Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Trade and Finance

Bachelor Thesis

Impact of Adopting Renewable Energy Technologies on the Economic Growth and Ecology in the Russian Federation

Vladimir Trifonov

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Faculty of Economics and Management

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The Impact of Adopting Renewable Energy Technologies on The Economic Growth and Ecology in the Russian Federation

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Objectives of thesis

The major goal of this thesis is to examine the potential and prospects of using alternative energy sources in the Russian Federation. To achieve this goal, the following tasks must be completed:
1. Research a variety of basic theoretical concepts related to this issue.
2. Assess the potential of alternative energy sources in the Russian Federation.
3. Assess the effect on Russian economy from the renewable sources of energy.
4. Formulate and propose possible measures to improve the situation in the alternative energy field.

The prospects of employing alternative energy in the Russian Federation are investigated in this thesis. The thesis explores the feasibility of utilizing alternative energy sources in the Russian Federation in addition to the main course of the work.

Methodology

The following thesis incorporates the quantitative approach which will primarily be based on deduction.

The literature part consists of a deep analysis of related scientific articles and the current status of renewable energy worldwide and especially in the country of interest, thus being the Russian Federation.

The practical part consists of a quantitative analysis of basic macroeconomic indicators, as well as the level of CO_2 emission in the country with the help of a simultaneous econometric model. The following results will be correlated with the tendency of growing the basis of renewable sources of energy in the country.

The proposed extent of the thesis

45-55

Keywords

Renewable energy, Gross Domestic product, Carbon Dioxide emission, ecology, development, information society.

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Fortov, V.E., Popel', O.S. The current status of the development of renewable energy sources worldwide and in Russia. Therm. Eng. 61, 389–398 (2014). https://doi.org/10.1134/S0040601514060020

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The Bachelor Thesis Supervisor

Ing. Ghaeth Fandi, Ph.D.

Supervising department

Department of Trade and Finance

Advisor of thesis

Ing.Tarek Husein

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prof. Ing. Luboš Smutka, Ph.D.

Head of department

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doc. Ing. Tomáš Šubrt, Ph.D.

Dean

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Declaration

I declare that I have worked on my bachelor thesis titled "Impact of Adopting Renewable Energy Technologies on the Economic Growth and Ecology in the Russian Federation" 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 any copyrights.

In Prague on 27.11.2022 ____________________________

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Impact of Adopting Renewable Energy Technologies on the Economic Growth and Ecology in the Russian Federation

Abstract

In his work, the author focuses on researching a variety of basic theoretical concepts related to the issue of renewable sources of energy in Russia, assessing the potential of alternative energy sources, quantifying the effect on Russian economy from the renewable sources of energy and formulate and propose possible measures to improve the situation in the alternative energy field. Research is carried out with the help of a quantitative analysis of basic macroeconomic indicators, as well as the level of CO2 emission in the country with the help of a simultaneous econometric model.

As a consequence, the author concludes that Russia does not entirely rely on renewable sources of energy and its contribution to the Russian economy is extremely low, while the degree of the positive effect on the country's ecology is considerably high. Yet, other sources of energy such as thermal plants are much more efficient, and the country prefers to focus on economic efficiency instead of sustainable growth. The author suggests that the country will undergo a transition and slowly increase the share of renewables at the expense of economic growth to reach a more sustainable economic growth.

Keywords: Renewable energy, Gross Domestic Product, Carbon dioxide emission, ecology, development, information society

Dopad přijetí technologií obnovitelné energie na hospodářský růst a ekologii v Ruské federaci

Abstrakt

Ve své práci se autor zaměřuje na výzkum řady základních teoretických konceptů spojených s problematikou obnovitelných zdrojů energie v Rusku, hodnocení potenciálu alternativních zdrojů energie, kvantifikaci vlivu obnovitelných zdrojů energie na ruskou ekonomiku a formulování a navrhování možných opatření ke zlepšení situace v oblasti alternativní energie. Výzkum se provádí pomocí kvantitativní analýzy základních makroekonomických ukazatelů a úrovně emisí CO2 v zemi pomocí současného ekonometrického modelu.

Důsledkem k tomu je závěr, že Rusko se zcela nespoléhá na obnovitelné zdroje energie a jeho příspěvek k ruské ekonomice je extrémně nízký, zatímco míra pozitivního vlivu na ekologii země je značně vysoká. Jiné zdroje energie, jako jsou tepelné elektrárny, jsou však mnohem efektivnější a země se raději zaměřuje na ekonomickou efektivitu místo udržitelného růstu. Autor navrhuje, aby země prošla přechodem a pomalu zvyšovala podíl obnovitelných zdrojů na úkor hospodářského růstu, aby dosáhla udržitelnějšího hospodářského růstu.

Klíčová slova: Obnovitelná energie, Hrubý domácí produkt, emise oxidu uhličitého, ekologie, rozvoj, informační společnost

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1 Introduction

Renewable energy sources (hence referred to as RES) are a complex problem in Russia. On the one hand, Russian leaders expressed a strong political commitment to increasing the use of renewable energy sources and set a goal of increasing the share of electricity production and consumption based on renewable energy technologies to 4.45 percent of total production and consumption by 2020 (Boute, 2016). These goal indicators have been included into federal legislation governing the electric power business. These political signals have sparked high hopes among potential renewable energy investors and the worldwide community, which is worried about the challenge of climate change. Specific assistance measures, on the other hand, take a long time to create. More than two years after the objectives were announced, there is still no legal framework in place to make renewable energy projects in Russia cost-effective.

Organizations charged with developing support mechanisms are tasked with a number of tasks, ranging from estimating the amount of governmental assistance required to guaranteeing the safe running of Russia's Unified Energy System. Simultaneously, the government, worried about the rapid rise in power prices for end-users, has lately suggested tariff growth controls. The following criticism may emerge as a result of this trend: Because the cost of RES assistance is higher than the cost of producing energy from fossil fuels, such support will result in a rise in power costs.

All of these Russian authorities' reservations are reasonable, especially given that many nations are cutting back on renewable energy subsidies due to the economic slump and budget restrictions. However, there are clear benefits to employing renewable energy sources in Russia in terms of environmental conservation, economic growth, and energy security. In the next chapters, the author of this work will go into the aims and strategies utilized to find solutions in greater depth.

2 Objectives and Methodology

2.1 Objectives

The major goal of this thesis is to examine the potential and prospects of using alternative energy sources in the Russian Federation. To achieve this goal, the following tasks must be completed:

1. Research a variety of basic theoretical concepts related to this issue.
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2.2 Methodology

The following thesis incorporates the quantitative approach which will primarily be based on deduction.

The literature part consists of a deep analysis of related scientific articles and the current status of renewable energy worldwide and especially in the country of interest, thus being the Russian Federation.

The practical part consists of a quantitative analysis of basic macroeconomic indicators, as well as the level of CO2 emission in the country with the help of a simultaneous econometric model. The following results will be correlated with the tendency of growing the basis of renewable sources of energy in the country.

3 Literature Review

3.1 Renewable Sources of Energy

3.1.1 Perspective and Types of RES

Renewable energy sources are those that are continually renewable owing to natural processes: Solar energy, wind energy, and water's hydrodynamic energy are all sources of energy. Soil, groundwater, rivers, reservoirs, and human sources of geothermal energy are all examples of geothermal energy. Biomass, biogas, and other organic waste-derived fuels are utilized to generate electric and thermal energy.

Renewable energy sources (RES) are energy sources whose stocks are regenerated naturally, mostly owing to the incoming flow of energy from solar radiation to the surface of the Earth and are essentially limitless in the foreseeable future (Famiglietti, 2014).

This includes solar energy and its derivatives such as wind energy, plant biomass energy, water flow energy, and so on. Renewable energy sources also include geothermal heat that rises from the Earth's bowels to the surface, low-grade heat from the environment that may be exploited, for example, using heat pumps, and some human life energy sources (thermal "waste" of the dwelling, organic industrial and agricultural waste, household waste, etc.).

Alternative energy sources Given their potential for application in many nations, the problem of creating renewable energy is becoming increasingly widely explored. By lowering pollutant emissions caused by the combustion of fossil fuels, renewable energy may considerably enhance the environment. Furthermore, there are chances to diversify energy sources in the energy mix, laying the groundwork for improved energy security. Renewable fuels successfully force traditional energy sources (oil, gas, coal) out of the market competition, according to recent research (Doukas, 2006).

Energy exporting countries must take this tendency into account. Furthermore, alternative energy enables the development of decentralized energy supply systems. According to some experts, it is more compatible with the needs of sustainable development than traditional energy sources. It is crucial to note that, in addition to government backing, several other variables influenced the increase of interest in renewable fuels. Two elements are critical: governmental efforts to assure energy security, and climate change. Climate change and the influence of this process on different countries' economic policies are frequently discussed in the literature.

The approval of treaties such as the Kyoto Protocol and the Paris Agreement sparked the implementation of renewable energy policy (He, 2021). The agreement obliged countries that had ratified the protocol to reduce or stabilize greenhouse gas emissions till 2012. The Paris Agreement is a follow-up to the Kyoto Protocol, requiring the regulation of carbon dioxide emissions into the atmosphere beginning in 2020, with the objective of keeping world average temperature below 2 degrees Celsius. Climate change is a worldwide problem that poses a strategic danger to 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. As a result, one of the primary incentive factors for the development of RES as a fundamental technique to reduce emissions is global warming (Bartolomeu, 2011). Tougher requirements for greenhouse gas emissions have a significant impact on large corporations' behavior strategies. As a result, in the face of shifting markets, investments in renewable energy sources are becoming one of the ways for oil and gas firms to diversify their holdings (Pincus, 2002). Several papers examine various elements of enterprises' tactics for increasing their RES position in inter-fuel competition (Grushevenko, 2018).

