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Decentralized Power Supply by Small Geothermal Plants

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ABSTRACT

The paper states a conception of small geothermal power plants application for autonomous power supplying of small loads distributed on the vast territory under condition that the area has geothermal water resources.

West Siberia has 70% of total geothermal water resources of Russia. And these resources are distributed on the huge territory of the region. Therefore it is very promising area for implementation of projects targeted on decentralized power supplying.

The main requirements for small geothermal power plants are: power capacity under 100kW; temperature of the intraformational water 80-100oC; module structure of the plant allowing easy transportation with automobile transport.

The turbines provided for power units' realization in the project are two types: hydro-steam turbines of the Segner's wheel type, and turbines using "coming to a boil (poppling)" water. It is shown by calculation that 1kW of geothermal plant installation can be estimated at $500 - $600.

Building of the pilot geothermal power plant with power rate of 30kW and water consumption of 20 m3/h is intended in Trubatchevo Village, Tomsk Region, Russia. There is a temporarily abandoned well there. Average temperature of the intraformational water in the well is 105oC.

It is expected in the future that several small geothermal plants will be erected in the area for decentralized power supplying with total capacity up to 12MW.

1. INTRODUCTION

Distributed power supply is characteristic of little-developed, considerably removed from electric networks territories with underdeveloped infrastructure and low population density.

Absence, in most cases, enough powerful consumers of the electric power supply means use in such zones of low power power plants focused on maintenance by the electric power of concrete object: small settlement, a farm, the small local enterprises, tourist bases, etc. The most widespread variant of electrification of local objects today is use of power stations with internal combustion engines. However, necessity for expensive delivery of fuel and nonoptimality of operating conditions of power stations due to the non-uniform schedule of electric load result in high cost of the generated electric power.

2. DISTRIBUTED POWER SUPPLYING WITH GEOTHERMAL RESOURCES UTILIZATION OF TOMSK OBLAST

Reasonable variant of power supply for the local consumer is use of local power resources, including local fuel and all spectrum of natural renewable power resources, the majority of which basically available at any place of the planet.

Under certain conditions geothermal energy of underground waters can be quite competitive with others sources of energy. In particular, environmental and social - ecological conditions of the Western Siberia are favorable enough for large-scale use of low power geothermal power stations (small geoPS) for self-contained power supply of stand-alone consumers. A vivid example of the region with mid-annual temperatures below zero and problematic power supply of significant territories is the Tomsk oblast. An average population density is 3,4 person/km^2 up to 40% of its territory has no centralized power supply. In stand-alone zones more than 40 settlements are supplied with the electric power from diesel power stations and the electric power costs on average 5-6 rubles for kW*h.

At the same time, the bowels of the Western Siberia on accessible depth 1-4 km hold up to 70 % of stocks of geothermal waters of Russia. Practically all territory of Tomsk oblast is characterized by presence of geothermal waters with temperatures up to 100-110˚ C. Development of geothermal power in the region is facilitated by a plenty of the inhibited oil and gas exploration wells, many of which can be used for geothermal waters pumping out. In the given situation the concept of «a deposit of geothermal waters» and «stocks of thermal waters» loses sense. For practical use it is necessary to choose areas with most high-grade heat underground waters and to geographically relate them to an arrangement of the settlements requiring energy. The map of the region, illustrating distribution of geothermal waters is shown on fig. 1.

The basic regional requirements to geoPS are the following: capacity of station - up to 100 kW at the water temperature of 80-100˚ C. Modular embodiment of station capable of motor transportation. The various chemical composition of underground waters in different areas and horizons determines requirements to chemical resistance of constructive elements of installation. Small capacity of installation and, accordingly, small discharges of thermal water (it is usual within the limits of 20-30 m^3/hour) with a small mineralization do not exclude gushing geoPS operation with complex use of thermal water.

Variants of technical realization of low-grade heat installations can be constructed with use of hydrosteam turbines of the Segner's wheel type, running directly on thermal water, or the turbines running on boiling liquids.

Preliminary designs and pre-production models of the power stations using low-grade heat underground waters there are in public corporation « G.M. Krzhezhenevskogo power institute » (Moscow), Kaluga and Poltava turbine factories, and other organizations. According to joint-stock company "Turboskop" (Kaluga), the estimated cost of the power equipment for similar installations in a power range of 50-500 kW, comes to 500 up to 750 $ for 1 kW depending on presence of exhaust-steam condenser.

Technical and economic efficiency of stand-alone systems of power supply from geoPS can be determined in view of the basic parameters of station: capital expenses for the complete equipment and expenses for preparation of a well plus running costs. Running costs of geoPS include wages of the workers and expense for repair of the equipment throughout all term of operation of the station was accepted as equal 20 years.

