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Geothermal Energy Resources, Present Utilization and Future Developments in Mongolia

Iderbat Lkhagvadorj [1] (MSc) and Batbayar Tseesuren [2] (MSc)

Renewable Energy Corporation, PO Box 479, Ulaanbaatar 210136, Mongolia

E-mails: [1] - idergerel@mobinet.mn, idergerel@yahoo.com; [2] - tseebat@yahoo.com

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ABSTRACT

The report presents an overview of the studies for the assessment of geothermal energy resources and current utilizations of geothermal energy in Mongolia. The objective of the report is to evaluate present situations, investigate reasonable and profitable applications of geothermal energy in Mongolian circumstances and point out the suitable ways to develop the geothermal energy exploration and utilization. Mongolia is rich in low temperature geothermal resources, but there are almost no reliable commercial uses of geothermal energy. Ample and comprehensive studies on geothermal resources and their potential uses have not been carried out in Mongolia. The most of the natural hot springs are used for traditional balneology purposes, some greenhouses and small-scale heating systems are being used to limited extent. Using geothermal energy in centralized or small-scale heating, health treatment, eco-tourism and industrial uses are the main incentives for developing a geothermal infrastructure in Mongolia.

1. INTRODUCTION

Mongolia is situated in the northern part of the Asian plateau, where mean elevation is 1500m above sea level, covering an area of 1.57 million sq. km. The northwest and central parts of Mongolia are high mountainous regions, where the eastern part is a vast plain steppe and southern part is semi-desert. Population of Mongolia totals 2.4 million, where 45% is rural, 55% is urban, and 30% of total population lives in the capital city. Because of vital importance of pastureland for livestock, nomadic families settle scattered, constantly moving all the year around.

Centralized electricity network in Mongolia consists of western, central and eastern grid systems, where electricity is produced by coal fuelled thermal-electric power plants or imported, and serves 50% of the total population, but only 40% of land area. District heating systems in major cities are based on thermal-electric power plants or coal fuelled boilers, which serve 40% of total population. Other local centres are in critical situation of energy supply, where diesel power stations and five hydro power plants are supplying domestic consumers with electricity mainly for 4-5 hours daily, except for four provincial centres for 24 hours a day. Some major institutions such as hospitals, primary schools, telecommunication facilities, and governmental offices are supplied by small photovoltaic systems and wind turbines. Heating demand is covered by small coal boilers and simple household stoves fired by coal, firewood, agricultural waste, animal dung etc. Nomadic families, 45% of total population, are self-sufficient with small-sized photovoltaic, wind electric systems. The rest of them have no reliable access to modern electricity and space heating system. These situations encourage an increase in the efficiency of existing energy systems and the investigation of alternative and renewable energy sources such as solar, wind, hydro, as well as geothermal energy.

Mongolia is rich in low- and medium-temperature geothermal resources but presently, there is almost no commercial use of geothermal energy. Mongolia has 42 hot springs, mainly distributed in central and western provinces. (See Figure 1) Some of the hot springs is used for bathing and traditional balneology purposes only. Some greenhouses and small scale heating systems are in operation to a limited extent. Ample and comprehensive studies on geothermal resources and their potential uses have not been carried out in Mongolia. Using the geothermal energy for centralized or small-scaled space heating, electricity generation, health treatment, eco-tourism and industrial uses would benefit the local people and be the tourist attraction.

2. GEOTHERMAL ENERGY RESOURCES

2.1. Distribution and Use of Hot Springs in Mongolia

Mongolia has 42 hot springs, mainly distributed in central and western provinces and some of them are used for traditional health resorts and small-scaled greenhouse / space heating only.

