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**Article**

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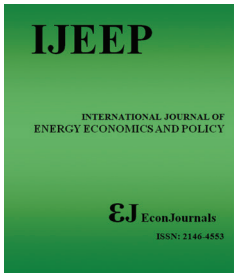

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# Alternative Energy Sources: Opportunities, Experience and Prospects of the Russian Regions in the Context of Global Trends

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**ABSTRACT**

The main goal of modern energy development all over the world is to make it accessible. Russia has large reserves of energy minerals and a significant potential for renewable energy sources. However, in Russia traditional sources of energy, for many objective and subjective reasons, are often unable to provide widespread and inexpensive electricity accessibility. In this regard, the importance of alternative energy is increasing. The article given presents an assessment of the trends in the development of renewable and alternative energy in the world. The Russian energy potential and the shaping factors have been estimated. Possibilities and experience have been considered; prospects of using alternative energy sources in the Russian regions with fundamentally different social-economic, natural-climatic and energy characteristics have been estimated. It has been proved that, despite diametrically opposite characteristics, the Russian regions have prospects and conditions for the development of alternative energy similar in many respects.

**Keywords:** Renewable Energy Sources, Alternative Energy, Wind Power Generator, Solar Batteries, Biogas Energy
**JEL Classifications:** Q26, Q42, R11

## 1. INTRODUCTION

The main goal of modern energy development all over the world is to make it accessible. Traditional sources of energy, for many objective and subjective reasons, often can't achieve this goal. In this regard, the importance of alternative energy is increasing. Alternative energy is a set of promising methods to generate energy from renewable sources, which are not as widespread as traditional, but are of interest because of the advantage of using them at low risk of harming the environment.

Directions of alternative energy sources:

a. Wind power engineering
b. Solar power engineering
c. Alternative hydraulic power engineering
d. Geothermal power engineering
e. Space power engineering
f. Tidal power engineering
g. Hydrogen and hydrosulfuric power engineering
h. Biofuel
i. Distributed power generation.

The recent years were outstanding for the alternative energy sector. A large number of alternative energy sources have been installed worldwide. Nevertheless, old and new challenges continue to await an answer. Many challenges have arisen outside the energy sector.

The relevance of our research is that in recent years the energy sector has undergone a number of changes, each of which concerned alternative energy to some extent. First, oil prices have taken a nosedive. Secondly, the demand for energy has increased, including demands from the developing and young world economies. Thirdly, the political situation has negatively impacted on trade with Russia, including the energy sector. Fourthly, a number of long-term contracts have been signed around the world for the purchase of alternative energy at record-low tariffs. Fifthly, the governments of many countries have showed interest in alternative energy sources and supported innovation in

this area. And sixthly, in 2015 in Paris, a global climate summit took place, which consolidated the world community.

The study is aimed to assess the possibilities and experience of using as well as to develop the prospects for the development of alternative energy in the Russian regions that have fundamentally different social-economic, natural-climatic and energy characteristics, taking into account the world and all-Russian trends.

To achieve this goal, it is planned to solve a number of interrelated tasks:

1. To estimate trends in development of renewable and alternative energy in the world;
2. To estimate Russian energy potential and shaping factors;
3. To estimate possibilities and give experience in applying the alternative energy sources in the Russian regions;
4. To develop prospects in development of alternative energy in the Russian regions with fundamentally different social-economic, natural-climatic and energy characteristics.

In our study we proceeded from a number of hypotheses:

a. The indicators of renewable and alternative energy in the world are steadily increasing.
b. The development rate of alternative energy sources is comparable to the development rate of traditional renewable energy sources.
c. At present and in the foreseeable future, alternative energy does not represent a special interest for the Russian state and business.
d. Opportunities for the development of alternative energy in the Russian regions are formed individually, taking into account natural-climatic, economic, production and organizational factors.

## 2. LITERATURE REVIEW

The priority direction of alternative energy is the search for and use of alternative (non-traditional) energy sources. The need of mankind in energy is inexhaustible and constantly increases. At the same time, fossil natural energy sources are finite and the reserves are reduced every year. Therefore, renewable or "green" energy is of great interest (Foley et al., 2011). The basic principle of renewable energy is the extraction of energy from sources that, on a human scale, are inexhaustible (Pittman et al., 2011; Hill et al., 2006).

