

# Survey of Public Attitudes and Availability of Radiophobia in Bulgaria in the Context of Development of the Nuclear Energy Sector

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**Abstract.** This article represents a brief overview of the results of the survey among adult citizens of the Republic of Bulgaria. The method of the sampling is a quota based on the characteristics of age, sex, education and the type of the settlement. The citizens from different social and demographic groups replied to a set of questions. The goal is to follow the trends and the development of the public opinion depending on the issues. The results of the survey were subjected to cross-analysis on the basis of the dependence between the individual factors.

**Keywords:** nuclear energy, public concern, survey, radio phobia

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## 1 Introduction

During the last decade, there has been a significant increase in the public concern about the nuclear energy. The reason of this public perception could be the anxiety concerning the risks. The fear is widespread among the people worldwide and particularly it is based on the nuclear weapon exploitation during the World War II and the Cold War and the two severe accidents in Chernobyl Nuclear Power Plant (NPP) and Fukushima NPP. But according to the statistical data published by World Health Organization (WHO), 4.2 million people died from outdoor air pollution each year and the deaths are more than these from all the nuclear accidents and atomic bomb explosions over Hiroshima and Nagasaki together [1].

Typical for the radiation as a physical phenomenon is that it has got no taste and smell. People can neither see nor feel radiation but they feel fear of invisible threat. The fear is one of the most powerful human emotions and in the case it can be defined as fear of the unknown. The label “radiophobia” has been used in the former Soviet Union regarding to the fear from the radiation but it is important to notice that this does not correspond to the medical terminology. The Diagnostic Manual of Mental Disorders, 4th edition (DSM-IV), has strict clinical criteria for phobias, including “Marked and persistent fear that is excessive or unreasonable, cued by the presence of a specific object or situation” (criterion A) and “The person recognizes the fear is excessive or unreasonable” (criterion C) [1]. The radiation is invisible, so in the absence of physical dosimetry or biodosimetry, exposure can be uncertain. Long-term health effects, especially in the low range (20-70 cGy) or below, are also uncertain and in this context it is impossible to know if fear is excessive or unreasonable. In the same time, in our everyday life, we are continuously exposed to natural background radiation which is a part of

our ambient since our birth.

Radiation exposure can be a risk for all living organisms and particular for people. It is important to note that radiation is not healthy, but it is difficult to assess the long-term effects of non-lethal doses. Therefore, the general opinion of the risk management and risk control can be applied to it. The modern principle which is widely applied to the technology as risk-management tool and allowing some tolerance for the risk, is the so called ALARA – “As Low as Reasonably Achievable”. The philosophy of this principle is based on the assumption that the higher radiation dose increases the risk of cancer and other health effects, and therefore, a lower dose implies a lower risk. The main goal of ALARA (or ALARP “As Low as Reasonably Possible”) corresponds to the fundamental base of working processes with sources of ionising radiation - to maintain the lowest levels of radiation dose which are achievable at reasonable costs and technical resources [2]. Although some authors deny the harmful effects of low-dose radiation, the ALARA principle is applied to all activities concerning to exposure of ionizing radiation.

The applying of ALARA together with the highest safety standards in all nuclear energy and ionizing radiation application is not enough prerequisite for the human calmness and confidence in the technologies. Often observed reaction of the people regarding to these processes is total fear of fatal accident or lethal result. But many research shows that this phenomenon is not science obeyed and the analytical and experimental data show the opposite results. The study of the biological effects of radiation has found that the level of fear exceeds the real danger. The root of “Radiophobia” is in a fear of the nuclear weapons, but during the years it has increased significantly and has been intensified by accidents in nuclear power plants. There are three severe NPP incidents in the NPP Three Mile Island in 1979, NPP Chernobyl in 1986,

and NPP Fukushima Daiichi in 2011. They have caused damages over a wide range, but radiophobia could be more harm to human health than the radiation released in the nuclear accidents because in some cases, the damage is a result of the disaster response.

