Renewable energy in St. Petersburg and Leningrad Region

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Abstract. The article is devoted to the topic of the most current interests - renewable energy development. Alternative sources of energy play an increasingly significant role in the development of the whole energy power use in different countries. Russia is more and more focusing on this field to decrease in energy consumption and the mutual penetration of natural and technological components. The current instruments of support in the field of renewable energy are presented on the level of the Russian Federation as well as on the chosen regions - Saint Petersburg and Leningrad region. The paper observes the Governmental program for support of the development of renewable energy in Russia. The information about types of the alternative sources of energy that are more used in St. Petersburg and Leningrad region is summed up. Best practice in current cases of acting projects on the territory of the chosen regions is accumulated. It was concluded that the most efficient way to use alternative sources is in its combination, but not individually.

1. Introduction

The Russian Federation is among the most important oil and gas producers in the world and is entering the new era and studying renewable potential in the energy mix. The Energy Strategy of the Russian Federation for the period up to 2030 [1] determines the prospects for the development of various types of generation, where an important role is assigned to the energy-efficient direction - the development of renewable energy sources.

Recently, the government approved the layout of new energy facilities. In 2020 the Ministry of Energy predicts the Russian Federation, at least 6 GW of generation generated from renewable energy sources should be introduced annually. After that, the share of alternative sources is expected to grow 2.5 times. Renewable energy sources are a promising direction for the development of world energy [2, 3, 4]. The economy is moving into a new “non-resource state”, characterized by a decrease in energy consumption and the mutual penetration of natural and technological components.

In the International Energy Agency (IEA) report, in the last decade, the global economy has moved on to green growth, and the total installed capacity of green energy in 2015 exceeded fossil fuels and amounted to 153 GW [5]. Unfortunately, despite the alleged rapid implementation of green technologies in the world, the development of renewable energy is not going as fast as we would like. It is because of some constraints, such as the instability of alternative energy sources, the absence or
poorly developed culture of energy consumption, significant initial investments of a long investment cycle [3].

According to experts, every year our country pays more attention to renewable energy sources to increase the availability of energy resources and improve the environmental situation and energy security. The Government of the Russian Federation defined as a strategic objective the increase in the share of renewable energy sources in the country's energy balance from the current 1% for the period until 2030 - 7.5% of the total projected level of energy production in 2030.

There are favorable prerequisites for organizing the process of application and development of renewable energy sources, among which the natural and technical resources of the territory [6] in some Russian regions. Such regions are St. Petersburg and the Leningrad region. They have already cases that showed a positive result in solving the energy problem.

The research aim is to find opportunities for the development of renewable energy that are used currently at the moment on the example of the Leningrad region and Saint Petersburg. The tasks set up to achieve this goal are to observe the Governmental program of support of the development of renewable energy in Russia, to find out what are the alternative sources of energy that are more used in St. Petersburg and Leningrad region and to accumulate best practice in current cases of acting projects on the territory of the chosen regions.

2. Methods
In the Russian Federation, Government resolution of April 15, 2014 No. 321 "On approval of the state program of the Russian Federation Development of Energy ", the implementation period of which is up to 2024 years, is in force [7]. The objectives of the state program are to provide reliable, high-quality and economically justified requirements of the domestic market for energy carriers, energy and raw materials based on the principles of energy saving and energy efficiency, as well as the fulfilment of obligations under foreign contracts. The parameters of the state program are updated under the strategic guidelines of the Russian Federation for the period up to 2024, as well as the main areas of activity of the Government of the Russian Federation for the period up to 2024.

The structure of the state program provides for the implementation of 4 subprograms that have a sectoral focus, 33 targets (indicators) and 21 main activities, including two federal and one departmental projects, namely: Federal project “Guaranteed Provision of Affordable Electricity”; Federal project "Guaranteed Transport of Oil, Petroleum Products, Gas and Gas Condensate"; Departmental project "Digital Energy".

In the sub-program "Development and modernization of the electric power industry", one of the tasks is the development of the domestic scientific and technological base and develop advanced technologies in the field of renewable energy sources. Separately in the passport of the sub-program “Development of the use of renewable energy sources” state program paragraphs, which will stimulate the production of electric energy by generating units based on renewable energy sources and increasing the technological and economic potential of renewable energy sources in Russia. The target indicators for these objectives are:

- The share of installed capacity of generating facilities operating based on the use of renewable energy sources in the total volume of generating capacities of the Unified Energy System of Russia.
- Commissioning of installed capacity of generating facilities operating based on renewable energy sources (excluding hydroelectric power plants with an installed capacity of more than 25 MW).