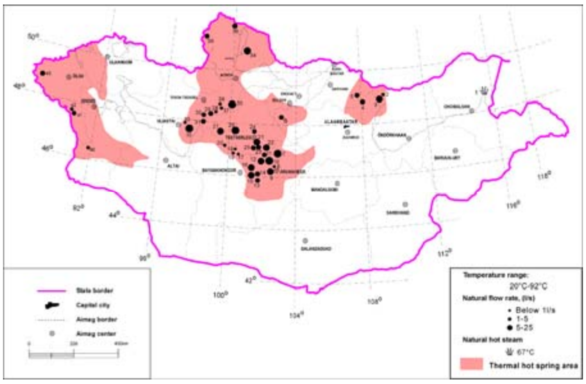

Figure 1. Distribution of hot springs in Mongolia (Batbayar 2001)

Mankind has used hot springs for bathing and washing since the dawn of civilization. In the same way, Mongolia has a considerable experience in health resorts that use geothermal water for relieving many kinds of sickness, such as liver, gallbladder and stomach problems, neurological and skin disorders, hypertension, rheumatism, fatigue and etc. Commercial health resort facilities were built and used in several hot springs such as Tsenkher, Shivert of Arkhangai province, Ikh Shargaljuut of Bayankhongor province, Otgontenger of Zavkhan province, Khujirt of Uvurkhangai province and etc.

Geothermal water from some of the hot springs in Khangai region is used for greenhouse heating, namely Tsenkher of

Arkhangai province, Baga Shargaljuut, Ikh Shargaljuut of Bayankhongor province and Khuremt, Teel of Uvurkhangai Province. (Batsukh et al, 1999)

First attempt to use geothermal water for space heating of health resort in Ikh Shargaljuut were made in 1973. Concrete dam to collect hot water was built on the origin of 3 hot springs with temperature of 88°-89°C and total discharge of 5.5 kg/s. Sanatorium building with 50 beds and restaurant with 120 seats were heated by geothermal water with temperature of 88°-89°C and flow rate of 2.5 kg/s. Return water temperature was 72°C. (Lkhagva, 1973) Today, geothermal water with temperature of 70°-89°C, total flow rate of 720-750 m^3/day is collected from the 5 hot springs and is been used for heating of sanatorium and hotel buildings, cultural centre, restaurant and greenhouse. Geothermal water with temperature of 40-50°C, total flow of 30-40 m^3/day, is used for balneology purposes (Dorjsuren et al, 1990). Geothermal water is only been collected with a concrete dam and stored in reservoir tank, which is located approximately 17 m above the buildings, and is being used by gravity flow.

2.2. Geothermal Structures of Mongolia

Ample and comprehensive studies on geothermal resources and their potential uses have not been carried out in Mongolia. Some general studies on regional geology, tectonics, geophysics, geology, hydro-geology, study of hot springs and chemical analysis carried out. The Ministry of Agriculture and Industry of Mongolia investigated a research programme "Geothermal Energy" in 1999 and as a result of it, scientists reached some conclusions, compiling existing research results.

A geophysical survey on the crustal structure affirmed that accumulative thermal sources (magma lumps) are located near the surface under the Khangai and Khentii mountainous region. Heat flow in Mongolia was studied from 32 heat flow stations (gradient wells) (See Figure 2). However, the heat flow map does not cover the South Mongolia and the Mongolian Altai province, where information is scarce. The average heat flow in different tectonic regions is approximately estimated as follows: Mongolian Altai mountainous region: 54±24 mW/m^2, Khangai mountainous region: 52±6 mW/m^2, Khuvsgul lake region: 80±10 mW/m^2, East Mongolian steppes: 44±6 mW/m^2. (Dorofeeva et al, 1986-1987 and Dorjderem, 1992-1994)

Besides the local anomaly, there is a large regional anomaly with a maximum heat flow in two regions, the North East and South West of Kherlen-Argun regions (Khangai and Khentii mountainous regions).

