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Nuclear energy sector and cooperation with Russia on the path to energy transition in Serbia

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Abstract: The paper explores the scope and limitations of nuclear energy in general and the suitability of a nuclear power plant in the necessary energy transition of the Republic of Serbia. Energy cooperation between Serbia and Russia already exists in the fossil fuel sector, where Russia's strength is unmatched globally. As the largest supplier of gas and oil to European countries, Russia uses the power of its resources for foreign policy purposes, so even the current war in Ukraine has not stopped the gas supply to the European Union. The author analyzes the potency of ROSATOM as the world's largest exporter of nuclear technology and the possibilities for Serbia to use the strategic partnership with Russia for the arrangement of the construction of a nuclear power plant. The work is based on a realistic theoretical setting of international relations. The main hypothesis is that, on the path of the energy transition, Serbia must gradually reduce its dependence on coal-fired thermal power plants, which are inefficient and enormous environmental polluters. The best solution is the construction of a nuclear power plant based on Russian technology. Serbia has already taken steps to improve cooperation with Russia in the nuclear field through several signed agreements from 2018 to 2022. This serves as a solid starting point for the repeal of the law forbidding the construction of nuclear power plants and entering into an arrangement for the construction of such a plant on the territory of the Republic of Serbia.

Keywords: nuclear energy, nuclear power plant, Serbia, Russia, energy, energy transition, energy security, energy diplomacy, ROSATOM.

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Introductory considerations

Energy has enabled the creation and development of humanity. It can be said that it is synonymous with life, considering that all matter and energy are interchangeable categories. However, when we talk about energy today, we mostly think of external sources outside of ourselves, such as traction power, steam engine power, internal combustion engines, solar power, electricity, etc. Man has figured out how to convert one type of energy into another and use it to his advantage. In the modern world, the hunger for energy is becoming greater because it is necessary for starting cars and airplanes, preparing food, industrial production, lighting, and heating rooms. Numerous wars have been fought over the control of energy resources, and the relationship between energy and politics is very complex. Since the production, access, and distribution of energy sources are first-rate geopolitical issues, the concept of energy security is increasingly discussed.

From the mid-18th century, coal became the main energy resource that, combined with the steam engine, enabled mass industrial production and the storage of surplus products. When we talk about the dominant energy resources, we can roughly say that the 19th century was the century of coal, the 20th century was the century of oil, and that the 21st century opened new fields of energy creation (nuclear fusion energy), although the dominance of the triad of fossil energy sources continues (coal, oil, and gas). The principle of nuclear fusion can potentially provide almost unlimited and cheap energy to humanity, but we will have to wait for some time for its commercial profitability (Vujić, Stojanović and Madžgalj 2015). There is ever more discussion about an energy mix that includes non-renewable and renewable (solar, wind energy, geothermal, hydro energy, and biomass) energy sources. Regardless of the aggressive propaganda and lobbying activities of political-economic interest groups for renewable energy sources, the fact is that less than 12% of global primary energy comes from these sources (Ritchie and Roser 2022a). As much as 84% of global energy comes from fossil fuels, while nuclear energy occupies 4.3% of that mix (Ritchie and Roser, 2022a). In the energy of transport, oil derivatives dominate, while in electricity production, the situation is somewhat different. In the production of electricity, coal occupies 36.7%, gas 23.5%, hydro energy 15.8%, and nuclear energy 10.4% of the total share (Ritchie and Roser 2022b). Wind energy provides only 5.3%, and solar panels produce even less, i.e., about 2.7% of the world's electricity (Ritchie and Roser 2022b).

Serbia is fully dependent on coal for energy. About 70% of the total electricity is produced by the thermal power plants of Elektroprivreda Srbije, and the remaining 30% is produced by 16 hydropower plants (EPS 2022). The Oil Industry of Serbia (NIS) is the only company in the Republic of Serbia engaged in the

exploration and production of oil and gas, and it is majority owned by the Russian Gazprom (Gazprom). According to official data from the energy balance of the Republic of Serbia, domestic oil production covers only 20% of its needs, while 80% comes from imports (MRERS 2022). Only 10% of the required amount of gas is covered by domestic production, while 90% is imported (MRERS 2022). Serbia is completely dependent on Russian gas. Before the main gas pipeline "Balkan Stream," which transports gas via Turkey and Bulgaria, was put into operation in 2021, it was transported via Hungary (MRERS 2022). The above data speak of Serbia's general energy dependence on imports and the huge dependence on coal in electricity production. Apart from the strategic limitation, the additional problem of the outdated thermal power plants is the enormous pollution of the environment and the inhalation of almost the most unhealthy air in Europe according to the relevant scientific and expert data. As many as 10,000 people died in 2010, primarily due to inhalation of harmful particles and exposure to ozone. That is the second highest death rate due to air pollution in Europe (HEAL 2014). In the relatively near future, Serbia must enter the process of energy transition towards new energy sources, and renewable sources seem to be extremely expensive and insufficient. The most viable option, which would meet most needs and further the "green" aim of lowering environmental pollution, is an arrangement for the installation of a nuclear power station. From this perspective, it is critical to examine the potential for collaboration with Russia, Serbia's strategic energy partner and the world's top supplier of nuclear reactors at the moment.

