Nuclear power plants construction in developing countries as a leading direction of Russia's foreign economic interests in the global construction services’ market in the globalization context

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Abstract. The article is devoted to the problem of nuclear power plants construction in developing countries as one of the main directions in Russian foreign economic policy in the international construction services’ market in the globalization context. The purpose of the article is to analyze the current situation and to determine the prospects of the Russian Federation in the world market of nuclear building construction services. The research methodology is based on an integrated approach and includes the special methods: content analysis of scientific literature and legislative acts; analysis of statistical data, as well as a retrospective analysis method. In the article it is proved that the Russian Federation has all the necessary resource and the technological capabilities to strengthen its position in the world market of nuclear building construction services in the developed countries of the European Union, even under the sanctions imposed on the Russian Federation by these countries.

1. Introduction

In modern conditions, the world community needs energy at an enormous pace to ensure economic growth and development. At the same time, the existing problems of climate change and the prices’ instability for fossil fuels predetermine the need to find energy sources that would not only meet increasing needs, but also could ensure environmental safety and the ability to abandon fossil fuels, such as coal or oil.

Focusing on the above problems, it can be clearly stated that there are two options for energy sources that meet the environmental safety requirements and efficiency - renewable energy sources (RES) and sources based on atomic energy - nuclear power plants. Renewable energy sources, with all its positive aspects, have several main drawbacks - the lack of an adequate number of developments, the inability to use in certain regions and the need for huge financial investments. Nuclear power plants (NPPs), as an effective energy source, have long established themselves on the positive side: the number of accidents at nuclear power plants is minimal.

It is not surprising that about 60 countries of the world, according to the International Atomic Energy Agency (IAEA), have expressed interest in considering, actively planning or expanding nuclear energy for economic goals. A large proportion of these countries are in developing countries. At the same time, developing countries during design and survey, development work, reconstruction and construction of nuclear energy facilities are guided by Russian experience on this field.

This is due to the fact that the Russian Federation, the only country in the post-Soviet space, managed to preserve not only experience and knowledge in the field of nuclear power plant
construction, but also continued to improve the technology and the theoretical approach to construction in the nuclear industry itself.

So, at the time of 2020, out of nine NPPs being built by the Russian Nuclear State Corporation “ROSATOM” abroad. Seven NPPs were in developing countries (China, Turkey, Egypt, Belarus, Bangladesh, India) and only two in the countries of the European Union (EU) - Finland and Hungary [17]. Therefore, it should be noted that the construction of nuclear power plants in developing countries for the Russian Federation is the leading direction of foreign economic interests in the world market of construction services in the globalization context.

However, the demand for Russian construction services in the field of nuclear construction in developing countries should not impede the Russian Federation’s access to the construction of nuclear power plants in developed countries, even taking into account the anti-Russian sanctions introduced by many of them. Therefore, in the framework of this study, the author analyzes the prospects of the Russian Federation on the world market of nuclear building construction services taking into account the country's leading foreign economic interests - the construction of nuclear power plants in developing countries and the expected development direction - the construction of nuclear power plants in the developed EU countries.

2. Materials and methods
The leading direction of the Russian foreign economic interests of the Russian Federation on the world market of construction services was determined by analyzing and summarizing statistics: data from the official websites of the Russian Nuclear State Corporation “ROSTATOM” and materials from websites of foreign countries where nuclear power plants are being built.

The data contained in official studies by the IAEA and the International Energy Agency (IEA) made it possible to identify the need for developing countries in Russian construction services. To put forward the hypothesis that the Russian Federation, taking into account its experience and resource capabilities, has prospects for developing nuclear energy facilities in the EU construction market, the method of incomplete induction was used, which consists in monitoring individual particular cases - the construction of nuclear power plants in Hungary and Finland.

3. Results
The construction of nuclear power plants is noted in the Strategy for the Development of Services’ Export until 2025, approved by Decree of the Government of the Russian Federation of August 14, 2019 No. 1797-p [1] as the main direction of Russian export of construction services. And, according to the author of this article, this is not accidental.

| Year | CIS  | China | EU   | Bangladesh | Turkey |
|------|------|-------|------|------------|--------|
| 2016 | 1640 | 169.3 | 1056 | 100        | 510    |
| 2017 | 1030 | 178.8 | 1680 | 124        | 642    |
| 2018 | 1164.1 | 187.3 | 1230 | 131        | 689    |
| 2019 | 1432.9 | 231.1 | 1380 | 128        | 721    |

Figure 1. The main exporters of Russian construction services in nuclear energy 2016-2019 (million dollars).

