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GEOTHERMAL ENERGY USE IN RUSSIA

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Abstract

Geothermal energy use is one of the best approaches towards sustainable global development. In using geothermal energy, Russia takes advantage of its very high and low temperatures. The country's electricity is generated by geothermal power plants (GeoPP) found mainly in the Kamchatka Peninsula and Kuril Islands. It uses a lot of its low temperature geothermal resources for heat pumps in several of its regions and especially in its Eastern part and Ural.

There are two possible ways of using geothermal resources depending on structure and properties of thermal waters: heat/power and mineral extraction. The mineral-extraction method is best for geothermal waters, containing valuable components in industrial quantities. The most significant deposits of thermal waters represent the brines containing between 35 and 400 plus g/l of salts. In such situations, there are also mineral raw materials for many chemical elements.

1. Introduction

Thermal water has many uses. These include use for development of the electric power, central heating, central cooling, hot water supply, agriculture, animal industries, fish culture, chemical and oil-extracting industry, balneology, spa, as well as in the recreational industry.

In Russia the geothermal resources are used predominantly to supply heat to several cities and settlements in Northern Caucasus and Kamchatka. In other regions, it is also used in greenhouses. The most active hydrothermal resource use is found around Krasnodar territory, Dagestan and on Kamchatka (Figure 1).

In Russia's geothermal sector, some of the areas in which the issue of effective and efficient use of natural sources of raw materials is presented include in thermal mineral water and brine. The approach taken can positively and effectively contribute to the response to some of Russia's social, economic and environmental problems.

Figure 1: Prospects of geothermal development in Russia

Key: 1. Space heating by heat pumps, 2. Direct use , 3. Power generation

Promising Geothermal Areas of Russia: 1. Northern Caucasus (platform area), 2. Northern Caucasus (Alpine area), 3. West Siberia, 4. Baikal adjacent area, 5. Kuril-Kamchatka region, 6. Primorje

2. GEOTHERMAL ENERGY USE

In Russia the geothermal resources are used predominantly to supply heat to a total population of 500,000 in several cities and settlements of Northern Caucasus and Kamchatka. Besides in some regions of the country the deep heat is used for greenhouses of common area covering an area of 465,000 m^2. Some of the most active hydrothermal resources are found in Krasnodar territory, Dagestan and on Kamchatka. (Gadzhiev *et al*. (1980), Kononov *et al*. (2000), Svalova (1998-2008)). Approximately half of the extracted resources is used to supply heat to homes and industries, while the rest is used in heating green houses and in industrial processes. Thermal water is also used in at least 150 health resorts and 40 mineral water bottling factories.

The amount of electrical energy generated by Russian geothermal stations has doubled since 1999.

The Western Siberian region has great potential for direct use applications. The aquifers located down to 3 km in this region have a high hydrostatic pressure, temperatures of up to 75°C, and are capable of producing about 180 m^3 /s of water. These waters are used to heat dwellings in some small settlements and, on a small scale, assist in the recovery of oil, the extraction of iodine and bromide and for fish farming. The region is rich in natural gas, which has limited geothermal development.

The most common use of low temperature geothermal resources is in heating pumps. It is used in many parts of Russia particularly in its Eastern and Ural regions. Heat pumps are at an early stage of development in Russia. An experimental facility was set up in early 1999 in the Philippovo settlement of Yaroslavl district. The source supplies 5-6°C to eight heat pumps that heat the water to 60°C for a 160-pupil school building.

Figure 2: Moscow, Anokhina Str.,50. A building of pilot heat-pump installation. An example of a building in Moscow with supply of heated water, using heat pumps.

Figure 3: Moscow, Anokhina Str., 62. An example of a building in Moscow with supply of heated water, using heat pumps.

The electricity is generated by some GeoPP located in the Kamchatka Peninsula and Kuril Islands. Presently, there are three stations operating in Kamchatka: Pauzhetska GeoPP (11MW $_e$ installed capacity)

Table 1: Geothermal Energy Utilization For Electric Power Generation in Russia

Locality	Power Plant Name	Year Commissioned	No. of Units	Total Installed Capacity MWe	Annual Energy Produced 2008 GWh/yr	Total under constr. or planned MWe
Kamchatka	Pauzhetskaya GeoPP	1966	3	14.5	59.5	2.5
Kamchatka	Verkhne-Mutnovskaya GeoPP	1999	3	12	58.3	
Kamchatka	Mutnovskaya GeoPP	2002	2	50	322.93	
Kuril Islands, Kunashir	Mendeleevskaya GeoPP	2007	1	1.8	n/a	3.2
Kuril Islands, Iturup	Okeanskaya GeoPP	2007	2	3.6	n/a	
Total:			11	81.9	440.73	5.7