In 2019, the commissioning of new renewable energy facilities amounted to about 375 MW, and the total capacity of renewable energy facilities commissioned from 2014 to the present is about 905 MW. The leading regions (figure 1) in terms of the volume of implemented projects under the existing support mechanism are the Orenburg Region, Astrakhan Region, Ulyanovsk Region, Saratov Region, Altai Republic and the Republic of Bashkortostan. As the investment projects of renewable energy
sources planned under the results of competitive selection by 2024 are implemented, the Krasnodar Territory, Rostov Region and Murmansk Region will be added to the list of leaders.

Figure 1. Various energy sources distribution in Russia [8].

The priorities and goals of state policy, including the general requirements for regional state policy, also reflect the development of advanced technologies in the field of the use of renewable energy sources.

The main principles, goals and objectives in the field of energy efficiency and energy saving promotion in St. Petersburg were defined in the “Concept of improving energy efficiency and stimulating energy saving”, which was approved by the St. Petersburg Government Resolution of November 11, 2009, N 1257. The goals, indicators and activities for energy efficiency further concretized in the State program of St. Petersburg "Integrated development of public infrastructure systems, energy and energy saving of St. Petersburg for 2015-2020" [9].

That is why it is important to study the existing experience of already launched projects to determine the possibilities for further development of the Russian electric power industry. In the framework of the study, the case analysis method is used for these purposes.

Among the methods of qualitative analysis, the case study method is one of the most commonly used. It is based on careful and complete observation of a social unit (person, family, institution, cultural group, or even the entire community). The case study focuses more on the full analysis of a limited number of events or conditions and their relationships.

The object of study is renewable energy in St. Petersburg and the Leningrad region. Cases in the areas of energy using various sources of alternative energy are considered.

3. Results
The main direction of discussions on the current energy production policy in Russia is the coordinated development of different energy sources including renewable energy (mainly wind and solar plants). At the same time, further development of renewable energy is considered not as an end in itself, but as one of the necessary components of sustainable development of the energy complex of Russia.

Changes in the structure of the installed capacity of the Unified Energy System of Russia over the 2015-2018 years is presented in figure 2.
The share of installed capacity of generating facilities operating based on the use of renewable energy sources in the total volume of generating capacities of the Unified Energy System of Russia in 2018 amounted to 0.42%, and in 2019 there was a 2-fold increase to the planned value (plan 2019 - 0.39%, and the fact - 0.9%). This indicates a growing interest in this type of energy and various regions are increasingly involved in this process.

The development of projects related to renewable energy installations demonstrates the focus on sustainable energy stability in the region. Renewable energy is used marginally in the Northwest region. They are mainly associated with large hydroelectric power plants operating in the structure of federal and regional energy companies. However, some studies [3, 10, 11] show that the resources of renewable energy sources in the North-West of Russia are not so small. In St. Petersburg, as well as in such a rapidly developing region as the Leningrad Region, there are both the possibility and the feasibility of using the following renewable energy sources: geothermal energy, wind energy, solar energy, low water hydropower, as well as the energy contained in stored biomass and other agricultural waste.

As for the potential of geothermal energy, according to the All-Russian Research Geological Institute, large potential of thermal energy is contained in a thermal anomaly under the southern shore of the Gulf of Finland.

Speaking about the case of using wind energy, it should be noted that in the Leningrad Region and St. Petersburg there are favorable conditions for the development of wind energy and the commissioning of wind power plants of various power classes. To date, 7 objects of the wind energy complex are operating in the Leningrad Region and St. Petersburg, and 1 object is under construction.
(Kotlinskaya wind farm) [12]. Most of the facilities are of the type of wind diesel power plants with autonomous purpose and the possibility of parallel operation with the network. In 2001, in the city of Krasnoye Selo, the first network wind power installation was installed to supply power to the industrial consumer, LLC Krasnoe. This installation allowed to reduce energy consumption at the enterprise in certain periods to 40-50%. For additional energy supply to Kotlin Island and the city of Kronstadt, a project is underway to build a wind energy complex of 5 or 6 wind turbines. The payback period for construction with the financing of wind farms in full will be 4.5 years. Also, a project for the construction of the first wind farm in the Volkhov district of the Leningrad region is under development. The planned launch date for the project “Windpark No1 in the Leningrad Region” is 2022-2023, the payback period will be 10 years.

The main wind farms that are developing in the Leningrad region: Wind Farm Dam, Wind park in the seashore of the Gulf of Finland in the Leningrad region.