Despite the widespread radioactive contamination after the accident in NPP Chernobyl, the radiation was directly responsible for only 31 deaths in the first 60 days after the accident. The radiation doses from Chernobyl dust were estimated and compared with natural doses by United Nations Scientific Committee on the Effects of Atomic Radiation published in 2000 [3]. During the first year after the accident, the average dose received by an average inhabitant of the Northern Hemisphere was estimated by UNSCEAR as 0.045 mSv, that is less than 2 percent of the average global annual natural dose (2.4 mSv per year)." [4] However, the strong psychological effect of radiation may have contributed to more deaths, as suggested by the increased number of voluntary abortions [5]. Of course, the late effects cannot be denied, but the problem is that they are difficult to assess and is difficult to determine the root cause of the disease due to the nature of the stochastic effects of ionizing radiation. Similarly, the partial collapse of three reactors at Japan's Fukushima Daiichi nuclear power plant in 2011 led to mass evacuations and abortions. Many experts say more deaths were caused from the earthquake and the tsunami prior the accident.

The risk of radiation is studied not only regarding to the accidents but also in aim to clarify the radiation influence onto biological processes in live organisms in the nature. No harmful health effects have ever been detected in high natural background radiation areas. Studies on the relation between cancer mortality and early childhood deaths and natural background radiation show the absence of positively correlation between dose rates in different regions and number of dead [6].

One of the important application of ionizing radiation is in medical diagnostics and cancer treatment and the radiophobia could be key parameter for wrong decision making by people which will directly cause negative onto their health. The examination of benefits and harm of radioation in medicine are widely studied as for example in Great Britain is investigated the cancer mortality of radiologists exposed to X-ray and the results show that it is up to 50% lower compared to those of male population in England and Wales [7].

Among the other population groups exposed to low doses of ionizing radiation (i.e., patients diagnosed with iodine-131 and X-rays, watch dial constructors, chemists, and others exposed to ingest or inhale radium or plutonium, persons exposed to higher levels of indoor radon, and also atomic bomb survivors) a lower percentage of neoplastic malignancies was observed [8–10]. In a wide range study, among approximately 200 000 American, British, and Canadian nuclear workers exposed to radiation, the total cancer deaths ranged from 27 percent to 72 percent of the total cancer deaths in the control group of non-nuclear workers [9].

Other important nuclear sector is power production in

NPP and the topic of radiophobia in countries, where this industry is developed, is very discussible and social researches are continuously performed. A recent study, based on collective doses for about 400,000 nuclear workers, found a 31 % decrease in relative cancer mortality [11], but this conclusion was based on an accepted assumption of a "healthy worker" effect for the tested cohort. It was assumed that the nuclear workers were selected for employment because they were healthier [4]. In Bulgaria where the nuclear industry is well developed especially in electricity production sector and based on the Chernobyl accident historical heritage the society is involved in discussions and the people has an own opinion regarding to benefits and harms of nuclear physic potential.

The Kozloduy Nuclear Power Plant is the biggest electricity generation company in Bulgaria and it is an important factor of the economic stability in national and regional aspect. There are 6 power units of light water nuclear reactors. After the first four power units were decommissioned, there remain two power units of 1000 MWe. The currently working units provide more than a third of the whole electricity generated in the country. With its highly qualified personnel and 40 years of experience the Kozloduy NPP operates safely and properly and a few years ago the prolongation of exploitation life had been technically proven for further period of 3 decades.

Since 50 years the possibility for building of new nuclear power units under the Belene NPP project in Bulgaria has been discussed. The intention to building a second nuclear power plant started in the early 1970s and the site's preparation according to the draft projects began in the early 1981 and it abandoned in 1990. Since then the Governments have decided to restart the Belene Project several times through the years 2013, 2016, 2018, 2019. A number of environmental organizations opposed the project during the years like they expressed the following concerns, such as the risk of a terrorist attack, its location in a seismically active area, concerns about the use of nuclear safety technologies, problems with transportation, procession and storage of nuclear waste and others. The opinion about the need for further nuclear power prevail but the future of the project remains unclear to this day.

