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Prospects for the development of Russia's international cooperation with friendly countries in nuclear technology

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Abstract. This study analyzes the prospects for Russia's international cooperation in nuclear technology with friendly countries amid the global energy transition and geopolitical tensions. The relevance is justified by nuclear energy's growing role as a stable low-carbon source ensuring energy security and compensating for renewable intermittency. The study aims to identify competitive advantages of the Russian nuclear industry and key challenges to expanding its global presence under sanctions pressure. The methodology employs systematic and comparative analysis of IEA, IAEA, and Rosatom data, along with case studies of foreign projects. The results show Russia's global leadership in the number of nuclear power plants simultaneously constructed abroad. Rosatom's competitive advantages include technological superiority, lower construction costs compared to Western competitors, and flexible financial mechanisms such as intergovernmental loans and build-own-operate models. Particular attention is given to African markets, where demographic growth and energy deficits create demand for small modular and floating nuclear power plants. The discussion highlights the uniqueness of Russia's integrated approach combining turnkey solutions with local production localization and personnel training, fostering long-term technological dependence and political loyalty of partner countries. Challenges include growing competition from Chinese and Korean companies and the need to adapt technologies to developing economies' specific conditions. The conclusion emphasizes that in a multipolar world, nuclear energy serves not only as an energy transition tool but also as a lever for Russia's geopolitical influence, enabling high-tech export diversification and strengthening ties with Global South states. A distinctive feature of the study is its focus on the dual role of nuclear technologies as both a sustainable development driver and a factor shaping new international economic relations amid global fragmentation.

Keywords: global energy transition, energy security, low-carbon energy, African region, small modular reactors, floating nuclear power units, technological sovereignty, foreign partners

Contribution. All the authors participated in the development of the concept of this review, data collection, processing and analysis, drafted the manuscript, and formulated the conclusions.

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Перспективы развития международного сотрудничества России с дружественными странами в сфере атомных технологий

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Аннотация. Представлен комплексный анализ современного состояния и перспектив развития международного сотрудничества России в сфере атомных технологий с дружественными странами в условиях глобального энергетического перехода и усиления геополитической напряженности. Актуальность исследования обосновывается возрастающей ролью атомной энергетики как стабильного низкоуглеродного источника, способного обеспечить энергетическую безопасность и восполнить нестабильность возобновляемых источников энергии. Цель исследования — выявить ключевые конкурентные преимущества российской атомной отрасли и определить основные вызовы, препятствующие расширению ее присутствия на мировом рынке в условиях санкционного давления. Методологическую основу составили системный и сравнительный анализ данных Международного энергетического агентства, МАГАТЭ, отчетности Росатома, а также метод кейс-стади при рассмотрении зарубежных проектов. Результаты исследования демонстрируют, что Россия занимает лидирующие позиции в мире по количеству одновременно сооружаемых АЭС за рубежом. Конкурентные преимущества Росатома обусловлены не только технологическим превосходством и более низкой себестоимостью строительства по сравнению с западными аналогами, но и гибкими финансовыми механизмами, включая межправительственные кредиты и модели build-own-operate. Особое внимание уделено перспективам выхода на рынки Африки, где высокий демографический рост и дефицит энергоснабжения создают спрос на малые модульные и плавучие АЭС. В обсуждении подчеркнуто, что уникальность российской стратегии заключается в комплексном подходе, гибко сочетающем поставку технологических решений «под ключ» с возможностью локализации производств и подготовки национальных кадров, что формирует долгосрочную технологическую зависимость и политическую лояльность стран-партнеров. В числе вызовов продвижению российской экспансии по данному направлению выделены растущая конкуренция со стороны китайских и корейских компаний, а также необходимость адаптации технологий к специфическим условиям развивающихся экономик. Заключение резюмирует, что в условиях многополярного мира атомная энергетика становится не только инструментом энергоперехода, но и важным рычагом геополитического влияния России, позволяющим диверсифицировать экспорт высокотехнологичной продукции и укрепить связи с государствами Глобального Юга. Отличительная черта исследования — акцент на двойной роли атомных технологий, с одной стороны, как драйвера устойчивого развития, с другой стороны, как фактора формирования новой архитектуры международных экономических отношений в условиях фрагментации мировой экономики.

