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Analysis of Renewable Energy in Russian Federation with Focus on Solar Energy

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Methodology

The thesis contained descriptive and comparative methods as well as logical inference methods.

The proposed extent of the thesis

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Anderson, D., A. Environmental Economics and Natural resource management, 3rd Edition, Routledge, USA, 2010

Perman, R., Ma, Y., Mcgilvray, J., Common, M. Natural Resource and Environmental Economics, 3rd dition, Prentice Hall, 2003

Tietenberg, T., Lewis, L. Environmental and Natural Resource Economics, 8th edition, Pearson Education, USA, 2009

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Declaration

I declare that I have worked on my bachelor thesis titled "Analysis of renewable energy in Russian Federation with focus on solar energy" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on March 15th, 2020 ______________________________

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Analysis of Renewable Energy in Russian Federation with Focus on Solar Energy

Abstract

The main objective of this thesis was to assess the potential and prospects of using alternative energy sources in the Russian Federation and especially in its southern regions using the example of a project for the small solar construction in Krasnodar. It can be considered the growing interest in renewable energy sources. Despite the positive trends, there are a number of unsolved problems. The barriers to the development of renewable energy include obsolescence of technologies and infrastructure, the lack of effective coordination of the construction of various types of renewable energy plants, and low interest from the government and investors in relation to the construction of renewable energy sources. The potential of alternative energy sources using in the whole Russian Federation was made. There is a paradoxical situation when a country has a huge potential for renewable energy, but practically does not use them. It was concluded that the most beneficial for the South region (especially for the Krasnodar territory) is the use of solar energy, which can also be combined with hydropower energy. Wind power can be used only in 20 % of the South regions territory. The Krasnodar Territory has relatively small reserves of fuel and energy resources (traditional) and it depends on external energy supplies in Russia (more then 60 % of energy is imported). Energy demand, however, is growing steadily – the region is developing (it is promising for investors in terms of tourism, manufacturing). Based on the analysis and conclusions made, it is possible to unequivocally point out the large role and prospects of renewable energy in certain regions of Russia, and especially about solar energy in the Krasnodar territory. In this work the calculation of the installation of a solar structure for a flat roof using the data of the leading manufacturer of solar panels was made. The total cost of 6.6 million rubles. It is shown that in modern economic conditions it is possible to build a solar construction with a payback period of up to five years.

Keywords: analysis, electricity, energetics, energy, potentials, power station, renewable energy, Russian Federation, solar energy.

Analýza obnovitelné energie v Ruské federaci se zaměřením na solární energii

Abstrakt

Hlavním cílem této práce bylo posoudit potenciál a perspektivy využití alternativních zdrojů energie v Ruské federaci a zejména v jižních regionech pomocí příkladu projektu pro malou solární konstrukci v Krasnodaru. Lze tvrdit o rostoucím zájmu vůči obnovitelným zdrojům energie v Rusku. Přes pozitivní trendy existuje řada nevyřešených problémů. Překážky rozvoje obnovitelných zdrojů energie zahrnují zastarávání technologií a infrastruktury, nedostatek účinné koordinace výstavby různých typů obnovitelných zdrojů energie a nízký zájem vlády a investorů o výrobu energie z obnovitelných zdrojů. V práci byla provedená analýza potenciálu alternativních zdrojů energie v Rusku. Existuje paradoxní situace, kdy má země obrovský potenciál pro obnovitelné zdroje energie, ale prakticky je nevyužívá. Dospělo se k závěru, že nejvýhodnějším pro jižní region (zejména pro území Krasnodaru) je využití solární energie, kterou lze také kombinovat s vodní energií. Větrná energie může být použita pouze na 20 % území jižních regionů. Region Krasnodaru má relativně malé zásoby tradičních energetických zdrojů a závisí na vnějších dodávkách energie (více než 60 % energie se dováží). Poptávka po energii však neustále roste – region se rozvíjí (pro investory je slibný turismus a zpracovatelský průmysl). Na základě provedené analýzy a závěrů je možné jednoznačně poukázat na velkou roli a vyhlídky obnovitelné energie v určitých regionech Ruska, zejména na solární energii na území Krasnodaru. V této práci byla provedena kalkulace instalace solární konstrukce pro plochou střechu s využitím údajů předního výrobce solárních panelů (celkové náklady 6,6 milionu rublů). Ukázalo se, že v moderních ekonomických podmínkách je možné postavit solární konstrukci s dobou návratnosti až pět let.

Klíčová slova: analýza, elektřina, energetika, energie, potenciál, elektrárna, obnovitelná energie, Ruská federace, solární energie.

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1 Introduction

The whole variety of energy sources can be divided into two categories – non-renewable and renewable. Non-renewable energy sources include coal, oil and gas, as well as nuclear energy. Renewable, or regenerative, "green" energy is energy from resources that are renewable or inexhaustible on a human scale. Renewable energy is obtained from natural resources such as sunlight, water currents, wind, tides and geothermal heat, as well as from biofuels: wood, vegetable oil, ethanol.

Although developments in the sphere of alternative sources using were carried out earlier, the active development of alternative energy on a global scale began after the oil crisis of 1973, when people realized an unacceptably high degree of their dependence on non-renewable energy sources and their prices. Despite the active opposition of the oil and gas lobby, the alternative energy sources usage is promising direction in terms of economic and energy efficiency.

An additional factor for the alternative energy development was also the political, economic and environmental crises that have occurred in recent years, which potentially affect the energy security of states and regions. Such crises include the attacks in the USA in 2001, the Moscow energy accident in 2005, interruptions in gas transit through Ukraine to the EU countries in 2009, and the accident at the Japanese Fukushima-1 nuclear power plant in 2011, as well as other similar events. After such incidents, humanity is increasingly becoming aware of its unacceptably high degree of dependence on non-renewable energy sources, as well as the danger of some of them.

The Russian Federation has significant potential in the field of alternative energy. In almost every region of our country, there is the possibility of using one of the renewable energy sources. And although some research and development in this direction was actively conducted in 1950s and 1960s, the active development of alternative energy in Russia began only in the 2000s.

At the moment, Russia has successful experience in creating power plants using almost all known types of renewable and alternative energy sources. The main problem is the lack of real state support for alternative energy, despite the adoption of a number of fundamental decisions in the late 2000s.

The relevance of researching the alternative energy potential is undeniable for every country. The relevance of using non-traditional energy sources will continuously increase, requiring accelerated search and implementation processes.

2 Objectives and Methodology

The main objective of this thesis is to assess the potential and prospects of using alternative energy sources in the Russian Federation and especially in its southern regions using the example of a project for the solar power plant construction in Krasnodar.

To achieve this goal it is necessary to solve the following tasks:

- to study the range of basic theoretical concepts that relate to this issue,
- assess the potential of alternative energy sources using in the Russian Federation,
- to propose and to plan the project of solar power station construction a in the city of Krasnodar,
- formulate and propose possible measures to improve the situation in the field of alternative energy.

In this thesis the study of the possibilities of alternative energy using in the Russian Federation is made. The subject of the thesis is the possibility of using alternative energy sources in the Krasnodar territory. A comparative analysis and basic methods of financial calculations for a specific project are chosen as research methods.

To solve the first and second problems, an analysis was carried out on the basis of literature devoted to this issue.

Results from the analysis in the practical part are compared with findings from the literature review.

3 Literature Review

First known use of the term “**energetics**” belongs to 1855. It named “*the branch of mechanics that deals primarily with energy and its transformations*.” (Merriam-Webster, 2019). Now the term “energetics” is used for the „*total energy relations and transformations of a physical, chemical, or biological systém*“ (Merriam-Webster, 2019). In the Oxford Dictionary “energetics” defines as “*the branch of science which deals with the properties of energy and the way in which it is redistributed in physical, chemical, or biological processes*” (Oxford, 2019).

Energy sources are divided to two main groups: primary and secondary. **Primary energy sources** are natural resources that are not transformed by man. They can be divided into non-renewable and renewable.

Nonrenewable energy sources are:

- fossil fuels: coal, oil, gas,
- nuclear fuels.

Renewable energy sources (RES) are:

- water power,
- wind energy,
- solar energy: thermal, photovoltaics,
- biomass,
- geothermal energy.

Secondary energy sources are resources generated by human activity. According to Matějů (2013) they are:

- municipal waste (energy waste incineration),
- used oils (mainly for heating),
- landfill gases (they are produced in landfills of municipal waste, non-degassing can create explosive mixtures, can be used for electricity),

- waste heat (by using otherwise thwarted heat it is possible to achieve energy savings or it can be used for direct electricity production).

Alternative energy sources are mainly renewable, which, in the context of normal human perception, are able to regenerate themselves, unlike fossil fuels and other non-renewable sources. In addition, the sources of energy produced by human society are also alternative sources. The main advantage of alternative energy sources is that they are environmentally friendly and do not leave radioactive waste, as is the case with nuclear power plants (EPET, 2019).

General energetics as a field of scientific activity arose at the beginning of the twentieth century. Before World War I, seven All-Russian Electrotechnical Congresses consolidated disparate groups of researchers in various fields of energy in the course of extensive educational work, formulated tasks and gave examples of complex energy-economic analysis and design of the development of energy facilities in their relationship with each other and with by consumers. In 1921, the 8th Electrotechnical Congress discussed the first ever state document on the comprehensive development of the economy, electric power and fuel industry of an entire country – the GOELRO plan (Makarova, 2010).

The need for environmental protection, the permanent increase in fuel and energy prices and, above all, the scarcity of world energy sources – are the factors, that leads to the increasingly discuss about the alternative solution – alternative energy sources.

3.1 The development of alternative energy in the Russian Federation: state policy

The USSR policy in the field of the alternative and renewable energy sources (“RES”) usage was somewhat destructive. The Soviet Union in the 1970s, as a result of rising oil prices, significantly increased its supplies, and its policy was different from the West's course on the development of alternative energy. At the same time, the USSR did not refuse its necessity and the relevance of research and development in the field of renewable sources. In fact the priorities of the policy shifted to the oil, gas and nuclear energy.

In 1983 the USSR Energy Program designed for 20 years, was adopted. (Troickiy, 2007). It was composed of two ten-year stages. At the first stage, it was supposed to force the extraction of traditional sources – oil, gas and nuclear energy. The purpose of the first stage was reliable energy supply to the national economy in the USSR. At the second stage, the program provided development of the renewable energy sources, controlled fusion energy and nuclear energy. The purpose of the second stage was energy saving based on the development of new energy production technologies. However, due to socio-economic and political changes in the Soviet state, the USSR Energy Program was not implemented (Makarova, 2010).

By the 2000s, research in the field of alternative energy in Russia had practically stopped. However, the understanding that the future energy demand, and therefore new ways of its producing, will only increase, did not completely stop the Russian “alternative” energy projects. The increase in the oil cost (InflationData.com, 2019) was beneficial for the Russian oil and gas industry, so it made difficult to develop alternative energy in the country.

Belokrylova and Kologermanskaya (2017) noted, the Russian Federation has been actively working to create the necessary bill regulating relations in the field of development and use of RES since 1997. However, laws only indirectly regulate this sphere till today. Thus, Federal Law No. 35-FZ “On the Electric Power Industry” established only the framework for the RES development. Specific documents, required for the full implementation of this law, have not yet been adopted. Existing laws regulate only the need for the development of alternative energy and contain a large number of declarative and programmatic norms (Belokrylova, Kologermanskaya, 2017).

According to the report of the Committee of RES at the 9th international conference “Renewable and Small Energy 2012”, it is noted that in 1999 a draft law “On state policy in the field of the use of non-traditional RES” was prepared and adopted by the State Goverment and approved by the Federation Council. However, for purely formal reasons, it was rejected by the Administration of the President of the Russian Federation Yeltsin in 1999, so this bill was vetoed (Bezrukikh, 2012).

