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

Geothermal Development in Mongolia: Country Update

Purevsuren Dorj

Mailing address, Clean Energy Consulting LLC, 150/3 Building, Chinggis Avenue, Khan-Uul District, Ulaanbaatar 17032, Mongolia

E-mail address, dorj.purevsuren@yahoo.com

Keywords: Ground source heat pump, traditional sanatorium and bath, tourist camps

ABSTRACT

This paper describes an update of geothermal development in Mongolia in last decade. Previous update, which is presented on the Proceedings World Geothermal Congress 2005 and stated general characteristics, geothermal resource potentials and present applications of existing 43 hot spring fields.

Several hot springs at Ikh Onon, Saikhan khulj, Khujirt, Khuremt, Mogoit, Taats, Shargaljuut, Uheg, Tsenkher, Tsagaan Sum, Shivert, Chuluut, Noyon, Zaart, Otgontenger, Ulaan khaalga, Salbart, and Khunjil are more developed as most popular tourist sites of domestic and foreign tourists for sanatorium and bathing.

Due to the high air pollution in the capital city Ulaanbaatar, several projects and activities implemented for a ground and groundwater source heat pumps for both public and private sectors. A first groundwater heat pump system based on utilization of shallow ground water (Single Well System) built in Ulaanbaatar. It provides building with heating and cooling, as well as with domestic hot water. Also the ground source heat pumps have been installed at the kindergarten, school and hospital buildings.

1. INTRODUCTION

The Government of Mongolia aims to overcome dependence on traditional energy sources (~95% of total energy consumption derives from coal burning) via the National Renewable Energy Program (2005-2020), which proposes 3-5% energy use from renewable sources by 2010, and 20-25% by 2020. The Program targets sustainable social-economic development by increasing efficiencies and the share of renewable energy in the total energy supply, particularly in rural areas where geothermal development will play a role in future building and district heating schemes.

Table 1: Installed capacity of power plants in Mongolia and its percentage share (2014).

#	Type of Power Plant	Installed Capacity, MW	Percentage share, %
1	Combined Heat and Power	877.3	72.2
2	Diesel Generator	46.4	3.8
3	Hydro	28	2.3
4	Wind	50	4.1
5	Solar	3.7	0.3
6	Import	210	17.3
	Total	1215.4	100

A current status of the energy production is shown in Table 1 and Figure 1. So far the renewable energy development in Mongolia has over the main goal of the National Renewable Energy Program by 2010 and the renewable energy share is 6.7 % at the 2014 (Dorjpurev 2014).

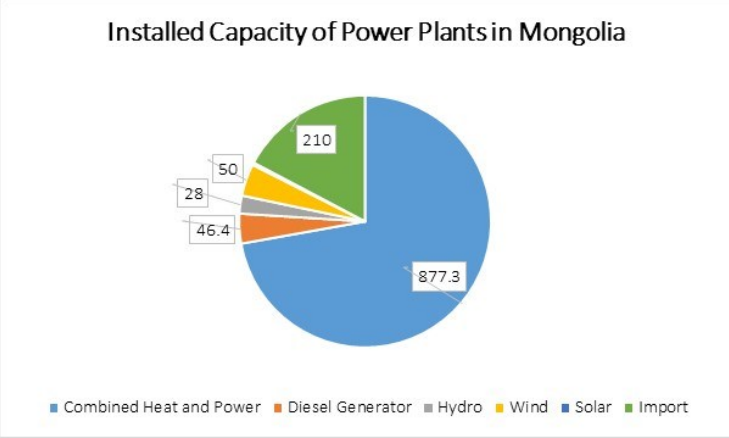

Figure 1: Installed capacity of power plants in Mongolia in 2014.

2. GEOTHERMAL RESOURCES AND APPLICATIONS - UPDATE

This section describes geothermal energy resource utilization in Mongolia and a new application of a ground source heat pump.