Nowadays for the nuclear sector development, e.g. nuclear energy and nuclear medicine, it is important to evaluate the fear in deep the public perception's origin and to evaluate if it comes from the fear of real risk during the exploitation and different kind of accidents or it comes from radiophobia. With aim to clarify these points about the development of nuclear industry in Bulgaria the anonymous survey was conducted among different social groups in the country.

## 2 Methodology

The method of the sampling is a quota based on the characteristics of age, sex, education and the type of the settlement. The citizens from different social and demographic groups replied to a set of 33 questions. The questions cover wide range of potential factors influencing the personal

opinion as: the source of knowledge about ionizing radiation, the source of information about trends, the different personal fears from transportation, the opinion for nuclear energy production before and after the HBO production, etc. [12]. All questions provide up to 4 possible answers which are constructed with defined meaning to achieve as much as possible objective results. The results are studied regarding to trends following and the development of the public opinion depending on the issues. The obtained almost 600 filled quotes of the survey were subjected to cross-analysis on the basis of the dependence between the individual factors.

### 3 Results

For the evaluation of regional dispersion in social groups participated in the survey the country is divided in 6 geographical regions, not administrative as it shown in Figure 1. Highest obtained voting activity is from the Southwest (41%) and the North Central region (40%).

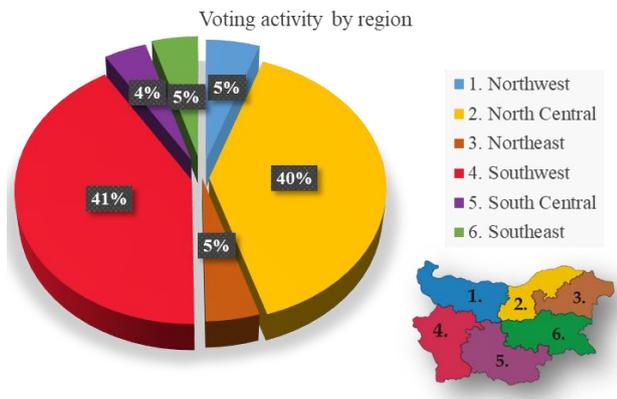


Figure 1. Participation activity in the survey by regions.

The age distribution of the participants was also assessed as preliminary the range of 18 to 80 years is divided into subgroups. The highest number of voters (51%) are in the range of 31 ÷ 45 years old, 27% are 18 ÷ 30 years old, 14% are between 46 and 55 years and 8% are 56 ÷ 80 years old. The educational profile of the interviewed people is established as upper like more than 75% have a university bachelor and/or master degree.

For the evaluation of people’s opinion, the survey has been taking into account also their professional involvement in the nuclear sector. A quarter of respondents are employed in the nuclear sector, and 55% of all voters have a relative or a friend employed in the field.

The first group of questions is dedicated to the public opinion towards the development of nuclear energy in Bulgaria and the participants expressed their attitude on several issues. The defined questions by this part and the results are presented in Figures 2, 3, and 4.

According to the data presented in Figure 2, over 90% of voters believe that the licenses of Units 5th and 6th should be extended for more 10 years after 2029. The answer is encouraging and it shows the public attitudes of Bulgarians are for a sustainable energy future and security of electric-

ity supply in the long term. Only 10% of people voted for the decommissioning of the two operating nuclear facilities after their expiration of the licenses.

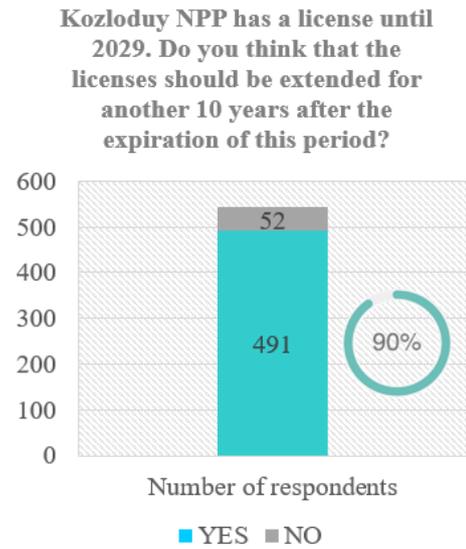


Figure 2. Distribution of responses regarding the extension of exploitation of the units on Kozloduy NPP site.

