Translation from Bulgarian

NATIONAL STRATEGY

FOR HUMAN RESOURCES DEVELOPMENT

IN THE NUCLEAR FIELD

2022 - 2032

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1. INTRODUCTION

1.1. Definition of concepts

Human resources can generally be understood as the totality of people with their knowledge and skills working in all sectors of the economy.

According to the definition of the United Nations Human Development Program, human resources comprise the integrated use of the efforts for educational, organizational and career growth in order to improve the individual, group and organizational effectiveness [1].

This definition provides a more specific system of concepts and it will be the basis of the National Strategy for Human Resources Development in the Nuclear Field.

The nuclear field (sector) includes all organizations performing activities related to the safe use of nuclear energy and ionizing radiation, the safe management of radioactive waste and spent fuel, the regulation of such facilities and activities, as well as all institutions and organizations performing educational, research and development activities related to the use of nuclear facilities (NF) and locations with sources of ionizing radiation (SIR).

1.2. Justification of the need for a strategy. The public image of the nuclear energy

The national policy in the field of the use of nuclear energy and ionizing radiation is carried out in compliance with the requirements and principles of nuclear safety and radiation protection with priority over all other activities. An essential element necessary to ensure and maintain the nuclear safety and the radiation protection at the highest possible level is the availability of staff with relevant qualification in all organizations operating in the nuclear field. The nuclear field, including industry, government agencies, regulatory authority, science-research organizations and educational institutions, relies heavily on a specialized, highly trained and motivated workforce for its sustainability and development. The ageing workforce, the declining student numbers and the resulting risk of losing accumulated nuclear knowledge and experience are serious challenges that impact the management of human resources in the nuclear field. It is important that government institutions, industry and academia cooperate at national and international level to create a functional framework to support education and training. There is a vital need to establish close cooperation between industry and academia in the research and development activities. Such an approach will contribute to ensure the earliest possible stage of interest of the younger generation to study the wide range of sciences applicable in the nuclear sector. Thus, it will also ensure that the training and the subsequent qualification will be adequately adapted to the real needs of the sector, rather than remain based on theoretical and outdated presentation of information.

In the established nuclear programs, the preservation of human resources is a key factor. The attraction of specialists for the development of new applied technologies and the planning of a complex of nuclear applications allow maintaining the necessary high level of knowledge and skills of those employed in the sector.

Despite the state's efforts and the investments in the education system, there is an imbalance between the needs of the economic activities and the quality of the available human resources.

The nuclear field is a specific area of human resource use. In recent years, the public image of the nuclear energy has been influenced by a number of contradictory factors, both at national and European level. On the one hand, in the course of the negotiations for the accession to the European Union, Bulgaria made a political commitment to close and gradually decommission units 1 to 4 of Kozloduy NPP. On the other hand, there is a program to extend the life of the units 5 and 6.

The nuclear program of the Republic of Bulgaria started in 1961 with the commissioning of the IRT-2000 research reactor at the Institute of Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences (BAS). This marks the beginning of the research and scientific-applied activities carried out at the newly built experimental reactor. This was a unique facility for its time, which played a key role in creating

experienced nuclear professionals who later provided invaluable assistance in the commissioning of Kozloduy NPP. This is reflected in the fact that Dipl. Eng. Simeon Ruskov, the first head of the research reactor, was the first director of our nuclear power plant.

In 1970, the construction of power unit 1 of the Kozloduy NPP began. For 20 years, 5 more power units were been built on the same site. In implementation of the country's commitments upon the accession to the European Union and in compliance with Decision of the Council of Ministers No. 848 of 19 December 2002, units 1 and 2 of Kozloduy NPP were disconnected from the national energy system on 31 December 2002. Pursuant to Decision of the Council of Ministers No. 52 of 21 December 2006, on 31 December 2006, units 3 and 4 were stopped.

Currently, units 5 and 6 of Kozloduy NPP are in operation following a large-scale modernization program. As a result of the analyses carried out during the implementation of the project for extending the period of operation, the possibility of having units 5 and 6 operating until 2047 and until 2051, respectively, is substantiated.

Units 1 to 4 undergo a process of decommissioning and the relevant activities are carried out by State Enterprise "Radioactive Waste" with the financial support of the EU through the Kozloduy International Decommissioning Support Fund [2].

A wet storage of spent fuel, a dry storage of spent fuel, and facilities related to decommissioning activities and radioactive waste management are operating at the site of Kozloduy NPP. National Repository for the disposal of low and intermediate level radioactive waste is under construction.

By Decision of the Council of Ministers on para. 1 of Protocol No. 14 of 11 April 2012, the Council of Ministers agrees in principle to the construction of a new nuclear power capacity of the latest generation at Kozloduy NPP. In compliance with this decision, a licensing procedure is in progress for the construction of a new nuclear power capacity of the latest generation at the site of the nuclear power plant. Currently the site has been approved by Order No. AA-04-30 of 21 February 2020 of the chairman of NRA. The process has been stopped at the design permit stage due to the lack of a decision on the substance of the CM on the construction of the new nuclear power capacity. According to the Decision of the Council of Ministers on para. 34 of Protocol No. 5 of 20 January 2021, possibilities for expanding and diversifying our national nuclear program are being considered, conducting analyses and evaluating various options for the realization of new III+ generation nuclear power capacity at the site of Kozloduy NPP in a cost-effective, technically and legally justified manner.

The uncertainty surrounding the construction of Belene NPP has continued for more than 30 years. By Decision No. 260 of 8 April 2005, the Council of Ministers consents in principle to the construction of a new nuclear power capacity at the site of Belene NPP. In 2012, by Decision No. 250 of 29 March 2012, the CM annulled the aforementioned decision. Following Decision No. 447 of 29 June 2018 of the CM, the search for a strategic investor for the construction of Belene NPP has been resumed.

Regardless of the controversial decisions regarding the possible construction of a second nuclear power plant in Belene and new capacities at Kozloduy NPP, they do not negatively affect the public image of the nuclear energy. The attitudes of the Bulgarian society have been relatively stable over the years. For example, in the national referendum in 2013, 61% of the votes supported the development of the nuclear energy. Seven years later, a survey carried out by Trend sociological agency in the period 1 to 8 August 2020 shows that 58% of the Bulgarians continue to support its development. The results of a nationally representative survey carried out by the National Center for Parliamentary Research (NCPR) to the National Assembly of the Republic of Bulgaria in September 2020 regarding public attitudes on topics and issues related to energy, show that 62% of the Bulgarian citizens of legal age support the development of the nuclear energy in Bulgaria. The logic of the development shows that the technical and economic advantages of the nuclear energy – its low carbon emission profile and low production costs – may not be ignored in the development of the Bulgarian power energy. Therefore, the Energy Strategy of the Republic of Bulgaria until 2020 adopted in 2011 and the Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030, with

a horizon to 2050 provide for the construction of 2000 MW capacities. The draft Strategy for Sustainable Energy Development of the Republic of Bulgaria until 2030 with a horizon of 2050 also reads that "the state will continue to support the development of the nuclear energy in the country by providing institutional assistance for the implementation of an investment project for the construction of two new nuclear units, each with a capacity of 1,000 MW, to be phased into operation after 2030."

Another factor affecting the public image of the nuclear energy is the debate taking place on a European scale about its role in achieving the objectives of the Green Deal. In opposition to the "anti-nuclear states", ten European Union member-states believe that nuclear energy plays a crucial role in climate protection and it is imperative that it be included in the EU taxonomy.

The lack of sustainable solutions for the construction of new nuclear capacities and the ongoing debate in the EU have a negative impact on the attractiveness of the nuclear specialties for the young people. This, together with the unfavourable demographic trends, leads to ever deepening problems related to the training of specialists with secondary and higher education, necessary for the development of the nuclear sector.

Regardless of whether the development of energy in Bulgaria will continue with the construction of new nuclear capacities or not, the extended period of operation of units 5 and 6 of Kozloduy NPP requires the availability of highly qualified specialists, necessary not only for the safe operation of the units, but also for all organizations involved in the nuclear field according to the definition referred to in para. 1.1. This is one of the reasons for the need to elaborate a strategy for the development of human resources in the nuclear field. The development of this strategy is substantiated in the regulatory framework. The Safe Use of Nuclear Energy Act lays down requirements according to which "only persons who meet the established statutory requirements for education, qualification and certified competence for employment in nuclear facilities shall be allowed to work in the nuclear field" (Art. 16(4)), as well as requirements for ensuring staff training and improvement and control of staff qualification (Art. 16(3)) [3].

Article 19 of the Ordinance on Radiation Protection [4] (adopted by Decree of the Council of Ministers No. 20 of 14 February 2018) stipulates the requirement that the enterprises "shall be required to ensure maintenance and control of the professional qualifications of their employees in compliance with the requirements of the Safe Use of Nuclear Energy Act and the Ordinance on the Conditions and Procedure for Acquiring Professional Qualification and on the Procedure for Issuing Licenses of Specialized Training and Competency Certificates to Use Nuclear Energy (adopted by Decree of the Council of Ministers No. 209 of 6 August 2004) [5].

According to the international requirements for Bulgaria as a full member of the International Atomic Energy Agency (since 1957), our country must provide and maintain the necessary human resources with appropriate education and qualification in the field of nuclear safety and security.

According to Art. 11 (2) of the Convention on Nuclear Safety, "*Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life*" [6].

According to Art. 22(i) of the Joint Convention on Safety of Spent Nuclear Fuel Management and Safety of Radioactive Waste Management, "*Each Contracting Party shall take appropriate steps to ensure that* ***qualified staff*** *are available as needed for safety-related activities during the operating lifetime of a spent fuel and a radioactive waste management facility*" [7].

In the period 15-16 February 2021, a mission of the International Atomic Energy Agency (IAEA) was held in our country with the main emphasis being "the activities of the Nuclear Regulatory Agency in building professional capacity in the field of nuclear safety and security". As a result of the mission, the main recommendations [8] addressed to Bulgaria are:

- NRA should proactively present to the government and the relevant authorities the need for the development of a National Strategy for building professional capacity in nuclear safety and security in Bulgaria;
- The Government should consider taking measures to increase the number of graduates of nuclear specialties in the higher education institutions of the national education system;
- A strategic document should be drafted for the development of human resources in the nuclear sector in Bulgaria.

1.3. The problem of human resources in the nuclear field in the European context

Article 33 of the Treaty Establishing the European Atomic Energy Community (EURATOM) of 25 March 1957 states that each Member State shall "*take the necessary measures with regard to teaching, education and vocational training*" [9] in the field of atomic energy.

There is a debate within the EU about the role of the nuclear energy. Regardless of the decisions to be made, it is necessary to develop the human potential which is of key importance to ensure the safe use of the nuclear energy.

According to Art. 8 of Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, "*Member States shall ensure that the national framework require all parties to make arrangements for education and training for their staff, as well as research and development activities to cover the needs of the national programme for spent fuel and radioactive waste management in order to obtain, maintain and to further develop necessary expertise and skills*".

Furthermore, according to Art. 7 of Council Directive 2014/87/EURATOM of 8 July 2014 amending Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations, "Member States shall ensure that the national framework requires all parties to make arrangements for the education and training for their staff having responsibilities related to the nuclear safety of nuclear installations so as to obtain, maintain and to further develop expertise and skills in nuclear safety and on-site emergency preparedness."

In a number of its conclusions on the need for professional capacity in the nuclear field, the Council of the EU emphasizes the danger of insufficient competence in the nuclear field if appropriate measures are not taken. The EC and the Member States are required to introduce a "review of the professional qualifications and skills" in the nuclear field [10].

The European Commission, in its study [11] published in 2008 - "Nuclear safety in a situation of declining nuclear experience", analyses the condition of the staff related to nuclear safety and expresses concerns for the period until 2020 about a looming shortage of staff. A number of challenges that need to be addressed are also outlined, such as the insufficient numbers of students in nuclear majors due to a perceived lack of career growth prospects, and the difficulty of attracting young technical graduates to the nuclear sector. There is a growing need to ensure mobility and multicultural skills in response to the globalization in the nuclear industry and to maintain a high level of competence of the workforce.

There are a number of initiatives at EU level in the area of human resources development in the nuclear field. In 2003, the European Nuclear Education Network (ENEN) Association was established to promote the free flow of knowledge in the field of nuclear energy, particularly through higher education and training at EU level. Members of this association are 60 universities and various other structures. The European Nuclear Education Network Association strives for the harmonization of the European master's programs in nuclear specialties, for the support of PhD programs and for the cooperation between different entities that use staff in the nuclear field.

The training programs of EURATOM are aimed at researchers and those working in higher education.

The EC's Joint Research Center (JRC) has a technical base of nuclear facilities for scientific and training purposes. The Center also offers specializations in nuclear technology related to nuclear security.

Education and training are also part of the Sustainable Nuclear Energy Technology Platform (SNE-TP), which includes over 75 organizations from the field.

In 2009, the European Human Resources Observatory for the Nuclear Sector (EHRO-N) was established to analyse the situation and trends in the supply and demand of human resources in the nuclear field for the various interested parties in the nuclear sector.

A number of conclusions can be drawn from the overview of the EU structures and initiatives in the field of human resources in the nuclear sector:

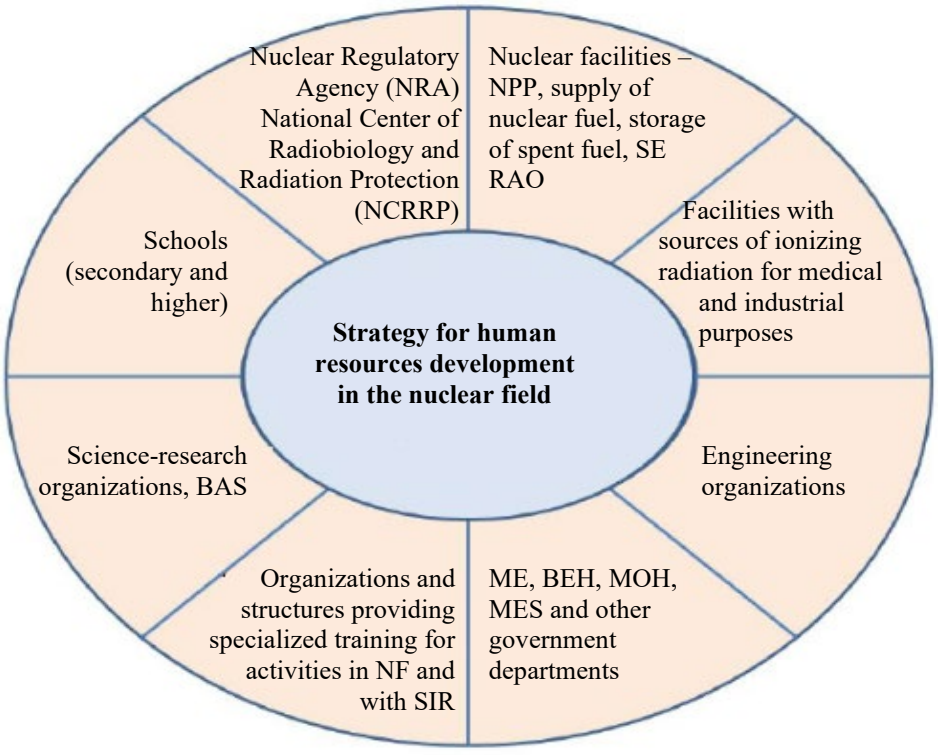
- The problem of human resources has been identified and realized at national and European level;
- Actions have been taken from which results are expected;
- It is expected that the problems will be solved primarily at the national level.

2. STRATEGY SCOPE, METHODOLOGY AND PRINCIPLES

2.1. Scope

The strategy covers all structures and organizations from the nuclear sector, including all organizations performing activities related to the safe use of nuclear energy and ionizing radiation, the safe management of radioactive waste and spent fuel, the regulation of such facilities and activities, as well as all institutions and organizations performing educational, research and development activities related to the use of nuclear facilities and locations with sources of ionizing radiation. The scope of the strategy is schematically shown in Figure 1.

Figure 1. Scope of the Strategy



Actions should be taken for the development of human resources that would lead to the improvement of the managerial, technical, professional and economic aspects in the nuclear sector.

The strategy outlines what needs to be done to address the accumulated challenges in the field of human resource development in the nuclear field, as well as the need for interaction between the interested parties.

The scope of the Strategy includes:

- Implementation of actions to achieve positive results in the education and training of human resources in the nuclear field;
- Entire cycle of working with nuclear facilities – design, construction, commissioning, operation, modernization, decommissioning, RAW and SNF management;
- Implementation of actions to set up and develop human resources that would lead to the improvement of the managerial, technical, professional and economic aspects in the nuclear sector;
- Determination of mechanisms for education, training and interaction between the interested parties to positively change the state of human resources in the nuclear sector;
- Integration of the main guidelines of the Strategy with other strategic development documents;
- Creation of mechanisms for linking the demand and supply of staff in the nuclear field.