The Mongolian-Siberian mountainous province includes the Sayan-Baikal, the Altai-Sayan regions and West Mongolian high ranges, and those of Mongolian Altai, Gobi Altai and Khangai. In the Late Cenozoic all this provinces were involved in an intensive orogeny, the latter occurring both in the area under extension and in that under compression (the Sayan-Baikal domain uplift and the Altai uplift system, respectively) (Zorin et al, 1990)

Geothermal energy resources in Mongolia are mainly distributed in Khangai, Khentii mountainous regions, Khuvsgul lake regions, Mongolian Altai platforms, where intensive orogeny took place in Late Cenozoi.

The Mongolian geothermal structural map was made based on regional research materials. (Batsukh et al, 1999).

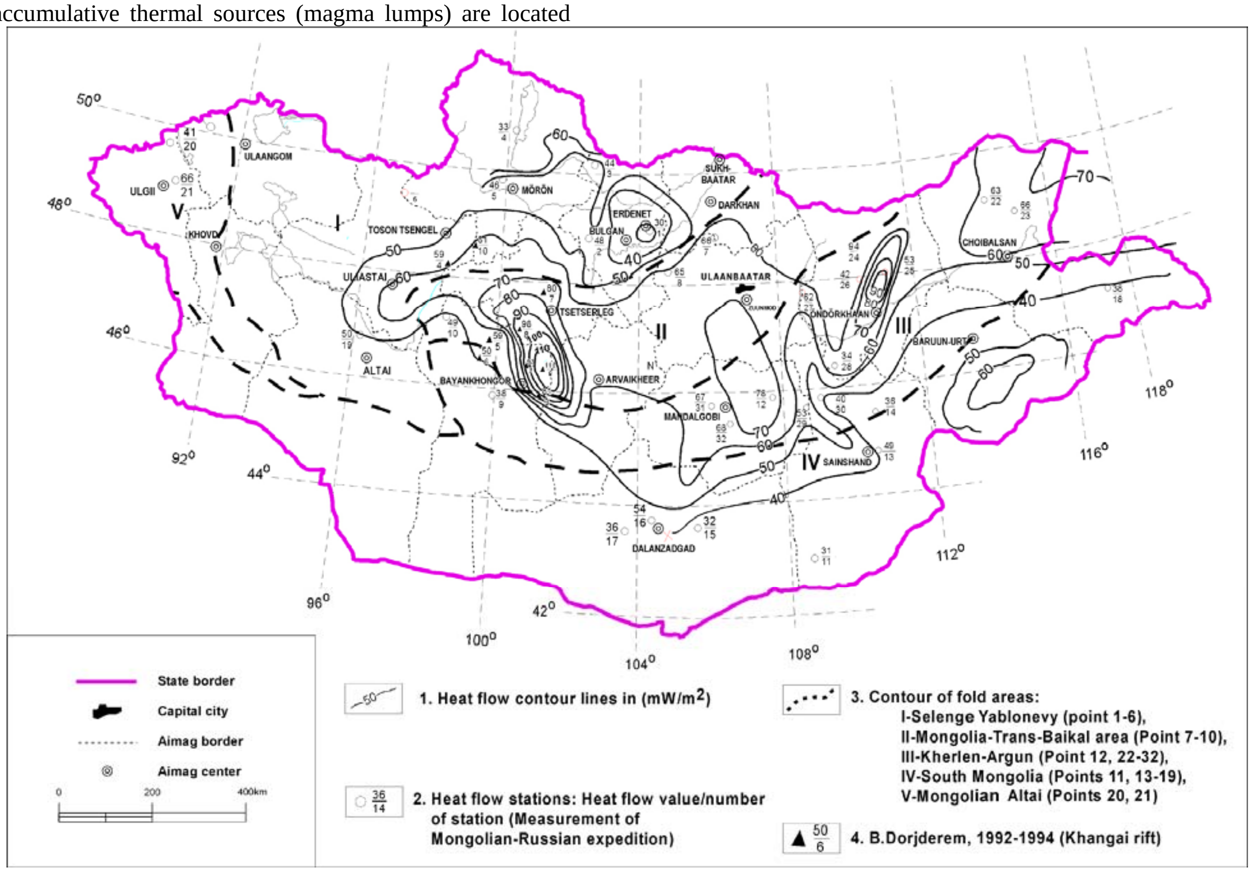

Figure 2. Heat flow map of Mongolia (Dorofeeva, Sintsov, Bat-Erdene, 1986-1987 and Dorjderem, 1992-1994)