When asked about the reasons for use the nuclear energy, 39% of voters answered that the strongest argument is the low cost of electricity production, for 31% of voters the main reason is the significant contribution to the environment protection and to reduce greenhouse gases and for 13% the most important reason is the security of electricity supply. The data are presented in Figure 3.

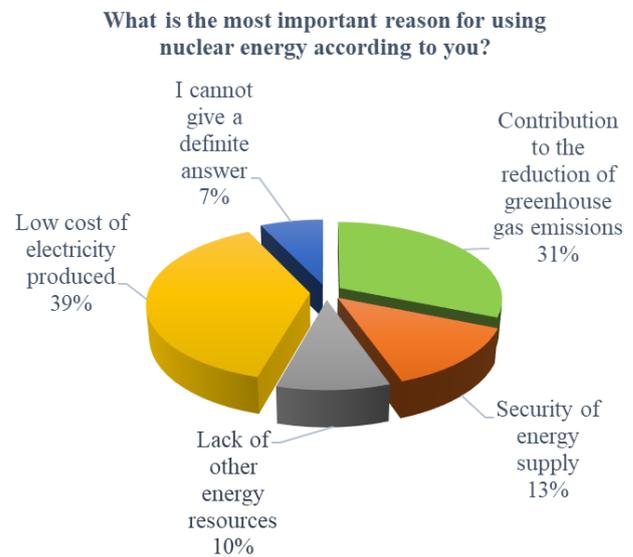


Figure 3. The importance of nuclear energy in the energy mix according to the respondents.

In Figure 4 summarized respondents’ answers to the question “If it was up to you, what would you choose to build ...” are shown. In this question, people had the opportunity to choose more than one answer. Here are some examples of the different combinations of suggested answers that respondents chose:

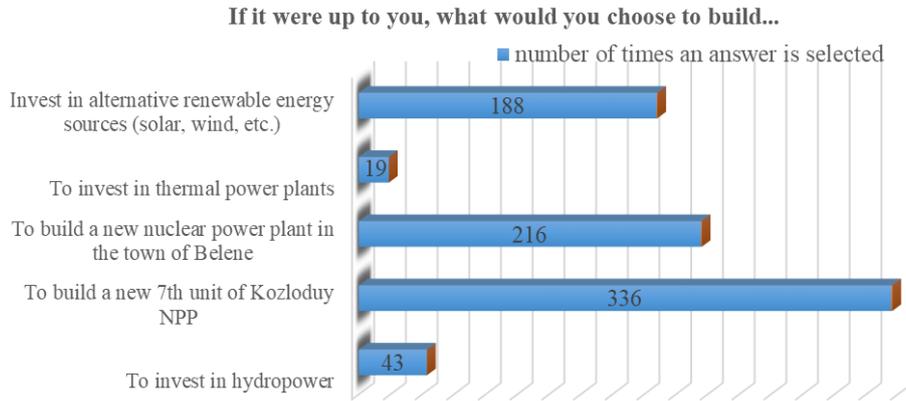


Figure 4. The opinion of people about the perspectives of Bulgarian electrical power sector development.

- To build a new nuclear power plant Belene NPP and to build a new 7th unit of Kozloduy NPP;
- To build a new 7th unit of Kozloduy NPP;
- To invest in alternative renewable energy sources (solar, wind power plants, etc.) and to invest in hydropower plants;
- To build a new nuclear power plant Belene NPP;
- To build a new 7th unit of Kozloduy NPP and to invest in hydropower plants;
- To build a new nuclear power plant Belene NPP and to invest in thermal power plants;
- To build a new 7th unit of Kozloduy NPP and to invest in alternative renewable energy sources (solar, wind power plants, etc.).