The Strategy will play an important role for the activities and decisions of the state structures, including the national nuclear regulator, as well as for educational institutions and organizations and economic entities in the field of human resources.

The challenges analysed in the Strategy and the activities to overcome them apply to people working: in the nuclear power plant; with ionizing radiation; in radioactive waste management; in transportation of radioactive materials; in the national nuclear regulator; in technical service organizations; in educational institutions and organizations.

The Strategy should be used by managers in the field of nuclear energy at state level, by managers and decision-makers in the nuclear sector itself, by managers in maintenance organizations, by managers in the education system, managers in scientific research units, in training organizations [12].

The time frame of the Strategy is the ten-year period **2022-2032**.

2.2. Methodology

The methodology of the Strategy is based on an analysis of the needs for development of human resources in the nuclear field. The development is based on active consultations with the interested parties – state bodies, educational institutions and organizations, users of staff, part of which are also included in the Interdepartmental Task Force (ITG) for the development of the Strategy.

In the light of data collection, an international and national review is carried out of the existing documents, studies and analyses relevant to the topic. Special attention is given to the IAEA publications. In this sense, the methodology used by the ITG is original and specifically formed for the development of this Strategy.

The collection and comparison of data from the national statistics on the demand and supply of human resources, as well as administrative data and data from surveys of economic subjects was carried out.

On-site meetings were held with key organizations operating nuclear facilities, with educational institutions, with scientific research institutes, with training centers.

In terms of the methods of data analysis:

- The connections and interactions, the leading mission and vision and the corresponding guiding principles for the development of human resources have been established;
- The state of the human resources and the views on future needs have been analysed;
- The main strategic goals and challenges have been formulated;
- Consultations were held regarding the expected results of the implementation of the Strategy;
- The main activities that would lead to the improvement of human resources practices in the nuclear field have been outlined;
- The possibilities for managing the planned main activities have been outlined;
- All opinions, views and judgements received have been discussed;

The implementation of the Strategy is accompanied by a monitoring and evaluation system.

2.3. Principles

The Strategy is based on the following basic principles:

- **Legality**. Compliance of the objectives, principles, priorities and activities in the Strategy with the national laws and other regulations.
- **Partnership and dialogue.** Possible broad participation of institutions at national, regional and municipal level, business structures, educational institutions and organizations, civil organizations. The compliance with the principle of partnership will contribute to the effective implementation of the Strategy and increase the effectiveness of the activities undertaken.
- **Complementarity**. The activities planned in the Strategy to overcome the challenges in the field of human resources development in the nuclear field will be complemented and upgraded by activities and initiatives implemented and financed beyond the scope of the Strategy. The activities in the Strategy interact horizontally with other strategic documents, such as the Strategy for Higher Education Development in the Republic of Bulgaria 2021-2030, Updated National Strategy for Demographic Development of the Population in the Republic of Bulgaria, National Development Program 2030, Strategic Framework for Education, Training and Learning 2021-2030, Strategy for Scientific Research in the Republic of Bulgaria 2021-2030, etc.
- **Concentration**. The implementation of the Strategy will concentrate on a specific area, such as the nuclear field, and an even more specific process within it, such as the development of human resources.
- **Preventiveness.** Planning the activities in the Strategy in terms of overcoming or limiting the action of factors that negatively impact the development of human resources in the nuclear field.
- **Continuity**. The Strategy should not be interrupted due to changes in the political situation or other reasons.
- **Sustainability over time.** Continuation of the actions to achieve the goals of this Strategy which have shown their effectiveness and efficiency even after the end of the time and horizon.
- **Effectiveness**. Achieving optimal results with minimal resource consumption.
- **Efficiency**. Adequacy of the set goals, set activities and set results with the real needs of the development of human resources in the nuclear field.
- **Transparency and performance control.** The preparation and implementation of the strategy are fully in line with the principle of transparency. The performance control will be carried out by the competent authorities.

3. ANALYSIS OF THE HUMAN RESOURCE SITUATION

3.1. Analysis of the human resource situation at national level

The demographic situation in Bulgaria is characterized by two main processes – population decline and population ageing. Along with this, the total birth rate is decreasing, the total mortality rate is increasing, whereby the decrease in the infant mortality rate should be noted.

According to NSI data for 2020, as a result of the negative natural growth, the population of Bulgaria decreased by 65,649 people. People aged 65 and over are already 21.8% of the country's population and the tendency is to increase their share.

The trend of population ageing leads to changes in its age structure as well. The legislative changes related to retirement also have an impact on the aggregates of the population at and above working age. For 2020, the limits of the working-age population are up to 61 years and 6 months for women and 64 years and 3 months for men, and early retirement also exists and its rules apply in the nuclear sector.

The working-age population in 2020 is 4,139 thousand people or 59.8% of the country's population. In 2020, the number of the working-age population decreased by 17 thousand people or by 0.4% compared to the preceding year.

The reproduction of the working-age population is characterized by the demographic replacement rate, which shows the ratio between the number of people entering the working age (15-19 years of age) and those leaving the working age (60-64 years of age). As at 31 December 2020, this ratio is 67. For comparison, in 2001, 100 people leaving working age were replaced by 124 young people.

A brief analysis of the labour market as of December 2020 gives an idea of the situation of the structure of the employed, the structure of the unemployed, the regional imbalances. The problems we face related to the labour market also affect the recruitment and development of human resources in the nuclear field.

According to data from the Labour Force Survey conducted by the National Statistical Institute, employment in 2020 decreased compared to 2019 and unemployment increased. According to data of the Employment Agency, the unemployed registered in the labour offices in December 2020 reported an increase on an annual and monthly basis. The state of emergency introduced on 13 March 2020 and the measures taken by the government to limit the spread of the corona virus in the country have a significant impact on the dynamics of the registered unemployment. In 2020, according to data from the National Statistical Institute (NSI), employed persons aged 15 and over decreased by 111.4 thousand compared to 2019, and their number is 3,121.7 thousand. The employment rate for the population aged 15-64 is 68.5%, decreasing by 1.6 percentage points (p.p.) compared to 2019. The employment rate for the 20-64 age group is 73.4% – again decreasing by 1.6 p.p. compared to 2019.

The number of unemployed increased by 25.8 thousand compared to 2019 and reached 168.6 thousand. The unemployment rate in 2020 is 5.1%, i.e. by 0.9 p.p. higher than in 2019. During the period under review, the youth unemployment rate (15-24 years of age) increased by 5.3 p.p. to 14.2%, and the long-term unemployment rate decreased by 0.1 p.p. to 2.3%.

In its report, the Ministry of Labour and Social Policy presents a short-term and medium-term forecast, providing grounds for policies and proactive actions for the development of human resources in the nuclear field [13].

The number of the working-age population follows the dynamics of the total population of Bulgaria (according to the main scenario of the NSI demographic forecast). For the forecast period from 2018 to 2032, the working-age population is expected to decrease by 529.5 thousand people (11.6%). For the period from 2018 to 2022, this number will shrink from 4,563.7 to 4,381.7 thousand people, and the absolute change will be by 182.1 thousand people. The cumulative decline in percentage terms amounted to 4.0%. This value is significant, considering the relatively short period, which is why it should be taken into account when considering the growth opportunities of the economy. In the absence of investment in new technologies to offset the decline in the

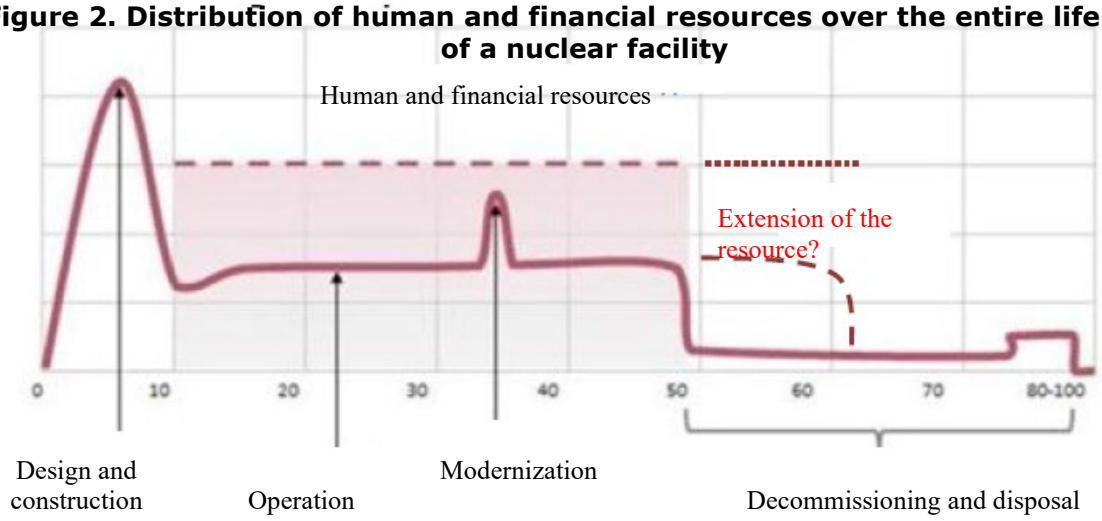
employment, the economic growth rates will not be able to keep up with the pace of the past few years. For the period from 2023 to 2032, the process of decline is predicted to continue, and in the last year the number of the working-age population is expected to reach 4,034.2 thousand people (decrease by 7.9%). If there are no significant socio-economic changes to counteract the negative demographic processes, the observed short-term problem with the limitation of the economic growth will deepen in the long-term. Effective stimulation of growth would be achieved with a significant increase in the investment in innovations and high-tech industries. Regarding the educational structure of the working-age population, the forecasts indicate the following positive trends: In 2022, the population with primary and lower education aged 15-64 will come to 1,188.6 thousand people, and in 2032 – 960.6 thousand people. The share of these individuals will be 27.1% in both 2018 and 2022 (a slight increase in this indicator is expected in the period 2019-2021, followed by a reversal of the trend), then it is expected to fall to 23.8% in 2032. The number of individuals with secondary education in the working-age population will be 2,098.0 thousand in 2022, and 1,961.1 thousand in 2032. The share of these individuals will be characterized by slight fluctuations and will remain relatively constant: its estimate for 2018 is 48.8%, and its estimated values for 2022 and 2032 are 47.9% and 48.6%, respectively. The employed individuals with higher education aged 15-64 will amount to 1,024.6 thousand in 2022 and 1,002.9 thousand in 2032, with the expected growth for the period 2018-2032 amounting to 2.6%. The employment rate for individuals with higher education will increase from 88.7% in 2018 to 93.6% in 2022, followed by a slight decline in the indicator and in 2032 it will amount to 90.1%. One of the factors determining the restructuring of the employment according to educational characteristics is the overall change in the educational structure of the population in the recent decades. In 1992, the share of individuals with higher education in the population was 7.9%, and in 2011 it already amounted to 18.3% (for the period 1985-2011, the share of individuals in the population who completed higher education increased three times). At the same time, the forecasts indicate a continuation of these trends in the medium and long term. At the beginning of the transition, the majority of the population had primary and lower education (55.0%). In 2032, this share will shrink to 23.8%, while the share of persons with higher education in the working-age population will reach 27.6%. The expected restructuring of the employment by educational characteristics is due to a number of factors. First of all, the overall change in the educational structure of the population, especially regarding the increase in the share of the population with higher education. Secondly, the increase in the number of employed persons with higher qualification, which leads to a change in the attitudes and expectations of the employers regarding the qualifications they seek. For example, due to structural imbalances in the labour market, in the recent years persons with higher education were employed for jobs that were previously held by persons with secondary education. The update of the job descriptions for such jobs will continue to follow these market processes, and in the future, persons with higher education will be increasingly sought for them.

3.2. Analysis of the human resource situation in nuclear energy

The development of nuclear energy is a responsibility that spans decades and has the potential to contribute to the economic prosperity.

The human resource requirements at the different stages of the life cycle of a nuclear facility are different, being highest during the design and construction periods and during the modernization. A typical distribution of human and financial resources over the entire life cycle of a nuclear facility is shown in Figure 2.

Figure 2. Distribution of human and financial resources over the entire life cycle of a nuclear facility



As at 2013, about 65% of the employees in the nuclear sector in Bulgaria are directly involved in the operation and the services at Kozloduy NPP. The specialists in companies performing maintenance and repair activities are 14%, 7% are in scientific and research institutes, in education and in engineering organizations. About 38% of the specialists have a master's degree.

As at 2020, about 58% of the employees in the nuclear sector in Bulgaria are directly involved in the operation and the services at Kozloduy NPP. The specialists in companies performing maintenance and repair activities are 18%, 9% are in scientific and research institutes and in engineering organizations.

3.2.1. Kozloduy NPP EAD

Kozloduy NPP EAD is a company operating a nuclear installation within the meaning of the Vienna Convention on Civil Liability for Nuclear Damage. It is the holder of the licenses and permits and bears the primary responsibility for the safety of the nuclear facilities pursuant to this Convention, the Convention on Nuclear Safety and the Safe Use of Nuclear Energy Act.

Kozloduy NPP EAD operates power units 5 and 6, the Spent Nuclear Fuel Storage Facility and the Dry Spent Nuclear Fuel Dry Storage Facility.

The sole owner of the company's share capital is Bulgarian Energy Holding AD. The ultimate owner of the Company is the Bulgarian state, through the Ministry of Energy.

In the conditions of long-term operation of the nuclear power units, the maintenance of qualified, competent and motivated staff is one of the main priorities of the management of Kozloduy NPP EAD. This priority is justified in the Human Resources Management Policy, which regulates the general framework of human resources management processes in the company.

To achieve the goals set in the Human Resources Management Policy, a Human Resources Management Strategy with a horizon until 2028 has been developed at Kozloduy NPP EAD. Although the strategy does not take into account the plans for the construction of a new nuclear power capacity, it clearly defines the strategic goals in terms of long-term operation and the means to achieve them.

The assessment of the current situation at Kozloduy NPP EAD, presented in the Strategy, shows that the majority (73%) of the company's staff is over 40 years old. The average age of the company’s age is about 46 years, with an average length of service at Kozloduy NPP being 17 years. The presented data on the age structure of the staff in the main structural unit of the power plant – Power Generation-2 (PG-2) demonstrate that the largest share of employees at PG-2 is that of the workers aged over 40, i.e. 70% of

the staff. The employees aged over 50 are 41%. 97.3% of the staff of EP-2 works under the conditions of I and II labour category and accordingly acquires the right to early retirement. In the period from 2021 to 2030, an average of 147 people per year will acquire the right to retirement. There is a permanent trend of change in the educational structure of the staff at Kozloduy NPP EAD – the share of employees with higher education is increasing (on average by 1.5% per year) compared to the share of staff with vocational secondary and general secondary education. The indicated data lead to the conclusion that it is imperative to take timely measures to provide staff for the implementation of the activities related to the long-term operation of the units, taking into account the time necessary for training, development and acquisition of the knowledge and skills necessary for the safe implementation of the activities by newly appointed people. The Strategy also states that the availability of sufficient number of students in the vocational schools and the higher education institutions in the specialties applicable at Kozloduy NPP EAD is essential to ensure the long-term needs for staff at the power plant.

An analysis was carried out to determine the future needs of competences in the organization during the period of long-term operation (LTO) of units 5 and 6, resulting in the determination of the most applicable technical specialties at Kozloduy NPP from the secondary and higher education. A plan for the needs of staff was drawn up based on the analysis by educational level and specialty for the period 2020-2030, as shown in Table 1.

Table 1. Staff needs at Kozloduy NPP EAD for the period 2021-2030

Educational degree	Specialty	Number
Higher Education - Master's Degree	Nuclear Energy	**76**
	Electric Power Engineering and Electrical Equipment	**30**
	Mechanical and Instrument Engineering	**29**
	Physics	**19**
	Nuclear Energy and Technology	**17**
	Automation, Information and Control Engineering	**17**
	Machine Engineering Equipment and Technology	**9**
	Chemical Technologies	**9**
	Electronics	**6**
	Information Technology	**5**
	Chemistry	**4**
Higher Education - Bachelor's Degree	Electric Power Engineering and Electrical Equipment	**20**
	Machine Engineering Equipment and Technology	**17**
	Mechanical and Instrument Engineering	**16**
	Automation, Information and Control Engineering	**12**
	Computer Control and Automation	**10**
	Computer Systems and Technology	**6**
	Engineering Chemistry and Advanced Materials	**4**
Secondary Vocational Education	Electric Power Engineering	**213**
	Technology of Machine Engineering	**190**
	Thermotechnics – heating, air conditioning, ventilation	**100**
	Automated Systems	**102**
	Technology of Inorganic Substances	**73**
	Computer Engineering and Technology	**48**
	Nuclear Energy	**42**
	Electrical Equipment in Production	**27**
	Industrial Electronics	**12**
	Ship Machines and Mechanisms	**7**

3.2.2. Kozloduy NPP - New Builds

Kozloduy NPP - New Builds Plc was established to implement the decision of the Council of Ministers of 11 April 2012 to take the necessary actions for the construction and commissioning of a new nuclear power capacity of the latest generation (III or III+) at the site of Kozloduy NPP. The company was registered with the Commercial Register on 9 May 2012.