The fundamental documents regulated the renewable energy use in Russia include:

- Federal Law No. 35-FZ from the 26th March, 2003 “On the Electric Power Industry”, under redaction from the 30th December 2012. This law defines RES, establishes the powers of state authorities in the field of regulation and support of RES usage, and provides mechanisms for state regulation of the RES use:
  (1) compulsory reimbursement (purchase) by network companies of losses of electric energy in networks, primarily due to energy produced at qualified generating facilities based on RES,
  (2) provision of subsidies from the federal budget in order to compensate for the technological connection cost of generating facilities based on RES with a capacity of up to 25 MW and recognized by qualified facilities,
  (3) the establishment of a premium added to the equilibrium price of the wholesale market for electricity generated on the basis of RES,
  (4) the implementation of other support for the RES use in accordance with the budget legislation of the Russian Federation.
- Decree of the Government of the Russian Federation No. 1-r from the 8th January 2009 “On the main directions of state policy in the field of increasing the energy efficiency of the electric power industry based on the use of RES for the period until 2020”. This decree defines the goals and principles of using RES, contains target indicators of the volume of production and consumption of electricity generated by RES, and also includes measures to achieve these targets (Ministry of Energetics, 2019).
- The main scheme of the location of the electric power industry objects until 2035 (based on the Decree of the Government of the Russian Federation no. 1209-r from the 9th June 2017). This scheme contains a forecast of the development potential of power plants based on alternative and renewable energy sources and recommendations on the commissioning of generating capacities of RES-based facilities in the period up to 2035 (Government of the RF, 2017).
- Decree of the Government of the Russian Federation No. 47 from the 23th January 2015 defines the procedure for implementing the mechanism for supporting

renewable energy in retail markets in the price and non-price zones of the wholesale market, as well as in geographically isolated energy areas. This resolution defines the procedure for the formation of long-term tariff regulation of renewable energy generating facilities in the retail markets, as well as the rules for their functioning (Ministry of Energetics, 2019).

- Order of the Federal Antimonopoly Service of Russia No. 900/15 from the 30th September 2015 approved methodological guidelines for setting prices and/or price limits for electric energy (power) produced on the RES basis by qualified generating facilities and acquired in order to compensate for losses in electric networks (Ministry of Energetics, 2019).

Moreover, the Energy Strategy of Russia for the period until 2030 is currently in force. It provides for the introduction of alternative energy in all spheres of state activity and conditionally distinguishes some blocks of political and economic tasks. Among them, by 2030 it is planned to achieve reducing the dependence of the Russian economy on the energy sector due to the accelerated development of innovative low-energy sectors of the economy and the realization of the technological potential for energy saving. According to the Energy Strategy it is planned to increase the share of non-fuel energy from 11 to 13-14 percent, to create and to develop new types of energy and energy technologies (Ministry of Energetics, 2009).

Despite the existence of certain laws and priorities, Russia's policy and economy remains in a strong oil and gas dependence. One of the reasons for the limited development of the RES in Russia is according to Belokrylova and Kologermanskaya (2017) a lack of adequate company financing. It was noted also by the Minister of Energy of the Russian Federation A. Novak in the report “On the Status and Prospects of the Development of the Electric Power Industry in the Russian Federation”. Indeed, in the Russian Federation there are legal entities whose activities are associated with the energy generated by alternative sources, but most of them work exclusively for export due to lack of funds. So, RusHydro organization, on which the Government of the Russian Federation has assigned the functions of developing all renewable energy, also does not yet have enough of its own funds to implement alternative energy projects (Novak, 2019).

In addition to the above, there is also the existence of the so-called „oil lobby“, which has occupied a certain niche in the Russian legislative body. Oil companies play an important role in the legislative process, in particular when making decisions by the government.

It should be noted that at the regional level there is no regulatory framework covering the regulation of the RES. For many regions, the use of alternative sources is more advantageous than the use of traditional ones. For example, according to the report of Kaplun the energetics based on RES is in many cases more profitable than traditional in the Far East of Russia today. Nevertheless, given the favorable prospects for the use of "green" energy, the regions do not seek full regulation, as well as regional support for the area under consideration (Belokrylova and Kologermanskaya (2017).

3.2 The Experience of foreign countries in the development of alternative energy

Interest in the development of renewable energy and RES in the world has increased after the oil shocks of 1973 and 1979. During 1974, the price of oil increased fourfold, and Western countries, having grasped the causes of the crisis, began research in the field of alternative energy. Their strategic goal was to ensure national energy security. Scientists worked on various types of alternative sources, the only obvious limiting factor of research was the natural and climatic conditions of specific territories (Massabié, 2008).

The industry of RES is developing rapidly around the world. It is already forecasted that by 2040 renewable energy consumption will be 14 % in the global energy mix. (BP, 2019). At the same time, renewable energy cannot yet exist without state support. The vast majority of states that have achieved success in the field of renewable energy development use certain methods of state assistance (Frondel, 2010). Many authors note a significant, and sometimes key, role of state support in this sphere. It is noted that the most active policy in the field of renewable energy development is typical for such countries as Germany, China, and the USA (Buchnev, 2015).

In modern studies devoted to the problems of the development of alternative energy, much attention is paid to questions of evaluating the state support effectiveness for RES.

This focus of work is not accidental. In foreign countries, state policy of RES supporting has been implemented for more years. Significant experience allows to evaluate the effectiveness of using various regulatory tools. Lyon and Yin (2010) discusses the development of alternative energy in the United States, explores political and economic factors that encourage different states to enact alternative energy laws. In addition, Lyon and Yin discuss the quality standards for investments in renewable energy (renewable portfolio standards or RPS). Lyon and Yin came to the conclusion, that states with high unemployment are less active in adopting RPS, and the environment conditions do not affect decision-making. According to this, authors conclude that political ideology is dominant (Lyon, Yin, 2010).

Chandler has also studied why the U.S. are installing RPS. An analysis of the data from 1997–2008 was carried out, and it was found that the state ideology and the availability of raw materials are significant variables for the state decisions about the state support mechanisms implementation (Chandler, 2009)

By the Steffen et al. (2012) different renewable energy associations in the U.S., the unemployment rate and the level of concentration of the electricity market play an important role in the RES development (Steffen et al., 2012).

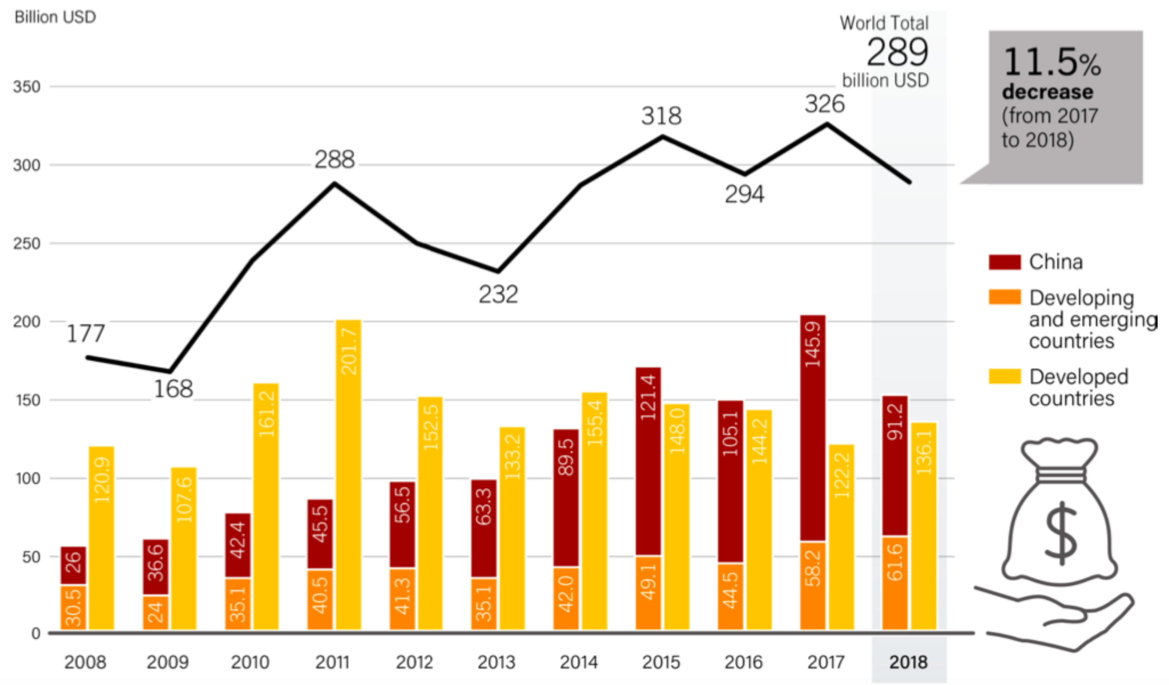
A number of articles discuss factors that stimulate the development of renewable energy in individual regions. Thus, in European countries, the main factors that limit the RES development are lobbying for traditional energy sources and restrictions on CO_2 emissions. Contrarily the focus on reducing energy dependence in Europe has a positive effect for the RES development (Marques, Fuinhas, Pires Manso, 2010).

Much attention is paid to the profitability of investments in renewable technologies, as well as to the technological and organizational factors that ensure the growth of the alternative energy competitiveness. Cumman (2006) notes that there have been significant improvements in the efficiency and availability of solar panels, wind turbines and biofuels. It allows these technologies to continue to evolve and gradually turn into a source of profit. The author also emphasizes the importance of forming industrial clusters for the development of the energy complex and shows the role of clusters in the development of alternative energy in the EU countries (Mirolyubova, 2011).

According to the Renewables 2019 Global Status Report, in 2017, about 18.1 % of global energy needs were met through RES, in 2016 around 26 % of electricity was renewable. Moreover, in the last decade there has been a significant increase in energy production from alternative sources. For example, from 2004 to 2016, the share of renewable energy produced in the European Union increased from 14 % to 25 %. Renewable energy consumption is also growing.

Investments in renewable energy are unstable, nevertheless, there is a general positive trend (Image 1). In 2018, global investments in clean energy amounted to 289 billion USD, which is 11.5 % lower than in 2017, but exceeded investments in 2016. For the fifth year in a row, investments in renewable energy sources exceeded 280 billion USD (REN21, 2019).

Image 1: Global new investment in renewable poer and fuels, 2008-2018, billion USD



Source: REN21, 2019

According to International Renewable Energy Agency (IRENA) in 2015, expectations of changes in government policy had a special impact on investments. Companies tried to complete projects as soon as possible before the expected decline in government support (examples of cancellation and reduction of feed-in-tariffs are China, Germany, Japan and the UK) (IRENA, 2018).

About 40 % of global investment in 2017 was made by China due to a significant increase in solar energy. The United States has become the second largest investment in renewable energy, despite the Trump administration's less concerned about alternative energy: the country's investments amounted to 56.9 billion USD, or 17 % of global investment. In 2016, Japan was on the third place, and Britain was fourth. India has also invested quite a lot in renewables (5th place). According to statistics, most of the states invested in solar energy technology, and the largest deals were in offshore wind energy (Louw, 2018).

In 2016, there was a slight decline in investments in alternative energy in China and Japan. It can be explained by the fact that after many years of intensive development of large projects in the field of renewable energy, the countries have moved to the stage of "acclimatization" and the implementation of new capacities. By the end of 2020, China plans to increase the share of renewable energy in the electric power industry to 15 %, Egypt – to 20 %, the European Union – to 30 % (GreenPeace, 2018). In the Iowa (United States) 37% of the energy is now supplied by wind and solar energy (Goldberg, 2017).

3.3 Types of alternative energy sources and the potential for their use

In many countries, the issue of developing renewable energy is discussed more often. Renewable energy can significantly improve the environmental situation by reducing emissions of pollutants arising from the burning of fossil fuels. In addition, there are opportunities to diversify sources of energy in energy mix, and so the prerequisites for improving energy security are made.

