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To the issue of complex increasing energy efficiency of electric receivers of oil and gas fields

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Abstract. When designing oil and gas industry facilities and petrochemical facilities, the issue of the organization of their power supply system does not lose its relevance. At the stage of the feasibility study, the options based on the use of renewable energy sources, as well as energy storage systems are not often considered due to the high cost of solutions. The absence of standard solutions for the use of renewable energy sources and energy storage systems, the incompleteness of the regulatory framework force designers to refuse to consider them when designing power supply systems. This article analyzes the theoretical aspects and practical examples of the use of additional non-traditional sources of power supply, contributing to the improvement of energy efficiency of power supply systems as a whole.

According to the electrical installation rules (EIR) [1], the category of reliability of power supply to consumers is selected based on the significance of the consequences of a power outage. Due to the fact that the shutdown of some technological processes leads to enormous losses, the Customer is ready to bear the financial burden for providing the required or higher category for reliability of power supply in almost any amount. If it is possible to make a technical connection to centralized electric networks, the main tasks are to choose the location of the main step-down substations, distribution points, transformer substations (TS), taking into account the laying of electric networks.

If it is impossible to make a technical connection, the project provides for the construction of facilities of its own generation in accordance with the degree of accessibility of a particular type of energy carrier. As a rule, in relation to deposits in the north of the Tyumen region, such an energy carrier is natural or associated petroleum gas.

The problem is that in both the first and second cases, insufficient attention is paid to energy efficiency issues. In particular, the possibility of saving money at this stage by using more efficient sources of temporary power supply with the possibility of their further integration into a permanent power supply system (PSS) is not taken into account. The aim of this work is to assess the applicability of renewable energy sources (RES) and energy storage systems (ESS) for the organization of PSS of enterprises in the early stages of construction and the possibility of their integration into a permanent PSS of the enterprise as a determining factor in energy efficiency.

For the period of construction of a permanent PSS, the project also provides for the organization of a temporary PSS, in which energy sources, as a rule, are diesel power plants (DPP). Upon completion of the construction of a permanent power station, these power stations can be connected to the TS buses as the third independent source of power supply to ensure the required reliability category of power supply to consumers. For example, this approach is quite common in the organization of PSS shift housing complexes (SHC). During the construction of the main technological facilities of the object, SHC is also under construction, and all workers and engineering personnel are located in the temporary town of builders (TTB), which, as a rule, also receives electricity from its own diesel power plants.

For technical and domestic water supply, enterprises build water intakes, which, depending on the presence near water bodies, can be surface or artesian. For the construction period, such water intakes provide water to TTB and SHC; their temporary PSS is also based on DPP. In the future, such water intakes are often integrated into the general water supply system of the enterprise.

A possible option for organizing temporary PSS of consumers, such as SHC, TTB and water intakes, may be the use of wind-diesel power plants (WDPP).

The inclusion of a diesel generator into the wind power installation (WPI) is due to the fact that WPI alone cannot guarantee the required amount of electricity without an additional power source (in this case, without a DPP). The volume of electricity will vary in time with an arbitrary nature, and its qualitative characteristics such as amplitude, frequency, voltage curve shape will also be unstable due to the strong dependence of these parameters on wind speed in a given area. To bring the above power parameters to a normalized level, a two-stage controlled transformation is used - rectification-inversion. However, there is no way to stabilize the inconstancy of the wind, so there are possible calm pauses. To assess the wind potential of the proposed WPI installation area, one can refer to the wind map of Russia [2-4] or the statistics on nearby weather stations for more accurate forecasting. With its help, it will be possible to draw conclusions about the feasibility of using WPI on the basis of vertical or horizontal axis wind generators, as well as select the optimal parameters of the control system.

In addition to a diesel generator, WDPP can include batteries that can be charged from a wind generator or DPP by means of a rectifier. Power supply in this case is carried out even in calm weather from the batteries through inverters or from the DPP. Thus, the use of WDPP instead of DPP for the construction period will reduce the consumption of diesel fuel and, accordingly, the costs of its purchase, transportation and storage.

