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The use of renewable energy sources for the introduction of construction projects in the Arctic regions

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Abstract
The article considers the operation experience at the Chukot wind-and-diesel power plant and substantiates the industrial, technological and environmental expediency of construction works in the Arctic regions with the use of renewable energy sources.

Keywords: development of Arctic regions, environmental safety, power supply, construction works under extreme conditions, energy-efficient technologies, renewable energy sources

Introduction
Nowadays one of the most important priority directions is the social and economic development of the Arctic regions. The Russian Federation Government aimed at the development of this region into the main supplier of material resources as well as into the zone of peaceful international cooperation. A very important requirement to this process is the preservation of unique Arctic environment (very susceptible to any human activities) as well as the development of favorable conditions for the traditional way of the life of Northern nations and the rise in well-being of all inhabitants of the Arctic region.
The aforesaid priorities are formulated in the following documents:

- "The principles of the RF State policy in the Arctic region for the period up to 2020 and for the further prospects", approved by the RF President Decree №1969 dated 18.09.2008;
- "The strategy of development of the RF Arctic region and of the national safety provision for the period up to 2020", approved by the RF President Decree №537 dated 12.05.2009;
- The State Programme "The social and economic development of the RF Arctic region for the period up to 2020", approved by the RF Government Decree №366 dated 21.04.2014;
- The complex project of the development of the Northern Shipping Route for the period up to 2030, approved by the RF Government Decree dated 08.06.2015.

Some large-scale projects in the field of civil and special construction including the development of the Northern Shipping Route are supposed to be introduced in the RF Arctic region. These projects will require some fresh power capacities as there will be erected 13 airfields and 10 radio-locating points (RLP) in the region soon [1]. The erection of the "Polar Star" complex from special module units for the service-people from the RF Arctic Army Group has started at the Wrangel Island and at the O.Schmidt Cape. Every complex will include residential, household, administrative and fitness units.
The power-supply, transport and social projects are intensively introduced at the territory of Yamal-Nenets autonomous area. The residential buildings, kindergartens, sports centers, roads, engineering systems, power sub-stations and others are erected for the personal of mining companies and oil-and-gas transport companies.

The RF Arctic region includes many natural protected areas, so the construction works there as well as the erection of power supply stations should observe the environmental safety standards.

Mostly the RF Arctic areas use the diesel power stations (DPS) [2]. These power stations have low efficiency values and high fuel consumption; the pollutant emission is considerable. The main debet item is fuel, which is rather expensive in the Arctic region. The fuel cost including the delivery cost comes up to $1000,- per ton, and so the prime cost of the electric energy comes up to 12 roubles per kWh. In addition to that, the maintenance of DPS under low temperatures may cause the leakage of fuel and motor oil, and so it leads to the soil and water pollution dangerous for the Arctic environment [6].

The use of local renewable energy sources (RES) in the Arctic region is one of possible solution to the problem of power supply at the Arctic construction sites; it may save the fuel and reduce the pollution of the environment.

The complex evaluation of the economic efficiency of the use of renewable energy sources in remote Arctic regions [3-4] as well as that of investment projects and programmes concerned showed that the most promising power stations for the Arctic regions are combined wind-and-diesel power stations (WDPS) or wind power stations (WPS). The use of RES will allow us to save the fuel (by 30 to 50%) and to make the service period of power stations 2 to 3 times longer.

Let us consider the organization of power supply of consumers with the use of wind power resources at the example of the Chukot WDPS (ChWDPS) [7], which has successfully operated under severe climatic conditions since 2003.

The power station is located at the Observation Cape; the general plan envisages the construction of 10 windmills (AVE-250 CM type), sites, roads, the cable equipment (6kV, KRU-6kV), 1 aerial power line (LEP-6kV, length: 8 km from the wind power station to the "Ugol'nye kopi" diesel power station), the control point building and the meteo mast 30m high with 2 layers of meteo devices. The natural climatic conditions of the region are given in Table 1.

TABLE 1. Natural climatic conditions in the region of operation of the ChWDPS station.