About 20% of the revenue from the export of services to the budgets of the budget system of the Russian Federation comes from the construction of nuclear facilities in foreign countries. Statistical data for 2016-2019 show that the largest share of such income comes from the CIS countries, Turkey and China [1] (figure 1).
However, the presence of stable revenues from the export of construction services of nuclear facilities does not only mean that the Russian foreign economic interests in the world market of construction services should be closed to developed countries. According to the author of the article, the positive experience of building nuclear power plants and reactors for nuclear power plants in developed countries should be extended to developing countries - in particular, EU countries that are closer in territorial distance than individual developed countries such as India or China, in which the State Nuclear Energy Corporation “ROSATOM” is building a nuclear power plant. According to the IAEA, the dynamics of the modern nuclear power construction market is such that the number of reactors under construction in various countries exceeds the number of stations under construction (figure 2) [22, 26].

Figure 2. Dynamics of the modern market for the construction of nuclear energy (pcs.).

According to the IAEA, the short-term and long-term prospects for the growth of the construction services market in the nuclear industry in the coming decade will be mainly concentrated in the countries of Asia and the CIS (figure 3) [29].

Figure 3. Capacity of plants and reactors construction of which will begin in 2019 (MW(e)).

However, in its report on the energy market for 2019, the IAEA noted that, despite the fact that most of the currently planned projects for the construction of nuclear power plants, reactors for nuclear power plants are located in the Asian region with a rapidly growing economy and rapidly growing demand for electricity. So, the development nuclear energy market in developed countries cannot be underestimated [13, 15, 17, 26, 27]. Thus, many developed countries with existing nuclear energy programs do not plan to modernize or build new energy reactors and nuclear power plants. For this reason, developed countries can become for the Russian Federation a promising market for the sale of construction services in the field of nuclear energy, even under the conditions of imposed sanctions.

4. Discussion
In order to determine whether the Russian Federation has prospects for the construction of nuclear power plants and reactors for nuclear power plants in developed countries, it is necessary to understand the reasons why developed countries give priority to Russian construction services in the
construction of nuclear energy facilities and what is the dynamics of the nuclear power plant construction market in the world.

According to various studies conducted by the IAEA, IEA and other organizations involved in studying the dynamics of nuclear energy development at the time of 2020, there are only 13 countries in the world in which nuclear power plants are being built. If analyze the dynamics of the nuclear reactors’ construction, it can be seen clearly that in 2016 construction began on 3 reactors, two of which were built in China by Russian contractors and one in Pakistan by contractors from China.

In the first half of 2017, the reactor construction was carried out in only one country of the world, namely in India. Such a weak dynamics in the construction of nuclear power plants in the world by 2020 is observed against the backdrop of a growing global interest in nuclear energy, caused by growing demand for electricity, the need to diversify energy sources and comply with environmental regulations. For example, in 2005-2010, a number of Middle Eastern states announced plans to build a total of about 90 nuclear power reactors at 26 facilities by 2030. Bahrain, Egypt, Iran, Jordan, the UAE and Yemen planned to launch the first nuclear power plants by 2017, and subsequently starting in 2018, launch 1 reactor per year in the region [24]. According to the author’s opinion, at least two reasons contribute to the weak dynamics of the construction of nuclear facilities. The first reason is the lack of need for the construction of new plants due to the long life of nuclear reactors and equipment installed at nuclear power plants. The second reason is the problems hampering the construction of nuclear power plants in the developing countries of the Middle East, especially in dire need of building nuclear power plants.

Consider each of the above problems in more detail. Historically, the peak of the construction of nuclear power plants in the world occurred in 1976, when the benefits of nuclear energy were scientifically proven and the consequences of accidents at nuclear power plants were not fully understood. It was in 1976 that the construction of the largest and currently operating nuclear power plants in the world was begun.

The initial minimum life of nuclear reactors in most of the nuclear power plants constructed at that time was initially 30-40 years. However, with large investments in systems, structures and components of nuclear power plants, the life of a nuclear reactor can be extended indefinitely. According to the IEA, in some countries there are active programs to extend the life of nuclear reactors of nuclear power plants built and put into commercial operation after 176 years. So, for example, in the USA, the period of industrial operation of nuclear reactors of nuclear power plants was extended to 60 years, from initially established to 40 years [25].

In France, only 10-year extensions [26] for the operation of reactors are issued. Such a short time is due to the French goal to reduce the nuclear share in the energy sector from three quarters at present to half by 2025. At the same time, 60 years is not the limit for the nuclear reactor functionality; therefore, significant capital costs for the modernization in systems and components of nuclear reactors are quite justified, including the creation of additional reserves of productivity than the new reactors’ construction.

Now it is need to focus on the reasons that impede the construction of nuclear power plants and nuclear reactors in the developing countries of the Middle East, especially in dire need of nuclear energy. First, taking into account the construction time of nuclear power plants and nuclear reactors, including all pre-contractual procedures, design and construction processes, and a limited list of construction contractors who can carry out the construction of such complex facilities, the plans of the Middle East countries were initially overly ambitions and doomed to failure. In other words, too little time was laid to implement plans within the established time frame.

