Power supply of remote and almost inaccessible settlements

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Abstract. Problems of power supply of remote and almost inaccessible settlements are analyzed. Variants of their connection to transmission lines and the use of diesel electric power stations are considered. It is suggested to revise the policy of power supply for consumers of this category based on the experience in implementation of nontraditional energy production technologies, namely, based on natural renewable resources.

1. Introduction

The special feature of Russia characteristic primarily for regions of Siberia and Far East is a significant number of small remote and sparsely populated settlements. The problem of reliable and high-quality power supply of such settlements remains urgent in social, technical, and economic aspects [1].

Generally, these consumers can be supplied either by centralized or decentralized power supply.

Technical feasibility of power supply of an object through transmission lines (TL) depends on the installed electrical power of the object of power supply and the distance to the nearest point of connection to mains.

2. Results and considerations

The All-Union Standard on the electric energy parameters establishes restrictions on voltage deviations from the nominal value within ±5%. Hence, the maximum TL extension l_{max} of power distribution networks with standard voltages of 6 and 10 kV can be calculated from the formula

$$max = \frac{\gamma F U_{nom} \Delta U}{P_{nom}} [km],$$

where γ is the wire material conductivity, m/Ω·mm^2; F is the wire cross sectional area, mm^2; U_{nom} is the nominal voltage equal to 6–10 kV; DU is a 5% voltage loss, kV; and P_{nom} is the nominal power of an electrical receiver, kW.

Rural distribution networks are typically made from aluminum wire with specific resistance of 32.2 Ωm/mm^2, and the minimum standard wire cross section for powers up to 160 kW is equal to 16 mm^2.

The maximum TL lengths are presented in Table 1 depending on the power of the supplied object for distribution networks with voltages equal to 6 and 10 kV, respectively (given that the voltage losses are 5%).

A higher voltage of the distribution network allows the distance of the centralized power supply to be increased under the same conditions.

Thus, electrification of objects with power smaller than 250 kW from the centralized electric networks is limited by distances ≤10 km.

Table 1. Maximal TL length (l_{max}) versus the object power (P) for network voltages of 6 and 10 kV.

P, kW	5	0	3	00	60	50	2
l_{max}, km (6 kV)	7	3	4				–
l_{max}, km (10 kV)	03	4	1	6	6	0	1

Construction of higher-voltage more expensive TL (for example, 35 kV) is inexpedient for low transmitted power because of the low load factor.

Hence, it would be inexpedient to estimate the economic characteristics of high-voltage TL operating in the regime close to idling one.

Thus, for the overwhelming majority of electrification objects located in regions with low population density and poorly developed infrastructure, the technical criterion for electrification by means of TL construction cannot be fulfilled.

In addition to this purely technical restriction, a question arises on the high cost of transmission lines themselves and of their maintenance and service.

All this taken together makes abundantly clear the low probability of possible electrical supply of small remote consumers through their connection to centralized electric networks.

In the second variant of power supply of sparsely populated and remote settlements, the most widespread electric power source are stationary and mobile diesel electric power stations (DEPS); more than 5 thousand stations can be counted in Russia. They produce about 1.8 billion kW·h of electric power and consume about 0.8 million ton of standard fuel annually.

The main problems of power supply of the remote and sparsely populated settlements from DEPS are:

- bad technical conditions of electric power sources,
- long-distance transport of fuel and dependence on its deliveries,
- limited terms of seasonal delivery (the fuel can be transported to some remote regions during a year and longer, with intermediate storage in storage terminals) to the most remote regions,
- poor development of transport infrastructure,
- dependence on budgetary financing.

The poor development of transport infrastructure complicates significantly fuel supply. Long transportation distances and multistage and seasonal delivery of fuel lead to large fuel losses and multiple price increase. The transport component of cost of the fuel delivered to the most remote consumers can reach 70–80%.

The low-power sources used for autonomous power supply, as a rule, have low technical and economic characteristics. In addition, the increased fuel prices and transport tariffs (especially large for remote regions) lead to high price of electric power production that is several times higher than its average value for systems of centralized power supply. Incomplete fuel delivery entails long interruptions in power supply.

The DEPS power required to supply an individual consumer is determined by the peak power consumption depending on the electrical load chart of the object. As a rule, individual consumers are characterized by extremely nonuniform electric energy consumption, thereby causing significant underutilization of the nominal DEPS power.