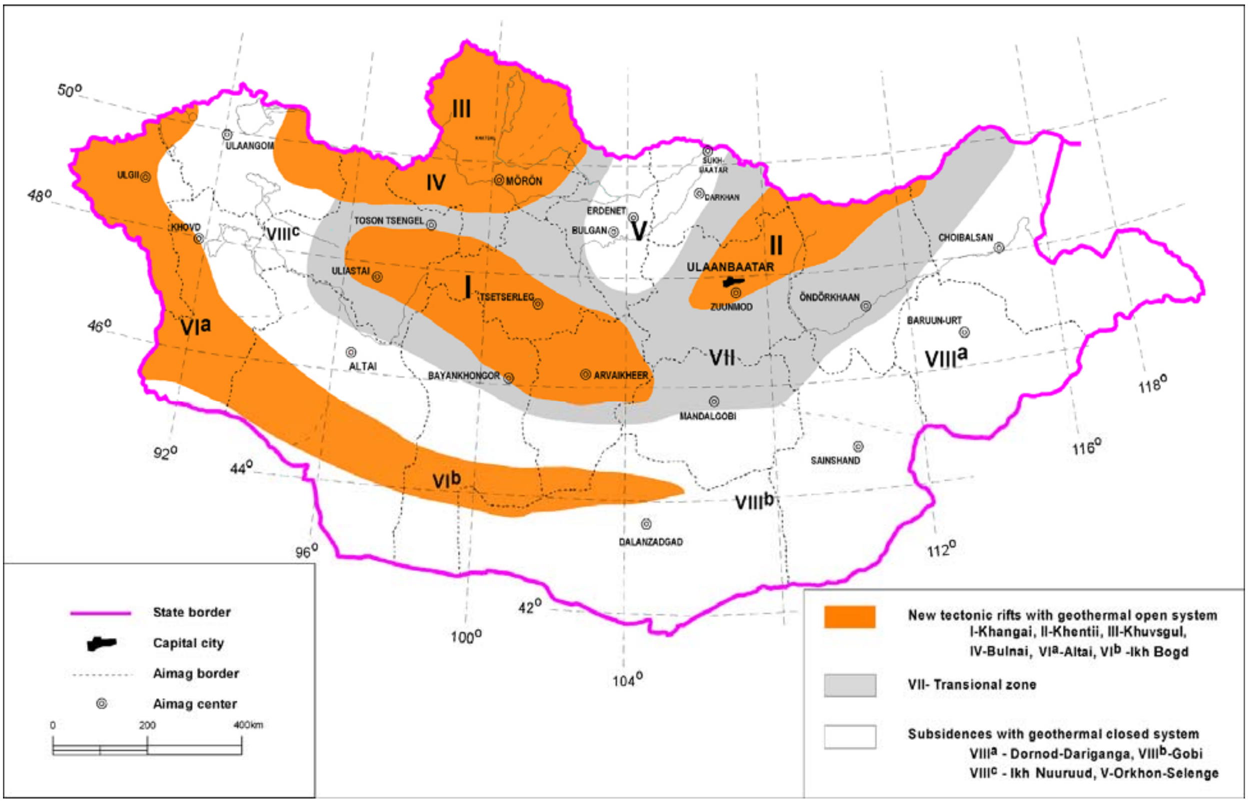

Figure 3. The main geothermal structures of Mongolia (Batsukh, Alei, Dorjderem, Borchuluun, 1999)

Table 1. Outlines of the main geothermal structures of Mongolia (Dorjderem, 1998)