In modern studies, it is often noted that renewable fuels successfully push traditional energy sources (oil, gas, coal) in the market competition (Mitrova, Galkina, 2013, Fortov, Popel', 2015). This trend has to be taken into account by energy exporting countries. In addition, alternative energy allows the development of decentralized forms of energy supply. According to some experts, it matches the requirements of sustainable development more than traditional energy (Alanne, Saari, 2006).

It is important to underline, that, in addition to state support, there were a number of factors with a significant impact on the growth of interest in renewable fuels. Two factors are key:

- the effort to ensure the energy security of states,
- climate change.

The literature pays a lot of attention to issues related to climate change and the impact of this process on the economic policies of individual countries. The adoption of documents such as the Kyoto Protocol and the Paris Agreement also stimulated the activation of renewable energy policies (Skjærseth, Skodvin, 2016).

The Kyoto Protocol was an international agreement that supplements the UN Framework Convention on Climate Change, adopted in Kyoto in 1997. The agreement obliged countries that had ratified the protocol to reduce or stabilize greenhouse gas emissions till 2012. The Paris Agreement is a continuation of the Kyoto Protocol: it calls for the regulation of carbon dioxide emissions into the atmosphere since 2020, and its goal is to keep the global average temperature below 2 degrees.

Climate change is a global issue that poses a strategic threat to doing business. The actions of companies, such as limiting greenhouse gas emissions, investments in energy efficiency and renewable energy, are examples of companies' responses to climate change. Thus, global warming is considered as one of the main motivation sources for the RES development a key tool to reduce emissions (Massabié, 2008).

Tighter requirements for greenhouse gas emissions significantly affect the behavior strategy of large companies. So, for oil and gas companies, investments in renewable energy sources are becoming one of the directions of their assets diversification in the conditions of changing markets (Goolg, Luchs, 1996). Various aspects of the adaptation of companies' strategies to strengthening the RES position in inter-fuel competition are analyzed in numerous works (Goold, Luchs, 1996, Levy, Kolk, 2002, Kolk, 2008, Sæverud, Skjærseth, 2007).

The benefits of using energy from RES can be summarized as follows (Kloz, 2007):

- energy production has less negative impact on the environment, it does not produce any additional greenhouse gases, no waste (except incineration of biomass, but biomass ash does not contain toxic substances),
- RES are practically inexhaustible resources (globally) compared to primary resources that are limited,
- RES are available regionally, they do not need to be imported from any other part of the country or from another country,
- the low installed capacity, which is typical of RES, causes dispersal of electricity production, which may increase security of supply security,
- RES (and biomass in particular) are more labor-intensive than non-renewable resources (this fact can be classified as both positive and negative).

However, alternative energy sources also have weaknesses and problems, which are listed in the following points (Kloz, 2007):

- RES have higher one-time and unit acquisition costs, because of the underdeveloped production and complexity of equipment,
- low energy concentration, in terms of energy obtained per meter. That is, RES need more space to install power, which is inevitably more investment,
- uneven energy supply, RES are dependent on natural conditions,
- the practical non-storability of the electricity produced, which is more pronounced in RES than in classical energy sources, precisely because of dependence on natural conditions.

Further, the potential of particular RES, including their advantages and dissadvantages, in the selected country (Russia) is explored.

3.3.1 Wind energy potential

According to the State Standard of the Russian Federation (no. 51237-98 „Alternative Energy. Wind Energy“, 1999) wind energy is a branch of energetics related to the development of methods and tools of converting wind energy into mechanical, thermal or electrical energy.

The most favorable areas for the location of windmills (structures for converting wind energy) are coastlines (at least 10-12 km from the coast). The temperature difference is stronger, there are more stable winds (at least 5 m/s) (Energo House, 2019).

Generating electricity using wind has several advantages (Teplo.com, 2019):

- environmentally friendly production without harmful waste,
- accessibility,
- practical inexhaustibility.

However, wind energy has a number of disadvantages (Rudakov, 2017):

- uneven energy output,
- the need for energy storage,
- the presence of noise pollution and interference for receiving a television signal,
- interference with the flight of birds and insects,
- high cost of wind turbines,
- the need for large areas for installing batteries.

The total wind potential of Russia is estimated at 26,000 million tons of oil equivalent (TOE), the technical potential – 2,000 million TOE, economic potencial – 10 million TOE (Bezrukikh, 2010).

The potential of wind energy is unevenly distributed across Russia. The highest average wind speeds are concentrated along the shores of the Barents, Kara, Bering and Okhotsk seas. Regions with a relatively high wind speed (5-6 m/s) include the coasts of the East Siberian, Chukchi Seas and the Laptev Sea in the north and the Sea of Japan in the east. Significant resources are also located in the Middle and Lower Volga regions, in the Urals, in the steppe regions of Western Siberia, in Lake Baikal (Petrov, 2017).

Over most of the territory of Russia, the wind speed in the daytime is higher than at night, and these differences are less pronounced in winter. The annual course of the average wind speed in most regions of Russia is insignificant and varies from 1 to 4 m/s, averaging 2-3 m/s. Higher amplitudes are observed in the center of the European part of Russia, in Eastern and Western Siberia, as well as in the Far East, where they reach 4 m/s. Annual amplitudes of less than 2 m/s are observed over the southeast and southwest of the European part of Russia and over Central Siberia (Bezrukikh, 2010).

3.3.2 Hydropower potential

Hydropower uses the energy of moving water as a source of energy. Dams, tidal and wave energy are the main sources of hydropower. According to the Russian state standard (no. 53905 2010) the tidal and wave hydropower is the conversion of tidal energy, waves into other forms of energy. So called „Small hydropower“ is an integral part of hydropower associated with the use of water resources and hydraulic systems using low-power hydropower plants.

Tidal power plants are located on the coasts with maximum drops in water levels during high and low tides. When assessing the economic benefits of the construction of tidal power plants, it must be underline, that the most fluctuations in water level during tides are characteristic of the marginal seas. Many of these coasts are located in sparsely populated areas and are significantly removed from areas of economic activity and massive electricity consumption. The main disadvantage of tidal energy is its negative impact on the environment. In the areas of construction of large tidal power plants, the tidal height changes, which upsets the water balance near the station and has an extremely negative effect on the flora and fauna living there (Kudryavcev, 2009).

The main advantage of using tidal energy is the fact that tidal behavior can be predicted quite accurately. Thus, it can be concluded that tidal energy is a reliable form of renewable energy. In addition, tidal energy is almost independent of weather conditions (Kartamysheva et al., 2016).

The largest tides in Russia are observed in the Sea of Okhotsk, as well as in the Mezen Bay of the White Sea. Tides in the Baltic and Black Seas are measured only in centimeters, so the construction of a tidal energy plant here is impractical. In terms of economic indicators, tidal energy plants are comparable to river hydropower plants, they are 2.5-3.5 times more profitable than solar power plants, and 10 % more economical than nuclear power plants (Sibinkin, Sibinkin, 2012).

Small hydropower plants does not require complex hydraulic structures, in particular, large reservoirs. Today's developments of small hydropower plants are characterized by full automation, high reliability and a long service life (Geograf Stud, 2019).

The main indicators to assess the hydropower potential of the regions are the water content of the rivers and the presence of significant changes in elevation of the relief. It means that the most favorable regions are mountainous parts, but the hydropower potential in this part of the country is not almost used. The example of the Caucasus region shows this fact, even with such a rare combination of favorable conditions – many rivers and mountains. The construction of hydropower plants can be an environmental problem – for example, the middle and lower Volga River has become a chain of reservoirs. Separate landscapes with especially valuable biodiversity are destroyed, the normal life cycle of flora and fauna is disrupted (Schi, 2019).

3.3.3 Geothermal energy potencial

According to the Russian state standard (no. 53905 2010) geothermal energy is the conversion of the energy of geothermal waters into other forms of energy. Geothermal sources are de facto inexhaustible and have a high degree of predictability with respect to the amount of energy received.

According to the classification of the International Energy Agency (in Garipov, Garipov, 2014), geothermal energy sources are divided into 5 types:

- deposits of geothermal dry steam,
- sources of wet steam (a mixture of hot water and steam),
- geothermal water deposits (contain hot water or steam and water),
- dry hot rock heated by magma,
- magma, which is a molten rock.

Depending on the temperature of water, steam or their mixtures, geothermal sources are divided into low-temperature and medium-temperature (up to 130–150 °C) and high-temperature (over 150 °C). The temperature of the geothermal source largely determines the nature of its use (Gigavat, 2012).

The use of geothermal energy has several advantages (Rogotovskaya, 2018):

- the reserves of this type are practically inexhaustible,
- geothermal energy is quite widespread,
- the use of geothermal energy does not require large costs.

However, at the same time, geothermal energy has two significant drawbacks:

- low concentration of geothermal energy in its source,
- steam contains poisonous gases, and water carries sulfur and other impurities.

In Russia, geothermal energy ranks first in terms of its potential use. The total reserves of this type of energy in Russia are estimated at 2,000 MW. The economic potential of geothermal energy is 115 million TOE / year (Bezrukikh, 2002).

Regions with the greatest potential for using this alternative source: Sakhalin, Kamchatka and the Kuril Islands, Krasnodar and Stavropol Territories, the republics of Dagestan and Ingushetia. Omsk, Tyumen, Novosibirsk and Tomsk regions can also be considered as regions promising for the use of geothermal heat supply. In addition, geothermal resources of the Kaliningrad region, where there are reserves of hot water with temperatures up to 110 ° C, are of great interest (Magomedov, 2010).

It should be noted that in Russia the main geothermal sources are economically located unprofitable. Kamchatka, Sakhalin and the Kuril Islands are characterized by poor infrastructure, high seismicity, sparsely populated, difficult terrain. However, at the moment, a program for the creation of geothermal energy supply in this region has already been developed and is beginning to be implemented, as a result of which about 900 thousand TOE will be saved annually (Geograf Stud, 2019).

3.3.4 Solar energy potential

According to the Russian state standard (no. 51594-2000), solar energy is understood as the field of energy associated with the conversion of solar energy into electrical and thermal energy.

Solar power plants use the energy of the sun to turn it into electrical energy. They consist of many solar cells. They do not pollute the environment with harmful substances, but their power is small, since they turn only 10-20 % of the sun's rays energy into electricity, and their performance depends on the weather. Solar power plants also have a huge material consumption. For example, the construction of an plant with a mirror system and a steam generator requires tens of times more steel and cement than the construction of a thermal power plant. But the production of these materials for the environment also does not pass without a trace (Kudryavcev, 2009).

Advantages of solar power plants (Gigavat, 2012):

- accessibility and inexhaustibility of the source,
- theoretically, complete safety for the environment, although the widespread introduction of solar energy can change the reflective ability of the earth's surface and lead to climate change (however, at the current level of energy consumption this is extremely unlikely),

The disadvantages of solar power plants (Gigavat, 2012):

- dependence on weather and time of day,
- as a consequence, the need for energy storage,
- in industrial production – the need for duplication of standard solar power plants with maneuverable power plants,
- the high cost of construction associated with the use of rare elements (for example, indium and tellurium),
- the need for periodic cleaning of the reflective surface from dust,
- heated atmosphere over the power plant.

Russia has significant potential in the use of solar energy. The territory of the Russian Federation is located between 41 and 82 degrees north latitude, and the levels of solar radiation on its territory vary significantly (from 810 kWh / m2 per year in the northern regions to 1,400 kWh / m2 per year or more in the southern regions). The total potential of solar energy is estimated at 2,300,000 million TOE, the technical potential of 2,300 million TOE, and the economic potencial – at 12.5 million TOE (Bezrukikh, 2002).

