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The Dawn of the Peaceful Atom: Prerequisites for the Intergovernmental Agreement and Prospects for Cooperation between the Russian Federation and Vietnam in the Field of Nuclear Energy Use

This article examines the current state and future trajectories of the Russian-Vietnamese partnership in nuclear power engineering, with a particular focus on the construction of nuclear power plants (NPPs). The current stage of cooperation between the two countries is reflected in plans to construct Vietnam's first nuclear power plant, the Ninh Thuan-1 NPP. The impact of the Ninh Thuan-1 NPP on the Vietnamese economy is anticipated to be multifaceted. The article considers the historical roots of bilateral interaction and analyses in detail the key provisions of the Intergovernmental Agreement governing the full scope of activities, from design to spent fuel management and personnel training. Particular attention is driven to the engineering parameters of the Generation III+ VVER-1200 reactor unit, its environmental performance and economic viability. The main feature of the VVER-1200 project is the unique combination of active and passive safety systems that make the plant as resistant as possible to external and internal impacts. A forecast assessment is provided of the plant's impact on Vietnam's fuel and energy balance, greenhouse gas emission reduction, the development of related industries, and regional infrastructure. The strategic importance of nuclear generation in the context of ESG principles and the green square concept is substantiated. It is concluded that implementation of the project will strengthen Vietnam's energy security, while enabling the Russian Federation to consolidate its presence in the high-tech Asian market.

Keywords: *nuclear power plant (NPP), Socialist Republic of Vietnam, Russian Federation, VVER-1200, Ninh Thuan-1, intergovernmental agreement, nuclear safety, economic multiplier, ESG, green energy, technology transfer*

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INTRODUCTION

Historical ties between Russia and Vietnam span decades of productive cooperation across various sectors, including oil and gas, automotive manufacturing, and military collaboration. The oil and gas industry, one element of the strategic partnership, is based on long-standing experience since 1975 and joint activities on the shelf of the South China Sea. On the Russian side, the main market player is Zarubezhneft. In addition, cultural and educational ties remain strong. Thousands of students have been educated at universities of the USSR, including MISI (now NRU MGSU). Tourism, as a rapidly developing area of business activity, should also be mentioned. In 2025, 690 thousand Russian tourists visited Vietnamese resorts. Over the first four months of 2026, Vietnam received 504,389 Russian travelers, indicating a four-fold increase compared with the same period in 2025.

The current stage of bilateral interaction is reflected in plans to build Vietnam's first nuclear power plant, the Ninh Thuan-1 NPP (Fig. 1, 2) which represents the second attempt by both countries to implement such an ambitious project [1, 2]. This step has specific features that make it strategically important both for Vietnam's energy future and for strengthening Russia's position in the international nuclear energy arena [3]. Importantly, Vietnam's nuclear power industry develops against the backdrop of the increasing importance of the global ESG agenda [4, 5].

The purpose of this paper is to analyse the provisions of the Intergovernmental Agreement and the engineering characteristics of the plant under construction, to assess the economic, environmental, and social effects of Russian – Vietnamese cooperation in the peaceful use of nuclear energy, and to substantiate the role of the NPP as a driver of integrated development not only in adjacent territories but also in nearby provinces.

CHARACTERISTICS OF THE NINH THUAN-1 NPP AND VVER-1200 REACTOR EQUIPMENT

The formula used to calculate the capacity factor (*CF*) is as follows:

$$CF = E_{act}/E_{nom} \cdot 100\ \%,$$

where *CF* is usually calculated for one calendar year;
E_{act} is actual electricity generated over the period (kWh);
E_{nom} is nominal reactor power (kW) multiplied by the number of hours over a period.

This factor is important for evaluating the efficiency of power plants (NPPs, TPPs, HPPs, and SPPs), as it determines the extent to which actual electricity generated over a period corresponds to the maximum possible output. Knowledge of this factor makes it possible to assess the profitability of a generating station, the actual load of equipment, and the efficiency of fuel use in the case of NPPs and TPPs.