2.1 Geothermal Resources

There are 43 geothermal areas in Mongolia, with many utilized for heating, bathing and medicinal purposes. There is presently no electric power utilization from geothermal resources. National Sanatoriums utilize thermal waters via shallow (typically <100 m deep) wells at Tsenkher, Hujirt, Shargarljuut, Zart, Shivert (renovated by Megawatt LLC in 2008), Khalzan uul, Eruu and Tsagaan Tal. Regional surveys have identified resource potential in the (i) Mongolian Altai (54±24 mW/m^2), (ii) Khangai region (52±6 mW/m^2), (iii) Khentii region (65±10 mW/m^2), (iv) Khuvsgul nuur region (60±12 mW/m^2), and (v) Dornod Mongolian region (44±6 mW/m^2), with hot springs at Tsenkher, Khujirt and Shargaljuut (Khangai) attracting development interest. There is no obvious heat source in the Khangai, although solute geothermometry points to resource temperatures up to 160 °C, with hot spring waters likely associated with conductive heat from the Baikal rifting system channelled to the surface via faults and fractures.

Pre-feasibility studies for energy projects have been conducted by government and private companies such as Newcom LLC and Megawatt LLC. The National Renewable Energy Centre of Mongolia has completed a number of surveys, and NewCom LLC plan exploration drilling at Bagashargaljuut. Resources in Tsetserleg are promising, with a pre-feasibility study completed for a geothermal heating system. In the future, international financial institutes and private sector investors will play a greater role in speeding up geothermal energy development in Mongolia.

2.2 Geothermal Application in Mongolia

Two types of geothermal applications are well developed in Mongolia last decade. Those are of course a traditional sanatorium and a new technology ground source heat pump. The ground source heat pump application started from 2008 in Mongolia.

2.2.1 Traditional sanatorium and tourist camps

The traditional sanatorium and bathing are continuously developing in the country and more for local and foreign tourists. Many tourist camps established nearby the hot spring areas and built a hot pots and small swimming pools for bathing and swimming. Also several private sanatoriums are established in the hot spring areas such as Ikh Onon, Saikhan khulj, Khujirt, Khuremt, Mogoit, Taats, Shargaljuut, Uheg, Tsenkher, Tsagaan Sum, Shivert, Chuluut, Noyon, Zaart, Otgontenger, Ulaan khaalga, Salbart, and Khunjil.

2.2.2 Shallow geothermal heat pumps

In the last decade, a several ground source heat pumps (GSHP) were installed in Mongolia.

(1) Heat Pump at the Corporate Nukht Hotel

A groundwater heat pump system based on original, innovative technology for the development and utilization of shallow ground water - the “Single Well System” (HYY SWS) is presented. It was developed by the Beijing Ever Source Science and Technology Development Co., Ltd (HYY) to provide buildings with heating and cooling, as well as with domestic hot water. So far, the HYY SWS has mainly been installed in China, with one system operating in Mongolia (Xu and Rybach 2010). This is a first groundwater source heat pump system installed in Mongolia.

Why is “Shallow Geothermal Energy” a smart choice?

Earth heat is an energy stored in the form of heat below earth surface. This energy can be used to heat buildings through geothermal energy probes and heat pumps. The heat pump converts low-level heat energy from the ground into a form suitable for heating buildings. Thus, about 75% of heating energy can be supplied through Shallow Geothermal Energy from the ground with the remaining 25% provided by electricity. By using Shallow Geothermal Energy, The Corporate Hotel and Resort is often been called a first green hotel in Mongolia. We put our best effort to reduce CO^2 from our Mother Earth (Corporate Nukht Hotel).

(2) Heat Pumps installed by the National Renewable Energy Center State Owned Enterprise

The National Renewable Energy Center State Owned Enterprise (NREC) has actively involved in a heat pump installation activities since 2010. They have installed the three ground source heat pumps in public buildings such as a school, dormitory and kindergarten located in the Tuv province center which is 45 km southwest of the Ulaanbaatar capital city (Badrakh E. 2012).

They have used Natura BWH280 and BWH268.1 types of ground source heat pumps in the following buildings:

- Total of 1,120 square meter kindergarten building. A capacity of the heat pump is 90kW. A type of the heat pump is NATURE BWH280.
- Total of 2,120 square meter school building. A capacity of the heat pumps are 90kW and 76.8 kW. Types of the heat pump are NATURE BWH280 and NATURE BWH268.1.
- Total of 600 square meter hospital building. A capacity of the heat pump is 76.8 kW and BWH268.1 type.