The following regions are promising for using solar energy: Kalmykia, Stavropol Territory, Rostov Region, Krasnodar Territory, Volgograd Region, Astrakhan Region and other regions in the south-west, Altai, Primorye, Chita Region, Buryatia and other regions in the southeast. Moreover, some areas of Western and Eastern Siberia and the Far East exceed the level of solar radiation in the southern regions (Ermolenko, Ermolenko, Proskuryakova, 2017).

The analysis of the potential for using alternative energy sources showed that the Russian Federation has large reserves of each of these energy sources. As for the southern regions of the country, the most promising alternative energy sources for development are solar, wind and geothermal energy. However, there are significant problems and disadvantages of these sources that do not allow to realize such a large-scale potential. Due to the specifics and large regional differences in Russia, there are various prerequisites for the development of alternative energy.

4 Practical Part

4.1 Energy production and consumption in the Russian Federation

According to the Federal State Statistics Service, the balance of energy consumption in the Russian Federation consisted of the balance of electricity production by 38.4 thousand power plants operating in the country, as well as the balance of export-import of electricity. The energy system of the Russian Federation consists of seven integrated energy systems (Unified energy system, UES) of the Center region, the Middle Volga region, the Urals, the North-West, the South and Siberia regions and the geographically isolated energy systems (Chukotka Autonomous Okrug, Kamchatka Territory, Sakhalin and Magadan Oblast, Norilsk Taimyr and Nikolaev energy districts, power systems of the northern part of the Republic of Sakha (Yakutia) (Ministry of energetics, 2019).

Energy production in Russia in 2019 increased by 0.5 % year-on-year to 1,096 billion kWh. At the same time, electricity consumption in the reporting period remained at the same level – 1,074.8 billion kWh. Electricity generation in the UES of Russia for 2019 increased by 0.9 % and amounted to 1,080.2 billion kWh, and in December a decrease of 2.2 % was recorded, to 103 billion kWh (TASS, 2020).

A significant increase in electricity generation was recorded in solar and wind power plants. So, in 2019, 1.6 billion kWh of electricity was generated at this category of power plants, which is 58.6 % more than a year earlier. In December, this indicator increased by 75% year-on-year and amounted to 0.1 billion kWh (TASS, 2020).

Electricity consumption in Russia is usually affected by the factor of increasing or decreasing average annual temperatures, as well as changes in the consumption of large enterprises (Ministry of energetics, 2019).

The structure of electricity generation by type of station is shown in the table 1. It is obvious that the share of wind and solar energy plants in total energy production is almost negligible – less than 1 %.

Table 1: Energy balance, billion kWh, 2017-2018

	2017	2018	%, change to 2017
Energy produced, total	**1,073.7**	**1,091.7**	**+1.7 %**
including:			
Thermoelectric power plants	622.4	630.7	+1.3
Hydropower plants	187.4	193.7	+3.3
Nuclear power plants	202.9	204.3	+0.7
Wind and solar power plants	0.69	0.98	+42.0
Power plants of industrial enterprises	60.3	62.0	+2,9
Energy consumption	**1,059.7**	**1,076.2**	**+1.6**
Balance of energy flows	**-14.0**	**-15.5**	

Source: based on Ministry of energetics, 2019

In 2018, the number of hours and the coefficient of installed capacity using (share of calendar time) was in Russian federation (Ministry of energetics, 2019):

- thermoelectric power plants: about 4,075 hours (46.5 % of the calendar time),
- nuclear power plants: 6,869 hours (78.4 % of calendar time),
- hydropower plants: 3,791 hours (43.3 % of the calendar time),
- wind power plants: 1 602 hours (18.3 % of the calendar time),
- solar power plants: 1,283 hours (14.6 % of the calendar time).

Compared to 2017, the use of installed capacity at thermoelectric power plants and hydropower plants increased by 20 and 84 hours, respectively, but decreased by 2 hours at solar power plants. Essentially, the use of installed capacity of nuclear power plants decreased by 409 hours, while the use of installed capacity of wind power plants increased by 304 hours.

The power capacity of wind power plants in different federal districts in Russia is shown by diagram 1, solar power plants – by the table 2.

Table 2: Energy produced by the types of plants and by the federal regions, 2019

	thermoelectric	nuclear	hydropower	wind	solar
Russia (UES, total)	**67.7 %**	**12.0 %**	**19.9 %**	**0.08 %**	**0.3 %**
Central region	70.6 %	25.9 **%**	3.4 **%**	-	-
Middle Volga region	59.3 %	14.8 **%**	25.3 **%**	0.3 **%**	0.3 **%**
Urals	93.3 %	2.8 **%**	3.5 **%**	0.0 **%**	0.5 **%**
North-West region	63.7 %	24.2 **%**	12.0 **%**	0.02 **%**	-
South region	55.3 %	17.1 **%**	25.3 **%**	0.4 **%**	1.9 **%**
Siberian region	51.1 %	-	48.8 **%**	-	0.1 **%**
East region	62.0 %	-	38.0 **%**	-	-

Source: based on Ministry of energetics, 2019

Thermoelectric power plants produce almost 68 % of the total energy produced in Russia. In some regions etc. Urals, this type of plants produce more then 93 % of total energy. Nuclear energy is produced the most in the Central federal region (26 %) and in the North-West region (24.2 %). Hydropower is used the most in Middle Volga region, Siberian region and in the South region, because of the huge water resources their (Volga river, seas in the South, many fast rivers in Siberian). Wind energy forms 0,08 % share on the total energy produced in Russia (the most – 0.4 % in the South region). The solar energy is also produced the most in the South region (1.9 %).

Given the topic of the thesis is further analysis focused on a selected southern region of Russia – the Krasnodar Territory, part of the South region. The analysis of natural, economic and institutional factors for the development of alternative energy in the Krasnodar territory is made.

4.2 Key information about the Krasnodar territory

In total, there are 85 regions in Russia – subjects of the Russian Federation, including 22 republics, 9 territories, 46 regions, 3 cities of federal significance, 1 autonomous region, 4 autonomous radiuses (StatData, 2020).

Krasnodar Territory (image 2) is a subject of the Russian Federation located in the south-west of the Russian Federation. It is part of the South federal region. The administrative center is the city of Krasnodar, established in 1793.

Image 2: Krasnodar territory on the map

Source: Wikimedia, 2019

The Krasnodar territory is washed by the Azov sea in the north-west and the Black sea in the south-west. 740 km of the total length of the border (1540 km) runs along the sea. Inside the Krasnodar territory is the Republic of Adygea. The greatest length of the region from north to south is 327 km and from west to east – 360 km. The territory of the Krasnodar Territory covers an area of 75.5 thousand km^2. In most of the Krasnodar territory, the climate is temperate continental, on the Black Sea coast – subtropical. In general, the region is characterized by hot summers and mild winters. Krasnodar territory is famous for its Black Sea resorts and hundreds of kilometers of beaches (Russia Tourism, 2017).

There is the largest basin of fresh underground water in Europe – Azov-Kuban basin, which contains huge reserves of thermal and mineral waters. Kuban forest is the main source of valuable wood species of the Russian Federation. The total forest area of the Krasnodar Territory is almost 2 thousand hectares (KrasnodrKr, 2019).

The population of the region is about 5,5 million people. 46 % of all people live in rural areas. The average population density is 66.7 people per 1 sq. km., which is 8 times higher than the average density in Russia (KubanMakler, 2020).

The main place in the structure of industry is given to processing industries. Tourism is an important sector of the economy of the Krasnodar territory. Krasnodar territory is an experienced oil producing region of Russia. Oil production was begun in 1864. There are three oil refineries in the region. About 23 % of the industrial output falls on the fuel and energy complex (KubanMakler, 2020).

Proximity to traditional international trade routes and markets, well-developed transport and market infrastructure stimulate the expansion of foreign economic relations. Krasnodar Territory still occupies a leading position in terms of foreign trade turnover among the subjects of the Southern Federal District of Russia. The region carries out investment cooperation with almost sixty countries of the world. Entrepreneurs from Kazakhstan, the Netherlands, the USA, Great Britain, France and Sweden are leaders in terms of attracted capital. Investing is carried out mainly in transport, food industry, trade and public catering. (KubanMakler, 2020).

The main economic indicators of the Krasnodar territory are given in the table №. According to last year, the economy of the Krasnodar city forms more than 30 % of the basic industries of the Krasnodar Territory. The city forms almost 40 % of the region's total retail turnover (Ministry of Economy of Krasnodar territory, 2019).

Table 3: The main economic indicators of the Krasnodar territory

Indicators	2019		2018	
	values	Growth rate, %	values	Growth rate, %
GRP growth	x	101.4	x	101.1
Industrial production index	x	103.2	x	105,2
Agricultural output, billion RUB	427.3	108.3	382.5	96.4
The volume of construction work, billions RUB	238.2	66.4	311.1	95.6
Wholesale turnover, billion RUB	2,073.8	101.6	1,900.5	104,3
Retail turnover, billion RUB	1,461.6	102.3	1,368.1	102.6
Consumer price index, %	x	104.5	x	102.5
Tax and non-tax revenues of the region budget, billion RUB	318.1	115.4	275.6	109.1
The financial result of enterprises	457.3	189.5	252.2	85.2
The share of unprofitable enterprises, %	23.3	x	25.7	x
The average cash income of the population, RUB per capita per month	35,820	104.2	34,372	102.9
Payroll debt	x	102.1	x	108.9
Registered unemployment rate	0.5	x	0.5	x

Source: Ministry of Economy of Krasnodar territory, 2020

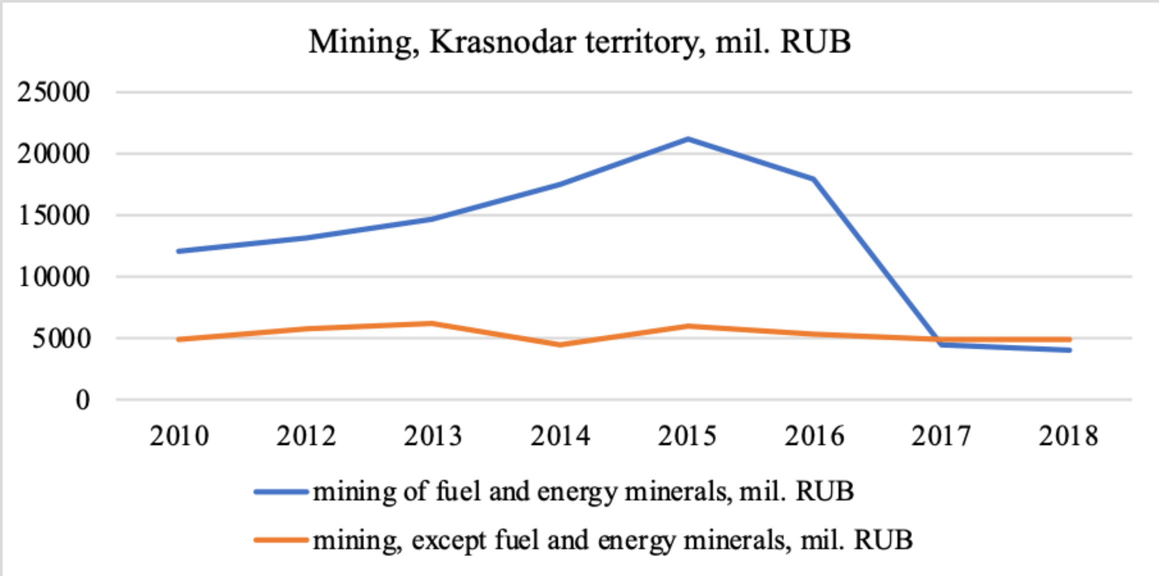
4.3 Fuel and energy complex of the Krasnodar territory and its problems

The fuel and energy complex (FEC) of the Krasnodar territory consists of more than 400 enterprises in the territory that work in various directions. FEC includes electric power, heat power, gas, pipeline transport, oil and gas producing, refining and supply. Key enterprises in the FEC of Krasnodar territory are LUKOIL-Yugnefteprodukt, Afipsky Oil Refinery, Ilsky Oil Refinery, Chernomortransneft, KTK-R, Gazprom Teploenergo, Kubanenergo, NESK. (Rufox, 2019). Enterprises of the Kransodar territory FEC employ about 60 thousand people (Executive bodies of the Krasnodar Territory, 2018).

