BgNS TRANSACTIONS volume 26 number 1 (2022/23) pp. 78–85

Vision for the Future of Nuclear Energy in Bulgaria by 2053

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Abstract. The European Union's ambition to be the first climate-neutral continent requires the adoption and implementation of policies to eliminate the threat of climate change and environmental degradation. For the future of the Bulgarian energy sector, the main strategic objective is the reliable delivery of clean and affordable energy to all consumers, in an environment of energy security and while maintaining the country's role as an energy leader in the region. A sustainable transition to low-carbon energy requires long-term vision, predictability and phasing in order not to risk the functionality of the electricity system. With the right objectives, achieving an energy transition using nuclear power would ensure the security, reliability and efficiency of the electricity system. Nuclear power is a well-established large-scale, low-carbon energy source and is capable of contributing to the decarbonisation of the electricity supply.

Keywords: nuclear power, decarbonisation, green transition, carbon net zero

1 Introduction

In the context of European and state policies to reduce greenhouse gas emissions and climate neutrality, the Bulgarian energy sector is facing a serious challenge. Specifically, which path to take in the transition to low-carbon, reliable and efficient electricity generation? Climate change and environmental degradation are the reasons to look for new ways to develop a modern, resource efficient and competitive economy. The aim is to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels by implementing climate, energy and transport policies [1]. The energy sector is one of the key sectors of the European economy, but due to the massive use of fossil fuels it is at the forefront of greenhouse gas emissions. In the context of Europe-wide policies to achieve climate neutrality, the Bulgarian government adopted the Recovery and Sustainability Plan for the Republic of Bulgaria. In the area of climate and environment, Bulgaria faces challenges related to decarbonising the energy sector and promoting clean and efficient production and use of energy and resources. In national terms, the energy sector is characterised by well-developed energy resources, which maintain a certain level of security, an established energy structure and a high percentage of electricity production from low-carbon primary sources, such as the Kozloduy NPP. Achieving these goals can be accomplished through the construction of new sustainable electricity generation capacity that will upgrade the electricity infrastructure while improving the emission performance of the Bulgarian electricity system. There should also be a focus on strengthening energy security in the face of secure energy sources, maintaining and enhancing connectivity with neighbouring countries and developing a highly liquid market. Nuclear power, with its ability to provide stable, constant and reliable energy - regardless of weather conditions - must be part of the solution.

2 Current State of the Bulgarian Electricity Sector

The Bulgarian energy sector is characterized by a diverse production mix, which ensures the security of electricity supply for both Bulgaria and Southeast Europe. The well-established energy infrastructure allows local energy resources to be developed and a certain level of stability to be maintained. A large percentage of electricity generation is due to low-carbon primary sources, which places nuclear fuel first among the main low-carbon fuels and second in importance (Figure 1). The primary fuel in the state's electricity system is lignite, which is low-grade and low-calorie. For the time being, and at least in the coming decade, lignite-fired thermal power plants will play a fundamental role in meeting the country's power balances and in fulfilling the transmission operator's functions of maintaining balance, frequency and exchange capacity within the national power system and in the single synchronous zone of continental Europe.

However, the future development of the Bulgarian energy sector must be carried out in the context of the transition towards lower carbon emissions [2]. This is a prerequisite for the construction of new sustainable power generation capacities to build on the existing electricity and gas transmission infrastructure, while improving the emission performance of the electricity system. To make the energy transition in a fair, cost-effective and competitive manner, a coherent government policy is needed, in particular on the setting and implementation of strategic priorities in energy development.

The increased and uncontrolled penetration of renewable energy sources, as well as the lack of significant industrial load in the country, will lead to the forced curtailment of the operating capacity of NPPs during certain periods of the year with an increasing trend. This is a prerequisite to seek ways to compensate for the loss of manoeuvrability and balance of the power system. Technologies and