The results of technical and economic calculations for geoPS <30 kW are tabulated in Table 1. In same table the data for diesel power station (dieselPS) of similar capacity are given.

Table 1: GeoPS outlays in comparison with DieselPS outlays.

Showing	Unit	DieselPS	GeoPS
Capital outlays (K)	x10^3 ruble*	178.5	5147.5
Fuel consumption (Year)	kg	64000	-
Fuel cost	x10^3 ruble	1260	-
Maintenance	x10^3 ruble	60	60
Running costs	x10^3 ruble	1373.1	138.16
Total outlays	x10^3 ruble	1385	481.33

* 1 RUBLE = 0.0345 USD

Calculations show, that notwithstanding considerably big capital investments in geoPS, absence of a fuel component provides real competitiveness of these stations with traditional dieselPS.

Except for the considered factors, the quantity of generated energy determined by a real consumption schedule and influences on the cost of the electric power.

The result of calculation of the power cost is shown on the chart (Fig. 2).

Calculation was carried out for two variants of geoPS installation: with drilling a supply well and with use of an existing supply well. From the chart it is visible, that at use of the second variant, even at change of loading capacity up to 50 % of nominal cost of generated energy $C_{el.en.}$ = 2,7-5,5 rubles/kWh is comparable to average cost of the electric power, generated by dieselPS in the Tomsk oblast which is equal $C_{el.en.}$ = 5-8 rubles /kWh.

In addition calculation of influence of thermal waters composition on cost of the generated electric power has been made. It is known, that the composition of thermal waters is various, and depending on it, cost of the equipment can increase due to application of more expensive antirust materials. However, some increase in capital expenses little affects on resulting economic parameters of station, in particular the cost of the generated electric power.

Thus, due to natural, geological-geographical and social and economic conditions the Tomsk oblast represents rather convenient region for introduction of geothermal technologies for autonomous power supply of consumers.

Tomsk Polytechnic University together with Tomsk Regional Center of Energy-saving offers the project of construction of several geoPS for power supply of some settlements of oblast. Placement of pilot geoPS is shown on Fig. 1. The project is supported by Administration of Tomsk oblast, the Ministry of Power of the Russian Federation, and international organizations. The suggested project will promote creation and practical realization of successfully working mechanism of the distributed power supply of rural areas and suburbs of the North, Siberia and the Far East by means of small geothermal installations, generating electric power and heat. The project will promote economic and social development of regions and improve their ecological situation.

Experience of practical application of geoPS for local generating of the electric power is supposed to be gained as a result of performance of the project pioneering stations in the settlement of Trubachevo of Bakcharski area of Tomsk oblast. Construction of geothermal power station with electric capacity 30 kW is projected along with volumes of consumed water of 20 m^3/hour. In the settlement there is a wet hole (inhibited exploration oil well) with average temperature of the reservoir 105°C. Resources, potential and available technologies provide all technical opportunities of the prospective project.

Advantages of realization of the project is acquisition of unique experience of introduction of new power technology in regions of Russia that will allow to improve essentially the situation with power supply in settlements of prospective construction of pilot installations.

In the long term, large-scale introduction of geothermal technologies will allow to receive the ecologically-friendly energy source, capable to replace a significant part of fuel energy in a number of regions.