The answers to the questions above showed that the future for Kozloduy NPP for the participants in the survey is related to the continuation of the operation of the plant, in accordance with the operating license, as well as the construction of new units on the site. The predominant opinion between the participants regarding to the perspectives of Bulgarian electrical power sector development is focused on the new nuclear power plant build with total of 552 votes.

In the next group of questions, the presence and etymology of the phenomenon radiophobia were evaluated. To the question: “Are you afraid of radiation?” 43% of all voters said they are afraid of radiation, 53% said they are not afraid and about 4% of people cannot specify an answer. Over 90% of participants who answer they are scared of radiation are employed in non-nuclear sector and the possible reason of their fears could be a radiophobia or a low level of information and knowledge about physics and nuclear science and technologies.

To the question “Do you think that working in a nuclear facility would lead to reproductive problems?” over 11% (62 voters) of the respondents answers they think that is possible (Figure 5). Over 95% of them are working in non-nuclear sector and only two of answered people are working in NPP. The people who are scared by the ionizing radiation are definitely agree with this statement as 84% of them give the answer “Yes” or “It’s possible in certain circumstances”. The dominant share of interviewed who gave these answers, over 90%, is of non-nuclear sector related.

The age distribution of people who are afraid of radiation, shown in Table 1, indicates inhomogeneous trend.

Over 49% of answered people are 31–45 years’ old which could be associated to the so-called “The Chernobyl generation”. This generation were witnesses of the events after Chernobyl NPP accident and the perplexed media information. After the Chernobyl accident it was a standard

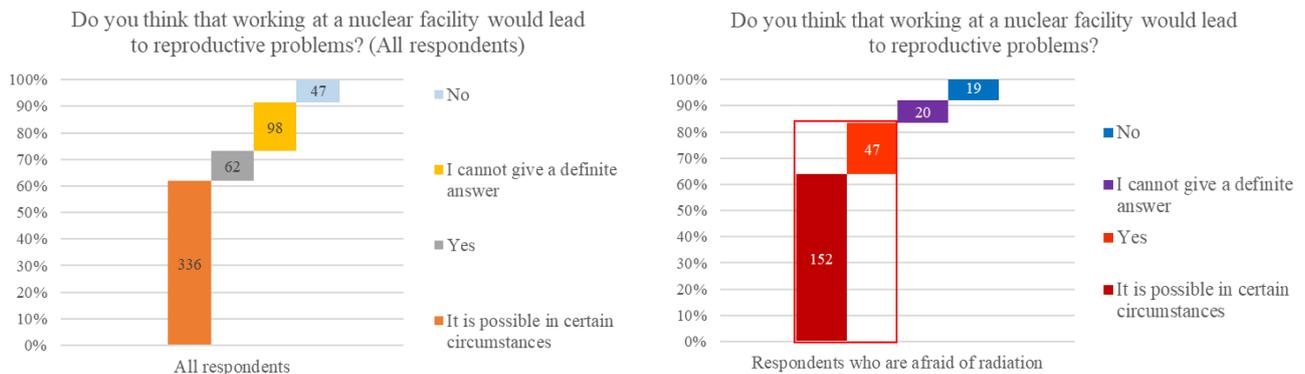


Figure 5. The opinion of interviewed about the possibility for reproductive problems among nuclear facilities’ employees and their distribution by the fear symptom.

Table 1. Age distribution of respondents who are afraid of radiation

Share	Age range			
	18 ÷ 30	31 ÷ 45	46 ÷ 55	56 ÷ 80
	30%	49%	13%	8%

practice in Bulgaria to give the Iodine pills to the children for almost a decade. Through the years students at schools were subjected to a thorough body examinations for radioactivity from the National Center of Radiobiology and Radiation Protection. What damage had this traumatic event caused? The events in 1986 had affected these children, who are currently in the age of 31–45. They still give signs of anxiety and fear of radiation. In this regard it is possible the fear of radiation to affects the attitudes of respondents about the possible choices for building a new power plants. What is the concept for future of power energy projects for these 49% respondents which afraid of radiation? Here the answers are unexpected and 53% of people afraid of radiation prefer Bulgarian government to invest funds in nuclear power plant.

