Collocated geothermal resources of the South of Western Siberia (Russia) and prospects of their use

A A Shevchenko¹*, O V Skrobot², E G Bord¹ and O V Shiganova³

¹Faculty of Civil Engineering, Novosibirsk State University of Architecture and Civil Engineering (Sibstrin), Leningradskaya str. 113, Novosibirsk, 630008, Russia
²SBG Ltd, Kuzbasskaia str., Kemerovo, 650000, 10, Russia
³Department of Geophysics, Siberian Research Institute of Geology, Geophysics and Mineral Resources, Krasny prospect 67, Novosibirsk, 630004, Russia

* int_links.sibstrin@mail.ru

Abstract. Low-temperature geothermal resources are widely distributed in the sedimentary cover of Western Siberia. In the southern part of the region the aquifer of the Pokur formation (K1-2), with temperatures up to 47° C at well heads, has the best prospects for direct heating. The energy extracted from this kind of geothermal resources must be used near the reservoir, that’s why collocation of the resource and a user is required. A new approach to the issue of using this energy potential is integrated use of existing water wells, drilled for domestic and drinking purposes, for heating of premises (including hot water supply) and water supply at rural communities in the south of Western Siberia. The research was aimed at the estimation of effectiveness of ground-source heat pump (GSHP) systems for extraction of energy from low-temperature groundwater, and their use for space heating of commercial buildings under the climatic conditions of the region. The computations were made by using NIBE AB (Sweden) software. It states that GSHP systems are very competitive with coal boilers, mostly used for hot water supply and space heating at domestic communities. The use of GSHP systems will also improve the ecological situation in the region.

1. Introduction
Western Siberia is a vast territory in the east of Russia extending from the Ural Mountains to the western part of the Yenisei River. From the hydrogeological point of view, the most part of its territory is a huge artesian basin with several hydrogeological complexes (Figure 1). They contain large hydrocarbon deposits (70% of total Russian production of hydrocarbons and 30% of coal), reserves of fresh, mineral and thermal groundwaters [1].

The Cenomanian water-bearing complex (K1-3) has the best hydro-geological parameters (depth, rate, mineralization, temperature) for geothermal raw materials for southern territory of Western Siberia [2, 3]. Its permeable part is confined to the Pokur formation and its analogs. The depth of the complex roof is from 150 to 1300 m, the total thickness is from 200 to 800-1000 m. The water pressure in most of the basin is 20-40 m above a well mouth, the water temperature is 20-43 °C, self-discharge rate is 10-25 l/s. In spite of its huge energy potential, the low-temperature groundwater is not currently competitive with traditional energy sources, because it cannot be directly used in hot water supplying and heating systems.
The use of ground-source heat pump (GSHP) systems makes it possible to expand the prospects of the subsoil thermal power potential [4]. Since the thermal energy extracted from these resources must be used near the reservoir, collocation of the resource and user is required [5]. It is possible in many cases to use the existing water supply wells for space heating and hot water supply of public and commercial buildings, such as schools, hospitals, greenhouses, etc. Due to the fact that the wells have already been drilled, the extracted energy will be cost-effective in most cases, as the cost of drilling comprises 70 - 90% of basic production assets.

2. Use of the hydrothermal resources of the region

According to the Department of Natural Resources and Environmental Protection of the Novosibirsk Region, one of the densely populated and economically developed regions of Siberia, in 2017 there were more than 750 licensed subsoil users for fresh groundwater of the Cretaceous aquifer and about 2000 wells had been drilled for that purpose. The water temperature at the mouth of these wells is +20 - +35 °C.

At present, groundwater of the Cretaceous aquiferous complex is mainly used for water supply. The groundwater heat energy is being lost and even creates additional technical problems for water supply networks. Its rational use could satisfy a significant share of the need for thermal energy at rural communities of the region.

Unfortunately, projects using collocated groundwater resources both in Russia as a whole, and in the south of Western Siberia are implemented in very limited quantities. Let us give examples of the successful use of geothermal low-potential groundwater in some towns of the region.

In Karasuk town (Novosibirsk region) low-temperature water from the well with the temperature of 24 °C at the wellhead was used for heating a secondary school with the area of 6000 m² for about 12 years. The system consisted of two GSHPs with a total thermal power of 700 kW. The facility was launched in 1992, the cost of the geothermal heat was about 40% of the cost of heating by a coal boiler in the region, the payback period was just 13 months [6].

