Creation of an autonomous energy supply system for isolated territories

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Abstract. In the presented study, existing design solutions for providing energy supply to various territories were analyzed. In the work, the volumes of electric energy production based on the use of renewable energy sources in different countries of the world were investigated, as a result of which, it was revealed that in some countries, this indicator reaches 50%. However, renewable energy sources are almost not used to provide thermal energy to consumers. As a result, it was proposed to use a design solution aimed at providing hot water supply to rural, remote and isolated territories.

1. Introduction

In recent years, questions have been updated in the world energy community aimed at moving the industry to the 3 "D" system - digitalization, decarbonization and decentralization. These problems were already actualized in the world energy community in the last century, when they thought about creating a system of remote control and supervision of energy facilities, reducing the use of fuel and energy resources that negatively affect the environment and creating a decentralized electricity and heat supply system for consumers, which ensures reliability and the effectiveness of the entire industry.

In the global energy sector, a similar trend began to be implemented in the last century, for example, in the European Union, energy packages were adopted aimed at reducing the environmental load on the environment and developing an alternative and distributed generation system. In Russia, similar trends are also gaining a new round of development, which include the adoption of state and corporate programs aimed at developing new technologies that provide improved quality of production processes at power plants, reduce the use of traditional resources and ensure a gradual transition to autonomous energy supply.

Of course, during the creation of the energy system, it was impossible to imagine that today the principles of managing the industry will radically change. Initially, the energy industry was created on the principle of electricity and heat supply to nearby houses and buildings; however, there was a trend to unite the energy industry, in order to ensure the flow of electric energy from surplus to energy-
deficient areas, which allowed providing all consumers with electric energy and increasing reliability and energy security.

At the time of its creation, the energy industry of the whole world was based solely on the use of fuel and energy resources and water resources. During this period, the main types of power plants were created that use coal resources, oil and fuel oil, as well as uranium raw materials. These power plants have existed in some states for decades, and some still use and produce electric energy. The use of these types of fuel, of course, negatively affects the environment and requires the constant use of non-renewable resources for the production of electric and thermal energy.

In recent years, issues related to uninterrupted, reliable and high-quality energy supply have been aggravated, as various transformations are taking place in the electric power industry, as well as problems related to the depreciation and obsolescence of capacities, a decrease in the functioning efficiency of individual elements of the electric power industry, an increase in pollutant emissions and fuel consumption - energy resources and other problems. At the same time, if in the central regions and city agglomerations the energy supply is stable and uninterrupted, in some regions, the energy supply system is isolated and interruptions in energy supply can be observed. It should be noted that not all households are provided with energy supply, which in the 21st century indicates the backwardness and inefficiency of individual states [1].

The inability to create a heat network in remote regions, in villages and small towns aggravates the problem of finding new options for providing energy to such consumers [2]. In the modern world, there are many options and technological solutions that can ensure human life and the functioning of small industrial facilities independently of the central electricity and heat supply, which, of course, provides some independence and stability of the operation of such consumers.

In this regard, we consider it necessary to consider issues related to ensuring reliable and sustainable functioning of energy facilities, as well as to propose a system of autonomous energy supply for isolated territories [3-4].

2. Materials and methods

The purpose of this study is to develop an autonomous energy supply system for isolated territories. To achieve this goal, the following tasks were formulated:

- Assess existing opportunities for providing autonomous energy supply to consumers;
- Submit design solutions allowing energy supply to isolated areas.

This study is based on the use of scientific methods and statistical information obtained from various sources.

3. Results

In the global energy sector, there are various approaches to the development of energy, for example, they distinguish a conservative, progressive and energy transition. Each of these approaches implies its own development path, for example, in the global and Russian energy sectors, these approaches are radically different and have completely different targets. Different types of energy transitions imply a gradual abandonment of the use of traditional types of resources that negatively affect the environment and provide a transition to alternative energy. These transitions will provide a qualitative path for the development of energy in the scale of both a single state and the entire world energy sector.

The placement of electric power facilities took place according to different principles that were developed back in the Soviet period. The first method involved placing power plants near sources of fuel and energy resources, with further transfer of electric energy to end consumers, the second method was based on transporting fuel and energy resources to stations that were located near consumers. Each of the proposed methods had its advantages and disadvantages, which required the electric power industry to develop new approaches to providing electric and thermal energy to various consumer groups [5].

The solution to energy supply issues was raised not only in the Soviet period, but also in modern times, this is due, first of all, to the creation of separate villages and territories, which, due to
technological features, cannot be connected to the electric and heat network. In this regard, in the territories of the countries of the world, questions have begun to be raised related to the need to provide such consumers with electric and thermal energy from independent and autonomous energy sources.

One of the ways to solve the issues of providing electricity to isolated, remote, special and other territories in foreign countries is carried out by creating a fleet of power plants operating on renewable energy sources. Renewable energy began to develop abroad in the last century, when the need for the purchase of expensive fuel and energy resources and the need to preserve the environment for future generations became more acute. The potential of renewable energy sources in the countries of the world is quite high, which has contributed to the development and appearance of ever-new types of power plants operating on various types of renewable sources [6-7].

The development of renewable energy requires not only the necessary organizational solutions, but also material, financial and labor costs. The directions of development are the creation of new technologies associated with an increase in the efficiency of existing or planned plants, as well as the need to ensure the production of human resources that carry out not only the development of new devices in the field of renewable energy, but also the management, maintenance and repair of these plants.

The use of renewable energy sources began for the first time in ancient centuries, when wind and sun were used in agriculture, agriculture, industrial production, domestic life and other fields of activity. In recent decades, wind and sun have been regarded as a source of electric energy. To date, a fleet of power plants operating on renewable energy sources has already been formed in various countries, which indicates the possibility of using these types of natural resources for the benefit of humankind.