Scope and limitations of nuclear energy sector

The use value of nuclear energy, apart from the practice of deterrence, has been seen in the production of electricity, medicine, agriculture and the transport drive of large vessels, icebreakers and even missiles (Стојановић 2013). Relevant analyses identify as many as 34 nuclear weapons development programs, of which only ten countries have developed nuclear weapons (Стојановић 2021). The most developed countries in the world started to develop civilian nuclear reactors, and the technology, whose evolution is still not final, has constantly advanced. Nuclear power plants indeed carry with them a certain risk, but so is any type of human activity. Are thermal power plants, the petrochemical industry, pharmacology, or biotechnology less dangerous to mankind today than nuclear power plants? They are not. Man is an ontologically unsafe being because, in addition to technological dangers, there is a constant possibility of extermination by a celestial body, a volcano, a super-tsunami or a virus. A cost-benefit analysis needs to be done for

every technological breakthrough. Empirical evidence suggests that even nuclear weapons, capable of ending human existence, can play a positive role if the right purpose is found for them. During the Cold War, Armageddon weapons contributed to stability and most likely prevented the outbreak of the much more devastating Third World War (Петровић и Стојановић 2012; Novičić 2005). The elimination of nuclear weapons can definitely have a humanitarian element due to the cataclysmic effect of potential use. At the same time, the need to dismantle nuclear power plants cannot have either a security or humane argument, which is stated by advocates of environmental movements and the so-called "green" lobby. In the US, in the decades-long nuclear history, there was only one incident at a nuclear power plant at Three Mile Island in 1979. On that occasion, no one died from radiation, but the US tightened the regulation and control of the operation of nuclear power plants (Lewis 1981). On the other hand, thousands of people die annually from harmful emissions from thermal power plants, such as sulfur dioxide and mercury. Relevant data on deaths caused by different methods of electricity production show that the death rate per trillion kilowatt hours of energy produced from coal is 100,000; oil 36,000; gas 4,000; hydro sources 1,400; solar 440; wind 150; while nuclear energy causes the death of "only" 90 people, which is by far the lowest of all types of production (Conca 2012). In its report, the World Health Organization identified biomass burning in developing countries as the biggest global health problem, with as many as 3.2 million directly caused deaths in 2020 (WHO 2022). A patient in a clinic who goes for a PET scanner in one day will receive a dose of radiation several times higher than what is allowed to workers in nuclear power plants annually (Clifford 2022a).

Because of its strong economic growth, China is continuously constructing nuclear power facilities to lessen its reliance on coal. China intends to build up to 150 nuclear reactors worth $440 billion over the next 15 years (Murtaugh and Chia 2021). Many developed countries or those aiming towards that goal are opening new nuclear power plants. These are Russia, India, France, Poland, South Korea, and Japan, which continued to build nuclear facilities after Fukushima. Today, about 40 countries in the world have at least one nuclear reactor. Thermal power plants enormously pollute the air with the emission of mercury and heavy metals, and countries are opting for a "cleaner" form of energy production. Global resistance to nuclear power is relatively weak, although media promotion sometimes gives the impression of its great strength. It has become an issue of which political lances break and where the "green lobby" has an influence on decision-making, particularly in Germany and Italy among European nations. Russia does not have that issue, and in addition to employing nuclear energy "at home," it leads in the export of nuclear technology at the global level (Economist 2018).

The working life of nuclear power plants is at most 20 years longer than the life of thermal power plants. As for the so-called alternative energy sources like solar energy or energy obtained from windmills that use wind power, the data show that their share is minor, even in the most developed countries in the world. Solar panels and windmills are very expensive, even for the wealthiest countries, such as Germany, where electricity prices have risen enormously after the decision to shut down nuclear power plants. The biggest problem with alternative energy sources is they are not real alternatives but idealistic options incapable of satisfying the global hunger for energy. Taking into account the initial investment, day-to-day operating costs and long-term investment, electricity from wind energy costs on average $90 per megawatt-hour, from solar cells $88.7, from coal-fired power plants $41, from hydroelectric plants $38, from gas plants 36 dollars, while the price of electricity produced from a nuclear power plant is "only" 33 dollars per megawatt-hour (Antonini 2022). According to the Institute for Nuclear Energy, a wind farm that generates electricity equivalent to one 1000-megawatt nuclear reactor requires more than 140,000 hectares of land (Antonini 2022). A nuclear power plant on an area of 103 hectares generates a million megawatt-hours, while the same amount of energy requires 3,200 hectares of solar panels or 17,800 hectares of full windmills (Antonini 2022). The fourth and fifth generations of nuclear reactors will certainly reduce the risks of disaster to the lowest possible extent, and nuclear technology is advancing daily, extending the "lifetime" of reactors and reducing the amount of initial investment. Nuclear waste from these reactors will be far less than in previous generations. Simply put, countries that refuse to build nuclear power plants will very quickly find themselves in the unenviable position of having to rely on fossil fuels (coal and oil), and due to their scarcity (their quantity will be permanently reduced), they will be in a position to import electricity.

In addition, nuclear technology shows the most room for improvement and progress. In this sense, it is necessary to mention potential fusion and thorium reactors. The principle of nuclear physics could definitely reconcile "hard" environmentalists with nuclear energy production. The most objective argument that is not in favor of nuclear energy today concerns nuclear waste, which, although small in quantity, can be problematic for the environment. If fusion reactors became economically viable (currently, they are not), nuclear energy production would not leave behind long-lived radioactive waste. In addition, fusion would reduce the cost of energy production given the cheap and sustainable energy sources (deuterium and tritium) (Vujić, Stojanović and Madžgalj 2015). Much progress has already been made in the direction of the commercialization of nuclear physics. The enormous ITER project (International Thermonuclear

Experimental Reactor) is well known as one of the most expensive scientific endeavors in history, which will cost 15 billion dollars in the first phase (Henley 2011). The ITER aims to commercialize nuclear fusion, and the EU, the US, China, India, Japan, South Korea, and Russia are participating in the construction of the reactor in the south of France (ITER 2022). The project was launched in 2006, and a fusion reactor is expected to be commissioned in 2025, with full commercial use in 2035 (ITER 2022). In the next few decades, the big challenge will be to collect the helium-3 isotope from the moon, where it is found in huge quantities. This element is potentially an almost inexhaustible source of clean energy based on the principle of nuclear fusion (Guven and Kuchdal 2012). The most powerful countries in the world, primarily Russia and the US, are trying to renew their presence on the moon by the end of this decade, so even the helium-3 collection facility will no longer be in the realm of science fiction (Stojanović 2020, 671).