At the same time, many renewable energy technologies have long been used by man and can be considered traditional. For example, the use of kinetic energy of water: The production of hydroelectric power in 2016 reached a value of 1096 GW (Russian Atomic Association, 2017). Also, energy production by burning biofuel is a traditional and oldest method of obtaining energy (Skorobogatov, 2017). But in addition to traditional renewable energy, there is also alternative energy, based on non-traditional production methods. The reason for searching for alternative energy sources is the need to get it from the energy of renewable or almost inexhaustible natural resources and phenomena. Environmental friendliness and economy can also be considered (Reay, 2011; Sims, 2004).

The solar and wind power engineering has got the largest development. Almost none of the researchers doubts in the need to develop these alternative energies (Hill et al., 2006; Northrop and Connor, 2016). The analysis of literary sources has shown that the use of different types of alternative energy largely depends on the following factors:

- Natural-climatic regional conditions (Shibu and Thallada, 2015),
- Demands of industry and population for energy (Epstein, 2014),
- Technical possibilities (Fargione et al., 2008),
- Governmental support (Reay, 2011).

Our comparative assessment of the energy efficiency of countries and regions of the world has shown that the level of energy consumption in the Russian economy is very high (Samarina et al., 2015). At that, the share of energy received from alternative sources is extremely low. Among the researchers of the problem there are enthusiasts who insist that alternative energy sources in Russia should be used as widely as possible right now (Klochkov, 2017). And there are pessimists, mainly from the fuel and energy complex, who argue that alternative sources for Russia are not very promising. This is explained by the fact that Russia is an energy-operated country with huge reserves of organic energy sources. Therefore, in the foreseeable future, alternative energy sources cannot make a significant contribution to the country's energy balance. As a consequence, they should not be studied seriously just now (Sudenko, 2016). It is more interesting to study the experience of regions that successfully implement alternative energy projects.

## 3. RESEARCH MATERIALS

### 3.1. General Characteristics of Research Objects

The study was conducted on the materials of two Russian regions. The first one is the Murmansk region. It is located in the Far North beyond the Arctic Circle in the north-west of Russia, on the border with Finland and Norway. The population is 758 thousand people as of 2017, of which 92.73% is urban population; this is 24.86% higher than the average in the territory of the Russian Federation. Density of population is 5.23 people/km$^2$; this is 38.92% lower than the average in the territory of the Russian Federation.

The main activities are extraction and primary processing of minerals (production of apatite concentrate, ferrous and non-ferrous metallurgy). Due to natural-climatic conditions, agriculture is not developed enough. It is represented by fishing, insignificant poultry and animal farming, including reindeer herding. In the region there are sparsely populated settlements; centralized electricity supply there is difficult due to objective (territorial, natural-climatic) and subjective (organizational, economic) reasons.

The Belgorod region is the second object of our study. In many respects this region is diametrically opposed to the Murmansk region. It is located in the temperate continental climate zone in the south-west of Russia, on the border with Ukraine. Area is 27.1 thousand km$^2$. Population is 1548 thousand people as of 2017, of which 66.23% is urban population; this is 10.23% lower than the

average in the territory of the Russian Federation. The population density is 57.23 people/km²; this is 5.68 times higher than the average in the territory of the Russian Federation. The main activities are mining (iron ore); agriculture, and the food industry. The Belgorod region is considered an agricultural region of Russia. Agricultural lands occupy 79% of the region's land area. On the territory there are more than 1200 objects of the agro-industrial complex.

### 3.2. Characteristics of Energy Power Systems of Traditional Energy Sources

The energy power system of traditional energy sources in the Murmansk region is unique in its structure. It includes 17 hydroelectric power stations, 2 thermal power stations, and the Kola nuclear power plant. The total installed capacity of the power system is 3633 MW.

The generation of electricity in the power system of the Murmansk region in 2016 amounted to 17.0 billion kWh, which is 2.19% lower than in the same period of 2015. The electricity consumption for the period of 2016 amounted 12.3 billion kWh, which is 6.82% less than in 2015. The positive total balance of electricity exports in 2016 was 4.7 billion kWh, which corresponds to the indicators of 2015.