During the period of operation of the facility, water intakes and SHC can be located at some distance from the main technological facilities of the object, but the construction of cable or overhead power lines to power these facilities is not so much associated with difficulties as the construction of such linear facilities to power well clusters, which, as a rule, They are located at a considerable distance from the main technological facilities of the facility, and, consequently, from the power center. In this regard, power and voltage losses during energy transfer are possible, therefore, the cross sections of the supply power lines are overestimated and, as a result, the capital costs increase. In general, the organization of PSS oil and gas fields is of interest, since instead of laying long power lines, the construction and operation of which in the north of the Tyumen region is a capital-intensive and labor-intensive measure, in some cases alternative options associated with the use of distributed generation are possible. However, when considering this issue, it is necessary to take into account the possibility of using ESS and their influence on PSS, and the influence of power sources on the functioning of industrial electric heating systems, the share of which in the energy consumption of oil and gas production enterprises is significant [5].

Improving the energy efficiency of the enterprise is also possible by introducing ESS into its power supply system and conducting a comprehensive assessment of the economic and technical feasibility of such a solution. Thus, the task in the field of optimizing energy consumption is based not only on regulating the energy consumption of the enterprise (load schedules) [6-11], but also on using the capabilities of the tariff policy [12].

Based on the analysis, the following concept of organizing an energy-efficient PSS of an oil and gas field enterprise is proposed, the structural diagram of which is shown in figure 1.

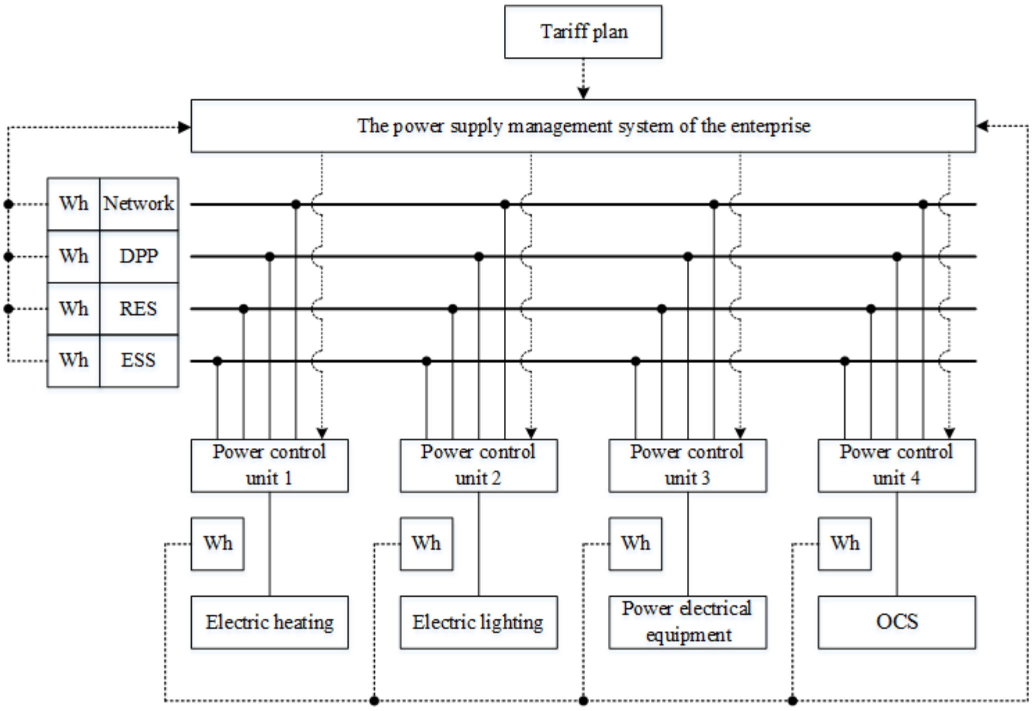

Figure 1. Block diagram of an energy-efficient power supply system.