With aim to investigate the etymology of radiophobia the survey includes questions regarding the source of information and knowledge of interviewed. Mostly of respondents (72%) answered that they had studied in school or university what radioactivity is and how can we be prevented from being exposed to – Figure 6.

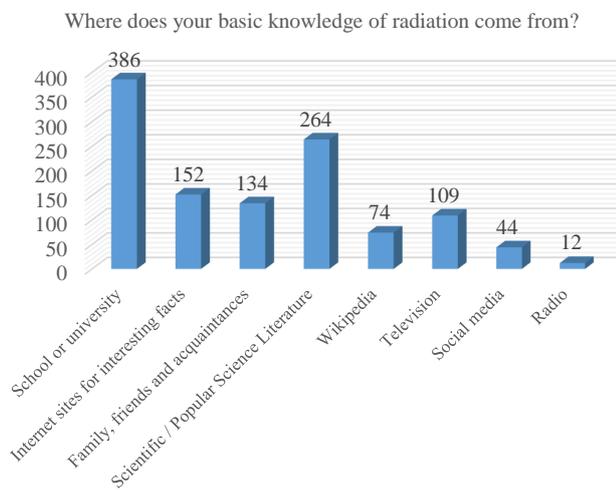


Figure 6. The source of knowledge of interviewed.

To the question “Which of the following sources of information do you trust the most?” people had the opportunity to point out several answers. And the result is shown in Table 2. The interesting point is that all combinations are unique. Voters rank “interesting fact sites” and “social networks” in combination with “scientific literature” as a reliable source of information. The number of respondents who chose answer number 4 is 314, which indicates that Bulgarian citizens have significantly increased their trust in government agencies and institutions.

Table 2. The sources of information which people are trust

Sources of information	Number of times an answer is selected
Wikipedia	37
Newspapers and news websites	33
Internet forums of interest	55
Official sites of government agencies and institutions	314
Radio and television	81
Social media	30

With aim to investigate and predict the human behavior during a nuclear accident specified question with multiple possible answers was included in the survey. Over 26% of responders in a case of an accident in Bulgarian nuclear power plant firstly will search for additional information and for the value of the radiation background on web platforms and official website of Kozloduy NPP and Bulgarian Nuclear Regulatory Agency – Figure 7. These responders are with bachelor, master or doctoral degree.

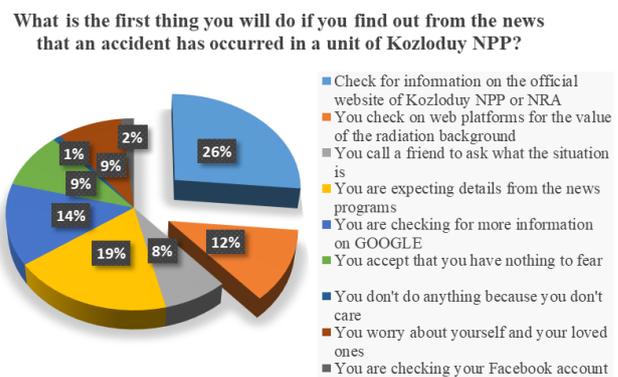


Figure 7. The human behavior during the nuclear accident.

And while people think that they have enough knowledge about ionizing radiation and rely on reliable sources of information, as many as 90% are of the opinion that the public is not sufficiently informed about benefits and risks of nuclear technologies – Figure 8. This imbalance can be worrying in terms of people’s objective assessment of their own knowledge and skills. The high assessment of own knowledge and the assessment of missing knowledge in the next generations is an indicator of deteriorating quality of nuclear knowledge management in Bulgaria.

Do you think the general public is sufficiently informed about the benefits and risks of nuclear technology?