	System	Subsystem	Blockage	Heat flow (kcal/cm^2)	Geothermal gradient (°C/km)	Chemical composition	Minerals (g/l)
Fold platform zone	Khangai	Tarvagatai-Uliastai Baidrag-Taishir Orkhon-Taats	open, semi-open	1.8-2.4	45-80	SO_4, HCO_3/Na, CO_3 HCO_3, CO_3/Na, SO_4	<0.5
	Khentii	Khoid Khentii Onon-Ulz	semi-open closed	1.0-1.2	35-50	HCO_3, CO_3/Na, SO_4 SO_4, HCO_3/Na	<1.0
	Khuvsgul	Nuur Murun	semi-closed closed	0.8-1.2	25-40	SO_4, HCO_3/Na	<1.0
	Bulnai	Bulnai	open	0.7-1.0	20-25	SO_4, HCO_3/Na, CO_3	<0.5
	Altai	Altai Ikh Bogd	semi-closed closed	1	20-30	SO_4/Na, HCO_3	1-5
Transitional zone	Transitional	Mongol-Daur Bayankhongor Bulgan Sant Zaamar	closed	1	20-35	SO_4Cl/Na	3-10
Subsided zone	Dornod-Dariganga	Dornod Dariganga				$ClSO_4$/NaCa	5-25 (150)
	Gobi	Sainshand Gobi	closed	1	20-35	$ClSO_4$/Na	20-80 (300)
	Ikh Nuur	Nuur				$ClSO_4$/Na	15-66 (120)
	Orkhon-Selenge	Orkhon-Selenge				$ClSO_4$/NaMg	10-20

Outlines of the different geothermal regions, transitional and subsided zones are shown in the Table 1. The open geothermal system of Khangai region is the most attractive site with regards to its location, social and economic situation.

2.3. Khangai Geothermal System

Khangai geothermal system consists of Orkhon-Taats, Baidrag-Tamir and Tarvagatai-Uliastai subsystems. Hot springs distributed in the Khangai geothermal system are distinguished with their physical and chemical characteristics due to geotectonic structures of the subsystems, faults, hydro-geological conditions and thermal activities etc.

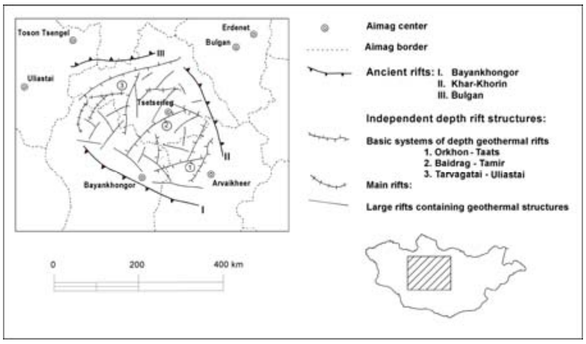

Figure 4. Tectonic rifts of Khangai geothermal system

Hot springs in Tarvagatai-Uliastai subsystem are characterized by water composition of sulphate-bicarbonate and sodium-sulphate-chloride, comparatively low flow rate of 0.1-6 l/s and medium surface temperature of 35-62°C. Hot springs in Baidrag-Tamir and Orkhon-Taats subsystems are characterized by water composition of sodium-bicarbonate, higher surface temperature of 53-92°C, higher flow rate of 4-50 l/s, low mineralization of 0.1-0.2 g/l and high in fluoride and silica. (Batsukh et al, 1999)

Table 2. Characteristics of some hot springs in Khangai geothermal system (Batsukh et al, 1999)

	On the surface		In the depth of 150-300 m	
	T (°C)	Flow (l/s)	T (°C)	Flow (l/s)
Mogoi	66-70	3.5	90	10-15
Tsenkher	69	15	100	20-25
Bor tal	40	18	80	15-20
Ukhug	40	5	90	20
Urguut	50	6	80	10-20
Shargaljuut	90	51	160	30
Tsagaan sum	58	18	90-120	10-15

