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Analysis of the possibilities of using renewable energy sources in budget organizations on the Volgograd region example

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***Abstract* — This work is aimed at the analysis and justification of the possibility to use renewable energy sources (RES) for budget organizations on the Volgograd region example. Research is being conducted all over the world, its purpose is the search for the most effective non-traditional renewable energy sources, the use of which will allow the transition to resource-saving energy. Since the potential of application in various power systems is practically unlimited, the analysis of the RES implementation in the budget sector organizations taking into account the natural features of the Volgograd region possibility currently appears to be an urgent task requiring a comprehensive study. Traditional power supply systems used in budget organizations are characterized by relatively small initial investments, high annual fuel consumption and the cost of maintaining systems, while systems based on non-traditional and renewable energy are characterized by high initial investments, but also high resource savings and low operating costs. For budgetary organizations, the most pressing issue is the saving of allocated funds and optimization of current costs, in connection with which the issue of developing the most effective not only in technical but also in economic terms RES, the introduction of which is consistent with the existing energy system of the organization, becomes particularly relevant. To date, the organizations of the budget sector practically do not use RES, which is mainly due to the ratio of prices for equipment and energy, as well as due to the unresolved number of technological and organizational problem.**

Keywords* — *renewable energy sources, fuel and energy resources, energy saving and energy efficiency, budget organizations

I. INTRODUCTION

The economic development of the region is largely determined by the nature and efficiency of energy consumption. The relatively high share of heavy energy-intensive industry in the structure of the GRP of the Volgograd region, as well as the high degree of fixed assets depreciation obviously determine the region's relatively high level of energy intensity. Comparative analysis of the energy efficiency policy in the Volgograd region effectiveness in comparison with other regions of the South of Russia and regions of the same type in the energy economic development, shows a significant region lag in the field of energy saving and energy efficiency. A powerful breakthrough in the production of electricity from renewable energy sources can change this situation. The existing significant potential of wind and solar energy of the Volgograd region, as well as the possibility of introducing small distributed energy, determine the priority direction of improving the efficiency of electricity consumption in the region, and can also serve as a driver to overcome the region's lag in socio-economic indicators.

There are various examples of renewable energy sources implementation in agriculture or utilities. However, there is no development of complex solutions from different types of RES, combined with the existing level of energy efficiency of budget organizations. In this connection, the purpose of this work is to analyze the possibilities of using renewable energy sources in budget organizations on the example of the Volgograd region.

To achieve this goal, the following tasks were solved: to analyze the accumulated experience in the application of the main types of non-traditional and renewable energy in the

organizations of the budget sector in Russia and abroad; to assess the status and trends in the energy saving policy implementation in the budget organizations of the Volgograd region; to identify the possibility of using RES in the Volgograd region, taking into account its climatic and geographical features.

II. Materials and Methods (Model)

To achieve this goal and solve the tasks, we used systematic and dialectical approaches, General scientific methods of retrospective, subject-object, functional-structural, comparative, descriptive, factor analysis, content analysis of scientific literature, economic-statistical, comparative, analytical methods of research.

III. Results and Discussion

A. The Russian and international experience of the main types of non-traditional and renewable energy sources use in the public sector organizations.

The cost of energy is one of the significant cost items for most organizations. It continues to grow in recent years, both in Russia and in the world. In General, most public sector organizations have significant potential to reduce energy costs and reduce carbon dioxide emissions through energy efficiency measures. The energy efficiency technologies that provide these savings are available, tried and tested, and often recoup their initial capital expenditures in just a few years. In European countries, thanks to state subsidies and modern technologies that reduce the cost of RES, the payback period for investments in renewable energy is reduced: for geothermal energy is 6-7 years; for wind power plants, depending on the type of technology used - 7-10 years; for solar farms, depending on their size, investments pay off in 6-10 years. These terms vary slightly among different countries [1].

The popularity of renewable energy sources in the world is driven by the need to reduce greenhouse gas emissions, as well as reduce dependence on hydrocarbon sources of energy [2]. There are many examples of public sector organizations successfully reducing the consumption of traditional energy sources. In India, for example, there is a significant increase in solar, wind and biomass generation capacity. Today the leaders in the development of alternative energy are countries such as China, Denmark, Kenya, and Iceland. In China 77 GW of solar and 149 GW of wind power plants were built in 2016. In Denmark the production of wind electricity covered 43% of all electricity needs in 2017.