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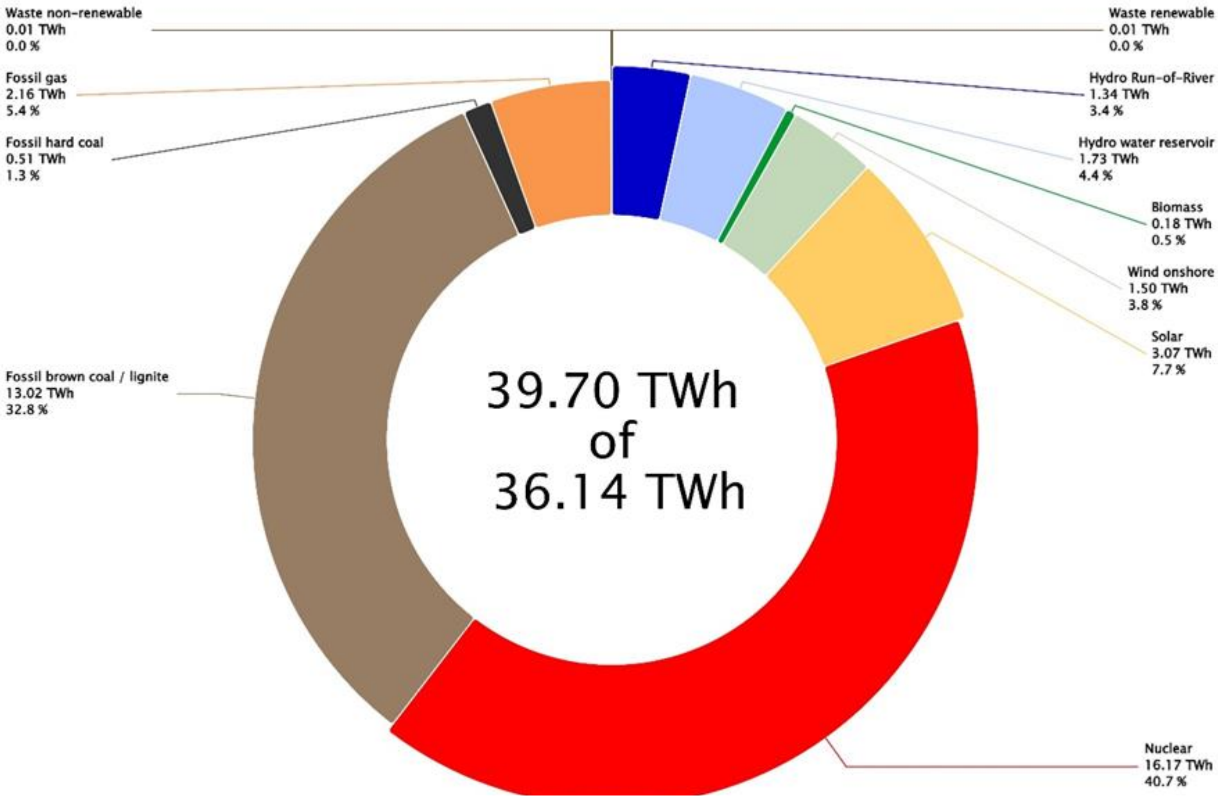

Figure 1. Distribution of net electricity generation in Bulgaria for 2023.

processes for converting energy into hydrogen and other alternative gases to allow energy storage at times of surplus are a possibility.

A threat to the development of the Bulgarian energy sector is the lack of human potential, which is explained by the demographic crisis, but also by the lack of educational strategies in the field. This leads to low interest in energy careers and a loss of energy knowledge. The consequences of a lack of qualified personnel will be the loss of power generation assets due to poor operation and maintenance.

In the context of the tense geopolitical situation, it is crucial for Bulgaria to find the right way to achieve its main strategic objectives, which will lead to preserving its energy sovereignty by maximizing the use of domestic energy resources – both existing and new ones.

3 Role of the Bulgarian Energy Sector in the Electricity Market in the Region and Europe

Bulgaria is among the leading net exporters of electricity in the European Union for 2022. The reasons for this are high electricity prices and less energy production in Europe, as well as the fact that production exceeds consumption at national level. Realised exports for 2022 amount to 12.24 TWh, generating approximately BGN 6.7 billion in revenue. This equates to 4.8% of the country's GDP, or three times the previous year's 1.55%. Compared to 2021, Bulgaria's electricity imports decreased by 21.3% , with a value of 0.7 TWh.

Bulgaria is a significant net exporter to the countries of the region, with a tendency to maintain this role due to the future energy policies of the consumer countries (Figure 2). One of the main recipients of Bulgarian electricity, Greece, and Romania, are planning to decommission their coal-fired power plants and switch to low-emission renewable energy generation. The main trend in the Western Balkans is the decommissioning of low-efficiency capacities, which will lead to the need to build new energy-compatible facilities. This creates the risk of electricity exports ceasing, which could lead to destabilisation of the financial situation of the country and society. At times of higher consumption, such as during the winter months, there will be a need for emergency imports of electricity from neighbouring countries to maintain the security of the electricity system. Considering the energy development plans and forecasts of the neighbouring countries, there is no reason to worry about Bulgaria's role as an exporter. The need to export electricity is expected to grow, as is the need for storage systems for the electricity generated by renewable energy capacities.