The company's staff is insufficient, even at the stage of preparatory activities carried out until year 2021. This deficit is compensated by the staff of Kozloduy NPP, but it is necessary to determine the needs and plan the required staff based on the upcoming activities.

At this point in time and in connection with the plan to launch a new license stage "Design", the need for additional human resources in the company, mainly in the technical and engineering fields, has been identified.

The company's critical needs, at this time, are for experts in the following areas:

- Nuclear and Thermal Power Engineering;
- Construction - Architect, Civil Engineer;
- Instrumentation and Automated Control Systems;
- Mechanical Engineering;
- Electrical Equipment.

Within the scope of the study "Technical and Economic Analysis for Justifying the Construction of a New Nuclear Capacity at the Site of Kozloduy NPP", prepared in 2013 and commissioned by Kozloduy NPP - New Builds, the issues were addressed and an assessment was made of the human resources necessary for the construction and operation of the new nuclear capacity. The demographic structure of the population in the town of Kozloduy and the neighbouring areas, the social and living conditions in a 100 km zone, the opportunities for professional training and a number of other factors were analysed. The information presented hereinafter is from year 2013, but with certain conditionality it can be referred to 2021, considering the information described in the section related to Kozloduy NPP EAD.

With regard to the number and structure of the staff required for the operation of new nuclear facilities depending on the project selected for implementation, the technical and economic analysis specifies data for projects of NPP with an AP1000 reactor (Table 2) and with a VVER reactor- 1000/V-466 under the AES 92 project (Table 3).

Table 2. Number and structure of the staff required for the operation of a NPP with an AP1000 reactor

Group	1 unit	2 units
Engineering Support	47	74
Technical Support	108	174
Operation	77	144
Radiation Protection	38	57
Safety	113	176
Site Maintenance	100	147
Management	19	31
Total	502	803

Table 3. Number and structure of the staff required for the operation of a NPP under the AES 92 project

Group	2 units
Engineering Support	109
Technical Support and Operation	929
Auxiliary Activities	71
Total	1109

The conservative estimate made within the scope of the study regarding the number of workers and specialists needed during construction shows that an average of 3,000 people will be needed annually, of which managers and engineers are 25% of the average number (750), qualified workers (welders, fitters, machine operators, etc.) are approximately 70% (on average 2,100, during the peak period 2,500) and low-skilled work force (auxiliary activities) approximately are 5% (on average 150, during the peak period 200).

The data on the necessary human resources specified in the technical-economic analysis show that the construction and operation of new nuclear facilities require a large number of highly qualified specialists, the availability of which is currently a challenge.

In addition, it is necessary to pay attention to the interdisciplinarity as a trend in the scientific research, since the nuclear energy forms significant financial flows and engages large capital resources at all stages of its life cycle. This, in turn, predetermines the requirement for trained staff and scientists who have an economic and managerial profile. In this regard, multidisciplinarity is of key importance not only for the creation of quality scientific research, but also for the improvement of the financial and economic results and the management process in the specific enterprises and projects.

3.3. Analysis of the human resource situation for activities related to decommissioning of nuclear facilities and radioactive waste management

3.3.1. State Enterprise "Radioactive Waste"

By Decision of the Council of Ministers of the Republic of Bulgaria, the State Enterprise "Radioactive Waste" (SE RAW) was established on 1 January 2004 with the status of a state enterprise, being a legal entity under Art. 62(3) of the Commercial Act, incorporated pursuant to Art. 78(1) of the Safe Use of Nuclear Energy Act. The company's seat is located in Sofia and has specialized divisions geographically situated at the location of the nuclear facilities, as follows:

- Specialized Division "Radioactive Waste - Kozloduy";
- Specialized Division "Decommissioning Units 1÷4";
- Specialized Division "National Radioactive Waste Repository";
- Specialized Division "Permanent Radioactive Waste Repository - Novi Han".

The State Enterprise "Radioactive Waste" is designated as the only national operator for radioactive waste management (RAWM) in the country outside of the sites where the waste is generated. In accordance with the national Strategy for Management of Spent Nuclear Fuel (SNF) and Radioactive Waste (RAW) until 2030 and the adopted new decisions, directives and regulations of the Community institutions, the commitments of SE RAW are related to the safe management of the activities on the collection, handling, pre-treatment, processing, conditioning, storage and disposal of RAW, including the decommissioning of nuclear facilities in the country.

In compliance with the law, the national and international regulations and good practices in this area, the staff management policy at SE RAW complies with the IAEA Standard GS-R-3:2006 "Safety Requirements. Management System for Facilities and Activities" and the requirements are listed in the documents for the processes "Human Resources Management" and "Information and Knowledge Management" of the integrated management system.

The current status of the staff at SE RAW is as follows:

- **The average age** is 46.3 years, and only 8.8% are young people (workers and employees up to the age of 30). The rest of the staff distribution by age criteria is: 18.5% up to 40 years; 29.8% up to 50 years; 38.7% up to 60 years and 3.6% up to 70 years.

The conclusion is that for the most part the staff is ageing, the share of employees aged over 41 is 71.7%. For the most part, the staff works under the conditions of I and II category of work and acquires the right to early retirement. In the period 2021÷2032, on average about 50 workers/employees will acquire the right to early retirement. There is a permanent trend of a lack of candidates who meet the requirements for educational qualifications to work in the company's structures. Another reason for the ageing of the staff can be found in the reluctance of young people to train in technical specialties/professions, as well as in the decreasing number of graduates of specialized training (physics, chemistry, radiochemistry, etc.).

- **Education** – with higher education of all educational and qualification degrees - 43.7% (0.2% with PhD academic degree; 31.6% Master's Degree, 6.7% Bachelor's Degree and 5.2% Professional Bachelor's Degree); with vocational secondary education - 39.2% and with general secondary education - 17.3%.
- **Sex** - 63.4% of the employees are men and 36.6% are women
- **New hires** – the analysis from year 2010 to the present shows the highest growth of newly appointed staff in the last three years (in 2019 – 67; in 2020 – 96 and as at 1 November 2021 – 68), which is related to providing the staff necessary for the implementation of the production program on decommissioning. The fact that at the end of Q3 2021, out of 68 new hires only 19 (27.9%) were young people under the age of 30 is indicative of the interest in working at SE RAW.
- **Terminated employment contract** – the analysis again shows data with the highest growth in the last three years (in 2019 – 74; in 2020 – 70 and as at 1 November 2021 – 64), which is mainly due to the implementation of the conditions and the acquisition of the right to retirement under the Social Security Code for the first, second and third category of work.

The social policy is aimed at providing wages corresponding to and remunerating the work of everyone in the relevant position/workplace under safe and healthy working conditions. The enterprise also provides additional social benefits to the staff: health, pension insurance, medical care, free food, arranged transport from home to the workplace and back, conditions for sports, etc.

Knowledge management is a set of management practices for recognition, creation, systematization, storage and transfer of knowledge, united in a system that:

- Implements the SE RAW policy and synchronizes it with the IAEA standards, with special attention to information management and knowledge preservation as a resource;
- Develops the knowledge management system as a management priority, and its implementation takes into account the modern standards, criteria and experience in applying industry-specific processes and tools;
- Increases work efficiency and preserves key knowledge, skills and experience in order to minimize cost overruns for individual activities as a consequence and due to low performance competence;
- Enforces a culture of safety, prioritizing continuous learning and constant and sustained improvement in human performance of activities;
- Applies methods, means and tools for information management, development, preservation and transfer of accumulated corporate knowledge; acquisition of new knowledge consistent with conditions for career development.

In connection with the long-term programs for the decommissioning of units 1÷4 of Kozloduy NPP, the construction, commissioning and operation of the National Repository for the disposal of low and intermediate level radioactive waste, as well as the production program of SE RAW, the following tables (Table 4, Table 5 and Table 6) demonstrate the need for workers and specialists by education and professions.

Following an analysis of the long-term schedule for the implementation of the production program and the future needs for competences, the applicable technical specialties from secondary and higher education, a plan was drawn up for the needs of staff by structural units in the enterprise for the period 2022-2032.

Educational degree	Specialty	Number
Higher Education - Master's Degree	Nuclear Energy	**75**
	Physics/Nuclear Physics	**10**
	Plasma Physics and Plasma Technology	**8**
	Engineering Physics	**8**
	Nuclear Energy and Technology	**15**
	Electric Power Engineering and Electrical Equipment	**22**
	Material Science	**22**
	Mechanical and Instrument Engineering	**22**
	Machine Engineering Equipment and Technology	**16**
	Chemical Technologies	**11**
	Chemistry/ Chemical Engineering	**8**
	Radiochemistry	**8**
	Radiochemistry and Radioecology	**5**
	Automation, Information and Control Engineering	**11**
	Electronics	**8**
	Information Technology	**8**
	Automation, Information and Control Computer Systems	**8**

Table 5. Needs of SE RAW for staff with higher education - bachelor's degree for the period 2022-2032

Educational degree	Specialty	Number
Higher Education - Bachelor's Degree	Electric Power Engineering and Electrical Equipment	**15**
	Machine Engineering Equipment and Technology	**11**
	Mechanical and Instrument Engineering	**11**
	Engineering Chemistry and Advanced Materials	**5**
	Automation, Information and Control Engineering	**6**
	Computer Control and Automation	**6**
	Computer Systems and Technology	**6**

Table 6. Needs of SE RAW for staff with vocational secondary education for the period 2022-2032

Educational degree	Specialty	Number
Secondary Vocational Education	RAW Management (Nuclear Energy)	**40**
	Electric Power Engineering	**44**
	Electrical Equipment in Production	**20**
	Electrical Systems	**10**
	Electrical Machinery and Apparatus	**10**
	Industrial Electronics	**8**
	Automated Systems	**34**
	Automation of Continuous Production	**18**
	Thermotechnics (heating, air conditioning, ventilation)	**40**
	Technology of Inorganic Substances	**33**
	Technology of Machine Engineering	**110**
	Lifting and Transport Equipment Mounted on Road Vehicles	**33**
	Computer Engineering and Technology	**16**

There is a trend of change in the educational structure of the staff, increasing the share of employees with higher education and the share of staff with specialized secondary vocational education.

In this regard, it is imperative to take the necessary long-term steps and timely measures to ensure the staff required for the implementation of the activities (including commissioning and providing for the operation of the national repository). It is important to assess the training time, the time for the development and acquisition of the necessary knowledge and skills by the newly appointed employees, as well as to calculate the sufficient number of young people in training for the respective jobs.

3.4. Analysis of the human resource situation in the engineering organizations

The engineering organizations in the nuclear field aim to meet the modern dynamic needs of the business organizations in the sector (operators of nuclear facilities, SIR users, etc.) by ensuring and providing consulting and engineering services in the field of nuclear energy, radiation protection and safety and radiation monitoring, performing complex analyses and environmental impact assessments of nuclear facilities and installations, as well as technical assurance and instrument construction, modelling, engineering analyses and automated preparation, management, control, design and implementation of advanced technological processes using modern technical means of production, equipment, systems, etc.

After having reviewed the issue of staffing in the engineering organizations, by analysing the information received from them in connection with this Strategy, the following problems common to these organizations can be highlighted:

- Lack of sufficient number of young employees (more than 60% of the staff are over 40 years of age);
- Shortage of nuclear and reactor physicists, nuclear engineers, specialists in nuclear electronics, electronics, electrical technicians, staff with STEM and good computer training;
- Lack of a strategic human resource development plan in the organization;
- Inability of targeted financing of the education of students in nuclear specialties;
- Inability to attract staff from abroad.

The following aspects of the human resources development process in the engineering organizations could be highlighted as positive:

- Support and organization of follow-up training for the employees of the organization;
- Maintaining close ties and communication with higher education institutions in order to attract students-interns in the specialty; participation in seminars, career open days, etc.

3.5. Analysis of the human resource situation in the educational and scientific-research institutions

According to the adopted National Map of Higher Education in the Republic of Bulgaria, the ratio of the number of graduated Bulgarian citizens in the period 2016-2020 in the Bachelor's educational and qualification degree (EQD) in professional field 5.4 Energy, compared to the number of admitted students - Bulgarian citizens in the same EQD in the period 2012-2016 is 55%. For Professional Bachelor's EQD in professional field 5.4 Energy, the ratio of graduates (2016-2020) to admitted students (2013-2017) is 89%, for Master's EQD, the ratio of graduates (2016-2020) to admitted students (2011-2015) is 89%. Regarding professional field 4.1 Physical Sciences, the data correlated for the same periods are: For Bachelor's EQD - 49% and for Master's EQD - 75%.[1]

[1] National Map of Higher Education in the Republic of Bulgaria, adopted with Council of Ministers Decree No. 538 of 22 July 2021.

It should be taken into account that professional fields 4.1 Physical Sciences and 5.4 Energy, where most nuclear specialties are concentrated, according to the National Map of Higher Education fall into group 2, which refers to professional fields and specialties of the regulated professions with a high level of realization of the graduates and a low level of demand for higher education by the prospective students. This is also shown by the data from the register of current and discontinued students maintained by the National Centre for Information and Documentation (NACID) and the capacity of the professional field determined by the National Evaluation and Accreditation Agency (NEAA) for year 2021 (Table 7). The conclusion that can be drawn is that the allocated capacity for the professional fields of NEAA is completed to less than 50%.

Table 7. Information at national level for all higher education institutions regarding the training capacity, the number of students, the realization of the graduates and the demand among the prospective students in the professional fields of Energy and Physical Sciences

Professional field	Number of current students	Maximum capacity (NEAA)	Current students as a share of the NEAA-defined capacity	Realization of the graduates (points)	Demand for higher education by prospective students (points)
Professional field 504 - Energy	1548	3100	49.9	54	43
Professional field 401 - Physical Sciences	744	2090	35.6	51	40

Nuclear specialists with higher education (Bachelor's and Master's EQD and PhD ESD) are trained mainly at the Technical University of Sofia, Faculty of Power Engineering and Power Machines, and St. Kliment Ohridski Sofia University – Faculties of Physics and Chemistry. Nuclear specialists are trained in the Faculty of Physics within professional field 4.1 Physical Sciences. In the program accreditation of Sofia University dated 20 September 2018 and valid for a period of six years, the National Evaluation and Accreditation Agency determines the capacity for training in professional field 4.1 Physical Sciences of 900 students in Bachelor's EQD and 300 students in Master's EQD. The specified capacity significantly exceeds the actual demand and can easily satisfy many times greater interest. The situation is similar for the Faculty of Chemistry, where students are trained in the specialty Nuclear Chemistry in professional field 4.2 Chemical Sciences (the capacity determined for Bachelor's EQD is 1100 students and for Master's EQD is 400 students).

For the Technical University of Sofia, NEAA determines a capacity of 1240 students for professional field 5.4 Energy. Of these, 340 for Professional Bachelor's EQD, 620 for Bachelor's EQD and 300 for Master's EQD. In recent years, the capacity for professional bachelors has been fully filled. It is important to point out that the capacity is determined for the professional field, not for the specialty, and within both universities there are a number of specialties that belong to the specific field. Ultimately, the lack of students in the nuclear specialties is not related to capacity constraints.