The following are some of the advantages of employing renewable energy sources (Maradin, 2021):

- Energy production has a lower environmental effect since it produces no new greenhouse gases and no waste (unless in the case of biomass incineration, which does not include hazardous compounds),
- RES are almost endless resources (globally) compared to finite primary resources
- RES is locally available; they do not need to be imported from elsewhere in the nation or from outside
- The limited installed capacity of renewable energy sources generates dispersion of power generation, which may improve supply security

- RES (and especially biomass) needs more labor than non-renewable resources (this fact can be classified as both positive and negative).

Alternative energy sources, on the other hand, have flaws and drawbacks, which are outlined below (Zachary, 2008):

- because of the undeveloped manufacture and intricacy of technology, RES has larger one- time and unit influence on price
- poor energy concentration in terms of energy collected per meter
- unreliable energy supply, as RES are dependent on natural conditions
- useful non-storability of the power generated, which is more noticeable in RES than in traditional energy sources due to their reliance on natural conditions.
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In addition, the potential of certain renewable energy sources, including their benefits and drawbacks, is investigated in the chosen nation (Russia). The wind speed in the afternoon is greater than at night throughout much of Russia's area, and these variations are less noticeable in the winter. In most parts of Russia, the yearly cycle of the average wind speed is negligible, ranging from 1 to 5 m/s, with an average of 3-4 m/s. Higher amplitudes may be found in the heart of Russia's European region, Eastern and Western Siberia, and the Far East, where they can exceed 4 m/s. Annual amplitudes of less than 2 m/s are seen across the southeast and southwest of the European section of Russia and over Central Siberia (Cherniavskih, 2019).

Specialists also will consider hydropower, which has enormous potential in this area. Hydropower is a type of energy that uses the energy of flowing water to generate electricity. Dams, tidal, and wave energy are the main sources of hydropower. Tidal and wave hydropower is the conversion of tidal energy and waves into other forms of energy. Small hydropower is a subclass of hydropower that includes generating energy from water resources and hydraulic systems using low-power hydropower installations. Tidal power plants are constructed along coastlines where water levels drop the greatest during high and low tides. When evaluating the economic benefits of constructing tidal power plants, it is important to remember that the marginal seas have the biggest swings in water level during tides. Many of these beaches are in sparsely inhabited areas, far from centers of commercial activity and large-scale electricity usage.

The most significant downside of tidal energy is its severe environmental effect. The tide height fluctuates in regions where major tidal power plants are being built, disrupting the water balance surrounding the station and having a severe detrimental impact on the flora and wildlife that live there (Lavrillier, 2013). The primary benefit of employing tidal energy is that tidal behavior can be anticipated quite precisely. As a result, tidal energy may be considered a reliable source of renewable energy. Furthermore, tidal energy is essentially unaffected by weather conditions (Neill, 2018).

The biggest tides in Russia may be found in the Sea of Okhotsk and the White Sea's Mezen Bay. Because the tides in the Baltic and Black Seas are barely measured in millimeters, building a tidal energy plant here is impossible. Tidal energy facilities are equivalent to river hydropower plants in terms of economic indicators, 2-3 times more lucrative than solar power plants, and 11% more cost-effective than nuclear power plants (Marchenko, 2015). Small hydropower facilities do not need complicated hydraulic systems, such as big reservoirs. Small hydropower plant innovations nowadays are distinguished by full automation, excellent dependability, and a long service life (Quaranta, 2020).

The water volume of rivers and the occurrence of major fluctuations in relief elevation are the key indications used to assess a region's hydropower potential. It indicates that while mountainous areas are the most ideal, the hydropower potential in this section of the nation is essentially untapped. Even with such a rare mix of good conditions – many rivers and mountains – the Caucasus area demonstrates this. Hydropower plant building can be an environmental issue — the middle and lower Volga Rivers, for example, have become a network of reservoirs. Separate ecosystems with particularly significant biodiversity are lost, and flora and fauna's typical life cycles are interrupted (Bukvareva, 2015). Potential of geothermal energy Geothermal energy is defined as the conversion of the energy of geothermal waters into other kinds of energy. Geothermal sources are almost limitless and provide a high level of predictability in terms of energy output.

Geothermal energy sources are classified into five categories by the International Energy Agency (Rybach, 2015):

- geothermal dry steam deposits
- geothermal wet steam sources (a mixture of hot water and steam)

- geothermal water deposits (contain hot water or steam and water)
- dry hot rock heated by magma
- magma (molten rock).

The temperature of water, steam, or its mixtures is used to classify low-temperature, medium- temperature (up to 125–145 °C), and high-temperature (over 145 °C) geothermal sources. The nature of the geothermal source's utilization is mostly determined by its temperature (Dickson, 2003). Geothermal energy has several advantages (Svalova, 2012):

- geothermal energy reserves are virtually limitless
- geothermal energy is extensively used
- geothermal energy does not require expensive pricing

Geothermal energy, on the other hand, has two big drawbacks:

- geothermal energy has a low concentration in its source
- steam includes dangerous gases, and water contains sulfur and other contaminants.

Geothermal energy is the most potential source of energy in Russia. The total reserves of this type of energy in Russia are estimated to reach 2,000 megawatts (MW). Geothermal energy has a 113 million TOE per year economic potential. Sakhalin, Kamchatka, and the Kuril Islands, the Krasnodar and Stavropol Territories, and the republics of Dagestan and Ingushetia have the highest potential for exploiting this alternate source. The regions of Omsk, Tyumen, Novosibirsk, and Tomsk might also be regarded potential for geothermal heat supply. Furthermore, the Kaliningrad region's geothermal resources, which include hot water deposits with temperatures up to 115 ° C, are of tremendous importance (Svalova, 2012). It should be mentioned that the primary geothermal sources in Russia are unproductive from an economic standpoint. Poor infrastructure, strong seismicity, low population, and rough terrain define Kamchatka, Sakhalin, and the Kuril Islands. However, a scheme for the development of geothermal energy supply in this region has already been designed and is now being executed, resulting in the yearly savings of around 900 thousand TOE (Arkhipov, 2014).

The Russian Federation possesses considerable reserves of each of these energy sources, according to an examination of the potential for employing alternative energy sources. Solar, wind, and geothermal energy are the most viable alternative energy sources for growth in the country's southern areas. However, these sources have severe flaws and drawbacks that prevent them from realizing their full potential. There are several criteria for the growth of alternative energy in Russia, due to the country's unique characteristics and vast regional variances.

3.1.2 Usage History

The usage of alternative energy sources (RES) has a lengthy history dating back to the dawn of time. However, as of late. Since then, there has been a huge surge in interest in renewable energy. Renewable energy production is considered as a solution to minimize the usage of fossil diesel and their related carbon dioxide emissions and other hazardous chemicals from an environmental standpoint. Increased use of renewable energy sources is considered as a solution in certain nations, with the strategic goal of reducing reliance on foreign fuel and energy supplies (FER).

From an economic standpoint, RES may be viewed as a method of boosting agricultural activity and creating extra jobs, as well as enhancing the dependability of delivering electricity to remote rural regions.

3.1.3 Modern Application

Renewable energy is currently expanding in all parts of the world: the capacity of renewable energy, mostly solar and wind energy (excluding hydropower), surpasses 11 GW in 18 nations and 2 GW in 46 countries. More than 92 nations have more than 1 GW of renewable capacity, and 28 countries have more than 9 GW, if hydropower is included. Nearly 160 million people in Africa and emerging Asia now have access to power because to off-grid solar photovoltaic installations. Supportive policies and regulatory frameworks are crucial for the continuous expansion of renewable energy consumption, since they create an enabling environment for markets and the renewable energy industry, as well as a fair playing field that encourages growth. Increases in the percentage of renewable energy in power generation have been aided by large-scale governmental commitment. In 2018, 140 nations used renewable energy regulatory measures in the electrical sector (such as feed-in tariffs or utility quotas), up from 74 countries in 2010.

A strategic vision, investment in research and development, and an industrial plan have all helped to lower the worldwide cost of renewable energy technology and attract private sector funding in several nations. Renewable energy technology, as well as successful integrated policies and commercial models, have expanded over the world, building on the success of pioneering nations. Renewable energy's increasing use throughout the world has disproved misunderstandings about its inability to fulfill global energy demands. Renewable energy technologies have shown to be dependable and, in many cases, are the most cost-effective power generating solutions. Renewable energy generating plants may also be effectively incorporated into the electricity grid. In 2018, at least nine nations with variable power generation generated more than 20% of their electricity from renewable energy sources (wind and solar energy) (Sepuldeva, 2018).

3.2 Experience of Other Countries in Alternative Energy

3.2.1 Background

Foreign nations' experience in alternative energy development Following the 1972 and 1980 oil crises, there has been a surge in global interest in the development of renewable energy and RES. The price of oil quadrupled in 1974, and Western countries, having grasped the root reasons of the issue, initiated research into alternate energy sources. Their strategic objective was to secure the security of the country's energy supply. The only clear limiting feature of study was the natural and climatic circumstances of distinct locations (Matzarakis, 1997). Scientists worked on a variety of alternative sources. RES is a fast-growing business all around the world. Renewable energy usage is expected to account for 13% of global energy consumption by 2041 (Ahmad, 2020). Renewable energy, on the other hand, cannot exist without government backing. The great majority of states that have had success with renewable energy production have used certain types of government aid.

Many authors emphasize the important, and sometimes critical, role of government support in this area. It should be emphasized that nations like Germany, China, and the United States have the most active renewable energy development policies. Much emphasis is dedicated to topics of measuring the efficacy of governmental support for RES in current research devoted to the difficulties of alternative energy development. This concentration of labor is not by chance. State policies promoting RES have been in place in several nations for many years. Significant experience enables evaluation of the efficacy of various regulatory methods. Lyon and Yin examine the evolution of different energy in the United States, as well as the political and economic variables that drive states to implement alternative energy legislation. Lyon and Yin also examine the quality criteria for renewable energy investments (renewable portfolio standards or RPS). Lyon and Yin concluded that states with high unemployment are less likely to adopt RPS, and that environmental factors have no bearing on decision-making. As a result, the authors conclude that political view is dominant (Lyon, 2010). Chandler has also investigated why the US is putting in RPS. An examination of the data from 1996 to 2009 revealed that state ideology and raw material availability are major determinants in state decisions concerning the establishment of state assistance systems (Shneider, 2016). The unemployment rate and the amount of concentration of the electricity market play a significant effect in the growth of renewable energy in the United States (Bayulgen, 2019). A lot of articles look at the variables that encourage the growth of renewable energy in different parts of the world. Petitioning for conventional energy sources and CO2 emission limitations are thus the key issues limiting RES expansion in European countries. The European Union's focus on lowering energy reliance, on the other hand, has a favorable impact on the development of renewable energy sources (Belkin, 2008).