4 European and National Energy Development Targets by 2053

The European Union's ambition to be the first climate-neutral continent requires the adoption and implementation of policies to eliminate the threat of climate change and environmental degradation. The overarching objective is to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. The European Green Pact covers important aspects that are fundamental to achieving the transition objectives properly and effectively. First and foremost is the setting of mutually sup-

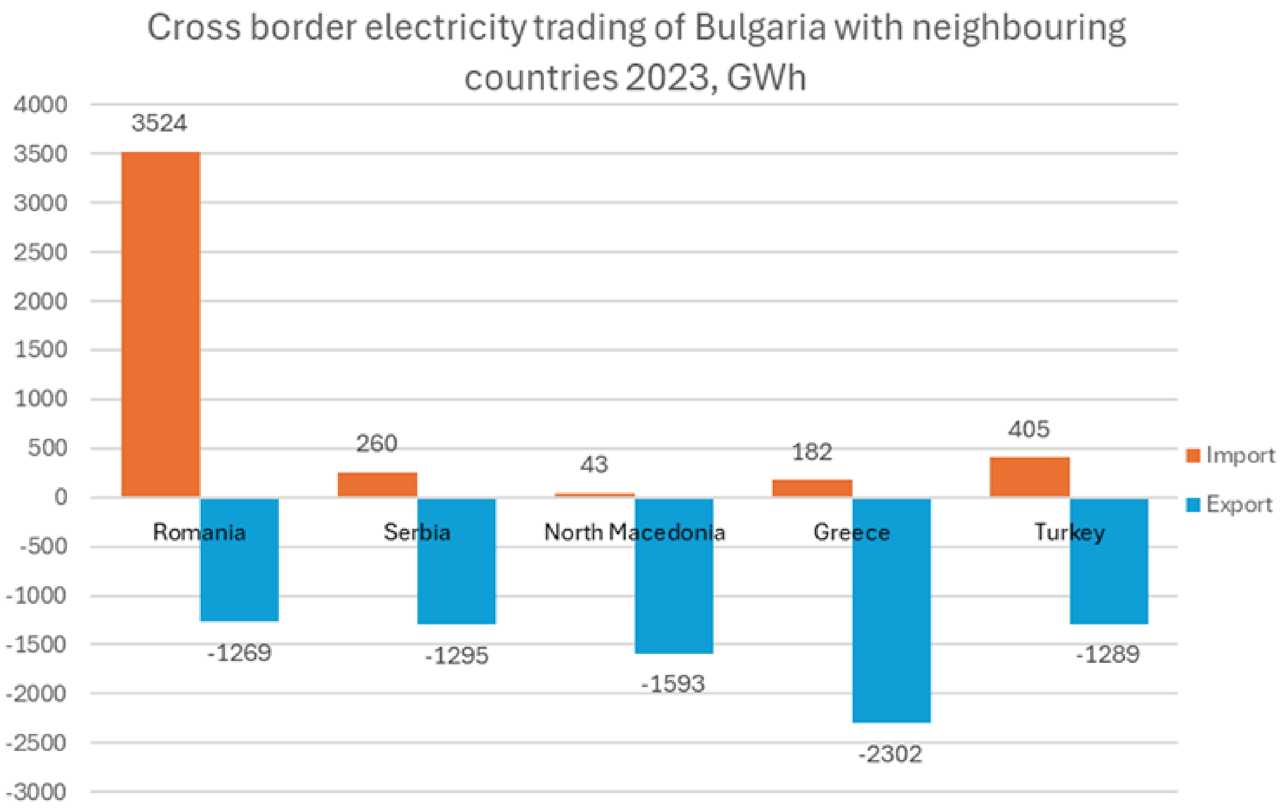

Figure 2. Cross border electricity trading of Bulgaria with its neighbours in 2023.

portive science-based targets for decarbonisation and nature restoration . This is underpinned by the need to introduce model initiatives to transition to sustainable food systems in the European Union and to correct the global environmental footprint. This is a consequence of the interconnectedness of climate and biodiversity. Ecosystem conservation and restoration is essential both to mitigate climate change and to prevent further biodiversity loss. There is also a need to focus on the measures that will be implemented in the event of non-compliance or poor enforcement of environmental laws to ensure a just transition for people and the environment.

One of the main strategic plans to combat climate change is 'Fit for 55' [3]. In addition to achieving at least a 55% reduction in greenhouse gases by 2030 compared to the 1990 baseline, it also aims to increase the share of renewable energy in final gross consumption to 40% in 2030. A target of 9% reduction in energy consumption at EU level compared to the 2020 reference scenario is also set.

At the national level, Reform 10 of the Recovery and Sustainability Plan of the Republic of Bulgaria is adopted, which sets the decarbonisation of the energy sector as a key objective [4]. It envisages a 40% reduction in carbon emissions from electricity generation by 2025 based on 2019 baseline levels. In order to achieve this target, an update of national legislation in the Climate Change Mitigation Act is on the table, as well as a timetable for the phase-out of lignite-fired power plants and the imposition of a regulatory cap on their carbon dioxide emissions. In order to achieve the energy transition properly and efficiently, it is necessary to rethink the targets and build a plan in line with the European climate targets, which does not, however, jeopardise the security of Bulgaria's electricity system.