The next point concerns the limited nuclear infrastructure in the Middle East, ranging from qualified personnel and the regulatory framework for the development of nuclear energy. The accident at the “Fukushima-1” nuclear power plant provoked a new mistrust crisis in nuclear power also played a significant role in adjusting the plans of the Middle East. It should be noted that the first wave of the mistrust crisis in nuclear energy came after the accident at the nuclear power plant in “Chernobyl” in
the USSR. By the way, the territory of the Middle East states - Bahrain and Oman is comparable in area with the exclusion zone in Japan after the accident at the “Fukushima-1” nuclear power plant.

Another factor that violated the global nuclear energy plans in the Middle East was the Arab spring, which forced more attention to be paid to internal stability, economic growth and the region’s security from external invasions.

To summarize some of the interim results, it can be noted that currently there are thirteen large nuclear power plant construction projects on the world market for construction services, seven of which are carried out by Russian contractors. Moreover, most of these projects are implemented in developed countries.

One of the reasons why developed countries prefer Russian contractors is the experience of the Russian Federation in contracting related to the construction of nuclear power facilities. The predecessor of the Russian Federation - the USSR - was the first in the world to build and put into commercial operation nuclear power plants.

For example, in early September 2018, former Russian Prime Minister Dmitry Medvedev and the head of the government of Uzbekistan Abdulla Aripov signed an agreement on cooperation in the construction of nuclear power plants in the Republic. The construction of the nuclear power plant is carried out by the Russian State Nuclear Corporation “ROSATOM”. According to the statement by the director general of the Uzatom agency, Zhurabek Mirzamakhmudov, the choice in favor of the Russian “ROSATOM” was based on the results of studying the experience of building nuclear power plants in Russia, the USA, China, France and South Korea. The “ROSATOM” outperformed competitors from other countries of the world for a number of factors such as construction experience, the timing of preparing the necessary documents and personnel for work at the station, as well as the use of the latest technology [27].

The advantages of Russian construction services in the field of nuclear construction were also noted by other developed countries. So, when the Government of the Socialist Republic of Vietnam made a decision on the construction of the “Ninh Thuan-1 NPP” under the new generation Russian project, the Russian experience of building nuclear power facilities was significantly taken into account, which exceeded the experience of foreign competitors, including “Korea Electric Power” (KEPCO), “Westinghouse-Toshiba”, “Hitachi - General Electric”, AREVA, AECL, China “Guangdong Nuclear Power Holding”, jointly with China National Nuclear Corporation [6]. In addition, unlike many foreign construction companies specializing in the design and construction of nuclear facilities, only the Russian Federation can supply not only proven technologies, but it is also ready to provide training for work at nuclear power plants, guarantees the supply of fuel for nuclear power plants, as well as Russia is ready pick up spent nuclear fuel for reprocessing, provides service during operation.

Another reason why Russian construction services in the construction field of nuclear energy facilities are in demand in developed countries is the short construction time.

Achievement of short and accurately predicted construction periods is crucial for the financial success of any construction project in the nuclear energy field. In the globalization context and in the dynamically increasing demand for energy, reducing the construction time for facilities is also one of the most important tasks facing the nuclear industry.

According to the IAEA, collected over many years of monitoring the results in the nuclear industry for a long time, the construction of nuclear power plants, from the first placement in structural concrete to network connections, ranged from less than five to more than twelve years. So, thirty years ago, the minimum construction period for a nuclear power plant ranged from 7 to 11 years from the start of design and survey work to the loading of nuclear power plants with fuel.

At present, building a nuclear power plant taking into account the full cycle from project development to putting the facility into operation has become possible in less than 52 months. The construction actual duration will depend on the complexity of the design and the experience with the technologies. According to the IAEA, about 75 % of nuclear power plants under construction around the world experience delays. So, the construction period of individual nuclear power plants can be
more than 20 years, which is unacceptable in conditions of increased energy demand. Thus, achieving short and accurately predicted construction periods is crucial for selecting a contractor for the construction of a nuclear power plant.

To analyze the Russian experience in building nuclear power plants in developing countries, it can be concluded that the construction of individual nuclear power plants is carried out in the shortest possible time. For example, during the construction of the “Ruppur NPP” in Bangladesh, the first concrete was poured on November 30 in 2017, and at the beginning of 2020 the final cycle of construction and installation work was already underway at this NPP.

In its reports, the IAEA notes that there are other problems in the construction of nuclear power plants such as: the complexity of the relationship between the construction company and equipment suppliers, the length of the supply chain, the problems of attracting labor to carry out work and training specialists to work in the equipment of nuclear power plants after construction is completed [17].