Coastal zone of the Gulf of Finland is considered one of the most promising regions for the development of wind generation in the wholesale market. The Russian small wind turbine market is in its initial phase, however, it is represented by NPO ElektroSfera located in St. Petersburg. The company NPO ElektroSfera produces and sells through a network of dealers wind power settings and hybrid systems with single-phase or three-phase alternating current with a capacity of 5 to 60 kW for autonomous power supply of consumers who do not have access to centralized power supply networks.

The main development of the company is a 5 kW Breeze 5000 wind turbine, on which basis the Breeze-Leader complexes and the Breeze-Diesel+, Breeze-Diesel-Bars, and Breeze-Diesel complexes for cellular stations are presented.

Buyers are mobile operators, farmers and hunting farms, tourist camps, owners of private hotels and cottages in Russia and the near abroad.

Solar energy is a leading component of heat balance and allows solving several scientific and applied problems. For the case of the solar energy use in the Leningrad Region and St. Petersburg, the duration of sunshine noticeably deviates from latitudinal.

According to information resources about solar energy facilities in the city and the region, there are 8 operating solar power stations on lighthouses; 18 - operating in private homes; 1 - under construction.

Solar heating systems can be used for low-temperature processes, such as water heating, for servicing cottage complexes; in agriculture, on farms and homesteads. The return on investment in such a project will be from 7 to 20 years [13]. The use of solar installations is relevant for solving some global problems. The user is attracted not only by the possibility of the autonomy of the system but also by additional social and environmental factors that make it possible not to harm the environment, which is a definite impulse for studying the resources of this type of renewable energy source.

The solar energy dealers located in St. Petersburg are:

- “Avtomonye energeticheskiye sistemy” company is designing and installing in the field of renewable energy. The main company products are solar panels - NAPS, Trunsun, Chinaland.
- “Energia” company is the producer and wholesaler of a chemical current source for domestic and industrial use. The main company products are electrical, solar panels Panasonic HIT.

As mentioned earlier, another case that is actively developing and has potential is low-energy hydropower. The heyday of small hydropower for the Leningrad region falls on the 50-60s of the XX century. Several dozens of small hydroelectric power stations were put into operation and were subsequently closed under continuous network electrification.

At the beginning of 2018, six large hydropower stations were operating in the region: Nizhne-Svirskaya and Verkhne-Svirskaya (Svir river), Narvskaya (Narva river), Volkovskaya (Volkhov river), Lesogorskaya and Svetogorskaya (Vuoksa river). However, the potential of hydropower resources of small rivers in the region is used in a small proportion, which in percentage terms is about 0.2%. Development projects in the field of small hydropower are aimed at resolving the issues of re-
equipment and reconstruction of former abandoned small hydroelectric power stations, where hydraulic structures and down-stream, which are used for recreational and reclamation purposes, have been preserved. All this allows solving problems related to the ecological state of the region and issues related to the energy efficiency of the region. One of the facilities involved in the reconstruction of small hydropower plants is the Andreevskaya mini-hydroelectric power station on the Tukalsioki River near the city of Vyborg, which was decommissioned in the 1950s. According to experts, when starting 100 small hydropower plants and micro hydropower plants, one can expect to receive up to 0.15 billion kWh per year electricity, which will be 5-10% of electricity consumption in agriculture of the region. As a result, it will significantly increase the stability of energy supply in agriculture. The list of SHPPs: Luga-I, Luga-II and Ivanovo.

There should be presented one more case that shows the combination of the use of different resources of renewable energy - Krasnoe Ozero project. The Autonomous House Energy System project Krasnoe Ozero will increase the energy efficiency and environmental friendliness of the Krasnoe Ozero resort, making it one of the first sites to introduce advanced energy-efficient construction technologies [14]. The Autonomous House Energy System consists of:

- the wind generator set is a source of electric energy (37-meter windmill, the blades of the structure are 23 meters in diameter);
- a solar collector - flat radiators with a selective coating that converts solar energy into heat;
- heat pump - converter of low-potential energy (heat of land, reservoirs, wastewater, etc.);
- heat accumulator – a thermally insulated container with water.

Energy saving activities are compulsory and basic ones allowing to ensure general economic efficiency of a range of energy efficient measures.

Therefore, this case unites several types of resources of renewable energy - wind, solar, geothermal and hydropower. And perspectives of its implementation look more efficient based on the combination of resources.

4. Discussion

Due to the existing competition in the renewable energy market in 2016-2019, it was possible to significantly reduce the average planned capital expenditures for projects per 1 kW of installed capacity: in solar energy, this indicator by the end of 2019 fell by 59.5% compared to 2015, in the field of wind generation for the same period, by 58.2 %. As part of a targeted policy to stimulate the localization of renewable energy equipment, the production volumes of the respective components have so far increased to 900 MW per year (from 140 MW per year in 2012), while estimates have been received from the Ministry of Industry and Trade of the Russian Federation on the possibility of ensuring the growth of industrial potential in the amount of 1, 4 GW of manufactured equipment per year, which will employ at least 12 000 people.

