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# Assessment of Infrastructure Development Requirements for Embarking on Nuclear Power Program in Macedonia

**Nikola Popov, Igor Ilijovski, Vladimir Popovski**

*Macedonian Power Plants – Skopje – ELEM, 11 Oktomvri 9, 1000 Skopje, Macedonia*

**Abstract.** Over the past decades nuclear energy has been proven as reliable and economical energy supply that is capable of meeting demanding energy market requirements. Many countries around the world consider entering into new nuclear energy programs and building new power reactors for satisfying their increasing electrical energy needs. A nuclear power program is a major undertaking requiring careful planning, preparation and investment, and human resources for building adequate nuclear infrastructure. Preparations for making a decision to enter into a new nuclear energy program requires a significant amount of financial and human resources, time, and assistance from already developed countries and international nuclear organizations. The International Atomic Energy Agency (IAEA) from Vienna provides technical help, financial assistance, and documented knowledge that are important for countries facing the challenge of entering nuclear programs for the first time. The IAEA organizes technical courses and information exchange meetings for new countries at which experiences and lessons learned are provided to new countries.

This paper describes the key activities in the process for making a decision to enter a new nuclear energy program. It describes the efforts currently being conducted in the Republic of Macedonia in the direction of collecting information, performing various feasibility studies, and engaging in regional cooperation for utilizing experiences of the regional countries in performing such activities, and in developing their nuclear power programs. This paper also provides an overview of the IAEA documents and recommendations that are relevant for this topic. A version of this paper was presented at the Bulgarian Nuclear Society annual conference [1].

**Abreviations and Scronyms**

ELEM : Macedonian Power Plants
IAEA : International Atomic Energy Agency
IZIIS : Macedonian National Institute for Seismic Engineering
MANU : Macedonian Academy of Sciences and Arts
MEPSO : Macedonian Electric Transmission Company
NEA : Nuclear Energy Agency
NEP : Nuclear Energy Program
NEPIO : Nuclear Energy Program Implementing Organization
NPP : Nuclear Power Plant
OECD : Organization for Economic Cooperation and Development
TC : Technical Cooperation
WNA : World Nuclear Association

## 1 Introduction

Today, the world produces as much electricity from nuclear energy as it did from all sources combined in 1960 [2]. Civil nuclear power can now boast over 15,500 reactor years of experience and supplies more than 12% of global electricity needs, from reactors in 31 countries. In fact, through regional grids, many more than those countries use nuclear-generated power. The nuclear power industry is a well established industry that uses proven technology and provides a reliable and economic electrical energy to the world [3]. There are number of characteristics of nuclear power which make it particularly valuable in addition to its low actual generation cost per kWh. Nuclear power contributes to clean air and low-$CO_2$ objectives, and it gives good voltage support for grid stability, and other benefits and advantages.

Sixteen countries depend on nuclear power for at least a quarter of their electricity. France gets around three quarters of its power from nuclear energy, while Belgium, Czech Republic, Hungary, Slovakia, Sweden, Switzerland, Slovenia and Ukraine get one third or more. Also, South Korea, Bulgaria and Finland normally get more than 30% of their power from nuclear energy, while in the USA, UK, Spain and Russia almost one fifth is from nuclear power plants. The province of Ontario in Canada gets more than 50% of its power by nuclear power generation. Japan is used to rely on nuclear power for more than one quarter of its electricity, and is expected to return to that level following an interruption resulting from the Fukushima accident in 2011. Among countries which do not host nuclear power plants, but use nuclear power from other regional countries that have nuclear power programs, are Italy and Denmark, which get almost 10% of their power from nuclear power in European countries.

A nuclear power program is a very demanding national undertaking that needs comprehensive and systematic national planning and preparation, along with major investments in time, human and financial resources. Therefore, a decision to enter a national nuclear program needs to

be made at the national government level with a complete understanding of the risks, consequences and possible outcomes of such decision. To prepare for such step, a national government must be completely informed and familiar with the international regulations, legal obligations and laws, and financial commitments that must be adhered to.