The high-voltage network unites all power plants for operation under a single dispatch control. The Murmansk regional power system is connected by a high-voltage network with the interregional integrated power system of the North-West of Russia. This power system is included in the unified energy system of Russia. Also, the power system of the Murmansk region has exits to the energy systems of Norway and Finland. The electricity is exported to these countries. The problem of electric power industry in the Murmansk region is insufficient development and capacity of the electricity distribution network.

Thus, at present in the Murmansk region the following conditions have developed:

- Electricity production excessive for the region;
- Reduction of internal demand for electricity;
- Presence of remote settlements, centralized supply of electricity to which is difficult due to a number of objective and subjective reasons;
- Insufficient development and carrying capacity of the electricity distribution network.

The existing conditions dictate the need for the development of traditional energy sources and the distribution electricity network. At that, alternative energy sources are possible to be used where the expansion of the centralized power supply zone is impossible due to extreme distances and insignificant energy loads of settlements.

The power system of traditional energy sources in the Belgorod region is clearly insufficient for production and provision of vital activity of the population. It includes 4 thermal power plants: The total capacity of power plants does not exceed 170 MW. The region ranks 72nd position in the Russian Federation in terms of electricity production. At the same time in the Belgorod region industry has been developed.

Electricity consumption in the power system of the Belgorod region in 2016 was 15216 million kWh, which is 2.2% more than in 2015. Power generation in the power system of the Belgorod region in 2016 amounted to 597.6 million kWh, which is 19.5% lower than the same period in 2015. The deficit of electricity production in the territory of the Belgorod region's power system was covered by the flows of electricity through inter-system transmission lines from adjacent power systems. The total balance-flow to the power system of Belgorod region in 2016 amounted to 14,618 million kWh, in 2015 - 14,148 million kWh.

In this regard, we note the lack of electricity production in the Belgorod region. Equipment of power plants had yet installed in the Soviet Union. It has a low efficiency. Negative is the fact that natural resources used as fuel at thermal power plants in the Belgorod region are an irreplaceable, non-renewable natural resource. Due to the depletion of the reserves, the cost of such fuel is constantly increasing (Skorobogatov, 2017). In addition, thermal power plants are one of the main suppliers of pollutants to the atmosphere of the region. Our investigations have shown that the territory's landscape and the wind rose lead to the fact that fuel combustion waste is transported to considerable distances (Samarina, 2008).

Thus, at present in the Belgorod region the following conditions have developed:

- Acute shortage of electricity;
- Ever-increasing demand for electricity;
- Limited and expensive traditional fuel resources;
- Presence of remote settlements, the centralized supply of electricity to which is difficult due to a number of objective and subjective reasons;
- Pollution of atmospheric air and other elements of the natural environment from fuel power stations.

The existing conditions dictate the need to seriously solve the issue of finding reserves of electricity. Industrial enterprises, including agro-industrial enterprises, actively develop and implement energy-efficient technologies (Samarina et al., 2015). Another direction is attraction of alternative, renewable energy sources.

## 4. RESEARCH RESULTS AND DISCUSSION

### 4.1. World Trends in Development of Renewable and Alternative Energy

In 2016, about 20% of the world's energy consumption was sufficed from renewable energy sources. Table 1 shows the growth rates of the main indicators of renewable energy.

The number of countries officially having renewable energy development goals has grown every year. A special peak of growth occurred in 2010-2012. In recent years, the growth rate has declined. But this is not due to a decrease in interest in the problem of renewable and alternative energy, but because most countries are already implementing these goals. Between 2008 and 2016, the number of countries increased from 79 to 176. These countries are adopting appropriate energy development programs from renewable sources, including alternative energy