The total investment of the three heat pumps was 1,360,000,000 MNT or approximately 1,027,648.3 US$ (the Mongol Bank rate is 1323.41 MNT equals 1 US$ dated as 01 October 2010). The investment is done by the State budget 2010 of the Government of Mongolia.

The Natura BWH280 type heat pump and solar vacuum collector coupling scheme is shown in the Figure 2. To ensure the heating supply is enough during the cold winter in Mongolia below -30°C the heat pump system is feed by a solar vacuum collector system

which is installed on the building roof. Some photos taken during the installation of the heat pump and solar vacuum collector hybrid system is shown in the Figure 3.

The three buildings were separately heated by a coal burning heat only boilers before the heat pump installed. For instance, the kindergarten burn approximately 357 tons of coal in a year. Since the heat pump installed in 2009, the coal fired boiler not in use and kept us back up heat source.

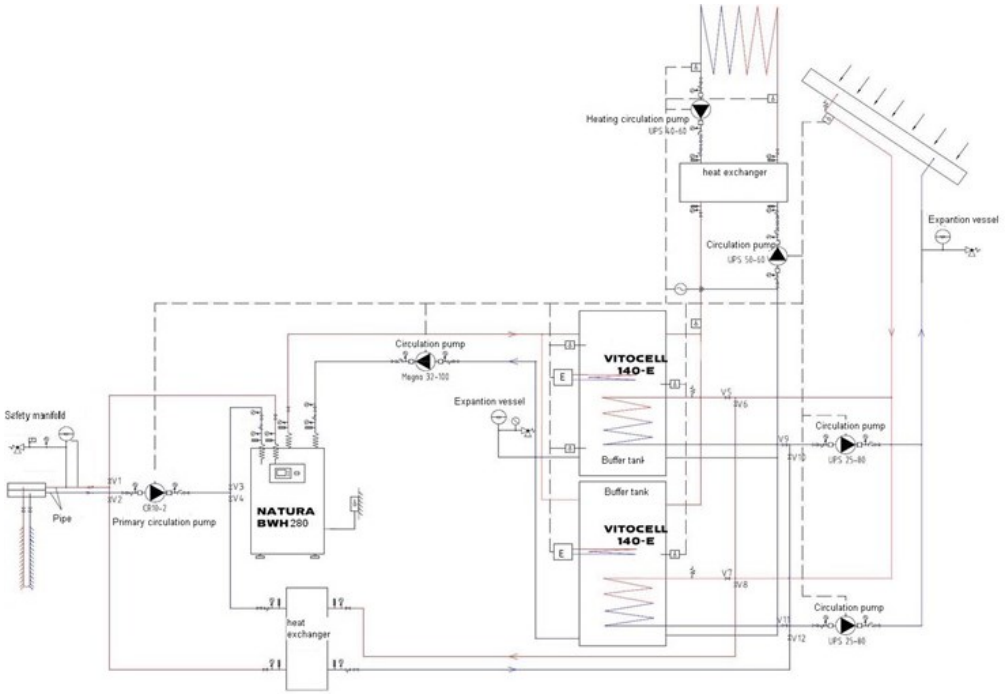

Figure 2: Heat pump and solar collector coupling scheme/device.

Figure 3: Ground source heat pump and solar vacuum collector hybrid building heating system.

(3) Heat pumps installed by Steppe Solar LLC

The Steppe Solar LLC is a private company which is specialized for a research and development of a ground and groundwater source heat pumps in Mongolia. A first heat pump system installed by the Steppe Solar LLC is VITOCAL 242-G type ground

source heat pump in a school building (total of 134 square meter) in Bayanzurkh district of Ulaanbaatar in 2009. After that they have installed a three heat pumps in the following buildings (Tsolmonbaatar 2011):

- Total of 149 square meter a kindergarten building in Songinokharkhan district. A capacity of the heat pump is 16.7 kW. A type of the heat pump is BWH113.
- More 9.4 kW BWT242 in a kindergarten.