The main strategic objective for electricity development for Bulgaria is the reliable provision of clean and affordable energy for all consumers, which should take place in an environment of energy security and with the country maintaining its role as an energy leader in the region. A sustainable transition to low-carbon energy requires a long-term vision, predictability and phasing to avoid risking the functionality of the electricity system. The focus is on the introduction of reliable low-carbon technologies that have the availability to secure domestic consumption and the manoeuvrability to avoid balance sheet problems. Some of the action measures foresee the construction of new nuclear and green energy capacities as well as green hydrogen production capacities as a substitute for gas and a means to balance the energy system.

5 Nuclear Energy as a Key Factor for Achieving Energy Transition

Nuclear energy has the potential to play an important role in helping the country to make its energy transition without significant consequences and in an environment of security and reliability. The construction of new nuclear capacity has the potential to reduce dependence on imports and consumption of fossil fuels, as well as to help neutralise carbon dioxide emissions. Globally, nuclear energy is the second largest source of emission-free energy after hydropower.

Nuclear power is a well-established large-scale, low-carbon energy source and has the potential to contribute to the decarbonisation of electricity supply [5]. To have a significant place in the energy transition, the nuclear industry needs to develop policies to implement projects in a timely manner as well as to regulate their cost. The Department of Energy's energy model makes key assumptions for 2023-2053 to preserve Bulgaria's energy dependence and its role as a net exporter of electricity and balancer for the region. The nuclear sub-sector envisages the construction of 2000MW of new capacity at the Belene site by 2035/2040, the construction of 2000MW of replacement capacity by 2045 at the Kozloduy site, the retirement of 2000MW of capacity at the Kozloduy site by 2050-2052.

The predominance of solar and wind in the energy mix and the cessation of fossil fuel generation must be complemented by energy sources that can provide stability, flexibility, and sufficient capacity during periods of peak demand. In this respect, nuclear energy sources complement renewable ones by providing critical services to electricity systems.With the right targets, achieving an energy transition using nuclear power would ensure the security, reliability, and efficiency of the electricity system. It is necessary to maintain the share of nuclear power generation in the national energy balance, and to provide for its expansion in a normal market environment and objective competition for development. Safety must be a priority for the development of the nuclear industry. This will help to facilitate the introduction and acceptance of nuclear technology facilities by society. To be operated properly, the energy infrastructure will need highly qualified personnel. There is a need to build a sustainable system for their training. Ensuring the safe treatment and permanent storage of all categories of radioactive waste and spent nuclear fuel is also a key objective on the path towards low-carbon energy involving nuclear power. Achieving carbon neutrality will require the construction of new nuclear capacity as well as the introduction of new nuclear technologies for combined heat and power generation. The introduction of new technologies will contribute to reducing technological losses on the grid, expanding the energy market, helping to achieve decarbonisation, reducing energy costs for consumers, and reducing emissions.

6 Small Modular Reactors as an Option for Low-Emission Energy

Small modular reactors (SMRs) combine the advantages of large nuclear power plants – clean, uninterrupted, reliable power with no greenhouse gas emissions – but require little space to operate and provide improved nuclear safety resulting from the adoption of passive principles in safety systems.

Small modular reactors are a new generation of reactors with an electrical power of up to 300MW per unit [6]. The definition 'small' means physically a fraction of the size of a conventional nuclear power reactor and the word 'modular' defines one of the key attributes for this technology, namely the ability for systems and components to be factory assembled and transported as a unit to an installation site. Small modular reactors are attracting interest due to the growing demand for smaller and simpler nuclear systems for power generation and process heat. They could be a solution for countries where the electricity system does not have a well-established infrastructure and remote areas need to be supplied with power. With their low capital costs, SMRs are an opportunity to develop nuclear power at a reasonable cost to give energy independence, security and stability.

The precarious economics of nuclear power are mainly due to the complex and sophisticated nature of nuclear power plants, resulting in increased construction costs. Because of the absence of complex buildings and structures, SMRs have lower capital costs as well as operation and maintenance costs. A further advantage of SMRs is the ability to use spent nuclear fuel (SNF) from today's nuclear power plants as their fuel, thus reducing fuel costs and increasing the refuelling period. The spent fuel from these SMRs would have lower radioactive toxicity and would not require such a long storage period, which determines the lack of need for fresh fuel and SNF storage facilities.

The idea of SMRs is that they will be factory and mass produced, which is a prerequisite for facilitating the licensing and commissioning process. The modular design simplifies the construction of the complete plant as well as the space it will occupy, thus creating more potential deployment sites. The smaller size of the facilities will make transportation to site easier, which is also a factor in reducing capital costs.