**Table 1: The growth rate of the world's main indicators of renewable energy, in percent (Based on REN21 REN21 (2013), REN21 (2015), REN21 (2017), author's calculations)**

| Indicators | 2008-2009 | 2009-2010 | 2010-2011 | 2011-2012 | 2012-2013 | 2013-2014 | 2014-2015 | 2015-2016 |
|---|---|---|---|---|---|---|---|---|
| Number of countries with renewable energy development goals | 12.66 | 10.11 | 20.41 | 16.95 | 4.35 | 13.89 | 5.49 | 1.73 |
| Annual investments in renewable energy | 23.08 | 31.88 | 21.80 | −5.06 | −4.92 | 16.38 | 5.93 | −15.73 |
| Total installed renewable energy capacities | 7.89 | 7.32 | 3.03 | 8.09 | 7.35 | 8.49 | 8.00 | 9.09 |
| Energy production by hydroelectric power plants | 3.39 | 3.28 | 2.65 | 2.06 | 2.83 | 3.63 | 0.85 | 3.01 |
| Energy production by wind generators | 31.40 | 24.53 | 20.20 | 18.91 | 12.72 | 15.99 | 17.03 | 12.47 |
| Energy production by solar batteries | 43.75 | 73.91 | 75.00 | 42.86 | 38.00 | 28.26 | 28.25 | 33.48 |
| Ethanol production from biomass | 13.43 | 13.16 | 0.00 | −3.49 | 4.82 | 8.05 | 4.26 | 1.02 |
| Biodiesel fuel production | 48.33 | 3.93 | 15.68 | 5.14 | 15.56 | 14.23 | 2.02 | 1.65 |

development programs. The state renders special support to the business involved in the production of renewable energy.

Annual investments in renewable energy fluctuated over the years, but eventually increased from 130*109 US dollars in 2008 to 241*109 US dollars in 2016. The total installed renewable electricity capacities increased by an average of 7.4% per year and rose from 1.14 GW in 2008 to 2.02 GW in 2016.

The production of electric power by hydroelectric power plants steadily increased by an average of 2.7% per year and increased from 885 GW in 2008 to 1096 GW in 2016. Energy production by wind generators grew at an accelerated rate by an average of 19.16% per year and increased from 121 GW in 2008 to 487 GW in 2016. The production of electricity by solar batteries grew at an even faster rate by an average of 45.44% per year and increased from 16 GW in 2008 to 303 GW in 2016.

Ethanol production from biomass increased not so actively, on average by 5.16% per year and increased from 67*109 L in 2008 to 99*109 L in 2016. The biodiesel production increased by an average of 13.32% per year and increased from 12*109 L in 2008 to 30.8*109 L in 2016.

Thus, the hypothesis that the renewable and alternative energy indicators in the world are steadily increasing has been partially confirmed. In recent years, there has been a decline in the growth rates of indicators, and some, for example, an increase in annual investments in renewable energy in 2015-2016, have negative values.

The analysis shows that the alternative energy sources have been intrenched in the status of dominant throughout the world. Indeed, it was the energy production by wind generators and solar batteries that grew at the most accelerated rates. This indicates a widespread interest in alternative energy sources. The production of ethanol and biodiesel from biomass is not so obvious. In recent years, production growth has decreased significantly. Criticism of biomass conversion to ethanol and biodiesel fuel is growing worldwide (Northrop and Connor, 2016; Shibu and Thallada, 2015; Epstein, 2014; Amer et al., 2017; Johnson et al., 2014). Nevertheless, the interest of private businesses and authorities of many countries to renewable and especially alternative energy sources is not reduced.

Thus, the hypothesis that the development rate of alternative energy sources is comparable with the development rate of traditional renewable energy sources has not been confirmed. The development rate of alternative energy sources outstrips the development rate of traditional renewable energy sources.

### 4.2. Russian Energy Potential

The Russian Federation is among the ten most energy-rich countries in the world. It has large reserves of energy minerals and a significant potential for renewable energy sources. Power sources are actively used. For example, in 2013 Russia consumed 30.5 quadrillion of British thermal units (Btu). The structure of the Russian consumption of electricity sources includes primarily natural and fossil non-renewable sources: Natural gas (53%); oil (22%) and coal (14%) (Russia-International Energy Data, 2015).