Ключевые слова: глобальный энергопереход, устойчивая энергетика, энергетическая безопасность, Африканский регион, малые модульные реакторы, плавучие атомные станции, экспортный потенциал, зарубежные партнеры

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Introduction

The rapid development of the global nuclear energy market is driven by increasing demand for low-carbon energy solutions, which is directly correlated with the issue of ensuring energy security at the national level and is a key component of the global energy transition towards sustainable and reliable electricity generation. As of 2024, the capacity of the global nuclear energy market is estimated at 400 gigawatts, and by 2028 it is projected to grow to 600 gigawatts [1].

In the context of the global energy transition, rapid technological progress, and geopolitical changes, Russia's interaction with friendly countries is becoming an important factor in ensuring energy security and sustainable development. Russia, possessing significant scientific potential and advanced developments in nuclear technology, actively participates in international cooperation, directing efforts to strengthen partnership relations with friendly countries. Such interaction aims to strengthen positions in the global nuclear energy market, enhance the safety and efficiency of using nuclear technologies, as well as jointly solve environmental problems and ensure sustainable development.

The purpose of the study is based on examining the features of the development of Russia's international cooperation in the field of nuclear technologies, to identify the competitive advantages of Russian developments and outline the main challenges to strengthening Russia's position in this market in the current context of intensifying inter-country contradictions and the tightening sanctions policies of unfriendly states.

Materials and Methods

To achieve this goal and solve research problems, a comprehensive methodological approach combining qualitative and quantitative analysis methods was applied. The choice of methodology is due to the multifaceted nature of the object of research, international cooperation in the field of nuclear technology, which includes legal, economic, technological, and geopolitical aspects.

The theoretical basis comprises the works of Russian and foreign scholars specializing in the study of nuclear energy, energy policy, and international economic relations. Researchers, including N.V. Gorin, B.K. Vodolaga, V.P. Kuchinov, V.V. Shidlovskiy [2], confirm that nuclear power plants (NPPs), despite high capital costs, provide competitive and clean generation in the long term. The particular potential for the decarbonization of Africa is noted in [3; 4], while the prospects of small modular reactors (SMRs) are analyzed in [5; 6]. Issues of regional development of industry in Asia, the EU, and BRICS are raised in [7]. The systematization and critical analysis of the literature allowed us to identify the extent to which the issues have been studied and determine research gaps related to Russia's positioning as a leading exporter of nuclear technologies under sanctions pressure.

The empirical basis of the study comprises official data and reports from the State Atomic Energy Corporation "Rosatom", statistical materials from the International Energy Agency (IEA) and the International Atomic Energy Agency (IAEA), regulatory legal acts and intergovernmental agreements regulating Russia's cooperation with friendly countries in the field of nuclear energy, as well as data from specialized industry publications and news agencies.

The research methods relied on qualitative and comparative analysis tools, as well as the case study method. The processing and interpretation of the results obtained were carried out using methods of logical generalization, classification, and synthesis. Tables and graphic materials were used to visualize the results. The limitations of the methodology are related to the limited availability of some commercial and technical details of ongoing projects, which required reliance on open official data and expert assessments. Furthermore, the dynamic nature of the geopolitical situation necessitates constant monitoring of changes in the regulatory framework and market conditions, which opens directions for further research.

The proposed methodological framework ensures the representativeness of the results obtained and allows for the formulation of well-founded conclusions about the competitive advantages and prospects for the development of Russia's international cooperation in the field of nuclear technology with friendly countries.

