Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

Country Update of Japan: Renewed Opportunities

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Keywords: Japan, geothermal energy use, power generation, direct use, ground-source heat pump

ABSTRACT

Estimated theoretical potential of geothermal energy in Japan to a depth of 3 km is 20 GWe or larger. However the present total capacity of geothermal power plant is merely 517.8 MWe and there opened no new geothermal power plant for more than a decade. It is mainly due to lack of economic competitiveness with other power sources and of social systems which limits geothermal development. However after the nuclear accident in March 2011, the government re-started giving incentives for geothermal development, such as financial supports for exploration drillings and PA activities, cost incentives by FIT price, and mitigation of constraints in national parks. A guideline for geothermal drilling license was also newly authorized, which may shorten the period taken for drilling permission. Such supports by the government encouraged new geothermal exploration activities by private sectors as well as quick installation of small binary systems. As of year 2014, over forty prospects are under exploration or development; nineteen prospects over 10MWe, seven prospects from 1 to 10 MWe, and eighteen prospects under 1 MWe. Seven small binary systems (0.003 to 2 MWe) are installed in years 2013 and 2014. Although expansion of ground source heat pump (GSHP) systems is rather slow, the number of installations is multiplicatively increasing these years. The total installation number in Japan in 2014 is around 1,000. On the other hand, conventional direct use in Japan is rather stable, allowing dominant part to be bathing.

1. INTRODUCTION

Japan, located along Circum-Pacific Volcanic Belt; "Ring of Fire," is rich in geothermal energy with theoretical potential to a depth of 3 km of over 20 GWe (Muraoka et al., 2008). In spite of its rich geothermal resources, the use of geothermal energy in Japan is quite limited and its contribution to national power supply is merely 0.2% with a total installed capacity of 517.8 MWe (Table 1). No new geothermal power plant had opened for more than a decade since year 2000 mainly because of legal, socio-economical problems. Under the federal policy pushing nuclear power, laws and regulations which limit geothermal development had not been improved. The three major reasons are; 1) regulations on natural parks, 2) development risk and cost and 3) negative campaign by hot spring owners. However, the former two problems were mitigated after the nuclear accident in 2011 by supports of the federal government which changed several regulations on natural parks and put new subsidies to promote geothermal development. The third one may not be easily mitigated by regulations only, but still the government made a new guideline on geothermal drilling in which standard procedure of discussion with local residents is indicated. Given such support from the government, private sectors moved toward geothermal development drastically.

Installation of ground source heat pump (GSHP) systems increased steadily in Japan. Although the numbers of installation is limited to few thousand yet, the annual installation is rapidly increasing. The government gives incentives in installation of GSHP system both from environmental and energy saving aspects. On the other hand, it seems conventional direct use have not changed since last country update (Table 2). This paper provides status of Japan in 2014 for geothermal power generation, conventional direct use, and GSHP separately.

Table 1. Present electricity production in Japan

Geothermal*		Fossil Fuels		Hydro		Nuclear		Other Renewables		Total	
Capacity MWe	Gross Prod. GWh/y	Capa. MWe	Gross Prod. GWh/y	Capa. MWe	Gross Prod. GWh/y	Capa. MWe	Gross Prod. GWh/y	Capa. MWe	Gross Prod. GWh/y	Capa. MWe	Gross Prod. GWh/y
517.8	2,689	129,040	831,667	36,090	79,027	43,530	15,994	Solar 4,914	4,478	216,615	936,115
								Wind 2,501	2,260		

Data other than geothermal are for 2012 from "The federation of Electric Power Companies of Japan." , *Geothermal "capacity" is of 2014 and "gross production" is of FY2011 (April 2011 - March 2012) from TNPES (2013).

2. GEOTHERMAL POWER GENERATION

2.1 New Opportunities

After the Great Earthquake and the following nuclear accident in March 2011, the government made new regulations and laws to encourage renewable energy use including geothermal power. The two major changes of the rules for geothermal power generation are the ordinance of the Ministry of Environment (MOE) on development in national parks and enactment of the Feed in Tariff system for geothermal power by Ministry of Economy, Trade and Industry (METI).