Past experience indicates that there are numerous ways to establish a successful nuclear power program. Countries wishing to embark on a first nuclear power plant project may be at various levels of capability and nuclear safety infrastructure development, ranging from no experience, to experience with laboratory scale nuclear facilities and industrial applications, to experience with operation of research reactors, and to handling of radioactive material in large amounts. Therefore, the plan for entering into a nuclear power program will depend on the level of supporting nuclear infrastructure development in a country [4-7].

The International Atomic Energy Agency (IAEA) has developed a significant amount of expertise and documentation on the topic of new nuclear power programs around the world. The IAEA systematically keeps informed about new national nuclear power programs, collects past experience, and offers this experience and lessons learned to countries starting a new program. From the earliest phase of the development of nuclear safety infrastructure, IAEA places the prime responsibility with the national government to establish an effective governmental, legal and regulatory framework to support a high level of safety infrastructure.

## 2 Process for Entering Into a New Nuclear Power Program

Considering the complexities and uncertainties of forecasting the nuclear power utilization level in the world in future, it is quite challenging for new countries to plan nuclear infrastructure development and maintenance. The IAEA has issued various documents which explain the process and provide assistance to countries that are preparing to make a knowledgeable decision to begin a new nuclear power program, and to build a supporting nuclear infrastructure. The key relevant IAEA document NG-G-3.1 [8], which describes the milestones (phases) in preparation for a new nuclear power program. The IAEA document NG-T-3.2 [9] is used to evaluate the initial level of infrastructure development, and decide when it has reached a level that ensures a successful nuclear power program implementation. The IAEA document SSG-16 [10] and the INSAG-22 document [11] are used to focus on the infrastructure elements and processes required for a healthy safety infrastructure.

There are a number of IAEA documents that provide guidance and support in various areas important to nuclear infrastructure development. Among numerous documents, the IAEA document covering guidance on site evaluation feasibility studies, NS-R-3 [12] was recently used in Macedonia.

One of the key topics for development of nuclear infrastructure is the issue of human resource development. We have extensively used in Macedonia the IAEA document NS-G-2.8 [13] that provides guidance on the recruitment, qualification and training of personnel. The IAEA guidance on nuclear engineering education is provided in the recent IAEA document NG-T-6.4 [14].

In addition, the IAEA organizes technical meetings for exchange of information and experience among countries that have been or are going through a process for embarking on a nuclear power program. Recent technical exchange workshops include the IAEA workshop on national position development [15], and the IAEA technical workshop on self-evaluation methodology [16].

In the area of South-East Europe there are several countries that already have a developed nuclear power programs, such as Bulgaria, Romania, Slovenia and Hungary. Other countries in the region have medium and long term electrical energy needs that can be partially met with nuclear power implementation. However, these small countries need regional cooperation and help to embark on such a financially-demanding complex industrial program. The IAEA has recently started technical exchange meetings to bring these countries together, to provide guidance on energy planning studies, and other aspects of the decision making process that can be conducted on a regional basis. One of these meetings was organized in Skopje, Macedonia, in September 2013 [17], and another similar meeting was organized in Bucharest, Romania early in September 2014 [18].

Because of the current situation in nuclear power development around the world, the global financial situation, and the impact of the accident in Fukushima, many newcomer countries have decided to use a “step-by-step” approach in the direction of making a decision on new nuclear power program. Basically, this approach provides flexibility to national governments to proceed in a systematic and comprehensive fashion, without prematurely over-committing financial and human resources. This approach is being used in small countries, and is focused on following the world trends in nuclear power utilization, and in monitoring experience exchange among developed countries already in the nuclear power program.

The IAEA document on safety infrastructure development [10] provides guidance how to approach the process of making a decision for entering into a new nuclear power program or staring a construction of a new nuclear power plant. Figure 1 from this document provides a summary of this process. Pre-phase 1 is an initiating phase that covers preparation activities and collection of information needed seriously embarking on Phase 1. Furthermore, in