Table 8. Graduates of higher education by educational and qualification degree (Source - National Statistical Institute)

		Total	Technical sciences and technical professions (number)[1]	Technical sciences and technical professions (%)[1]
2018	Professional Bachelor	1,869	297	15.9
	Bachelor	27,831	2,857	10.3
	Master	23,415	1,666	7.1
	PhD	1,365	116	8.5
2019	Professional Bachelor	1,843	284	15.4
	Bachelor	25,807	2,825	10.9
	Master	22,529	1,544	6.9
	PhD	1,285	118	9.2
2020	Professional Bachelor	1,712	307	17.9
	Bachelor	23,151	2,427	10.5
	Master	20,395	1,288	6.3
	PhD	1,097	77	7.0
[1] According to Classification of Fields of Education and Training 2015 (CFET 2015)				

Table 9. Graduates of higher education by educational and qualification degree in selected narrow areas of education, year 2020 (Source - National Statistical Institute)

Narrow areas of education	Bachelor	Master	Professional Bachelor
Biological and Related Sciences	282	132	–
Environment	134	79	–
Physical, Chemical and Earth Sciences	270	193	–
Mathematics and Statistics	102	36	–
Information and Communication Technology	1,318	732	77
Technical Sciences and Technical Professions	2,427	1,288	307
Generation and Production Technologies	314	171	16
Architecture and Construction	154	530	–
Engineering, Manufacturing and Construction, Interdisciplinary Programs and Qualifications	113	113	–
[1] According to Classification of Fields of Education and Training 2015 (CFET 2015)			

Table 10. University students by educational and qualification degree in selected narrow areas of education, academic year 2020/2021 (Source - National Statistical Institute)

Narrow areas of education	Bachelor	Master	Professional Bachelor
Biological and Related Sciences	1,998	348	–
Environment	969	168	–
Physical, Chemical and Earth Sciences	1,707	474	–
Mathematics and Statistics	584	104	–
Information and Communication Technology	9,664	1,860	704
Technical Sciences and Technical Professions	20,126	4,358	1,457
Generation and Production Technologies	2,371	461	71
Architecture and Construction	1,079	3,669	–
Engineering, Manufacturing and Construction, Interdisciplinary Programs and Qualifications	718	748	–
[1] According to Classification of Fields of Education and Training 2015 (CFET 2015)			

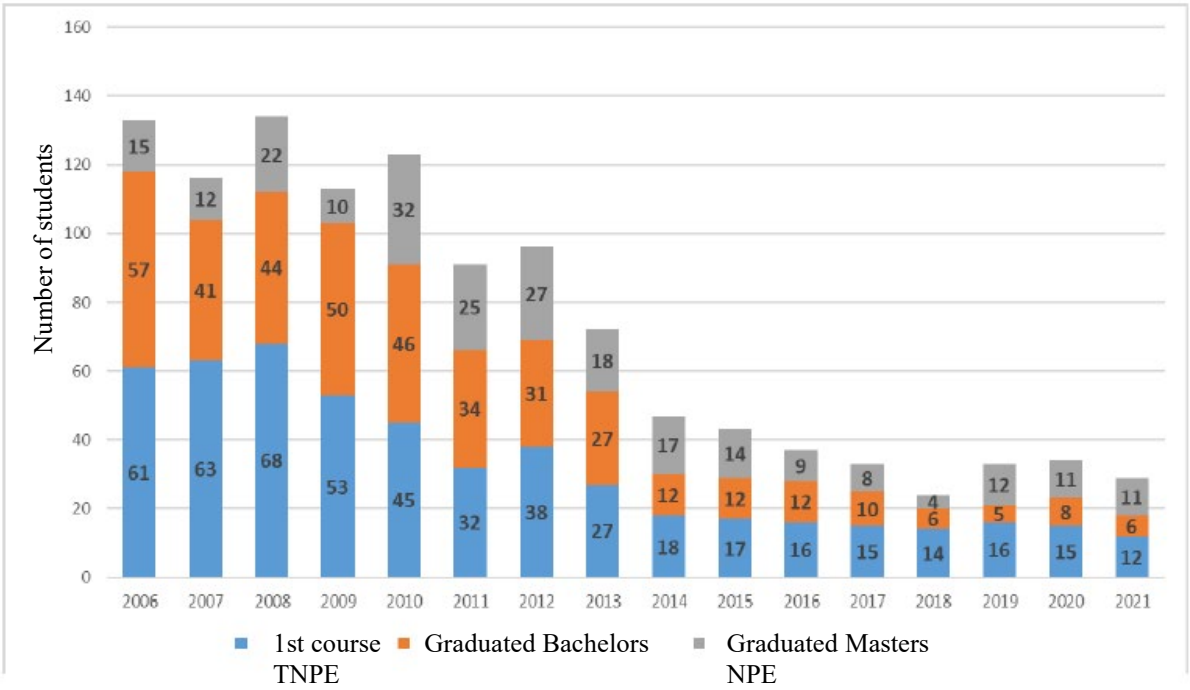
3.5.2. Technical University of Sofia

Technical University of Sofia provides training in nuclear specialties in the three degrees - Bachelor, Master and PhD. The Bachelor's degree specialty is general – Thermal and Nuclear Power Engineering – and provides training in the basic disciplines that underlie the technology. The Master's degree speciality Nuclear Power Engineering provides training in narrowly specialized disciplines related to the operation of nuclear facilities, nuclear safety, nuclear fuels and nuclear fuel cycles, with special attention paid to advanced designs of nuclear power reactors, simulator training and use of specialized software products that are widely used not only in the Master's course but also in the Bachelor's course. PhD students are trained in 7 PhD programs, three of which are Nuclear Power Installations and Systems, Nuclear Reactors and Thermal and Nuclear Power Stations. The specialty Nuclear Power Engineering is the only one in the country that prepares nuclear engineers, and the Master's program is a natural continuation of the Bachelor's specialty Thermal and Nuclear Power Engineering.

The academic staff of the Thermal and Nuclear Power Engineering department consists of 10 lecturers. Those closely focused in the field of nuclear energy include one associate professor, two chief assistants, one of whom is due to retire in 3 years, and one assistant employed under a fixed-term contract for two years.

In recent years, there has been a drastic decrease in the number of the newly enrolled students in the Thermal and Nuclear Power Engineering specialty and, respectively, of the graduated Bachelors in Thermal and Nuclear Power Engineering and Engineers with Master's degree in Nuclear Power Engineering, and the decrease from 2006 to 2021 is more than 6 times approx. (Figure 3).

Figure 3. Number of newly enrolled students in Thermal and Nuclear Power Engineering (TNPE), number of graduated Bachelors in TNPE and number of graduated Masters in Nuclear Power Engineering (NPE) for the years from 2006 to 2021 at TU Sofia



The analysis carried out shows that the reasons for the outflow of students include:

- Lack of a clear state commitment regarding the future of nuclear energy leading to a lack of clear career development prospects;
- Poor material support of the educational process due to insufficient funding;
- Outdated material-technical and laboratory base;
- Insufficient regulation and control of the quality of education;

- Lack of interest in engineering and mechanical specialties and a large admission in the "unprofitable" specialties for the Bulgarian economy;
- Insufficient number of classes in natural sciences in the primary and the secondary education;
- Negative public attitudes towards nuclear energy in general;
- Lack of promotion of the education in the less attractive nuclear specialties;
- Lack of clearly expressed interest from users of the workforce.

The outflow of students also has a negative impact on the scientific and teaching staff of the department. A unit in which there are not enough students is doomed to exist without a budget for the purchase of stationery and teaching aids, and the renewal of the material-technical base is unthinkable. In addition to creating demotivation in teachers, which is inevitably transferred to students, the potential for training narrow specialists is also gradually and irreversibly lost. On the other hand, the practising teachers are over-burdened with teaching activities and are not able to pay attention to their research work, to apply to various programs or to manage research projects. It is difficult to appoint new teachers, both because of the lack of students and the corresponding inability to pay wages, and because of the lack of interest in teaching work. Again, there is a gradual loss of scientific potential and a lack of adequate equipment for conducting scientific research, which closes the circle.

3.5.3. St. Kliment Ohridski Sofia University

The Faculty of Physics (FP) of Sofia University provides training to students in narrow nuclear-engineering disciplines in the Bachelor's degree Nuclear Engineering and Nuclear Energy and in the Master's degree Nuclear Power Engineering and Nuclear Technology. A detailed report on the number of enrolled and graduated students in these disciplines in recent years is presented in Table 11. In addition to them, in the FP at SU, nuclear specialists graduate from the Bachelor's degrees Medical Physics, Physics and Engineering Physics and from the Master's degree Nuclear and Particle Physics. The average number of these students is slightly higher than that of the narrow nuclear engineering specialties, as demonstrated in Table 12.

Table 11. Reference for the number of enrolled and graduated students in the Bachelor's degree Nuclear Engineering and Nuclear Energy and the Master's degree Nuclear Power Engineering and Nuclear Technology at the Faculty of Physics of Sofia University

Bachelors			Masters			
			Enrolled		Graduated	
Academic Year	Enrolled	Graduated	Full-time	Part-time	Full-time	Part-time
2011 / 2012	7	3	2	11	3	4
2012 / 2013	7	4	3	1	3	4
2013 / 2014	9	4	2	2	1	5
2014 / 2015	6	3	3	2	3	4
2015 / 2016	5	4	3	1	2	2
2016 / 2017	3	2	1	–	4	2
2017 / 2018	1	3	–	3	1	–
2018 / 2019	2	3	1	–	–	2
2019 / 2020	7	–	1	3	–	–
2020 / 2021	5	–	2	3	2	3
2021 / 2022	8	–	–	–	–	–
Total number:	60	26	18	26	19	26

Table 12. Reference for bachelor's and master's students, in Physics, Engineering Physics (EP), Medical Physics (MP), Quantum and Space Theoretical Physics (QSTP), Nuclear and Particle Physics (NPP)

Academic Year	Bachelors		Masters	
	Physics + EP + MP + QSTP + NPP		NPP+MP	
	Enrolled	Graduated	Enrolled	Graduated
2016 / 2017	38	1	12	4
2017 / 2018	48	11	7	2
2018 / 2019	46	10	10	2
2019 / 2020	56	3	7	9
2020 / 2021	55	8	8	5
2021 / 2022	75	–	11	–
Total number:	318	33	55	22

NOTE: The "Enrolled" column indicates the total number of students admitted in all listed specialties for the relevant year; The "Graduated" column indicates the total number of students from all listed specialties who graduated with theses related to nuclear or radiation physics.

Sofia University also trains students in the PhD ESD. For the last five years, 7 PhD students have successfully graduated (defended theses) in the broader nuclear-related programs Nuclear Physics and Particle and High Energy Physics. In the specialized nuclear engineering PhD program Neutron Physics and Nuclear Reactor Physics, two PhD students successfully defended their theses.

Similar to TU Sofia, the analysis of data from SU shows a significant decline in the number of Bachelor's and Master's graduates in the nuclear engineering specialties in recent years.

The academic-scientific staff engaged in teaching nuclear disciplines in the Faculty of Physics at SU is differentiated as follows:

- Fundamental nuclear physics (experimental nuclear physics, theoretical nuclear physics, nuclear reactions) - 1 professor, 4 associate professors, 2 chief assistants;
- Applied nuclear physics (nuclear methods, dosimetry and radiation protection) - 2 professors, 2 associate professors, 1 chief assistant;
- Nuclear Engineering Physics (physics of nuclear reactors, reactor calculations, neutron physics) - 2 chief assistants, one of them employed for half position;

The foregoing numbers are without repetition and exclusive of the academic-scientific staff engaged in particle physics, who are also partly involved in the teaching of nuclear physics. It should be noted that in 2020 the Department of Nuclear Engineering and Nuclear Energy at FP joined the Department of Atomic Physics due to a shortage of scientific and teaching staff necessary for the existence of an independent department.

The funding provided for the educational activities in the nuclear specialties is not sufficient here either. The state subsidy is granted depending on the number of enrolled students. With decreasing numbers, funding generally decreases as well, which inevitably affects the ability to maintain and equip buildings, teaching laboratories, computer equipment and supplies.

3.5.4. Vocational schools of nuclear energy in the towns of Kozloduy and Belene

A total of 352 students, distributed by specialties as shown in Table 13, study at Igor Kurchatov Vocational School of Nuclear Energy (VSNE) - Kozloduy.

Table 13. Distribution of students at Igor Kurchatov VSNE - Kozloduy, by specialty

No.	Specialty	Grade	Number of students
1.	Applied Programming	8 and 9	49
2.	Electric Power Engineering	8, 9, 10, 11, 12	56
3.	Nuclear Energy	8, 9, 10, 11	76
4.	Thermotechnics – heating, air conditioning, ventilation and refrigeration	8, 9, 10, 11, 12	60
5.	Radioactive Waste Management	8, 9, 10	36
6.	Computer Engineering and Technology	8, 9, 10, 11, 12	75

In the specialties Nuclear Energy - 26 students in the 10th grade and Thermotechnics - Heating, Air Conditioning, Ventilation and Refrigeration - 13 students in the 9th grade are trained in a dual form of education. The students have signed contracts with Kozloduy NPP EAD. The high school has concluded contracts with Kozloduy NPP EAD, Lavina 02 OOD and Satcomm LTD for conducting production practice in the form of daily training.

About 50% of graduating students continue their studies in higher education institutions: Technical University of Gabrovo, Angel Kanchev University of Ruse and Technical University of Sofia in the specialties Electrical Engineering, Thermotechnics, Thermal Power Engineering and Industrial Heat and Gas Systems. About 25% of secondary school graduates start work at Atomenergoremont AD, Interpriborservice LTD, Energomontazh - AEK AD in the area of the town of Kozloduy.

Igor Kurchatov VSNE - Kozloduy employs 28 pedagogic specialists, of which 13 are engineers. The teachers are highly qualified, as 60% of them hold a degree of professional qualification in their specialty, as follows: 5 with 5 PQSs, 3 with 4 PQSs, 3 with 4 PQSs, 4 with 2 PQSs. In addition, worth noting is the fact that 26% of the teachers are under the age of 35, 18% are under the age of 55 and only three teachers are over the age of 55.

In Marie Skłodowska–Curie VSNE - Belene, there are 46 students in full-time form of study only, distributed by specialties according to Table 14.

Table 14. Distribution of students at Marie Skłodowska–Curie VSNE - Belene, by specialty

No.	Specialty	Grade	Number of students
1.	Economics and Management	12	5
2.	Electric Power Engineering	11, 12	12
3.	Automation of Continuous Production	10	11
4.	Automated Systems	8, 9	18

Students from the Automated Systems specialty are included in scholarships under the Kozloduy NPP scholarship program for the second year in a row. They receive a scholarship as follows: for the first term of 8th grade - BGN 60 per month, then until the end of the training course for excellent performance - BGN 200 per month, for very good perfoemmance - BGN 100 per month.

In order to conduct educational and production practice for the students, the school has concluded partnership and cooperation contracts with Kozloduy NPP EAD, ET Bobicom - Belene, Belene Substation, SEVER NET EOOD - Belene.

The graduating students continue their education mainly in the specialties of Automation, Electric Power Engineering and Electrical Equipment, Computer Systems and Technology in the technical universities.

The vocational school has signed a memorandum of cooperation with Vasil Levski National Military University in Veliko Tarnovo. Students from the Marie Skłodowska–Curie VSNE - Belene also participate in the scientific conference Radiation Safety in the Modern World, which took place on18 and 19 November 2021 at the university.

Not a small part of the graduating students (some even after graduating from higher education) start working for CEZ Bulgaria, Substations, Kozloduy NPP EAD, Site of NPP Belene and in other subdivisions of the energy industry.

The school employs 11 teachers, 5 of whom are engineers. The teaching staff is highly qualified as well. Most teachers have a professional qualification degree. The average age of the teaching staff is 47 years.

3.5.5. Institute for Nuclear Research and Nuclear Energy (INRNE) at the Bulgarian Academy of Sciences

The general situation of the human resources in the nuclear sector negatively impacts the performance of INRNE. A comprehensive analysis of the causes of the staff attrition in the institute was performed, covering the period from 2010 to 2021. According to the information presented in this analysis, a total of 144 people were dismissed of their own accord and by the employer during the period under consideration, with an average number of employees for the period - 257 people, which makes up a staff attrition rate of 56%. If the percentage of retired employees (29.18%) is added to this percentage, the total staff attrition rate at INRNE for the period 2010-2021 is 85.18%.

The data show that most of the employees leave of their own accord. This fact was analysed considering the age and the length of service of the leavers. The data for the analysed period show that the majority (44%) of the leavers were between the ages of 26 and 40 on the date they terminated their employment with the institute. In terms of length of service, the largest (46%) is the percentage of those who left during the first 5 years of their employment at the institute, with 14% of them leaving in the first year. This is followed by the loss of employees with experience between 6 and 10 years (23%) and employees with experience between 11 and 15 years (14%).

In order to identify the factors influencing the decision of the employees to leave the institute, "exit" interviews have been conducted at INRNE since 2017. A total of 12 factors are analysed – personal reasons, financial conditions, working conditions, additional benefits, security, management and organization, company life, relationship with managers, relationship with colleagues, recognition, opportunity to increase competences, opportunity for development.

The statistics collected during this period show that the main factors motivating the employees to leave the institute are three.