Another technological breakthrough in the field of nuclear energy could be the use of thorium as nuclear fuel. Thorium is less radioactive and produces less nuclear waste than uranium. Its isotope thorium-232 can be converted into uranium-233, and besides being more widespread in nature than uranium, thorium provides safer handling and leaves far less nuclear waste (Петровић 2010). Thorium is easier to obtain because it comes from surface mines, whereas uranium comes from deep mines.

The conclusion is that nuclear energy is overall the most profitable, although no less safe than other types, due to the mentioned ontological insecurity of man. With a 70% share of nuclear power plants in energy production, France is the leading European country and the only energy independent from fossil fuels (WNA 2022a). It always has a surplus of electricity, and today, it is the largest exporter of electricity in the world (WNA 2022a). In some countries, there is a pronounced strength of the "green lobby", which has an interest in preventing the construction of nuclear plants under the pretext of environmental protection, all to make enormous profits from the distribution of overpriced windmills, turbines, and solar panels. Even the Middle Eastern countries are saving their oil and investing in nuclear power plants to ensure long-term energy independence. Many will say that it is unprofitable for them, considering that in the OPEC countries (Organization of the Petroleum Exporting Countries), a liter of bottled water is more expensive than a liter of oil. However, strategists in those countries made a good long-term decision to diversify energy sources. The development of alternative forms of energy propagated by the "green lobby" is certainly good and desirable but, at the moment, it is too expensive, inefficient (there is no consistency of production and the possibility of energy storage is weak), and insufficient for growing energy needs.

From this, we can conclude that Serbia, as a poor country, cannot afford the luxury of investing too much in unprofitable alternative energy sources. It seems that Serbia's best strategic decision on the path to the energy transition could be reflected in the arrangement for nuclear plant construction. The cost of building a nuclear reactor is not small, but with the scientific and professional help of a world nuclear giant like Russia, one could talk about a realistic project that would make Serbia a more energy-stable country. The arrangement could include one of the neighboring countries, such as Hungary or Bulgaria, given the high cost of the initial investment.

Russian energy policy as an instrument of foreign policy

The power of gas as a political weapon can be seen in times of crisis, such as the current war in Ukraine. Europe's dependence on Russian energy sources is so great that, according to official Eurostat data, the EU imports 24.8% of oil and 39.2% of gas from Russia (Eurostat 2022a). A deeper analysis of the connection between political power and energy is a separate topic for consideration. Energy products are highly politicized commodities which means their influence extends far beyond the energy sector. Long-term foreign policy definitions and political processes are influenced by the geographical distribution of energy sources and the directions of providing oil and gas pipelines (Proroković 2020).

Energy is a first-rate issue of national security. Oil became a faithful companion in geopolitical disputes during the transition from the 19th to the 20th century, and similarly, gas became a geopolitical factor in the transition from the 20th to the 21st century (Simurdić 2019, 13). Therefore, the science of international relations is increasingly discussing the terms "energy security" and "energy diplomacy". The American conceptualization of energy security is based on two basic elements. First, to ensure the absence of any kind of threat to energy sources and resources. Second, the necessity of finding and conquering new sites for the purpose of energy independence (Lečić 2019, 54). The Russian energy strategy defines energy security as resource sufficiency, economic availability, and ecological-technological possibility (exploitation, production, and processing of energy resources) (Lečić 2019, 54). Andreas Goldthau defines energy security as "reliable supply at acceptable prices in the case of the buyer, and reliable demand at sustainable prices on the exporter's side" (Goldthau 2010, 26). According to the same author, energy diplomacy is defined as "the use of foreign policy to ensure secure access to energy supplies abroad and to promote (mainly bilateral) cooperation in the energy sector" (Goldthau 2010, 28). Accepting the

aforementioned definition of energy security, we can conclude that Russia is an energy-secure country, given the guaranteed demand for its export goods on which the entire economy rests. The term "energy diplomacy" has to be updated to encompass the situation in which a state uses its energy resources to pursue foreign policy objectives. As a result, energy diplomacy encompasses both the use of foreign policy to promote a steady energy supply and vice versa. Russia has a highly developed mechanism of energy diplomacy, not to ensure its supply, given that it is energy self-sufficient, but to achieve political goals through the levers of dependence of other countries on Russian energy sources. Therefore, the most adequate definition of energy diplomacy seems to be the one by Daniel Yergin, with a small addition. According to Yergin, energy diplomacy is "the skill of adequately managing energy dependence (its own but also that of others, ed.) and avoiding vulnerability to supply asymmetries" (Simurdić 2019, 24). The relationship between the EU's dependence on Russian energy sources best speaks of the power of Russian energy diplomacy. Regardless of the introduction of sanctions against Russia by all EU countries, they are generally not ready to give up the supply of Russian gas, which continues to flow unhindered. Russia can condition the payment of gas in rubles, and countries that do not comply with the request may become energy-endangered, which brings with it political repercussions.