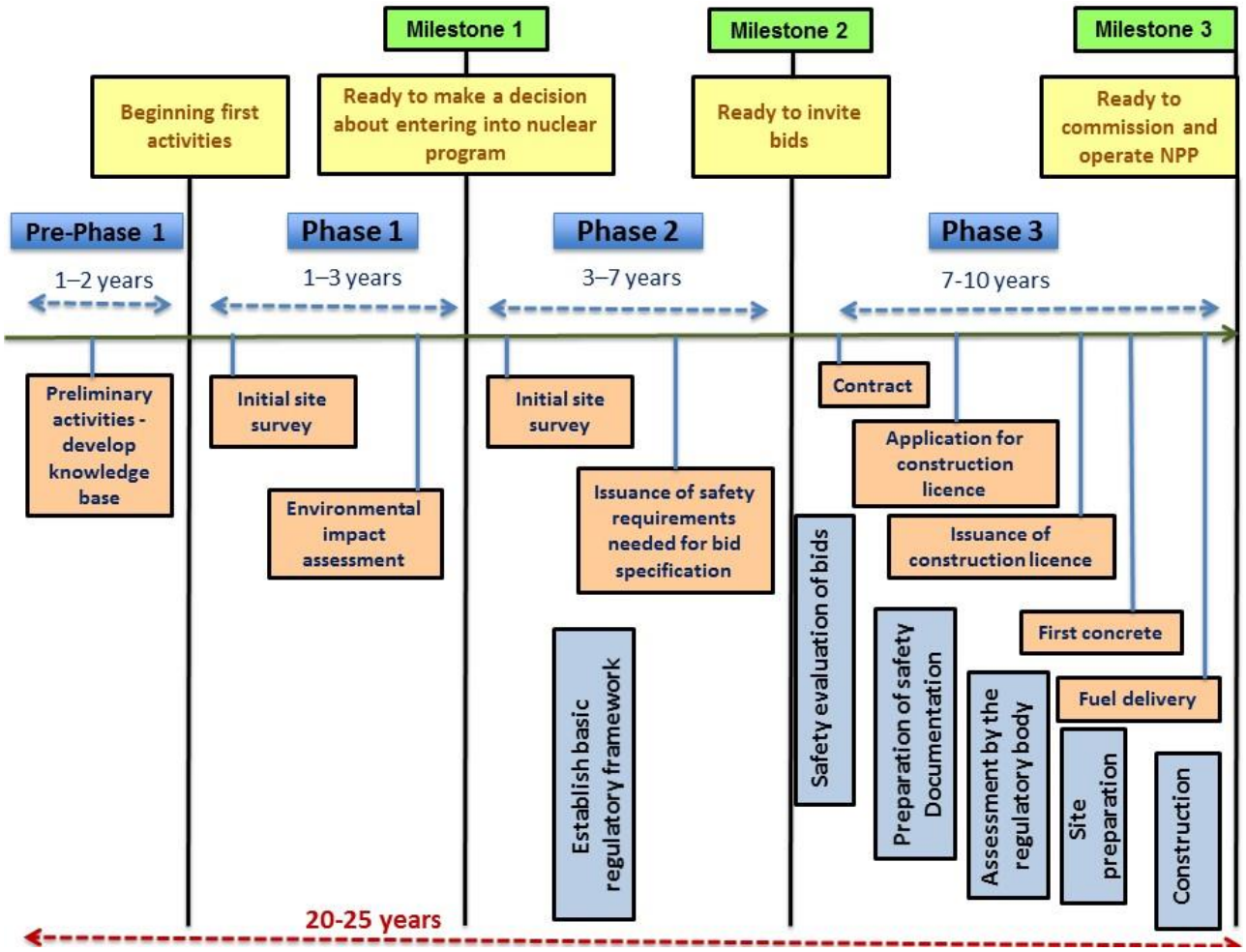


Figure 1. IAEA Suggested Process for Development of Nuclear Power Program.

Phase 1 the status of all aspects of nuclear power program implementation at the national level are reviewed and assessed and gaps are identified. Phase 2 refers to preparations for the bidding process for a nuclear power plant. Phase 3 is focused on the activities for choosing a nuclear technology, and granting appropriate licenses: environmental license, site license and construction license, and includes actual construction of the NPP. The required time to complete each of these phases is quite dependent on the level of national industrial development, and on the national government preparedness to support and fund such activities.