The "financial conditions" factor is given the highest weight. The problem with labour payment is reported in all age groups, regardless of the position held. The analysis indicates that, in addition to being a means of satisfying multiple needs, the pay is an indicator of the value that the employer attaches to the skills and abilities, i.e. it shows the employees how important they are to the organization, and in this regard, the existing pay system is perceived by the leavers as unfair.

The second most important factor indicated by the leavers is "opportunity for development".

In third most important factor causing dissatisfaction and contributing to the decision to leave is "working conditions". In addition to other reasons, such as outdated building stock, lack of a clearly defined individual workplace and the lack of a personal office computer, the lack of sufficient and modern equipment for conducting experiments is also indicated.

The next reason for leaving specified in the analysis is “retirement”. The concept of retirement includes both termination of the contract at one's own will in order to exercise the right to a pension, and termination of the contract at the employer's initiative due to the acquired right to a pension. The staff attrition caused by this reason is practically inevitable, but also manageable. A more detailed review shows that for the 11-year

period under consideration, 29.18% of the average number of employees retired. This percentage rate is due, first of all, to the traditionally ageing staff at the institute and at the Academy as a whole. Another reason is the practice of the so-called "forced retirement campaign", where a large number of people are dismissed in a short period for reasons beyond the control of the management of the institute.

3.6. Analysis of the situation of the human resources engaged in activities involving sources of ionizing radiation

3.6.1. National Center of Radiobiology and Radiation Protection (NCRRP)

The National Center of Radiobiology and Radiation Protection (NCRRP) is a scientific organization and specialized body of the Ministry of Health in Bulgaria, aimed at all activities related to sources of ionizing radiation and protection of the health of the population and of individual groups thereof.

The National Center of Radiobiology and Radiation Protection studies the biological effects and assesses the risk of exposure to ionizing radiation, diagnoses, conducts consultations and treatment of occupationally exposed persons, training and upgrading the qualifications in the field of radiation protection. The annual Management's review of the quality system of NCRRP according to ISO 9001:2015 reports and analyses the reasons for the staff attrition in the Center.

The full-time staff, according to the Rules of Procedure of NCRRP, in the period 2010-2020 decreased from 120 full-time employees to 102 full-time employees. The average staff numbers employed vary between 80-85% in the period. Over the 10-year period, about 17% were appointed on average.

A major percentage of the employees of NCRRP leave of their own accord. The majority (55%) of the leavers are between the ages of 28 and 38 at the time they left their employment. The percentage rate of the employees leaving during the first 2 years of their employment at NCRRP is about 28%. The percentage rate of the employees who left and retired in the period 2010-2019 is 22%.

The main factors motivating the employees to leave NCRRP are two.

The factor of financial conditions has the greatest weight.

The next reason for leaving is retirement.

The main conclusions are that during the 10-year period under consideration, a constant and annual staff attrition is observed. The main reasons for this are the ageing staff (pensioners permanently employed due to a lack and shortage of specialists in this field) and the low pay, mainly of the young specialists.

There is a permanent trend of not filling the staff vacancies at NCRRP due to a lack of specialists in the field and the difficulty of finding suitable employees.

3.6.2. Regional Health Inspectorates (RHI) - Varna, Vratsa, Ruse, Burgas and Plovdiv

Summary data on the human resource situation at Radiation Control Departments at RHI:

The full-time staff, according to the Rules of Procedure of RHI in the period 2010-2020 is within 7-8 full-time positions. The average number of employees varies about 70-80% due to the lack of specialists in the regions of the country. Over the 10-year period, about 29% were appointed on average.

A major percentage of the employees leave of their own accord. The percentage rate of the employees who left and retired in the period 2010-2020 is about 20%. On average, about 10% of employees are dismissed during the trial period, with the remaining percentage of staff leaving due to retirement, death of the employee and dissatisfaction with the pay.

3.7. Analysis of the human resource situation at the Nuclear Regulatory Agency (NRA)

The Nuclear Regulatory Agency (NRA) is an independent specialized body of the executive power (an agency established by law) the task of which is to exercise state regulation of the safe use of nuclear energy and ionizing radiation and the safe management of radioactive waste and spent fuel. The status of the chairperson of NRA is defined under Chapter II of the Safe Use of Nuclear Energy Act (SUNEA), with a clear distribution of responsibilities, assignment of regulatory functions and provision of financial and human resources for their implementation. The chairperson of NRA is the licensing authority for nuclear facilities and activities and bears the full responsibility for ensuring the reasonable decision-making process when issuing the license document pursuant to SUNEA. The Nuclear Regulatory Agency carries out the reviews and assessments necessary to determine the compliance with the safety requirements of the facilities and activities – both when issuing the license document and during the subsequent operation of the facility and carrying out the permitted operations.

The structure, activity and organization of NRA are defined in the Rules of Procedure. The staff is divided into general and specialized administrations. The General Administration includes the General Administration Division and the Specialized Administration includes the divisions of Nuclear Safety, Radiation Protection, Safety Analysis and Assessments and International Cooperation.

The Nuclear Regulatory Agency has 114 statutory determined full-time staff members. As at 31 December 2020, there are 97 positions occupied (35 men and 62 women): 15 employees are engaged under employment contracts pursuant to the Labour Code, and the rest – under the Civil Servants Act, i.e. 84 employees have the status of civil servants, of which 59 are inspectors under Art. 100 SUNEA.

More than 95% of the employees of the Specialized Administration are with higher education, with an average professional experience of more than 20 years, whereas four employees have graduated with PhD scientific and educational degree.

The average age of the staff of NRA as at 31 December 2020 is 50 years and 4 months; 19 employees are under 40 years old (including 9 inspectors). As at 31 December 2020 – 27 employees (including 23 inspectors) have acquired the right to retirement, and 20 of them (including 16 inspectors) have benefited from it. As at 31 December 2022 – 35 employees (including 29 inspectors) will be entitled to retirement.

As a result of the analysis of the available human resources in NRA, the following conclusions could be drawn:

- NRA has highly qualified staff prepared to perform the activities defined in the job description for the relevant position;
- NRA maintains permanently (since 2013) about 10-13% unoccupied vacancies;
- The basic salary at NRA of the employees under the Civil Servants Act is below the average one as provided for in the Ordinance on the pay of the employees in the state administration for the relevant level and grade of the position according to the Classification of Positions in the Administration;
- It is expected that as at 31 December 2022, 36% of the staff (including 40% inspectors) will be retired or have acquired the right to retirement;
- The number of competitions held for the appointment of civil servants (not all of which end in appointment) is close to the number of employees who have left. The number of pensioners appointed is 37% of all appointed for the period 2018-2020.

4. CHALLENGES TO THE IMPLEMENTATION OF THE STRATEGY

For the implementation of the set strategic goals, a number of challenges should be handled, both in the sector of workers in nuclear facilities and in the service organizations, in the secondary and the higher education and the scientific research field, by implementing the relevant activities.

4.1. Challenges in nuclear energy to be addressed responsibly

4.1.1. Kozloduy NPP EAD

The SWOT analysis carried out within the scope of the strategy of Kozloduy NPP EAD identifies the strengths and weaknesses of the company. The goals and tools for their achievement defined in the strategy of the NPP will unequivocally solve a large part of the problems caused by internal factors. As for the identified threats related to external factors, for the most part they are common to all interested parties. Considering the seriousness of the problems, the management of the NPP has taken actions to find sustainable solutions. However, in order to achieve a lasting effect, the efforts and actions of Kozloduy NPP need to be supported at the institutional level.

Listed below are some of these threats that could lead to a lasting trend of deterioration in the situation of the human resources at the NPP, as well as the opportunities that can be used to reduce the threats.

Negative image of nuclear energy worldwide

Regardless of the fact that the negative attitude towards nuclear energy in Bulgaria is not as clearly expressed as in some EU countries, it is necessary to strengthen the information strategy for popularizing the nuclear energy and the professions related to its use. The construction of modern information centers not only in Kozloduy, but also in the university centers is a good opportunity to improve the image of the industry.

Insufficient interest of young people in technical specialties

In order to overcome the negative trends, Kozloduy NPP EAD has taken a number of actions to attract young people.

The list of protected specialties, approved by Decree of the Council of Ministers No. 64/2016, includes the specialties as follows: Nuclear Engineering and Nuclear Energy for Bachelor's EQD in professional field 4.1 Physical Sciences; Thermal and Nuclear Power Engineering for Bachelor's EQD and Nuclear Power Engineering for Master's EQD in professional field 5.4 Energy. This means that the specified "protected specialties" are higher education specialties for which there is no expressed interest or the expressed interest is low, but at a certain stage of the economic and social development of the Republic of Bulgaria there is a need to train highly qualified specialists for these fields. In this regard, the state, by making changes to the Higher Education Act aimed at attracting the interest of prospective students, has exempted the students enrolled in protected specialties from paying the due fees. Decree of the Council of Ministers No. 137 of 25 June 2020 and Decree of the Council of Ministers No. 283 of 19 August 2021 were adopted in this regard. Furthermore, by amendments to the Higher Education Act and the adopted Ordinance on the terms and conditions for ensuring the payment of the training costs of students with concluded contracts with an employer, adopted by Decree of the Council of Ministers No. 12 of 20 January 2021, additional incentives have been introduced to attract prospective students for certain specialties by applying a mechanism regulated in the aforementioned ordinance in order to optimize the relations between the higher education and the needs of the economy and the society. This will stimulate the training in specialties important for the development of the country, where there is a shortage of highly qualified staff. One of the ways to achieve this is to provide an option for the state to cover the training costs of students who have concluded contracts with employers for the provision of internship in the relevant specialty for the period of the training and at a workplace after their successful graduation.

In view of the justified thirty-year period for long-term operation (LTO) of the nuclear power plant, in order to meet the future needs of staff in the organization, Kozloduy NPP EAD takes a number of measures, based on detailed Analysis and Plan of Staff Needs in the company for the LTO horizon.

In the field of higher education:

- Based on the Analysis and Plan of Staff Needs at Kozloduy NPP EAD, specialties in the field of higher education have been designated as priority for the company.

- Aimed at attracting specialists from all over the country and shortening the recruitment time in the specialties prioritized for Kozloduy NPP EAD, a permanent acceptance of job application documents has been announced.
- Kozloduy NPP EAD provides scholarships to students from Technical University of Sofia and St. Kliment Ohridski Sofia University, studying in specialties important for the company, directly related to nuclear energy. After graduating, the scholarship holders are committed to work at Kozloduy NPP EAD. By Decree of the Council of Ministers dated year 2020, these specialties are declared protected and are exempt from the payment of semester tuition fee as determined for students enrolled on government order.
- The company has a developed internship program for students – paid and unpaid internships, group and individual internships.
- Kozloduy NPP EAD maintains close ties with the Bulgarian Academy of Sciences and universities in the country where students are trained in priority specialties.

In the field of vocational secondary education:

- Based on the Analysis and Plan of Staff Needs at Kozloduy NPP EAD, priority specialties of the secondary education have been determined. Some of them are included in lists of protected specialties and specialties of professions with an expected shortage of specialists on the labour market prepared by the Ministry of Education and Science.
- Kozloduy NPP EAD cooperates with Igor Kurchatov VSNE - Kozloduy and Marie Skłodowska–Curie VSNE - Belene in order to support the educational process, arrange student internships and practices and improve the material resources of the schools.
- Kozloduy NPP EAD provides scholarships to students studying in the priority specialties in the nuclear energy vocational schools.
- A project for training in a dual form (training through work) in the specialties Nuclear Energy and Thermotechnics has been launched with Igor Kurchatov VSNE - Kozloduy.
- The Nuclear Power Plant participates in various thematic student competitions to stimulate the interest in STEM-sciences and support the students' awareness of the benefits and opportunities of the nuclear energy. The NPP provides a year-round opportunity for holding themed visits and lectures.
- Kozloduy NPP EAD is a member of a number of organizations related to human resources in the nuclear sector. Among those are Electromobility Sector Council at the Ministry of Education and Culture, United Nations Global Compact Network Bulgaria, Bulgarian Nuclear Society, Kozloduy Nuclear Competence Center, BULATOM.

The implementation of these measures is expected to attract young specialists to the specialties that the nuclear industry will need in the coming decades. Young people can also be attracted by increasing the share of knowledge and skills in the field of application of the digital technologies – their application at the level of facilities, but also their application in process management.

Insufficient linkage between education and business

The interaction between companies and higher and secondary schools in the field of training and development of human resources is of key importance to overcome the current negative trends. There are many forms of joint initiatives, such as organizing conferences, seminars, competitions, but they are not sufficient to create a lasting interest among young people in the specialties related to nuclear energy. The bilateral contracts concluded between the NPP and a number of universities are appropriate but insufficient form of cooperation due to their framework nature. Encouraging the exchange of knowledge and practices between employees in different industrial units and work in different disciplines with the support of the NGOs in the branch such as BulAtom,

the Scientific and Technical Union of Energetics and BEMF can also contribute to the interaction between business and education.

A new and promising form of interaction is the Kozloduy Nuclear Competence Center – an association established by Kozloduy NPP EAD, Kozloduy NPP - New Builds Plc and State Enterprise "Radioactive Waste". The goals of the association specified in the Articles of Association are aimed at:

- Supporting and improving the education system in the preparation and training of staff in the field of nuclear energy;
- Maintaining, improving and preserving nuclear knowledge;
- Supporting the development of an innovation environment and research infrastructure for nuclear energy purposes;
- Using the knowledge and experience of the members of the association to promote nuclear energy as a foundation for sustainable development of the Bulgarian energy industry.

A good basis for interaction with the higher education institutions and BAS and the development of projects with a practical orientation provides the possibility for joining associate members provided for in the Articles of Association.

One of the objectives of Kozloduy Nuclear Competence Center Association is the development of the research infrastructure for the purposes of nuclear energy by supporting the construction and maintenance of material-technical base, laboratories and research infrastructure. Due to the limited resources available to the association, its dissipation in a large number of laboratories may not lead to the achievement of the desired goals. A good option for effective use of the resource would be the development of a plan for the construction of a centralized laboratory-research complex, e.g. at INRNE, Kozloduy NPP EAD or any of the university centers.

Project for a new nuclear capacity in Bulgaria

The challenges facing any large-scale and long-term project are discussed in depth and presented in a number of IAEA documents. Among them, the challenges in staffing already during the preparation and construction of the nuclear plant stand out, considered as part of the document *„Milestones in the Development of a National Infrastructure for Nuclear Power (IAEA Nuclear Energy Series NG-G-3.1"*:

"…The knowledge and skills required to build a nuclear power plant include much of the knowledge and skills required for other large-scale energy projects. These include managerial and administrative skills and technical skills common in most scientific and engineering disciplines. There are also specific needs for nuclear energy knowledge, for example experience in reactor, nuclear and atomic physics and nuclear materials science. This applies to the regulatory body, the owner/operator, the technical support organizations and other relevant organizations.

Many jobs require several years of specialized training and experience in the design and operation of the specific technology selected for implementation. Specialized education and training can be obtained from nuclear technology providers. To ensure a sustainable workforce, it is important for a country to expand its own education and training capacities and develop a strategy to retain skilled human resources."

In the prepared Risk Assessment for the new capacity project, the risk of shortage of trained staff was identified with a high level of impact (very high probability of occurrence with significant consequences).

The foregoing shows the significant challenges facing the development of projects for new capacities, requiring a proactive approach in providing, preserving and increasing the necessary human resources. In this regard, cooperation with leading suppliers of nuclear equipment, including those for Small Modular Reactors, should be developed in solving the scientific and applied ongoing challenges. Joint initiatives of the scientific units in our country and the suppliers of nuclear equipment will help to participate in renowned international projects and to train staff to carry out the activities for the development of new nuclear technologies.

4.1.2. State Enterprise "Radioactive Waste"

Human resource management is a strategic and consistent approach to managing the most valuable capital for any organization to achieve its goals. The management recognises that human capital with individual and collective contribution, with competence and knowledge is the main resource for achieving success.

The operation of SE RAW are financed with funds from the Radioactive Waste Fund (RAW Fund) and the Decommissioning of Nuclear Facilities Fund (DNF Fund) of the Minister of Energy. The decommissioning of nuclear facilities (units 1÷4 of Kozloduy NPP) is financially supported by the European Union through the Kozloduy International Decommissioning Support Fund (KIDSF) through the European Bank for Reconstruction and Development (EBRD).

Staff planning in a ten-year perspective is consistent with the set parameters of the funds' financial framework and with a view to realizing the company's strategic goals by:

- Determining the requirements for staff;
- Setting quantitative and qualitative parameters for the required staff;
- Planning relevant activities in parallel in order to attract, retain and/or create conditions for career development and growth in the enterprise.