Today's large nuclear facilities face a number of technological hurdles. Their core is required to operate under high voltages, creating the risk of steam explosion and dispersion of highly radioactive chemical elements into the environment. In small modular reactors, this problem is eliminated due to the smaller geometric dimensions of the core. This allows the use of integral designs, resulting in higher safety and simplification of systems as well as operation and maintenance activities. One of the main characteristics of SMRs is their enhanced nuclear safety, which is due to the presence of passive principles in the safety systems.

The aim of small modular reactors is to increase the safety, reliability and efficiency of nuclear power plant operation by enclosing all the major components of the reactor units in compact units.

A large number of small modular reactor designs are being developed around the world to meet different end uses and power generation capacities. The list is constantly changing as new companies are established and concepts are developed, and as companies restructure or merge to secure the confidence of potential customers in different Member States [7]. More than 70 projects are currently under development for various applications (Figure 3). As of mid-2020, two of the projects are at an advanced stage of development: the Argentinian CAREM, which is a small prototype of a future larger commercial facility, and the Chinese HTR-PM, an industrial demonstration plant.

Bulgarian legislation may need to be adapted for the successful licensing of small modular reactors to be deployed on an industrial site, due to the specific decision-making process and site-specific requirements that have been developed for the licensing procedure of a large power nuclear reactor. In contrast to RETs, small modular

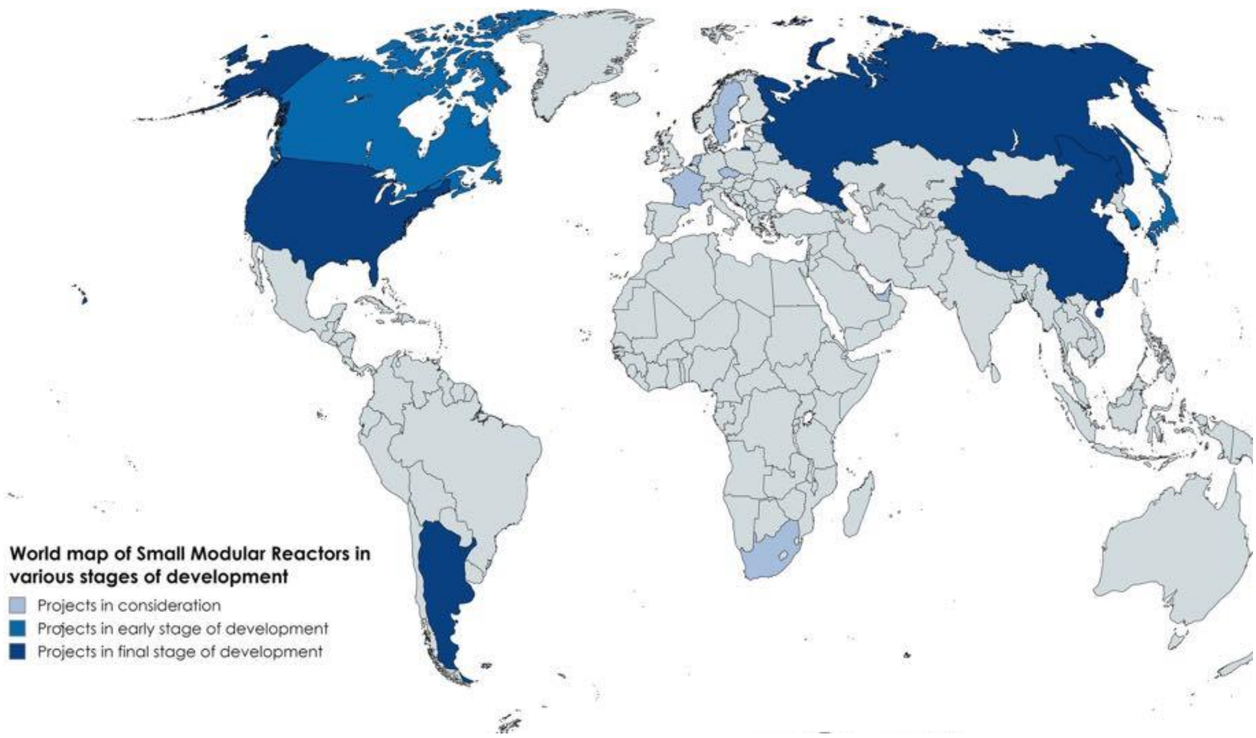

Figure 3. World map of Small Modular Reactors in various stages of development.

reactors are not only far more productive, but their load can be planned years in advance. At the same time, however, they also have the flexibility of gas-fired plants, but are not as dependent on fuel price fluctuations. In order to keep pace with the development of new nuclear technologies, Bulgaria needs to take measures to implement scientific projects that will introduce small modular reactors into the country's energy infrastructure.

