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

Main Geothermal Installations in Belarus

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Keywords: Geothermal Energy, Geothermal Installations, Geothermal Heat Pumps, Belarus.

ABSTRACT

The whole territory of the Republic of Belarus belongs to comparatively cold Precambrian East European Platform. Therefore there are no high-enthalpy geothermal resources, like the underground steam, water-steam manifestations or warm soil localities, within the platform cover suitable to create the electricity production. In result available low temperature and low-enthalpy geothermal resources are used as a rule for heating purposes.

First geothermal Installations were put into operation in Belarus since the beginning of nineties of the last century. They represented ground source heat pumps (GSHP) systems used for heating of buildings at territories of waterworks located in the vicinity of Minsk city (the capital of Belarus). Later GSHP installations were constructed and put into operation in vicinities of other towns and settlements all over the whole territory of the country. Most of them are used for heating of houses and different buildings such like dwelling houses, greenhouses, waterworks, one border crossing station, a sport building, local hospital, etc. The country belongs to the area of lukewarm climate, therefore not many of them also provide cooling of living quarters during summer time. All geothermal heating systems are based on the heat pump technology. The total number of installations under exploitation for the end of 2014 exceeds 100 – 130.

The output of all geothermal heating systems (installed capacity) is above 6 – 6.5 MW_{th}. The individual installations range from 6 to 1000 KWth depending on the type and size of the building they serve. The highest installed capacity is 1 MW_{th} at the greenhouse "Berestye" located at the eastern edge of the Brest town close to the Belarus–Poland national boundary. This installation uses the groundwater pumped out of a deep borehole with the temperature of 24 °C at its wellhead; this water is used also for watering of growing plants. Dozens of geothermal systems are located in dwelling houses. Several typical examples of geothermal heating systems are considered below.

1. INTRODUCTION

Many countries of the World including Europe develop renewable sources of energy to reduce a consumption of mineral fuels such as coal, oil, and natural gas due to growing prices on the one hand and their gradual depletion on the other hand. Moreover the "green energy" programs were adopted and implemented in many countries including Belarus. In result at the moment the 18 MW_e Grodno hydropower plant on the Neman river was recently put into operation and the construction of the Vitebsk one on the Zapadnaya Dvina river was undertaken, Several wind turbines are used in use in the country as well as dozens of PV panels are under exploitation. A number of geothermal installations available in the country and others are under construction now.

The country has no high-enthalpy geothermal resources, as well as visible at the ground surface geothermal manifestations like geysers, fumaroles, warm water springs, etc. Nevertheless first geothermal heat pump installations were put into operation here since the middle of nineties. Now after several years of gaining an experience of their exploitation it was understood that the utilization of low-enthalpy underground heat could be profitable. Systematically growing prices for imported natural gas from Russian Federation is one more reason for wider utilization of local renewable sources of energy in Belarus including available geothermal resources. Several examples of successful utilization of geothermal energy in the country are considered in the paper.

2. MAIN GEOTHERMAL INSTALLATIONS

Since 1997 first small heat pump systems of 20–40 KW_{th} were installed in Belarus to provide heating of waterworks and sewage header buildings mostly in the Minsk District. They used already drilled boreholes to deliver drinking water for Minsk city. Practically all available geothermal installations in Belarus could be possible to qualify as Ground Source Heat Pumps (GSHP's). Only compression type machines are used with heat pumps of different manufacturers (NIBE, Carrier, Ochsner, Daikin, etc.). The exact number of them is not known, as it was not necessary earlier to register such systems in the Ministry of Natural Resources and the Environmental Protection. Their number is estimated approximately to be around 100 – 130 geothermal installations. Among them are used all over the country systems of different type and thermal capacity from 6 to 505 kW_{th}. A few more geothermal heating systems are under construction at the moment. All available installations are used for space heating purposes and sometimes simultaneously to produce warm water or cooling of buildings. As the country belongs to the area of lukewarm climate, not numerous of them provide cooling of living quarters during summer time.

The areal distribution for main heat pump installations in Belarus is shown in Fig 1.

Additionally several dozens of small heat pump systems were installed in private cottages within and around the main towns and cities (Brest, Gomel, Grodno, Minsk, Mogilev and Vitebsk) with total hhermal capacity around 1.0–1.5 MW_{th}. Most of installations use cold groundwater taken from shallow boreholes with ambient temperature of 8–10 ºC as a primary energy source. Others of them use horizontal or vertical circulations loops. A few installations are based on the utilization of lake or river water. Names of the main 28 installations with their locations, primary heat sources and thermal capacities are listed in Table 1.