Table 1. Main technical characteristics of the VVER-1200 reactor

Parameter	Value
Reactor type	Pressurised water — water power reactor
Thermal power	3,220 MW
Electrical power	1,200 MW
Fuel	Uranium dioxide (U-235) with a maximum enrichment of 4.95 %
Number of primary coolant circulation loops	4
Number of steam generators	4
Coolant temperature at reactor inlet	298.2 °C
Coolant temperature at reactor outlet	328.9 °C
Primary circuit pressure	16.2 MPa
Secondary circuit pressure	7 MPa
Primary circuit coolant consumption rate	86,000 m^3/h
Steam output of steam generators	6,400 t/hour
Design service life	At least 60 years (extendable by 20 years)
Capacity factor	> 90 %
Power plant efficiency	37 %

Fig. 1. Sketch of the future Ninh Thuan-1 NPP

For example, the *CF* is 90 % for Russian nuclear generation, approximately 40 % for hydroelectric power plants, and 29–35 % for gas- and coal-fired generation.

TECHNICAL DESCRIPTION OF THE NPP

According to Article 2 of the Agreement between the Government of the Russian Federation and the Government of the Socialist Republic of Vietnam on Cooperation in the Construction of a Nuclear Power Plant on the Territory of the Socialist Republic of Vietnam [1], the Russian Federation assumes the following obligations:

1. The Parties shall cooperate in the construction, on the territory of the Socialist Republic of Vietnam, of the Ninh Thuan-1 nuclear power plant (hereinafter referred to as the NPP) on a turnkey basis, consisting of two Generation III+ power units based on a water-water power reactor according to the Russian design, with an installed capacity of each power unit of up to 1.3 GW, based on the reference design of the Leningrad NPP-2 and the improved technology of water-water power reactors [2] (Table 1).

2. The cooperation provided for in this Agreement includes:

• updating the feasibility study and the site approval dossier;

Fig. 2. Construction site of the Ninh Thuan-1 NPP

- conducting engineering surveys at the NPP site for the development of NPP design documentation;
- conducting an environmental impact assessment;
- design, construction, and installation of NPP equipment;
- supply of the necessary equipment and materials;
- use of digital tools, including software and infrastructure, throughout the entire period of design, construction, and operation of the NPP;
- supply of nuclear fuel;
- commissioning of the NPP, including start-up and adjustment works;
- warranty operation of the NPP;
- management of spent nuclear fuel and radioactive waste throughout the entire period of NPP operation;
- decommissioning and dismantling of the NPP;
- training of personnel for the construction, operation, and maintenance of the NPP;
- operation, maintenance, repair, modernisation, and reconstruction of the NPP;
- safety regulation and related support measures for radiation and nuclear safety throughout the entire NPP operation period;
- improvement of the NPP infrastructure necessary for the construction and operation of NPP power units;
- development of the state safety regulation system for the use of atomic energy for peaceful purposes, necessary for the implementation of the national nuclear energy programme of the Socialist Republic of Vietnam;
- establishment of a physical protection system for the main and auxiliary NPP facilities;
- cooperation in the field of localisation and transfer of knowledge concerning the construction, operation, and maintenance of the NPP and the development of nuclear infrastructure, in accordance with agreements (contracts) to be concluded under this Agreement;
- response to radiation and nuclear incidents and emergencies;
- other areas of cooperation as may be agreed by the Parties in writing.

The above provisions are necessary for understanding the scale of cooperation between the two countries.

The planned NPP will have Generation III+ VVER-1200 reactors, which are known for their high environmental safety and efficiency.

Compared with traditional power units of the same type, the VVER-1200 design has a number of strengths that greatly improve its economic performance and safety (Fig. 3). For example, the reactor unit capacity has increased by 20 % compared with the previous generation (VVER-1000), staffing requirements have been reduced by 30 %, and the design service life of the main equipment has doubled to 60 years, with the possibility of extension by another 20 years.