Table 2. Present status of geothermal use in Japan

	Power Generation (MWe) *1	Conventional Direct Use (MWt) *2	GSHP (MWt) *3
Installed capacity	517.8	2,099.5	62.0
Used (produced) Energy	2,688.82	7138.9	NA

*1 Data for "used energy" is from TNPES (2013). Installed capacity has been reduced from 540.1 to 515.1 MWe in December 2013 due to replacement of a power generator in Mori power plant from 50 to 25 MWe. Nevertheless the steam production rate of the Mori field is the same as before, resulting in raising its capacity factor double. Then for "installed capacity", new small binary plants, installed in 2013 and 2014 of 2.7 MW in total, are added. *2 Sugino and Akeno (2010) and Lund et al. (2010), *3 MOE (2012)

2.1.1 Regulation on national parks

Eighty percent of geothermal energy in Japan exists inside national parks. Although most parts of Japanese national parks are not categorized in "national park" in the standard of International Union for Conservation of Nature (IUCN) but ordinary land, no geothermal exploitation had been allowed in these areas and even scientific survey had been strictly limited. However, considering the advantage of geothermal power as a low CO_2 emission energy source, the cabinet decided to mitigate restrictions in national parks in June 2010. MOE finally made new ordinance in March 2012 giving possibility of small scale geothermal development in Class 2 and 3 Special zones of national parks, which development used to be strictly prohibited. This change enlarges technical geothermal potential significantly (see Fig. 1).

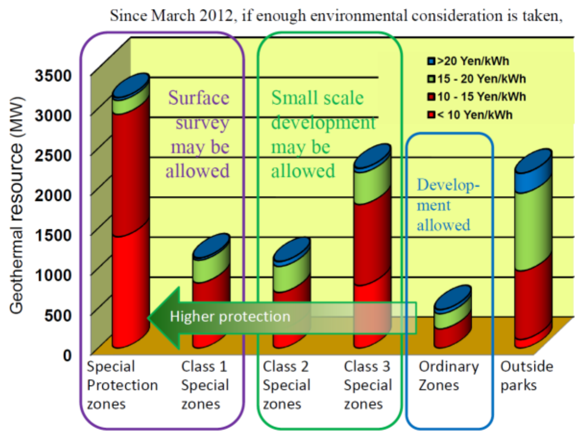

Fig. 1: Estimated amounts and power costs of geothermal resources in different zones of national parks (Sakaguchi, 2012).

Table 3: Ordinance of the Ministry of the Environment on geothermal development in national parks

	Former ordinance (Before March 2012)	Renewed ordinance (After March 2012)
Special Protection zone and Class 1 Special zone	Development is strictly prohibited. Even surface survey is prohibited.	Development is not admitted but surface surveys such as gravity or MT survey will be admitted. A deviated well drilling toward this zone is not admitted.
Class 2 and 3 Special zones	Development is prohibited. Even surface survey is prohibited.	Development is basically not admitted but small scale development may be allowed if environmental consideration is well treated.
Ordinary zones	The development is basically not admitted but small scale development may be allowed if environmental consideration is well treated.	Development is admitted.

2.1.2 Financial supports by METI

Since 2012, METI has been supporting domestic geothermal businesses by financial support as follows: (1) Subsidization for exploration drilling; Government's support for geothermal drilling (~USD 15 million a year) was to be abolished in FY2011. However after the nuclear accident in 2011, the government decided to increase this budget to ~USD 90 million from FY2012 covering up to 50% of the cost of exploration well drillings, (2) New budget for Public Acceptance (PA) covering 100% of PA activities by private sectors, and (3) RD&D including EGS and ordinary hydrothermal systems. These financial supports by METI, which used to be done through NEDO, is conducted by Japan Oil, Gas and Metals National Corporation (JOGMEC) since FY2012, though some part of RD&D is still conducted by NEDO.