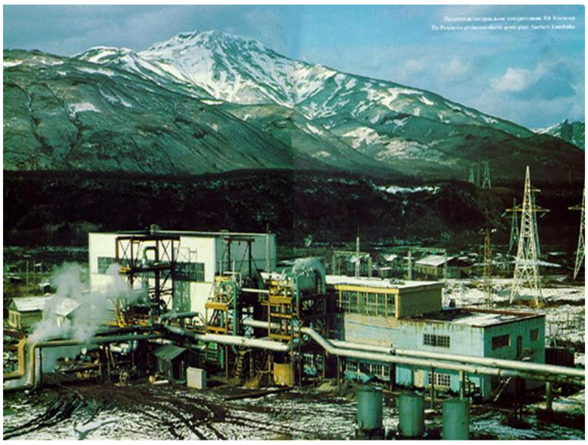

Figure 4: Pauzhetka GeoPP (11MW). There is also Verkhne-Mutnovskaya GeoPP and Mutnovskaya GeoPP (12 and 50 MWe respectively). Another GeoPP of 100 MVe is now under construction at the same place.

3. CURRENT CONTEXT

Russia has considerable geothermal resources and the available capacity is far larger than the current application. This resource is far from adequately developed in the country. In the former Soviet Union, geological exploration was well supported for minerals and oil and gas. Such expansive activities did not aim to discover geothermal reservoirs even in a corollary manner; geothermal waters were not considered among other energy resources.

In spite of this, the results of drilling thousands of “dry wells” (in oil industry parlance), that have taken place in the past bring a secondary benefit to geothermal research. The wells themselves have since been abandoned, but the data that was collected on subsurface geology, water-bearing horizons, temperature profiles, etc during exploration is still available. Few companies currently operating are willing to disclose their well data, but considering the costs of maintaining shut-in wells, it is cheaper to pass on the information for new ventures.

Development and implementation of geothermal power technology is facilitated by social, scientific, economical and environmental aspects. Social aspects reflect public opinion and willingness to reject old, traditional power generating methods and implement new, non-traditional, environmentally-friendly geothermal power technology.

In 1999 the unique pilot Verkhne-Mutnovskaya GeoPP (V-MGeoPP) of 12 (3x4) MW was constructed (Fig. 5). The current scientific and technical level of geothermal technology in Russia is very high.. Unique geothermal power equipment has also been developed domestically and for the first time globally, two environmentally-friendly power plants were constructed in Kamchatka.

Figure 5: Verkhne-Mutnovskaya GeoPP (12 MW) constructed in 1999.

3.1 Verkhne-Mutnovskaya GeoPP

The Verkhne-Mutnovskaya GeoPP has been operating in extremely severe climatic conditions on a site that is about 1000m above sea level. High levels of environmental protection is provided so as to isolate the geothermal fluid from the environment by using both air condensers and a system of full re-injection of the waste geothermal fluid back into reservoir. The major problem of protecting the GeoPP equipment from corrosion and salt depositions was solved by using a special technology of film-forming amine additives. Over the last years the V-M GeoPP has proved sustained reliability in generating reasonably priced electricity of about 1.5 cents/kWh (Nikolski, Parshin, and Bezotechestvo (2003). The experience gained while constructing and operating the V-M GeoPP was used for construction of the 50 MW Mutnovskaya GeoPP – a completely automated power plant with a satellite-based communication and control system (Figures 6, 7, 8).

The economic impact from geothermal power plants is especially high in remote locations. As there is practically no detrimental gases emission, modern GeoPPs can be considered as practically absolutely environmentally friendly (Tomarov, Bubon, and Martynova (2003)).

Figure 6: Mutnovskaya GeoPP.
The installed capacity of this set for the first stage is 50 MW

Figure 7: Main building of Mutnovskaya GeoPP.

Figure 8: Separator's building of Mutnovskaya GeoPP.

4. THERMAL WATERS COMPLEX USE

Thermal waters have many uses as already discussed in the Introduction section of this paper. It has chloride brines saturation which have a complex mix of metallic and non-metallic micro-components. Brines micro-components saturation depends on the brine's genetic essence, lithological structure and the geothermal features in question The interest in geothermal waters and brines as mineral raw material is connected to a number of advantages of this kind of raw material compared to firm sources of rare elements, metals and mineral salts.

Industrial underground waters are characterized by wide regional distribution and big geological and exploitation stocks. They are polycomponental raw materials and can be used simultaneously in balneology and power system. Extraction of this raw material is done using boreholes methods, thus enabling hydro mineral raw materials to be taken from the deep down.

Geothermal waters and brines are characterized by wide variety of mineralization, chemical compound, the contents of useful components and their quantitative ratio, and also gas structure and temperatures. The most widely used types of hydro mineral raw materials are: thermal brines of intercontinental rift zones; thermal waters and brines of island arches and areas of Alpine folds; waters and brines of artesian pools; brines of modern evaporate pools of a sea or oceanic origin and continental lakes; sea waters.