The legal regulation related to the staff provision for operations in nuclear sites and facilities that ensure and control the nuclear safety and radiation protection, stipulates that they shall be carried out by persons who meet the requirements for their qualification, imperatively defined in the Ordinance on the Conditions and Procedure for Acquiring Professional Qualification and on the Procedure for Issuing Licenses of Specialized Training and Competency Certificates to Use Nuclear Energy, as follows:

- Master's EQD and Bachelor's EQD in programs and specialties such as Nuclear Energy, Nuclear Energy and Technology, Nuclear Physics, Physics, Chemistry, Chemical Technology, Radiochemistry, etc., in professional fields, field of natural sciences, mathematics and informatics, technical sciences, etc., depending on the specific job position;
- Completed initial specialized training with a certain minimum term, which is of different duration depending on the specific job position;
- Certain minimum length of service in a previous position;
- For specific legally regulated positions – successfully passed exam before the qualification examination commission of the national regulator - Nuclear Regulatory Agency, and issued certificate of competence.

The prospective training of staff for the nuclear sector in the country based on a prepared strategy is a challenge to all interested parties preparing and using competent specialists in this sector. The Safe Use of Nuclear Energy Act and the IAEA Safety Standard *GS-R-3:2006, Safety Requirements. Management System for Facilities and Activities* formulate the main objective in the human resource management process at SE RAW: *"To ensure and maintain the competence of the workers and employees at SE RAW on the basis of appropriate education, training, qualification and professional experience to perform the assigned work in a safe manner and achieve the goals of the enterprise".*

The responsibilities of SE RAW to the public determine high requirements for maintaining qualified, legally competent and motivated staff as an important condition for ensuring safe, effective, efficient and environment-friendly management of radioactive waste. The personal contribution, professionalism and commitment of each worker/employee is a guarantee for the successful implementation of the company's goals. In this regard, the management of SE RAW faces the following challenges:

1. In the activities of planning, development and maintenance of human resources

The enterprise has introduced and maintains a system for professional selection and appointment of staff that meet the requirements and conform to the good global practices. The necessary managerial, engineering-technical, executive and support

personnel are discussed annually, and the planning is consistent with the normative-regulatory amendments and parameters. The analysis by structural units **so far shows that with the appointed staff it is possible to provide for and perform the subject of the operations of SE RAW.** The forecast analysis in perspective shows a shortage in the recruitment of young and educated staff with higher and secondary technical education. The process deepens, as workers and specialists are dismissed annually due to the acquisition of the right to retirement for length of service and age (mainly in the first and second categories of the staff of the specialized divisions). The nationwide trend of outflow of young people from the technical specialties, of young people and specialists up to the age of 40 leaving the country, continuing education and/or arranging work abroad (with no desire to return to Bulgaria) is also deepening.

The management of SE RAW took preventive actions (which should be developed in the future), jointly with:

- Kozloduy Municipality, the public in the area and the Ministry of Education and Science – for the opening of a new class (specialty "Management of RAW") at Igor Kurchatov Vocational School of Nuclear Energy - Kozloduy starting from the academic year 2019/2020, which will partially solve the problem with the technical staff with secondary education upon timely professional orientation;
- Technical Universities in Sofia, Ruse, Gabrovo and the University of National and World Economy – provision of training opportunities for their employees to upgrade the acquired education to a Master's degree, inclusion in specialized courses and programs to increase qualifications, with the aim of preventing the qualified staff attrition and ensuring staff eligibility for the relevant job position.

The expectation is to solve legally at national level the issue of providing opportunities and concluding contracts between energy companies and higher and secondary educational institutions to guarantee jobs for the realization of young specialists from certain specialties according to a certain procedure and within a specific period. This will guarantee the retention of young people not only from Kozloduy Municipality and the region.

The process of recruitment, selection and appointment of staff in the enterprise is regulated by internal documents, updated in an ongoing basis in compliance with the needs and changes in the legislation, the management policy, the professional and qualification requirements for the relevant job positions, the methods of motivation, career development and staff incentives.

2. In the activities of knowledge management, training and qualification of staff

The task of training, building and maintaining a system of staff knowledge is to store the experience accumulated over time and provide an opportunity to recall it at a future time. The built system for specialized and additional training aims at ensuring the compliance of the performed activities with the provisions of para. 4 of the IAEA Standard GS-R-3:2006 *"Training is of utmost importance for the continuous staff development. It focuses on safety, satisfying the requirements, needs and expectations of the interested parties".*

The annual analyses of the effectiveness of the training conducted by structural units is the basis and the guarantee for proper planning and taking corrective measures for continuous improvement of the operations in compliance with the requirements.

In connection with the already experienced difficulties in recruiting qualified staff with higher and secondary technical education, the need for national measures related to the provision of staff resources, their training, use of their knowledge and professional experience is evident. Some of the necessary measures are:

- Regulatory binding of the options for paid training of students during their studies by the enterprises with guaranteed jobs and contracts for labour and career development;
- Taking measures to improve the material resources of the educational institutions preparing staff for energy sector and the qualification of the

teaching staff, using the capacities of the funds, the European operational programs for development in the field of human resources and ensuring appropriate incentives for the specialists;

- Using the capacity of the working specialists at NPP, SE RAW, INRNE-BAS, etc., as teachers in the secondary schools and the higher education institutions (subject to the requirements of the Ministry of Education and Culture).

4.2. Challenges in the system of higher education and science

4.2.1. St. Kliment Ohridski Sofia University and Technical University of Sofia

The academic-scientific staff engaged in teaching nuclear engineering disciplines is at its critical minimum. Urgent measures are needed to increase its number, mainly including measures to attract young professionals to pursue academic career.

Insufficient funding. The material-technical equipment in the educational laboratories at SU and TU Sofia is old and obsolete and urgently needs to be modernized, e.g. with one-time targeted funding. For each student, state funding is allocated according to the formula: *"BGN 693 x (Differentiated standards for maintenance of a professional field) x (Coefficient of quality and realization)".* It is extremely necessary to significantly increase the coefficient "Differentiated standard for maintenance of a professional field" (DSMPF) for the professional fields Physical Sciences and Energy (as well as in all other natural and engineering fields).

Meeting the needs to maintain active research and laboratory activity, currently minimized in the applied nuclear engineering disciplines. Specific suggestions to improve this situation include:

- To ensure sustainability of the development of academic potential related to the training of staff for the nuclear industry and sustainability in the maintenance and development of nuclear knowledge. The government and the nuclear industry must recognize nuclear research as a priority and make a long-term commitment to its maintenance and development;
- To state in all strategic documents the priority of the nuclear research and nuclear technology;
- To create a national scientific program Nuclear Technologies and Engineering on the example of already existing similar national scientific programs, aimed exclusively at nuclear engineering research, since scientific research is the least developed in this field of nuclear knowledge. Participants in this program must be TU Sofia, BAS and SU;
- To arrange more competitions and projects, giving priority for employment of new, young specialists and PhD students, including by attracting suppliers of new nuclear technology.

Attracting more students to nuclear specialties. It is necessary to adopt a clear set of "soft" measures, such as:

- Specialized competitions, summer schools and schools on nuclear topics;
- Internships in nuclear research centers and enterprises for students;
- Promotion of nuclear research and nuclear industry among the students and the general public;
- Promotion of the nuclear physicist and nuclear engineer professions;
- A clearly expressed state commitment is needed regarding the future of nuclear energy – when, where and what the new Bulgarian nuclear capacities will be;
- Renovation of the material-technical base and laboratories for scientific research activity.
- It is important to build **nuclear information centers** (e.g. on TU Sofia and SU campuses) to demonstrate the benefits of the nuclear technologies and to draw

the public attention to the nuclear energy applications, which would significantly contribute to increasing the positive attitudes to the training in nuclear specialties.

Targeted funding aimed at supporting the educational process. A disadvantage that has been manifested for the last two years, since nuclear energy was included in the list of protected specialties – the list is announced after the university candidate campaign is over and after the admission of students to Bachelor's specialties is over (this year on 18 August 2021). This needs to change.

Cooperation between nuclear business and academia exists, but could be improved and optimized by:

- More active inclusion of specialists actually employed in the nuclear business in the training process;
- Active participation of the business in training by building laboratories, including with equipment that is no longer needed, student internships and practices, proposals for updating curricula and programs;
- Establishment of theses and dissertations on nuclear topics by the nuclear business. The awards should be not only for the defending student, but also for the student's supervisor;
- Sponsorship of external meetings and/or conferences involving all relevant academic circles.

Attracting young people to the nuclear sector and ensuring their career development and financial incentives through:

- Creating of an eco-environment, including the closed link *University ⇔ Research ⇔ Industry*, i.e. the young person should know the options and *see more than one perspective for development;*
- Attracting foreign students – a real possibility is the opening of targeted admissions (implemented pursuant to decrees of the Council of Ministers) of students from the diaspora (Macedonia, Moldova, Albania), supported by relevant additional scholarships;
- Providing additional material incentives, such as additional health insurance, use of the rest facilities of the energy sector companies or similar, not directly related to additional individual pay, but generally to the improvement of the social status of the employed.

Exercising control over the educational process and creating minimum regulatory requirements for educational content. Participation of the relevant interested and responsible state institutions and structures in the creation, implementation and control of the set criteria, thus ensuring the protection of the training both in terms of content and capacity.

Analysing natural science curricula with a view to their practical application and emphasizing the key competencies. In the field of nuclear sciences, the specifics of the technology should be taught objectively, instead of presenting it as dangerous, harmful and competing with renewable energy sources in terms of energy production.

4.2.2. Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences

Very high levels of staff attrition are observed at INRNE-BAS. The main reasons include the progressively ageing staff and the low pay, especially for young professionals. On the other hand, growing in the academic career requires a lot of time and effort which these young professionals are not willing to invest. This, combined with the financial conditions, which are often not sufficient to cover even basic needs (food, rent, minimal social life), make the work at the institute highly unattractive. In addition, in the conditions of increasingly globalized, high-tech and highly competitive environment, as well as the increased mobility of today's workforce (employer loyalty is now obsolete, as

the employees do not aspire to lifetime employment in a single company), it becomes increasingly difficult to find suitable employees and retain them for a long period.

4.3. Challenges related to staff training in the secondary education

A major challenge in the secondary education in Bulgaria is the difficult provision of teachers for general and vocational education. A large part of the teachers nationwide are of pre-retirement age and over time it will be increasingly difficult to find young teachers. Young specialists focus on the teaching profession only if they fail to find another suitable job related to the specialty they studied. In some cases, they are even realized in fields that have nothing to do with the professional qualification they acquired in their higher education. Retaining teachers in the nuclear energy vocational schools is additionally difficult due to the fact that they are in labour competition with Kozloduy NPP EAD, which offers very good pay and career development for the teachers who are engineers.

Another serious challenge in the secondary education is the low level of knowledge of high school candidates and their weak motivation for learning and employment. About 30% of the students in Igor Kurchatov VSNE - Kozloduy and Marie Skłodowska–Curie VSNE - Belene come from families without education or with primary education, who are not employed. Bulgarian is not the mother tongue for some students which further complicates their studies.

The material-technical base in Igor Kurchatov VSNE - Kozloduy is obsolete. Only partial emergency repairs are carried out. The positive change is that in the last 5 years the school applied for and won projects under national programs, such as Vocational Education and Training, Modernization of Material-Technical Base Module, thanks to which 5 practice rooms were renovated and equipped.

The material-technical base in Marie Skłodowska–Curie VSNE - Belene is obsolete and needs major repairs. In recent years, the school has not applied to programs and projects of the Ministry of Education since the school management assumes that due to the small number of students they will not be included.

4.4. Challenges related to the sustainable development of human resources in Nuclear Regulatory Agency

- Achieving sustainability in human resource management by improving the system for staff attracting, selecting and appointing.

According to the legislation, the selection and appointment of civil servants takes place after holding a competition with clearly defined requirements. This significantly limits the options for NRA to hire employees. Furthermore, the practice shows that there is extremely low interest in these competitions, including there are competitions for which no one has applied for participation. As a result, in recent years the NRA has permanently maintained about 10-13% unoccupied vacancies. Therefore, actions should be taken to improve the recruitment process, aimed at reducing the number of vacancies to no more than 3%.

- Maintaining a high level of staff motivation by developing the system for employees' professional development.

More opportunities for professional development should be provided to the employees at NRA, with a clear career path and uniform rules that are in line with their specific expectations and needs. Ensuring a uniform approach to the career development of all employees is an important motivating factor and a precondition for increasing the work efficiency.

Career development should be tied to the performance which requires an objective approach in evaluating the performance of the employees based on objective and measurable criteria. Professional qualification improvement should also be stimulated and reflected in the career development. To achieve efficiency in the process of planning the needs for human resources, it should be tied to the corresponding financial compensation.

Clearly outlined policies for career development are needed, combined with clear and firm actions to increase the Personnel Costs part of the NRA budget, as well as

consideration of opportunities to increase the social benefits of employees – including through proposals for changes in regulations, if necessary.

- Developing a knowledge management system with an emphasis on managing the risk of loss of key nuclear knowledge at NRA and ensuring continuity.

Preserving, storing and transmitting knowledge, skills, understandings, perceptions, actions and experiences, and ensuring the possibility of their easy retrieval is a way of maintaining a well-prepared and competent staff. In the NRA, 19 employees (including 9 inspectors) are under the age of 40, 20 employees are retired (including 16 inspectors), and another 7 employees have acquired the right to retirement, which does not provide sufficient options for continuity of knowledge and accumulated professional experience.

To the extent that the regulations allow retired employees to continue working, it is difficult to predict at what point in time how many of these employees will effectively exercise their right to retire and leave the agency. This, in turn, complicates the process of knowledge storing and transmitting. More efficient and effective planning and forecasting in the development of human resources is needed, which will give clarity regarding the areas (fields of activities) where there will be a shortage of specialists, and a possibility for proper planning of human resources, both in terms of numbers and in terms of the required knowledge and skills; creating systematic procedures for identification and establishment of the so-called agency-critical knowledge (i.e. knowledge of extreme importance to the functioning of the organization); formalizing the knowledge retention process when an employee leaves, ensuring the preservation and transfer of knowledge to the employee who will take over the relevant functions.

5. SWOT ANALYSIS

The performed **SWOT** analysis (**S**trengths, **W**eaknesses, **O**pportunities, **T**hreats) outlines the picture of the problematic situation in Bulgaria from the point of view of the situation of the human resources in the nuclear field – strengths, weaknesses, opportunities and difficulties or threats.

5.1. Strengths

- There is a well-developed regulatory framework, harmonized with the EU legislation, which defines the legal framework of the state regulation of the safe use of nuclear energy and ionizing radiation, the safe management of radioactive waste and spent fuel, as well as the rights and obligations of the persons to ensure nuclear safety, radiation protection and physical protection;
- There is a fully developed nuclear infrastructure, including regulatory, academic, operating, support and non-governmental organizations;
- There is a favourable legislative framework for collective bargaining in the direction of stimulating the development of human resources;
- There is a legal ground in the Safe Use of Nuclear Energy Act, as well as the texts in the relevant subordinate legislation, which imperatively require appropriate staff training and qualification;
- There are traditions in the training of specialists working in the nuclear field. Training in nuclear specialties is carried out in all three educational and qualification degrees - Bachelor's, Master's and PhD;
- There are long-standing traditions and experience in the operation of nuclear facilities;
- High degree of educational level of the employees operating the nuclear facilities, of qualified and competent staff with a high safety culture;
- There are educational institutions that train students and undergraduates in nuclear specialties, albeit with great difficulty. In secondary education, these are the nuclear energy vocational schools in the towns of Kozloduy and Belene. In higher education, these are mainly St. Kliment Ohridski Sofia University and Technical University of Sofia;

- The Institute for Nuclear Research and Nuclear Energy at the Bulgarian Academy of Sciences operates, where PhD programs and professional training are conducted;
- A training center functions within Kozloduy NPP EAD, which provides continuing education and maintains contacts with secondary schools and higher education institutions;
- Strategic documents aimed at the development of human resources in Bulgaria have been prepared, as well as a Human Resources Management Strategy with a horizon until 2028 at Kozloduy NPP;
- An assessment of staff needs in the two largest nuclear enterprises has been made;
- Motivational incentives and social benefits are applied in relation to the staff at Kozloduy NPP EAD and SE RAW;
- Eight licensed training organizations carry out professional training and qualification for working in the nuclear area and issue relevant competence documents;
- Knowledge management systems exist in the large economic entities;
- The specialists working in the field of the nuclear science and technology have formed a community where they interact with each other for the purpose of knowledge exchange and improvement.