7 Construction of New Large Nuclear Power Plants

Large nuclear facilities face economic hurdles. Today's generation of nuclear power plants needs to undergo a number of improvements, including increased security and reliability requirements. This will increase capital costs and may lead to construction disruptions caused by difficulties in accumulating the necessary funds for project implementation. One of the disadvantages of large capacity nuclear plants is that they cannot always keep up with the load on the system, and a reduction in their output overnight is directly reflected as increased operating costs and degraded competitiveness. The specific nature of nuclear reactors leads to the need for them to be fully and evenly loaded over time.

There are two projects for the construction of large nuclear power plants in the country. At the beginning of May 2012, the project company "Kozloduy NPP – New Capacities" EAD was established. The main objective of the project is the construction and commissioning of a new nuclear power plant of the latest generation (pressurized water reactor Generation III or III+) at the Kozloduy NPP site with a capacity of about 1200 MW, with two alternatives: using equipment ordered for the cancelled project and using another PWR model [8]. In 2017, after a final review, the Nuclear Regulatory Agency found that the submitted project documentation complied with the regulations without any exclusion factors for the safe operation and deployment of new nuclear power on the Kozloduy NPP site. In June 2023, the contract with Westinghouse Energy Systems LLC Bulgarian Branch for the initial engineering and design works was launched. The main objective of the contract is to provide a package of services to support the implementation of a new nuclear power project based on the AR1000 technology on the Kozloduy NPP site. The results of the services provided will be used to prepare preliminary design and construction activities for the future nuclear facility.

The construction and commissioning of a new nuclear power plant on the Kozloduy site will contribute to several objectives. It will achieve an economically viable and efficient use of the full capacity and capabilities of the available infrastructure on the Kozloduy NPP site, as well as create a prerequisite for increasing employment of the population in Northwest Bulgaria. An important aspect of the project is the aim to preserve the scientific and technical potential of the Republic of Bulgaria in the use of high technologies and a strong stimulus for the growth of the Bulgarian economy. The construction of a new nuclear power plant will preserve the country's status as a leading exporter of electricity to the countries of the Balkan region and Southeast Europe and will ensure secure energy supplies, in the context of expanding peaceful uses of nuclear energy, in a manner that ensures nuclear safety and security and minimizes the risk of proliferation of nuclear materials. The main objective of the project is to significantly reduce overall greenhouse gas emissions through the development of nuclear power together with the implementation of other efficiency measures such as energy conservation, improving energy efficiency and increasing the use of renewable energy sources.

In the early 1980s, a second site was selected near the town of Belene for the construction of new nuclear units. The Belene NPP project is a third-generation pressurised water reactor with a developed concept of passive and active safety and proven reliability under extreme combinations of external influences [9]. The facility is planned to have a capacity of 2000 MW and a 60-year lifetime. The Belene site was approved by the Nuclear Regulatory Agency in December 2006. During the construction works until July 2009, the dismantling of the existing structures was carried out, as a result of which the site was prepared for the implementation of the plant design.

The design of the Belene plant is analogous to the well-established technology used in the existing Kozloduy NPP units. The required high level of safety is ensured by applying the principle of constructing the safety protection systems in such a way that all essential safety functions are performed by both active and passive safety systems. Based on the results of the studies carried out, it is concluded that the Belene NPP project is prepared for events beyond the design basis. The design also foresees the construction of an on-site dry storage repository with an initial capacity of 10 years of operation of the two units and a lifetime capability.

In March 2012, the Council of Ministers adopted a decision to cancel the designation of the Belene nuclear power plant as a site of national importance and to build a nuclear power plant at the Belene site. The decision was justified by the impossibility at that time to structure the project in a way that would guarantee its economic viability in the conditions of the global financial and economic crisis at that time. In June 2018, the Council of Ministers revoked the March 2012 decision to suspend further actions related to the implementation of the Belene project and resumed activities to search for opportunities to build the plant together with a strategic investor.

8 Public Opinion on Nuclear Energy

For the period 1-9 August 2020, a national survey on "Attitudes towards nuclear energy development in Bulgaria." It shows that the opinion of Bulgarians about nuclear energy is positive and more than half of them think that it is necessary to develop nuclear energy in Bulgaria. Public opinion shows that the development of the country's nuclear infrastructure should be carried out through the construction of the Belene NPP and new units at the Kozloduy NPP. The survey shows that half of the respondents support the construction of Belene NPP.

The nationally representative survey on "Public Attitudes on Topics and Issues Related to Energy", conducted in September 2020 by the National Centre for Parliamentary Research at the Parliament of the Republic of Bulgaria (NCPR), shows a high level of public support both for the development of nuclear energy in Bulgaria and for the implementation of the main projects [10] (Figure 4).