Results

Currently, a fundamental paradigm shift is occurring in the global nuclear energy market, driven by three main factors: technological progress, geopolitical changes, and the tightening climate agenda. On the one hand, there is a growing awareness of the need for a transition to low-carbon energy sources, which stimulates interest in nuclear generation as a stable and environmentally friendly alternative to fossil fuels. On the other hand, there is an expansion in the use of renewable energy sources (RES). This trend further highlights a key drawback of RES, which lies in the instability of generation and its direct dependence on weather conditions and time of day. Nuclear power plants, in contrast, provide base load for energy systems with a capacity factor of up to 90–92%, making them indispensable for guaranteed energy supply to industry and the population [8].

According to estimates by the International Energy Agency (IEA), the total capacity of the global NPP fleet, which was about 400 GW in 2024, could reach 600 GW by 2028 [1]. Particular attention is paid to the development of SMRs. According to IEA forecasts, with favorable political support, the capacity of such units could reach up to 80 GW by 2040, or about 10% of global nuclear generation [IEA][1]. SMRs are attractive due to lower capital costs, shorter construction times (3–5 years versus 10–12 for large units), and the possibility of phased capacity commissioning, which reduces financial risks for customers [5; 6].

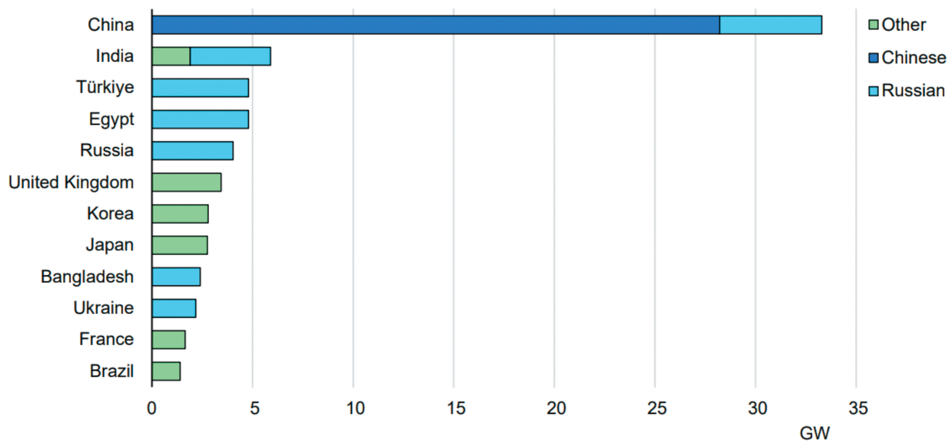
Cooperation in the field of peaceful atom extends beyond energy, covering scientific research, medicine, agriculture, and industry. The implementation of joint projects, such as NPP construction, development of innovative reactors, and personnel training, contributes not only to the technological development of partner countries but also to strengthening their energy independence. At the same time, nuclear energy is seen as a source of additional energy for global data centers: some US IT giants have begun investing in nuclear energy to solve

[1] The Path to a New Era for Nuclear Energy. *IEA.* Paris: IEA Publications; 2025.

the problem of increased electricity shortages needed to operate huge data centers[2]. Training large language models (LLMs) requires 10–100 times more energy than traditional computing. These factors are provoking increased competition in the world from companies in the nuclear energy sector.

Several key players dominate the global nuclear technology market: American Westinghouse Electric Company, French Framatome, Chinese CNNC, South Korean KEPCO, and Russian State Corporation "Rosatom". Each of these companies possesses a full cycle of NPP development and construction, while in terms of the volume of foreign order portfolio, Rosatom is the undisputed leader.

Nuclear energy currently produces less than 10% of the world's electricity. As shown in fig., Russia accounts for about 70% of the global market for NPP construction abroad: of the 59 power units whose construction began in the world after 2017, 28 units are being built using Russian technologies, and another 23 using Chinese ones [9].



Nuclear power capacity under construction by region and technology origin country (as of December 2024)

Source: made by Yu.V. Zvorykina, O.A. Pavlova, A.V. Sotnikova according to the data from the International Energy Agency[3].