In 2016, the total installed capacity of electricity generation in Russia was 244.1 GW (the main share of 65.63% is for thermal power plants on fossil fuels). For comparison, in the United States the installed capacity of power generation was 1072 GW, and in China - 1454 GW. The major share in these countries also falls on fossil fuel thermal stations: 72.39% in the US and 72.49% in China. The structure of energy generators in terms of the installed capacity is shown in Table 2.

Analysis shows that in Russia, as in all over the world, traditional energy generators predominate: Fossil fuel thermal stations, hydroelectric power stations, nuclear power plants. Alternative energy generators exist, but their share in the overall structure of energy generators is significantly behind the USA and China in terms of installed capacity.

Electricity production in Russia in 2016 was 1064.1 TWh (for comparison, in the USA - 4047 TWh; in China - 5650 TWh). The major share of energy in these countries was generated at fossil fuel thermal stations: 59.02 in Russia; 68.57% in the USA and

79.70% in China. The analysis shows that in 2016 the amount and share of alternative energy in Russia lags far behind the USA and China (Table 3).

Thus, alternative energy sources do not make a significant contribution to the Russia's energy balance. The hypothesis that at present and in the foreseeable future alternative energy is not of particular interest to the state and business in Russia has been confirmed. This is largely due to the fact that Russia is an energy-operated country with huge reserves of organic energy sources and a developed system of a traditional electricity production.

Sadly, it should be recognized that unlike many other countries, in Russia a clear and consistent state policy in the field of alternative energy has not yet been formulated. Political declarations about the importance of alternative energy are not yet confirmed by the necessary set of legislative acts and normative documents. The lack of clarity in the "rules of the game" for investors and consumers of alternative energy reduces the potential for its development. In addition, the sanctions and the fall in oil prices put pressure on the Russian economy as a whole and have led to the loss of income. This made it difficult for Russian companies to finance new projects in the field of alternative energy. Nevertheless, there

**Table 2: The structure of energy generators in terms of the installed capacity (based on the Russian Atomic Association, the author's calculations)**

| Energy generators | Russia GW (%) | USA GW (%) | China GW (%) |
|---|---|---|---|
| Thermal plants on fossil fuel | 160.2 (65.63) | 776 (72.39) | 1.054 (72.49) |
| Hydroelectric power plants | 48.1 (19.71) | 79 (7.37) | 198 (13.62) |
| Nuclear power plants | 27.9 (11.43) | 102 (9.51) | 32 (2.20) |
| Wind generators | 0.01 (0.004) | 59 (5.50) | 128 (8.80) |
| Solar batteries | 0.08 (0.03) | 3 (0.28) | 42 (2.89) |
| Total capacity of electricity generation | 244.1 (100.00) | 1.072 (100.00) | 1.454 (100.00) |

**Table 3: The structure of energy production by different generators (based on the materials of the Russian Atomic Association, the author's calculations)**

| Energy generators | Russia TWgh (%) | USA TWgh (%) | China TWgh (%) |
|---|---|---|---|
| Thermal plants on fossil fuel | 628 (59.02) | 2.775 (68.57) | 4.503 (79.70) |
| Hydroelectric power plants | 186.7 (17.55) | 276 (6.82) | 800 (14.16) |
| Nuclear power plants | 196.4 (18.46) | 769 (19.00) | 123 (2.18) |
| Wind generators | 0.09 (0.01) | 140 (3.46) | 186 (3.29) |
| Solar batteries | 0.16 (0.02) | 4 (0.10) | 38 (0.67) |
| Total capacity of electricity generation | 1.064.1 (100.00) | 4.047 (100.00) | 5.650 (100.00) |

are prospects for the development of alternative energy. Consider the situation that has been established in two Russian regions that are actively implementing alternative energy generation projects.

### 4.3. Capacities and Experience of Applying Alternative Energy Sources in the Russian Regions

Let's estimate the possibilities of using alternative energy sources in the Murmansk region.