3. DISCUSSION / TABULATED DATA

Mongolia has vast land area and a large number of small, isolated settlements with 50 to 200 households and using coal fired individual furnaces. In the future, it is likely that an individual ground source heat pump solution will prove the most economic means of solving the country's problem of providing heating to the rural areas.

There are three heating systems in Mongolia. About 30% of the population obtains heat from a central source, through a district heating system. Another 10% obtain heat through a non-centralized system, such as small-sized boilers. The vast majority of the population, however, provide their own heat, either by the use of coal in stoves (urban centers) or by bringing wood and/or dried dung (rural areas).

Now Mongolia is over in transition from a centrally planned to a market oriented economy and going to shift from developing country to developed country in near future. Also one of a fast economic growth country in the world now. The GDP was 17.5% in 2011 (World Bank 2014). The Government of Mongolia is continuously supporting renewable energy development in the country and one of the country has legal environment to use renewable energy such us solar, wind, hydro and geothermal energy in the country. The feed-in tariff of the renewable energy for on-grid and off-grid systems set in the Renewable Energy Law (Renewable Energy Law 2007).

At present, there are almost no electrified areas in the country but heating has problem due to the high operation and maintenance cost of coal firing and environmental issues such as an air pollution, health and etc.

Thus, the ground source heat pump will play a main heat energy source for Mongolians in the near future. The following tables summarize the present state of geothermal development and utilization in Mongolia:

Table 2: Present and planned production of electricity.

#	Fossil Fuels		Hydro		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
operation in December 2014	923.7	5.23	28	0.065	53.7	0.052	1005.4	5.347
Under construction in December 2014	150				50		200	
Funds committed, but not yet under construction in December 2014					102		102	
Estimated total projected use by 2020	1325	8.7	784		468		2577	2577

Table 3: Utilization of geothermal energy for direct heat as of 31 December 2014 (other than heat pumps).

			Maximum Utilization					Capacity[3)]	Annual Utilization		
Locality		Type	Flow Rate	Temperature (°C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
			(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
1	Sharlgaljuut	H	3.15	92	40			0.685	3.1	21.3	0.99
2	Ikh Onon	B	11	88	30			2.669	5.5	42.1	0.50
3	Saikhan khulj	B	2.3	55	30			0.241	1.15	3.8	0.50
4	Khujirt	B	16	55	30			1.674	8	26.4	0.50
5	Khuremt	B	5	55	30			0.523	2.5	8.2	0.50
6	Mogoit	B	7	72	30			1.230	3.5	19.4	0.50
7	Taats	B	2.5	55	30			0.262	1.25	4.1	0.50
8	Shargaljuut	B	25	92	30			6.485	12.5	102.2	0.50
9	Uheg	B	5	57	30			0.565	2.5	8.9	0.50
10	Tsenkher	B	10	86	30			2.343	5	36.9	0.50
11	Tsagaan Sum	B	8	69	30			1.305	4	20.6	0.50
12	Shivert	B	4	55	30			0.418	2	6.6	0.50

13	Chuluut	B	1.2	45	30			0.075	0.6	1.2	0.50
14	Noyon	B	6	38	30			0.201	3	3.2	0.50
15	Zaart	B	2.8	44	30			0.164	1.4	2.6	0.50
16	Otgontenger	B	1.7	56	30			0.185	0.85	2.9	0.50
17	Ulaan khaalga	B	0.2	37	30			0.006	0.1	0.1	0.50
18	Salbart	B	6	44	30			0.351	3	5.5	0.50
19	Khunjil	B	0.1	62	30			0.013	0.05	0.2	0.50
TOTAL								19.396		316.26	

Note: H = Individual space heating (other than heat pumps), B = Bathing and swimming (including balneology).

Table 4: Geothermal (ground-source) heat pumps as of 31 December 2014.

