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Specifics of Green Energy Development in the Russian Federation

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Abstract

Introduction. The issues of sustainable development, environmental protection and transition to a low-carbon economy remain relevant for countries worldwide, including the Russian Federation. In the context of global climate change and depletion of traditional energy sources, the need to develop “green” energy has become increasingly important. However, despite the presence of a certain potential, this sector in Russia is still underdeveloped, which is due to various economic, technological and legislative factors. There are numerous theoretical studies on renewable energy sources in the scientific literature, but many aspects of their functioning and development remain insufficiently explored. This scientific gap makes it difficult to fully understand the mechanisms and strategies for its further development.

In connection with the above, this study aims to analyze the current features and trends in the development of green energy in the Russian Federation. The study will also identify potential obstacles and opportunities for the expansion of green energy, as well as ways to overcome negative aspects of its functioning. The objectives of the authors of the study are focused on analyzing the priorities of public policy in Russia as a signatory to the UN Framework Convention on Climate Change, the Paris Climate Agreement, and the Kyoto Protocol on Reducing Greenhouse Gas Emissions, on determining the impact of public policy, technology and investment on the development of renewable energy sources, as well as on studying factors that can accelerate the country's transition to more sustainable energy models. The results of the study aim not only to fill a current gap in scientific knowledge, but also to provide the basis for developing recommendations that can help optimize energy policy in the country.

Materials and Methods. The authors analyzed legislative materials related to the topic of study. Statistical data on the types of energy capacities in the country over the past decade were used. The study was conducted based on regulatory and legal acts of the Russian Federation. Results from monitoring the implementation of government programs and strategies on the issue were also studied. Content analysis, structural and functional analysis were used as main research methods. The current state of affairs in the energy industry was presented based on the analysis of hierarchies, which was a set of elements, each of which reflected a specific step in achieving the goal.

Results. The clear growth of renewable energy sources (RES) use in the total global energy capacity has been explicated. It has been established that Russia is paying significant attention to the development of renewable energy sources, with a focus on introducing public-private partnerships in this area. Methods and principles of government support aimed at developing this sector, as well as competitive technologies (RES.1 and RES.2) for the commissioning of generating facilities using various forms of renewable energy, have been analyzed. It has been confirmed that the energy development roadmap in Russia corresponds to a proposed hierarchy of strategies based on a hybrid approach. Priorities in reducing greenhouse gas emissions and combating pollution have also been established.

Discussion and Conclusion. The data obtained from the research conducted by the authors indicates that Russia has started to move towards the active implementation of renewable energy sources while not disregarding the use of traditional energy from non-renewable resources, taking steps to minimize associated costs. The development of green energy in the country is still proceeding at a slow rate. Its development is hampered, on the one hand, by the already powerful potential of energy capacities, and on the other hand, by negative factors affecting both the production and use

of renewable energy sources. While advocating for a faster transition to green energy, it is important to acknowledge that this process is fraught with challenges that must be predicted and addressed. To do so, a thorough analysis of the impact of different types of renewable energy sources on the environment and human health is necessary. Therefore, the introduction of renewable energy sources should be phased and carefully thought out. In this regard, this topic requires further study.

Keywords: Russian Federation, the country's energy system, renewable energy sources, legislative acts, stages and prospects of development

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Оригинальное теоретическое исследование

Особенности развития зелёной энергетики в Российской Федерации

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Аннотация

Введение. Вопросы устойчивого развития, охраны окружающей среды и перехода к низкоуглеродной экономике не теряют своей актуальности для стран по всему миру, в том числе и для Российской Федерации. В условиях глобальных изменений климата и истощения традиционных источников энергии необходимость в развитии зелёной энергетики приобретает особую значимость. Однако несмотря на наличие определённого потенциала данный сектор в России пока ещё недостаточно развит, что обусловлено различными экономическими, технологическими и законодательными факторами. В научной литературе существует ряд теоретических исследований, посвящённых вопросам возобновляемых источников энергии (ВИЭ). Тем не менее, многие аспекты функционирования и становления зелёной энергетики пока ещё мало изучены, этот научный пробел затрудняет полноценное понимание механизмов и стратегий её дальнейшего развития.

В связи с вышеизложенным цель данного исследования заключается в том, чтобы проанализировать существующие особенности и тенденции развития зелёной энергетики в Российской Федерации, выявить потенциальные препятствия и возможности для её расширения, определить пути преодоления негативных аспектов её функционирования. Задачи авторов исследования сосредоточены на анализе приоритетов государственной политики России, подписавшей Рамочную конвенцию ООН об изменении климата, Парижское соглашение по климату и Киотский протокол о сокращении выбросов парниковых газов, на определении влияния государственной политики, технологий и инвестиций на развитие возобновляемых источников энергии, а также на изучении факторов, которые могут способствовать ускорению перехода страны к более устойчивым энергетическим моделям. Результаты исследования призваны не только заполнить текущий пробел в научном знании, но и стать основой для выработки рекомендаций, направленных на оптимизацию политики в сфере развития зелёной энергетики в стране.

Материалы и методы. Авторами проанализированы законодательные материалы, касающиеся исследуемой темы. Были использованы статистические данные по видам энергетических мощностей страны за последнее десятилетие. Исследование проводилось на основе нормативных и правовых актов РФ. Изучены результаты мониторинга реализации государственных программ и стратегий по рассматриваемому вопросу. В качестве основных методов исследования были использованы контент-анализ и структурно-функциональный анализ. Современное положение дел в энергетической отрасли представлено на основе анализа иерархий как совокупности элементов, каждый из которых отражает конкретную ступень в достижении поставленной цели.

Результаты исследования. Эксплицирован явный рост использования возобновляемых источников энергии в общей мировой энергетической мощности. Установлено, что в России уделяется значительное внимание развитию возобновляемых источников энергии, при этом акцент делается на внедрение механизмов государственно-частного партнерства в этой области. Проанализированы методы и принципы государственной поддержки, направленные на развитие данного сегмента, а также технологии конкурсного отбора (ДПМ ВИЭ.1 и ДПМ ВИЭ.2) для ввода в эксплуатацию генерирующих объектов, использующих разнообразные виды возобновляемых источников энергии. Подтверждено, что дорожная карта развития энергетики в России соответствует предложенной иерархии стратегий, разработанной на основе гибридного подхода. Также установлены приоритеты в области сокращения парникового эффекта и борьбы с загрязнением окружающей среды.