In summary, it can be stated that there are basic conditions and traditions in the educational training of specialists. Motivational and incentive activities are also implemented for staff satisfaction. The development of a strategic document would help to systematize the problems more clearly and, based on what has been done, to take appropriate actions to solve them.

5.2. Weaknesses

- The majority of those employed in the sector (e.g. in Kozloduy NPP EAD, SE RAW, INRNE-BAS, etc.) are over 40 years old. For example, the share of employees over the age of 40 at Kozloduy NPP is over 73%;
- In the period 2021-2030, a relatively large number of people will acquire the right to retirement at Kozloduy NPP EAD, SE RAW, INRNE-BAS, etc.;
- Insufficient attention paid by the institutions and users of staff on the preparation of new staff for the nuclear energy;
- Insufficient attention paid by the institutions on the continuing training of the employees in the sector who are engaged in various activities – operation of nuclear facilities, management of radioactive waste, scientific and engineering services;
- Established discrepancy between the needs of human resources and the quality of the available ones;
- Inadequate quality regulation and control of primary and secondary education, which hinders the prospective students' confidence in their ability to cope with the matter taught in the nuclear specialties;
- Insufficient financial incentives in the main units of the sector, such as the higher education institutions, BAS, NCRRP and NRA, leading to a lack of motivation;
- Need to increase the administrative capacity in the higher education institutions, BAS, NRA, etc.;
- Lack of a sufficient and well-equipped base for scientific research and experimental activity;
- Lack of a systematic approach to attract young staff – sustainability in decision-making for the development of the nuclear sector, attractiveness of the

relevant specialties in the higher education system, opportunities for career development, social mechanisms for attracting young people;

- Insufficient promotion of training in nuclear specialties;
- Insignificant part of the employees in the structures of the nuclear field are interested in participating in teaching in the relevant specialties;
- Insufficient number of students in the vocational schools and the higher education institutions for the needs of the long-term operation of nuclear facilities or the possible construction of new facilities, taking into account the time required for training and acquiring the knowledge and skills necessary for the safe implementation of the activities;
- Risk of loss of nuclear and energy knowledge;
- Insufficient communication at national level inside the nuclear infrastructure and in particular between the state institutions and the operating organizations on the one hand and NGOs on the other.

In summary, it can be stated that the most serious weakness is the serious delay in taking action for the development of the human resources in the nuclear sector. The weakness – ageing of the workforce – is also a consequence of the overall situation of the human resources at national level. The weaknesses act as a whole complex of factors – ageing, problems in the education system, insufficient mechanisms for attracting young people to education and the workplace, insufficient financial incentives.

5.3. Opportunities

- In Bulgaria, there are conditions and some experience for creating mechanisms to attract young people to the nuclear specialties. The first steps have already been taken with the introduction of protected specialties and dual training in the regulatory framework, as well as workplace incentive systems;
- Use of the well-developed secondary and higher education network in Bulgaria, which with more targeted management and with better coordination and stimulation, can provide for the needs of trained staff in the field of the nuclear sector;
- There is a recognized need to take action on human resources in the nuclear field, which is an important factor in the efforts to successfully implement this strategy;
- Use of the fully developed nuclear infrastructure to attract the attention of the young people to the nuclear science;
- Creation of a Professional Training Center at Kozloduy NPP;
- Prioritizing STEM education;
- Improvement of the regulatory framework in the education system;
- Improvement of the mechanisms for financial incentives;
- Stimulation of the participation of good specialists from the practice in the teaching activity;
- Development of cooperation with the suppliers of innovative nuclear technology by enriching curricula, diversifying research and supporting skills acquisition courses;
- Ability to use innovative training methods – 3D models, digital modelling and simulations, as an alternative to laboratories;
- Creation and development of information centers to promote the activities of employees in the nuclear field;
- Increase in the share of employees in the sector with higher education in recent years (on average 1.5% per year);

- Attracting students and specialists from abroad – a real possibility is the opening of targeted vacancies for the admission of students from the Bulgarian diaspora in Ukraine, North Macedonia, Moldova and Albania, supported by relevant additional scholarships;
- Use of the options of the international cooperation – in terms of human resources in the nuclear sector, there are long-standing traditions in the country. It is important that it continues and deepens through the inclusion of new Bulgarian organizations and joining a larger range of initiatives, provided by the international organizations. The Republic of Bulgaria is a Member State of the International Atomic Energy Agency (IAEA), the Joint Institute for Nuclear Research in Dubna, Russian Federation, the European Organization for Nuclear Research - CERN and the Nuclear Energy Agency (NEA) at the Organization for Economic Cooperation and Development (OECD). The membership in these organizations provides numerous opportunities for training and upgrading the qualifications of the employees in the nuclear field;
- Attracting good specialists from the practice to participate in public activities.

In conclusion, it can be stated that there is a system of opportunities to overcome the challenges regarding the development of human resources in the sector. A well-developed network of secondary and higher education has been built for all educational and qualification degrees, which, when adequate management decisions are made, is able to prepare staff consistent with the needs of the nuclear sector. It is necessary to build on what has been achieved in the protected specialties and in the dual education, paying special attention to the training of teachers. Staff users should develop their own special human resource motivation policies.

5.4. Threats

- Lack of clarity about the construction of new nuclear capacities is a highly demotivating factor for young people due to the lack of prospects for realization after completing their education;
- Negative image of the nuclear energy globally – nuclear energy is not yet included in the EU Green Deal;
- Negative demographic trend in the country and the region of north-western Bulgaria;
- The fact that educated young people are leaving the country due to finding more attractive working conditions and pay;
- Outdated material-technical and laboratory base in the education system is a problem;
- The number of classes in natural sciences in the primary and the secondary education is insufficient;
- Existence of a drop – more than 6 times – in the number of newly enrolled students in the specialty Thermal and Nuclear Power Engineering for the period 2006-2021;
- Possibility that the weak interest in the specialties preparing specialists for the nuclear field will continue over time;
- Possibility that the weak interest in teaching in the relevant specialties will continue over time;
- Accumulated momentum of insufficient attention to the preparation and development of human resources in the nuclear field;
- Lack of traditions for good coordination between the interested parties and the preference to work separately;
- Lack of planning and offering sufficiently effective mechanisms to attract young people;

- Insufficient interest in public activity on the part of specialists working in the nuclear field.

There is a system of problems and if no systematic solutions are found for them, the expected development of human resources in the nuclear field could not be achieved.

One of the biggest threats is that the interested parties may not act in a coordinated manner. The problems must be systematically removed – both the outdated material-technical base in the field of education, and the weak interest in the relevant specialties and in the teaching profession, and a new review of the number of classes in natural sciences in the secondary education system.

If the identified challenges are not overcome, the specified objectives would be difficult to achieve.

6. VISION

The Strategy provides for the creation and maintenance of a sustainable system for the development and improvement of human resources to ensure the efficient functioning of the nuclear sector.

7. STRATEGIC GOALS AND ACTIVITIES FOR THEIR ACHIEVEMENT

STRATEGIC GOAL 1. Improving the quantitative and qualitative characteristics of human resources in the nuclear field.

- **Activity 1.1.** Providing sustainable solutions for the development of the nuclear energy;
- **Activity 1.2.** Priority planning of manpower needs in the nuclear sector in the plans for the implementation of strategic documents concerning the development of human resources – Strategy for Higher Education Development in the Republic of Bulgaria (2021-2030), Strategic Framework for Education, Training and Learning (2021-2030), National Strategy for Scientific Research Development in the Republic of Bulgaria (2021-2030);
- **Activity 1.3.** Encouraging the development and implementation by employers in the sector of specific policies and programs aimed at the development of human resources;
- **Activity 1.4.** Developing and implementing specialized programs by staff users in the nuclear field aimed at acquiring specific knowledge and skills characteristic of the sector;
- **Activity 1.5.** Annually providing, on the part of the state, vacancies for the admission of Bulgarian nationals and Macedonian citizens in protected specialties in the nuclear field at the state-owned higher education institutions in accordance with the proposals of the higher education institutions and their available capacity for training in the relevant field;
- **Activity 1.6.** Developing programs and creating conditions for attracting educated and highly qualified young people from emigration;
- **Activity 1.7.** Determining nuclear research as a priority and making a long-term commitment to its maintenance and development, including through the creation of a national scientific program Nuclear Technology and Engineering aimed exclusively at nuclear engineering research.

STRATEGIC GOAL 2. Improving the educational training of students in nuclear specialties and specialties related to the nuclear field.

- **Activity 2.1.** Concentrating efforts for priority development of STEM-oriented training, for which there are already adopted national strategic documents.
- **Activity 2.2.** Adding provisions in the plans for the implementation of the strategic documents specified in Strategic Objective 1, Activity 1.2, for the improvement of the funding of the educational activity in the relevant specialties.

- **Activity 2.3.** Creating incentives on the part of the business for the participation of established specialists from the practice in the discussion and adoption of the curricula and programs in secondary schools and higher education institutions related to the preparation of staff for the sector and the development of national exam programs for the state exam.
- **Activity 2.4.** Creating effective mechanisms for the participation of established specialists from practice in the educational process in secondary schools and higher education institutions in the relevant specialties.
- **Activity 2.5.** Establishing in Kozloduy of a vocational training center for acquiring qualifications in technical specialties applicable in Kozloduy NPP EAD and SE RAW, with full-time, independent or remote form of studies in Kozloduy, with outsourced training bases in other locations as well.
- **Activity 2.6.** Updating the curricula for the improvement of the skills for working in a digital environment and specialized modules for studying new nuclear technologies.

STRATEGIC GOAL 3. Improving the preparation and increasing the motivation of the academic and teaching staff training specialists in the nuclear field.

- **Activity 3.1.** Creating incentive mechanisms for exercising the teaching profession in secondary schools and higher education institutions – financial incentives, career growth, social benefits, measures to increase the public authority of the profession.
- **Activity 3.2.** Ensuring continuity between generations, building on the existing knowledge and experience in the teaching and research work.
- **Activity 3.3.** Creating incentive mechanisms for increasing the teaching staff in specific disciplines by creating conditions for a scientific career and research activity.

STRATEGIC GOAL 4. Improving and modernising the material-technical and experimental base in the academic field.

- **Activity 4.1.** Adding provisions in the plans for the implementation of the strategic documents specified in Strategic Objective 1, Activity 1, for financial resources for the improvement of the material-technical and experimental base.
- **Activity 4.2.** Adding provisions in the plans of the strategic documents specified in Activity 1 for the creation of nuclear information centers intended for demonstrating the benefits of the nuclear technologies and drawing the public attention to the applications of the nuclear energy, aimed at increasing the positive attitudes towards the training of specialists in the nuclear field.
- **Activity 4.3.** Supporting the activity of the higher education institutions and the Bulgarian Academy of Sciences for specifying and planning the needs for material conditions and a laboratory base for scientific research and experimental activity.
- **Activity 4.4.** Creating effective mechanisms for the participation of economic entities in the planning and financing of the material-technical and experimental base for scientific research.

STRATEGIC GOAL 5. Ensuring conditions for career growth of young people in the nuclear field.

- **Activity 5.1.** Ensuring a connection between the secondary and higher schools and the employers with the aim of the provision of financial support from the employers to the training of students and university undergraduates who, after graduation, will be employed by them.
- **Activity 5.2.** Encouraging the involvement of employers in the implementation of dual training at the relevant economic entity.

- **Activity 5.3.** Developing by the employers of individual plans to increase the qualification, knowledge and skills of young specialists.
- **Activity 5.4.** Linking the upgrading of qualifications and professional development of young people with career development.
- **Activity 5.5.** Linking the level of pay for the work of young specialists with the development of their professional capacity.
- **Activity 5.6.** Creating a system of social benefits to attract and retain young people.

STRATEGIC GOAL 6. Creating mechanisms for preservation and exchange of acquired knowledge in the nuclear field.

- **Activity 6.1.** Making efforts to preserve and upgrade the accumulated knowledge and experience in the nuclear field – through printed publications, arrangement of trainings, seminars, forums.
- **Activity 6.2.** Ensuring the support of the non-governmental organizations working in the nuclear field in their role as a mediator for the exchange of knowledge and information between the different entities of the nuclear infrastructure, as well as between the nuclear community and society at national level.
- **Activity 6.3.** Creating mechanisms for intergenerational exchange of knowledge among those working in the nuclear field.
- **Activity 6.4.** Using the channels of international cooperation - EU, OECD, IAEA, Joint Institute for Nuclear Research (JINR), Dubna, European Organization for Nuclear Research (CERN) for participation in training programs and forums, aimed at mastering the positive foreign experience.

STRATEGIC GOAL 7. Improving the interaction between state authorities, as well as between state authorities, economic entities and non-governmental organizations in the nuclear field.

- **Activity 7.1.** More efforts directed by the state – ministries, agencies, educational institutions – for interaction aimed at creating the necessary institutional and regulatory framework and degree of coordination for the development of the human resources in the nuclear field.
- **Activity 7.2.** Developing measures to increase the quality control of the education.
- **Activity 7.3.** Encouragement made by the state for the employers for coordinated actions together with non-governmental organizations from the nuclear field, aimed at developing human resources.
- **Activity 7.4.** Arranging joint forums with the participation of all interested parties regarding the solution of the problems of human resources development in the nuclear field.

8. ENSURING THE IMPLEMENTATION OF THE STRATEGY

8.1. Role of state institutions

State institutions will play a key role in the implementation of the Strategy.

The **Ministry of Energy** plays a crucial role in establishing a competitive and effective energy sector, including nuclear energy. Nuclear energy is essential to guarantee the energy independence of the country and the key role is that of its human potential. One of the goals embedded in the activities of the Ministry of Energy is "developing the nuclear energy in compliance with the nowadays requirements for reliability, safety and economy". The Ministry of Energy develops the regulations and strategic documents related to the energy sector.

The Minister of Energy is the principal of Bulgarian Energy Holding EAD and SE "Radioactive Waste". The Minister of Energy is the chairperson of the Decommissioning Fund and the Radioactive Waste Fund, which can encourage research activities with a long target horizon.

Bulgarian Energy Holding EAD (BEH EAD), as a state-owned company aims to guarantee the security and relative independence of the energy supplies to Bulgaria and to preserve and develop the specific advantages of the Bulgarian energy sector and its position on the regional and European markets. In order to implement its essential role for the development of the national energy sector, BEH EAD implements a policy of promoting cooperation with scientific and educational institutions to stimulate the interest of young people in the nuclear industry and supports the creation of mechanisms for attracting and retaining them to work in its subsidiaries.

BEH EAD is the principal of the energy companies operating in the production and transmission of electricity, including Kozloduy NPP EAD, which is one of the largest users of staff in the sector.

The **Ministry of Education and Science** prepares all regulatory and strategic documents of the education and science – for education, training and learning, for higher education, for vocational education, for scientific research, for lifelong learning. All these documents make up the regulatory basis for the educational training and development of human resources in the nuclear field.

The education system – secondary and higher education. Nuclear specialties and nuclear-related specialties are studied in state-owned educational institutions.

For some years, efforts have been made to incorporate innovative elements into the organization and content of the secondary school education, among which digitization is a key element. More and more STEM centers are being established. They constitute an integrated set of specifically built and equipped learning spaces with a focus on the learning and application of competences in the field of mathematics, science and technology. In regard to the forecast for staff shortage, the procedure of admission in school education is under restructuring. The admission in vocational education system is gradually increasing, as well as the admission in the professional fields and profiles related to mathematics, engineering, natural sciences and information technology. Additionally, classes for acquiring qualifications in protected specialties are financed. Scholarships for training in protected specialties, in specialties with expected shortage of specialists on the labour market, as well as for students who have chosen the dual form of education, are increasing. Partnerships between the schools and the employers have been activated and the interest in the dual education system is constantly growing.

Financial incentives have been set up in the higher education system intended for training in priority professional fields and protected specialties and for training more students in STEM fields.

The amount of public funds invested in the development of scientific-research and innovation activities is still too small, and a significant change is needed in this area. Applied scientific activity still lags behind.

There are also difficulties in attracting young people to teaching activities. Efforts will be taken in creating and maintaining an attractive material environment and scientific-research base, as well as in improving the financial incentives.

Building an effective link between education and business and activating the partnership of the higher education institutions with the employers remains an important task.

The **Ministry of Health** develops the regulations and strategic documents related to the monitoring of the radioactivity levels in the living environment. An important role is played by the **National Center of Radiobiology and Radiation Protection**, which monitors the population in normal and elevated natural radiation background and studies the biological effects of exposure to ionizing radiation. The center has an important role in increasing the qualifications of the staff in the field of radiation protection. The Regional Health Inspectorates play an exceptional role through their Radiation Control

Departments, employing highly qualified specialists whose qualifications must be constantly maintained at an appropriate level.