This trend indicates the high competitiveness of Russian solutions, especially in the "turnkey" segment. Despite increasing sanctions pressure in recent years, Rosatom continues to implement projects, demonstrating flexibility and adaptability. The company is implementing a number of large-scale infrastructure projects for foreign partners, designed to provide them with reliable energy sources (Table).

[2] Amazon, Google make dueling nuclear investments to power data centers with clean energy. *The Seattle Times*. URL: https://www.seattletimes.com/business/amazon-google-make-dueling-nuclear-investments-to-power-data-centers-with-clean-energy/ (accessed: 29.12.2025).

[3] *International Energy Agency. Official website.* URL: https://www.iea.org (accessed: 29.12.2025).

Overseas projects implemented by Rosatom State Corporation

NPP (Country)	Terms	Number of Units	Capacity, MW	Construction Period	Cost, billion USD
Akkuyu (Turkey)	100% financing by Rosatom under build-own-operate terms	4	4800	2018–2027	23–24
El-Dabaa (Egypt)	EPC contract for construction + package of contracts for all subsequent services and NPP operation support. Loan provided by Russia covers 85% of the total amount	4	4800	2022–2028 (2030)	32
Rooppur (Bangladesh)	EPC contract. Loan from Russia covers 90% of the cost	2	2400	2017–2025 (2026)	12.6
Xudapu (China)	Design of power units by Rosatom and equipment supply. Construction and installation works carried out by China	2	2400	2021–2027 (2028)	1.7
Tianwan (China)		2	2400	2021–2026 (2027)	1.702
Kudankulam (India)	Phase 2: EPC contract and loan from Russia for 3.4 billion USD	2	2000	2017–2024	4
	Phase 3: EPC contract and loan from Russia for 4.2 billion USD	2	2000	2028–2029	6
Bushehr-II (Iran)	EPC contract. Phase 2 provides for a loan from Russia for 3.4 billion USD	2	2000	2019–2027	10
Paks-II (Hungary)	EPC contract for the second phase of NPP units. Loan from Russia for 10 billion euros	2	2400	2025–2030s	12.5 billion euros

Source: developed by Yu.V. Zvorykina, O.A. Pavlova, A.V. Sotnikova independently based on internet research.

Rosatom's portfolio of foreign orders includes projects in Turkey, Egypt, Bangladesh, China, India, Iran, and Hungary. The geographical diversification of orders allows Rosatom to accumulate unique experience in implementing projects in various climatic, seismic, and regulatory conditions, which strengthens its competitive position. The advantage of nuclear power plants is that they feature relatively low electricity generation costs at large volumes of generation, and their environmental footprint (considering proper waste disposal) is significantly lower than that of traditional thermal power plants. In addition to large stations, Rosatom is actively developing medium and small power projects, including floating NPPs (FNPP), which allows:

- Quickly organize electricity supply to regions with underdeveloped infrastructure;
- Reduce construction volumes and commissioning times;
- Ensure mobility of energy solutions and their adaptation to regional conditions.

Let us examine in more detail the technical specifics of project implementation in the industry. One of Rosatom's competitive advantages is the already operational FNPP "Akademik Lomonosov", which has been providing electricity to the town of Pevek in Chukotka since 2019[4]. It generates up to 76 MW of electric power and 146 Gcal/hour of thermal energy, allowing it to supply energy not only to residential areas but also to important industrial facilities in the region. This is the world's first FNPP specifically designed to operate in remote northern regions where traditional forms of energy are less efficient or difficult to build. The plant operates using KLT-40S type reactors, which have a reliable safety system that prevents leaks of radioactive materials even in extreme conditions.

"Akademik Lomonosov" can provide energy not only to cities with a population of 100,000 people but also to industrial facilities, including mining operations and the Northern Sea Route infrastructure[5]. This is a key project that shows how nuclear energy can contribute to economic development and improved living conditions in remote areas, independent of external energy systems and ensuring stable energy supply.