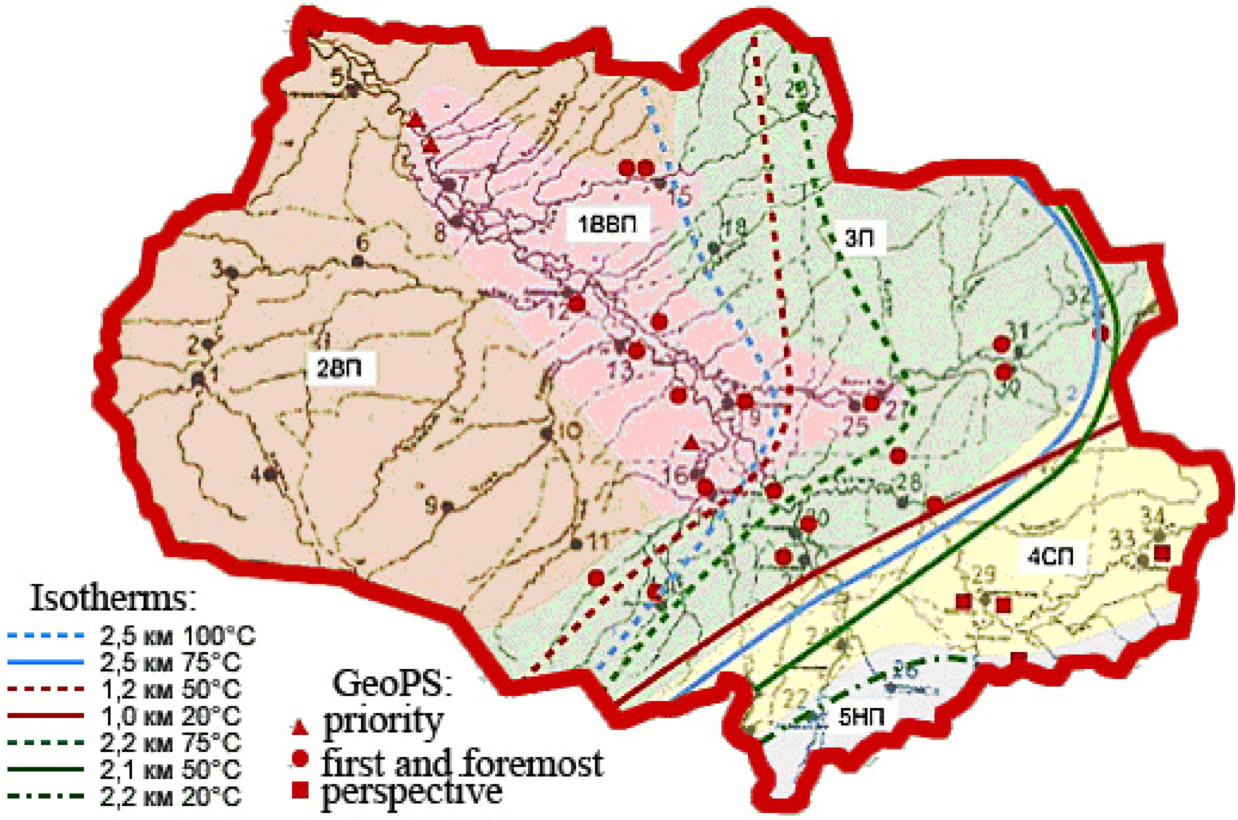

Figure 1: Geothermal resources of Tomsk oblast.

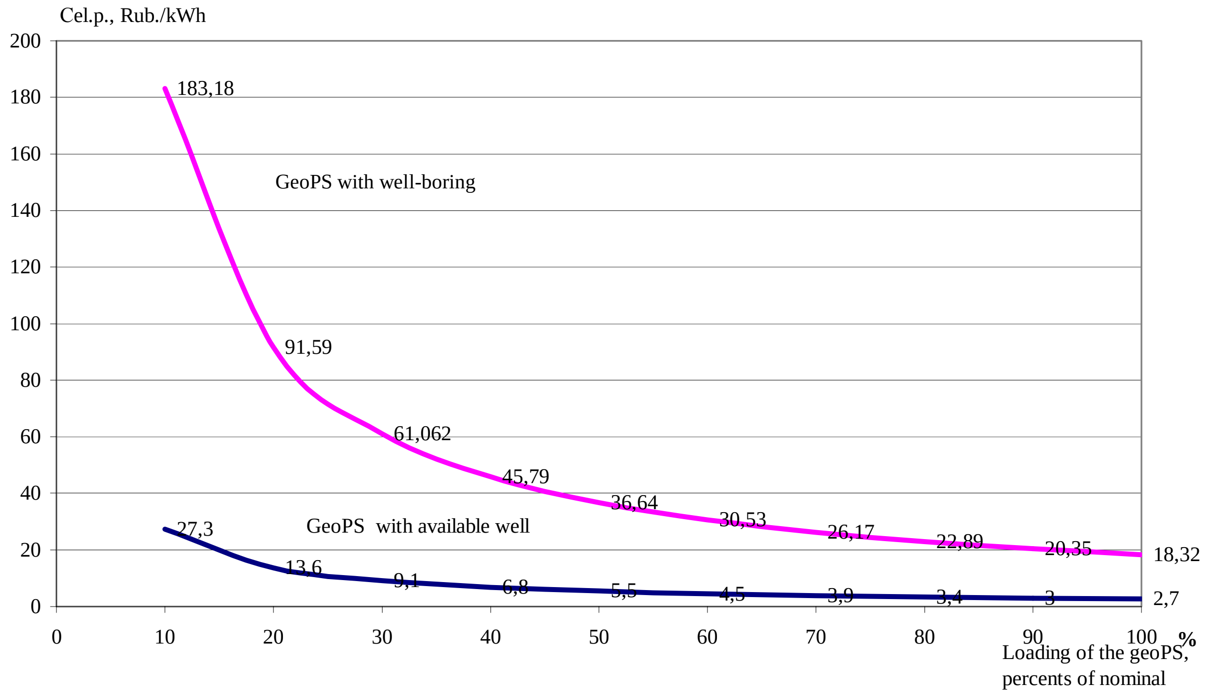

Figure 2: Power cost depending on loading of the geoPS.