Climatic characteristics	Tundra, permafrost, sub-Arctic maritime climate
Average annual temperature	-6,9 °C
Average January temperature	-22.6 °C,
Average July temperature	+11.6 °C
Absolute minimum of the air temperature	-46.8 °C,
Absolute maximum	+30.0 °C
Average annual wind velocity at the height of weathercock (10m):	6,7 m/s (average monthly in winter: up to 7,8 m/s)
Maximum wind velocity (gust)	54 m/s (46 m/s)

The average monthly output at the ChWDPS was about 465,000 kWh, the maximum demand could reach (1.0-1.2)$\cdot 10^6$ kWh.

The power utilization factor (PUF) during the maintenance period was equal to 14.5%, which was one of the best results for the WPS in Russia (including the Kaliningrad WPS supplied with Danish windmills).

Under favorable conditions and with automatic operation mode, the power utilization factor for the ChWDPS could reach the value of 19 to 22% (average world showing equals 25 to 30%).

The key parameter of the economic efficiency in construction, the cost of installed power, was equal to $1400, -/kWh, which is considered to be quite good for the Arctic region.

The positive experience of the process of maintenance of the ChWDPS [7] allows us to come to the following conclusion: the windmills can be quite efficient with various wind velocity values and different power output values.

Nowadays, the total power output of wind-and-diesel power stations and wind power stations in the coastal Arctic regions is about 100 to 110 MW, so the annual consumption of the diesel fuel may be reduced by 130,000 tons [3, 5], and the prime cost of the electric power is considerably lower. However, the planned intensive development of infrastructure projects in the RF Arctic regions requires the increase in the total power of the aforesaid power stations by 10 to 15 times.

The use of WDPS and WPS for the power supply of the construction sites along the Northern Shipping Route (NSR) will be very important as the transport capacity of the NSR requires a considerable development, and the key condition for an accident-free maintenance of the NRS and safe works in Arctic regions is a reliable power supply of high quality. A set of local power supply stations can provide for the operation of sea and coastal navigation systems ship tracking systems, safety and rescue systems and others. These power supply stations can also serve as temporary power supply facilities at initial stages of the construction of coastal and naval projects. After the development of a stationary coastal power supply system, the aforesaid power supply units can be moved to another region.

The construction works in Arctic regions require special design projects and special construction materials [8-14] as well as the consumers with small power loads (not more than 20 to 25 MW) isolated from the power systems. This is due to the use of autonomous power stations (DPS) and small boiler houses, which consume the imported fuel. The influence of the fuel cost on the prime cost of produced electric energy is shown in Fig.1.

Such factors as the remoteness, non-adequate development of transport routes, season import of goods and others lead to a considerable increase in the fuel cost for the end consumer. The transport component of the fuel cost may come up to 70 or 80% of its total cost, and this fact effects much on the prime cost of produced electric energy and, therefore, negatively influences the cost of construction works.

In this connection, the power supply of construction sites from an isolated power supply system always requires some budget subsidies. The use of renewable energy sources makes it possible to reduce the volume of imported fuel and so to reduce the budget subsidies.

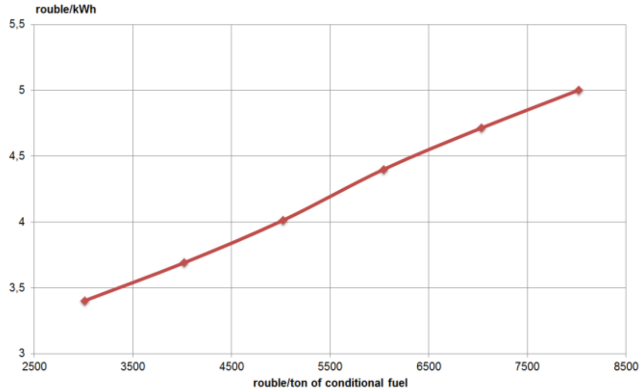

Fig.1. The dependence of the prime cost of produced electric energy on the fuel (coal) cost according to the data from [15].

Conclusion

This article proves the production and technology expedience as well as real economic profits for the process of construction works in Arctic regions with the use of renewable energy sources will allow us to improve the energy efficiency of construction works and to save material and energy resources.

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