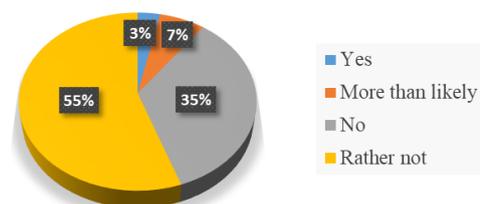


Figure 8. The respondents assessment of level and quality of public information.

In addition to the new nuclear facilities in Bulgaria, the projects for processing and storage of low and intermediate level nuclear waste, an integral part of the operation of nuclear facility for energy, medical and other needs, are also subjected to development. To the question about the construction of a National Repository for short-lived low- and intermediate-level radioactive waste near Kozloduy NPP site 137 respondents (25%) answered that they were concerned about – Figure 9.

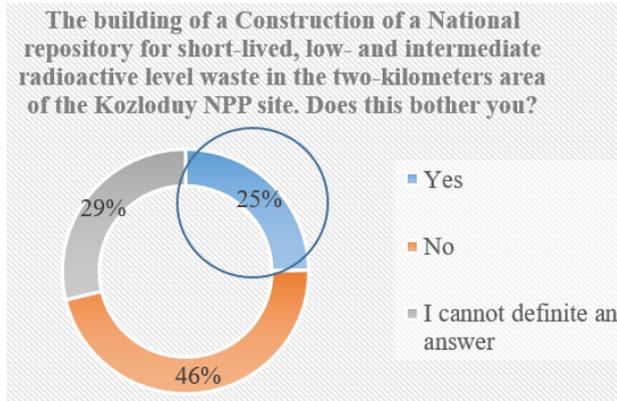


Figure 9. People’s concerns about the construction of a nuclear waste repository.

From all respondents who are bothered about the construction of a nuclear waste repository, about 75% have a master or bachelor degree and they are mostly from the Southwest and Northwest part of Bulgaria - 42% and 38% respectively. Only 13% of these people are employed in the nuclear sector, and the remaining 87% are people working in other business areas – Figure 10. The people who are not familiar to the nuclear technology does not evaluate the necessity and the technological requirement of radioactive waste management. The same attitudes have been observed many times in the recent past in Bulgaria regarding the storage and processing of household waste.

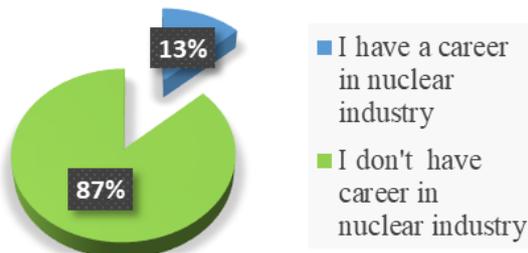
Two questions about the people’s trust in nuclear safety in Bulgarian nuclear facilities are included in the survey. To the question “Do you think during the storage of the

radioactive waste in the newly built storage facility near Kozloduy NPP will be ensured long-term safety of the people and environment?”, 27% responses negatively. Almost 40% of them think that nuclear facilities in Bulgaria cannot provide a sufficiently high level of radiation protection and they are concern about the safety of the people and the environment. This opinion contradicts the previously expressed trust in government institutions, but confirms the low assessment of the participants in terms of knowledge and skills of operational staff.

Provoked by the high rating and large influence of the HBO miniseries “Chernobyl”, we included a couple of questions in regard to it. To the question about a possibility of a nuclear accident in the Kozloduy NPP similar to those in Chernobyl we have got a definite negative answer from only 26% of respondents. The collective memory and the fear from unknown or from invisible, create economic, social and health prejudice not only to the people living in the accidents’ areas. People believe that actions and positions regarding to some accidents in the past of the politicians, medias, different kind of ecological and charity organizations and even scientists leads to discreditation and trust missing of the nuclear sector nowadays.