Обсуждение и заключение. Данные, полученные в результате проведенного авторами исследования, свидетельствуют о том, что Россия начала движение в направлении активного внедрения возобновляемых источников энергии, не оставляя при этом без внимания и функционирование традиционной энергетики на невозобновляемых источниках, осуществляя мероприятия по минимизации возникающих при этом издержек. Становление зелёной энергетики в стране пока идёт медленными темпами, её развитие тормозят, с одной стороны, уже имеющийся мощный потенциал энергетических мощностей, а с другой стороны, негативные факторы, отрицательно влияющие как на изготовление, так и на применение ВИЭ. Но, радуя за повсеместное форсирование внедрения зелёной энергетики, нельзя не принимать во внимание тот факт, что процесс перехода к ней таит в себе немало угроз, которые надо уметь прогнозировать и устранять. Для этого должно быть проведено тщательное исследование влияния различных видов возобновляемых источников энергии на окружающую среду и здоровье людей. Поэтому внедрение ВИЭ должно быть поэтапным, тщательно продуманным. В связи с этим данная тема требует дальнейшего изучения.

Ключевые слова: Российская Федерация, энергосистема страны, возобновляемые источники энергии, законодательные акты, этапы и перспективы развития

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Introduction. The urgency of developing green energy in Russia stems from the need to transition to more sustainable and environmentally friendly energy sources due to global climate change and the depletion of traditional resources. Given that the Russian Federation possesses vast hydrocarbon reserves and heavily relies on nuclear energy, the challenge of introducing and promoting renewable energy sources within the country has not been thoroughly explored, particularly with regard to their potential negative impacts on the environment and public health. Significant attention is given to existing energy production capacities and volumes, yet the utilization of alternative energy sources like solar, wind, and hydropower, as well as their integration into the overall energy system, remains underexplored and lacks scientific justification.

The Russian Federation is a country rich in natural energy resources. This makes it a world leader in hydrocarbons and nuclear energy use and export. The adopted Energy Strategy of the Russian Federation for the period up to 2035¹ outlines forecast indicators for the production of various fuels. Figure 1 shows these data for two stages of the Strategy's implementation: for 2024 and for 2035 in accordance with two types of scenarios — the lower and upper. Both scenarios aim to maintain the macroeconomic stability of the state. The scenario corresponding to the upper limit of the range of parameters for the development of the fuel and energy complex assumes the achievement of economic growth rates above the global average. The scenario corresponding to the lower limit indicates the limit of the sustainability of the country's energy sector and ensuring its energy security.

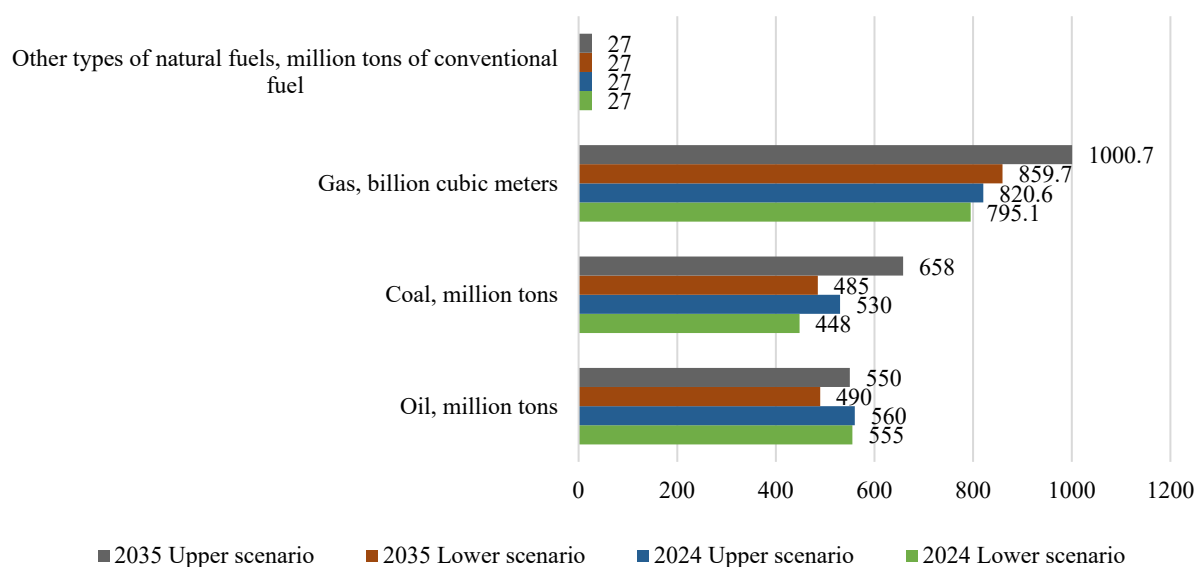


Fig. 1. Forecast of Russia's fuel and energy balance (2024, 2035)

¹ Energy Strategy of the Russian Federation for the Period up to 2035. Decree of the Government of the Russian Federation No. 1523–r dated June 9, 2020. (In Russ.) URL: <http://static.government.ru/media/files/w4sigFOiDjGVDYT4IgsApssm6mZRB7wx.pdf> (accessed: 13.01.2025).

According to the data in Figure 1, the country has no plans to significantly decrease the extraction of natural, non-renewable energy resources until 2035. The Energy Strategy emphasizes that one of the main objectives of energy development is to support the socio-economic growth of the state and encourage the development of other economic sectors, which highlights as priorities of the state energy policy “guaranteed energy security of the country as a whole and at the level of the subjects of the Russian Federation, especially those located in geostrategic territories; primary satisfaction of domestic demand for products and services in the energy sector”².

At the same time, the volumes of extraction and production of energy resources from extracted raw materials, fuel and electric energy production in the Russian Federation consistently exceed domestic consumption: for oil — by more than 1.9 times, for gas — by 1.5 times, for coal — by 1.8 times, for diesel fuel — by 2.6 times, for automobile gasoline — by 1.1 times [1]. This makes Russia one of the leading exporters of energy resources in the world. The profits from these exports are planned to be used for various purposes, including developing the industry, accelerating technological and digital evolution, and achieving national goals such as sustainable growth in real incomes for citizens.

The Strategy notes that among the world's largest economies, the fuel and energy balance of the Russian Federation is one of the most environmentally friendly (low-carbon). More than a third of electric energy generation comes from nuclear power, hydropower and other renewable energy sources. About half of the energy comes from natural gas³, which is in line with global trends in the energy industry. Despite having abundant natural resources, the Russian Federation adheres to the goals of sustainable energy production and consumption, as defined by the United Nations Environment Programme⁴.