1. Use of solar energy: In the Far North conditions, the use of solar batteries is difficult because in the winter months, when the energy needs are maximum ones, the solar energy supply is minimal. In addition, in northern latitudes the number of days with clear sunny weather is relatively small. Therefore, at present, practical use of solar energy takes place only on small objects (beacons, buoys, etc.), where traditional energy supply schemes are too expensive.
2. Use of wind energy: To convert the kinetic energy of the wind into electrical energy, wind generators are used. Technical resources of the wind in the Murmansk region are estimated at 360 billion kWh. The average wind speed on the northern coast of the Kola Peninsula is 7-9 m/s (Sergeev, 2009).
   The most spectacular example of the alternative energy sources use in the Murmansk region is the implementation of a project to provide power supply for remote settlements in the Tersky district of the Murmansk region through the construction of integrated wind-solar-diesel power plants. One integrated power plant unites 4 wind turbines, 2 diesel generators and 60 solar panels. This installation allows using all the features of the region's climate: Constant strong winds and a polar day. Prior to the implementation of this project, the remote rural communities in the Murmansk region did not have a centralized 24-h power supply. Energy was generated by diesel-generator sets, fuel for which was carried out at the expense of the regional budget.
   The use of alternative energy sources has already allowed significant saving of financial resources: Before the project, more than 290 tons of diesel fuel was annually imported to supply electricity to the remote settlements, and now only 143 tons are imported.
3. Use of kinetic energy of water: The use of small river energy in the Murmansk region has very good prospects. There is experience in the use of hydropower of small rivers. In the 40-50 s of the 20$^{th}$ century, several small rural hydroelectric power stations with a capacity of 10-100 kW were built in the region. Later they were replaced by diesel engines which were cheaper at that time. At present, due to a significant increase in prices for organic fuels, interest in using the small rivers' energy has increased significantly. Technical hydropower resources of small rivers of the region are estimated at 4.4 billion kWh at 516 MW of average annual capacity. At the moment, projects are being developed for the construction of demonstration small hydroelectric power plants with a capacity from 500 kW to 6 MW.
4. The use of tidal energy, but in fact the kinetic energy of the earth's rotation. In the Murmansk region there is the first and only in Russia tidal power station. The station was installed in the narrow part of the Kislaya Guba Bay of the Barents Sea; the height of the tides reaches 5 m. The station's capacity is

1.7 MW. Currently, the station is used as an experimental base for testing new theologies and units for tidal power plants.

Let's estimate the possibilities of using alternative energy sources in the Belgorod region.

1. Use of solar energy: At the Belgorod region latitude, the average annual duration of sunshine is about 1920 h per year. This is sufficient for the effective use of solar energy.
   Currently in the Belgorod region 1320 modules of solar batteries with an active surface of 1046 $m^2$ have been installed. The nominal peak power of a unit is 100 kW (each module is 20 kW). The region uses two types of solar batteries: Polycrystalline and amorphous. The last type of solar batteries is especially effective, because they are able to generate electricity even in cloudy weather. However, the power of one polycrystalline module is 213 W, and amorphous - 50 W. In the future, in the Belgorod region it is planned to build a plant for the solar battery production.
2. Use of wind energy: The natural-climatic conditions of the Belgorod region provide powerful opportunities. The average annual wind speed at a height of 50 m from the earth surface is 5 m/s, and at the 10 m height - 4 m/s. According to our research, the wind speed of 3 m/s is recorded in 2/3 of the measurements regardless of the season and temperature conditions. The flat relief promotes a uniform movement of air masses. The wind rose is quite symmetrical (Samarina, 2008). The existing conditions open up prospects for the development of alternative energy through the use of wind energy.
   In the Belgorod region, it is reasonable to use small and inexpensive compact wind generators. They can provide electricity to farms, small agricultural processing enterprises. The more powerful industrial units produce more electricity, but they cost several times more. The only significant drawback of this method of providing energy is interruptions in power supply in those periods when the wind speed is insufficient. Therefore, wind generators must be supplied with batteries capable to preserve the received electricity. In addition, it is reasonable to combine wind generators with other energy sources.
   Wind generators and solar batteries for the alternative energy production have been used in the Belgorod region since 2011. The first five wind generators with a total capacity of 100 kW were installed in the area of the Krapivensky Dvory farm in the Yakovlevsky district. In the same territory, a solar park was modeled from solar batteries. The complex combines 347 $m^2$ of polycrystalline batteries with a capacity of each module of 213 W and amorphous batteries of 883.2 $m^2$ with the power of each module of 50 W. The project implemented by AltEnergo Company within the framework of the regional concept of bioenergy and biotechnology development was financed by the Tsentralny-Chernozemny Bank of the Sberbank of Russia (Site of AltEnergo Company, 2017).
3. Use of kinetic energy of water: The natural-climatic conditions of the Belgorod region, on the contrary, do not provide an opportunity of using this type of alternative energy. The region belongs to shallow water regions: About 1% of the region is covered by water flows and reservoirs. The rivers of the region, for the most part, are shallow and not numerous, with small differences in the water level (Samarina, 2008).
4. Biogas power engineering: It is based on the production of biogas, a combustible mixture of gases formed as a result of decomposition of organic substances (biomass) as a result of an anaerobic microbiological process (methane fermentation) (Shibu and Thallada, 2015). This type of alternative energy is actively developing in the Belgorod region. The first biogas plant in Russia in industrial scale was built in the Prokhorov district of the Belgorod region. It works on the waste of a meat processing plant and other agricultural enterprises developing in the region with accelerated rate. For the year the biogas plant produces on average about 20 million kWh of electricity, 18,000 Gcal of thermal energy and about 70,000 $m^2$ of organic biofertilizers.