During Pre-phase 1 work energy demand and supply studies are carried out, along with other site investigation studies, and human resource studies. The responsible organization for carrying out the Pre-phase and Phase 1 process is NEPIO (*Nuclear Energy Program Implementing Organization*), which needs to be established and funded by the national government. Activities for establishing or strengthening already existing regulatory body need to start in Phase 1 and to be intensified in Phase 2 and 3. NEPIO can be established using different organizational models, very often as a government department that is directly funded by the national government, or as part of the government-owned electricity utility.

The objective of Phase 2 is to prepare for a bidding process for NPP procurement. This Phase may consist of several steps that include the activities for selection of a nuclear technology, the investment model, and other preparatory work for development of the documentation for the environmental and site license regulatory reviews. Phase 2 ends by readiness to invite bids for a nuclear power plant contract.

In Phase 3, many activities which are necessary for the process of choosing a vendor for delivery of the equipment are planned and conducted. In the first step important activities in the selection of the vendor of the NPP are carried out by reviewing the answers to the announced tender. Also preparation of the contract for buying the NPP is planned. In the same period, the national nuclear regulator should undertake all the activities related to the examination and approval of the documentation submitted for the site license and the environmental license. In this period, the vendor and the investors start preparation of the documentation for construction. In the second step of Phase 3, completion of the documentation for submission of the application for a construction license of the NPP is carried out. In the third step the regulatory body reviews the documentation for construction of the NPP and issues a construction license. The last step of Phase 3 involves

construction of the NPP, and it is usually subdivided into several sub-steps.

All preparatory phases above require the involvement of three key stakeholders in the process: the government, the regulatory body and the owner/operator. Past experience in certain countries and in the IAEA shows that the government role is essential in Pre-phase 1 and Phase 1. In Phase 2, the government role is slowly being reduced while the nuclear safety regulatory body and the operating organization slowly take a more important role. In Phase 3, while the strong nuclear safety regulatory body is now completely equipped and prepared to take on the challenge of review and approval of the construction license, the operating organization continues to build expertise and mobilize resources and knowledge to prepare for the operation of the first NPP. This process may require a different dynamic in the model when a foreign technology vendor or investor own most of the assets of the new NPP.

There are a number of elements of the self-evaluation process described in the IAEA document NG-T-3.2 [9] that a country needs to complete during the process of decision making. Performing a self-evaluation is encouraged by the IAEA as the first step in any overall review of the readiness to proceed to each phase in the development of a nuclear infrastructure. Self-evaluation is an essential tool for any learning organization and country. Usually the first self-evaluation is managed by the national government and includes staff members who are part of the organizations involved, such as the government, regulatory body, etc. However, IAEA encourages countries and organizations to consider augmenting the assessment team with experts from other countries that have already been through the infrastructure development process. The key requirement for any evaluation is to assign people who have a good understanding of the infrastructure issues, and have knowledge and experience in conducting evaluations. It is also important that the evaluation team have a level of independence from those who have been involved in the development of the NPP project.

Planning for a self-evaluation is usually performed by the countries taking this step, in consultation with the IAEA experts, and experts from other countries that have previous experience performing self-evaluations. The self-evaluation process includes several main steps: (1) identifying the terms of reference for the evaluation, the organizations to be involved and the individuals who will conduct the evaluation; (2) evaluating the status of development of the infrastructure against the basis; (3) identifying areas needing further attention; and (4) preparing an action plan to address these areas.

The key objective of the self-evaluation process is to identify gaps in the infrastructure development that need to be addressed before proceeding to the next phase of entering into a nuclear power program. The gaps are typically grouped corresponding to the actions which will address the gaps: those that require significant actions, those that require minor actions; and those that require no special actions. During this process it is essential that the country prepares good documentation that justifies the conclusions from the evaluation process. These documents should be made available to the public in the country to demonstrate transparency and openness.

A considerable period of time is necessary before operating a nuclear power plant to acquire the necessary competences and a strong safety culture. While prime responsibility for safety must rest with the operating organization, the country's government has the primary responsibility upon committing itself to a nuclear power program to create a robust framework for safety. Establishing a systematic and sustainable safety infrastructure is a long process, and it has been internationally acknowledged that a period of 15-20 years under optimum conditions would generally be needed, particularly in countries with no previous experience in nuclear engineering.