To date, literary sources have primarily focused on specific aspects of green energy, including legal, economic, and technological aspects. However, a comprehensive analysis of the current state of renewable energy in Russia is lacking. This indicates a gap in scientific knowledge about the interaction between public policy, capital markets, and scientific developments required for the successful promotion and implementation of innovative and sustainable energy technologies in the country's energy sector. Furthermore, empirical data on the actual opportunities and growth potential of this sector of the Russian economy has not been thoroughly explored.

Therefore, the aim of this research was to conduct a comprehensive analysis of the features and trends in the development of green energy in the Russian Federation. This included studying the impact of government policies on the adoption of renewable energy sources, identifying existing barriers and opportunities for growth in this sector, and developing recommendations to improve conditions for further development of green energy in the country.

Materials and Methods. The study used regulatory and legal acts of the Russian Federation: the Energy Strategy of the Russian Federation for the period up to 2035, the State Program of the Russian Federation “Energy Development”, the Decree of the President of the Russian Federation “On Reducing Greenhouse Gas Emissions”, the Strategy of Socio-Economic Development of the Russian Federation with low greenhouse gas emissions until 2050, Decree of the Government of the Russian Federation “On the Main Directions of State Policy in the Field of Improving the Energy Efficiency of the Electric Power Industry Based on the use of Renewable Energy Sources for the Period up to 2035”, Federal Law “On Electric Power Industry”.

The data of the Federal State Statistics Service of the Russian Federation, the Association for Renewable Energy Development (ARWE), RES statistics, and information articles on the UNEP (United Nations Environment Program) website were used. The United Nations Environment Programme's assessment reports presented on the IPCC (Intergovernmental Panel on Climate Change) website and materials on the problems of green energy development in the world and Russia presented in scientific works by domestic and foreign authors were also considered. Special attention was paid to the results of the “Renewable Energy in Russia and the World” review presented by Rosenergo⁵. Plans, reports, and results of monitoring the implementation of the State Program “Energy Development”⁶ of the Russian Federation were analyzed using content analysis and structural-functional analysis methods.

A mixed research method was employed, which included qualitative and quantitative analysis. Public speeches by government officials, texts in the open press, and regulatory documents were analyzed qualitatively, while secondary information from statistical sources was analyzed quantitatively. The authors applied the methodological approach proposed by [1] as a basis for determining and analyzing the interrelationships of strategies for financing sustainable development in the Russian Federation.

² Id.

³ *Energy Strategy of the Russian Federation for the Period up to 2035*. Decree of the Government of the Russian Federation No. 1523-р dated June 9, 2020. (In Russ.) URL: <http://static.government.ru/media/files/w4sigFOiDjGVDYT4IgsApssm6mZRb7wx.pdf> (accessed: 13.01.2025).

⁴ *The United Nations Environment Programme*. (In Russ.) URL: <https://www.unep.org/ru> (accessed: 13.01.2025).

⁵ *Renewable Energy in Russia and the World*. The Ministry of Energy of Russia. Moscow: 2022. 105 p. (In Russ.) URL: <https://rosenergo.gov.ru/upload/iblock/e04/3xtm87iv99x76b23c6wjul3as5pzz8zi.pdf?ysclid=lxzlwzc66231521884> (accessed: 13.01.2025).

⁶ *The State Program of the Russian Federation “Energy Development”*. Decree of the Government of the Russian Federation No. 321 dated April 15, 2014. (In Russ.) URL: <https://minenergo.gov.ru/activity/government-program?ysclid=m7afzr9it1340468075> (accessed: 13.01.2025).

Results. The analysis of statistical data, scientific research, and government documents conducted by the authors as part of this work suggests that the number of non-renewable energy sources is decreasing year after year, despite their significant reserves. This could lead to the eventual depletion of these resources. The growth of the global population and constant increase in living standards have led to an increase in energy consumption. Since the 1960s, energy consumption has increased by 3.6 times⁷. This is a major reason for the active search for and implementation of alternative energy sources.

Other reasons are outlined in the United Nations Environment Programme. First and foremost, this is climate change on Earth, the need to eliminate its consequences. Greenhouse gas emissions are known to be the main cause of global warming. In 2020, the average surface air temperature exceeded the pre-industrial level of 1850–1900 by 1.1°C. If the current situation is ignored, the climate can warm by more than 2.9°C over the next century. According to the 2021 report of the Intergovernmental Panel on Climate Change, anthropogenic climate change is unprecedented over the last 2,000 years and is increasing in all regions of the world⁸. This can have disastrous consequences for life on Earth. According to the Paris Climate Agreement, which was adopted in 2015, the preferred temperature rise limit is 1.5°C. This requires a significant reduction in greenhouse gas emissions, by 50% by 2030 and by 100% by the end of the 21st century⁹. Review [2] examines in detail the driving forces of climate change, analyzes its consequences, and explains measures to mitigate these effects.

It should be understood that we are living in a time of natural crisis. Therefore, conservation, restoration, and the responsible use of natural resources are the main priorities at the moment. To prove this, UNEP provides specific examples of how human activity has led to the destruction of nature. This proves that “we are using the equivalent of 1.6 Earth to maintain our current lifestyle, and ecosystems are unable to keep up with our demands”¹⁰.

Supporting territories affected by natural disasters, industrial accidents, and anthropogenic crises; combating environmental pollution; minimizing the adverse effects of chemicals — these activities can and should contribute to the restoration of nature and its riches. At the same time, they have a significant impact on states taking all necessary measures to implement them.

Currently, the legal basis for international cooperation on climate change is the United Nations Framework Convention, which was adopted on May 9, 1992 and developed into the Kyoto Protocol on December 11, 1997. To achieve the goals of the Framework Convention, the Paris Climate Agreement¹¹ was also adopted on December 12, 2015. The Russian Federation is a signatory to the Framework Convention, the Kyoto Protocol and the Paris Agreement. On November 25, 2020, the Russian Federation announced its first nationally determined contribution to the implementation of the Paris Agreement. These data are posted on the official portal of the secretariat of the United Nations Framework Convention on Climate Change¹². The basis for this statement was the Decree of the President of the Russian Federation “On Reducing Greenhouse Gas Emissions”, which tasked the government of the country with ensuring a reduction in greenhouse gas emissions by up to 70% by 2030, relative to 1990 levels. This reduction was to be achieved while taking into account the maximum absorption capacity of forests and other ecosystems, and subject to the sustainable and balanced socio-economic development of the Russian Federation¹³, and the Strategy of socio-economic development of the Russian Federation with low greenhouse gas emissions until 2050¹⁴. The strategy provides for two scenarios of such development: inertial and targeted (intensive). It is the target scenario that is considered as the main one, which assumes the implementation of the commitments undertaken by the Russian Federation under the Paris Agreement and the Framework Convention and the achievement of a balance between anthropogenic greenhouse gas emissions and their absorption by 2060 at the latest. As part of technological development, the Strategy pays special attention to the development of renewable energy sources in the country.

