88	2,886	1.81%	0	0	0	716	2,170
Hualien-Taitung geothermal area	5,403	100,431	62.92%	15,900	43,334	15,443	12,880	12,874
Lushan Geothermal Area	954	19,366	12.13%	10,143	5,194	3,859	170	0
Total amounts for all four areas (Ratios in %)	6,977	159,606		56,262 (35.25%)	48,541 (30.41%)	19,758 (12.38%)	15,866 (9.94%)	19,179 (12.02%)

* Development possible at depths below 1,000m except in the Yangmingshan National Park area where development is forbidden (1,405 MWe must be deducted)

3. NATIONAL ENERGY PROGRAM FOR GEOTHERMAL ENERGY DEVELOPMENT

A 5-year National Energy Program-Phase II (NEP-II) was launched in 2014 until 2018 to continue the development of the potential geothermal energy in Taiwan. The budget and personnel for the geothermal activities is increasing significantly (Table 4 & 5) and several drilling wells will be conducted for the exploration of geothermal potential in Taiwan and the installation of pilot EGS power planet (Table 6).

Table 4. Allocation of professional personnel to geothermal activities in Taiwan

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010	1	13.1	0			6
2011	1	14.4	10			6
2012	1	12.4	10			6
2013	1	14	15			6
2014	1	12.5	20	4		6
Total	5	66.4	44	4		30

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

Table 5. Total investments in geothermal (US$) in Taiwan

Period	Research & Development Incl.	Field Development Including Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	0					
2000-2004	0					
2005-2009	7.5				0	100
2010-2014	15.7	1			6	94

Table 6. Wells drilled for electrical, direct and combined use of geothermal resources from January 1, 2010 to December 31, 2014 in Taiwan

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)	7				0.8
Production	>150° C	1				1.1
	150-100° C					
	<100° C					
Injection	(all)					
Total		8				1.9

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

The main goals of the program include: (1) Review and reassessment of currently existing geothermal fields and construction of geothermal power plants; (2) Estimation of the potential and properties of geothermal resources in Taiwan; (3) Research and development of key technologies for the exploration and exploitation of geothermal energy resources in deep strata; (4) Better understanding of the impact of the development of geothermal energy resources for the environmental systems; (5) Construction of an EGS pilot plant; (6) Transfer of technology to the private sector to spur the development of geothermal industries and increase the percentage of green energy and carbon reduction.

In short-term plan, the goal of NEP-II is to construct a conventional geothermal power plant with the capacity of 4-5 MWe, as well as, pioneer an EGS power plant with a capacity of 1 MWe by the year 2016. For a long-term plan, the goal is to achieve an installed power generation capacity of 60 MWe and 150 MWe by year 2020 and 2025, respectively; and to make the EGS geothermal energy plant commercialized.

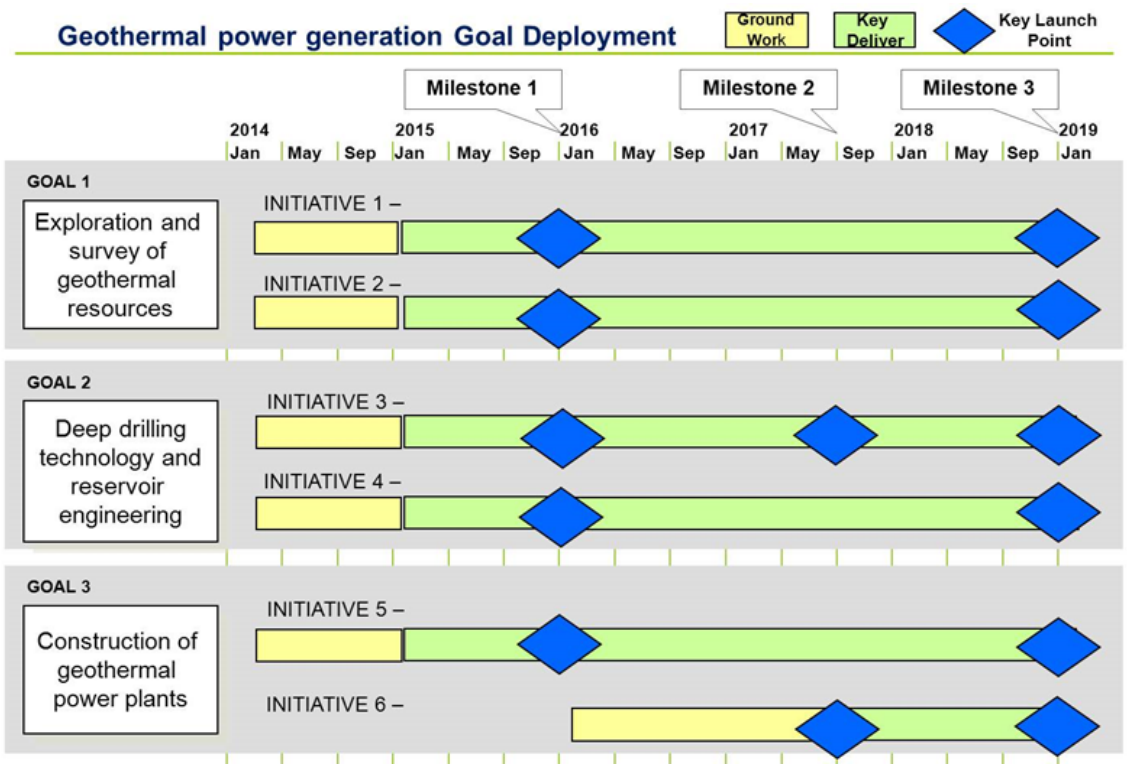

Figure 2: Short-term plan for the geothermal energy development of NEP-II in Taiwan (2014-2018)

4. ACKNOWLEDGEMENTS

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