Various instruments of energy diplomacy are available, such as dictating the price of energy, interruptions in supply, control over assets in the energy sector of other countries, and the policy of oil and gas pipeline routes. Considering nuclear energy, a small number of countries control the export of technology and fuel for nuclear reactors. Russia is the world leader with 60% of world exports of nuclear technology (Zoe 2022). The Russian State Atomic Energy Corporation (hereinafter: ROSATOM) controls as much as 36% of the world's uranium enrichment market and supplies nuclear fuel to 78 nuclear reactors in 15 countries (Zoe 2022). Interruptions in the supply of nuclear fuel can cause energy instability. During the 2014 Ukrainian crisis, then-Deputy Prime Minister Dmitry Rogozin imposed a ban on supplying nuclear fuel to Ukraine (Zoe 2022). The new war in Ukraine since March 2022 has led Ukraine to sign a contract with the American Westinghouse Electric Corporation on fuel supply for all four nuclear power plants (Reuters 2022). Ukraine gets as much as 55% of its electricity from nuclear power plants, so cutting off the supply would completely collapse the country's energy system (Fleck 2022). In the EU, 24.6% of electricity is produced by nuclear power plants (Eurostat 2022b). There are numerous examples of geopolitical decisions to reduce dependence on Russian nuclear components. For instance, Lithuania shut down its nuclear reactor, which produced 70% of the country's total electricity (WNA 2022b). Although the main export product of this Baltic state was the electricity

produced in the nuclear power plant, it was forced to close it under pressure from the Western allies. The main reason for the irrational shutdown of the nuclear power plant was to reduce political dependence on Russia, where the fuel for the reactor was supplied. Finland, in addition to expressing its desire to join NATO (North Atlantic Treaty Organization), after the launch of the Russian special military operation in Ukraine canceled the contract for the construction of a nuclear power plant with ROSATOM worth 7.5 billion euros (Pohjanpalo 2022). The argument of the Finnish political leadership was reflected in the avoidance of Russian nuclear technology and nuclear fuel supply. The nuclear energy sector in Europe, regardless of all attempts to break away from Russian influence, is highly dependent on imports of Russian technology and uranium. In 2020, 20.1% of total uranium imports into the EU were from Russia and 19.1% from Kazakhstan, Russia's ally (Appun 2022). Dependence on Russian nuclear technology is highest in Eastern Europe, where as many as 18 nuclear reactors are calibrated to consume nuclear fuel purchased from ROSATOM (Appun 2022). In Germany, the remaining three reactors in operation also run on Russian uranium (Apunn 2022).

How high the stakes are in nuclear energy is best shown by the fact that European countries dependent on Russian gas timidly discussed diversification and a possible alternative to Russian gas supply. At the same time, there was no mention of possible sanctions on the import of Russian nuclear fuel and nuclear technology (Clifford 2022b). The war in Ukraine instantly launched the story of Europe's gas dependence on Russia. The focus was on the debate on the import of liquefied gas from the US and increasing imports from Algeria, while nuclear energy was not mentioned at all, even though most European nuclear power plants are dependent on Russian fuel. The opening of another painful topic within the EU would lead to complete destabilization, given that the energy segment of the EU is the most vulnerable. The "most terrifying Russian weapon" is not just gas, whose supply was unabated by the Iron Curtain of the Cold War, but also nuclear fuel, whose delivery to European power plants will not be stopped by crises or even wars. Once again, Russia has demonstrated its strength to take energy power to the geopolitical level, which confirms the hypothesis of the inseparability of energy and foreign policy.

Serbia's energy problems and the necessity of energy transition

Serbia is an energy-poor country. Oil and gas reserves make up less than 1% of the total balance of reserves, and the remaining 99% are coal reserves dominated

by low-quality and low-caloric lignite (Стратегија 2015). As mentioned, Serbia is energy dependent on coal that is burned in outdated thermal power plants. Serbia does not have an adopted foreign policy strategy, but the statements of officials and the harmonization of legal acts during the accession negotiations speak in favor of Serbia's declarative goal of becoming an EU member. On the other hand, Serbia is completely dependent on the import of gas and oil from Russia, with which it signed the Declaration on Strategic Partnership in 2013 (RTS 2013). In 2005, Serbia signed the Agreement on the Formation of the Energy Community of Southeast European Countries in Athens, which created a unique, stable, and regulatory framework for cross-border energy trade together with the EU (Закон о ратификацији 2006). Serbia effectively took over all EU legal acquis by signing this framework and became obligated to align its legislation and behavior with EU requirements. Serbia has adopted the Law on Energy, which enables the full application of EU energy regulations and the so-called Third Energy Package (Закон о енергетици 2021). The obligations provided for the separation of production and supply of energy from transport, providing access to the energy network to an interested third party, as well as the separation of activities in companies engaged in the production, supply, and transport of electricity and gas (Закон о енергетици 2021).

In practice, there is constant political pressure from Brussels on how Serbia implements its energy policy. By putting into operation the "Balkan Stream" in January 2021, which delivers Russian gas via Turkey and Bulgaria and along a 403-kilometers route through Serbia, the EU pointed out that Serbia is violating its commitments and the Third Energy Package. The Energy Community previously demanded Serbia to cancel the exemption of third-party access to the "Turkish Stream" gas pipeline and to provide access to other market entities (Doklestic 2019). The report states that "Balkan Stream" will only further strengthen Gazprom's dominance in Serbia (Doklestic 2019). The transit of Russian gas to Europe is perceived in the West as a geopolitical penetration of Russian "malignant" influence. The US and the EU appear as protectors of interests and all-knowing interpreters of the national interests of European countries, where they see the fight against Russian energy occupation as a primary goal. Regardless of the strong anti-Russian efforts from the West, where Serbia is not an exception but probably the object of stronger pressures due to historical ties with Russia, Europe has no realistic alternative for Russian energy producers. The pressures of the EU on Serbia's energy policy can be classified into three main categories. First, the aforementioned requirements related to competitiveness, which give energy buyers a choice of several different market offers (liberalization). Second, the diversification of energy sources, given that Serbia is exclusively dependent on

fossil fuels. Third, environmental protection and the reduction of carbon dioxide emissions into the atmosphere. The Paris Agreement is a reflection of the world consensus because it was signed by almost all the countries in the world, including Serbia (The Paris Agreement 2015). With this, it committed itself to contributing to the reduction of greenhouse gas emissions, which in the energy sector would mean shutting down coal-fired thermal power plants in the near future. All three categories of changes in the Serbian energy sector determine the concept popularly called "energy transition".