⁷ Id.

⁸ *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Intergovernmental Panel on Climate Change, Cambridge University Press. IPCC; 2021. URL: <https://www.ipcc.ch/report/ar6/wg1/> (accessed: 13.01.2025).

⁹ *The Paris Agreement*. United Nations. URL: <https://www.un.org/r/climatechange/paris-agreement> (accessed: 13.01.2025).

¹⁰ *Facts about the nature crisis*. UN environment programme. URL: <https://www.unep.org/facts-about-nature-crisis> (accessed: 13.01.2025).

¹¹ *On the Ratification of the UN Framework Convention on Climate Change*. Federal Law. URL: <http://www.kremlin.ru/acts/bank/7188>. *On the Adoption of the Paris Agreement*. Decree of the Government of the Russian Federation No. 1228 dated September 21, 2019. (In Russ.) URL: <http://static.government.ru/media/files/10US0FqDc05omQ1VgnC8rfL6PbY69AvA.pdf> (accessed: 10.02.2025).

¹² *NDC Registry*. United Nations. URL: <https://unfccc.int/ru/NDCREG> (accessed: 13.01.2025).

¹³ *On Reducing Greenhouse Gas Emissions*. Decree of the President of the Russian Federation No. 666 dated November 4, 2020. (In Russ.) URL: www.kremlin.ru/acts/bank/45990 (accessed: 13.01.2025).

¹⁴ *The Strategy of Socio-Economic Development of the Russian Federation with Low Greenhouse Gas Emissions until 2050*. Decree of the Government of the Russian Federation No. 3052-r dated October 29, 2021. (In Russ.) URL: <http://static.government.ru/media/files/ADKkCzp3fWO32e2yA0BhtlpyzWfHaiUa.pdf> (accessed: 13.01.2025).

The decree of the Government of the Russian Federation “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 renewable energy sources for the period up to 2035”¹⁵ states that the use of renewable energy sources is one of the significant measures “related to the fulfillment of the international obligations of the Russian Federation to limit greenhouse gas emissions”.

According to the Federal Law “On Electric Power Industry”, there are several types of renewable energy sources (Table 1)¹⁶:

Table 1

Renewable Energy Sources

Sun energy
Wind energy
Water energy (including wastewater energy), with the exception of cases when such energy is used in pumped storage power plants
Tidal energy
Wave energy of water bodies, including reservoirs, rivers, seas, and oceans
Geothermal energy using natural underground heat carriers
Low-potential thermal energy of earth, air, and water using special heat carriers
Biomass, which includes plants specially grown for energy production, including trees, as well as production and consumption waste, with the exception of waste obtained from the use of hydrocarbon raw materials and fuels
Biogas
Gas released by production and consumption waste in landfills of such waste
Gas produced at coal mines

The global technical potential of all types of renewable energy differs in terms of volume. Thus, the share of solar energy is 62.52%, geothermal energy (at depths up to 10 kilometers) — 32.75%, ocean energy — 4.47%, wind energy — 0.23%¹⁷.

There is a steady increase in the use of renewable energy sources in the total global energy capacity (Fig. 2) [3].

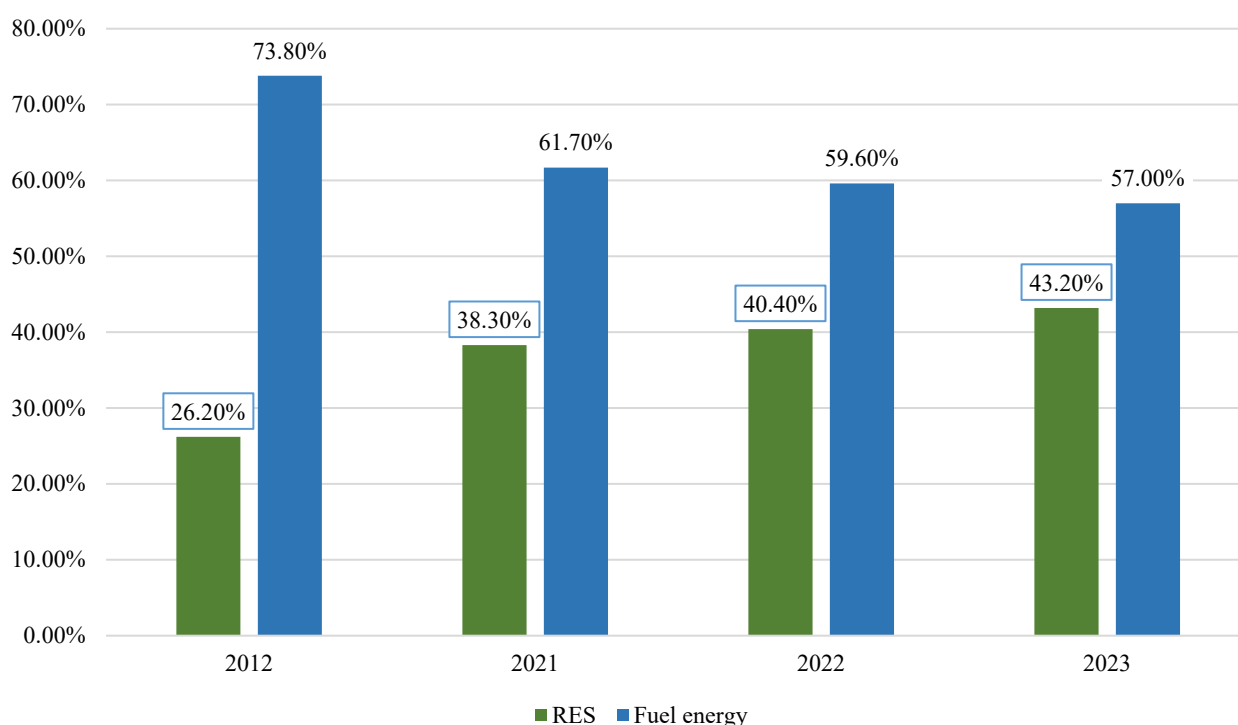


Fig. 2. Growth in the use of renewable energy sources

¹⁵ 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 Renewable Energy Sources for the Period up to 2035. Decree of the Government of the Russian Federation No. 1-r dated January 8, 2009 (as amended by Decree of the Government of the Russian Federation No. 1446-r dated June 1, 2021). (In Russ.) URL: <http://government.ru/docs/all/66930/> (accessed: 13.01.2025).