Another survey [11] conducted in Bulgaria aims to examine public attitudes towards nuclear energy, radiation, and radiophobia. It revealed that the regions with the highest voting activity were the Southwest (41%) and North Central (40%). The survey delves into issues such as radioactive waste management, public opinion on nuclear energy, and concerns about safety and risk management in the nuclear sector. It also touches on topics like ionizing radiation, medical diagnostics, and the impact of radiation on health. The survey aims to understand the public's knowledge, attitudes, and fears regarding nuclear facilities, radiation exposure, and the development of the nuclear industry in Bulgaria. Public concerns about nuclear energy, radiophobia, and radiation exposure were prominent in the survey findings. While most participants expressed trust in nuclear technology, there was a prevalent fear of invisible radiation among the public. Despite this fear, there was significant support for investing in nuclear power plants in Bulgaria. The study also found that Bulgarian citizens have a significantly increased trust in gov-

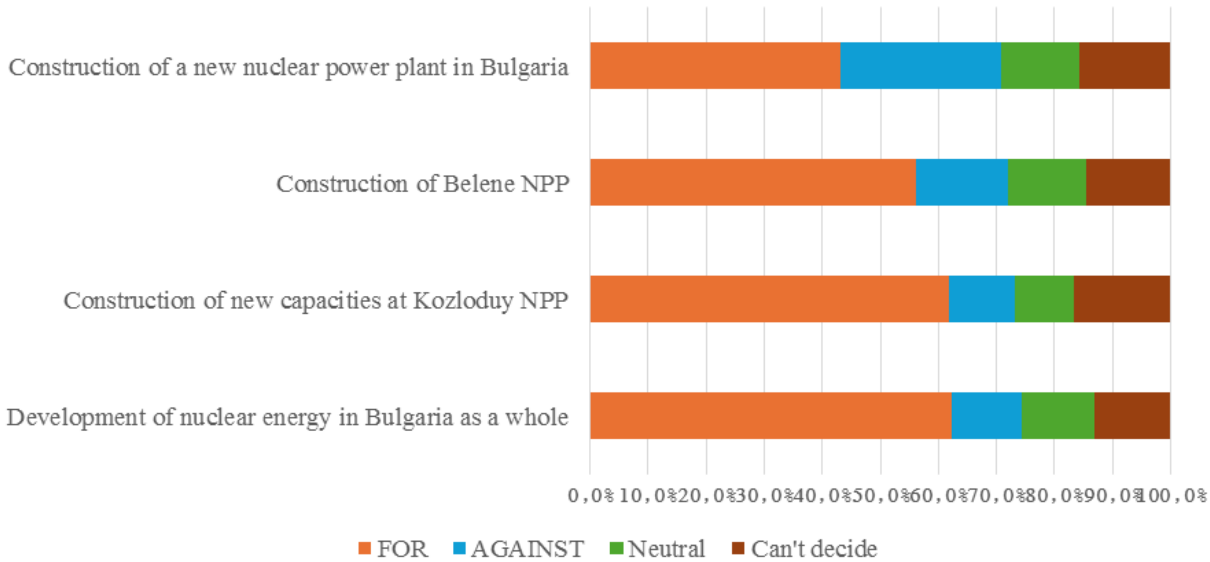

Figure 4. Public attitude towards the development of nuclear energy in Bulgaria.

ernment agencies and institutions for information on radiation. It also discusses the impact of media, such as the HBO miniseries "Chernobyl", on public opinion. Opinions varied on the construction of a nuclear waste repository, and the level of education influenced individuals' knowledge and fear of radiation in the survey.

9 Maintaining the Balance of the Power System by Combustion of Hydrogen

Hydrogen can be used as a feedstock, fuel or energy carrier and energy storage medium and has many possible applications in industry, transport, energy, and construction. Most importantly, it does not emit C and there is no air pollution from its use. It is therefore an important factor in finding a solution to the European Green Pact's climate neutrality target of 2053.

Hydrogen can help to decarbonise industrial processes and economic sectors where reducing carbon emissions is both urgent and difficult to achieve. At present, the amount of hydrogen used in the European Union remains limited and is largely produced from fossil fuels. The aim of the strategy is to decarbonise hydrogen production. This has been made possible by the rapid reduction in the cost of renewable energy and the acceleration of technological development, as well as by expanding the use of hydrogen in sectors where it can replace fossil fuels.

Hydrogen is a flammable gas and needs to be produced, stored, transported, and used safely. Standards are in place and the European industry has built up considerable experience with over 1500 km of dedicated hydrogen pipelines in place.

As hydrogen consumption expands to other markets and end-use applications, the Strategic Vision for the Development of the Electricity Sector of the Republic of Bulgaria states that the need for safety standards in production, transport, storage, and use is critical and includes a monitoring and verification system.