## 5. PROSPECTS OF ALTERNATIVE ENERGY IN THE RUSSIAN REGIONS

Despite diametrically opposite social-economic, natural-climatic and energy characteristics, the Murmansk and Belgorod regions have in many respects similar prospects for alternative energy. Currently, alternative energy sources do not make a significant contribution to the energy balance of the Russian regions. Both in the energy-rich Murmansk region, and energy-deficient Belgorod region, alternative energy sources will not take the lead in the foreseeable future. Nevertheless, in some segments of power supply, their use is very promising.

Often in remote rural settlements and farms the traditional stationary sources are absent or work intermittently. Currently in the Murmansk region about 80-100 settlements are not covered by a centralized power supply. Their power consumption is from 5-10 kW to 500-800 kW. In the Belgorod region, due to better development of the territory, the energy infrastructure is better developed. But even there in remote rural settlements there are interruptions with electricity.

For remote settlements in the Russian regions, the use of wind and solar electricity is especially important. Solar or wind power plants are virtually maintenance-free. They do not need constant repair and adjustment. Replacement of damaged or end-of-life parts, such as photovoltaic converter panels, occurs in the current mode. The maintenance of power plants practically does not require specialized knowledge and skills. From the ecological point of view, the difference between solar and wind power generators from thermal plants and diesel generators traditionally used in separated settlements is the complete absence of waste (excepting worn out and end-of-life parts) and of any raw materials (Epstein, 2014). This is the undeniable advantage of alternative energy before the traditional energy for the Russian regions.

Surely, alternative energy projects need to be developed taking into account regional features. Wind energy is the most important alternative energy source in the Murmansk region. This is due to the following prevailing climatic conditions:

- A part of the territory of the Murmansk region is located on the northern coast of the Kola Peninsula, which is the most

windy place in the entire European North of Russia: Therefore, the wind energy potential is extremely powerful;
- A wind rose with a predominance of south and south-west winds: This allows more compact and efficient location of wind generators;
- The maximum intensity of the wind falls on the winter period: This, on the one hand, coincides with the growing demand for electrical and thermal energy from consumers; and on the other hand, can compensate for the decline in the efficiency of solar energy.

Therefore, the project for the construction and commissioning of a wind park with an installed capacity of up to 220 MW, uniting a complex of wind generators, will be promising for the region. An ideal place for building a wind park is the northern coast of the Kola Peninsula, which has extremely powerful wind energy potential.

For the Belgorod region, the most promising source of alternative energy is waste from the agro-industrial complex. As it was said above, in the territory of the Belgorod region there are more than 1200 objects of the agro-industrial complex. It seems reasonable to build biogas stations in the places of greatest accumulation of such objects.