The advantage of Russian contractors of the state corporation “ROSATOM” over many foreign contractors, as the practice of building nuclear power plants in developed countries has shown, is the ability to offer turnkey solutions, including the creation of the necessary national legislative framework, the development of nuclear and network infrastructure, and financing decisions nuclear projects, training and retraining of national personnel, production localization of necessary equipment in the territory of the customer country, guarantor a balanced supply of fuel for the entire life cycle in a nuclear power plant, service, reprocessing and handling of nuclear waste, as well as comprehensive solutions in the field of decommissioning a nuclear power plant.

Such opportunities make Russian NPP projects one of the best in the world in terms of those indicators for which the greatest number of problems arise. When developing nuclear power plant construction projects, “ROSATOM” also focuses on the requirements of the IAEA in the field of NPP safety during operation, offering developed countries modern designs that take into account all IAEA requirements, taking into account the latest accident at “Fukushima-1 NPP”, including balanced combination of active and passive security systems. Such an approach allows NPPs built according to the Russian project to withstand any possible accidents and be protected from external threats.

The positive experience of Russian construction in developing countries can be used in developed countries of the EU, especially since competition in the field of nuclear construction in the EU countries has declined over the past few years. Due to the fact that well-known construction companies in the field of nuclear energy, such as “Westinghouse” in the United States and “Framatome” (formerly “Areva NP”, now owned by EDF Energy) in France, suffered numerous problems related to bankruptcy, were forced to delay the construction of nuclear power plants and cost overruns. In the presence of problems with the contract’s execution for the construction of nuclear power plants, in the United States an attempt was made to limit nuclear exports by preventing the sale of equipment and technologies to individual companies, trying to enter the national construction market. By imposing export sanctions on foreign nuclear equipment for foreign companies, USA tried to restrict access to the construction services market in the field of nuclear construction in the EU.

At the same time, according to the author’s opinion, the Russian Federation, even under severe sanctions and restrictions, has every chance to enter the markets of construction services in the field of nuclear energy in developed countries.

According to experts from the IAEA and IEA, in the next decade, between 2020 and 2030, it will be necessary to replace about 194 units of nuclear reactors with a total capacity of 179 GW. This is almost four times more than the number of newly built nuclear reactors over the past ten years worldwide. Even taking into account the fact that it is possible to extend the life of nuclear reactors, the number of such reactors in the EU would not be significant, given the possibility of extending the life for only 10 years. In addition, according to the author of the study, given the recent events on the world stage related to the spread of the new coronavirus infection COVID-2019 in the EU, the complication of the economic situation in the region, the timing of the EU’s reduction in the share of nuclear energy will increase. It is obvious that by 2030 the number of operating reactors in the EU will
decrease and there will be a need for the construction of new reactors, since it will be necessary to compensate for losses in the amount of energy.

The most frequently requiring replacement components of nuclear reactors are steam generators and pressure pipes. Such components require replacement every 30 years, when the average life of a nuclear reactor, taking into account the extension, is 60 years.

The second point is the nuclear reactor control technologies. For example, older Soviet reactors have analog instruments and control systems. The VVER-1200 project is the most modern Russian project and belongs to the “3+” generation and has reference units and a fully automated control system. It was developed on the basis of the VVER-1000 reactor options that were built for foreign customers in the 1990s and 2000s: “Bushehr NPP” (Iran), “Kundankulam NPP” (India), “Tianwan NPP” (China).

They tried to improve each parameter of the reactor, as well as introduce a number of additional safety systems that would reduce the likelihood of radiation coming out during any accidents and their combinations outside the tight reactor compartment. As a result, VVER-1200 is characterized by increased power by 20% with comparable equipment sizes, service life of 60 years, the ability to maneuver in the interests of the power system, high KIUM (90%), the ability to work for 18 months without refueling and other improved specific indicators [28].

In particular, with thermal and neutron irradiation, mandatory investment in the repair or replacement of components and assemblies is required to ensure the reliability and safety of nuclear reactors and nuclear power plants in general. In addition, the IAEA conducts periodic safety reviews in accordance with safety principles and principles. The advantage will again be on the side of the Russian Federation.

All that is needed for design, construction and operation before decommissioning of nuclear reactors and other facilities. Orientation on experience and knowledge in the field of “ROSATOM” among foreign competitors is very respectful. A nuclear power plant can be changed by several generations of engineers. However, data on the features of the systems operation must be available for transmission through several generations. Experience can be successfully applied in construction in developed countries.

Given the problems in foreign companies involved in the nuclear energy construction and all the experience of the Russian Federation for the implementation of nuclear projects in developing countries it is necessary to emphasize that the Russian NNP projects in developing countries were safe, reliable, risk-free and timely executed. Despite the fact that at present the main Russian foreign economic interests on the world construction services market are concentrated on the countries' construction services market, the Russian Federation has all the necessary resource and technological capabilities to strengthen its position in the world construction services market under even the conditions introduced against the Russian Federation sanctions.

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