The main feature of the VVER-1200 design is its unique combination of active and passive safety systems, which makes the plant extremely resistant to external and internal impacts. In particular, the VVER-1200 unit uses a “core catcher”, a device for localising the molten core of a nuclear reactor; a system of heat dissipation through steam generators, designed to ensure long-term heat removal from the reactor core to the atmosphere in the event of a complete loss of all power supplies; inner and outer containment shells

Fig. 3. Diagram of the reactor unit with a VVER-1200 reactor

constituting the hermetic zone; a passive heat removal system on the dome with hydrogen recombiners; and electromagnets that hold the absorber rods, which fall into the core under gravity when the NPP is de-energised. Thus, a number of safety systems do not require human intervention and operate under gravity. According to the project description, no operating plant in the world is equipped with such a configuration of safety systems [2].

ECONOMIC COMPONENT: CONTRIBUTION OF THE NPP TO VIETNAM'S NATIONAL ECONOMY

The impact of the Ninh Thuan-1 NPP on Vietnam's economy is expected to be multifaceted. First, it is expected to create new jobs both during the construction period, with peak employment of up to 15–18 thousand employees, and after commissioning, with approximately 2–2.5 thousand highly qualified specialists. Second, project implementation will stimulate investment in infrastructure and related industries, including road networks, port facilities, power transmission lines, building materials production, and logistics. Third, lower electricity tariffs resulting from the introduction of nuclear generation, with costs of approximately 4–5 cents per kWh compared with 6–7 cents at coal-fired TPPs, will increase the competitiveness of the national economy, particularly for energy-intensive industries.

One of the key values used to support decisions regarding the construction and operation of an NPP is the Levelized Cost of Energy (LCOE), which takes into account all types of NPP life-cycle costs, including design, construction, operation, and decommissioning. In practice, this value is used to calculate the cost of electricity, and this calculation is relevant not only for NPPs but also for any type of electricity generation.

LCOE is calculated as the ratio of the present value of total costs over the entire service life of the facility to the present value of all electricity produced over that period. It takes into account:

- capital expenditures (CAPEX), or capital costs for construction and purchase of equipment;
- operating and maintenance expenditures (OPEX), or costs of operation, repair, nuclear fuel, insurance, and taxes;
- financial costs, or interest on loans and project financing;
- decommissioning and dismantling costs at the end of service life;
- electricity generation, or the output over the life cycle, taking into account maintenance periods for nuclear fuel replacement;
- discount rate that accounts for the time-dependent value of money and inflation;
- planning period which is the service life of the capital asset; in the case of a VVER-1200 NPP, this is 60–80 years.

Formula:

$$LCOE = [\sum ((I\_t + M\_t + F\_t))/((1 + r)^t))]/(\sum E\_t/((1 + r)^t)),$$

where I_t denotes investment costs in year t;
M_t denotes operating and maintenance costs in year t;
F_t denotes fuel costs in year t;
E_t denotes electricity generation in year t;
r denotes the discount rate;
t — the life cycle of the system.

For a quantitative assessment of the economic effect, a multiplier is calculated using the methodology tested in the Akkuyu and El-Dabaa projects. The cost of constructing two VVER-1200 units is estimated at USD 10 billion (USD 5 billion per unit). The multiplier coefficient for the customer country, Vietnam, is taken as 1.4–1.5. In this case, the total contribution to Vietnam's GDP from direct, indirect, and induced effects is expected to reach approximately USD 14–15 billion during the construction period and the first years of operation (Table 2).

Table 2. Projected economic effects of the construction of the Ninh Thuan-1 NPP (two units)

Indicator	Value	Note
Total capital investment, billion USD	10–11	Including auxiliary infrastructure
Direct employment during peak construction, thousand persons	15–18	Including rotational staff and local residents
Permanent NPP staff, thousand people	2.0–2.5	Operators, engineers, and security personnel
Employment in related sectors, thousand people	8–10	Logistics, construction industry, and catering
Cumulative increase in Vietnam's GDP (over 10 years), %	+1.8–2.2	By analogy with projects in Turkey and Egypt
Reduction in the average-weighted wholesale electricity price by 2035, %	10–15	After design capacity is reached
Savings on coal and gas imports over 60 years, billion USD	45–55	Assuming constant fuel prices

Thus, the Ninh Thuan-1 NPP serves not merely as an electricity generator but also as a powerful driver of economic growth, job creation, and technological development for Vietnam.