¹⁶ On the Electric Power Industry. Federal Law No. 35-FZ dated March 26, 2003. The official website of the President of Russia. (In Russ.) URL: www.kremlin.ru/acts/bank/19336 (accessed: 13.01.2025).

¹⁷ Id.

The largest volume of electricity generated from solar (SES) and wind power plants (WPP) is produced in China, followed by the United States, India, Germany, Brazil. Due to a large number of hydroelectric power plants, Russia is considered to have access to renewable energy sources to some extent, but it still lags behind in most other forms presented in Table 1. This has led to the need for further development of renewable energy sources in the country, which are given sufficient attention at the state level. The main focus is on the implementation of public-private partnerships in this area. In particular, the government decree¹⁸ provides for competitive selection with the establishment of targets for the commissioning of renewable energy generating facilities, as well as basic limits for capital expenditures per kilowatt of installed capacity for each type of facility. It also sets basic limits for efficiency indicators, etc.

Government support and financial incentives for the development of renewable energy between 2013 and 2021 produced results that are significantly different from the occasional cases of previous years.

Meanwhile, the total capacity of renewable energy sources in the Russian energy system is still small, and the main contribution to the country's energy sector is still made by traditional fuel. Renewable energy accounts for only 2.41% of the country's unified energy system. As of April 1, 2024, the total capacity of renewable energy facilities in Russia was 6.11 GW, with wind and solar power plants leading the way (Fig. 3).

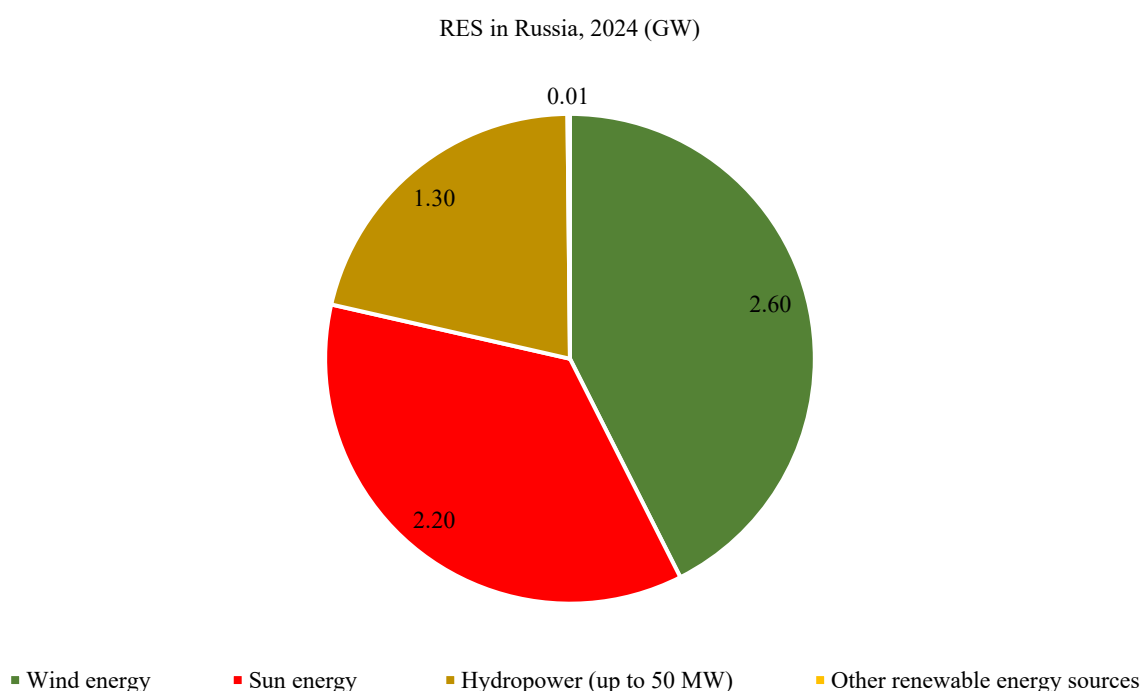


Fig. 3. Renewable energy sources in Russia in 2024

From 2013 to 2024, the country implemented a Capacity Delivery Agreement RES 1.0. The program was aimed at supporting the introduction of renewable energy sources financially. A competitive selection process was conducted among applicants, with the condition for signing contracts for the provision of renewable energy capacity for 15 years. Andrey Maksimov, Deputy Director of the Energy Development Department at the Ministry of Energy of the Russian Federation, emphasized that “investors receive a guarantee of returns on their investments through fixed income payments for capacity” [4].

It is important to note the constant increase in the commissioning of new renewable energy capacities during this period. From 2014 to 2023, the capacity increased from 1.66 to 6.11 GW. The highest peak occurred in 2020 and 2021. After that, due to sanctions imposed by states unfriendly to Russia, there was a noticeable decrease in the commissioning of new capacities (Fig. 4)¹⁹.

¹⁸ 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 Renewable Energy Sources for the Period up to 2035. Decree of the Government of the Russian Federation No. 1-r dated January 8, 2009 (as amended by Decree of the Government of the Russian Federation No. 1446-r dated June 1, 2021). URL: <http://government.ru/docs/all/66930/> (In Russ.) (accessed: 13.01.2025).

¹⁹ RES statistics. RREDA. (In Russ.) URL: <https://rreda.ru/industry/statistics/?ysclid=lxxa7d8w6b624652409#graph2> (accessed: 13.01.2025).