Table 3. Chemical compositions of hot springs in Khangai geothermal system (Batsukh et al, 1999)

SO_4	60.2-107.0 mg/l
HCO_3CO_3	14.6-90.0 mg/l
Cl	5.7-6.7 mg/l
Na	95-99 mg-eq/l
K	0.3-0.9 mg-eq/l
H_2S	5.9-10.6 mg/l
H_4SiO_4	110-213 mg/l
PH	9.4
Mineralization	0.26-0.80 g/l
N_2	95-98%

3. POTENTIAL USES OF GEOTHERMAL ENERGY IN MONGOLIA

Direct utilization of geothermal energy refers to immediate use of heat energy, without converting it to some other forms such as electrical energy. Generally, the geothermal fluid temperatures required for direct-use applications are lower than those for economic electric power generation. Most direct-use applications use low to moderate temperature geothermal fluids in the range between 50°C and 150°C. Conventional water well drilling equipments can be used for drilling into low and medium temperature geothermal reservoir. And low-temperature systems are also more widespread than high-temperature systems, and they are most likely located near potential users.

The Lindal diagram (Gudmundsson, Freeston and Lienau, 1985) shown in Figure 5, indicates the temperature range suitable for various direct-use applications of geothermal energy. Agriculture, animal husbandry, aquaculture, and recreation require the lowest temperatures, with values from 25° to 95°C. The amounts and types of chemicals and dissolved gases are major problem with plants and animals, thus heat exchangers are often necessary. Space heating in buildings and greenhouses, some industrial processes such as drying and washing, require temperature in the range of 50° to 100°C.

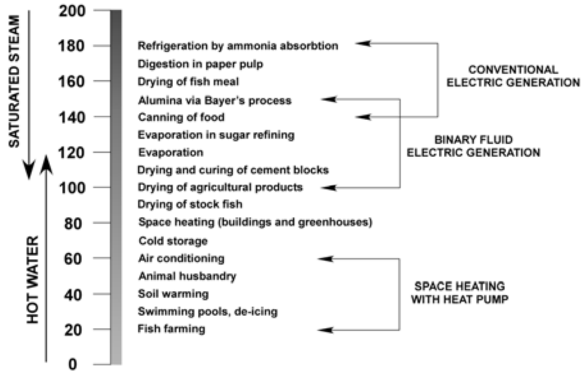

Figure 5. Lindal diagram on direct-use applications of geothermal resources. (Gudmundsson, Freeston and Lienau, 1985)

3.1. Space Heating

Urbanization is increasing from year to year in Mongolia, and it encourages an increase in the efficiency of existing energy systems and the investigation of alternative energy sources for electricity production and space heating. Mongolia has harsh and continental climate, where winters are extremely cold and summers are hot. There are large variations in seasonal and diurnal temperatures. As outdoor temperature is below +15°C for about 8000 hours a year in Mongolia, space heating is needed almost all the year around. (Iderbat, 2003)

Tsetserleg, Bayankhongor and Arvaikher provincial centres are located in the Khangai geothermal region and have a population of approximately 20,000 people each, there would be chance to introduce geothermal space heating in this region. For this purpose, additional geological, geophysical and hydro-geological explorations for the detailed assessment of geothermal energy resources should be done in this region.

3.2. Tourism, Health Spa and Recreation

As most of the hot springs is located in naturally preserved, tourist attracted sites, geothermal water can be used for health spas, recreation centres and heating of tourist camps etc. Mongolia receives approximately 200,000 tourists every year and main tourist attracted areas located in the central and western provinces, where geothermal activity is. As an example, utilization oh geothermal water in small tourist camp in Tsenkher hot spring of Arkhangai province is shown in Figure 6.