Consider the volumes of the actual share of electricity generation in wind and solar power plants in the total volume of electricity production (figure 1) [8].

![Figure 1. The share of electricity generation at wind and solar stations in the total balance in 2017, in percent.](image-url)

It can be seen from the figure that in Denmark the volume of electricity production from renewable sources is more than when using traditional energy. In Uruguay, Germany, Ireland and Portugal, the share of electricity generation from renewable energy sources is one third of all electricity produced, while in other countries of the European Union this indicator is from 10 to 20%. However, in the
Russian Federation, the volume of electricity production based on renewable energy does not exceed 1%, which indicates the underdevelopment of this type of activity [9-11].

In recent years, wind and solar power plants have been installed to provide electrical energy to isolated territories and urban agglomerations, mainly exclusively for generating energy. At the same time, such electric parks do not produce thermal energy, which is necessary to provide heating and hot water supply in order to satisfy consumer and industrial needs of consumers [12].

Because humankind has learned to use the potential of renewable energy to generate electric energy, we consider it necessary to consider design solutions that will provide thermal energy to various consumer groups.

4. Discussion
This means that large amounts of energy are required that can produce thermal energy. Today, the production of thermal energy is carried out directly at thermal stations, various non-traditional stations that use geothermal energy, burning biofuels and various household wastes.

Consider various engineering solutions that focus on the use of solar energy to produce thermal energy. Of course, such plants cannot be used today for the heat supply of entire urban agglomerations, since there is no design and technological solutions for creating a park of solar stations that produce thermal energy. Moreover, today such installations can be used to provide hot water supply to individual residential buildings, households and other industrial buildings [13].

Consider a schematic diagram of a solar installation to provide consumers with hot water (figure 2).

![Schematic diagram of a solar installation to provide hot water to consumers.](image)

A solar installation converts solar energy into hot water, which can be used for domestic purposes. The principle of operation of such an installation is as follows. The collector provides the collection of solar flux or solar radiation all year round and in any weather conditions. Such solar collectors are located on the roofs of various buildings, special devices that are largely remote from the ground to ensure continuous absorption of solar fluxes. In this case, the collectors should be placed at a certain angle, since it is necessary to ensure the circulation of chemically purified water - a coolant. Collectors and coolant are combined into a primary circuit, which is connected to the secondary circuit through a heat exchanger. In the second circuit, tap water is already heated through a heat exchanger, in which heat energy is exchanged in the heat exchanger between the heat carrier and cold water. Similarly, on sunny days, the water is heated to 45-60 °C, which allows the use of hot water in domestic consumption without additional heating. At the same time, in the winter period, especially in the northern latitudes, solar energy does not allow providing the desired temperature at the exit of the hot water; therefore, a battery tank is installed, which, by burning fuel or using electric energy, heats the water to the desired temperature [14-15].
Of course, the presented technology is not the only one that must be applied to provide various groups of consumers with thermal energy. In ancient times, man learned to use various natural phenomena to solve his own domestic and community issues; today humankind has made a qualitative breakthrough in the use of various natural phenomena that help humankind solve global issues related to the need for electric and thermal energy. Today, many technologies are known for converting wind, solar, water, various natural phenomena into electrical and thermal energy.

According to researchers, the development of such technologies will allow for a qualitative and quantitative breakthrough in the energy industry, the functioning of which is provided by engineering enterprises, the railway complex, the metallurgical complex and other types of industries. It should be noted that Russia has enormous potential for renewable energy, however, this potential is currently not being fully utilized and, therefore, forced to consume fuel and energy resources, which not only increase operating costs for energy production, but also negatively affect ecological situation.

Today in the Russian Federation, several industries are being launched related to the creation of solar panels, blades for wind turbines, and new technologies are being developed for generating electric energy from various renewable sources. However, these technologies are solely individual in nature and in rare cases are used massively for the production of electric and thermal energy. Requirements for the development of alternative energy throughout the entire state come to the fore, as the environmental situation in certain regions requires an early resolution, as a result, state and scientific institutions are developing various programs to gradually phase out the use of fuel and energy resources and ensure the transition to alternative energy [16-17].

Thus, the presented technology would provide the majority of residents with hot water supply, who live mainly in rural areas, remote and isolated areas [18-19]. In modern conditions, when the need to preserve the environment for future generations and reduce the use of traditional resources is aggravated, the proposed recommendations would help solve environmental safety issues and the rational use of fuel and energy resources.

5. Conclusion
As part of the study, we analyzed the potential for the use of renewable energy in different countries of the world, because of which we found that the share of electric energy generated by renewable energy sources in Denmark is more than 50%, in Uruguay, Germany and Ireland - 30% of the total consumed electrical energy. In the Russian Federation, this indicator does not exceed 0.1%. Despite the fact that Russia has a great potential for traditional energy, the country only today sets the task of developing renewable energy. At the same time, it was found in the work that the use of wind and solar energy is used for the production of electric energy; as a result, the authors of the study examined the available technological solutions for the production of hot water using solar energy, which can be used to power rural, remote and isolated territories. Thus, according to the results of the study, the stated goals of the work were achieved.

World experience, which is currently used in almost all national energy sector, provides the development of these complexes, which gives a synergistic effect for the national economy. At the same time, we see that the results of each country differ depending on the scale of use of alternative energy. Of course, Russia should apply the positive international experience in the territory of its country, since the necessary technologies have already been created, and the use of wind and sun gives certain results in national energy companies. One of the mechanisms for implementing the policy in the field of transition to alternative energy can be projects of large industrial enterprises that will ensure the construction and operation of alternative energy and, as a result, receive electric energy from such plants.

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