Feed in Tariff (FIT) law for renewable energy was enacted and price is fixed in 2012 except for PV (PV is proceeding to other renewables). FIT price for larger geothermal power generation (15 MWe or larger) is 27.3 yen/kWh for 15 years. For smaller geothermal power generation (smaller than 15 MWe) is 42 yen/kWh for 15 years. Thus geothermal projects get double financial support from the government (drilling support and FIT). It gives incentives for geothermal developers. The only remaining economical obstacle is high power transmission fee requested by electric power companies (monopoly service). However it may also be reduced by free competition of transmission services introduced in 2013.

2.1.3 Guideline for drilling license by MOE

A guideline for geothermal drilling license was authorized by MOE in 2013. It may shorten the period taken for drilling permission given by prefecture government and may help holding discussion with local residence, especially hot spring (onsen) owners, who might be against geothermal development.

2.2 Present Status

Such supports by the government encouraged new geothermal exploration activities by private sectors. Japan Geothermal Association (JGA) was established in Dec. 2012. It consists of 49 companies and 3 organizations (dated May 2013), including metal developers, oil and gas developers, power supplier, trading companies, construction companies, turbine makers, plant makers, geothermal consultants, drillings companies, and banks.

Table 4. Utilization of geothermal energy for electric power generation as of 31 December 2014

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 GWh/yr 4)	Under Constr. or Planned MWe
Hokkaido	Mori	1982	1		2F	25*2	9.36	81.956	
Iwate	Matsukawa	1966	1		D	23.5	10.79	94.563	
Iwate	Kakkonda	1978	3		1F	50	18.24	159.799	
		1996			1F	30	16.92	148.204	
Akita	Sumikawa	1995	1		1F	50	34.24	299.955	
Akita	Uenotai	1994	1		1F	28.8	20.56	180.081	
Miyagi	Onikobe	1975	1		1F	15	4.16	36.452	
Fukushima	Yanaizu-Nishiyama	1995	1		1F	65	28.41	248.886	
Tokyo	Hachijojima	1999	1		1F	3.3	1.66	14.56	
Oita	Takigami	1996	1		1F	27.5	26.83	235.012	
Oita	Otake	1967	1		1F	12.5	7.86	68.838	
Oita	Hatchobaru	1977	3		2F	55	39.63	347.189	
		1990			2F	55	36.42	319.004	
		2006			B	2	1.07	9.384	
Kagoshima	Ogiri	1996	1		1F	30	25.85	226.488	
Kagoshima	Yamakawa	1995	1		1F	30	17.36	152.042	
Akita	Onuma	1974	1		1F	9.5	6.33	55.462	
Oita	Suginoi	2006	1		1F	1.9	0.884	7.746	
Oita	Kuju	2000	1		1F	0.99	0.338	2.964	
Kagoshima	Kirishima-kokusai	2010	1		1F	0.1	0.027	0.235	
Gifu	Abo-tunnel	2013	1		B	0.003			2 (2015)
Nagano	Shichimi Spring	2014	1		B	0.02			
Hyogo	Yumura Spring	2014	1		B	0.03			
Kumamoto	Hagenoyu	2014	3		B	2			
Kumamoto	Oguni Matsuya		1		B	0.06			
Oita	Goto-en	2014	2		B	0.09			0.054
Oita	Beppu Spring	2014	4		B	0.5			
Total						517.8	306.94	2688.8	

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.
2) 1F = Single Flash, 2F = Double Flash, D = Dry Steam, B = Binary (Rankine Cycle)
3) Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.
4) Data for FY2011 (April 2011-March2012) from TNPES (2013).