#	Locality	Ground or Water Temp.	Typical Heat Pump Rating or Capacity	Number of Units	Type	COP	Heating Equivalent Full Load	Thermal Energy Used
		(^{o}C)	(kW)				Hr/Year[4)]	(TJ/yr)
1	Kindergarten in Zuunmod	8	90	1	V	3.9	3960	2.6
2	School in Zuunmod	8	90	1	V	3.9	3960	2.6
3	School in Zuunmod	8	76.8	1	V	3.9	3960	2.4
4	Hospital in Zuunmod	8	76.8	1	V	3.9	3960	2.4
5	Corporate Nukht Hotel	6	400	1	W		3960	13.2
6	1 floor kindergarten	8	16.7	1	V	3.8	3960	0.6
7	1 floor kindergarten	8	9.4	1	V	3.8	3960	0.4
	TOTAL		759.7					24.2

Note: V = vertical ground coupled, W = water source.

Table 5: Allocation of professional personnel to geothermal activities.

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010	1	3	2	2		10
2011						
2012	1					
2013						
2014						
Total	2	3	2	2	0	10

Note: (1) Government, (2) Public Utilities, (3) Universities, (4) Paid Foreign Consultants, (5) Contributed Through Foreign Aid Programs, and (6) Private Industry.

Table 6: Total investments in geothermal in (2014) us$.

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999						
2000-2004	0.03					
2005-2009	0.05				100	
2010-2014			1.02			100

Note: The Icelandic company called Rafhonnun has spent over 30 thousand US dollars for the prefeasibility study on Tsetserleg Geothermal Heating system. The NewCom LLC has spent approximately 50 thousand US dollars for pre-feasibility study of Baga Shargajuut hot spring area in 2006. The Government of Mongolia has provided 1.02 million US dollar for the investment of three ground source heat pumps in Tuv province center in 2010.

Purevsuren

4. CONCLUSIONS

At present, there is no geothermal resource utilization in Mongolia for electricity (power) generation. In the foreseeable future, most geothermal resource utilization is anticipated be for direct use applications, which are expected to include district heating schemes, cashmere and wool processing, horticultural applications, balneological and therapeutic purposes, and development of the country's tourism industry.

The ground source heat pump utilization is promising to develop among the rural community for the individual space heating and will replace the coal burning heat only boilers and reduce GHG emission.

ACKNOWLEDGMENTS

The authors wish to thank Mr. Badrakh (National Renewable Energy Center State Owned Enterprise) and Mr. Tsolmonbaatar (Steppe Solar LLC for their support during the preparation of this paper.

I am sincerely grateful to the staff of the UNU Geothermal Training Programme, the professors of the University of Iceland, and the staff of Orkustofnun and ISOR, for their lessons, lecturers, supports and guidelines during my study in Iceland in 2001 and 2003-2005 and given knowledge on geothermal energy, which made this report possible.

I also want to thank the WGC reviewers for their suggestions to improve the manuscript.

REFERENCES

Badrakh, E. and et al.: Result of the Installation of Ground-Source Heat Pump System in Kindergarten in Zuunmod Soum of Tuv Province, *Scientific Report,* National Renewable Energy Center State Owned Enterprise, Ulaanbaatar, Mongolia, (2012), 56 p.

Corporate Nukht Hotel: Introduction, http://www.corporatehotel.mn/nukht.html, (2013).

Dorjpurev, D.: "Energy Mongolia-2014", *Proceedings*, International Conference and Expo, 22-24 May 2014, Ulaanbaatar, Mongolia, (2014), 10 p.

Renewable Energy Law of Mongolia, *Parliament of Mongolia*, Ulaanbaatar, Mongolia, Approved in 2007.

Tsolmonbaatar Ts. and et al.: Renewable Energy and Rural Electrification Project, *Proceeding*s, 3rd Renewable Energy Forum, Ministry of Energy, Ulaanbaatar, Mongolia, (2011), 8 p.

World Bank: Introduction on Mongolia, http://www.worldbank.org/en/country/mongolia, (2014).

Xu, Sheng-heng, Rybach, L.: Innovative Groundwater Heat Pump System for Space Heating and Cooling in USA and

China, *Proceedings*, World Geothermal Congress 2010, Report 2914 , Bali, Indonesia, 25-29 April (2010).