It is principally proven that physical or mechanical effects, and dissolved minerals of thermal water help human body to rest and relax, and treat some diseases or disorders. The thermal effects of geothermal water are dominant over other effects associated with it, unless the chemical composition is very special. For balneological and therapeutic purpose, thermal water with relatively low temperature is currently being used for bathing with a combination of special mud treatment. Modern health spas, sauna, and steam baths should be designed and used in the resort centres, in order to offer better quality service for costumers.

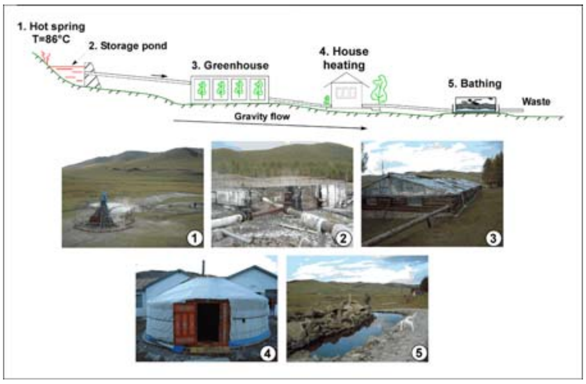

Figure 6. Simple geothermal direct-use in Tsenkher hot spring of Arkhangai province.

3.3. Industrial Uses

Mongolia produces great amount of cashmere every year and the most of the cashmere production involves Bayankhongor province, where the main geothermal activity is also found. Hot water of 50°C can be obtained directly or indirectly from the geothermal sources for washing of cashmere or wool.

By adopting a water-air heat exchanger hot air can be obtained that used for process applications such as drying of wood, cashmere or wool, foods, as well as drying of beef by Mongolian traditional technology.

Mongolian main gross domestic product comes from animal husbandry. Geothermal water with higher temperature can also be used for processing, sterilizing and packing of milk products.

3.4. Power Generation

For power generation from geothermal energy in Mongolia, see the report "Taking the waters? Shargaljuut hot springs (Mongolia)", written by Dr. Greg Bignall et al.

3.5. Horticulture

A number of commercial crops or seedlings can be raised in greenhouse, for harvesting or prior to cultivating on outside field. As Mongolia has a harsh and cold climate, especially in winter, greenhouse farming might not be feasible in wintertime due to high cost of heating, but it could benefit during early spring to late autumn.

The main purpose of soil heating is to extend the growing season and maintain constant soil temperature in order to be able to increase yield. Monthly mean soil temperature in Mongolia is below 0°C during early spring and late autumn, and exceeds 20°C in July. But it is possible to defrost soil and start planting in early spring and maintain over 20°C with soil heating, during all the cultivation period. In winter the soil normally freezes, forming a core of ice. The ice-core prevents drainage of the soil in spring taking a time for it to melt away so soil gets waterlogged and cold. If soil heating is applied ice formation is prevented and soil preparations, planting or sowing can already take place early in spring, and risks from frost damage after planting or sowing can also be reduced.

CONCLUSIONS

As an approximation, Mongolia has a great resource of geothermal energy and potential of geothermal energy utilization.

The possible utilization of geothermal energy in Mongolia has been studied from the technical point of view. For future geothermal developments in Mongolia, there is considerable need to compile existing results of geological, geophysical and hydro-geological studies, make further studies for the assessment of geothermal energy resources of Mongolia, and to investigate feasible and reliable applications in Mongolian circumstances.

Most of the hot springs is located far from soum (county) and provincial centres. Bringing geothermal water to soum (county) centres will be relatively expensive for piping and long distance piping is not suitable for the extreme climate of Mongolia. Detailed feasibility studies are highly desirable due to these long distances and limited market in the rural areas of Mongolia, where most of the geothermal activities is found. Therefore it is advisable to drill near the soum (county) centres and if successful, it will be an incentive for developing direct use of geothermal energy.

Using geothermal energy in centralized or small-scale heating, health treatment, eco-tourism and industrial uses would be the main incentives for developing a geothermal infrastructure in Mongolia.

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