In the Energy Sector Development Strategy of the Republic of Serbia until 2025, with projections until 2030, the following goals are highlighted as key priorities: ensuring energy security; development of the energy market; and overall transition to sustainable energy (Стратегија 2015). The EU, whose policies Serbia complies with as part of the reduction of pollution emissions, foresees a change in the structure of the energy cycle and infrastructure. A special problem for Serbia is the large coal-burning plants, which, according to all relevant scientific studies, pose a danger to the environment and human health. According to the Greenpeace report, the "Nikola Tesla" thermal power plants are in the 9th place among the world's largest polluters of sulfur dioxide, and Serbia as a whole occupies an unenviable 18th position on the list of the largest global polluters of this gas (Dahiya et al. 2020). The obsolescence of coal-burning technology and the lack of devices for flue gas desulfurization additionally alarm Serbia on the way to its energy transition. In the aforementioned Strategy, one of the main requirements for the future is the production and consumption of energy with as few negative consequences as possible for the environment, water, air, soil, and consequently the food chain, biodiversity, and human health (Стратегија 2015). In February 2022, the European Commission included gas and nuclear energy as "green" energy sources whose usage has the task of accelerating the shutdown of liquid and solid fossil fuel plants, primarily coal-fired thermal power plants (European Commission 2022). Serbia inherited the legal ban on the construction of nuclear facilities in accordance with the Memorandum of the Socialist Federal Republic of Yugoslavia (SFRY) from 1989 and confirmed the ban by adopting the Law on the Prohibition of the Construction of Nuclear Power Plants (Закон о забрани 2005). The existing legal framework prohibits any nuclear facility and is valid indefinitely, i.e., until the Parliament of the Republic of Serbia adopts a new regulation that would invalidate the law. The problem of the lack of a legal framework for the future nuclear power plant in Serbia is more of a technical nature, and what represents a bigger problem is the lack of scientific and professional staff that would monitor the construction and operation of such a demanding plant. The training of personnel for the needs of nuclear energy has long been discontinued, but the

relic of the former Yugoslav nuclear program exists in terms of certain experience and infrastructure. The Energy Sector Development Strategy does not exclude the possibility of building a nuclear power plant. However, it is estimated that it would take 10 to 15 years from the moment of the repeal of the Law on the Prohibition of the Construction of Nuclear Power Plants to the moment of overcoming the listed problems and starting the operation of the nuclear power plant in Serbia (Стратегија 2015).

Back in the seventies of the 20th century, Yugoslavia had very ambitious plans for the construction of nuclear power plants throughout the country. In 1982, the plans were formalized through a strategic document entitled "Basic Agreement on a Long-Term Plan for the Development and Application of Nuclear Energy in Yugoslavia Until 2000" (Dogovor o osnovama 1982). The first nuclear power plant out of four planned was put into operation in 1981 on the left bank of the Sava river near the town of Krško in Slovenia. In 1985, the Business Community for Research, Development, and Peacetime Use of Nuclear Energy proposed a plan for Yugoslavia to independently master nuclear fuel cycle technology (Perović-Nešković 2000, 63). Nuclear ambitions have been curbed by a combination of factors: political instability, separatist drives, and a strong anti-nuclear campaign caused by the 1986 Chernobyl nuclear disaster. The final shutdown of the nuclear program in Yugoslavia followed in 1989, but the "Krško" nuclear power plant, based on American technology, still produces electricity for Slovenia and Croatia. If Serbia were to lift the legal ban today and make a political decision to build a nuclear power plant, it would take 10 to 15 years to put it into operation. When the opponents of the nuclear power plant argue their positions, they often cite Serbia's personnel and technological incapacity for such an undertaking, but at the same time, they forget that the largest number of nuclear power plants in the world were started with the external assistance of a country exporting technology and expertise. There is certainly a sensitivity regarding the fact that the energy system depends on raw materials and "know-how" from outside, but the situation today is not much different when it comes to oil and gas. In this sense, such a decision is not only energy-related but also political. Therefore, Russia is emerging as the most favorable partner for the future nuclear power plant. We analyzed the existing dependence of Serbia, but also of the whole of Europe, on Russian gas and oil to a lesser extent. Serbia and Russia already have a strategic partnership, strong cultural and historical ties, and a political alliance unlikely to be shaken by anti-Russian sentiments among the part of Serbian political elite. Russia is the world leader in the export of nuclear technology and has vast experience in the installation of reactors in all parts of the planet, which guarantees the success of the eventual nuclear arrangement and the energy transition of Serbia.

Untouchable energy titan – ROSATOM

Russia is the world leader in nuclear technology export quantity as well as quality, as it leads in advanced innovations in nuclear transport and reactor design. The ambition to launch the world's first "fourth generation" nuclear reactor is not only at the level of an idea, but is effectively developing the fast neutron reactor BN-1200, with the goal of operational commissioning by 2025 (Sitaras 2018, 4). Also, Russia has the world's only fleet of nuclear-powered icebreakers (Manaranche 2020). A special technological breakthrough of Russia is the first floating nuclear power plant, "Akademik Lomonosov", put into operation in 2020 (ROSATOM 2019a). "Atomstroyexport" is the body responsible for the negotiation, design, and implementation of cross-border nuclear projects, and as such, today it is part of the nuclear empire of the Russian ROSATOM, founded in 2007 by the decision of President Vladimir Putin (Reuters 2007). The first successful project to export a nuclear reactor outside the territory of the former Warsaw Pact was in 1999, when the contract with China for the Tianwan 1 nuclear power plant was realized (Sitaras 2018, 15).