In the Tomsk region (Tomsk city) geothermal energy has been used to heat a kindergarten since 2017. Three GSHPs of 42 kW each (with a total power of 126 kW) heat the premises of 1500 m² and supply hot water. The estimated payback period of the project is 7 years.

At a secondary school in Novosibirsk three GSHPs of 60 kW each (total power 180 kW) have been installed in 2019, the heated area is 1900 m², hot water supply is also provided. The estimated payback period of the project excluding the cost of existing equipment is 4 years.
To estimate the effectiveness of using collocated resources of the Pokur Formation the authors have carried out some evaluation by the example of a single well with the wellhead temperature of 20 °C, a flow rate of 60,000 m³/year. The calculation parameters and gained results are shown in Table 1.

Table 1. Parameters of effectiveness of using collocated geothermal resources of the Pokur Formation.

| Climatic characteristics of the region, °C | Premises parameters | Energy, kWh / year | Conversion factor (COP) |
|------------------------------------------|---------------------|--------------------|------------------------|
| Annual average                           | Minimal Area, m²    | Interior temperature, °C | Building heat loss, W/m² | Produced by 2 GSHPs | Consumed by 2 GSHPs |
| 1.8                                      | -40                 | 2000               | 21                     | 75                  | 340,006             | 68,420              | 5.15                 |

Estimated payback period under equal conditions of construction, installation and equipment cost: compared with a coal boiler - 3 years, compared with a diesel boiler - 2 years. The evaluation shows the obvious benefit of using heat pumps in comparison with traditional sources of thermal energy used in the region.

There are some other important benefits of using GSHP systems apart from heating and hot water supply. They are: cooling tap water for a consumer to the norm, opportunity to connect the GSHP to the supply and exhaust ventilation system and use it as a heat exchanger, using the GSHP for air conditioning of the premise during summer season. Thus, one unit of energy spent on the work of the GSHP could be used to meet 5 goals at once and the degree of GSHP usefulness would grow significantly. Environmental benefits of using GSHPs in the region are also obvious [7]. The analysis of their implementation experience will help to develop recommendations for the programs planned.

3. Conclusions
The use of GSHP systems can dramatically enhance the prospects of using collocated geothermal resources for heating residential and industrial buildings at rural communities in the region. Long-haul raw materials, high emissions of soot into the atmosphere and very costly installation of soot separators make the issue of switching to less expensive and environmentally friendly geothermal resources very relevant.

Since the 1980s, a number of regional programs for assessing geothermal resources were at work in some administrative districts of the area, such as Novosibirsk and Omsk regions [7]. Unfortunately, at present they are not developed any more, despite the task, given to the Ministry of Natural Resources and Ecology of the Russian Federation in 2014 [8], to initiate the development of federal targeted programs for the use of thermal water as a source of electricity and heat.

In this situation it’s very important to encourage study of collocation geothermal resources in the region by the local governments and public-private partnerships.

Acknowledgments
The computations to evaluate the effectiveness of using collocated resources were made by NIBE AB (Sweden) software (www.nibe-evan.ru).

References
[1] Geological Structure and Raw Mineral Resources of Western Siberia 1998 vol 2 (Novosibirsk: Siberian Branch of RAS Publ. House, NIC OIGGM) p.301
[2] Shiganova O V 2000 Proc. 4th Int. Congress “Water: Ecology and Technology” AQUATECH-2000 Moscow (Moscow: SIBIKO Int.) pp 123-126
[3] Shiganova O, Marchenko Y and Shevchenko A 2017 Proc. 18th Symp. on Thermal Science and Engineering of Serbia (Sokobanja) (Nis: University of Nis, Faculty of Mechanical Engineering), pp 392-396
[4] Spitler J D 2016 *Proc. European Geothermal Congress (Strasburg)* (EGEC: Brussels) pp 1-7
[5] Boyd T L 1996 *Trans. Geothermal Resources Council (Portland United States)* vol 20 (Davis: CA) pp 43-50
[6] Petin Yu M 2001 The Experience of a Heat Pump Manufacturing Decade in ZAO “Energia” *The Energy Policy* vol 3 pp 28-33
[7] Shevchenko A, Shiganova O 2018 *E3S Web of Conferences* 33 02053
[8] Decision of the Joint Extended Meeting of the State Duma Committee’s Higher Ecological Council on Natural Resources Management and Ecology on the topic "Legislative support, protection and use of groundwater" (https://www.sgidrogeo.com/optimos/pages/reshenie_zasedaniya_sektsiy_ves_431)