Diagram 1 illustrates the development of the volume of natural resources mining in the Krasnodar territory (in mil. RUB). Available data from the regional statistical collection are used here. Surprisingly, they are no information in the statistics for 2011, the data after 2016 are also collected a new way. It is evident that the financial volume of all raw materials mining except fuel and energy minerals is truly stable, while the volume of fuel and energy minerals grew significantly until 2015 then began to decline in Krasnodar territory. This is related to a fall in oil prices and a decrease in its production in the region (diagram 2).

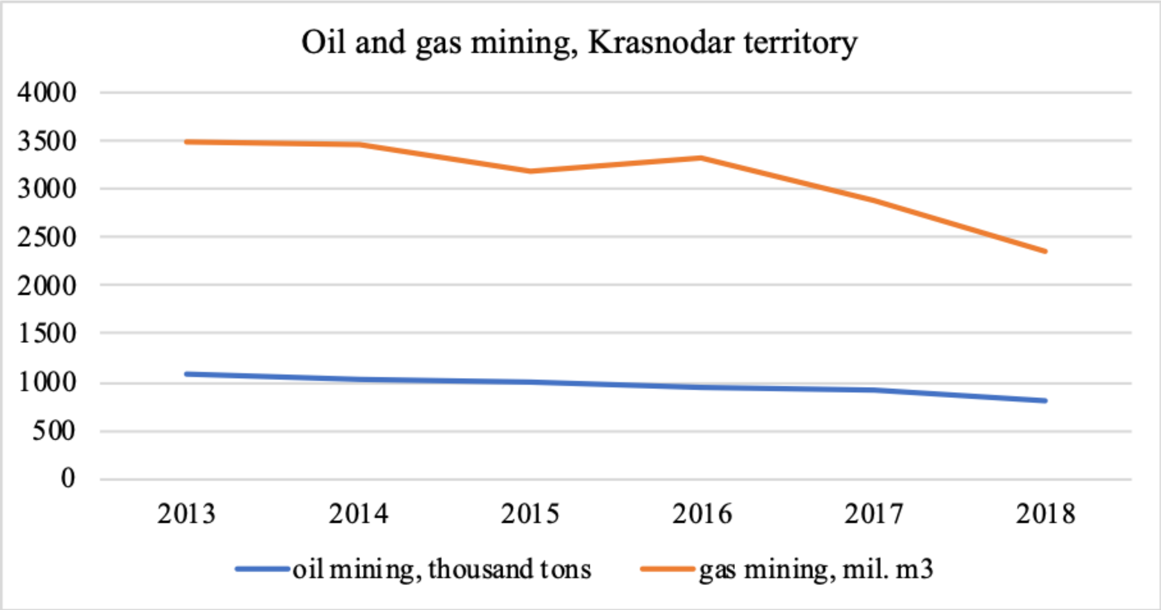
An unprecedented decline in production was a reaction primarily to a dramatic drop in oil prices, as well as to imposed sanctions by the European Union and the United States, imposed against the Russian oil industry. Due to sanctions, mining companies could have difficulties with the supply of equipment and technologies.

Diagram 1: Volume of mining in Krasnodar territory, mil. RUB, 2010-2018



Source: based on KrsDStat, 2016, KrsDStat, 2018

Diagram 2: Oil and gas mining in Krasnodar territory, thousand tons and mil. m3, 2013-2018



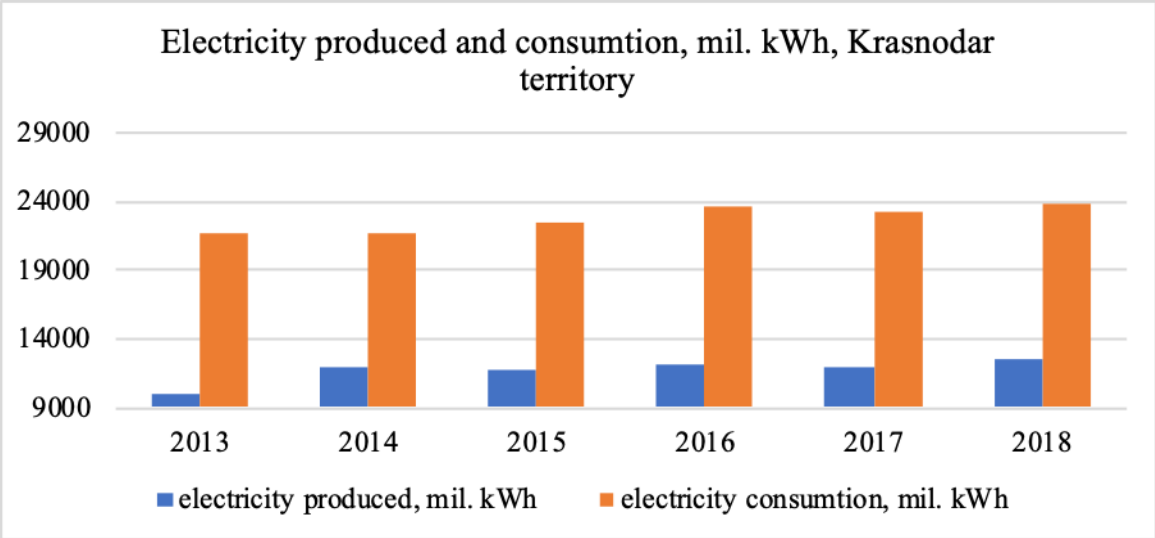
Source: based on KrsDStat, 2016, KrsDStat, 2018

The electric power complexes

The electric power industry is a highly automated complex of power plants, electric grids and electric grid facilities developing on a regional scale, with a total number of 12 thousand employees and huge tax payments to the budget of the Krasnodar Territory (more then 1 billion RUB annual) (Executive bodies of the Krasnodar Territory, 2018).

The volume of total electricity produced in the region is gradually increasing, but it does not satisfy the need for electricity in the region (see Diagram 3).

Diagram 3: Electricity, produced in Krasnodar territory, mil. kWh, 2013-2018



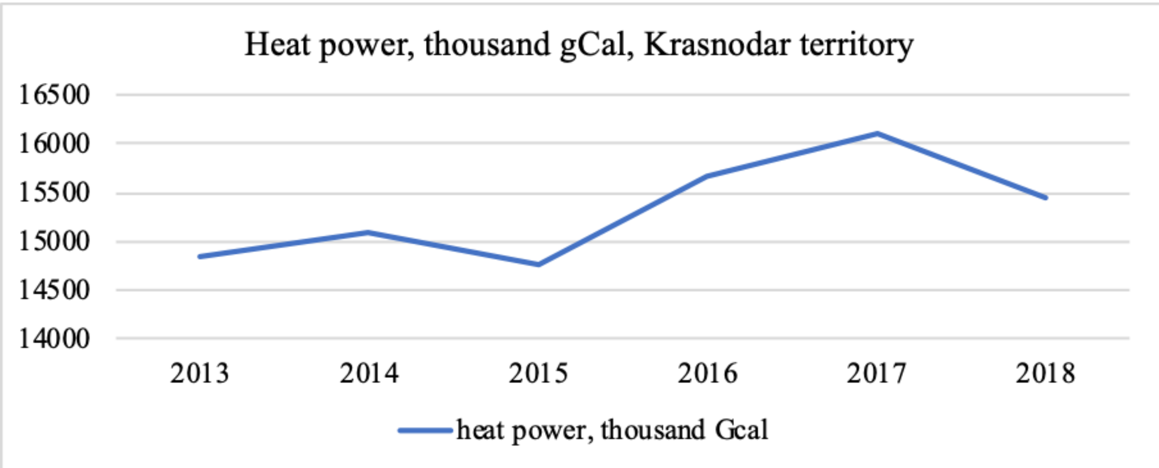
Source: based on KrsDStat, 2016, KrsDStat, 2018, RosStat, 2018

According to the estimates of the Kuban regional dispatching department of SO UES, the total loads in the power system in the period 2009-2020 are increasing from 3,541 MW to 7,100 MW, that is, more than 2 times (Rufox, 2019).

Heat power complex

The district heating systems of settlements are technologically closed, interconnected systems of production and distribution of thermal energy. The dynamics of heat power production volume changes are illustrated in Diagram 4.

Diagram 4: Heat power, produced in Krasnodar territory, thousand Gcal, 2013-2018



Source: based on KrsDStat, 2016, KrsDStat, 2018

There are a number of problems in the heat power complex of the Krasnodar Territory. Among them are (Executive bodies of the Krasnodar Territory, 2018):

- high cost of heating and hot water services, high tariff growth rates,
- lack of investment in the industry,
- extremely high degree of deterioration of boiler equipment and heating mains,
- inefficiency of existing methods and methods of managing the thermal business etc.

Gas complex

The gas complex is the basic sector of the economy of the Krasnodar Territory, providing the needs of the economy and the population in natural gas. The total number of working specialists in the gas industry is about 13 thousand people (KubanMakler, 2020). The need for natural gas with full gasification of the population of the Krasnodar Territory is: 8.3 billion m3 (the maximum actual natural gas consumption per year), including a consumption of population – 3.4 billion m3. The additional demand for natural gas for the complete gasification of the population per year is 7.7 billion m3. The following problems are relevant for gas complex (Executive bodies of the Krasnodar Territory, 2018):

- the tempo of the gas pipelines and networks reconstruction and modernization is not synchronized with the development of infrastructure of the Krasnodar Territory,
- the heterogeneity of gas distribution organizations does not allow the establishment of uniform prices and tariffs for the transportation of natural gas.

Pipeline transport

Pipeline transport of the Krasnodar territory is represented by gas, oil and gas pipelines. The length of main oil and oil product pipelines in the Krasnodar territory is 3.0 thousand km, the tank farm is 1.77 million m3, and the volume of oil transportation and transshipment is 93.0 million tons per year. The total number of working specialists in pipeline transport is about 7.8 thousand people (Executive bodies of the Krasnodar Territory, 2018).

Oil and gas producing

The oil and gas resource base of the Krasnodar territory was formed mainly in 1950-1960th. Over the entire period of active exploitation of deposits in the Krasnodar territory, about 230 million tons of oil and 400 billion m3 of gas were produced (Executive bodies of the Krasnodar Territory, 2018). In 2018, the volume of extracted crude oil and natural gas in the Krasnodar Territory was equal to the equivalent of more than 4 billion rubles (KrsDStat, 2018).

Problems of the oil and gas industry of the Krasnodar Territory are (Executive bodies of the Krasnodar Territory, 2018):

- exhaustion of oil reserves,
- complicated geological structure of deposits,
- insufficient capital investments in exploration,
- lack of modern methods of oil exploration,
- lengthy processing of permits,
- problems of the state border between Russia and Ukraine.

Oil refining

The oil refining industry of the Krasnodar Territory is represented by 3 large enterprises, 1 medium-sized oil refinery and 1 mini-oil refinery. The total volume of oil refining in the Krasnodar Territory amounted to more then 12 million tons per year. The geographical position of the Krasnodar Territory is favorable for the export of oil and oil products.

The main problems of the oil refining industry:

- limited transportation opportunities for the supply of raw materials and the sale of finished products,
- limited territorial opportunities for the development of refineries existing in the territory,

- deterioration of equipment of oil refineries.

Petroleum products supply

In the Krasnodar territory, large companies dominate the wholesale and retail oil products market: NK Lukoil, NK Rosneft, Gazprom, TNK-BP. The main share of oil products in the Krasnodar territory occurs by rail. The oil products market of the Krasnodar territory accounts for more than 30 % of consumption in the Southern Federal District of Russia. In general, the oil product supply market of the Krasnodar territory is sufficient to meet existing demand (Executive bodies of the Krasnodar Territory, 2018).