An important additional function of the FNPP is seawater desalination — the unit can produce up to 240,000 m^3 of fresh water per day, which is critically important for arid coastal regions[6]. The market potential of this technology is enormous, as the global desalination market exceeds $15 billion USD, and about 40% of the world's population experiences drinking water shortages.

Rosatom can also export the safest and newest VVER-1200 reactors, which are equipped with safety systems capable of ensuring their operation for 72 hours without electricity, "core catchers", etc. The Akkuyu NPP could

[4] Floating nuclear thermal power plant (TPP) in Pevek. *Rosenergoatom: official website.* URL: https://www.rosenergoatom.ru/stations_projects/sayt-pates/ (accessed: 29.12.2025). (In Russ.).
[5] Ibid.
[6] Ibid.

become a reference in terms of seismic stability in the future, as it is designed to withstand record earthquakes of magnitude up to 9 and other extreme natural phenomena[7].

The RITM-200 reactor developed by Rosatom, previously used on icebreakers, is becoming the basis for new land-based and floating stations. Its power is up to 55 MW in a two-reactor configuration; this volume is optimal for power supply to isolated territories, mining clusters, and port infrastructures. An important advantage is the factory readiness of the modules, which reduces on-site installation time to 2–3 years.

According to IEA estimates, by 2040, the total capacity of SMRs in the world could reach 80 GW. Russia, possessing a working reference sample and serial production of reactors, has every chance to capture a significant share of this market. Moreover, serial production allows reducing the unit cost of units by 30–40% compared to the prototype due to the learning curve effect [6].

Analysis of the projects implemented by Rosatom allows us to identify systemic factors ensuring the leadership of the Russian nuclear industry in the global market:

1. **State support and flexible financing —** reduces the financial burden on the customer and makes Russian offers more attractive compared to commercial loans from Western banks;
2. **Low construction cost —** specific capital costs for constructing Rosatom's power units are about $2000 USD per kW of installed capacity, whereas for Western competitors this figure reaches $5000–5500 USD/kW;
3. **Technological superiority —** availability of a wide range of technological solutions ensuring a high level of safety and automation, as well as the possibility of compact installation;
4. **Comprehensive approach** — Rosatom offers customers not just "turnkey" construction, but a full life cycle: supply of nuclear fuel, maintenance, spent fuel reprocessing, training of national personnel.

In the 21st century, a reliable energy supply system is the foundation of sustainable economic growth and technological development. The transition to digital technologies, industrial development, transport infrastructure, social sphere, and healthcare systems — all require stable access to electricity.

The most promising region for the expansion of Russian nuclear technologies in the coming decades is Africa. The continent has colossal demographic potential: about 45% of the continent's population is under 14 years old, while the average age is about 18.6 years, with prospects of growing

[7] *Akkuyu nuclear.* URL: https://akkuyu.com/ru/safety (accessed: 29.12.2025).

to 24.4 years by 2050. Rapid population growth and urbanization require a multiple increase in electricity generation. At the same time, today more than 600 million Africans lack access to electricity, and in rural areas this figure reaches 80% [3; 4].

According to the International Energy Agency, Africa accounts for only 6% of global energy consumption[8]. Energy demand in the region is growing, but per capita energy consumption remains one of the lowest in the world, despite the continent's rich energy resources [1; 8]. This phenomenon is explained by the dependence of many countries on the continent on imports of oil and gas, making them vulnerable to fluctuations in world energy prices.

Another problem is that most African states depend on generation from hydroelectric power plants and thermal power plants. However, these sources face a number of problems:

- Instability of water resources for HPPs due to seasonal fluctuations and droughts;
- High cost and unstable supply of hydrocarbon fuels;
- Environmental constraints, including growing attention to reducing harmful emissions.