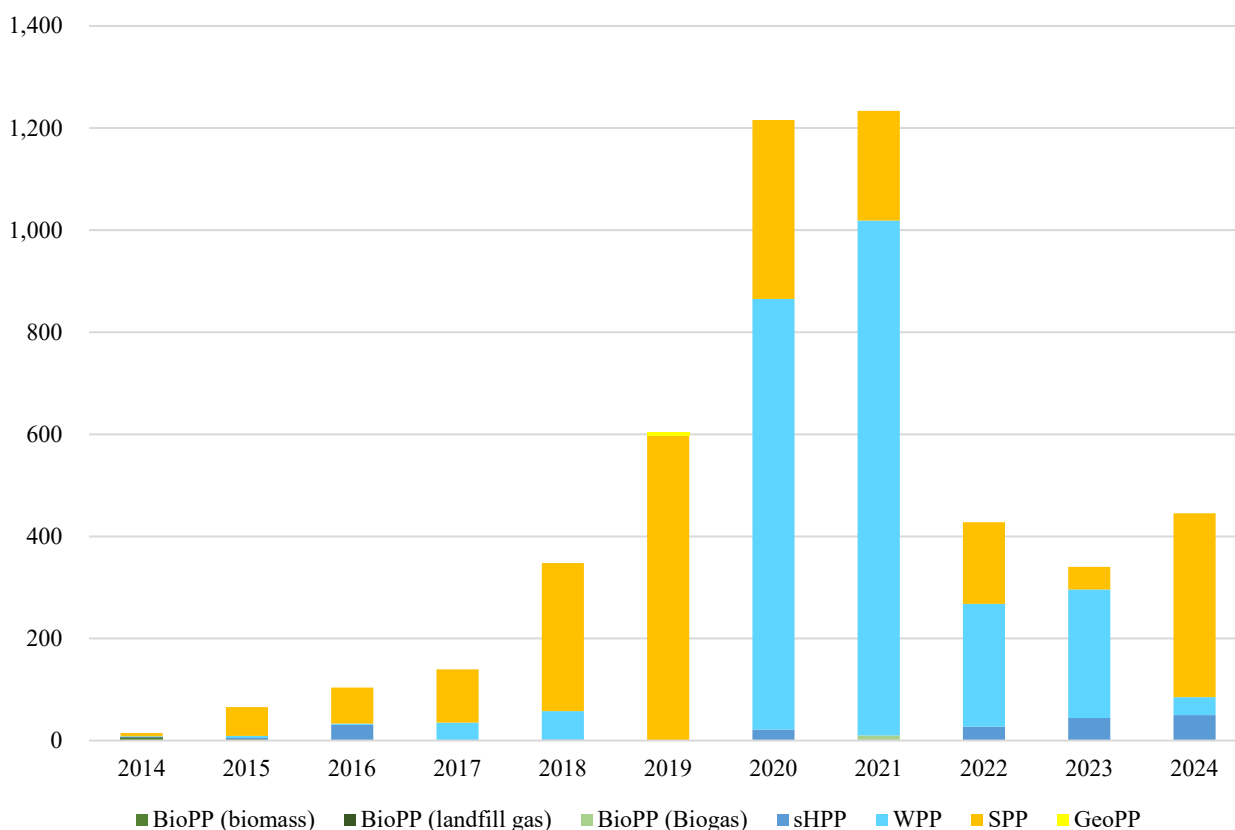


Fig. 4. Dynamics of commissioning of renewable energy power plants in Russia

The dependence on foreign components and materials for the production of domestic renewable energy equipment has led to delays in several investment projects²⁰. At the same time, all previously announced investment projects continued their work. The government has taken measures aimed at specifying the timing of competitive selections for the construction of renewable energy generating facilities in the wholesale and retail electricity markets, and amendments have been made to the policy documents regulating this industry²¹.

The CDA RES 1.0 program contributed to the creation of a production base of equipment for the commissioning of green energy capacities, which did not exist in the country in sufficient quantity. It determined the dependence of this industry on imported goods. As A. Maksimov noted, “the result of the first program was the introduction of new renewable energy facilities and the creation of a scientific basis for the production of necessary equipment” [4]. Since 2024, there is the CDA RES 2.0 program. It is designed to last until 2035. It aims to improve on the achievements of the first program. In the second program, the competitive selection process for projects has been adjusted. In the first program, projects were selected based on the level of capital expenditure. Now, the projects that demonstrate a higher efficiency in the facilities being commissioned are considered for nomination. The first competitive selection under the second program was held in 2021. The total capacity of the supported projects was 2.7 GW. The new approach has led to an increase in efficiency and a decrease in the cost of renewable energy facilities by approximately 85%.

²⁰ Renewable Energy Market of the Russian Federation: Current Status and Development Prospects. Plumbing, Heating, Air Conditioning. (In Russ.) URL: <https://www.c-o-k.ru/articles/rynok-vozbnovliaemoy-energetiki-rf-tekuschiy-status-i-perspektivy-razvitiya-chast-1> (accessed: 13.01.2025).

²¹ On Amendments to Certain Acts of the Government of the Russian Federation Regarding the Postponement in 2022 of the Competitive Selection of Investment Projects for the Construction of Generating Facilities Based on the Use of Renewable Energy Sources in the Wholesale Electricity and Capacity Market and the Competitive Selection of Projects for the Construction of Generating Facilities Based on the Use of Renewable Energy Sources in the Retail Markets Electrical Energy. Decree of the Government of the Russian Federation No. 338 dated March 10, 2022. (In Russ.) URL: <https://normativ.kontur.ru/document?moduleId=1&documentId=460412> (accessed: 13.01.2025).

On Amendments to Certain Acts of the Government of the Russian Federation on the Issues of Conducting Competitive Selections of Investment Projects for the Construction of Generating Facilities Operating on the Basis of Renewable Energy Sources in the Wholesale and Retail Electric Energy Markets and on the Establishment of Certain Features of State Regulation of Prices (Tariffs) in the Electric Power Industry in 2022 and 2023. Decree of the Government of the Russian Federation No. 999 dated June 01, 2012. (In Russ.) URL: <http://publication.pravo.gov.ru/Document/View/0001202206010030?ysclid=lxgus4o9z227009000> (accessed: 13.01.2025).

On Amendments to the Decree of the Government of the Russian Federation No. 1172 dated December 27, 2010. Decree of the Government of the Russian Federation No. 2389 dated December 29, 2023. (In Russ.) URL: <https://base.garant.ru/408323687/?ysclid=lxhxa7ty7t736108420> (accessed: 13.01.2025).

In [1], a roadmap is presented that outlines strategies for promoting green development through a hybrid approach. The authors identify 12 strategies, indicating that lower-level strategies are more significant than higher-level ones (Fig. 5). Based on this hierarchy, the researchers analyzed the extent to which Russia's energy development meets these criteria.