As part of the implementation of the Action Plan for the development and adoption of departmental and governmental regulatory legal acts of Russia, aimed at eliminating excessive requirements for the design, construction and operation of renewable energy generating facilities, several regulatory acts have been adopted aimed at:

- elimination of excessive requirements for equipping electric energy meters with generating facilities operating based on renewable energy sources;
- clarification of the requirements for the formation of groups of supply points in the wholesale electricity and capacity market to generating equipment for solar and wind power plants;
- providing the supplier with the right to redistribute the amount of power provided between the generating facilities selected based on the results of tenders that operate based on using renewable energy sources;
- clarification of requirements for installation locations of electric energy meters to generating equipment of solar and wind power plants;
introduction of amendments to the Rules for establishing protection zones for electric energy production facilities and special conditions for the use of land located within the boundaries of such zones (the establishment of protection zones for wind generating facilities is excluded).

The adopted Federal Law of December 27, 2019 No. 471 “On Amendments to the Federal Law “On Electric Power” regarding the development of micro-generation”, which includes classification of micro-generating facilities and solutions based on renewable energy sources (for example, solar panels, submersible installed on the roofs of private houses micro-hydroelectric power station, etc.), will create legal mechanisms so that citizens and small businesses can sell the "surplus" of unused energy to sales companies. They can also connect to the network in a simplified model. In parallel with this law, amendments to the tax legislation of the Russian Federation were also adopted, aimed at exempting owners of microgeneration facilities from income tax on individuals when they sell electricity to sales companies [15].

The problems of the energy industry functioning are considered by scientists from different countries. Today the global energy industry is undergoing major changes shifting towards the green growth and circular economy solutions [16, 17]. Separate interests are renewable energy sources [18, 19] and real-world examples of such projects in different countries [2, 20]. At the Leningrad region level, there are also confirmations of the feasibility of using renewable energy sources [3, 9, 21, 22], for example for public buildings. An important part of the analysis of the use of alternative energy sources is the assessment of their potential. Boris V.Ermolenko, Georgy V.Ermolenko, Yulia A.Fetisova, Liliana N.Proskuryakova [11], suggested measurement methodology and assessments for wind and solar PV technical potentials in Russia.

Speaking about the prospects for the development of renewable energy in the Leningrad Region and St. Petersburg, it should be noted that these regions have significant potential, the choice of direction is debatable. Perhaps it is worth paying more attention to complex projects involving various sources of alternative energy. Also, it is necessary to study in detail the regulatory framework to identify additional measures to support renewable energy in the studied territories, which may serve as an additional direction for research.

5. Conclusions
The issue of the accelerated development of renewable energy (including hydropower), aimed at diversifying the country's fuel and energy balance, is one of the keys to achieving the strategic goals of developing the country's electricity industry.

The main results of the measures taken to support and develop renewable energy in 2019 contributed to stimulating the production of electric energy by generating facilities operating based on renewable energy sources and to improve the technological and economic potential of renewable energy sources in the Russian Federation. The current program is designed until 2024. The government made a fundamental decision on its extension, taking into account the positive results of its implementation in the current period, since such a decision will allow preserving the emerging Russian industrial potential for the production of renewable energy-based energy equipment, integrate into global trends in the development of energy systems, reduce the anthropogenic pressure on the environment and allow significant Russian climatic resources. Work is underway to improve the regulatory framework for support of renewable sources in retail markets, as well as in isolated energy systems.

St. Petersburg and the Leningrad Region have significant potential for renewable energy sources from geothermal to biomass energy, while wind and solar energy are most actively used - the largest number of implemented projects is observed. Since the weather conditions of St. Petersburg and the Leningrad region are characterized by a small number of sunny days per year, but with increased gusts of wind due to the close location to the Gulf of Finland and other reservoirs, it seems appropriate to use combined energy from various sources. In this case, Krasnoe Ozero, considered in the article, is a good example of such combined private energy production and consumption.
The given cases in various areas of renewable energy using various alternative energy sources confirm the active involvement of Russia in work in this direction. At the same time, the case on the Red Lake reflects increasing opportunities due to the creation of complex projects for the development of renewable energy, where no one but a group of alternative energy sources is involved, which gives a cumulative effect.

The future of renewable energy sources is the creation and implementation of complex projects since the complexity of the project solves one of the biggest difficulties of renewable energy - stability and uninterrupted energy flow due to available alternatives.

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