In this respect, the government, using its legal system, establishes, maintains and enforces the national policy for safety by means of different instruments, statutes and laws. The regulatory body, as designated by the government, is given the statutory responsibility for the development and implementation of policies and strategies through a regulatory program, and through regulations or standards. In addition, the government establishes laws and adopts policies specifying the responsibilities and functions of different governmental entities with respect to safety and emergency preparedness and response.

There are a number of serious challenges that a country faces during the process for establishing a required readiness for starting a new nuclear power program. Among the most serious challenges especially for small countries in the area of South East Europe are: establishment of appropriate regional cooperation, development of competent human resources, attracting capable and interested investors to fund an expensive power project, and establishment of adequate safety culture. All these challenges require a committed and stable government to address them and complete them successfully in timely fashion.

## 3 Macedonian Nuclear Power Infrastructure Assessment

The Republic of Macedonia was part of the Yugoslav Federation before 1991; it reached its independence in September 1991. As part of Yugoslavia, along with the other provinces, Macedonia was involved in nuclear infrastructure development in preparation for construction of one nuclear power plant on its territory. As per the Yugoslavnuclear power program, the first nuclear power plant was built in Slovenia, the Krsko NPP, where it continues to operatefor about 30 years.

Yugoslavia had a very developed nuclear R&D laboratories in several of its provinces that were recognized internationally, and were used by the Macedonian engineers and scientists. The R&D program was supported by strong ed-

ucational program at the main universities. The Macedonian part of this educational program was located at the University of Cyril and Methodius in Skopje, the capital of Macedonia. Many Macedonian engineers and scientist were educated by this nuclear program, and were employed in the Yugoslav R&D laboratories and in the Krsko NPP.

Following the separation from Yugoslavia, Macedonian government put on hold planning and preparation for implementation of nuclear power program. As a result, with time, the human resources that were trained to be used in the Macedonian nuclear power program were subject to requalification to other jobs. Consequently, Macedonia today has limited technical resources familiar with nuclear power requirements and elements, and NPP construction and operation.

Figure 2 shows the key electric power plants in Macedonia currently in operation. Presently, Macedonia imports in the average year more than 25% of its electrical energy needs. Domestic production of electrical energy is mostly based on lignite utilization in thermal power plants. However, the lignite reserves are being depleted at a fast rate that presents a serious challenge to sustainable coal-fired power plant operation in the next 20-30 years. Macedonia has also a number of hydroelectric power plants that provide about 40% of the electrical energy production. However, the hydroelectric power plants are highly dependent on the atmospheric conditions that widely vary from one year to another.

Macedonia has some hydroelectric reserves that can be further developed, and can provide up to 600 MW of installed capacity in the future. Recently, a few additional new lignite reserves were confirmed that can provide fuel for 20-30 years for production of about 300 MWe. However,


Figure 2. Most Important Power Plants in Macedonia.

if the Macedonian government decides to base its medium and long term energy future on coal-fired power plants, it will face the need to import significant amount of coal. This will present a number of challenges. Although gas-fired power plants can be used to relieve the pressure on coal imports, the gas-fired power plants are also accompanied with gas imports that can present different challenges.

As a result of the above explained electrical energy needs, and following the strategy of assessing future energy alternatives, the Macedonian government decided late in 2010 to start preparations for collecting information on the requirements, benefits and risks of re-entering into a nuclear power program. This process was based on the assumption to start one NPP operation after 2035. The first feasibility study was conducted by the Macedonian Academy of Sciences and Arts in 2011 [19]. Since 2012, the activities on nuclear infrastructure assessment and development were moved to the Macedonian Power Plants (ELEM), where work is currently in progress in this direction [20]. The feasibility studies that are currently in progress at ELEM are briefly described below.