In Europe, in order to control energy consumption and expand the use of energy from renewable sources, the European Union Directive [3] was introduced, which prescribes a General framework for the shares of RES used, including "wind, solar, geothermal, ocean energy, hydropower, biomass, landfill gas, gas treatment facilities and biogas". It is expected that the share of RES in total energy consumption in Europe will increase to 20% by 2020 [4]. In particular, the United Kingdom's goal is to increase the share of renewable energy consumption from 1.5% in 2005 to 15% by 2020. In Germany, the share of electricity provided by renewable energy sources should be at least 35% by 2020. At the same time, in 2016, the installed capacity (including micro-generation) of Germany's wind power generation was 45 GW (31% of the EU), and solar — 40 GW (40%). The share of RES in the total electricity supply in Germany in 2016 was a record 33.9% [5].

The world practice of RES development has revealed a significant potential for energy efficiency through the introduction of small distributed generation. This type of generation has one of the highest growth rates in the world. For example, in the USA the installed capacity of microgeneration from solar batteries is 16 GW [6]. In many countries such as Belgium, the UK, Germany, the Netherlands, Italy, Canada, the USA, China and Japan microgeneration based on RES has received significant support and encouragement from the state through the providing of bonus tariffs (feed-in-tariff), tax incentives, grants and subsidies, as well as through the mechanisms of the carbon market [7].

Currently in Russia the share of renewable energy in total energy mix accounted for less than 1% . The reasons for this level of RES are regulated and relatively low electricity prices, as well as a number of restrictions on micro-generation using renewable energy sources. There are some examples of renewable energy: wind farms in Bashkortostan and Kaliningrad region, Geothermal power station on Kamchatka and Kurillo, Kislogubskaya tidal power plant on the Kola Peninsula. However, there is still no widespread advent of non-traditional energy sources in Russia.

B. Current status and trends in the implementation of energy saving policy in the public sector organizations of Volgograd region.

Budgetary institutions include all state and municipal institutions financed by the budget, namely: educational institutions; medical institutions; sports institutions; cultural institutions; pre-school institutions; children's homes, children's health camps; homes for the elderly and disabled; communal institutions; student dormitories, military units, as well as municipal and cultural enterprises, institutions and other organizations financed in whole or in part from the budget of any level. institutions established by the Russian Federation, the subject of the Russian Federation and the municipality [1]. At the regional and municipal levels, education and health facilities are the largest budget consumers.

The budget sector is the largest consumer of energy resources, spending a significant part of the budget to pay for them. Firstly, the increase in the energy efficiency of budgetary organizations in Russia is caused by the Federal law No. 261 "On energy saving...", and secondly, by the decrease in the cost of paying for energy consumption. In accordance with this law, the duty of government-founded organizations was the annual reduction of energy consumption by at least 3%, as well as the installation of metering devices for water, natural gas, heat and electricity [2].

The following tools to improve energy saving and energy efficiency were proposed for budget organizations [3]: development of regional and municipal programs in the field of energy saving and energy efficiency, which should contain not only activities, but also targets in this area until 2015 and further until 2020, the introduction of energy management, energy audit, energy service contracts, as well as obtaining energy certificates – conclusions about the state of the energy complex of budget institutions. Thus, the reduction of fuel and energy resources consumption in the public sector was primarily due to the administrative and organizational mechanisms of energy management, as the fastest for implementation and do not require significant financial resources.

One of the indicators of the program on energy saving and energy efficiency is a preliminary class of energy efficiency — a reference indicator automatically calculated GIS "energy Efficiency" on the basis of the energy Declaration, taking into account specific indicators of fuel and energy consumption and the implementation of key technologies. In the State report, energy-efficient buildings operated by public sector organizations include buildings with a preliminary energy efficiency class D (normal) and above. The average share of such buildings is 18.3 % in 2017 in Russia. In the Volga, Siberian and southern Federal districts, the share of energy-efficient buildings operated by public sector organizations is lower than the average in Russia. Despite the positive trend, the overall percentage of energy-efficient buildings remains low. The distribution of buildings operated by public sector organizations by preliminary energy efficiency classes for Russia as a whole is shown in table 1.