The economics of investing in renewable technologies, as well as the technological and organizational variables that assure the rise of alternative energy competitiveness, are all given a lot of thought. Solar panels, wind turbines, and biofuels have all seen significant improvements in efficiency and availability (Collet, 2014). It permits these innovations to continue to develop and eventually become profitable. The author also underlines the need of developing production bases for the growth of the energy complex, as well as the significance of clusters in alternative energy development in EU nations (Chiciudean, 2018). According to the Renewables 2019 Global Status Report, RES met around 17 percent of global energy demands in 2018, and roughly 24% of power was renewable in 2017. Furthermore, there has been a huge growth in energy generation from other sources in the recent decade. For example, the percentage of renewable energy generated in the European Union climbed from 13% to 22% between 2003 and 2017 (Hafner, 2020).

3.2.2 Presence in Developing Countries

The rate of expansion of solar and wind power plants and the declining cost of solar and wind power surprises even optimistic industry players and outside analysts. Ahead of all forecasts and contrary to the prevailing negative perceptions, solar power plants and wind turbines began to successfully compete with traditional energy sources in the world's largest markets, even without the use of subsidies. Wind and solar power plants have already reached price parity and have almost achieved performance parity with conventional energy sources. In many countries around the world, the unsubsidized levelized cost of electricity (LCOE) generated by ground-based wind turbines and solar power plants has equaled or fallen below the cost of energy generated by most other technologies. Some sources of energy supply, such as combined cycle power plants, are more adaptable to the load schedule of the power system.

However, the growing availability of batteries and other innovations is helping to reduce the volatility of wind and solar power generation, which increases the reliability of renewable energy needed to compete with traditional sources. In terms of price, onshore wind turbines have already become the cheapest source of electricity in the world. The unsubsidized levelized cost of wind and solar energy is $25-55 per megawatt-hour (MWh), which is below the price range for the cheapest fossil fuel, natural gas ($40-80 per MWh). By the end of 2017, onshore wind capacity had more than doubled from the 216 gigawatts (GW) recorded in 2011. With the help of ground-based wind turbines, about 490 GW of energy was produced in 120 countries of the world. The leaders were China, USA, Germany, India, Spain, France, Brazil, Great Britain and Canada. At the same time, in these nine countries, price parity with traditional energy sources has been achieved for land-based wind turbines. In the United States, the cost of wind power is lowest in regions prone to strong winds, such as the Great Plains and Texas, and the highest in the northeast of the country.

Globally, the lowest prices are recorded in the top nine countries listed above, as well as in Eurasia and Australia. In terms of efficiency, large photovoltaic solar power plants are only slightly inferior to wind turbines, taking second place. In particular, the upper end of the levelized electricity cost range for large PV PV ($40-56/MWh) is lower than for any other energy source. In 2017, a record 92.9 GW of solar power capacity was commissioned in 188 countries worldwide, more than the total global capacity as of 2012 (67 GW). As a result, the global figure was 391 GW. The leaders in this direction are China, Japan, Germany, USA, Italy, India and Great Britain (Sahu, 2015).

In all these markets, with the exception of Japan, solar energy has reached price parity with energy from conventional sources. In Japan, the cost of solar energy is one of the highest in the world, mainly due to high capital costs. In Japan, price parity for solar energy is expected to be reached between 2024 and 2032 as the country moves towards competitive energy auctions. In the US, the lowest electricity costs are found in the Southwestern states and California. Globally, electricity costs are lowest in Australia and highest due to high investment costs in Africa. In addition to these leading countries, the price parity of solar and wind energy with energy from traditional sources will also soon be achieved in other countries of the world, as the price gap between these and other sources is constantly increasing. Over the past eight years, the levels of the levelized cost of electricity from conventional sources of all types (excluding combined cycle power plants) and stable renewable sources have remained unchanged (for example, for biofuels and coal) or increased (for example, for geothermal plants, hydroelectric power plants and nuclear power plants), while the levelized cost of electricity for ground-based wind turbines and large photovoltaic solar power plants decreased by 65% and 88%, respectively, due to a sharp decrease in the cost of components, which in turn led to an increase in efficiency. Both trends are expected to continue in the future. According to Bloomberg New Energy Finance, generation costs for onshore wind turbines and photovoltaic solar power plants have already fallen by 19% in the first half of 2018. In Europe, Japan and China, one of the main incentives to reduce the cost of energy is competitive energy auctions, which help to reduce the cost of introducing renewable energy sources without resorting to subsidies (Johnstone, 2010). Modernization and technical re- equipment of wind turbines in developed countries also lead to a decrease in the average global cost of wind energy by increasing the power factor. Energy costs may also come down in emerging markets, as global developers and international organizations are already coming together to work together on various projects. Such partnerships help resolve the problem of energy imbalances. In Japan, Germany and the UK there is a shortage of solar resources, but these countries are world leaders in the field of solar energy. At the same time, Africa and South

America have the largest amount of solar and wind resources, but a significant part of these resources is still not used.

As solar and wind capacity grows, many conventional sources will exhibit lower IFC, resulting in higher levelized cost for both existing and new conventional power plants. Ultimately, the cost of new SPPs and wind turbines can be lower than not only the cost of new traditional power plants, but also the cost of further operation of existing traditional power plants around the world. For example, last year Enel won a tender to build a complex of wind, solar and geothermal power plants in Chile that would sell electricity at a price less than the price of fossil fuels used in already operating coal and gas combined heat and power plants.

Massive SPPs and wind turbines with power storage are more competitive, approaching price and performance equality with traditional power plants. Energy storage makes it easier to control solar and wind energy, dispelling long-held beliefs about the advantages of conventional energy sources. Although renewable energy is more expensive to create and maintain, alternative sources can give high performance as well as the capacity to supply networked system functions, increasing their value. Regulatory and commercial structures impact how viable the monetization of extra benefits is.

Although if system services cannot be applied, the RES-facility plus storage approach is more advantageous because it can help utilities better meet their own needs and shift energy usage from the centralized grid to the period of the power system's minimum load when energy costs are lower. The utilization of renewable energy sources in conjunction with energy storage also allows for comparable prices with traditional sources. Indeed, the price of lithium-ion batteries has dropped by about 80% since 2010, while solar panels have grown increasingly common. Large solar power plants with energy storage are being built in all the world's key markets for solar energy. PV + storage solutions are already sufficiently competitive in selected US regions.

Solar projects with electricity storage will arrive in the United States as early as next year, providing an equivalent alternative for traditional sources due to the potential of earning an investment tax credit. This will begin in Arizona, followed by Nevada and Colorado, where "wind turbine plus storage" initiatives will be implemented to assure grid parity. The RES + storage technique may be integrated with distributed energy resources and demand management, according to a recent RMI research. This will aid in the creation of "clean energy portfolios" that can deliver the same system services at a cheaper cost than building or managing a new gas-fired power plant today (by 2027) (Dyson, 2021).

Large alternative power plants have not been the only ones to attain grid parity. Small, scattered power sources, such as rooftop solar collectors, are also on the verge of attaining price- performance parity with centralized power networks. When it becomes cheaper to create energy on your own rather than pay the energy company's bills, price parity is reached in the case of distributed power generation. Commercial photovoltaic solar plants are already demonstrating grid parity with traditional power plants in all the world's main solar energy markets that have previously reached grid parity (except for India). Incentives, such as a tax credit or the ability for energy providers to account for the energy that consumers create using renewable energy (net metering), have been introduced by such markets.

Installing battery-powered solar panels is already less expensive than buying electricity from a utility provider in 20 US states. The same can be stated for many places in Australia and Germany, where 42 percent and 55 percent of residential solar panels installed in 2017 featured power storage, respectively. The amount of domestic and commercial photovoltaic panels installed on building rooftops in Australia and Europe surpasses the number of big SPPs. This suggests that, if network parity is achieved, market growth will be controlled by competition between autonomous distributed solar panels and centralized solar power plants with energy storage.

3.3 Development of Alternative Energy in Russia

Government policy The Soviet Union's stance on the use of alternate and RES was detrimental. As oil prices rose in the 1970s, the Soviet Union greatly boosted its supply, and its attitude on alternative energy development differed from that of the West. At the same time, the Soviet Union did not deny the importance of research and development in the field of renewable energy sources. In truth, the policy's priority switched to oil, gas, and nuclear power. The USSR Energy Program, which was meant to last 20 years, was enacted in 1983 (Pryde, 1991). It was divided into two ten- year periods.

At initially, it was intended to compel the exploitation of traditional energy sources such as oil, gas, and nuclear power. The first stage's goal was to provide a steady supply of energy to the USSR's national economy. The program's second stage included the development of RES, regulated fusion energy, and nuclear power. The second stage's goal was to save energy through the creation of new energy generation technologies. The USSR Energy Program, however, was not realized owing to socioeconomic developments in the Soviet state (Eshchanov, 2011).