In these conditions, small and medium-sized nuclear power stations offer an optimal solution. Advantages of SMRs for Africa:

- Siting flexibility — modular units with power from 10 to 300 MW can be built in remote areas without developed grid infrastructure;
- Fast construction times — 3–5 years versus 10–15 years for large NPPs;
- Risk minimization — smaller amount of radioactive material and passive safety systems reduce the likelihood of severe accidents and simplify regulatory oversight;
- Desalination capability — floating NPPs can be both a source of energy and clean drinking water.

According to expert estimates, by 2035, Africa could commission up to 15 GW of nuclear capacity, of which at least 30% will come from SMRs [10]. Beyond the direct export of energy technologies, cooperation in the nuclear sphere opens new horizons for the digital economy and financial innovations. The reliability and round-the-clock nature of nuclear generation make it ideal for powering data centers, which are being actively built in Africa. Furthermore, the development of algorithmic trading and tokenization of commodity assets creates prerequisites for issuing digital

[8] International Energy Agency. Africa. *IEA: official website*. URL: www.iea.org/regions/africa (accessed: 29.12.2025).

currencies backed by kilowatt-hours of nuclear energy. This instrument could serve as an additional source of financing for the industry and local personnel training.

Russia needs to timely carve out its niche in the field of nuclear energy on the African continent. The capacity of nuclear power stations is most efficient, while resources from other sources are insufficient and lack stability. The nuclear program can act as a conduit for projects with Russian participation in Africa. Cooperation with foreign countries may include not only the supply of Russian equipment and technologies but also the formation of joint ventures, localization of certain production stages, training of local personnel, and organization of scientific and technical centers. Such an integrated approach helps strengthen bilateral ties and jointly develop technological potential.

Discussion

The obtained results confirm Russia's global leadership in the nuclear industry. Rosatom's extensive portfolio of foreign orders, including 28 out of 59 units being built worldwide, correlates with forecasts for the growth of the global nuclear fleet [1] and aligns with conclusions about the role of nuclear technology exports in sustainable development [9]. The competitive advantages of Russian nuclear technologies identified by the authors, consisting of low construction costs, flexible financing, and technological superiority, complement the findings of previous scientific research on the importance of reducing capital costs for the competitiveness of nuclear generation [2; 5].

Special potential has been identified in the segment of small modular reactors and floating NPPs. The experience of the FNPP "Akademik Lomonosov" confirms the possibility of cost reduction through serial production [6] and opens prospects for energy supply and desalination in Africa, which corresponds to the assessments of foreign researchers regarding the demand for nuclear technologies on the continent [3; 4]. The main challenges remain competition from China and the need for adaptation to local conditions [1; 7]. The scientific contribution of this work lies in systematizing the factors that turn nuclear cooperation into a tool for long-term geopolitical influence in the context of the fragmentation of the global economy.

Conclusion

In the context of the formation of a multipolar world, Russia's international cooperation in the nuclear sphere acquires not only economic but also geopolitical significance. Russia's cooperation with foreign countries on nuclear energy development helps strengthen economic, political, and cultural ties, including increasing the competitiveness of the Russian nuclear industry on a global scale, developing key sales markets and raw material suppliers for Russia, and strengthening Russia's reputation as a reliable and long-term partner.

In the context of the Russian economy's focus on the export of raw materials such as oil and gas, Rosatom's activities stand out as an example of successful export of high-tech products. The company's key advantages include competitive Russian technologies covering the full cycle of NPP project implementation, from design to operation, which strengthens its image as a reliable technological leader.

Rosatom is actively developing international projects for the construction of nuclear power plants, demonstrating a wide geographical scope of activity. Creating a network of Russian NPPs of various capacities in Africa is intended to become an economic integration lever that will allow implementing joint projects not only in energy but also in industry, transport, and digitalization. The successful implementation of current projects and timely development of new markets, primarily the African one, will ensure the further strengthening of Russia's position in the global energy technology market and expand its contribution to the global energy transition.

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