4.3.1 State program of the fuel and energy complex development

State program of the Krasnodar Territory „Development of the fuel and energy complex 2016 – 2021" estimated the total amount of financing 3,658,812.1 thousand RUB, including funds from the regional budget – 2,822,371.5 thousand RUB (Rufox, 2019).

The priorities for the FEC development of the Krasnodar territory are focused on ensuring the energy security of the Kuban, primarily the reconstruction and construction of generating capacities. Along with the development of large generating facilities, the administration of the Krasnodar territory supports the development of small, alternative energy and the involvement of renewable energy sources in the energy balance (Business-Kuban, 2003).

In February 2019, the authorities of Krasnodar presented at the Russian Investment Forum in Sochi an investment project for a new Thermal power plant, which will be located in the eastern part of the capital of the Kuban. The capacity of the plant will be 450 MW. The project cost is 30 billion RUB, the implementation period will be three years. It is supposed to build the new plant in a new land area of 1.5 thousand ha in the area of the Znamensky and Zelenopolsky. It is assumed that the new plant will power the facilities located in the area of these settlements, as well as increase the reliability of heat and energy supply of existing suburban settlements and microdistricts (Kuban RBC, 2019).

4.3.2 Problems of the total FEC of Krasnodar territory

An urgent problem of the FEC of the Krasnodar territory is the high degree of depreciation of fixed assets created in the Soviet period. The consequence of this is low efficiency, growing accidents and high risks, which adversely affects the competitiveness of the economy, negatively affects the quality of life of the population and technological threats. Also factors that negatively affect the development of the FEC are (Rufox, 2019):

- the loss of a significant part of the scientific and technological potential in a number of energy sectors,
- insufficient degree of innovation in the FEC,
- decrease in the quality of scientific and technical personnel training, insufficient level of interaction between fuel and energy companies and highhigh schools,
- low efficiency of intellectual property management,
- imperfection of innovation systems of enterprises.

The most important feature of energy supply in the Krasnodar territory is high energy dependence of the economy on external supplies of fuel and energy resources. Power supply to consumers in the Krasnodar territory is only 35 % provided by its own sources. More then 60 % of the electricity comes from neighboring regions – the power system of the Krasnodar territory is one of the most scarce in terms of electricity among the power systems of the Southern Federal District of the Russian Federation, as a result of which electricity tariffs in the Krasnodar Territory are higher than in other regions. At the same time, the region is developing dynamically. During the 2014 Olympics in Sochi, some facilities, produced energy, were launched, which partially solved the problem of energy demand, however, only in one local zone (Maksimova, 2016).

In addition, the Krasnodar Territory is closely connected with two other regions of the country – the Republic of Crimea and especially with the Republic of Adygea. Although the Republic of Adygea is an independent subject of the Russian Federation, in many aspects, including in energy supply, it is inseparable from the Krasnodar territory. And in 2014, after the reunification of Crimea with Russia, the Krasnodar territory played its role in the integration of the peninsula into the Russian energy system. An energy bridge was built between the Crimea and the Krasnodar Territory (Maksimova, 2016).

A paradoxical situation is observed in the region: lack of energy resources, on the one hand, and the presence of rich natural reserves, on the other. Krasnodar region is unique because possesses almost all types of alternative energy sources: wind, solar, geothermal, as well as biomass energy.

4.4 Renewable energetics in the Krasnodar territory

Krasnodar territory is, due to its natural potential, an ideal platform for implementing large-scale projects on the use of renewable energy sources and is able to become one of the leading regions of the country in this area. However, at present, the degree of use of renewable energy sources in the energy balance of the region is not more than 2 % (Melkonian, 2019), and unit capacities and specific indicators of existing plants have slightly improved over the past twenty years.

At the same time, the feasibility of developing renewable energy in the Kuban is confirmed by the following data on the availability of appropriate resources and the possibilities for their use (table 4).

Table 4: Renewable energy resources, Krasnodar territory

Source	Forecast power
Geothermal energy	More then 1,500 MW(t) and 100 MW(e)
Wind energy	More then 1,000 MW(e)
Solar power	More then 500 MW(t) and 100 MW(e)
Biomass energy	More then 200 MW(t) and 100 MW(e)
Total	More then 2,200 MW(t) and 1,300 MW(e)

Source: based on Bezrukhih, 2013, Bekirova, Zelinskaya, 2016

Renewable energy potential of Krasnodar territory is also evaluated at the highest levels of management.

4.4.1 State program and politics of the renewable energetics development

The idea to create a new energy cluster based on the use of renewable energy in the Kuban was voiced on the annual form Energy Efficiency and Innovation held in Sochi in 2014 (Kisin, 2014).

In order to develop renewable energetics, the Scheme and Program for the Development of the Unified Energy System of Russia 2017-2023 provides the construction of wind and solar power plants. The largest amount of investment by the state program of the energetics development is although provided for the development of nuclear power in Russia (EY, 2018) In the South federal region, the wind power (691 MW) and the solar power (395 MW) is planned to achieve (EY, 2018). The Avelar Solar Technology company will have to deal with the construction of a total of 18 solar power plants in the Kuban. The capacity of each of them will reach, according to Krasnodar specialists, a mark of 4.9 MW. This project will cost 9.8 billion rubles (Pronedra, 2019).

At the site of the Adygea wind plant, the installation of the first wind turbine was completed in the summer 2019. The height of the tower with a rotor, the diameter of which is 100 meters, is 149 meters. The power of each wind turbine is 2.5 MW (Novawind RosAtom, 2019).

In accordance with the program approved by the legislative assembly of the Krasnodar territory, widespread implementation of geothermal resources in the economy of the region is provides. There was made the concept of the development of geothermal heat supply, business plans for geothermal heat supply of the cities of Labinsk, Ust-Labinsk, Goryachy Klyuch, Apsheronsk, Anapa, Mostovsky. This concept is based on the principle of highly efficient integrated use of geothermal resources in energy supply of housing and communal services, industrial enterprises and social facilities and medical and health purposes (Bekirova, Zelinskaya, 2016).

Further analysis of the potential, using and problems of the three most valuable renewable energy sources – geothermal, wind and solar energy in the Krasnodar territory is made.

4.4.2 Geothermal energy in the Krasnodar territory

Another strategically important direction for the development of the Krasnodar territory’s energy sector is the diversification of the fuel and energy balance in its resource part is the use of geothermal energy sources.

In the Krasnodar Territory, geothermal studies were begun in 1927 by N. Ignatovich at the Psekupsky deposit (the city of Goryachiy Klyuch). Russia's transition from a planned to a market economy has led to stagnation in the development of geotherms. New wells are not drilled, the volume of geothermal water production at existing fields is reduced, the geothermal heat supply systems are not updated and are replaced by gas heating. At the same time, there is a trend toward mass construction of thermal spas with swimming pools and balneotherapy centers. Prospects for the Kuban geothermal resources is in their integrated use with the construction of large-scale combined heat supply systems and thermal resorts according to European experience.

Krasnodar Territory is the third in Russia in terms of geothermal water production and the fourth in their proven reserves – 18 geothermal fields have been explored, in which 74 wells have been drilled with a total potential capacity of 250 MW. The maximum achieved annual production of geothermal water is 8.5 million m3. The cost of only drilling these wells is more than 3 billion RUB (Butuzov, 2019).

Table 5 shows the values of thermal power and annual heat production of the main geothermal deposits of the Krasnodar territory. Geothermal waters are distributed throughout the Krasnodar territory literally everywhere. The main investigations of geothermal waters were carried out to a depth of 3 km, however, there are also several deeper wells in the region that were drilled to search for oil, but were mothballed due to the lack of prospects for oil production, which nevertheless are of practical interest for geothermal energy. (Bekirova, Zelinskaya, 2016). Voznesenskoye and Yuzhno-Voznesenskoye fields (total thermal power is 50 MW) possess the greatest potential, the separation of this regions is conditional.

Table 5: Thermal power and annual heat production of the main geothermal deposits, Krasnodar territory

Geothermal deposit	thermal power, MW	annual heat production, thousands MWh
Juzhno-Voznesenskoye	20 MW	71 000 MWh
Voznesenskoye	30 MW	106 000 MWh
Mostovskoye	45 MW	158 000 MWh
Labinskoye	31 MW	110 000 MWh
Maikopskoye	32 MW	114 000 MWh
others	80 MW	275 MWh

Source: Bekirova, Zelinskaya, 2016

The analysis shows that the Krasnodar Territory has significant potential also for small hydropower, amounting to 0.75 % of the total Russian potential. The economic potential of the region’s small hydropower plants is 25-30 % of the expected electricity consumption in 2020 (Bekirova, Zelinskaya, 2016). To date, the region's small hydropower industry is represented by only three stations commissioned in the 1950s. Technical and energy indicators of these hydroelectric power plants are presented in epy table 6.

Table 6: Characteristics of small hydropower plants, Krasnodar territory

Hydroelectric power plant	**Location**	**Installed power, MW**	**Electric power produced, mil. kWh**
HEP Sochinskikh elektrosetey	Sochi	28.5 MW	164.3 mil. kWh
Belorechenskaya HEP	Belorechensk	48 MW	232.7 mil. kWh
Maikopskaya HEP	Maikop	9.4 MW	46.4 mil. kWh
Total		**86.3 MW**	**443.4 mil. kWh**

Source: Bekirova, Zelinskaya, 2016

Table 7 shows the parameters of small hydropower plants, promising for the construction on the rivers of the Krasnodar territory. This estimate was made in a study of Russian experts team – Grigorash, Khamula, Kvitko. The construction of 17 small hydroelectric power stations in the territory, including 9 stations on the rivers of the Black Sea coast and 8 thermal power plants on the tributaries of the Kuban river, is technically and economically justified. The total installed capacity of these facilities will be 75.3 MW, the average long-term power generation is 420.7 million kWh per year (Grigorash, Khamula, Kvitko, 2013).

Presented data (table 7) clearly demonstrate the extremely high investment attractiveness and economic efficiency of small hydropower projects in the Krasnodar territory. High energy efficiency corresponds to a low cost of 1 kWh compared to other energy sources and relatively short payback periods for construction projects of these generating facilities.

Table 7: Promising small hydropower plants and their paramteters, Krasnodar territory

Hydroelectric power plant	Installed power, MW	Electric power produced, mil. kWh
Smal HEP on the coas of the Blach sea		
Nebug river	920 MW	3.7 mil. kWh
Agoy river	430 MW	2.2 mil. kWh
Pshenakho river	1,180 MW	6.0 mil. kWh
Pseushko river	620 MW	3.0 mil. kWh
Shepsi river	960 MW	4.2 mil. kWh
Armaluk river	100 MW	0.5 mil. kWh
Makopse river	600 MW	2.8 mil. kWh
Bezymyanke river	600 MW	4.4 mil. kWh
Mzymta river	4,800 MW	38.0 mil. kWh
Smal HEP on the pool of the Kuban river		
Bugunzhe river A	1,360 MW	5,8 mil. kWh
Bugunzhe river B	1,360 MW	5,8 mil. kWh
Khamyshkinskaya on the Belaya river	23,000 MW	139,8 mil. kWh
Dakhovskaya on the Belaya river	15,000 MW	78.3 mil. kWh
Malaya HEP-1 on the Cica river	2,600 MW	17.5 mil. kWh
Malaya HEP-2 on the Cica river	2,760 MW	14.6 mil. kWh
Shapsugskaya malaya HEP	970 MW	1.8 mil. kWh
MHEP on the Afipskaya	330 MW	1.0 mil. kWh

Source: Grigorash, Khamula, Kvitko, 2013

4.4.3 Wind energy in the Krasnodar territory

Another promising alternative energy industry for the energy subsystem of the Krasnodar Territory is wind energy. It should be noted that modern technologies for the construction of wind power plants provide a very high reliability of construction, which will allow them to be installed even in densely populated areas, without fear for safety.