TABLE I. THE DISTRIBUTION OF BUILDINGS OPERATED BY THE PUBLIC SECTOR, ACCORDING TO PRELIMINARY CLASSES OF ENERGY EFFICIENCY

Type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**Total**
Number	5	662	7	670	47267	100715	120172	**269498**
%	0,002	0,25	0,003	0,25	17,5	37,4	44,6	**100**

* The source:[11]

The buildings with a preliminary energy efficiency class E (reduced), F (low) and G (very low) occupy about 82 % of the total number of buildings operated by public sector organizations. The buildings with advanced energy efficiency class D occupy about 85 % of buildings with advanced energy efficiency class D and above, that indicates a significant potential for energy efficiency in the public sector.

Let us consider the main results achieved in energy saving and energy efficiency in the public sector on the example of Volgograd region (hereinafter referred to as VR).

The main activities in the field of energy saving in budgetary institutions of Volgograd region, the bulk of which were health care, education and culture, were as follows:

- replacement of existing outdated and inefficient windows with modern ones, with a high level of thermal protection and tightness;
- replacement of lighting devices with modern energy-saving (led);
- installation of automatic lighting control devices (sensors);
- repair or replace exterior entrance door units with insulation and sealing of joints, installation of door closers automatic door closing;
- replacement of valves of engineering technical networks for more effective;
- installation of automatic lighting control devices.

The dynamics of consumption and unit costs of energy resources by public sector organizations in 2016-2017 are presented in tables 2-3.

TABLE II. SPECIFIC CONSUMPTION OF FUEL AND ENERGY RESOURCES IN THE PUBLIC SECTOR IN 2016-2017

Scope of work of the institution	**The types of FER**	**Specific expenses of FER**		**The average for the SFD**	**Average in Russia**
		2016	***2017***		
Healths	Thermal Energy, Gcal/m2	0,17	0,16	0,152	0,2
	Electricity, kWh/m2	50,4	50,6	73,4	57,6
Education	Thermal Energy, Gcal/m2	0,15	0,15	0,11	0,19
	Electricity, kWh/m2	27,3	28,3	31,2	32,1

The source:[11]

One of the main measures in the field of energy saving and energy efficiency in Volgograd region is the replacement of old (non-energy efficient) lamps with new led in both internal and external lighting of public sector institutions. These actions are provided practically in all municipal programs of Volgograd region. In 2017, the share of led light sources in the total number of lamps in the internal lighting of VR public sector institutions according to the GIS "energy Efficiency" was 9.43%., and in the outer-11.66%, which is on average higher by 5 % of similar indicators in 2016.

TABLE III. THE CONSUMPTION OF FUEL AND ENERGY RESOURCES IN 2016-2017

The types of FER	**The consumption**		**Change, %**
	2016	***2017***	
Thermal Energy (Gcal)	2237145,69	1072093,41	-52,1
Electricity (kW.CH.)	98717305,09	89124276,17	-9,7
Cold water (m3))	3304795,28	2464528,45	-25,4
Natural gas (thousand cubic meters.)	364150,69	136745,39	-62,4

* The source:[11]

In 2017, the average specific consumption of thermal energy for the supply of state and municipal health institutions in VR amounted to 0.16 Gcal/sq. m. which is 20% lower than the average for the Russian Federation and 5% higher than the average for the southern Federal district. However, in the Southern Federal district this rate is lower by 21 % than the average for Russia, which could be driven by natural and climatic conditions. At the same time, this indicator in VR decreased by 6% compared to the previous year, while in the whole of the Russian Federation this indicator increased by 3 %. A similar indicator in educational institutions in VR was 0.15 Gcal/sq. m. which is 21% lower than the average for the Russian Federation and 36% higher than the average for the southern Federal district. This difference is possible due to the different potential and the initial level of energy efficiency of the objects in the areas included in the Southern Federal District. In the Russian Federation in 2017, this rate increased by 4 % compared to the previous period, and in the Southern Federal District the rate has not changed — probably due to less dependence on weather conditions in winter. At the same time, in general, the volume of consumption of fuel and energy resources decreased by 52.1% in 2017.

The average specific consumption of electric energy for the supply of state and municipal health institutions in VR for 2017 amounted to 50.6 kWh/sq. m., which is 31% lower than the average for the Southern Federal District and 12% lower than the average for the Russian Federation. The same indicator for educational institutions was 28.3 kWh/sq. m., which is 9% lower than the average for the Southern Federal District and 11% lower than the average for the Russian Federation. At the same time, this rate for the whole of the Russian Federation for 2017 has not changed in relation to the indicators of the previous year. However, in the Southern Federal District there is a significant increase in the specific consumption of electric energy — by 10% compared to the previous year, and the level of specific consumption of electric energy exceeds the average in the Russian Federation by 28 %.