### 3.1 Feasibility study on human resource development

Nuclear power infrastructure development requires a large number of different resources that need to be directly or indirectly involved in NEP implementation and NPP construction and operation. Usually, for a country embarking on a nuclear power program, development of an adequate human resource infrastructure is the most challenging task. In particular, the operating organization should be staffed with competent managers and a sufficient number of qualified personnel having due awareness of the technical and administrative requirements for safety of a nuclear power plant. A sufficient number of experienced staff, supplemented as necessary by consultants or contractors, should be available to ensure the safe construction and operation of the plant, so that duties relevant to safety may be carried out without undue haste or pressure.

A particularly challenging situation arises in newcomer countries where nuclear power training and resources are not available. This situation can significantly delay the process of nuclear infrastructure development, and will require significant financial resources to compensate. The best solution in such situations is to get help from already well-established international organizations and companies that have experience and resources while national training centers, trainers and trainees are being developed. Regional cooperation and establishment of joint regional programs in development and utilization of nuclear power resources, along with getting help from international centres, may be the solution for small countries that are not capable alone to address this challenge.

ELEM has initiated in 2014 a feasibility study on the human resource assessment of the current situation in Macedonia. This study is being conducted in several phases. Phase 1 of this study is already completed, and phase 2 is in progress. The study is being conducted by the Department of Electrical Engineering at the University Cyril and Methodius. The key elements of this study are:

- Assessment of the potential human resource gaps in Macedonia as per the IAEA guidance documents;
- Review of human resource development activities in the countries of South-East Europe that are already

in NEP, and in countries that are in the process of human resource development;

- Review of the existing national electrical power industrial infrastructure;
- Assessment of the educational programs currently available in Macedonia that are useful for nuclear resource development; and
- Review of possible options in human resource development in Macedonia.

Preliminary results indicate that human resource development in Macedonia imposes a serious challenge to the NEP implementation. Although there are a number of courses at the undergraduate and graduate level at the educational institutions in Macedonia that can be directly or indirectly used in NEP implementation, development of human resources at an adequate level will take a significant time and financial resources.

Three main options were considered for human resource development in Macedonia. The first option is to develop national-specific human resources educated at the educational institutions in Macedonia. This is the most financially-demanding, time-consuming, and challenging option. The second option is to use educational institutions in regional countries, which will is more effective and can deliver results sooner. The third option is to use human resources jointly with other countries in the region. This is the most effective and the least financially challenging option, and at the same time the fastest option. Discussions, workshops and meetings have already been initiated at the regional level supported by the IAEA, organized with countries in the region to consider human resource utilization. Further details on human resource planning are provided in Ref. [21].

### 3.2 Feasibility study site seismic adequacy

The site selection process, also called siting for a new nuclear installation, is divided into several phases. In the first phase, usually termed as site survey phase, potential sites are considered on the basis of available data, and suitable candidate sites are chosen. In the second phase, termed as site selection stage, an NPP site is selected based on detailed assessments. In he third stage, the acceptability of the selected site is confirmed, its complete characterization is performed and the site related parameters needed for the design of the nuclear power plant are derived. The site evaluation process follows the site survey and should be continued throughout the entire lifetime of the nuclear power plant to take into account changes in the site characteristics, and in evaluation methodologies.

In Phase 1 of NEP implementation (Figure 1), the government needs to ensure that potential sites are identified and candidate sites are selected on the basis of a set of defined criteria, at a regional scale and with the use of available data. In the Phase 2 of NEP implementation, the regulatory body needs to establish specific safety requirements for site evaluation, including requirements for the process for authorizing the selected sites, in compliance with the relevant IAEA safety standards. The operating organization needs to complete the investigations relating to the acceptability of the candidate sites and select the preferred candidate site for the first nuclear power plant, by making use of specific data, information and studies, and assessments conducted on thefullest possible temporal and spatial scales.

Preliminary site survey and selection have been completed as part of the Yugoslav nuclear power program by the Macedonian National Institute for Seismic Engineering (IZIIS). In early 1980s three potential sites have been selected in Macedonia, among which the site of Mariovo was suggested as the most appropriate in terms of seismic adequacy. Other preliminary evaluations were also completed, including hydrological, geological, environmental, social, and other areas.