A new era in the export of Russian nuclear technology began in 2007 with a structural reorganization and the establishment of an "empire" called ROSATOM. According to official data from the internet presentation of this giant, ROSATOM has activities in 50 countries in the world. Its activities relate to the construction of nuclear power plants; mining and enrichment of uranium; manufacturing and supply of nuclear fuel; and innovations such as hydrogen energy, nuclear medicine, and new ways of energy storage (ROSATOM 2022). There are 350 companies and organizations under ROSATOM, with a total of 290,000 employees (ROSATOM 2022). ROSATOM insists that it is one of the world's largest contributors to the reduction of the greenhouse effect and that nuclear power plants are the "green" way to produce electricity with the lowest level of spread of harmful substances compared to all other energy production models (ROSATOM 2022). The headquarters of the company is in Moscow, and among the numerous "daughter" companies, the most important are: "Rosenergoatom", which manages all nuclear power plants on the territory of Russia; "Atomenergoproekt", as the main engineering company in charge of designing nuclear power plants; "OKB Gidropress", the main design bureau for reactors; and the aforementioned "Atomstroyexport", with the task of exporting nuclear technology. The quality of Russian nuclear technology is reflected in the variety of client countries, the most interesting of which is the Akkuyu nuclear power plant project in Turkey. The NATO member and American ally for many decades ordered four Russian nuclear reactors with a total power of 4,800 megawatts from ROSATOM, and the first reactor will

start operating in October 2023, exactly on the centennial of the founding of the modern Turkish Republic (ROSATOM 2018). The nuclear power plant, together with the launch of the "Turkish Stream" gas pipeline, creates an unbreakable geopolitical link between Russia and Turkey, regardless of Turkey's formal membership in NATO and different geopolitical interests in Syria. The power of energy diplomacy can be greater than all other strategic calculations and practically untouchable even in times of crisis, such as the one in Russian-Turkish relations after the downing of a Russian fighter jet in 2015 (BBC 2015). The latest war in Ukraine is no exception. Although there is a flight ban for Russian planes in all EU countries, Russian transport planes have already landed in the Czech Republic and Slovakia without problems on several occasions. The reason for the exception was the precious cargo that the "Ilyushins" were carrying, which was nuclear fuel produced by TVEL, a subsidiary of ROSATOM, for the needs of Czech and Slovak nuclear power plants (Chastand 2022). These power plants are based on Russian technology, and the Slovak Minister of Economy, Richard Sulik, clarified the exception by arguing that all nuclear reactors in Slovakia are of Soviet design, which produce more than 50% of the total electricity for a small landlocked Central European country (Chastand 2022). The relationship between sanctions, on the one hand, and trampling on one's own words, on the other hand, seems like hypocrisy with the conclusion that energy needs break down most of the geopolitical barriers. The Slovak Minister's argument is a reality experienced by almost all European countries in relation to energy dependence on Russia.

The decision of all EU member states from May 2022 to reduce dependence on Russian gas by two-thirds by the end of the year, with the complete abandonment of Russian fossil fuels by the end of 2027, was not accompanied by a strategic decision to abandon the import of Russian nuclear fuel (Wesolowski 2022). Despite the strong initiatives of the Ukrainian side to put ROSATOM on the "black list" in Brussels, this did not happen. Hungary continues its cooperation with ROSATOM in the construction of two new blocks of the Paks nuclear power plant, and the German Siemens sends a message that it continues all agreed-upon deals with the Russian energy giant (Wesolowski 2022). The French nuclear conglomerate Framatome also refused to cut off communication with ROSATOM and continued strategic cooperation in the field of nuclear fuel production and the development of new technologies (Wesolowski 2022). While thousands of Western companies suspend arrangements with Russian institutions and companies, ROSATOM continues its activities unhindered. Despite the conflict in Ukraine, even the US did not forbid the import of nuclear fuel, 16% of which originates from Russia (Lorenzini and Giovannini 2022).

State-of-the-art Russian reactors are guaranteed to operate for 60 years without any technical overhaul, making nuclear cooperation agreements long-term ties between Russia and the country ordering the technology. ROSATOM, next to Gazprom, is the second striking fist of Russian energy and geopolitical influence. ROSATOM has a wider global reach considering that it operates on the entire planet, while Gazprom is limited by not-so-long gas pipelines (a maximum of 4,500 km from the territory of Russia). Gazprom's clients are mostly European countries, except for the "Power of Siberia" gas pipeline that goes to China. In this sense, ROSATOM has greater geopolitical potential considering that it has contracts with the BRICS countries and developing countries with great economic and political potential, while Gazprom is linked to countries that have reached their zenith in economic terms. It seems that ROSATOM has escaped the skillful scientific and professional analyses of Western experts who talk about Russian political influence through energy, primarily discussing Gazprom's activities. Through ROSATOM's global projects, Russia undoubtedly achieves a permanent political presence and diplomatic influence on countries in the most geopolitically important regions of the world, such as the Middle East and Southeast Asia.