By the 2000s, Russian researchers around alternative energy had all but ceased. The realization that prospective energy demand, and hence new means of providing it, will only rise did not, however, fully deter Russian "alternative" energy initiatives. The rise in oil prices benefited the Russian oil and gas business, but it made developing alternate energy in the country more challenging. The Russian Federation has been continuously striving to produce the appropriate bill governing ties in the sphere of RES production and usage since 1997 (Etzkowitz, 2000). Laws, on the other hand, only indirectly control this domain to this day. According to the report of the RES Committee at the 9th international conference "Renewable and Small Energy 2012," the State

Government produced and enacted a draft legislation "On state policy in the field of non-traditional

RES" in 1998, which was approved by the Federation Council. However, the Russian Federation's President Boris Yeltsin's administration rejected it in 1999 for strictly legal reasons, and the law was vetoed (Vand, 2000). This legislation defines renewable energy, creates state authorities' powers in the sphere of RES regulation and support, and specifies procedures for regulatory oversight of RES use:

1. mandatory repayment by network companies of failures of electrical power in networks, primarily due to energy produced at qualified generating facilities based on RES,
2. provision of subsidies from the federal budget to compensate for the technological connection cost of generating facilities based on RES with a capacity of up to 23 MW and recognized by qualified facilities

3. the addition of a premium to the wholesale market's equilibrium price for electricity generated using renewable energy sources, and
4. the implementation of further support for the use of renewable energy sources in compliance with Russian Federation budget legislation.

Based on the Decree of the Government of the Russian Federation on energy efficiency, the goals and principles for using renewable energy sources, as well as target indicators for the volume of electricity generated and consumed by RES, as well as ways to meet these goals (Bertoldi, 2006). Until 2035, the principal strategy for the positioning of electric power industry items. This scheme includes a projection of the potential growth of power plants based on alternative sources of energy, as well as suggestions for the commissioning of RES-based facility producing capabilities up to 2035. (Chuang, 2019).

The method for applying the system for assisting renewable energy in retail markets in the pricing and non-price areas of the wholesale market, as well as in physically isolated energy locations, is defined by the government of the Russian Federation (Stepanova, 2020). The mechanism for establishing long-term tariff control of renewable energy producing facilities in retail markets, as well as the requirements for their operation, are outlined in this decision. The Federal Antimonopoly Service of Russia authorized systematic guidance for price setting and price limits for electric energy produced on the RES basis by competent configuration and acquired to recompense for losses in electric networks (Viral, 2015).

Furthermore, Russia's Energy Strategy for the period up to 2030 is now in effect. It calls for the use of alternative energy in all areas of government, as well as the conditional separation of some political and economic activities. Among them, it is hoped that by 2030, the Russian economy will have reduced its reliance on the energy sector because of the rapid growth of creative low-energy sectors of the economy and the fulfillment of technical potential for energy savings. According to the Energy Strategy, non-fuel energy will be increased from 10 to 12-13 percent, and new forms of energy and energy technologies will be created and developed (Energetics, 2009). Despite some rules and goals, Russia's policy and economy are still heavily dependent on oil and gas. One of the reasons for the RES's restricted growth in Russia is a lack of suitable firm finance (Bruton, 2002).

It was also included in the study "On the Status and Prospects of the Development of the Electric Power Industry in the Russian Federation" by Russian Federation Minister of Energy A. Novak.

Although there are legal businesses in the Russian Federation whose operations are related to energy provided by alternative sources, most of them work solely for export owing to a lack of money. As a result, the RusHydro organization, to whom the Russian Federation's government has delegated the task of creating all renewable energy, does not currently have the funding to conduct renewable power projects (RUSHYDRO, 2013). Aside from the aforementioned, there is also the so-called "oil lobby," which has carved itself a place in the Russian national legislature. Oil firms play a significant influence in the legislative process, particularly when the government makes choices. It should be highlighted that there is no regulatory system governing the regulation of RES at the regional level. Alternative energy sources are more cost-effective than traditional energy sources in many areas.

According to research by Kaplun, in many circumstances, RES-based energy is more lucrative than traditional energy in Russia's Far East today. Despite this, the regions do not seek complete regulation or regional assistance for the area under consideration to the attractive possibilities for the use of "green" energy (Bashmakov, 2009).

Bioenergy

Bioenergy constitutes only a small part of the used energy resources of Russia. In 2020, the bioenergy capacity was 1,365 MW.

Wood

Among renewable resources, wood is the most often used. This is largely for house heating, cooking, and water heating in undeveloped agricultural regions where there is little connection to mains natural gas, coal transportation is rather expensive, and forest reserves are substantial. The Northern Caucasus, Altai Territory, and the middle of Europe have the highest production, indicating that effective energy forest farming is viable. One of the most promising fields for the growth of wood utilization is hydrolysis technology.

Peat

Only until 1990s, the peat sector was a major player in the fuel energy business, with yearly output reaching 85 million tons in the mid-1970s. mostly fuel raw materials; peat output in the mid-2000s did not reach 4.8 million tons per year. The biggest deposits are centered in Western Siberia and the north-west of Europe, with about 155 billion tons of explored peat reserves (41 percent moisture). Up to 1 billion m3 of peat is created yearly. Peat deposits have a higher concentration of resources, but they are typically much harder to obtain than forest deposits.

Biogas

In the Belgorod region, there are two biogas power plants: Luchki (installed capacity 3.5 MW, annual output 30 million kWh of electricity and 28 thousand Gcal of heat) and Baitsury (installed capacity 3.5 MW, annual output 30 million kWh of electricity and 28 thousand Gcal of heat) (capacity 0.6 MW, annual output 7.5 million kWh of electricity and 3.3 thousand Gcal of heat). They're biogas-fueled gas piston power plants that run on agricultural waste. The station generates 90 thousand and 19 thousand tons of organic fertilizers each year, in addition to energy and heat (Rybach, 2015).

Geothermal energy

All of Russia's geothermal power stations are situated in Kamchatka and the Kurile Islands. The Mutnovskaya GeoPP in Kamchatka is the country's largest geothermal station. It has an installed capacity of 52 MW and a design capacity of 81 MW. Western Siberia, the North Caucasus, Kamchatka, and the Kuril Islands are all financially viable locations for geothermal installations; the entire power potential of Kamchatka's steam-water therms is estimated to be 1 GW of running electric power.

In 2006, 55 thermal water resources in Russia have been investigated, with a flow rate reaching 300 thousand m3/day. Paratunskoye (Kamchatka), Kazminskoye and Cherkesskoye (Karachay- Cherkessia and Stavropol Territory), Kizlyarskoye and Makhachkalinskoye (Dagestan), Mostovskoye and Voznesenskoye (Karachay-Cherkessia and Stavropol Territory), Mostovskoye and Voznesenskoye (Krasnodar Territory).

According to existing data, there is a 3 million m2 subterranean sea in Western Siberia with water temperatures of 71-94 ° C.

The capacity factor for direct use of heat was over 310 MW at the end of 2005. The Russian thermal potential was achieved in 2009 with an installed capacity of little over 82 MW and yearly output of roughly 451 million kWh. The geothermal power capacity for 2020 was 72 MW.

Wind power

Wind energy's technological potential in Russia is projected to be around 52 trillion kWh/year. The economic potential is estimated to be over 260 billion kWh/year, or almost 31% of total electricity output in Russia. The shores of the seas and the islands of the Arctic Ocean are promising places for the building of wind turbines in Russia.

The relative availability of natural gas, which diminishes interest in wind generating, has impeded the development of large-scale wind energy in the nation. Wind farms, on the other hand, can successfully supplement the current system in isolated places where there is no gas supply or connection to the energy grid, like as Kolyma or specific areas of Kamchatka, where movable hydropower is used.

As of 2018, the installed capacity of functioning wind farms in the nation is around 134 MW, with a total production of less than 200 million kWh per year. The following (for 2020) have the most capacity: Ulyanovsk wind farm (150 MW), Adygeiskaya wind farm (150 MW) (35 MW, Ulyanovsk region) (Kumpula, 2011).

Crimea (see Alternative Energy of Crimea), Ulyanovsk Region (Ulyanovskaya WPP), Kamchatka Territory, Chukotka Autonomous Okrug (Anadyr WPP), and Bashkiria have the largest functioning wind farms (Tyupkilda WPP). Wind power capacity was 942 MW in 2020 (71).

Solar energy

The Perovo SPP, with a capacity of 105.2 MW, is the biggest solar power plant in Russia as of 2020, and it is located in Crimea. The Samara SPP (Samara Region) has a capacity of 75 MW, the Nikolaevka SPP (Crimea) has a capacity of 69.8 MW, the Akhtubinskaya SPP (Astrakhan Region) has a capacity of 60 MW, and the Funtovskaya SPP (Astrakhan Region) has a capacity of 61 MW.

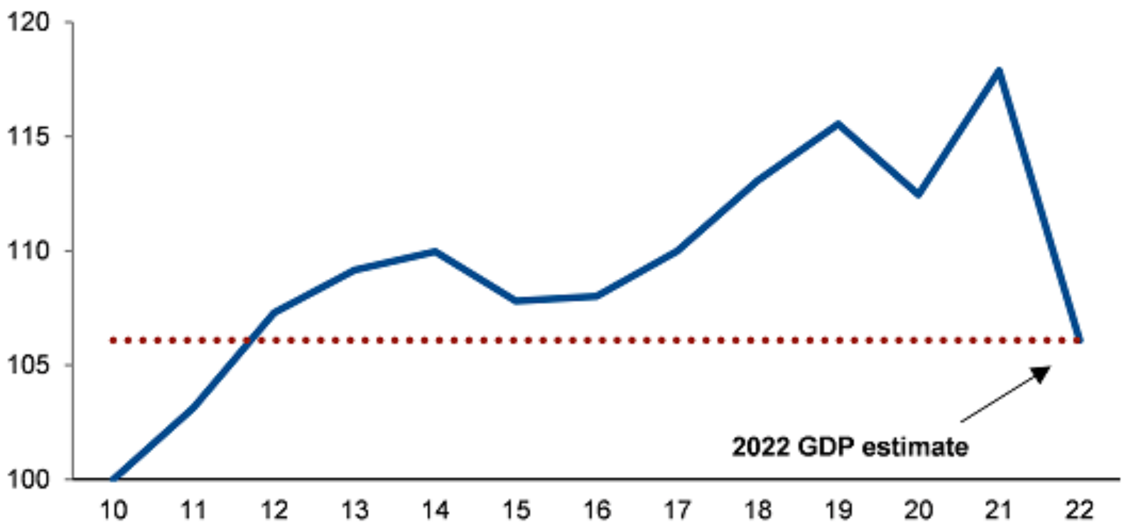
Bashkiria (Buribaevskaya, Bugulchanskaya, Isyangulovskaya SES), the Orenburg area, and the Altai Republic have the greatest solar power facilities. Solar energy capacity was 1,450 MW in 2020 (Mingaleva, 2006).