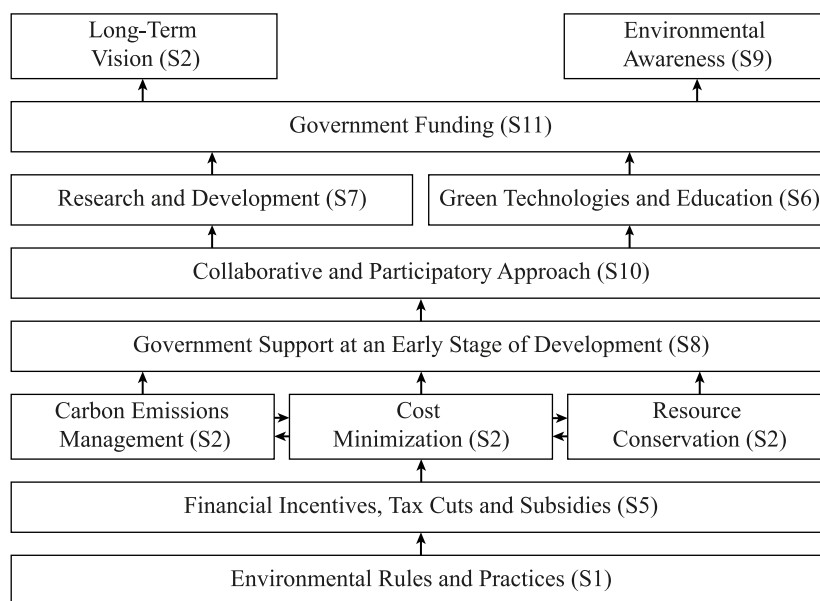


Fig. 5. Hierarchical structure of green innovation strategies [1]

The authors note that the fundamental basis of this structure is S1 “Environmental Rules and Practices” criterion. As mentioned above, Russia is a party to the Framework Convention, the Kyoto Protocol, and the Paris Agreement, having adopted all environmental rules and practices at the state level, as evidenced by the country's array of regulatory documents.

The next step in the proposed hierarchy is S5 “Financial Incentives, Tax Cuts and Subsidies”. The Russian Federation is the driving force behind the green transition, based on a public-private partnership. The Government of the Russian Federation²² has defined measures of state support to achieve real competitiveness of renewable energy technologies against fossil fuel-based energy production. These measures include preferential tariffs for the sale of electricity generated from renewable energy sources, tax credits, preferential loans, and the introduction of a green tariff in Russia to attract additional investments²³. From 2013 to 2021, the mechanism for supporting and stimulating the development of renewable energy sources has supported the commissioning of 121 power plants in Russia, including 83 SES, 27 WPP, and 11 sHPP. An important aspect here is the legal framework for the proportion of renewable energy sources in a country's overall energy mix.

As can be seen in Figure 5, the next most significant level is determined by three factors: S3 “Resource Conservation”, S4 “Cost Minimization” and S12 “Carbon Management”. Regarding S12, the Strategy²⁴ emphasizes that emissions management focuses primarily on their absorption by forests and swamps. Russia has a large number of forests and swamps, and there is a hypothesis that the absorption of greenhouse gases prevails over their release. The country has established a Unified national monitoring system for climatically active substances, and based on it, a National Cadastre has been created with information in a standardized international format for detailed verification of this hypothesis²⁵. By government decree, it was given the status of an innovative project of national importance²⁶.

²² The Main Directions of the State Policy in the Field of Increasing Energy Efficiency of the Electric Power Industry Based on the Use of Renewable Energy Sources for the Period up to 2035. Decree of the Government of the Russian Federation No. 1-r dated January 08, 2009. On Amendments to the Decree of the Government of the Russian Federation dated January 08, 2009. N 1-r. Decree of the Government of the Russian Federation No. 1446-r dated June 01, 2021. Legalact — laws, codes, and regulatory legal acts of the Russian Federation. (In Russ.) URL: <https://legalacts.ru/doc/rasporjazhenie-pravitelstva-rf-ot-01062021-n-1446-r-o-vnesenii/?ysclid=m7bge5ly4u984542445> (accessed: 13.01.2025).

²³ On Amendments to Certain Acts of the Government of the Russian Federation Regarding the Definition of the Specifics of Legal Regulation of Relations of Microgeneration Facilities Functioning. Decree of the Government of the Russian Federation No. 299 dated March 02, 2021. Official publication of legal acts. (In Russ.) URL: <http://publication.pravo.gov.ru/Document/View/0001202103060015?ysclid=m7bgl0kdf79000694> (accessed: 13.01.2025).

²⁴ On the Strategy of Socio-Economic Development of the Russian Federation with Low Greenhouse Gas Emissions until 2050. Decree of the Government of the Russian Federation No. 3052-r dated October 29, 2021. Electronic fund of legal and regulatory documents. URL: <https://docs.cntd.ru/document/726639341?ysclid=m7bgpyga7q176688002> (accessed: 13.01.2025). (In Russ.)

²⁵ In Europe, Everything was Cut Down. Russia has Become the Lungs of the Planet. RIA News. (In Russ.) URL: <https://ria.ru/20231011/poligon-1901702366.html?ysclid=ly5mwnjkql692557096> (accessed: 13.01.2025).

²⁶ On Approval of the Most Important Innovation Project of National Importance “Unified National Monitoring System for Climatically Active Substances” and the Action Plan (Roadmap) for the Implementation of the First Stage (2022-2024) of the Most Important Innovation Project of National Importance “Unified National Monitoring System for Climatically Active Substances”. Decree of the Government of the Russian Federation No. 3240-r dated October 29, 2022. Official publication of legal acts. (In Russ.) URL: <http://publication.pravo.gov.ru/Document/View/0001202211010041?ysclid=ly5ob08110614670035> (accessed: 13.01.2025).

Along with the measures commonly used in other countries, the Strategy also includes measures to restore previously drained wetlands, improve fire safety in wetlands and forests, develop forest infrastructure, expand afforestation areas, and more. Research into carbon sequestration using new integrated technologies for improving rural health is ongoing in various countries [5–14].

S8 level of “State Support at an Early Stage of Development” is proved by all the previous content of the article. In Figure 5, S11 “State Financing” level is located penultimate when moving up, that is, as a less significant strategy. However, the authors believe that it should be placed at the same level as S8, especially since S6 and S7 strategies are provided to a greater extent by S11, as indicated in the “Priority-2030”²⁷.