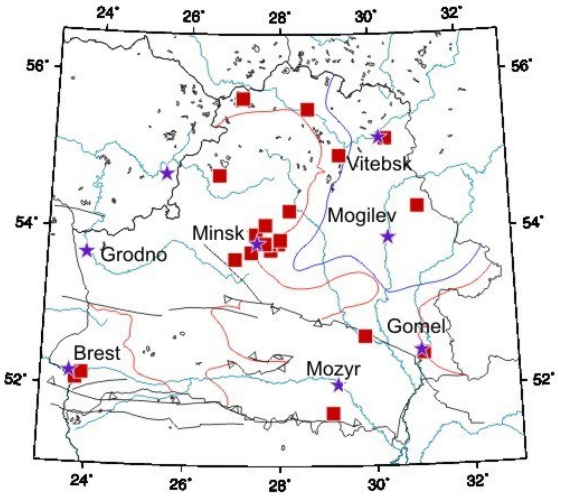

Figure 1: Position of main geothermal installations in Belarus.

Table 1: Some existed of geothermal installations in Belarus.

Location	Primary heat source	Heat capacity, kW_{th}	Location	Primary heat source	Heat capacity, kW_{th}
Greenhouse Complex "Berestye", Brest	Ground water	2 x 505	Sewage header building No.46, Minsk District	Ground water	156
Waterworks "Vitskovshchina", Minsk District	Ground water	43	Water purification station, Minsk	Ground water	165
Sewage header building No.9, Minsk District	Ground water	45	Pump plant "Uruchye", Minsk	Ground water	48
Waterworks "Vodopoy", Minsk District	Ground water	40+390	Pump plant "Sosny", Minsk	Ground water	40
Sewage header building No.19, Minsk District	Ground water	122	Waterworks "Felitsianovo", Minsk District	Ground water	29
Sewage header building No.24, Minsk District	Ground water	330	Waterworks No.11, Minsk District	Ground water	80
River waterworks, Novopolotsk town	River water	230	Waterworks "Sokol", Minsk	Ground water	150
Waterworks "Mukhavets", Brest	Ground loop	3x60	Rowing channel, Gomel	Ground water	2x46
Frontier point "Novaya Rudnya", Elsk District, Gomel Region	Ground water	273	Waterworks in Svetlogorsk town	Ground water	≈50
Hospital, Nesvizh town	BHE	375	Church near Braslav town, Vitebsk Region	BHE	≈40
Waterworks "Drozdy", Minsk District	Ground water	36	Office building, Vitebsk	BHE	≈40
Adamovo railroad station, Vitebsk Region	N/A	≈40	Waterworks in Gorki town, Mogilev Region	Ground water	≈140
Zaozeriye, Brest Region	N/A	≈50	Mogilev Region (total 10 GSHP's)	Mostly BHE	607
Recreation center near Beshenkovichi. Bitebsk Reg.	N/A	6	Private apartment houses	Mostly BHE	≈1500

Existed geothermal installations in the country are mainly used for supplying space heating for some of small industrial buildings, a frontier point Novaya Rudnya at the Belarus-Ukraine border, dwellings, etc. with the total installed heat pump capacity approaching to 6.0 – 6.5 MW_{th}. All heat pump installations are using shallow depth intervals with low-enthalpy geothermal resources to extract the underground heat.

Several dozens of small heat pump systems were installed in private cottages within and around the main towns and cities (Brest, Gomel, Grodno, Mogilev, Minsk and Vitebsk) with total heat capacity around 1.5 MW_{th}. Most of installations use cold groundwater taken from shallow boreholes with ambient temperature 7 – 10 ºC as a primary energy source. Some of them use borehole heat

exchangers or have horizontal circulations loops. A few installations are based on the utilization of lake or river water. The location for some of heat pump installations was shown in (Fig.1).

2.1 Greenhouse Complex "Berestye"

The biggest geothermal installation of 1 MW_{th} was put into operation at the Greenhouse Complex "Berestye", located at the eastern suburb of Brest town near the Belarus-Poland state border. It uses fresh warm water pumped out from a thick section (600 – 1000 m) of Cambrian sandstones by the Vychulkovskaya 201 borehole drilled to 1525 m. The content of dissolved chemicals in this water-bearing Cambrian horizon is around 0.5 g.p.l. Water temperature reaches of 24 ºC at the well mouth at the well flow rate around 42 m^3/hour. Two heat pumps Daikin EWWD 440MBYN, with heat output of 505 kW each, are used in this system (Fig.2) installed directly under the roof of one of greenhouse sections, Zui, Pavlovskaya, (2012). The installation provides heating with the temperature of 50–55 ºC of a part of the greenhouse complex around 1.5–2 ha. According to the project the water of drinking quality after heat pumps feeds a water-supply network of the easternmost part of the Brest town.