3.4 Economic Domain of Russia

3.4.1 GDP

The Russian Federation's gross domestic product (abbreviated GDP) is a macroeconomic indicator that reflects the market value of all final goods and services (i.e., goods and services intended for direct consumption) produced annually in all sectors of the Russian economy for consumption, export, and accumulation, regardless of the nationality of the factors of production used.

Figure 1, GDP development in time



Source: Dyson, 2021

3.4.2 Other Macroeconomic Indicators

Macroeconomic, technological, and social factors of both national and global character, as well as the Russian Federation's and Bank of Russia's economic policies, which were largely shaped by the pandemic coronavirus, had a significant impact on the development of the Russian financial market in 2018–2022. The Russian financial market created or exacerbated patterns that would primarily define its evolution in the next years during this time. Accelerated digitization and ecosystem transformation, as well as increased public participation in the capital market, are among them. Furthermore, while the widespread integration of digital technologies into financial market processes and products, as well as the creation of ecosystems and the entrance of big tech companies into the financial sector, are mainly national trends, the huge surge of financing from millions of extra private clients into the capital market and banks' active participation in ecosystem creation are trends that have become particularly apparent in Russia (Kumpula, 2011).

The Russian financial market demonstrated its endurance during the financial downturn caused by the coronavirus epidemic, as well as its capacity to sustain the economy and act as a channel for state anti-crisis efforts. This was primarily made feasible by the Bank of Russia's strategy of cleaning up the financial system of weak and unethical actors in past years, as well as enhancing the robustness of financial institutions to various types of shocks.

In the face of a considerable worsening in economic circumstances, the finance system played a critical role in ensuring the transfer of the Bank of Russia's monetary easing in 2020. At the same time, the banking industry increased by 7.2 percent in real terms in 2020, minimizing the magnitude of the GDP fall. In 2020, the financial sector's contribution to gross value added by areas of the economy climbed to 4.8 percent (from 4.2 percent in the previous two years) (Tabata, 2021). Measures of government assistance for the economy had an impact on the dynamics of certain parts of the financial market, along with a significant increase in lending rates lending to SMEs and non-financial companies in general. To prevent the emergence of "bubbles" in the real estate, consumer, and mortgage lending markets, it is critical to preserve the sustainability of the real and financial sectors as the economy normalizes.

After surviving the crisis, one of the important topics on the present global economic priority for central bankers in most nations is to achieve balanced development. The characteristics of financial markets, as well as the unpredictability and direction of foreign investment, will have a significant impact on how well this mission is completed. The ultra-loose monetary policy implemented in previous years and reinforced in the aftermath of the pandemic, and large-scale budgetary incentives implemented in most countries during this time, resulted in a significant increase in risk appetite among investors (in search of profit), aided the development of the private investment market, and created a considerable rise in asset values in the global financial market.

The slow phase-out of support measures in the future may disclose new problems in the government and industry, including those connected to debt burdens, particularly in emerging countries. This has the potential to have a profound impact on the dynamics and growth of financial markets. This macroeconomic backdrop must be considered to maintain the Russian financial market's systemic stability. The rising importance of the development agenda and its integration in economic policy is another worldwide trend that has been expanding in recent years and will continue to have an increasingly major influence on the global financial system.

Many countries have stated their commitment to sustainable development goals and have chosen the "carbon neutral" route. Sustainable development involves the notion of responsible financing, or the consideration of environmental, social, and governance (ESG) issues by investors when making an investment decision, which is starting to have a considerable influence on global capital flows redistribution. Integration of Russia into the sustainable future is becoming a more essential component in the growth of the Russian economy and local financial market, as well as a need for attracting finance. This necessitates a proper regulatory environment modification as well as the establishment of the requisite infrastructure, both of which must be acknowledged at the global level.

The fast adoption of technical advancements in the financial industry has been the most significant trend in recent years, determining the sector's growth both in Russia and throughout the world. The digitalization and the creation of platform solutions has resulted in fundamental shifts in the precepts of financing and the communication of businesses with clients, other financial market participants, and regulators, as well as an increase in transaction volume and speed. Because of the emergence of digital technology, financial goods and services are now more widely available, both regionally and in terms of fee levels. At the same time, digitization necessitates adequate security of customers, suppliers, and financial market infrastructures from cyber-attacks, fraud, and therefore social engineering, as well as a particular degree of citizen digital awareness and abilities. Furthermore, the implementation of new financial innovation that are governed by FATF rules necessitates a preliminary evaluation of money laundering and terrorism financing concerns (Nanyun, 2020).

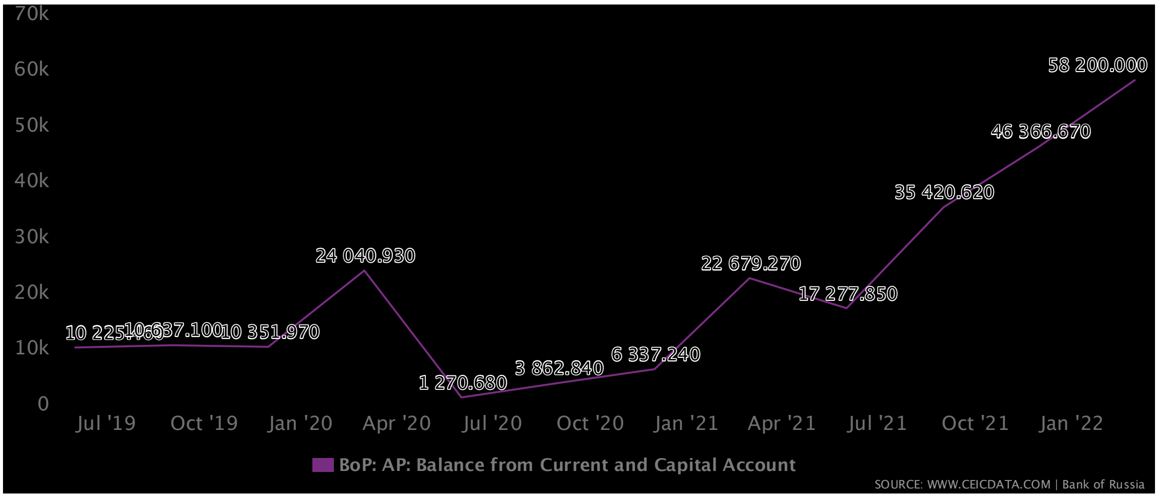
Consumer behaviors in the financial sector have altered as a result of the developing stage of platform solutions that enable remote access to a wide variety of financial products "in one click." Simultaneously, the adoption of information technology and remote sales channels is gradually altering the chain of interaction between financial service providers and consumers, removing from them, as unneeded, some of the functions that providers previously performed, resulting in disintermediation. Indicators of the key areas of the financial market indicated a favorable trend in 2019-2020. Financial institutions' assets increased by 24.9 percent in absolute terms (to 135.9 trillion rubles) and in proportion to GDP during the last two years (from 106.1 to 128.2 percent). The assets of financial institutions continued to expand in 2021, reaching 154.2 trillion rubles in the third quarter, up 12.7 percent from the beginning of the year.

Figure 2, recent development of the inflation rate

Source: Statista, 2022

As it becomes obvious after looking at the chart, the inflation seems to be a growing problem in Russia which is a sign of a relative economic distress of the country. In addition to this, the author also takes a look at the development of the balance of payments of Russia.

Figure 3, balance of payments account in Russia



Source: CEIC, 2022

Yet, the balance of payment account seems to be increasing, which is a primary consequence of the depreciating domestic currency.

3.5 Energy in Russia

3.5.1 Thermal

The energy industry of Russia is an area of the national economy, science and technology of the Russian Federation, covering energy resources, production, transmission, transformation, accumulation, distribution and consumption of various types of energy. In terms of total reserves of primary energy carriers, according to estimates, Russia ranks second in the world after the United States of America.

In 2017 the final consumption of fuel and energy resources amounted to 640.0 million tons of oil equivalent, of which coal, coke and peat accounted for 4.4%, liquid fuels - 18.3%, gaseous fuels - 21, 9%, electricity - 35.1%, heat - 17.9% and biomass and waste - 0.8%.

In 2017, 1047.3 billion kWh of electricity was produced in Russia, of which 195.1 (17.84%) were generated by nuclear power plants, 179.10 (17.55%) by hydroelectric power plants, 615 by thermal power plants, 34 (65.31%) (Vasileva, 2015).

The decisive role in the energy complex belongs to the electric power industry, the development of which determines the level of scientific and technological progress, the quality of life of the population. The outstripping pace of the electric power industry is a necessary condition for the development of the economic model. The basic concept in the electric power industry is the installed capacity of power plants (hereinafter, the term “capacity” may be used for brevity).