In the quest for cleaner and more sustainable energy sources, the potential shift from lignite to hydrogen is the subject of considerable attention. Lignite coal, with its low calorific value of 6 MJ/kg, has long been the main fuel for electricity generation, especially in regions with significant coal reserves such as Maritsa East in Bulgaria. However, the environmental and health consequences of lignite mining and burning are increasingly worrying. Hydrogen has a calorific value of 120 MJ/kg, making it a promising alternative for power generation. Comparing the heat produced by burning the two energy fuels, the heat produced by burning 1 kg of hydrogen is equivalent to that produced by burning 20 kg of lignite. Switching to hydrogen comes with its own set of challenges, especially in terms of the energy requirements for its production and the need for renewable sources of electricity to replace lignite. Hydrogen can be used efficiently in gas turbines, which are known for their quick start-up, allowing for rapid response and flexibility when additional electricity is needed. These turbines can be deployed in existing thermal power plants. In this way, part of the equipment already installed, namely the steam generators and condensers, can be used. This would considerably reduce the amount of investment needed to build such a facility.

Hydrogen production is an extremely energy intensive process. One kilogram of hydrogen produced using electrolysers requires 50 kWh of electricity. It is envisaged that this energy will be produced by photovoltaic plants, but a large-scale expansion of the installed capacity of PV plants is needed to fully support this process. Currently, relying solely on solar power to meet the significant electricity needs for hydrogen production is not feasible due to the intermittency of renewable energy and the need for consistent sources of power to offset the low values from the PV plant at certain times. An alternative approach is to combine nuclear plants as a stable baseload generator with hydrogen production during periods of surplus electricity, such as midday. This surplus electricity can be used to produce hydrogen as a way of efficiently storing energy for later use when demand exceeds baseload capacity, as in the hours of 17:00 to 21:00. This synergy between nuclear power as a permanent energy source and hydrogen as a storage and generation solution offers a promising solution in the quest to build a more sustainable and reliable energy system in a climate neutral environment.

10 Spent Nuclear Fuel and Radioactive Waste Management

There is no developed possibility for realization of a complete nuclear fuel cycle on the territory of the country, which is the reason for the establishment of a national practice for spent nuclear fuel management, related to its storage on the site of Kozloduy NPP in the pools for the aging of the caskets and the storage facilities for spent nuclear fuel (SNF) storage, with its subsequent transportation for technological storage and reprocessing.

The main principles regarding the management of SNF and radioactive waste (RAW), which are laid down in the national policy and applied, are the protection of human health and future generations, as well as their non-encumbrance, environmental protection, safe, controlled, and secure management of SNF and RAW management facilities [12].

The reprocessing of SNF is a necessary process that ensures the separation of fission products and at the same time the preservation and the possibility to use the energy resource of the fissile materials that are owned by Kozloduy NPP. This will allow the plant site to be cleared of SNF.

The most optimal alternative is the transportation of at least 50 TM of SNF per year from Kozloduy NPP for technological storage and reprocessing, provided that favourable financial and economic conditions are available. This is foreseen until the end of the lifetime of the units, with the funds to be provided by revenues from the sale of the generated electricity. To manage the SNF efficiently and safely, if the planned removals for reprocessing and storage of SNF and VVER1000 do not take place, there will be a need to construct a Dry SNF Storage Facility for VVER-1000, which will need to be ready for operation by 2030.

The construction of a repository for the long-term storage of high-level waste and long-lived intermediate-level waste is foreseen. The construction of such a repository will allow new data and technical solutions to be obtained which will be able to significantly change the methods of managing these wastes and avoid serious errors in the final disposal in stable geological formations.

Optimisation of the existing single technological system on an economic basis, with a priority on safety, is considered as options for the management of RAW. The main objectives are set in improving the efficiency of the sorting of RAW by using new categorisation and acceptability criteria for managed RAW. The focus is also on process optimisation towards a significant reduction of the volume of waste generated and the improvement of the technological processes of primary treatment of waste.

11 Conclusions

The Strategic Electricity Sector Development Plan underlines that nuclear energy plays a significant role in ensuring national, regional, and European energy security, while at the same time providing affordable energy and being a key element in the transition to a low carbon economy. Accordingly, nuclear energy, as a proven emission-free resource, is and remains a key element in the country's energy balance structure.

The Bulgarian energy sector plays a crucial role in ensuring national, regional, and European energy security, with a focus on providing affordable and clean energy while maintaining the country's leadership in the region. Nuclear energy is highlighted as a key element in transitioning to a low-carbon economy, offering emission-free energy and stability to the electricity system. Challenges such as the lack of qualified personnel due to demographic issues and educational strategies need to be addressed to prevent asset loss from poor operation and maintenance.

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