The **Ministry of Environment and Water**, in addition to preparing regulatory documents and carrying out strategic planning, also has regulatory and control functions to prevent environmental pollution, including with regard to radiation. The Ministry, through the Executive Environment Agency, carries out continuous and periodic monitoring of the radiation parameters of the main environment components, implementing the radiological monitoring program approved by the Minister of Environment and Water. Based on the results of the conducted radiological monitoring, daily and quarterly bulletins are prepared on the state of the radiation gamma background and the radiation status of the environment. All these activities require the preparation of highly qualified and specialized staff.

Nuclear Regulatory Agency, as an administration that supports the chairperson as an independent specialized body of the executive power that implements the state regulation for the safe use of the nuclear energy, the ionizing radiation, the safe management of radioactive waste and spent fuel, plays a key role in the efforts to ensure that the nuclear sector has the necessary human potential by placing the relevant conditions in the issued licenses and permits and exercising regulatory control.

8.2. Role of economic entities

The economic entities are the main employers and the driving force of the energy sector, including the nuclear field. Therefore, they are expected to play an important role in the development of human resources. The economic entities provide jobs and staff employment. They have important functions in terms of selection, motivation, continuing education, formation of professional skills, financial incentives and career development.

It is necessary to work with the employers in the nuclear field for establishing closer contact with the educational institutions, for planning and declaring their needs of workforce, for financing the training of students who will be hired after graduation, for providing internships and dual education, for participating in the teaching process of the relevant specialties.

8.3. Strategy implementation and monitoring

8.3.1. Strategy implementation

- The implementation of the Strategy will be guaranteed by and in accordance with specifically developed three-year action plans. The latest plan will cover four years and will be valid until the end of the period.
- The implementation plans will list specific activities to achieve the strategic goals, as well as: *indicators* (current and target), *institutions responsible for the implementation, deadline, indicative budget, funding sources* and *expected results* (expected effect).
- Principle indicators characterizing the successful implementation of the Strategy are specified in para. 8.3.3. The specification of the indicators and the addition of deadlines, responsible persons, budget and funding sources will be the subject of the action plans.
- The action plans will be developed by an *Interdepartmental Task Force*, comprising representatives of state institutions, universities, NGOs, other interested parties.
- The task of the Interdepartmental Task Force will also be the three-year reporting on the implementation of the planned activities in a report, and the presentation of the results to the Council of Ministers. The objective is to compare the resources used with the results obtained, to create a basis for accountability, to provide new data necessary for the further evaluation of the processes.
- Leading institutions for the implementation of the Strategy will be the Nuclear Regulatory Agency and the Ministry of Energy.

- The Nuclear Regulatory Agency will have the task to summarize the submitted information on the implementation of the activities by the responsible institutions provided for in the action plans, by preparing the periodic reports. Part of the periodic report will also be the assessment of what has been achieved so far. On this basis, a new implementation plan for the relevant period will be developed.
- The monitoring report on the implementation will be subject to publicity and transparency and will be published on a specialized website.
- If there is a proven need, the National Strategy for Human Resources Development in the Nuclear Field 2022-2032 can be updated and supplemented.

8.3.2. Monitoring

Monitoring and evaluation of the implementation of the activities within the Strategy, as well as the control on the implementation of the plans for its implementation, are essential for improving the effectiveness and efficiency of the Strategy.

Monitoring is the process of collecting and analysing information related to the implementation of a policy or program. It is essential to ensure that the information is collected in an organized and planned manner and at regular intervals. One of the main monitoring objectives is to track the use of the relevant financial resources and to assess whether progress has been made towards the expected results related to the development of human resources in the nuclear field over the next 10 years.

The progress related to the development of human resources in the nuclear field will be measured in three-year periods against the set goals, standards and criteria for effectiveness and efficiency, as well as against the situation at the beginning of the implementation of the Strategy, established with a special Questionnaire (Appendix No. 1). This requires the collection of databases relating to the period before the launch of the Strategy.

The indicators constitute part of the building blocks of an effective monitoring system. The process of defining the indicators will take place at the stage of the development of the action plans, and all key interested parties will be involved in this process.

The quantitative and qualitative characteristics of human resources should be maintained in accordance with the needs of the nuclear field in terms of labour productivity and safety and security.

The monitoring system will be developed to meet the needs of key interested parties in an efficient and timely manner. The participation of civil society in the monitoring processes will also be ensured through periodic presentation of the progress at NGO forums, invitations to prepare opinions on the achieved progress, etc.

The main data integrated in the implementation of the Strategy will be received from the National Statistical Institute on a periodic basis, as well as from other responsible institutions – the Ministry of Education and Science, the Ministry of Energy, the Nuclear Regulatory Agency, etc., including the universities and the business.

In the course of the development of the Strategy, a survey was conducted on the situation of the workforce in the nuclear field and the needs of staff (Appendix No. 1). It covers the economic entities, the educational institutions, the scientific and research area. A similar survey will be conducted at three-year periods following the launch of the Strategy to ascertain the impact of the Strategy's implementation.

8.3.3. Principle indicators for the expected results of the implementation of the Strategy

The progress in the implementation of the strategic goals will be reported through a system of indicators. The achievement of the set goals and the effectiveness of the implemented measures will be evaluated through the application of this system and corrective actions will be possible to be planned, if necessary. Specific indicators will be

developed to measure the progress for each of the seven strategic goals. The activities planned to achieve the strategic goals require interaction and coordination between the interested parties in order to avoid possible contradictions with already adopted strategic documents in the field of secondary and higher education. Therefore, the specific indicators and their target values are expected to be determined in the course of the preparation of the first three-year plan by the Interdepartmental Task Force.

A key objective of the Strategy is to improve the quantitative and qualitative characteristics of human resources in the nuclear field.

For example, as demonstrated in para. 3.2, Table 1, and para. 3.3, Table 4, the total needs of Kozloduy NPP and SE RAW for specialists holding Master's degree in the critical specialties Nuclear Energy and Nuclear Energy and Technology amount to 183 people in the following 10 years, i.e. about 18 people per year.

In order to be able to guarantee the sustainable operation of these two largest enterprises in the nuclear field and taking into account the needs of the engineering organizations, the scientific institutes and the higher education institutions, as well as that part of the graduates will not be realized in the specialty or will leave the country, the higher education institutions must produce at least 26 Masters (i.e. at least 30% more) in Nuclear Energy and Nuclear Energy and Technology per year.

Specialists with higher education (Bachelor's EQD and Master's EQD) in these specialties are trained mainly at TU Sofia and St. Kliment Ohridski SU, and currently 16 students are trained in them.

Taking into account the currently existing trend for professional field 5.4 Energy that the ratio of admitted to graduated students for Master's educational and qualification degree is approximately 89%, the number of graduated students per year in the specialties Nuclear Energy and Nuclear Energy and Technology is optimistically expected to be about 12 people for the next few years. Therefore, in order to meet the needs of the interested parties, the higher education institutions must admit at least 30 students per year to the specialties of Nuclear Energy and Nuclear Energy and Technology. In this way, it would be guaranteed that there would be a minimum of 26 students graduating from these specialties with Master's educational-qualification degree annually, which in turn means a two-fold increase compared to the current situation.

For these specialties, for example, the indicator Number of Master's Graduates can be presented as shown in Table 15.

Table 15. Performance indicator - Number of Master's Graduates for the specialties of Nuclear Energy and Nuclear Energy and Technology

STRATEGIC GOAL: Improving the quantitative and qualitative characteristics of human resources in the nuclear field.				
1	2	3	4	5
Operational goal	Activity	Performance indicator		Self-assessment indicator
		Current situation [number]	Target situation [number]	
Increase in the number of Master's graduates for the specialties of Nuclear Energy and Nuclear Energy and Technology on an annual basis.	Priority planning of manpower needs in the nuclear sector in the plans for the implementation of strategic documents concerning the development of human resources.	12	26	

A similar indicator is the increase in the number of Master's graduates in other critical specialties, such as Nuclear and Particle Physics taught at the Faculty of Physics of St. Kliment Ohridski Sofia University. The estimated needs of Kozloduy NPP and SE RAW for graduates of the specialty Nuclear and Particle Physics for a ten-year period is estimated at 29 specialists, i.e. three specialists per year. Therefore, at least 4 Master's graduates in NPP are needed per year, while currently 2 or less students graduate in this specialty from Sofia University, Table 16.

Table 16. Performance indicator - Number of Master's Graduates for the specialty Nuclear and Particle Physics

STRATEGIC GOAL: Improving the quantitative and qualitative characteristics of human resources in the nuclear field.				
1	2	3	4	5
Operational goal	Activity	Performance indicator		Self-assessment indicator
		Current situation [number]	Target situation [number]	
Increase in the number of Master's graduates for the specialty Nuclear and Particle Physics on an annual basis.	Priority planning of manpower needs in the nuclear sector in the plans for the implementation of strategic documents concerning the development of human resources.	2	4	

Achieving such an increase will be possible only after the implementation of a number of measures to create the necessary preconditions. The realistic scenario requires a gradual increase over several years in the number of graduates in the critical specialties, and therefore the specific indicators will be developed for each of the scheduled three-year plans.

It should be borne in mind that if new nuclear capacities are built, the need for nuclear specialists will increase many times.

Of utmost importance for the development of the human resources in the sector is the improvement of the educational training of the students in nuclear and nuclear-related specialties, as well as the improvement of the preparation and increase of the motivation of the academic and teaching staff training specialists in the nuclear field. For this purpose, indicators should be developed reporting the effectiveness of the incentives created to increase the number of PhD students participating in competitions for assistants in specialties related to the nuclear field; the created stimulating material, social and economic environment for young teachers, leading to improved teaching activity; the created favourable conditions for the involvement of the teachers in scientific research activities and realization of scientific career.

Important factors for the development of the human resources in the nuclear field are the improvement and modernization of the material-technical and experimental base both in the academic field and in the field of secondary education. The indicators reporting the progress in this area should be developed in such a way as to reflect the effectiveness of the investments made in the construction of advanced laboratories and classrooms, and to help in the proper planning of the budget necessary for the purpose.

The development of a complete system of indicators reporting the implementation of the planned activities and the achievement of the set goals requires a clear distribution of the responsibilities between the state institutions and active participation of the interested parties.

8.4. Funding

The planning and implementation of the activities incorporated in the Strategy for Human Resources Development in the Nuclear Field 2022-2032 will be funded from various sources.

The activities concerning the state institutions and the educational institutions of budgetary support will be funded within the framework of the program budgeting. The funding will be consistent with the medium-term budget framework through which the funds from the state budget are planned.

In a number of strategic documents, funds for the development of human capital are planned, such as: National Development Program 2030, National Strategy for Higher Education Development in the Republic of Bulgaria (2021-2030), Strategic Framework for Development of Education, Training and Learning (2021-2030), etc. Funds for the development of human resources are also set in the EU funds and programs. The

budgetary and EU funds will be spent according to the regulatory requirements. Ministries, agencies and departments, in the annual determination of their policies and budget planning, will provide for the funds necessary for the implementation of the objectives of the Strategy.

In addition to funds from the state budget, the implementation of the Strategy will be funded by the employers (staff users) in the nuclear field, by civil organizations operating in this field in relation with the principles of international cooperation.

When determining an indicative budget and sources of funding for the individual activities provided for in the periodic plans, the Interdepartmental Task Force will also involve representatives of other state institutions, such as: Ministry of Finance, Ministry of Labour and Social Policy, Ministry of Education and Science, Ministry of Economy, Ministry of Regional Development and Public Works, etc. The aim is to look for options to finance the activities for the implementation of the National Strategy through the operational programs and other donor international programs.

9. CONCLUSION

In the nuclear field, the challenges to the development of human resources are huge and unique. There are also classic challenges concerning the human resources in any field related to the educational training, recruitment, subsequent training and qualification, mechanisms for retaining relevant staff, ensuring productivity. However, an additional enormous challenge is valid in this field – the employees needed should also provide for the nuclear security and safety. This enormous challenge must be addresses against the background of serious objective problems in the field of human resource faced by the nuclear entities. These include: ageing workforce, difficulty in attracting young people, declining number of students, existing risk of losing the accumulated knowledge and experience. At the same time, it is necessary to comply with high standards and the time necessary for professional training and gaining experience is significant.

The National Strategy for Human Resources Development in the Nuclear Field 2022-2032 provides a number of answers with its in-depth analysis of the current situation of the human resources in the sector, outlining the challenges, the strategic goals and the activities to achieve them. There is every reason that it may have a positive impact on solving the problem situation.

10. ABBREVIATIONS

NEA	Nuclear Energy Agency
NRA	Nuclear Regulatory Agency
BAS	Bulgarian Academy of Science
BEMF	Bulgarian Energy and Mining Forum
SE RAW	State Enterprise "Radioactive Waste"
EC	European Commission
EU	European Union
SUNEA	Safe Use of Nuclear Energy Act
SIR	Sources of Ionizing Radiation
EP	Engineering Physics
INRNE	Institute for Nuclear Research and Nuclear Energy at BAS
QSTP	Quantum and Space Theoretical Physics
IAEA	International Atomic Energy Agency
ME	Ministry of Energy
MES	Ministry of Education and Science
CM	Council of Ministers
MP	Medical Physics
NEAA	National Evaluation and Accreditation Agency
NACID	National Centre for Information and Documentation
NSI	National Statistical Institute
NCRRP	National Center of Radiobiology and Radiation Protection
OECD	Organisation for Economic Cooperation and Development
EQD	Educational and Qualification Degree
ESD	Educational and Scientific Degree
SNF	Spent Nuclear Fuel
VSNE	Vocational School of Nuclear Energy
PQS	Professional Qualification in the Specialty
RAW	Radioactive Waste
RHI	Regional Health Inspectorate
UR	University of Ruse
SU	Sofia University
TU	Technical University
RAWM	Radioactive Waste Management
FP	Faculty of Physics
NPP	Nuclear and Particle Physics
CERN	European Organization for Nuclear Research
NE	Nuclear Energy
NET	Nuclear Energy and Technology
NF	Nuclear Facilities
ENEN	European Nuclear Education Network Association
EHRO-N	European Human Resources Observatory for the Nuclear Sector
JRC	European Commission's Joint Research Centre
SNE-TP	Sustainable Nuclear Energy Technology Platform
STEM	Science, Technology, Engineering, Mathematics

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12. APPENDICES

12.1. Appendix 1. - Questionnaire

Questions to all organizations/structures (human resources development units) relevant to the scope of the prepared National Strategy for Human Resource Development in the Nuclear Field

General questions

1. What is the total number of people employed in your structure?
2. What is the level of education of the employees - by number of employees: Secondary - general education; secondary - vocational education; higher education?
3. What is the number of employees in the average age ranges: 20-30 years of age, 30-40 years of age, 40-50 years of age, 50-60 years of age, over 60 years of age?
4. How many years of work experience do they have on average in the field they work in?
5. What is the recruitment procedure in your structure, e.g. by competition or without competition? If by competition, how many candidates apply on average?
6. What is the total number of vacancies in your structure?
7. How many and which are the jobs/positions for which you have difficulty finding and recruiting suitable candidates (the so-called "critical positions")? What are the entry requirements for these positions? How many years of work experience are required?
8. For what staff do you have shortage – with what education, specialty, work experience, qualities and skills?
9. How do you look for the insufficient staff you are missing?
10. What is the average salary in your structure? What is the average salary for "critical positions"?
11. Do you have a strategic human resource development plan?
12. Do you conduct follow-up training to upgrade the employees' knowledge and skills?
13. Do you have staff from abroad?
14. Is your structure capable to finance the education of university students in the field of nuclear field?
15. Are internship programs planned and used in your structure? How many interns are currently working for you on paid and unpaid internships?
16. What kind of relationships have you built with the universities that train students in the nuclear field?

Additional questions to educational institutions and scientific and research organizations

17. How many students enrolled and how many students graduated in nuclear specialties in the last five years at your university/institute?
18. How many people teach in the nuclear specialties?
19. Is the funding for the educational activity sufficient? Do you have any specific suggestions in this regard?
20. Is the funding for scientific-research and laboratory activity sufficient? Do you have any specific suggestions?
21. What are additional funds needed for?
22. Which prevails in the relations with other universities/institutes – competition or cooperation? What is useful?
23. What can the state do to attract students to the nuclear specialties?
24. What can improve the status of "protected specialty"?
25. Is the cooperation between the nuclear business and the academic structures sufficient and effective? What forms of cooperation do you suggest?
26. Do you have any suggestions for attracting young people to the nuclear sector and ensuring their career development and financial incentives?