Profitability of industrial reception of those or other components from hydro mineral raw material is determined not only by their concentration, but also by the depth of underground waters and operational chinks, filtration properties of rocks, flow rate of operational stocks, etc. The method of dumping the fulfilled waters in such a way that it protects the natural environment also has cost implications.

5. HYDRO MINERAL RAW MATERIALS EXTRACTION

Taking into account that thermal water is used as hydro mineral raw material in Russia and other countries. the guidelines on elements concentration limits in its water based on general conditions and laws of distribution of underground geothermal waters and brines containing rare elements is as follows: (mg / l): iodine - 10, lithium - 10, cesium - 0.5, germanium - 0.5, bromine - 200, rubidium - 3, strontium - 300. (Bondarenko (1999).

Even before the Second World War abroad, in particular, in USA, the technology of extraction from hydro mineral raw material of one of its components - lithium had been developed. In the 1970s about 85% of world extraction of this metal was being carried out in similar ways. (Kogan and Nazvanova (1974).

I, Br, B, Li, As, Ge and a number of mineral salts are extracted from geothermal underground brines in Japan. On the other hand, carnallite, bromine, chlorides of magnesium and calcium as well as raw material for the manufacture of medical products and perfumery are produced in Israle from Brines of the Dead sea In the 1980s 30% of the world's extraction of Lithium, 31 % of cesium, 8 % of boron, 5 % of rubidium, and also in significant scales Ca, Mg, Na, K, S, Cl, U, Ra, Cu. (Bondarenko (1999).

Thermal waters with a high mineralization are located in the greater territory of Russia and the former USSR. Huge stocks of rare-metal raw materials are also contained in geothermal underground waters and brines on territories of Russia and the CIS. They contain over 55 % of the common stocks of lithium, 40 % of rubidium and 35 % of cesium (Kremenetsky et al. (1999). Brines with mineralization higher than 200 g/l are known in Perm and Kujbishev areas, Tatarstan, Moscow, Ryazan and other central areas.

In Moscow, for example, chloride brines with mineralization of 274 g/l are found at a depth of 1650m. In Western and Eastern Siberia there are large deposits of brines with high temperature. Some deposits have mineralization of 400-600 g/l. There are many thermal brines in Central Asia, Kazakhstan, on Ukraine, Kamchatka, Kuriles, Sakhalin. (Shcherbakov (1985), Resources … (1985), Kurbanov(2001).

There are also certain chemical elements which can be obtained from underground waters. Iodine is for example extracted from brines because it easily disolves in water and cannot be collected from breeds. Iodine concentrates in seaweed. The extraction of sea weed as an industrial raw material is best done at economic scale where there is high sea weed concentration Bromine can be extracted from some salts and seaweed. However, bromine is traditionally extracted from super-strong chloride brines. (Antipov et al., (1998). The significant part of deposits of thermal waters represents the brines containing from 35 up to 400 and more g/l of salts. There are mineral raw material in many chemical elements. Many brines found deeper down, can become deposits of the most valuable chemical elements: cesium, boron, strontium, tantalum, magnesium, calcium, tungsten etc.

Under the cheap technological circuit from natural solutions, it is basically possible to extract iodine, bromine, boron, chloride salts of ammonium, potassium, sodium, calcium and magnesium. Extraction of other chemical elements is made difficult by the cost implication associate with technology. Ion-exchange pitches is a method used for selective extraction of certain components from natural waters. In choosing an extraction method, the principle of selective absorption of ions of useful elements or their complexes in solutions with special compounds.

The research work of some scientific institutes in Russia has enabled the introduction of processes of chemical processing of hydromineral raw materials and the expansion of its application. In general new methods of mineral and valuable elements extraction from industrial solutions are developed on the basis of biosorbsent use. Many laboratory and natural tests on extraction of valuable components from thermal waters confirm the necessity and an opportunity of complex use of this non-conventional raw material. In Russia there are now plans to use this method to extract I, Br, KCl, CaCl, NaCl from brines in Yaroslavl area. I

6. CONCLUSION

There two uses of geothermal resources: heat power and mineral-raw materials; are determined by the structure and property of the thermal water. .

The heat power use is best for fresh and low mineralized waters where valuable components in industrial concentration are practically absent, and the general mineralization does not interfere with normal operation of system. When high potential waters are characterized by the raised mineralization and propensity to scaling, recycling of mineral components should be considered as the passing process for promoting effective heat supply.

The mineral-raw use is best for geothermal waters, containing valuable components in industrial quantities. Thus the substantiation of industrial concentration is caused by a level of technologies. For such waters the heat is a passing product whose use can raise the efficiency of the production process as well as save fuel.

Designing such systems the process of allocation of valuable components should be dominant at. Calculations show that using thermal waters in a mineral-raw form is economically more effective, than in heat powe form. Making a decision on thermal energy use should be determined, not only by their structure and properties, but also by the level of technology required to extract and process the hydro mineral raw material as well as the availability and needs of the consumers.

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