ENVIRONMENTAL ASPECTS AND ROLE IN SUSTAINABLE DEVELOPMENT

In the context of global climate change, nuclear energy is considered one of the least polluting sources of electricity. According to international rankings, Vietnam is among the countries with a rapidly increasing carbon footprint, with CO_2 emissions growing by more than 5 % per year [6]. Coal-fired thermal power plants account for more than 50 % of generation, which creates serious environmental problems [7, 8].

An analysis of current greenhouse gas emissions and their possible reduction after the NPP is commissioned shows that replacing coal generation with nuclear power would prevent the emission of about 7 million tons of CO_2 per year per unit, assuming a capacity factor of 90 %. The two units of the Ninh Thuan-1 NPP would prevent the emission of approximately 14 million tons of CO_2 annually, which corresponds to about 5 % of the current emissions of Vietnam's entire energy sector [9, 10] (Table 3).

It is important to note the inclusion of nuclear energy in the so-called Green Square, a classification of sustainable sources recognised by the European Commission in the Taxonomy (2022) and supported by the IAEA. This opens access to "green" financing and increases the investment attractiveness of the project. The environmental advantages of nuclear energy should serve as an additional argument in favour of increasing its share in Vietnam's energy balance [11, 12].

Consequently, nuclear generation is comparable to renewable sources in terms of life-cycle emissions and is practically zero-emission during operation, while providing baseload power 24/7 without the need for storage systems [12].

CAPACITY DEVELOPMENT AND EDUCATIONAL INITIATIVES

To ensure reliable and safe operation of the NPP, a system for training specialised personnel must be established. The Intergovernmental Agreement provides for largescale educational initiatives. The Russian side undertakes to:

- allocate annual quotas for Vietnamese citizens at leading Russian industry-specific higher education institutions, including NRU MGSU, NRU MEPhI, Bauman Moscow State Technical University, and Peter the Great St. Petersburg Polytechnic University;
- organise internships for operating personnel at operating Russian nuclear power plants, including Novovoronezh and Leningrad NPPs, for at least 500–700 specialists in the five years before the plant starts operation;
- create a fullscale simulator (FSS) of the VVER-1200 at the Ninh Thuan-1 NPP site for operator training;
- develop training courses in nuclear physics, radiation protection, and automated control systems in the Vietnamese language.

By the time the first unit is commissioned, Vietnam is expected to have at least 600–800 qualified specialists capable of independently operating and maintaining the plant. This will lay the foundation for

Table 3. Specific CO_2-eq emissions for different types of power plants over the full life cycle

Source type	Emissions, g CO_2-eq/kWh
Coal (subcritical)	820–1,000
Gas (steam and gas unit)	380–490
Photovoltaic panels	30–60
Wind power generation	7–20
Nuclear energy (VVER-1200)	8–20
Hydraulic power plant	10–50

Source: IPCC (2022), NEA (2023), calculations for VVER-1200 [9–11].

further development of the national nuclear energy industry and possibly for the export of expertise to other ASEAN countries.

PROSPECTS FOR HEAVY INDUSTRY

The construction of an NPP has a positive effect on the development of related industries, including the production of specialised equipment and the provision of services. The transfer of technologies and know-hows, specified in Article 2 of the Agreement, will allow Vietnam to increase its own capacities for subsequent projects and to enter international markets.

Within the framework of the localisation policy, it is planned to:

- involve Vietnamese contractors in the performance of "non-nuclear" activities, including concreting, rebar installation, cable laying, and earthworks, as well as in the supply of materials and equipment not assigned to nuclear safety classes, accounting for up to 30–40 % of the total construction cost;
- establish joint ventures for the production of special construction materials, including high-density concrete and seismic-resistant structures;
- organise logistics hubs and port infrastructure for receiving largesized equipment;
- in the future, organise licensed production of individual components for small modular reactors.