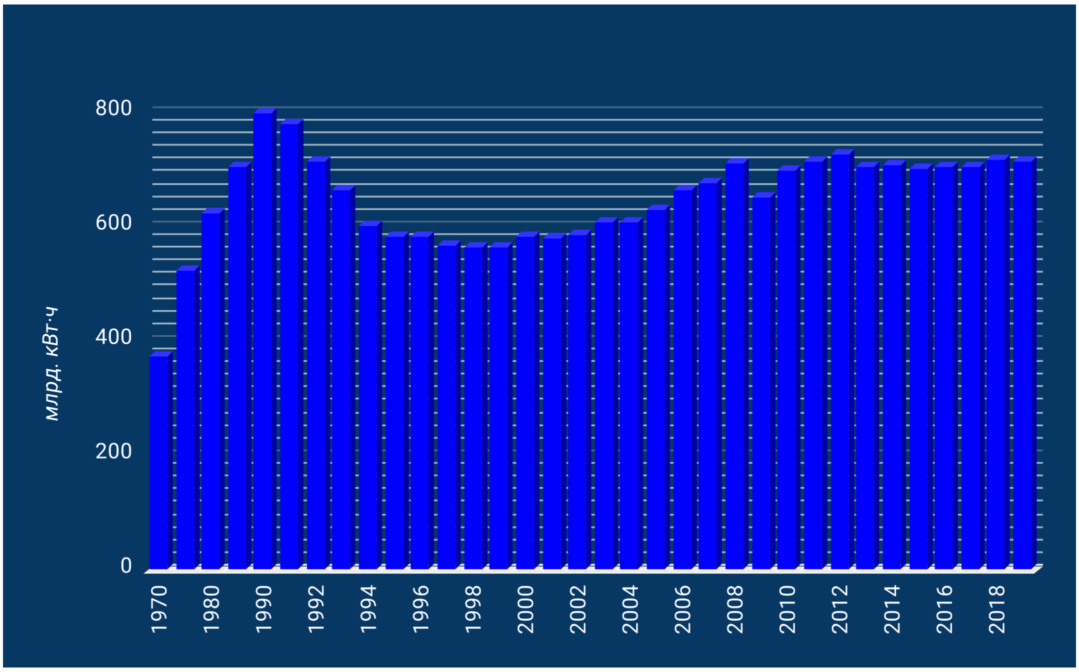
Period 1990-2020 characterized by a significant decrease in the integral criterion for the efficiency of the operation of Russian power plants - the number of hours of use of installed capacity, as well as the final consumption of electrical energy, and in industry and agriculture.

At the same time, there is a significant increase in prices for electrical and thermal energy.

Thermal power design is an area of energy science that deals with the production, use, and transformation of heat into other kinds of energy.

At the end of 2019, thermal power plants (TPPs) account for 69.5% of generation capacity and 63.8% of energy output in Russia. Steam turbines account for 77% of generation capacity of TPPs by tech, 15 percent for combined phase turbines, 5.1 percent for power plants, and 0.9 percent for others, according to the aforementioned information from the SO UES of Russia in the UES of Russia (Chukreyev, 2020).

Figure 4, thermal energy in Russia in billion kWh



Source: Chukreyev, 2020

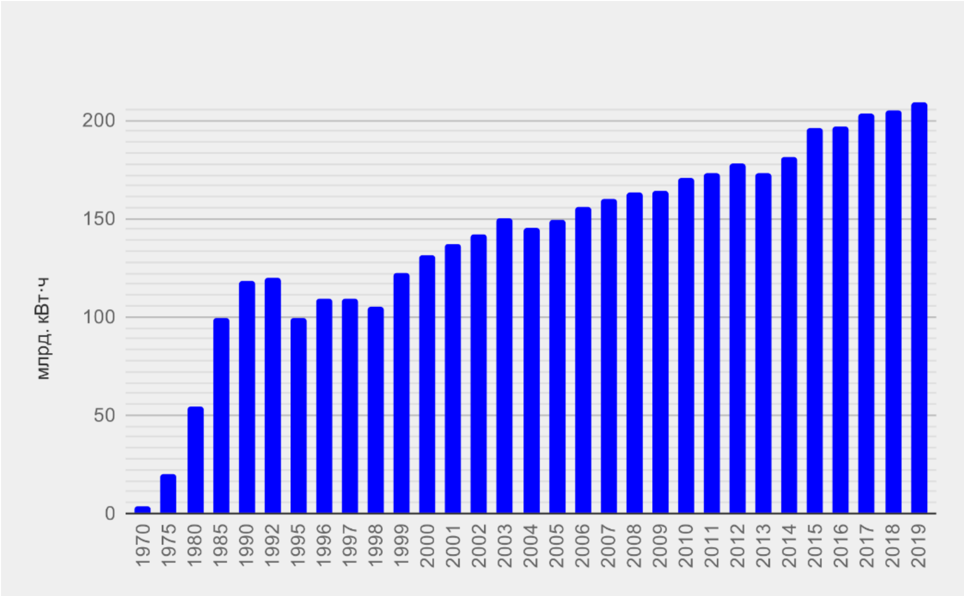
3.5.2 Nuclear

Nuclear energy is a form of energy that generates heat and electricity by using nuclear power. On January 1, 1951, the world's first nuclear power station was built in Obninsk, Kaluga Region, Russia, marking the official beginnings of nuclear energy in the world and in Russia.

As of January 1, 2021, the overall installed total capacity of operational nuclear power plants within the former USSR's boundaries, including the Baltic nations, is 30,482 MW, or 66.5 percent

of total generation capacity of reactors of running nuclear power plants within the former USSR's borders.

Figure 5, dynamics of gross electricity production at Russian nuclear power plants



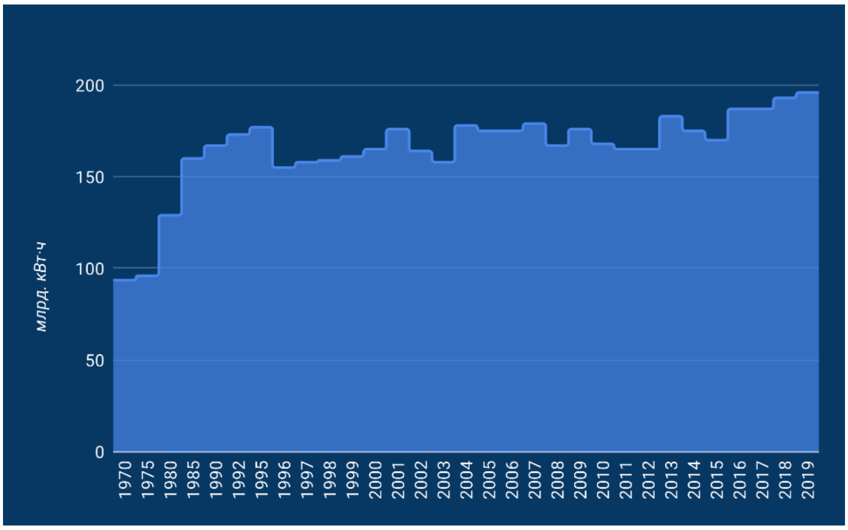
Source: Rosstat, 2020

By the beginning of 2019, nuclear power plants in Russia stood for 11.2 percent of installed capacity and 18.7 percent of energy output in the country. The related graphs depict the dynamics of nuclear power plant installed ability and electricity production-gross from 1970 to 2020.

3.5.3 Hydro

Hydropower is a type of energy that involves harnessing the mechanical power of water assets to produce electricity.

Figure 6, Gross electricity generation dynamics of Russian HPPs



Source: Maradin, 2021

Russia's hydropower potential (as of the end of 2008) was: gross theoretical hydropower potential — 2293 TWh/year; technically available hydropower potential — 1674 TWh/year economically available hydropower potential — 851 TWh/year.

Hydroelectric power plants accounted for 18.9 percent of installed capacity and 17.6 percent of energy output in Russia as of the end of 2019. Based on gross energy output at HPPs in 2019, the total technical hydropower capacity is used 11.4 percent of the time.

The related graphs depict the dynamics of hydro power plant gross installed capacity and gross electricity generation from 1970 to 2020. Hydropower capacity is expected to reach 51,790 MW by 2020 (Mingaleva, 2006).

3.6 Natural Resources

The oil and gas sector, which formed the foundation of Russia's fuel energy industry in the 1990s, was vigorously privatized. On a variety of reasons, the sector's most profitable assets were transferred to private ownership. By the end of 1997, the state held nearly as many businesses as the private sector, although these businesses were neither the largest nor of the highest quality.

With the surge in oil costs, the government attempted to reverse the trend. In 2002, the country's government took steps to bankrupt one of the country's major oil corporations, Yukos, and sell off its assets, which were primarily purchased by the state-owned Rosneft. In addition, Gazprom, a state-owned corporation, purchased Sibneft, a smaller private asset, in the summer of 2005. As a consequence, from 2004 to 2007, the government raised its share in the market from 16.36% to 40.64%. TNK-assets BP's have been under the management of Rosneft since 2013 (Alekseenko, 2020).

The exploitation of important gas resources in Western Siberia (Urengoyskoye, Yamburgskoye, Zapolyarnoye, and, in the future, Bovanenkovskoye) remained the primary source of fuel and, in general, domestic energy in the 2010s. In 2005, gas output was at 585 billion m3, while domestic consumption was 390 billion m3, accounting for more than half of the country's total energy consumption. Natural gas reserves are expected to be 47.79 trillion m3 in 2005, with annual exports of 188 billion m3. Gas storage facilities, including the Kasimovskoye UGSF, Europe's biggest, with a working volume of 8.6 billion m3, are utilized to assure the dependability of supplies in addition to the most major domestic pipelines "Central Asia - Center," "Northern Lights," and "Caucasus - Center." There are around 218 CNG filling pump stations in the network. Gazprom, a state-owned joint-stock enterprise, is the world's largest gas producer and transporter (Liuhto, 2008).

The oil industry, which provided domestic use of around 111 million tons of oil and natural gas condensate in 2005, accounting for nearly 20% of total energy consumption, is the second most significant sub-sector for domestic energy.

Samotlorskoye, Priobskoye, Russkoye, and Romashkinskoye are the greatest oil fields. Liquid hydrocarbon reserves are expected to be no less than 9.6 billion tons in 2007, with annual exports of 335 million tons. State-owned Rosneft and Gazprom Neft are the main oil firms in Russia; private enterprises include Lukoil, Surgutneftegaz, and Tatneft. The state-owned firm Transneft, which runs oil trunk pipelines, controls the majority of liquid hydrocarbon transportation. Transnefteprodukt, a state-owned corporation that was once distinct but is now part of Transneft, controls a major oil product pipeline network (Marchenko, 2015).