Thanks to the application of the above-mentioned measures to improve energy saving and energy efficiency in the public sector, by 2017 it was possible to achieve very high indicators to reduce the consumption of fuel and energy resources. However, these measures are low-cost measures and their re-application is no longer possible, so the further development of energy saving policies and reduce energy consumption requires the use of new technological measures, such as the introduction of renewable energy practices. Thus, in 2017, the project for the construction of a solar power plant with a capacity of 10 MW was launched in Volgograd region. Its completion was carried out in January 2018. The innovative project was completed in less than a year, despite the fact that its technological performance meets all international standards. The commissioning of the solar power plant allowed to reduce carbon dioxide emissions by 10 thousand tons and ensured the production of additional 12 million kWh annually. The payback period of this project was 6 years. Thus, on the basis of the experience the further introduction of renewable energy in the industrial and public sector is possible.

C. Identification of the possibilities of using renewable energy sources in the Volgograd region, taking into account its climatic and geographical features.

In the context of the exhaustion of traditional energy sources, there is a need to find alternatives – renewable energy sources. RES is commonly understood as energy of tides and waves; energy of the sun and wind; energy of gas released in landfills; energy of water (with the exception of hydropower plants); geothermal energy and low-grade thermal energy of the earth, air, water, biomass, waste, biogas; gas generated by coal mining [12].

In addition, it should be borne in mind that not all regions of Russia power generation facilities are in a satisfactory technical condition, which can lead to emergency situations and disruption of energy supply to areas remote from the centralized power supply. To solve this problem, it is necessary to create duplicate capacities that can meet the needs for electricity. For this purpose it is necessary to use renewable energy sources, whose potential in different regions is different.

For a comprehensive assessment of the territorial possibilities the method of calculating the total specific normalized potential (SNP) was developed and applied in the territory of India [13]. In accordance with the methodology, the specific technical potential of wind energy resources, the flow of solar radiation per unit area, the specific power of promising small hydroelectric power plants (SHPP)[1] [14], the specific potential of using geothermal energy, the specific technical potential of using agricultural waste in the region can be considered as separate indicators of the SHPP. These figures are calculated per 1,000 inhabitants of the region. SHPP is defined by the formula:

$$S_i = \sum_{j=1}^{m} \frac{x_{ij} - x_j^0}{x_j^{\max} - x_j^0}$$

$$i = 1, 2, 3, \ldots, n;\ i = 1, 2, 3, \ldots, m \qquad (1)$$

where n – is the number of territorial units; m – is the number of resource potential indicators; (x_{ij}), x_j^o – is the smallest value (for each resource indicator) from all regions, $x_j^{\max}$ – is the most different from x^o_j value of the indicator.

SHPP values vary in levels: low (SHPP < 1.0), average (SHPP = 1.0 to 2.0), high (SHPP = 2.0 to 2.5), very high (SHPP > 2,5).

According to the state statistics bodies, 2.5 million people live in the Volgograd region [15]. The region covers an area of 112.9 thousand km2[16] and has quite powerful resources of solar and wind energy. The average annual solar radiation is 4.03 kWh/m2, the data is close to the indicators of desert areas of the country; the Volgograd region is in second place after Sakhalin, Kamchatka and the Far North – the average wind speed of 5.5-6.5 m/s [17]. SHPP of the Volgograd region amounted to 1.52, which indicates the average level of RES territory's occurrence.

[1] Since 2012, the concept of "small hydroelectric power plants" has been excluded from the Russian legal framework.

The obtained data suggest the need to invest and subsidize electricity on the basis of renewable energy, which, in turn, will allow to achieve an increase in the share of renewable energy in the energy balance of the country in accordance with the guidelines of the "Energy development" state program.

Thus, we can talk about the possibility of RES application in the Volgograd region, taking into account their distribution and projected efficiency. The introduction of RES will have a positive impact not only on the regional energy development, but also on the entire economic situation in the region.

IV. Conclusion

As a result of the analysis it was found that the Volgograd region has a high potential of solar and wind energy. This potential, which exceeds the indicators of most EU countries, can be implemented within the framework of the program on energy saving and energy efficiency in the region's budget organizations. In addition, the use of RES allows to create alternatives to traditional energy sources in areas remote from the centralized power supply.

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