Figure 2: Two heat pumps Daikin EWWD 440MBYN at the Greenhouse Complex "Berestye" in the vicinity of Brest town (left) and the wellhead assembly of the Vychulkovskaya 201 borehole.

Another borehole Komarovka 91-z/10 in the same Brest District was drilled near a junction of the state borders of Belarus, Ukraine and Poland in the settlement of the same name to study geothermal conditions warm water ability to estimate possibilities of using the geothermal energy in this area. Its temperature-depth profile is shown in Fig. 3. At the depth of 950 m the temperature is 31 ºC, which exceeds its value (24 ºC) at comparable depth intervals in similar Cambrian sandstones for the borehole Vychulkovskaya 201. There is a possibility to construct another geothermal installation "Komarovka" with a capacity around 500 – 1000 KW_{th}. Cambrian sandstones in Vychulkovskaya 201 borehole contains fresh water, at the same time sandstones in the Komarovka borehole are saturated with a brackish ground water with the content of dissolved chemicals of 3.8 g/dm^3.

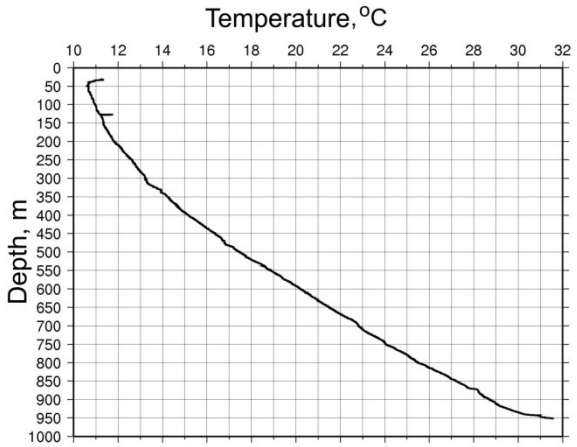

Figure 3: Temperature-depth profile for the borehole Komarovka 91-z/10, Brest District.

2.2 Frontier point "Novaya Rudnya"

A GSHP system is used almost during 10 years for heating of buildings at the Frontier Point "Novaya Rudnya" in the Elsk District of the Gomel Region at the Belarus-Ukraine state border. This crossing point is located aside of villages and other settlements in a vast forest massive. Three possibilities were considered when compiling a project: 1) a heating system using a gas boiler with required constructing of a gas pipe line around 20 km long; 2) an electric heating and 3) using of geothermal energy. The burning of a firewood was not desirable as this locality was slightly subjected to radioactive pollution after an explosion of the Chernobyl Nuclear Power Plant in Ukraine. As the geothermal installation was cheaper and more reliable to arrange than arranging gas and

electric boilers, it was constructed and put into operation. Engineers also kept in mind a necessity to provide an undisturbed operation the heating system with the twenty-four-hour service of this important object. An electric supply through a high-tension transmission line could be subjected during some of local winters to wire breaks due to ice.

Three shallow water wells with the depths of 20 m were drilled at the site. Typically one and seldom two holes are used to deliver actually cold fresh ground water with the ambient temperature around 9 – 10 ºC to a compression heat pump of the Carrier model, Fig 4. The rate of pumping out water is typically ranging from 14 till 20 m^3 per hour, the produced thermal capacity of the system is up to 273 KW_{th} and the output temperature is 55–63 ºC depending on the outdoor air temperature. The geothermal installation provides heating of four buildings (Fig 5) during 7 months per year (since October till April). All necessary service operations are fulfilled during summer time. Small amount of warm water for technological personnel (washstands, tea, coffee, etc.) is produced using small individual electric boilers. The cooling of buildings during summer time is technologically possible, but is used seldom.

Figure 4: Heat pump of the model Carrier Global Chiller 30HXC 080-375 at the Frontier point "Novaya Rudnya" between Belarus and Ukraine in the Elsk District, Gomel Region [Zui, Pavlovskaya, 2012].

Figure 5: Four buildings heated by the heat pump system at the Frontier point "Novaya Rudnya" in the Elsk District, Gomel Region [Zui, Pavlovskaya, 2012].