The coal sector, which supplied roughly 17 percent of the demand for fuel in 2005, with around 148 million tons of fuel coal, plays a little lesser role. In 2006, the country's known and produced coal reserves totaled at 156 billion tons, with annual exports of 82 million tons. The reserves of Kuzbass and the resources of the Kansk-Achinsk coal basin are the biggest thermal coal resources under exploitation (Berezovskoye, Borodino, Nazarovskoye). SUEK, Kuzbassrazrezugol, Yuzhkuzbassugol, and Yuzhny Kuzbass are the major coal mining businesses (Arkhipov, 2014).

Oil shale deposits are abundant in the nation. Around 35.50 billion tons have been explored, with 3.5 billion tons proved in the Leningrad region, 4.4 billion tons proven in the Volga region, and 2.9 billion tons confirmed in the Komi Republic in the Vychegodsk basin, however production is almost non-existent in 2007. Natural bitumen deposits are plentiful. The future of fuel energy in Russia is to employ scientific accomplishments to decrease fuel and raw material losses while also bringing new reserves online. The fuel and energy business has a huge detrimental influence on the environment: when minerals are extracted, the soil cover and natural landscapes are disrupted. The atmosphere, soils, and the World Ocean are all contaminated during the production and transportation of oil and gas.

3.7 Ecology

Energy generation has a tremendous impact on the environment. Sulfur, carbon dioxide, and carbon monoxide, and nitrous oxide, dust, soot, and other pollutants, are released when fossil liquid and solid fuels are burned.

Deep pit coal mine and peat removal alter natural environments, and in certain cases, destroy them. Spills of oil and oil products while manufacturing and transport have the potential to wipe out all life on wide swaths of land (water areas). The infrastructure required for coal, oil, and gas extraction has a significant negative impact on landscapes, flora, and animals.

The ruination of useful types of fish, for which dams become insurmountable obstacles on their manner to seeding basis, the lost opportunity of forest areas and strongly fertile soils, a rise in the danger of major earthquakes in foot of mount and mountainous regions, a rise in the risk of catastrophic floods in downstream areas, and landscape change and destruction are all consequences of the construction and maintenance of large hydroelectric power plants (Lavrillier, 2013).

Nuclear energy poses a risk of accidents at power facilities, which might result in the discharge of radioactive elements into the environment. Furthermore, there are issues with nuclear waste treatment and disposal, which is costly and lacks a viable engineering solution. For tens of thousands of years, nuclear waste is dangerous. This issue is particularly important for Ukraine, which has suffered greatly because of the Chernobyl nuclear power plant disaster.

Renewable energy sources, despite their evident advantages, can have a harmful influence on the environment. The operation of renewable energy stations is affiliated with the pullout of large land plots from circulation and, most likely, will be accompanied by certain negative environmental consequences in the future: landscape has changed (windmills, solar panels), excessive noise levels (windmills), soil pollution (geothermal and biomass power plants), and negative effects on other natural resources (tidal power plants).

4 Practical Part

4.1 Linear Regression Analysis

In order to prove the existence of connection between three concepts – ecology, economy and renewable energy, the author focuses on creating a simultaneous econometric model reflecting the relationship between all those concepts. The model consists of three individual linear regression models:

a) $Y1 = ß_0 + \gamma_1 Y_{2t} + ß_1 X_{1t} + ß_2 X_{2t} + ß_3 X_{3t} + ß_4 X_{4t} + ß_5 X_{5t} + ß_6 X_{6t} + U_e$
b) $Y2 = ß_7 + ß_8 X_{7t} + ß_9 X_{9t} + \gamma_2 Y_{3t} + U_e$
c) $Y3 = ß_{10} + ß_{11} X_{1t} + ß_{12} X_{2t} + ß_{13} X_{3t} + U_e$, **where:**

Y_1...........**CO_2 emissions in kt**

Y_2...........**GDP in current US$ billion**

Y_3...........**Industry value added in current US$ billion**

X_1...........**Thermal production in billion kW/h**

X_2...........**Hydro production in billion kW/h**

X_3...........**Nuclear production in billion kW/h**

X_4...........**Energy intensity level of primary energy in MJ/$2017 PPP GDP**

X_5...........**Nitrous oxide emissions in thousand metric tons of CO_2 equivalent**

X_6...........**Methane emissions in kt of CO_2 equivalent**

X_7...........**Cereal production in metric tons**

X_8…………**Production of energy in kWt/h**

Figure 7, original dataset

Year	Y1	X8	X1	X2	X3	X4	X5	X6	Y2	Y3	X7
2000	1563850	877,8	582	165	131	12,14	51670	523309,9976	0,25971014	0,088091006	64,242691
2001	1567170	891,3	578	176	137	11,67	54340	532330,0171	0,30660207	0,097613987	83,303483
2002	1565340	891,3	585	164	142	11,1	54270	539619,9951	0,34547049	0,100381264	84,730327
2003	1610000	916,3	608	158	150	10,71	55000	572650,0244	0,43034777	0,123308128	65,335462
2004	1600980	931,9	609	178	145	10,03	50790	574659,9731	0,59101669	0,187365426	75,986
2005	1611980	953,1	629	175	149	9,49	50750	589200,0122	0,76401711	0,249292915	76,1921
2006	1654850	995,8	664	175	156	9,02	50940	586440,0024	0,98993054	0,314602506	76,494549
2007	1658150	1015,3	676	179	160	8,34	51980	593119,9951	1,29970576	0,405794664	80,207513
2008	1655190	1040,4	710	167	163	8,11	56580	592690,0024	1,66084639	0,511322813	106,41789
2009	1546670	992,1	652	176	164	8,27	54980	573750	1,22264428	0,358564143	95,615476
2010	1617830	1038	699	168	170	8,48	53340	596299,9878	1,52491747	0,457468961	59,619074
2011	1699090	1055	714	168	173	8,39	56050	604900,0244	2,04592561	0,601780146	91,780914
2012	1675760	1069	726	165	178	8,17	54920	601710,022	2,20829577	0,642677406	68,753479
2013	1632680	1059	703	183	173	7,8	55230	603580,0171	2,29247325	0,646277762	90,364971
2014	1611960	1064	707	175	181	7,76	57350	604070,0073	2,05924197	0,575177727	103,135895
2015	1592560	1068	701	170	196	7,77	57100	610559,9976	1,36348106	0,406236366	102,444492
2016	1571520	1091	706	187	197	7,99	59570	626080,0171	1,27678698	0,372488621	117,753222
2017	1594550	1094	703	187	203	7,99	60310	641590,0269	1,57419939	0,482858852	131,294322
2018	1661000	1115	716	193	205	8,25	60930	669869,9951	1,65732965	0,539532033	109,838123
2019	1703590	1121	714	196	209	8,1	61740	684299,9878	1,6931139	0,544344515	117,876704

Source: own processing based on World Bank data

The ultimate goal of the regression analysis is to quantify the relationship between variables using the TSLS – two stages least squares approach. Thus, the author starts his analysis by creating the very first model under the letter a) reflecting the level of CO_2 emissions in the Russian Federation. The output from Gretl presented on the figure below.

Figure 8, output of the first equation

```
                        coefficient    std. error    t-ratio    p-value
  ---------------------------------------------------------------------
  const                 -47819.2       524296        -0.09121   0.9288
  GDPcurrentUSbill~     -10077.7        48780.2      -0.2066    0.8398
  ThermalProductio~       1505.76         847.688     1.776     0.1010
  Hydroproduction_~       -685.694        979.405    -0.7001    0.4972
  Nuclearproductio~      -3366.37        1245.31     -2.703     0.0192   **
  Energyintensityl~      26467.6        13051.4       2.028     0.0654   *
  Nitrousoxideemis~         -0.112556       4.33859  -0.02594   0.9797
  Methaneemissions~          1.89743        0.471836  4.021     0.0017   ***

Mean dependent var    1619736   S.D. dependent var    46314.47
Sum squared resid    6.60e+09   S.E. of regression    23460.43
R-squared            0.838002   Adjusted R-squared    0.743503
F(7, 12)             8.998780   P-value(F)            0.000579
rho                 -0.183919   Durbin-Watson         2.192802
```

Source: own processing

Thus, the author estimates the following model:

$Y_1 = -47819.2 - 10077.7Y_{2t} + 1505.76X_{1t} - 685.6X_{2t} - 3366.37X_{3t} + 26467.6X_{4t} - 0.1125X_{5t} + 1.89X_{6t} + U_e$

Then, the author proceeds to the second equation. The output from Gretl is shown on the figure below.

Figure 9, output of the second equation

	coefficient	std. error	t-ratio	p-value	
const	-2.47118	0.358790	-6.888	3.65e-06	***
ThermalProductio~	0.00441350	0.000513012	8.603	2.13e-07	***
Hydroproduction_~	0.00215859	0.00182068	1.186	0.2531	
Nuclearproductio~	-0.00280856	0.00133231	-2.108	0.0511	*

Mean dependent var	0.385259	S.D. dependent var	0.189499
Sum squared resid	0.053330	S.E. of regression	0.057733
R-squared	0.921836	Adjusted R-squared	0.907180
F(3, 16)	62.89898	P-value(F)	4.49e-09
Log-likelihood	30.89103	Akaike criterion	-53.78205
Schwarz criterion	-49.79912	Hannan-Quinn	-53.00454
rho	0.331601	Durbin-Watson	1.331675

Source: own processing

The second equation has the following parameters:

$Y_2 = 0.94 + 3.84Y_{3t} - 0.001X_{7t} + 0.0005X_{8t} + U_e$

Ultimately, the final equation's parameters are shown on the last figure containing the output of the TSLS method in Gretl.