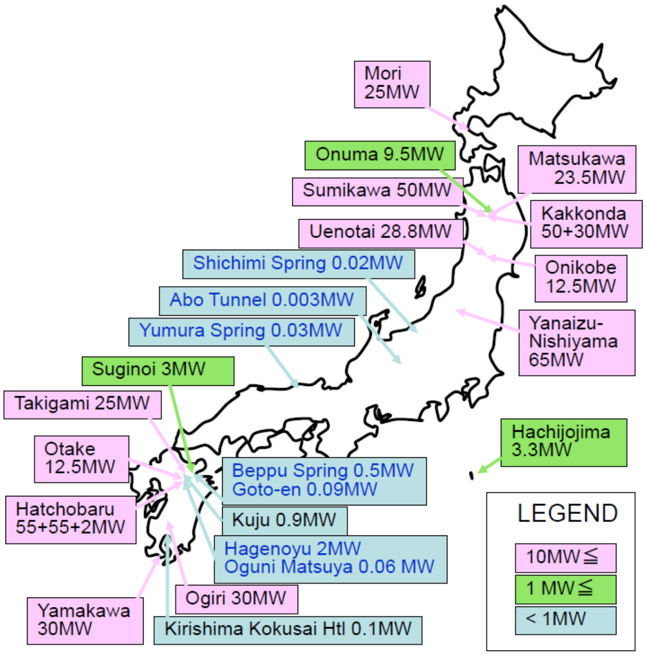

Fig. 2 Installed capacity of geothermal power plants in Japan (status of 2014)

Currently over 40 prospects are under exploration or development; 19 prospects over 10 MWe, 7 prospects from 1 to 10 MWe, and 18 prospects under 1 MWe. Seven small binary systems (0.003 to 2 MWe) are installed in years 2013 and 2014. As for larger plants, two projects which began before 2011 are preceding: TOHGEC group began exploration drilling in 2013 in Hachimantai, aiming at 10 MWe GPP and Yuzawa-Chinetsu Co. Ltd. (J-Power, MMC and Mitsubishi Gas) began environmental assessment in Wasabizawa geothermal field, aiming at 42 MWe GPP in 2020.

3. DIRECT USE

3.1 Conventional Direct Use

Data for conventional direct use is not collected by any organization for these five years. Considering the uncertainty of the data ever collected for bathing, which is the majority of direct use of the nation, and the fact there is no news of drastic change of direct use, it may be appropriated to show the same number as presented in WGC2010 by Sugino and Akeno (2010) as shown in Fig. 3.

Note that installations of shallow borehole heat exchange systems without heat pumps are increasing gradually in recent years. Most of these systems are installed with shallow borehole (less than 100 m) at non-geothermal area with normal geothermal gradient and used for both space cooling and heating. Thus such a system has different aspects from conventional direct use and more alike to GSHP systems (They are not included in Fig.3, but installed capacity is still negligible in the scale of Fig. 4.

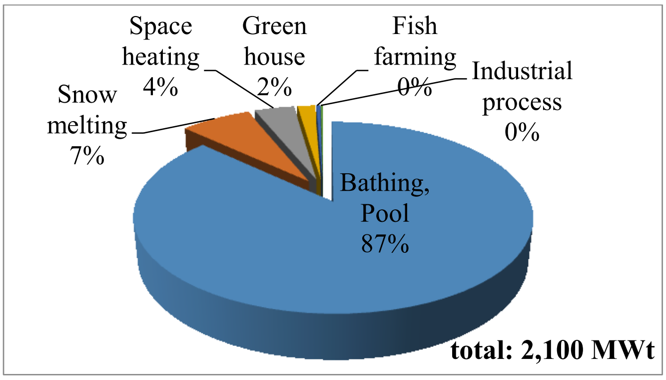

Fig. 3: Capacity of conventional direct use of geothermal energy in Japan (data from Sugino and Akeno, 2010).

3.2 Ground Source Heat Pump (GSHP)

Ground source heat pump (GSHP) systems are used for space heating, cooling, domestic hot water supply, and snow melting. They are classified into closed-loop and open-loop systems.

Many open-loop GSHP systems were installed in urban areas in the 60s and 70s. However, a new installation of an open-loop system was strictly restricted by regulations after the central and local government groundwater laws were in force to prevent land subsidence. Some of the old open-loop systems are still working in local cities where groundwater regulation is not applied.