ELEM has initiated in 2014 a feasibility study to evaluate and reconfirm the seismic adequacy of the site of Mariovo. This feasibility study is being conducted in several phases. Phase 1 is completed, and Phase 2 is in progress. The objectives of this study are:

- to review siting documentation prepared in the 80s;
- to confirm site acceptability from the seismic aspect;
- to identify gaps as per IAEA guidance documents in this area; and
- to identify further work that is needed to confirm site acceptability.

The preliminary results obtained so far have confirmed that the site of Mariovo is adequate and it meets the current international seismic requirements. Further details are provided in Ref. [22].

### 3.3 Feasibility study on transmission network capability

Macedonia has relatively well developed electrical energy transmission system, and is well connected to the key electrical power transmission corridors. The Macedonian Transmission Company, MEPSO, is a member of the ENTSO-E European transmission network. To confirm the capability of the Macedonian transmission system to accept a large NPP that needs to be well connected to the regional power systems, a feasibility study is being performed by MEPSO with the following objectives:

- to confirm capability of the current transmission network for export/import of large amounts of electrical energy;
- to perform assessment of impact of new NPPs with different sizes and locations in Macedonia or regionally on the national and regional electricity transmission; and
- to identify any issues, and make recommendations for further work.

The feasibility study is aimed to develop technical criteria for connection of one NPP on the regional transmission network, and it defines scenarios and variants that consider various demand forecasts, installed power and location of the NPP, while using appropriate assumptions of the regional network topology. The variants of the NPP location include the following sites: Mariovo in Macedonia, Skavica in Albania, and Kozloduj in Bulgaria. The grid analysis includes load flow, short circuits, and network dynamics. Further details are provided in Ref. [23].

## 4 Macedonian IAEA TC Project and Activities

The ELEM in Macedonia has received some funding from the IAEA to conduct a project entitled "Supporting Preparation Activities for Decision Making for a New Nuclear Energy Program", which in progress in the period 2014-2015. The objective of this project is to provide assistance to the Macedonian government in determining requirements and conditions for making a decision on embarking on a nuclear power program.The specific tasks of this project include:

- Organizing workshops on "Milestones and Issues in the development of a national infrastructure for nuclear power" aimed for educating decision makers in developing a nuclear power program;
- Development of long term energy demand analysis;
- Development of scenarios of long-term energy supply options;
- Development of a plan for nuclear infrastructure improvements, review of site evaluation and implementation methodology, and preparation of human resources development plan; and
- Training of national experts by scientific visits to international nuclear energy training centers, international nuclear laboratories and nuclear power operating organizations.

As part of this project the IAEA organized two workshops on the energy demand assessment, the first one by e-Learning in August 2014, and the other one in person in September 2014 in Macedonia. Both of these workshops were used to familiarize Macedonian energy planners and engineers with the IAEA tools, models and sample results in this area.

## 5 Conclusion

The nuclear power utilization in the world has started over 60 years ago, resulting in construction and operation of a relatively large number of commercial nuclear power reactors. The evidence over six decades shows that nuclear power is a safe means of generating electricity. Although there is some variety in the position and strategy, the current assessment indicates that the countries that have the most nuclear power units, such as USA, France, Russia and others continue to strongly relay on nuclear power in the energy mix of these countries. In addition, the largest countries in terms of population and industrial activity, China and India, remain strongly committed to continue and accelerate construction of new nuclear power plants.

Some countries are currently reconsidering their position with respect to nuclear power, some have decided to continue the preparation for embarking on a nuclear power program, while some decided to temporarily postpone planning for a nuclear power program. The process for making a decision to start a new nuclear power program involves a complex process that requires a significant amount of time, financial and human resources to make a decision. The IAEA and other well-known global organizations provide help, guidance and financial assistance to those countries that are about to make a decision to embark on a new nuclear power program.

Macedonia has initiated certain feasibility studies and is involved in an IAEA project to evaluate the need for nuclear power implementation in Macedonia and regionally. The scope of the work includes energy demand and supply study, seismic assessment of the Mariovo site in Macedonia, human resources assessments, and electric power transmission network assessments. Preliminary results are encouraging, but they indicate significant challenges in some areas.

Regional cooperation in the South-Eastern Europe is important for countries with insufficient human resource and financial capability. Certain activities in this direction have been initiated and are being supported by the IAEA.