Figure 10, output of the third equation

	coefficient	std. error	t-ratio	p-value	
const	-2.47118	0.358790	-6.888	3.65e-06	***
ThermalProductio~	0.00441350	0.000513012	8.603	2.13e-07	***
Hydroproduction_~	0.00215859	0.00182068	1.186	0.2531	
Nuclearproductio~	-0.00280856	0.00133231	-2.108	0.0511	*

Mean dependent var	0.385259	S.D. dependent var	0.189499
Sum squared resid	0.053330	S.E. of regression	0.057733
R-squared	0.921836	Adjusted R-squared	0.907180
F(3, 16)	62.89898	P-value(F)	4.49e-09
Log-likelihood	30.89103	Akaike criterion	-53.78205
Schwarz criterion	-49.79912	Hannan-Quinn	-53.00454
rho	0.331601	Durbin-Watson	1.331675

Source: own processing

The third equation has the following parameters:

$Y_3 = -2.47 + 0.0044X_{1t} + 0.0021X_{2t} – 0.0028X_{3t} + U_e$

After estimating individual equations, it is essential to transform all three parts of the simultaneous model into the reduced form – the one suitable for making general prognosis and predicting the development of three endogenous variables – carbon dioxide emissions, GDP in the Russian Federation and the value added from the industry.

The formula for calculating the reduced form is available below:

$M = -ß^{-1}\Gamma$, where:

M = reduced form of the simultaneous model

ß = matrix of endogenous variables' parameters

Γ = matrix of exogeneous variables' parameters

The calculations made by the author in excel are presented on the next figure.

Figure 11, M matrix calculation

	y1	y2	y3
	1	10077,7	0
ß =	0	1	-3,84
	0	0	1

	const	x1	x2	x3	x4	x5	x6	x7	x8
	47819,2	-1505,76	685,6	3366,37	-26467,6	0,11	-1,89	0	0
Γ =	-0,94	0	0	0	0	0	0	0,001	-0,0005
	2,47	-0,0044	-0,0021	0,0028	0	0	0	0	0

		const	x1	x2	x3	x4	x5	x6	x7	x8
Carbon	y1	38292,731	1335,48718	-766,86657	-3258,0146	26467,6	-0,11	1,89	10,0777	-5,03885
GDP	y2	-8,5448	0,016896	0,008064	-0,010752	0	0	0	-0,001	0,0005
industry	y3	-2,47	0,0044	0,0021	-0,0028	0	0	0	0	0

Source: own processing

Following the process of calculating the parameters for the reduced model, the author estimates the subsequent:

$Y_1 = 41272.5 + 1335.48X_{1t} - 766.86X_{2t} - 3258.014X_{3t} + 25467X_{4t} - 0.11X_{5t} + 1.89X_{6t} + 10.0777X_{7t} - 5.03885X_{8t} + V_e$

$Y_2 = -8.84 + 0.016X_{1t} + 0.008X_{2t} - 0.0107X_{3t} - 0.001X_{7t} + 0.0005X_{8t} + V_e$

$Y_3 = -2.47 + 0.0044X_{1t} + 0.0021X_{2t} - 0.0028X_{3t} + V_e$

The quality of the estimated equations are quite satisfying with the coefficient of determination relatively high, which means that a high percentage of variation in the dependent (endogenous) variables is explained by the variation in independent (exogeneous) variables.

The author will interpret the results in more detail in the next chapter.

4.2 Correlation Analysis

Second part of the author's practical part consists of an additional analysis of correlation between 4 elements – thermal energy production, nuclear energy production and hydro energy production and GDP in Russia. The dataset used for the calculation of correlation is available below.

Figure 12, dataset used for the correlation analysis

Year	Thermal Production_billion kW/h	Hydro production_billion kW/h	Nuclear production_billion kW/h	GDP (current US$ billion)
2000	582	165	131	0,259710142
2001	578	176	137	0,306602071
2002	585	164	142	0,345470494
2003	608	158	150	0,430347771
2004	609	178	145	0,591016691
2005	629	175	149	0,764017108
2006	664	175	156	0,989930542
2007	676	179	160	1,299705765
2008	710	167	163	1,660846388
2009	652	176	164	1,222644282
2010	699	168	170	1,524917468
2011	714	168	173	2,045925608
2012	726	165	178	2,208295774
2013	703	183	173	2,292473247
2014	707	175	181	2,059241965
2015	701	170	196	1,363481063
2016	706	187	197	1,276786979
2017	703	187	203	1,574199387
2018	716	193	205	1,657329646
2019	714	196	209	1,693113904

Source: own processing based on World Bank data

The author uses the correlation analysis to estimate if there is connection between different sources of producing energy with the main macroeconomic indicator of every country on Earth – nominal GDP, the total value of goods and services produced in a country within a year. The output from Gretl is shown on the next figure.

Figure 13, correlation analysis

```
Correlation Coefficients, using the observations 2000 - 2019
5% critical value (two-tailed) = 0.4438 for n = 20

 GDPcurrentUSbi~ ThermalProduct~ Hydroproductio~ Nuclearproduct~
          1.0000          0.9314          0.3123          0.7043 GDPcurrentUSbi~
                          1.0000          0.3946          0.8446 ThermalProduct~
                                          1.0000          0.6389 Hydroproductio~
                                                          1.0000 Nuclearproduct~
```

Source: own processing

Based on the correlation analysis, the author estimates that thermal production is the most positively correlated with the GDP, the second one is the nuclear energy and the last one is the hydro energy.

5 Results and Discussion

5.1 Ecological Imprint

After presenting the findings of the practical portion of the study, the author moves on to the interpretation of the findings presented in the prior chapter. The following is a conclusion that the author is able to reach after considering the simultaneous model in its simplified form:

• ***An increase of 1 billion kW/h in Russia's thermal energy output translates to an increase of 1,335 kt in the country's carbon dioxide emissions.***

• ***An increase of one billion kW/h in Russia's hydro energy output corresponds to a reduction of 766.86 kt in the country's carbon dioxide emissions.***

• ***An increase of one billion kW/h in Russia's nuclear energy output corresponds to a reduction of 3258 kt in the country's carbon dioxide emissions.***

• ***An increase of one kilowatt-ton in Russia's methane emissions translates to an increase of 1.89 kilowatt-hours in the country's carbon dioxide emissions.***

• ***An increase of one kilotonne in Russia's grain output equates to an increase of ten thousand kilotonnes in the country's carbon dioxide emissions.***

This information that is accessible from the simplified version of the simultaneous model gives the primary rationale for the favorable influence that renewable sources of energy have on the ecology of Russia as well as global warming. According to what the author indicated in his analysis of the relevant material, Russia does not place a large amount of emphasis on renewable sources of energy, and the only renewable source of energy whose presence is relatively substantial is electricity produced from hydro stations (the third most popular source of energy).

When compared to the most common source of energy, which is thermal plants, renewable energy in Russia not only does not contribute to an increase in the overall level of carbon dioxide emissions, but it actively works to reduce this overall level. Naturally, the production of energy from a different source cannot in any way bring the level of greenhouse gases down. However, when Russia was increasing the share of energy that was produced from renewable sources, it was willingly decreasing the share that was generated from thermal plants, which produce a significant amount of greenhouse gases and other gases that are harmful to the environment in Russia. Therefore, the author's premise regarding the beneficial effects of renewable sources of energy is totally explicable and supported by his results, which exactly agree with the findings of another author. This shows that the author's assumption was correct (Lanshina, 2018).

The importance of highlighting another finding made by the author cannot be overstated. Considering the size of Russia's cereal production, it should not have come as any kind of surprise that the volume of carbon dioxide emissions rises by ten metric tons for every metric ton of cereals produced in the country. In addition to this, the author draws the conclusion that the primary byproduct of thermal power plants, which is methane, contributes to the worsening of the situation with regard to environmental pollution and is particularly damaging to the environment.

5.2 Effect of Renewables Energy on Economy

Energy is what keeps the country's economic machine, which is broken up into three sectors - agriculture, industry, and services — primary, secondary, and tertiary sectors, respectively – operating smoothly. According to the author's calculations, the value of Russia's industry value added rises by 0.0044 billion US dollars for every billion kW/h that is generated by thermal plants, 0.0021 billion US dollars is added for every billion kW/H that is generated by hydro plants, and 0.0028 billion US dollars is lost for every billion kW/h that is generated by nuclear plants in Russia. Clearly, after looking at these numbers, it becomes apparent that the choice of thermal plants is somewhat justifiable by its efficiency and much more important influence on the industry in the nation. This is the case because it is plain that the choice of thermal plants is apparent.

In addition, the author hypothesizes that the country's gross domestic product will inevitably rise by 0.016 billion US dollars for every billion kW/h that is produced by thermal power plants, and it will rise by 0.008 kW/h for every billion kW/h that is produced by hydropower plants. These projections are based on the author's analysis of historical data. In point of fact, there is some effect, but one that is noticeably less significant than the effect of thermal sources of energy on the Russian economy. The author arrives at the same conclusion as the author author, who arrived at the same verdict after describing the phenomena in the same way (Fortov, 2014).

In addition to this, the correlation study helped throw further light on the issue, revealing that the impact of renewable energy sources on the Russian economy is not even close to being regarded important or powerful.

6 Conclusion

In conclusion, the author emphasizes the most important fact, which is that the use of renewable sources of energy in Russia will always have a beneficial influence on the country's ecological as well as its GDP. However, the influence that thermal stations have on the environment is far larger than that of renewable sources of energy, which are principally represented by hydro plants. Those thermal stations undoubtedly leave their mark on the environment, most notably on the amount of carbon dioxide and other gases that contribute to global warming that are produced in the nation.

However, Russia prioritizes sources of energy that are beneficial to the economy, and the government has no plans to expand its reliance on hydropower or other forms of renewable energy until 2022 at the earliest. The author came to the same conclusion that I did, which is that the thermal facilities, not the hydroelectric ones, are the primary sources of fuel for the industrial sector.

If the Russian authorities are willing to face a slight contretemps in the economic growth and perform a peaceful transition from thermal plants to renewables, they will unavoidably face a decrease in the economic growth. However, in 2- or 5-years' time, it is quite likely that the country will reach the same rate of economic growth with significantly fewer emissions of pollution caused by energy plans.

The most important piece of advice that the author can give to the Russian government in terms of energy production is to begin shifting their reliance away from thermal power plants and other highly polluting forms of energy production and toward hydroelectric power plants, wind turbines, and solar panels. This is the primary strategy that the author can recommend to the Russian government in order to reach a prosperous sustainable growth of the developing information society.

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