The structure of an energy-efficient power supply system suggests that several power sources are in operation at the same time. The block "Network" represents communication with a centralized power supply system or a large own generation based on traditional energy sources. Blocks "DPP", "RES", "ESS" respectively represent diesel power plants available at the facility, renewable energy sources and electric energy storage systems. Consumers, as a first approximation, are divided into functional groups in connection with their operating features: electric heating, indoor and outdoor electric lighting, power electrical equipment (mainly electric motors) and the operational current system (OCS). Depending on the belonging to one or another functional group, the consumer is supposed to install a power control unit, responsible for switching the power sources of this consumer and ensuring feeder protection.

Information on the amount of consumed and generated electricity by consumer groups and types of power sources flows into the enterprise's power supply management system. The power supply management system of the enterprise, in accordance with the tariff plan, manages the power control units of certain groups of consumers in such a way as to provide the most economically and technologically advantageous power supply option in the corresponding time period.

Particular attention is paid to the functioning of the electric heating system, as one of the most energy-consuming systems. RES based on WPI become a priority source of power for electric heating systems for pipelines. For example, the WDPP used for the period of construction of the water intake can be integrated into the permanent PSS of this facility as a power source for the electric heating system of the outlet from the water intake.

According to the maximum calculations, when heating with a self-regulating cable with heat dissipation of 16 W/m, two threads of a metal conduit with a diameter of D=63 mm with mineral wool insulation, length L=0.4 km with a water temperature inside the pipe of T_v=5 ºC, ambient temperature T_c= -30°C, a power of about 40 kW is required. Then for the winter period (210 days) we have the energy consumption of the electric heating system of this section of the pipeline of about 200 MW·h, which for consumers of the 4th price category corresponds to costs of about 0.25 million rubles.

Thus, when using WPI (the cost is about 1.15 million rubles per unit, including 20 batteries of 150 A·h each) to meet the needs of electric heating of the pipeline section under consideration, we have a payback period of about 9 years. Without a set of batteries (the cost of about 0.73 million rubles), the payback is about 6 years. In the future, it is possible that the cost of acquiring a WPI can be offset by government subsidies as part of a renewable energy support program.

Depending on the power of the WPI, the rectifiers and inverters included in it can have a significant cost. Therefore, it is of interest to utilize the power generated by WPI with minimal or no conversion, which will help reduce the cost of the installation and, accordingly, the payback period. It is known that there is an approach to increasing the efficiency of wind generators by utilizing power at a ballast load, but this approach involves supplying this load from a DC bus, that is, the rectifier is not excluded from the circuit. A possible option for utilization of WPI power without converters is to use the alternating voltage generated by them by consumers not demanding on the quality of power supply. Energy with characteristics that do not meet the requirements for the quality of electricity for most consumers without conversion can hypothetically be used for the needs of electric heating.

A possible field of application is the heating of pipelines, injection wells, heating of production wells in order to increase production by removing paraffins by temperature by lowering the heating element into the bottomhole zone or laying heating cable along the entire length of the well. However, studies in the field of electric heating of various kinds of objects (premises, pipelines, wells) with voltage, the nature of the change of which is stochastic, have not been carried out. But the authors consider this issue possible, an assessment of the technical and economic feasibility of such a solution should be carried out in the framework of increasing the energy efficiency of an industrial enterprise.

Thus, to solve the issue of energy efficiency of electric receivers, the concept of building a PSS of an oil and gas field enterprise using distributed generation based on RES, as well as using solar energy sources, is proposed. It is assumed that such a system will provide:

- lower costs for paying a tariff for electricity services;
- reduction in capital and operating costs for the construction of overhead and cable power lines;
- lower costs for the operation of the electric heating system;
- cost reduction for the organization and functioning of temporary PSS.

In the absence of a centralized power supply, an additional effect is possible due to:

- reducing the capital intensity of the construction of a gas turbine power plant and the loss of the customer in the form of lost profits due to gas consumption for own needs (generation);
- reducing capital costs by reducing the number of gas turbine units of hot and cold reserve in their composition.

To confirm the hypotheses put forward, it is necessary to proceed from conceptual design to a detailed study of specific options for arranging oil and gas fields, to determine the optimal composition of local power sources and their location, and also to develop an algorithm for optimizing the parameters of local power sources in power supply systems of oil and gas fields with distributed generation.

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