The amount of energy generated on the basis of traditional fuel and energy resources is a fairly constant value and can be predicted with a high degree of accuracy, then in the case of wind generation there can be no such confidence. There are no exact methods for predicting the direction and speed of the wind in a particular area, nor are there cheap methods for storing energy. However, some forecasts are still being created. According to one of them, wind farm capacity factors in the Krasnodar territory can reach 35% (3,000 hours per year) by 2030 (IRENA, 2017). Despite a certain uncertainty in the forecasts, investing in wind energy projects to cover the organizations own needs is considered very profitable. (Bekirova, Zelinskaya, 2016).

In order to assess the possibilities of using wind resources for the production of electric energy in the Krasnodar Territory, it is needed to ourselves with the map of Russian wind resources. According to the portal Energy Wind (2019) the maximum wind speed is on the territory of Novorossiysk (up to 44 m/s). The average annual wind speed at an altitude of 10 m in this region is 4.1 m/s. High average annual winds are also in Anapa (4.3 m/s), Temryuk (4.1 m/s). The wind reaches high speeds in winter on the Black Sea coast – in Sochi, Tuapse.

For optimal energy production by a wind turbine, a speed of about 15-17 m/s is required. In the areas located near the coastline in the Krasnodar territory, the wind speed sometimes reaches about 25 m/s, at which the wind turbine cannot work. In winter there is an icing problem. In general, wind energy in the Krasnodar territory can be used with benefit, but only in about 20 % of the territory (Dizendorf, Uskov, 2016). Significant coastal zones of the Black and Azov Seas, as well as the Armavir wind corridor region are of interest for large-scale development of wind energy in the region (Bekirova, Zelinskaya, 2016).

4.4.4 Solar energy in the Krasnodar territory

The practical construction of solar plants in the Kuban was started in 1985 by V. Butuzov, deputy chief engineer of the KubanTeploKommunEnergo production association, with the support of P. Surguchev, general director of this association. The first solar installation was built in 1987 in the city of Anapa at the boiler room of the city hospital with the support and assistance of the director of the Teplovye seti company in this city – P. Achkinadze. The installed capacity of this power plant was 320 kW, the area of it was 400 m². The second solar installation was built in 1988 on the roof of the three-story administrative building of the KubanTeploKommunEnergo association in Krasnodar. 360 solar pannels was produced by georgian SpetsGelioTeploMontazh company with a total area of 216 m². In the same 1988 in the city of Ust-Labinsk on the roof of the boiler room 180 solar pannels made by georgian company with a total area of 108 m² were mounted. Photos of the first solar pannels in Krasnodar territory are in the Appendix A. During

1987-1989 there were bulit six solar installations in the Krasnodar territory, their whole area was 1,560 m2.

The second stage of the development of solar technology in the Kuban was after the defense of V. Butuzov in 1987 with a candidate dissertation and the organization of the Krasnodar base laboratory of the Academy of Public Utilities. The third stage of the development of solar plants, since 1993, was based on long-term cooperation with the Kovrov Mechanical Plant (KMZ). In that time the chief designer of the plant A. Lychagin, on his own initiative, developed the design of the new solar construction. In total, KMZ produced more than 3,000 solar panels installed mainly in the Krasnodar territory. At this stage of development, the maximum volumes of solar installations were reached (COK, 2019).

In the 1990s, the most large-scale work in the Russian Federation on ground-based photovoltaics was carried out in the Krasnodar territory. In 2000 a specialized enterprise for solar installations was established LLC Teploproektstroy.

The new stage in the development of solar technology in the Kuban was the use of solar collectors by the German manufacturer WOLF, the most modern collectors for that time. They were used in 2011 in Ust-Labinsk for the largest solar installation in the Krasnodar territory with an area of 600 m² (see Appendix A). With the same collectors, in 2012, a geothermal-solar installation with an area of 144 m² was built in the village of Rozovoy, Labinsky district.

From 2011 to the present, AltEnergia company has been engaged in the manufacture of flat-panel solar collectors of its own design, as well as the installation of solar systems with their use in energy-efficient buildings, under the guidance of A. Temerov. Due to the lack of state support, low prices for fossil fuels and the depreciation of the ruble in 2015, almost doubled, there is no currently mass production of solar collectors in Russia. In 2019, in Russia, only two organizations produce solar constructions for individual orders – the New Pole company and VPK NPO Mashinostroenie.

In Russia, the installed capacity of solar power plants (SEP) operating in the country's energy system is 960 MW, and solar heat supply, according to expert estimates, is 48 MW (60 thousand m2). The capacity of SEP in Krasnodar territory is 8 MW (10 thousand m2). This region is a pioneer of ground-based use of photovoltaics (since 1964), as well as solar installations for heat supply systems. More than half of solar installations provide hot water supply to the recreation centers (COT, 2019).

At the initiative of the administrations of the Krasnodar Territory and the city of Krasnodar, the region is already taking active steps to implement autonomous solar energy systems in the public utilities sector. The first bus stops with autonomous illumination based on the use of solar modules were installed in Krasnodar, and then in Armavir. In these same settlements, the implementation of autonomous energy systems for lighting the entrances of residential buildings, autonomous solar lamps for lighting pedestrian crossings has also begun. And this practice is becoming more common.

Solar installations are actively used on the roofs of the recreation centers. As it was indicated, the Krasnodar territory has great tourist potential, many tourist complexes, hotels, and boarding houses are concentrated here. The Krasnodar territory (excluding Crimea) is in first place in Russia by the number of tourists. Solar panels can be installed on the roofs of hotel and boarding buildings and so save space (unlike ground-based solar installations). According to Butuzov (2018), the installation of solar panels on 50 percent of the roof area of hotels and resorts in the Krasnodar Territory will cover a total area of 535 thousand m2. This area can generate up to 500 MW of solar energy.

Based on the foregoing, it follows that the Krasnodar territory is the leader of Russia in the construction of solar installations. Over 30 years, considerable experience has been gained in the construction of solar plants of various capacities.

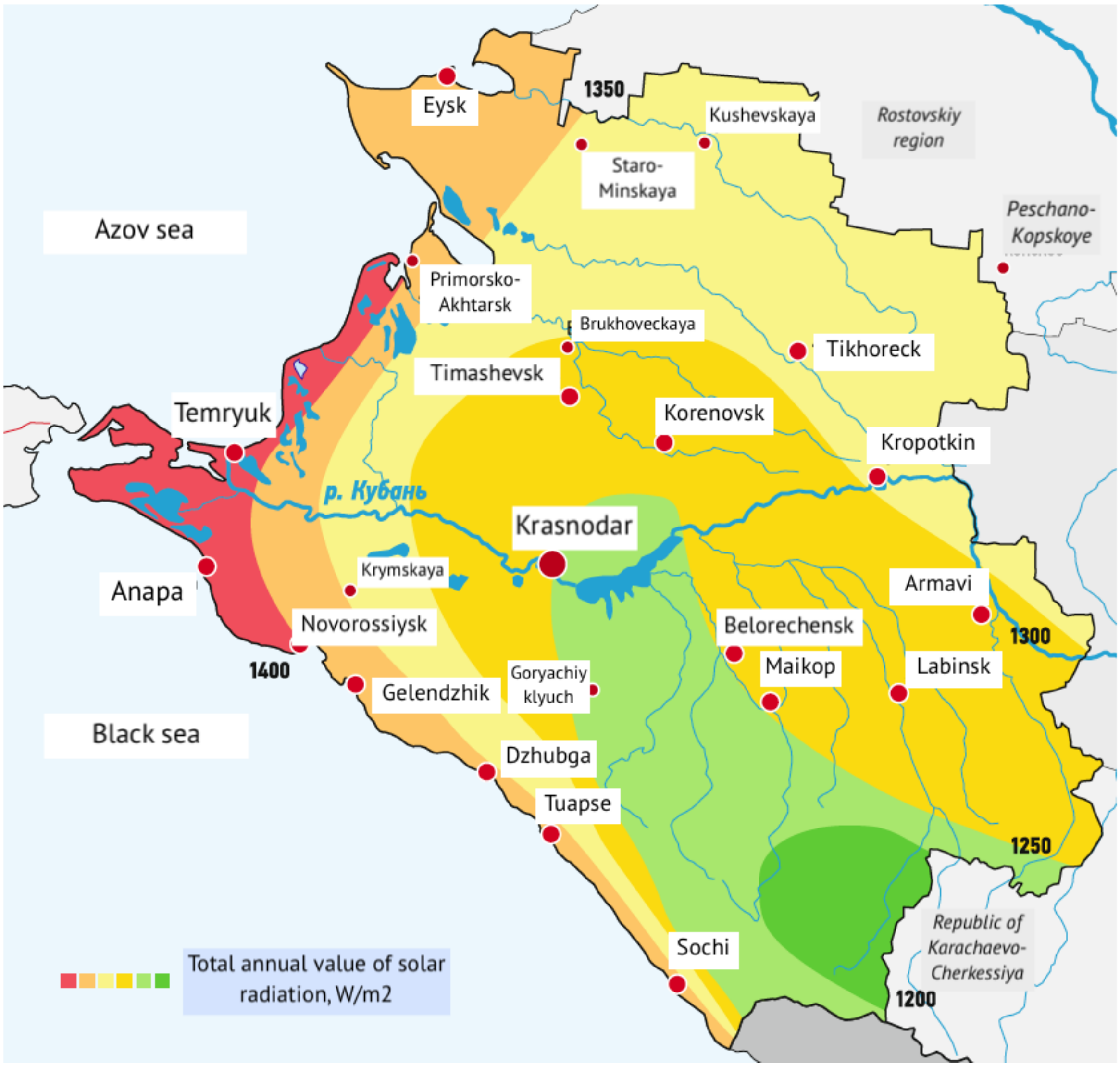
Thus, the development of non-fuel energy in the territory of the Krasnodar Territory as a whole can be considered promising. A detailed study of the technical issues of the further development of alternative energy in the region and the involvement of additional renewable energy sources in the economy is necessary.

4.5 Project of solar construction in the city of Krasnodar

4.5.1 Evaluation of the solar energy potential in the Krasnodar territory

For the solar industry, reliable information on solar radiation is essential. Image 3 presents a graphical interpretation of the total annual solar radiation in the Krasnodar territory in W/m². The image 3 show, that the Krasnodar Territory is located in a zone of strong solar radiation, which is a favorable factor for the development of solar energy in the region and a sufficient basis for the development of projects to involve this type of energy in a useful economic turnover.

Image 3: Solar radiation, Krasnodar territory



Source: COK, 2019

The regions with the highest solar radiation are located on the Azov and Black sea costs, near the sea border with the Crimea peninsular. The solar radiation is there more then 1,400 W/m2. For comparison, one of the lowest rates of solar radiation in St. Petersburg is 840 W/m2 (Muravleva, 2015). In Germany and the Czech Republic, which are among the leading countries in the development of photovoltaics, the level of solar activity in the southern regions is not more than 1100 - 1200 kW / m2 per year.

The analysis of average monthly cloud cover showed that more than 50 % of the time in a year in the Krasnodar Territory, average cloud cover exceeds 55 % (Bekirova, Zelinskaya, 2016).

In order to demonstrate the solar potential of the Krasnodar city, the table 8 below shows the average amount of solar energy falling on a horizontal platform (with optimal pitch of the panel).

Table 8: Solar potential of the city of Krasnodar

Month	**Solar radiation, kWh/m2**
January	42.8
February	77.8
March	127
April	147
May	178
June	171
July	194
August	172
September	148
October	123
November	81,7
December	55,6
Total	**1433**

Source: AltEngo, 2011

4.5.2 Solar construction

As the main elements will be used solar panels based on polycrystalline silicon. Polycrystalline silicon is less effective in solar panels than monocrystalline, but its relatively low cost makes it a fairly popular material in the market of renewable energy sources (UST, 2019).