Installation of closed-loop systems began in Hokkaido since early 1980s after the oil crisis. Some domestic companies manufactured heat pumps for GSHP systems. Other companies imported geothermal heat pumps and drilling machines to make a borehole for a ground heat exchanger. The number of annual facility installations were less than ten those years. Most Japanese people were not aware of energy efficiency of GSHP systems whereas the government conducted the "Sunshine Project" to promote renewable energies including research and development of geothermal resources mainly for power generation.

A renewed interest in GSHP system was risen after WGC2000 held in Japan. Private sectors established Geo-Heat Promotion Association of Japan in 2001 for its promotion. MOE began giving subsidies for installation of GSHP systems for the purpose of reduction of urban heat island phenomenon (UHIP) while METI also did later for energy saving purpose. A topical matter is that the building belonging to the highest tower in Tokyo, Sky Tree, built in 2013, is air-conditioned by GSHP system which made GSHP system more popular.

The statistics of GSHP systems were published by MOE in 2012 (MOE, 2012). It contains the data of closed- and open-loop systems from 1981 to 2011. The total number of facilities using GSHPs is 990 including 836 closed-loop, 149 open-loop, and 5 using both. Installed capacity of all the GSHPs is 62 MWt. Many systems have been installed in the northern districts including Hokkaido, indicating the economical predominance of GSHPs when they replace an old oil boiler into a new GSHP.

In 2010 the Japanese government published the Basic Energy Plan describing ground source heat pumps. In 2011, METI made a policy promoting the use of heat from renewable energy sources including granting subsidies to local municipalities and private companies. Thus an accelerated installation of GSHPs in Japan is expected in the coming years. Figs. 4 to 7 show the present status and recent increase of GSHP systems in Japan.

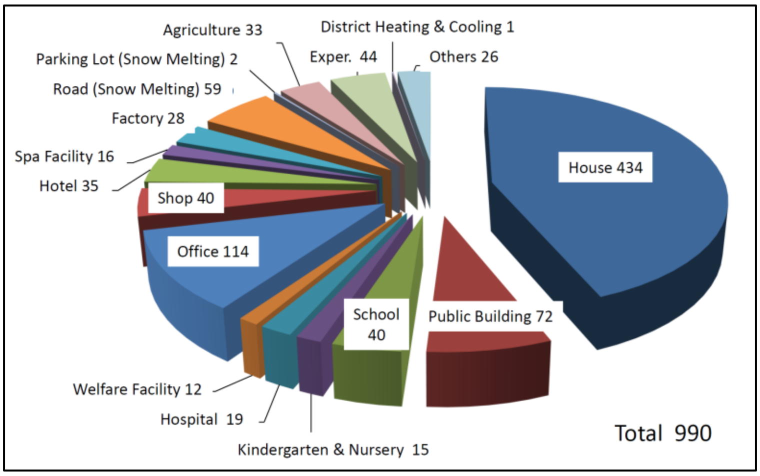

Fig. 4: The total number of installation for different facilities (MOE, 2012).

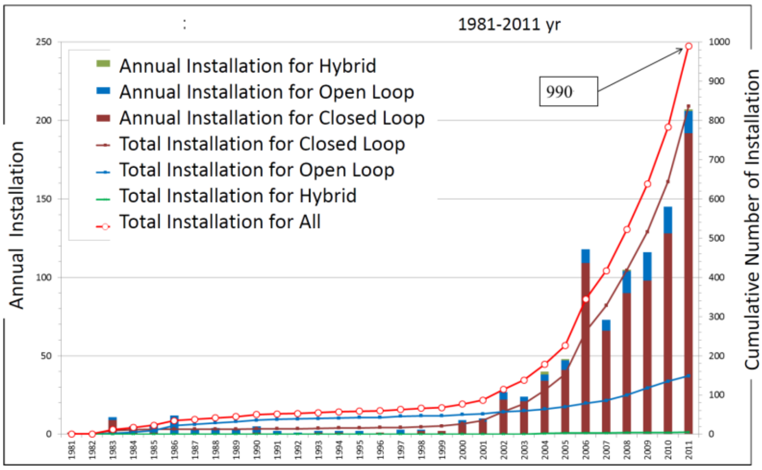

Fig. 5: Increasing number of GSHP installations in Japan (MOE, 2012).