We will summarize the strength of ROSATOM in several basic conclusions, which are of great importance in the potential relationship with Serbia. First, ROSATOM is the world leader in nuclear technology, with more than a third of global uranium enrichment production, the most sophisticated innovations, and full political support of the state. In contrast to Western nuclear exporters, ROSATOM enjoys full diplomatic support and state logistics (more than 15 nuclear attachés in embassies worldwide) (Sitaras 2018, 24). Second, ROSATOM is the only company in the world that offers a "build-own-operate" nuclear power plant service package where the contracting state does not have to spend a single dollar on the investment (this model is applied in Turkey). The contracts include a whole package of services, from fuel supply, training of workers, and the return of radioactive waste to Russia (Sitaras 2018, 24). Third, ROSATOM has a global reach far greater than Gazprom's, which is limited by pipeline infrastructure. This fact enables investments in countries with huge economic potential, not only a constant supply of already saturated markets. Finally, the security of the nuclear fuel supply does not depend on transit through the territory of other countries, and it is guaranteed regardless of crises and wars, which is best evidenced by the current war in Ukraine. Nuclear cooperation, even in a civilian program, is a very sensitive field of international politics and is capable of creating unbreakable bilateral ties between states. Undoubtedly, nuclear energy is a strategic level of cooperation, almost on par with contracts for the supply of the most modern military weapons.

In this sense, Serbia should consider ROSATOM as the most attractive partner in the country's necessary energy transition.

The Serbian-Russian connection and the future of nuclear energy in Serbia

Serbia and Russia have developed energy cooperation, the beginnings of which can be traced back to the Soviet-Yugoslav era of relations. Russian Gazprom is the majority owner of the Serbian Oil Industry according to the energy agreement from 2008, which was preceded by an agreement aimed at reducing Serbia's trade deficit in trade with Russia (Петровић и Јокић 2015, 100-106). Serbia's dependence on Russian gas and oil is huge. However, when we talk about potential cooperation in the field of nuclear energy, it is necessary to keep in mind the continuity of nuclear cooperation from the first Yugoslav-Soviet relations to the latest agreements between Serbia and Russia.

Yugoslavia was a pioneer in nuclear research, with one of the first nuclear programs. In fundamental and applied research, the Vinča Institute for Nuclear Sciences collaborated with many experts and countries worldwide. The crown of international cooperation was achieved with the Soviet Union, which built a research heavy-water reactor in Vinča, put into operation by Josip Broz in December 1959 (Nakićenović 1961, 53). The Soviet reactor in Belgrade was one of the most modern in the world at that time. Yugoslavia's ambitions for independence in nuclear research were so great that the Yugoslav leadership developed the nuclear fuel cycle, from the mining of uranium ore, through the processing process, to enrichment. Great ideas failed and the only relic of the Yugoslav nuclear program, apart from the Institute in Vinča, is the mentioned nuclear power plant "Krško".

Today, Serbia relies on coal in the production of electricity, and the issue of energy transition gained momentum after the problems of the Electric Industry of Serbia's system in 2021. The generally poor quality of coal, combined with the absence of homogenization (equalization of the quality of the mined raw material) and unprofessional management, led the entire system of power generation in thermal power plants in Serbia to the verge of a complete collapse. The shortage of electricity is replaced by imports at exorbitant prices, which are all reasons for the necessity of accelerating the process of energy transition towards a new way of energy production, of which the nuclear power plant is the most optimal solution. In November 2021, the President of the Republic of Serbia, Aleksandar Vučić, disclosed

talks with Hungarian leader Viktor Orbán about a joint investment in a nuclear power plant (Blic 2021). Vučić said very clearly: "We said that we would desire to be co-owners of 15% of their nuclear plant" (Blic 2021). On the same occasion, he added that he had previously had discussions on the same topic with the then Bulgarian Prime Minister Boyko Borissov (Blic 2021). Joint investment in a nuclear power plant with a neighboring country such as Hungary, Romania, or Bulgaria eases the financial pressure on the initial investment but additionally complicates political relations, given that the mentioned countries are EU members. In addition, Hungary and Bulgaria rely on Russian nuclear technology, while the Romanians, despite long-term cooperation with the Soviet Union, chose Canadian nuclear reactor technology. This means that, regardless of the division of costs between the two Balkan states, the help of a third state would be necessary for such an undertaking. A few days later, Aleksandar Vučić explicitly stated in an interview for the "Soloviev Live" channel that Serbia was considering the construction of a nuclear power plant in Serbia with ROSATOM (Tanjug 2021). "We will see how it goes, but we need further consultations with our Russian partners (ROSATOM) on how to work in the future," Vučić said on that occasion (Tanjug 2021).

The memorandum and subsequent law prohibiting the construction of nuclear facilities remain in effect, but Serbia has recently signed significant nuclear cooperation agreements with the Russian Federation. The first agreement was signed in 2018 between the Serbian Minister of Innovation, Nenad Popović, and the General Director of ROSATOM, Alexey Likhachev, at the Atomexpo International Forum in Sochi (RTV 2018). This agreement, although not much noticed by the Serbian public, is actually a blatant indicator of the direction of Serbia's future energy transition towards nuclear energy. The content of the agreement provided for Serbia's cooperation with ROSATOM in the development of innovative technologies in the application of nuclear energy for peacetime purposes, especially in medicine and agriculture (RTV 2018). The second agreement on cooperation in the use of nuclear energy for civil needs was signed by the same persons: the executive director of ROSATOM, Alexey Likhachev, and the minister in the Government of the Republic of Serbia, Nenad Popović, in January 2019 (The Government 2019). In October 2019, during the visit of Russian Prime Minister Dmitry Medvedev to Belgrade, an agreement was signed between the Government of Serbia and ROSATOM on the construction of the Center for Nuclear Technologies (ROSATOM 2019b). The Serbian media, intentionally or not, failed to mention the important information provided for in the agreement, which is the installation of a multi-purpose research nuclear reactor with a power of 20 megawatts in the future Center for Nuclear Technologies (ROSATOM 2019b). The last in a series of formal agreements signed between Serbia and Russia in the field of nuclear energy came shortly after Vučić's statements about

the potential construction of a nuclear power plant in Serbia. In December 2021, the Government of the Republic of Serbia and ROSATOM signed a general framework on the construction of the Center for Nuclear Technologies and the establishment of a joint enterprise for the implementation of this project on the territory of Serbia (The Government 2021). This agreement is the operational realization of the previously planned activities of ROSATOM in Serbia. Minister Popović emphasized the historic day for relations between Serbia and Russia and the agreement, which, as he said, "returns Serbia to the map of European countries capable of developing in the field of nuclear technologies" (The Government 2021). In none of the above three signed agreements, the construction of a nuclear power plant was explicitly mentioned because that would be against the current legislation in Serbia. However, general agreements on cooperation in the field of nuclear energy represent a solid basis for some future arrangements for the construction of a nuclear power plant based on Russian technology.