The consequences of the implementation of the submitted alternative energy projects are significant for the regions and for the Russian Federation as a whole. For the State, the following consequences are of particular importance:
- Implementation of the goals of Russia's energy strategy based on the use of alternative energy sources;
- Distribution of production technologies and experience in the implementation of alternative energy projects in Russia;
- Development of the country in the trend of modern world alternative energy;
- For the regions, the following consequences have particular importance;
- Reduction of energy deficit in the Belgorod region;
- Establishment of regular 24-h and year-round power supply to remote and sparsely populated settlements;
- Additional deductions to the regional consolidated budget;
- Creation of additional work places;
- Greening of agro-industrial processes;
- Increase of gross regional product with simultaneous reduction of carbon dioxide emissions into the atmosphere;
- Approbation of new theologies and devices for obtaining alternative energy.

However, modern alternative energy technologies are not able to meet the needs of industry and population. Producing electricity from alternative sources can and should be combined with other, traditional technologies of energy production. Such an approach will facilitate the rapid development of the regional economy.

In regions, the demand for alternative energy facilities could provide the most mobile small and medium businesses. But now, small and medium-sized businesses cannot be the main investor in alternative energy projects due to the long payback period of projects. In the Belgorod and Murmansk regions, the State has entered the industry of generating alternative energy as a co-investor. There have been appeared the programs of co-financing projects, projects on the terms of private-public partnership, and direct investments in alternative energy. Division of responsibility and financial burden with the State has become an effective mechanism for the development of alternative energy.

Other mechanisms for developing alternative energy in the regions are:
- Development and approval of a strategy and technical policy for the modernization of regional networks, taking into account alternative energy;
- Simplification of the procedure for technological connection of alternative generation to power networks;
- Approval of long-term tariffs for alternative energy;
- Development of new and improvement of existing measures of direct and indirect state support;
- Change in the Russian Federation legislation in terms of maximizing the use of alternative energy.

The conducted research has shown that the hypothesis that the opportunities for the development of alternative energy for the Russian regions are formed individually, taking into account natural-climatic, economic, production and organizational factors, is only partially true.

## 6. CONCLUSIONS

a. The hypothesis that the renewable and alternative energy indicators in the world are steadily growing has been partially confirmed. Indeed, over the period from 2008 to 2016, annual investments in renewable energy have increased; the total installed capacities of renewable electricity increased; the energy generation of by means of hydroelectric power plants, wind generators and solar batteries has grown. However, in recent years, there has been a decline in the growth rates of indicators, and some, for example, an increase in annual investments in renewable energy in 2015-2016, have negative values.
b. The hypothesis that the development rate of alternative energy sources is comparable with the rate of development of traditional renewable energy sources has not been confirmed. The development rate of alternative energy sources outstrips the development rate of traditional renewable energy sources. The production of energy by wind generators and solar batteries grew at the most accelerated rates.
c. The hypothesis that at present and in the foreseeable future alternative energy is not of particular interest to the State and business in Russia has been confirmed. The analysis has shown that alternative energy sources do not make a significant contribution to Russia's energy balance. This is largely due to the fact that Russia is an energy-operated country with huge reserves of organic energy sources and a developed system of traditional electricity production. Russia has not yet formulated a clear and consistent state policy in the field of alternative energy. This does not promise good prospects for the development of alternative energy in the whole country.

d. The hypothesis that the opportunities for the development of alternative energy for the Russian regions are formed individually, taking into account natural-climatic, economic, production and organizational factors, has been partially confirmed. Indeed, for the Murmansk region the most important alternative source of energy is the wind, and for the Belgorod region-the waste of the agro-industrial complex. But, despite the diametrically opposed social-economic, natural-climatic and energy characteristics, the Murmansk region and the Belgorod region are largely similar alternative energy prospects. And in the energy-rich Murmansk region, and in the energy-deficient Belgorod region in the foreseeable future, alternative energy sources will not take the lead. Nevertheless, in some segments of power supply, their use is very promising. The greatest prospects are to use the wind and solar energy in remote and sparsely populated settlements of the Russian regions. Organizational conditions for the implementation of alternative energy projects are similar.

They consist of direct and indirect state support, development and approval of a strategy and technical policy for the modernization of regional energy networks, taking into account alternative energy; change in the Russian Federation legislation in terms of maximizing the use of alternative energy.

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