## References


[1] N. Popov, I. Ilijovski, and V. Popovski, "*Macedonian Nuclear Infrastructure Development*",' Conference of Bulgarian Nuclear Society, Chiflica Palace Resort, 23-26 September, 2014.

[2] *Nuclear Power in the World Today*, World Nuclear Association, Update of April 2014.

[3] H.-H. Rogner, *Global Outlook for Nuclear Power,* International Institute for Applied Systems Analysis, Austria, IAEA Meeting on the Macedonian Project MAK2006, Skopje, Macedonia, June 23, 2014.

[4] J. Moore, *NPP Construction Activities,* IAEA, Nuclear Power Division, March 2013.

[5] M. Schneider, A. Froggatt, S. Thomas, *Nuclear Power in a Post-Fukushima World,* The Worldwatch Institute, Mycle Schneider Consulting, The World Nuclear Industry Status Report 2010-2011, 2012.

[6] *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050,* Reference Data Series No. 1, Edition 2012, IAEA, Vienna, 2012.

[7] *International Status and Prospectus for Nuclear Power 2012,* IAEA Report by the Director General, August 15, 2012.

[8] *Milestones in the Development of a National Infrastructure for Nuclear Power*, IAEA, NG-G-3.1, Vienna, 2007.

[9] *Evaluation of the Status of National Nuclear Infrastructure Development*, NG-T-3.2, IAEA, Vienna, 2008.

[10] *Establishing the Safety Infrastructure for a Nuclear Power Program*, SSG-16, Vienna, 2011.

[11] *Nuclear Safety Infrastructure for a National Nuclear Power*

*Programme supported by the IAEA fundamental safety principles*, INSAG-22, Vienna 2008.

[12] *Site Evaluation for Nuclear Installations*, NS-R-3, IAEA, Vienna, 2003.

[13] *Recruitment, Qualification and Training of Personnel for Nuclear Power Plants*, Safety Standards Series No. NS-G-2.8, Vienna 2002.

[14] *Nuclear Engineering Education: A Competence Based Approach to Curricula Development,* IAEA Nuclear Energy Series, No. NG-T-6.4, IAEA, Vienna, 2014.

[15] *Establishing a National Position and Decision Making on a Nuclear Power Program*, IAEA Technical Meeting, Zagreb, Croatia, 7-9 September, 2011.

[16] *Self-Evaluation Methodology and Action Plan Development for Nuclear Power Program*, IAEA Technical Meeting, Vienna, Austria, 17-20 October, 2011.

[17] *Regional and Trans-Boundary Energy Issues and Cooperation in Nuclear Power Programs,* IAEA Technical Meeting, Skopje, Macedonia, September 24-27, 2013.

[18] *Enhancing Energy Planning, Nuclear Power Infrastructure and Nuclear Safety Oversight for Countries Considering Developing or Expanding Nuclear Power Programs,* IAEA Technical Meeting, Bucharest, Romania, September 2-5, 2014.

[19] N. Popov et al. "*Perspectives for Implementation of Nuclear Energy in Macedonia: Strategic Study on the Needs, Benefits, and Possible Implications*", Macedonian Academy of Sciences and Arts, April 2012.

[20] N. Popov, "*Initial Preparations for Making a Decision For or Against Enteringinto a Nuclear Energy Program in Macedonia*", ELEM, 2012.

[21] A. Causevski, H. Spasevska, S. Nikolova-Poceva, and N. Popov, "*Development the Human Resources Infrastructure For Nuclear Energy Program in Macedonia,*" Conference of Bulgarian Nuclear Society, Chiflica Palace Resort, 23-26 September, 2014.

[22] V. Popovski, N. Popov, and I. Ilijovski, "*Seismic Assessment of Potential Sites in Macedonia*," Conference of Bulgarian Nuclear Society, Chiflica Palace Resort, 23-26 September, 2014.

[23] K. Naumoski, E. Achovska, and A. Paunoski, "*Macedonian Transmission Grid Capability and Development*," Conference of Bulgarian Nuclear Society, Chiflica Palace Resort, 23-26 September, 2014.