The Law on Radiation and Nuclear Safety and Security, which established the Directorate for Radiation and Nuclear Safety and Security of Serbia, was adopted under an emergency procedure in 2019 (ЗОРНСБ 2019). The pro-Western media immediately welcomed these activities and Serbia-Russia cooperation in nuclear matters with suggestive headlines such as "Is Serbia preparing to build a Russian nuclear power plant?" (Radio Slobodna Evropa 2019). This is a legitimate concern that the political establishment in Serbia will soon need to address. It is quite possible that public opinion not well-versed in proven scientific facts about "green" nuclear energy is being timidly prepared. Such a Copernican turnaround, in which it is necessary to change the legislation and convince the people that a nuclear power plant is the best option for growing energy needs, is not easy to do overnight. It is certain that, given the time since Yugoslav nuclear activities were halted, more people are thinking about this than ever before. It is also abundantly evident that Serbia cannot, in the long run, rely on obsolete thermal power plants and low-quality coal, which are among the worst polluters in Europe. Nuclear power would guarantee a constant energy supply regardless of whether the rivers flow, the sun shines or the wind blows.

Conclusion

From what has been said so far, we can draw several basic conclusions regarding nuclear energy and the energy transition in Serbia. First, nuclear energy, despite the flaws that every type of technology has, has the greatest potential for

improvement (fusion and thorium reactors), ensures constant supply regardless of natural conditions, produces the least polluting particles, gives the most energy in relation to the amount of fuel, reduces transportation costs, and, in the long run, it represents the most profitable form of energy production. Second, Serbia is completely dependent on coal and gas in terms of energy, so it is necessary to start the process of the energy transition. The history of the Yugoslav nuclear program and the current modest personnel resources at Serbia's disposal have been analyzed. Building on this, the third conclusion is that Serbia, as a small country, would solve most of its energy problems and needs with one nuclear power plant. Fourth, the environmental reasons for the enormous pollution of coal-fired thermal power plants and the recent collapse of the power system in Serbia accelerate the energy transition and thinking about nuclear power plants. The development of nuclear power facilities is currently prohibited on Serbian soil, but if political will exists, changing the law would be the easiest thing to do. Fifth, Russia is today the largest and most advanced exporter of nuclear technology in the world, which, along with the existing strategic partnership and energy arrangements with Serbia, guarantees certainty in the successful construction of a nuclear power plant, expertise and subsequent supply of nuclear fuel. Finally, Serbia has already taken concrete steps in cooperation with ROSATOM, the most powerful nuclear corporation in the world, with which it has signed several formal agreements. The Serbian political leadership publicly sends messages of cooperation with Russia in nuclear technology and talks about the potential for building a nuclear power plant, either independently or together with one of the neighboring countries. ROSATOM will build a research nuclear reactor in Serbia, and the signed agreements seem to be just the beginning of a much larger cooperation, the crown of which could be the construction of a nuclear power plant.

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Bogdan STOJANOVIĆ

SEKTOR NUKLEARNE ENERGIJE I SARADNJA SA RUSIJOM NA PUTU ENERGETSKE TRANZICIJE U SRBIJI

Apstrakt: U radu se istražuju uopšteno obim i ograničenja nuklearne energije, kao i mogućnost primene nuklearne elektrane u kontekstu neophodne energetsketranzicije u Republici Srbiji. Energetska saradnja Srbije i Rusije već postoji u sektoru fosilnih goriva i snaga Rusije je bez premca na globalnom nivou. Kao najveći snabdevač evropskih zemalja gasom i naftom, Rusija snagu svojih resursa koristi u spoljnopolitičke svrhe, tako da čak ni aktuelni rat u Ukrajini nije zaustavio snabdevanje gasom Evropske unije. Autor analizira moć ROSATOM-a kao najvećeg svetskog izvoznika nuklearne tehnologije i mogućnosti da Srbija iskoristi strateško partnerstvo sa Rusijom u postizanju dogovora oko izgradnje nuklearne elektrane. Rad je zasnovan na realističkoj teorijskoj postavci međunarodnih odnosa. Osnovna hipoteza je da Srbija na putu energetske tranzicije mora postepeno da smanji zavisnost od termoelektrana na ugalj, koje su, sem što su neefikasne, istovremeno i veliki zagađivači životne sredine. Najbolje rešenje bi bilo izgradnja nuklearne elektrane po ruskoj tehnologiji. Srbija je već preduzela korake na unapređenju saradnje sa Rusijom u nuklearnoj oblasti kroz nekoliko sporazuma koje je potpisala u periodu od 2018. do 2022. Ti sporazumi predstavljaju solidnu polaznu osnovu za ukidanje zakona o zabrani izgradnje nuklearnih elektrana i sklapanje aranžmana za izgradnju takvog postrojenja na teritoriji Republike Srbije.

Ključne reči: nuklearna energija, nuklearna elektrana, Srbija, Rusija, energija, energetska tranzicija, energetska bezbednost, energetska diplomatija, ROSATOM.