4. CONCLUSIONS

In spite of its rich geothermal potential, Japan had not utilized its energy sufficiently and geothermal power capacity had not been increased for more than a decade in the 21th century. It is mainly due to lack of economic competitiveness and of social systems which discourages new geothermal development. However after the nuclear accident in March 2011, renewed interests in geothermal power generation and government's supports led plural geothermal development projects recent years. As of in year 2014, over forty prospects are under exploration or development; nineteen prospects over 10 MWe, seven prospects from 1 to 10 MWe, and eighteen prospects under 1 MWe. Seven small binary systems (0.003 to 2 MWe) are installed in years 2013 and 2014.

Installation of GSHP system is steadily increasing these years. Although its total installation number is merely about 1,000 in the whole nation, it shows a multiplicative increase.

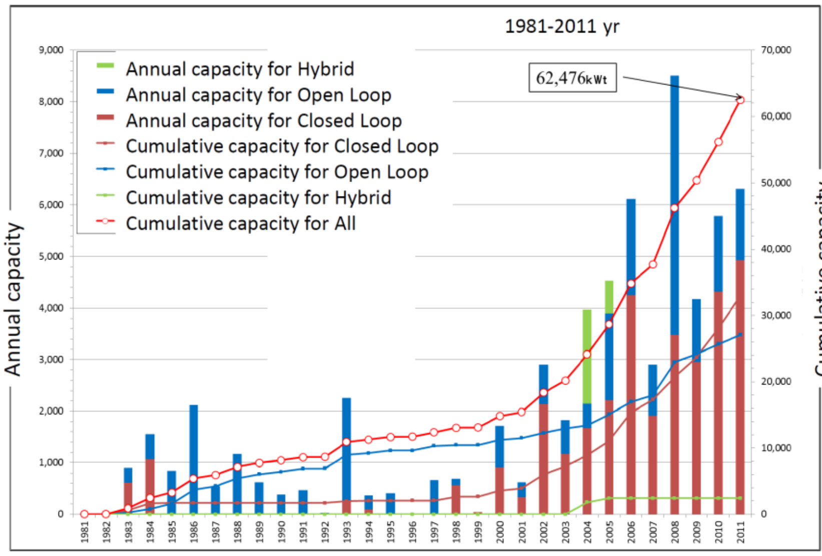

Fig. 6: Increasing capacity of GSHP systems in Japan (MOE, 2012).

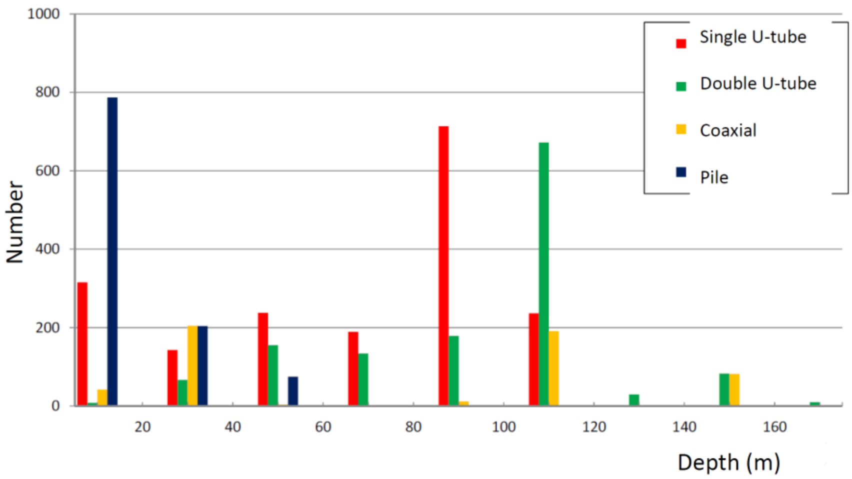

Fig. 7: The cumulative number of installed borehole heat exchangers with different types and depths (MOE, 2012)

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