S6 “Green Technologies and Education” and S7 “Research and Development” strategies emphasize the importance of cooperation between higher education institutions and industry. Here we should mention the Priority 2030 program, implemented by the Ministry of Science and Higher Education of the Russian Federation since 2016. This program brought together 142 universities across the country to ensure their integrative contribution to achieving Russia's national development goals, including the development of technologies that will help eliminate the negative effects of anthropogenic impact. The implementation of this program is supported by the Association of Green Universities in Russia, which unites 214 university volunteer teams and clubs that are actively involved in environmental protection activities. The interregional environmental public organization EKA is actively implementing the program “Green Universities of Russia” for 2021–2026 in educational institutions in order to enhance the ecological culture of Russian society²⁸. While the emergence of sustainable environmental trends in Russian universities is encouraging, the country's lack of development in renewable energy sources has also led to a lack of educational programs for training specialists in alternative energy technologies. The training of highly professional engineers in the field of renewable energy, as rightly noted in the hierarchy in Figure 5, is possible only if S6 and S7 are included in S10 “Collaborative and Participatory Approach”. In this regard, it is worth mentioning the inclusion of the “Advanced Engineering Schools” initiative in the list of initiatives for socio-economic development of the Russian Federation until 2030²⁹. This initiative is part of larger programs such as “Low-Carbon Development Policy” and “Clean Energy (Hydrogen and Renewable Energy)”. The federal project “Advanced Engineering Schools” is aimed at training specialists for high-performance sectors of the economy. They are created on a common basis by universities and technology companies for the formation of platforms for joint scientific research and project training of students in accordance with the profile of partners. One of the thematic areas is electric and thermal power engineering. The work includes 50 universities across the country and 150 companies. An obligatory part of the project is to attract extra-budgetary funds. According to the Ministry of Education and Science, in 2022, the financing of all schools from the federal budget amounted to 2.5 billion rubles, and the partner companies of the schools confirmed co-financing for another 3.8 billion. In 2023, the total financing amounted to about 10 billion rubles, and in 2024 it was planned to allocate about 18 billion rubles³⁰. It is hoped that in the future, a platform will be selected to solve scientific and technical problems in the field of renewable energy and educational programs will be developed for training engineering personnel in this area [15, 16].

As for S2 “Long-Term Vision” and S9 “Environmental Awareness” strategies, we agree with the authors [1] that environmental awareness programs expand knowledge and understanding of sustainable development issues. The long-term vision provides a strategic framework for governments, financial institutions, and businesses to integrate sustainable development into planning.

Having gone through all the steps of the roadmap, we can make conclusions about the effectiveness of the proposed navigation by the authors [1], and the priority of factors by using the example of the Russian Federation. We can also identify the level of implementation of these strategies in Russia's movement towards sustainable development.

Discussion and Conclusion. In the Russian Federation, due to the abundance of natural resources and the development of nuclear power compared to many other countries, interest in the use of renewable energy for industrial purposes came later than in other countries. This delay in the introduction of renewable energy sources into the country's energy system is due to a number of reasons:

- 1) large natural reserves of fuel and energy resources;
- 2) significant reserves of combined power systems capacity;
- 3) operation of large hydroelectric power plants built in the USSR;
- 4) advanced nuclear power industry;
- 5) low prices and tariffs for electric and thermal energy.

²⁷ The “Priority 2030” Program. Sociocenter. (In Russ.) URL: <https://www.garant.ru/products/ipo/prime/doc/405491263/> (accessed: 13.01.2025).

²⁸ The Program “Green Universities of Russia” for 2021–2026. Moscow: Interregional Environmental Public Organization “EKA”; 2021. 54 p. (In Russ.) URL: <https://ecamir.ru/upload/medialibrary/5e3/03gawihqv0b752qc2u2kgvgzsz0h0r4h.pdf> (accessed: 13.01.2025).

²⁹ A List of Initiatives for the Socio-Economic Development of the Russian Federation until 2030. Decree of the Government of the Russian Federation No. 2816-r dated October 06, 2021. (In Russ.) URL: <http://static.government.ru/media/files/jwsYsyJKWGQQAaCSMGrd7q82RQ5xEC03.pdf> (accessed: 13.01.2025).

³⁰ Modern Professional Competencies. Sociocenter. (In Russ.) URL: <https://engineers2030.ru/?ysclid=ly5v13806u55404777> (accessed: 13.01.2025).

However, according to Russian experts, the potential of renewable energy sources in Russia is also quite high. They estimate that it is 178 times higher than the current level of energy consumption in the country. This fact determines the priority of developing renewable energy. Government policy today aims to eliminate the gap between the Russian Federation and other countries in terms of the number of solar and wind renewable energy sources. It also aims to create competitive advantages for green energy over fossil fuels. A legislative definition of the timing of the introduction of renewable energy shares into the country's energy mix could be of great importance.

The country has begun to make a transition to more active use of renewable energy sources. At the same time, we should not forget that progress in one segment inevitably leads to regression in another. This is actually proved by the previous development of the fuel and energy sector. Therefore, it is important to continue studying the entire process of switching to green energy. While the introduction of alternative energy sources does require the use of fossil fuels for production and transportation, the production and maintenance of renewable components can lead to an increased demand for rare earth minerals. This can affect the issue of exhausting natural resources. Large-scale energy production, especially for solar energy, requires large areas of land. The production of solar panels can also lead to greenhouse gas emissions. Renewable energy sources create toxic waste, for example, at Solar Energy, compared to nuclear power plants, there are hundreds of times more of them. There is a risk of solar panels catching fire. Their harmful effects on the environment and wildlife are also possible. They have a low efficiency, as well as a relatively short service life, and are expensive. Renewable energy sources have a high degree of dependence on natural conditions, and there are serious risks in ensuring the sustainability of their operation.

The negative aspects of the introduction and operation of renewable energy sources and the environmental danger they pose are widely discussed by scientists [17–20]. Scientific research is underway to determine the impact of renewable energy on the environment, and experts are looking for technologies to eliminate related negative factors and increase the capacity of power plants. Russian President Vladimir Putin³¹ also drew attention to the need for a phased and thoughtful movement towards green energy, noting, in particular, that green energy was actively developing, but it would not be able to cover all the needs of the global economy for a long time. The processes related to the introduction and stable functioning of green energy will take a lot of time, as they take place in stages, including the scientific justification of the explication of threats that arise from the use of renewable energy, and the identification of ways to eliminate them. Therefore, at the present time, while non-renewable energy sources continue to be used, it is essential to reduce greenhouse gas emissions, combat environmental pollution, preserve, restore and use nature carefully, and increase the ecological culture of production and the population.

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³¹ Putin Considered the Idea of Carbon-Free Energy Dangerous for Civilization. Products of the Interfax information group. (In Russ.) URL: <https://www.interfax.ru/russia/684902> (accessed: 13.01.2025).

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