Model example – installation of 5 solar constructions (10 panels in each construction) with a total area of 100 m2, south orientation, angle of slope is 45. The installation of the solar construction involves the use of a fixed support for solar modules in order to minimize maintenance costs and achieve maximum autonomy. As already mentioned, it is advantageous to place the solar construction especially on the roof of accommodation facilities having a large capacity in the Krasnodar region. It is necessary to choose the manufacturer of solar panels.

The New Pole company (rusky „Novyi Plyus") offers solar collectors of its own production such as „YaSolar" of the following types: liquid, flat, air, air-liquid, tubular vacuum liquid. Solar collectors manufactured by Novy Pole are not tested and not properly certified, but were tested in some projects in Krasnodar territory. In 2019, New Pole completed the solar construction for the hot water supply system of the children's health camp („Zelenyi ogonyek", Tuapse) (see Appendix A). On the roof of the dining room, 120 solar collectors of the "YaSolar" type were mounted in blocks (five collectors in each block). The area of each solar pannel is 2 m^2. The payback period of this solar installation is estimated as 4.5 years (COK, 2019).

The second Russian manufacturer of liquid solar collectors is Military Industrial Corporation Scientific and Production Association of Mechanical Engineering JSC (rusky „Voenno-promyshlennaya korporaciya Nauchno-proizvodsvennoe objedinenie mashinostroeniya", VPK NPO Mashinostroenie) produces solar pannels with two types of sheet-tube absorbers: copper and aluminum. Their size (2008 × 1093 × 76.7 mm) is a little bigger then size of the New Pole pannels. Solar pannels of this manufactor are not also properly tested and not certified yet, but were already tested in the Goryachiy Klyuch city. The payback period is estimated up to 5 years (COK, 2019).

Among the advantages of using solar energy are:

- low cost,
- inexhaustibility of the source,
- environmental friendliness,
- consistency with the concept of distributed energy generation,
- the possibility of using both electric and thermal energy for the production,

- long service life (30-50 years).

The minuses include the high dependence of energy production on natural and climatic conditions, as well as the time of day, which leads to the objective need to use rechargeable batteries to store the generated electricity. And if the generation of electricity itself is relatively cheap, then the maintenance of energy storage means is expensive. However, the problem of energy storage is solved by the joint use of solar energy with other methods of energy supply, including traditional, less prone to intraday and climatic variations in conditions.

4.5.3 Calculation the cost of the solar construction

Calcualtion is made for the solar pannels made by VPK NPO Mashinostroenie, installed on the roof of the accommodation facility.

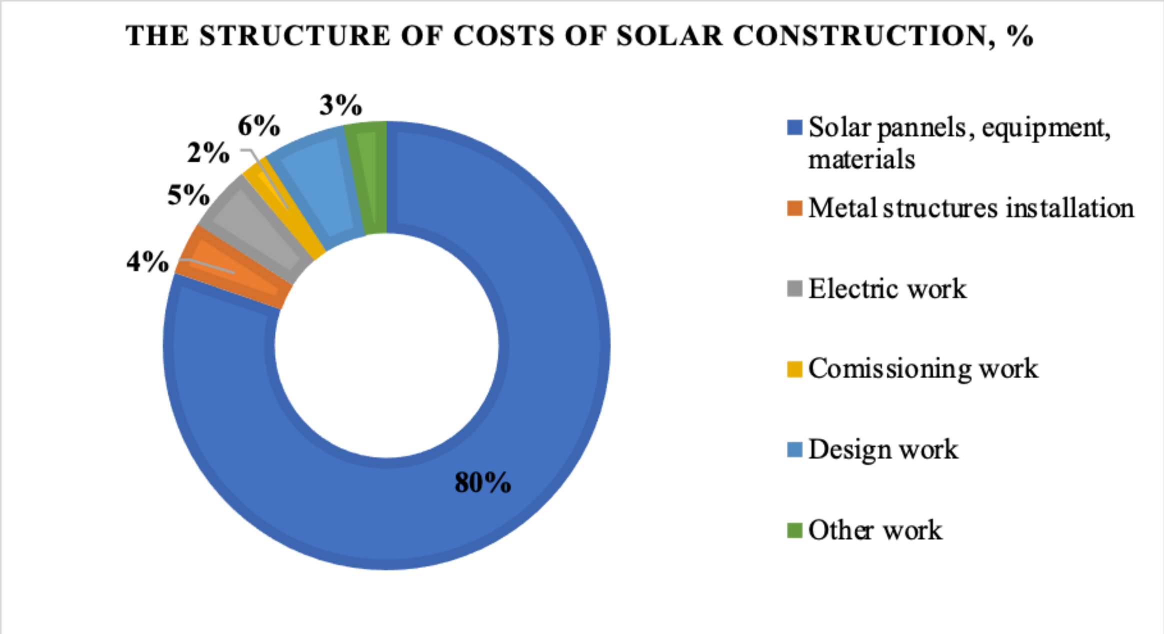
Construction costs include the cost of equipment, design and construction worksю The total estimated cost of this construction ilstallation (see Table 9) amounted to 6.6 million RUB. This price includes the cost of solar pannels, equipment and materials (5.3 mil. RUB, 80.3 %). The metal structures installation costs about 250,000 RUB (3.78 % of the total cost), electrical work – 314,000 RUB (4.76 %). Design work costs 400,000 RUB (6.1 %) and includes pre-design study, development of design and working documentation, as well as the development of a power distribution scheme. Diagram 5 shows the structure of this construction costs.

Table 9: Costs of solar construction

	RUB	**%**
Solar pannels, equipment, materials	5,300,000	80.3 %
Metal structures installation	250,000	3.8 %
Electric work	314,000	4.8 %
Comissioning work	140,000	2.1 %
Design work	400,000	6.1 %
Other work	200,000	3.0 %
Total	**6,604,000**	**100.0 %**

Source: based on prices of VPK NPO Mashinostroenie, 2020

Diagram 5: The structure of costs of solar construction



Source: based on prices of VPK NPO Mashinostroenie, 2020

4.6 Results

The problem of increasing the level of energy self-sufficiency of Russian regions has recently been extremely urgent and discussed. According to the most general concepts, the energy deficit is a systemic imbalance between the volumes of production and consumption of electricity within a certain territory, expressed in the impossibility of covering the existing demand for fuel and energy from available energy resources.

The annual steady increase in demand for electricity, caused not only by the growth of industrial production, but also by the expansion of the scale of life in the face of a reduction in the natural reserves of fuel and energy resources, leads to the need for conceptual changes in the structure of regional fuel and energy balances.

The high dependence of the Krasnodar Territory on external energy supplies, the minimum reserves of energy capacity for the implementation of strategic programs for the socio-economic development of the region determine the need for large-scale work on the implementation of energy conservation principles in all sectors of the economy, including taking into account territorial and other differences. Improving the efficiency of energy consumption as a reserve for reducing the energy deficit of the economy of the Krasnodar Territory is an extremely important area for improving the energy subsystem of the region.

The Krasnodar Territory has relatively small reserves of fuel and energy resources (traditional), therefore, the most promising way to increase the energy self-sufficiency of the region is to attract non-traditional (alternative) energy sources to electricity generation, which are largely renewable. Renewable energy in itself is usually cheap (due to the inexhaustibility of the energy source) and environmentally friendly (it is possible to note a significantly lower harmful effect on the environment when using non-fuel energy resources compared to traditional resources).

Due to its natural potential, the Krasnodar Territory is an ideal platform for implementing large-scale projects on the use of renewable energy sources and is able to become one of the leading regions of the country in this area. The significant potential of the region in the use of alternative energy sources is based not only on the availability of large-scale reserves of renewable energy sources, but also on many years of experience in their practical use.

The Energy Saving Program implemented by the Government today involves the introduction of innovative technologies, as well as the use of environmentally friendly electricity generators. Relying on the Energy Saving Program, the solar power plant is a unique solution – an environmentally friendly, innovative, qualified power generator that fits perfectly into the current Energy Saving Program and the construction of which, in fact, is a nationally beneficial project.

5 Conclusion

The main objective of this thesis was to assess the potential and prospects of using alternative energy sources in the Russian Federation and especially in its southern regions using the example of a project for the small solar construction in Krasnodar.

To achieve this goal, the study of the range of basic theoretical concepts that relate to this issue was made at first. Then the potential of alternative energy sources using in the whole Russian Federation was made. It was concluded that the most beneficial for the South region (especially for the Krasnodar territory) is the use of solar energy, which can also be combined with hydropower energy. Wind power can be used only in 20 % of the South region's territory – too strong wind and negative temperatures in some regions may limit traffic of wind plants.

Some significant conclusions can be drawn from the analysis of the energy sector in Russia. The Russian electric power industry continues to develop. Electricity consumption is growing, there is a gradual increase and updating of the installed capacity of generating companies, as well as an increase in their profitability. It can be considered the growing interest in renewable energy sources. Despite the positive trends, there are a number of unsolved problems. Currently, the greatest attention in Russia is given to nuclear energy. The generation and consumption of electricity from renewable energy remains very small, not comparable with many European countries. There is a paradoxical situation when a country has a huge potential for renewable energy, but practically does not use them. The barriers to the development of renewable energy include obsolescence of technologies and infrastructure, the lack of effective coordination of the construction of various types of renewable energy plants, and low interest from the government and investors in relation to the construction of renewable energy sources.

It is clear that for such a large country as Russia, which has established traditions in the use of traditional energy sources and the development of nuclear energy, the widespread transition to renewable energy sources is currently unrealistic. However, small RES plants can serve as an excellent source of energy for local consumption of regions, individual cities and towns. The prospect of building small renewable energy facilities is also due to the presence of state financial support. It is quite difficult to get subsidies in

Russia – from the point of view of resolving administrative issues, corruption, the need to have certain connections, but it is not unrealistic.

In this work, an analysis was made of the potential of renewable energy in certain regions of the country. Of particular interest are the southern regions of Russia, which have enormous potential for the use of renewable energy – especially wind, solar and hydrothermal. Solar energy is particularly promising for the Krasnodar Territory, which is part of the Southern Federal District. An analysis of the number of sunny days and solar radiation confirms that the construction of solar power plants in this region is particularly suitable for this region. Also, the Krasnodar Territory has relatively small reserves of fuel and energy resources (traditional).

The need to develop power plants in the Krasnodar Territory is obvious – the region is one of that regions, which most dependent on external energy supplies in Russia. Currently, more than 60 percent of energy is imported to the Krasnodar Territory. Energy demand, however, is growing steadily – the region is developing (it is promising for investors in terms of tourism, manufacturing). The Republic of Crimea and the Republic of Adygea are closely associated with the energy load in the Krasnodar Territory.

Based on the analysis and conclusions made, it is possible to unequivocally point out the large role and prospects of renewable energy in certain regions of Russia, and especially about solar energy in the Krasnodar territory.

In this work, the potential of solar energy in the Krasnodar Territory was analyzed in detail, as well as the calculation of the installation of a solar structure for a flat roof (area of 100 m2) using the data of the leading manufacturer of solar panels of its own model VPK NPO Mashinostroenie. The total cost of 6.6 million rubles. It is shown that in modern economic conditions it is possible to build a solar construction with a payback period of up to five years.

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7 Appendix

List of Supplements

Appendix A Solar installations in the Krasnodar territory

The first solar installation in Anapa city, Krasnodar territory, bulit in 1987

Solar installation on the roof of Sovetskaya Kuban Publishing in Krasnodar, bulit in 1989

Solar installation in Ust-Labinsk, the largest area in Krasnodar territory, bulit in 2011

Solar pannels on the roof on the chieldren's health camp near Tuapse city, 2019.
Made by the New Pole company.

Source: COK, 2019.