The majority of sources of autonomous power supply are unprofitable, since the cost of electric power production is much higher than the tariff established for population, and the absence of industrial enterprises in the overwhelming majority of small isolated settlements does not allow the payment to be compensated by the industrial tariffs. Therefore, the power supply of small individual consumers from DEPS is subsidized by budgetary funds of local and regional administrations.

Losses from sale of electric power at the price below the cost are covered by the budgetary grants to provide admissible tariffs on electric energy in remote and sparsely populated regions. The lack of budgetary financing leads to incomplete fuel delivery, thereby putting this category of consumers in extremely severe conditions of power supply.

The problems of power supply of consumers in remote and sparsely populated settlements are aggravated because of the financial situation in the country and require additional attention of management. However, design organizations develop schemes only of regional energy systems and energy centers, while problems of power supply of numerous small individual consumers are considered on the level of either consumers themselves (industrial enterprises participating in economic activities in the given territory and providing maintenance of all accompanying industrial and social infrastructure) or regional and municipal authorities [2].

The increased price of organic fuel and transport tariffs for its delivery and the inefficient regimes of operation of the existing DEPS necessitate revision of the power supply policy for consumers of this category based on the accumulated experience on the application of modern power production technologies, being guided primarily by the directions providing decreased consumption of imported fuel. One of such directions is the application of renewable energy sources (RES).

The total RES resources in the world and Russia are huge [3, 4]. The total technical potential of solar, wind, biomass, water, and geothermal energy in the world is $2.4 \cdot 10^5$ mln ton of standard fuel units (s.f.u.); it is $4.5 \cdot 10^3$ mln ton of s.f.u for Russia.

Converted into the traditional fuel and energy resources, for Russia this is equivalent to the replacement of about $3.15 \cdot 10^9$ ton of oil, $3.7 \cdot 10^{12}$ m^3 of natural gas, $5.7 \cdot 10^9$ ton of coal, and $1.3 \cdot 10^{10}$ m^3 of firewood per year.

For a comparison: Russia consumes about $1.6 \cdot 10^8$ ton of coal, $1.3 \cdot 10^8$ ton of oil, and $4.6 \cdot 10^{11}$ m^3 of gas per year for the activity of all types.

In the long term, the contribution of nonconventional renewable energy sources to the world energy balance is estimated from (1–2) to 10%, although already today there are countries where the contribution of these sources exceeds half the national energy balance.

3. Summary

One of the indispensable conditions for the successful development of objects of renewable power engineering is the state legislative support of institutions and persons engaged in the introduction and utilization of RES.

Thus, the active application of RES observed in the last few years in Europe is largely caused by the adoption of regional and all-European legislations and instructions on the development of renewable power engineering. Various mechanisms of RES stimulation have been developed and tested. Among the most efficient of them are recognized introduction of special tariffs on energy produced with the use of RES and commitments to the manufacture and (or) sale of energy from RES (bonds, green certificates, etc.).

Recently a number of attempts have been undertaken in Russia on the federal and regional levels to develop programs of utilization of energy sources based on renewable energy resources [5].

However, despite many adopted resolutions and developed programs, practical implementation of projects on power supply of individual consumers, including utilization of energy sources based on RES, is carried out on insignificant scales. This did not allow the problem of their power and fuel supply to be solved adequately.

Among the most *recent* guidance materials on the aforesaid issues are RF Government Order “On Utilization of Renewable Energy Sources” No. 1-r of January 8, 2009 and Federal Law “On Energy Saving, Increase in Energy Efficiency, and Amendments to Some RF Acts” No. 261-FZ of November 23, 2009.

However, no noticeable positive changes are observed in the development and expansion of works.

At the same time, the lack of the state legislation must not block the adoption by regional and municipal authorities of the corresponding standard-legislative documents and interfere with practical RES implementation of local decisions.

References

[1] Surzhikova O A and Nikulina I E 2006 *European Journal of Natural History* **2** 151
[2] Surzhikova O A 2008 *European Journal of Natural History* **3** 98
[3] Belyaev L S *et al* 2000 *World Power Engineering and Transition to Sustainable Development* (Novosibirsk)
[4] Shafranik Yu K 1995 *Novel Energy Policy of Russia* (Moscow)
[5] Nikulina I E and Surzhikova O A 2006 European Journal on Natural History **5** 69