There are differences in the memories of the social groups, communities and nations connected with the Chernobyl accident. The individuals who were exposed to a traumatic event develops anxiety symptoms, re-experienced by the event, and they avoid everything related to the event. Near 60% from the respondents, they afraid of the radiation allow the possibility of an accident in Kozloduy NPP similar to the Chernobyl NPP disaster – Figure 11. Half of these people are highly educated - with a bachelor, master or doctoral degree and 75% of all respondents are people working in a non-nuclear sector. Frequently although the high level of people education they have a lack of knowledge in specific areas. Only two persons from these responders are working in the nuclear sector. In general, it can be summarized that, the workers trust technologies and people’ knowledge. They think there is no danger of an accident because of the depth of knowledge in the field, but 17% of them are still afraid of invisible radiation.

**People concerned about the construction of a National Repository for short-lived, low- and intermediate-level radioactive waste near Kozloduy NPP (25% of all respondents)**



**People concerned about the construction of a National Repository answer to the question "Do you afraid of radiation?"**

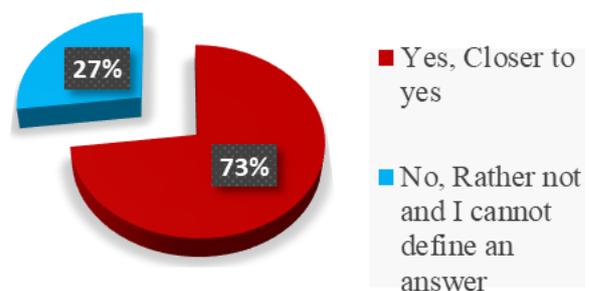


Figure 10. Relationship between concerns about the construction of a radioactive waste repository and other factors.

**Do you think it is possible to be an accident in NPP Kozloduy similar to the Chernobyl NPP accident in 1986?**

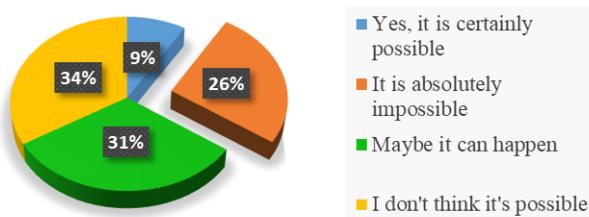


Figure 11. Opinion of interviewed about the possibility for nuclear accident in NPP Kozloduy similar to those in NPP Chernobyl.

When asked whether the HBO miniseries has influenced the participants' opinion on the safety of the nuclear power plant, many of them admit that they have changed their attitude in a negative direction, which is another proof of the strong influence of the media on public opinion.

#### 4 Conclusion

When we have to make quick decisions fear potentially guides our lives but sometimes fear can be misleading us applied to different or wrong problems. "Can I run away from the nearest exit of a burning building? Can I find a safety place during an earthquake?" Answers and decisions may be different for different people and situations. More information and more knowledge have to be the motto of our generation and then radio phobia will not exist in this scale.

The government and the organizations who apply the nuclear methods /NPP, SE RAW, NRA, scientific, medical and industrial laboratories, and the state regulatory body NRA/ should define their priority to promote the use of nuclear energy, nuclear knowledge, experience and developed technologies in the field of nuclear energy and nuclear applications.

People skills and their way of thinking must support and encourage each other. They do not have to become enemies against the technological progress. The processes of progress of the 21st century give the power and the ability of the ruling class to settle down feelings of a strong fear never seen before. Knowledge has the power to stop people's fear.

Analyzing the results of the vote in the survey, it can conclude that people in Bulgaria still are afraid of radiation. In 2020, in the situation of growing fears for people's lives and health, the public opinion is changing dynamically. In this context, the assessment for future action will be based on an assessment of two often conflicting group arguments for security and economic efficiency. We have to

work harder to gain a public confidence and a support for the nuclear energy. The nuclear power plants are proven as power source which could reduce the harmful carbon dioxide emissions and could provide a long-term energy security to the country. It is important all benefits and harms of nuclear technologies to be presented to the people on affordable way, objectively and without introducing various final opinions. Nowadays, when access to information is almost unlimited, consumers must receive reliable information, supported by data and analyzes that prove the presented. According to the obtained results could be concluded that the nuclear knowledge management in Bulgaria has to be intensively developed at all levels of educational, governmental, profit and non-profit organizations.

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