Two peak boilers could operate using diesel fuel. They are foreseen a reserve heat source on the occasion of a heat pump failure, they also could be put into operation when an outdoor temperature accidently drops below minus 20–30 ºC which is not typical for this area. A reserve diesel generator is foreseen as well for the occasion of an unforeseen interruption in a regular electricity supply by a high-voltage electric line, Fig. 6.

2.3 Sewage header building No.24 in Novy Dvor, Minsk District

Sewage header building No.24, Minsk District process and cleans waste waters delivered by a big collector from city Minsk. It operates during dozens of years and its heating was originally provided by a gas boiler plant. Originally it used an underground water pumped out from a shallow borehole for the technological process including cooling of slider bearings of huge pumps,

agitation of suspended solids in a waste water, etc. Later it was decided to construct here a heat pump geothermal heating system instead of burning the natural gas for heating a complex of buildings using the available shallow borehole.

Figure 6: Two reserve liquid-fuel boilers and a diesel electric generator at the Frontier point "Novaya Rudnya" in the Elsk District, Gomel Region.

Actually cold water taken from shallow water well with the temperature of 7 – 8 ºC was used for the primary circulation contour of the Carrier 30HXC110 heat pump with a heat productivity of 330 KW_{th}, Fig. 7. The pump manifold with corresponding shut-off-and-regulating elements didn't require a separate room and was mounted close to installed technological equipment in the same industrial premise

Figure 7: Heat pump Carrier 30HXC110 (to the left) in the process of its installation at the sewage header building No.24 in Novy Dvor, Minsk District (to the right) [Zui, Martynova, 2013].

The described system is regularly used in cold seasons since October till April during approximately 10 years. A cooling of the building is not used during summer time because of a moderate climate in the area in summer months. . After putting into operation the geothermal heating system a gas boiler (its chimney is visible at the background in the right side picture) was stopped and used as a reserve and as an additional heat source occasionally when the outdoor temperature drops below minus 20 ºC. Usually it happens only during a few days per year.

2.4 Other applications

Only thermal capacity of heat pump installations used for heating of waterworks in Belarus exceeds 1.5 MW_{th}. Besides described above geothermal systems there are dozens of them using heat pumps with a heating capacity below 100 KW_{th}. They are used to provide heating and cooling for a number of dwelling houses for 1–2 families, fuel stations, country cottages, a local hospital in Nesvizh town, Minsk Region, etc. Sport facilities of a boat racing base in Gomel town has similar geothermal heating system based on two heat pumps of the NIBE model, manufactured in Sweden. Their total thermal capacity is around 92 KW_{th}. The primary source of energy is the channel water. For instance the number of heat pumps of the NIBE model used in Belarus is approaching to 200. But not all of them are used in geothermal installations but also in other applications, e.g. air heat pumps, units used in water recycling systems, industrial wastewater and household sewage systems, etc. As it was mentioned above, the detailed record of those units used in geothermal heating systems is not available at present.

The most of installations listed in the Table 1 use ground water as a primary heat source. At the same time many installations use also horizontal or vertical (borehole heat exchangers) loops to extract heat from the ground. The latter ones became more popular for heating of comparatively small heat consumers, e.g. country cottages located in suburbs of big towns and cities and occupying relatively small ground area for each of them.

The practice shows that the terrestrial heat is a perspective renewable and ecologically clean resource of energy available in the country. Its utilization represents an important national goal for the economics of Belarus. Low-enthalpy geothermal energy could be used within the whole territory of the country.

3. CONCLUSIONS

The territory of Belarus belongs to the western part of the Precambrian East European Platform. There is no underground steam, water-steam manifestations or warm soil localities within the platform cover and no "geothermal" electricity production. All available geothermal installations in the country exploit low-enthalpy resources. Around 100–130 heat pump installations are in use in the country mostly for heating of buildings and more seldom for their cooling in summer. Every year new geothermal systems are put into operation all over the country. At the moment their actual number is not known as until now it was not necessary according to existing regulations to register them in the Ministry of Mineral Resources and Environmental Protection.

Dozens of geothermal installations are located at the waterworks stations for heating of technological buildings around Minsk city and other towns of the republic. The groundwater is used as the primary source of thermal energy for heat pumps. Another part includes geothermal systems used for heating of a number of dwelling houses located in suburbs of main towns and cities in the country. The biggest heat pump system with a thermal capacity of 1 MW_{th} was put into operation at the Greenhouse Complex "Berestye" located at the eastern edge of Brest town near the Belarus-Poland state border. It provides a heat supply for a part of the greenhouse around 2 hectares. At the same time the warm water with the temperature 24 ºC is used for watering of growing plants there.

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