For Vietnam, this means a transition from being an importer of technologies to becoming an adaptor and, potentially, an exporter of engineering services to the markets of Laos, Cambodia, and Indonesia.

ENSURING REGIONAL ENERGY SECURITY AND EXPORT POTENTIAL

Given the growth in energy consumption, with Vietnam showing an annual increase in electricity consumption of 8–10 %, the country requires stable sources of electricity. In addition to meeting domestic demand, the use of nuclear energy creates the potential for electricity exports to neighbouring countries, including Laos, Cambodia, Thailand, and the southern provinces of China. This direction could become a strategic instrument for strengthening energy security across the entire region.

Against this backdrop of increasing investment in the nuclear sector, the Russian side also gains a strategic advantage by strengthening its position in the Asian market. The Ninh Thuan-1 project serves as a showcase for Russian Generation III+ technologies for other ASEAN countries, demonstrating the reliability, safety, and economic efficiency of the VVER-1200 in tropical operating conditions, alongside the Akkuyu NPP currently under construction in the Republic of Turkey.

CONCLUSION

Cooperation between the Russian Federation and Vietnam in the field of nuclear energy, embodied in the Ninh Thuan-1 NPP project, opens up new opportunities for both parties. It will contribute to Vietnam's sustainable development by ensuring energy independence, reducing greenhouse gas emissions, creating highly skilled jobs, and developing related industries, while also providing impetus for deeper cooperation in education, science, and industry. The Russian Federation, in turn, will consolidate its position in the rapidly growing Asian market, replicate the successful turnkey export model of nuclear technologies with a full life cycle, and establish the foundation for a long-term strategic partnership with the Socialist Republic of Vietnam.

The implementation of the Ninh Thuan-1 project will become a tangible embodiment of the "dawn of the peaceful atom" in Southeast Asia and will confirm Russia's leadership in the global nuclear energy industry.

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Рассвет мирного атома. Предпосылки заключения Межправительственного соглашения и перспективы развития сотрудничества Российской Федерации и Вьетнама в области использования атомной энергии

В публикации анализируется текущее состояние и будущие траектории российско-вьетнамского партнерства в области ядерной энергетики с фокусом на возведение атомной электростанции. Современный этап взаимодействия двух стран находит отражение в планах строительства первой АЭС (Ниньтхуан-1) во Вьетнаме. Воздействие АЭС «Ниньтхуан-1» на экономику Вьетнама будет носить многосторонний характер. В статье рассмотрены исторические корни взаимодействия сторон, детально разобраны ключевые статьи Межправительственного договора, регламентирующего полный спектр работ — от проектирования до утилизации отработавшего топлива и повышения квалификации персонала. Углубленное внимание уделено инженерным параметрам реакторной установки ВВЭР-1200 (III+ поколение), ее экологической составляющей и экономической рентабельности. Главной особенностью проекта ВВЭР-1200 является уникальное сочетание активных и пассивных систем безопасности, делающих станцию максимально устойчивой к внешним и внутренним воздействиям. Представлена прогнозная оценка воздействия станции на топливно-энергетический баланс Вьетнама, сокращение эмиссии парниковых газов, эволюцию вспомогательных производств и региональной инфраструктуры. Обоснована стратегическая значимость атомной генерации в контексте ESG-принципов и концепции «зеленого квадрата». Сделан вывод, что реализация данного проекта укрепит энергобезопасность Вьетнама, а Российская Федерация упрочит свое присутствие на высокотехнологичном азиатском рынке.

Ключевые слова: *атомная энергостанция (АЭС), Социалистическая Республика Вьетнам, РФ, ВВЭР-1200, «Ниньтхуан-1», межправительственный договор, ядерная защищенность, хозяйственный мультипликатор, ESG, зеленая энергетика, трансфер технологий*

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