Innovative Approaches for Nuclear Knowledge Transition within the European Union

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Abstract. The consequences of the three major accidents in nuclear energy, and in particular that of the Chernobyl nuclear power plant in terms of their impact on nuclear energy regulation and the availability of staff for the nuclear energy are discussed in this paper. The lack of common standards for evaluation of the safe operation of nuclear power plants in the European Union (EU) has been demonstrated, as the main reason for this is the relatively large legal independence of EU Member States compared to federations of a similar scale, such as Russia and the United States. Taking into account the specificities of the EU as a union of independent states, it is proposed to evolutionary introduce common standards and criteria for the safe operation of nuclear power plants through centralized e-learning platform that provides knowledge and guidance on the basic concepts related to basics of this area. The available sources for feeding such platform with knowledge are identified among the EU funded activities, approaches to expand it to the full range of necessary knowledge are proposed. Contemporary distribution channels have been proposed to target the appropriate audiences, taking into account the interests of the youth and the convenience of well-established professionals. The benefits of the proposed approach for knowledge transfer at European level have been identified.

Keywords: common legislation, knowledge transition, nuclear safety, cyber learning.

1 Introduction

On April 26, 2019, 33 years have passed since the accident at the Chernobyl Nuclear Power Plant (NPP). The accident is rated at level 7 on the INES scale and is considered the worst in the history of nuclear power, both because of the 47 people who died as a result of the accident, as well as in economic terms, and because of the expected consequences on human health.

Along with the financial and health effects, the accident has also seriously affected the development of the nuclear industry worldwide. As a result, countries such as Italy and Austria have banned the construction of new NPPs and the operation of already built nuclear power plants, while others such as Poland and the United States have resumed their nuclear power programs in the last ten years.

Although the growth of nuclear energy has slowed down, the Chernobyl accident has given a significant boost to the improvement of reactor technologies and the development of standards for evaluation of NPP's nuclear safety. Much has been done with regard to the design of nuclear power plants and safety systems as well as emergency preparedness and response procedures. The reactors with pressurized water type WWER, PWR, AP and others who have innate safety, determined by physical laws [1], have received strong push for development and implementation. Strong support was given to research projects and knowledge management programs in the field of nuclear safety. This trend continues to this day, which is evidence that for the period 2014-2018 only the European Commission has invested more than 600 milion euros in nuclear safety and security developments [2]. From the results of these scientific research today, not only nuclear, but also radiotherapy, radio diagnostics, space research, areas related to the artificial and natural radioactivity of the substances, and a number of others have benefited. Anyway, dislike the other mega-states – USA, China and Russia, in the EU each member state follows own rules and standards for assessment of reactor components that are related to the safe operation on its NPPs [3].

At the same time, the world has realized that in a Chernobyl-sized accident, state borders are not insurance against environmental and public health impacts. The role of regulatory control in the face of the International Atomic Energy Agency (IAEA) and national regulators has become of great importance. As a result, the Convention on Nuclear Emergency Operational Notification (1986) and the Convention on Assistance in the Event of a Nuclear Accident or Radiological Emergency Situation was adopted. Several years later, the Convention on Nuclear Safety (Nuclear Safety Convention) followed by the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management and the Vienna Convention on Civil Liability for Nuclear Damage have been adopted. Later IAEA has increased the international control and has asked its 168 Member States to report any and even the smallest incidents. Each state operating nuclear reactors has to have emergency plan for action in case of nuclear or radiological accident that among other things requires enough personnel to safely mitigate the consequences of the event.

From safety point of view another important achievement on an international scale was the establishment of the World Association of Nuclear Power Plant Operators (WANO) in 1989 and a mechanism for periodic peer review of the 430 nuclear reactors in the world. Nuclear industry to no doubt is the first industry to learn the lesson that together they do the things better. Nevertheless The Chernobyl accident, together with the two other recognizable accidents, in Three Mile Island, and in Fukushima influenced the human resources development in two ways. Expectedly, there was significant decrease in the number of students that desired to study nuclear related disciplines [4, 5]. Another important impact is the severely increased conservatism that was imposed on the nuclear industry after the accidents, including by itself [6]. As a result the sector falls significantly behind the other economics areas in the use of modern technologies. It is especially clear in the ways of attracting young people to enter in the sector and moreover the ways and means of sharing the knowledge necessary to successfully work in the area of nuclear energy and its applications.

2 Necessity

The safe and sustainable use of the nuclear energy requires operating personnel that have adequate scientific and engineering capabilities. Correspondingly, the necessary regulating, engineering and technical support in all related fields (engineers, physicists, chemists, geologists, radiologists, lawyers, managers, etc.) should be available throughout the lifetime of a nuclear power plant from building to decommissioning. The European Union (EU) Member States have an excellent history in nuclear science and engineering, and thus in the safe operation of the nuclear power plants on their territory. Unfortunately, due to its relative novelty as method for base load energy production, the nuclear energy sector now suffers significantly from an increasing in the number of retirements of high qualified personnel. Additionally, due to the nowadays economic transitions and similarly to other areas that require state-of-the-art knowledge and skills in natural sciences, the nuclear sector now faces decreased number of people that initially graduate in the field of nuclear science and engineering. This is clearly visible in the all NPP operating countries across the EU. Most of the EU Member States that operate nuclear reactors are relatively small and not have the capability to manage on their selves with such problems that are of EU magnitude. Moreover, although all of these countries have educational and training programs in the fields of nuclear and radiation safety, nuclear energy, human health and isotope and radiation technology applications, the expertise is not homogenously distributed and the training outcomes are very different across the EU Member States. This is still the main obstacle in front of the Bologna process that has established [7] a Europe-wide Higher Education area to facilitate individual cross-border mobility, coordinated national quality assurance, the transparency and recognition of qualifications obtained elsewhere, and mutual recognition of duration and degrees of study courses. It is even more relevant to the Copenhagen process that had to enhance the European cooperation in Vocational Educational Training (VET) [8]. Goals include a unitary framework of qualifications and competencies, a system of VET credit transfer, common quality criteria, and improvements in citizens' access to education and training. It is obvious that training and refresher courses are essential, particularly when state-of-the-art science and technology must be implemented. Thus, access to high level education and training on the key matters has to be promoted and the availability of important knowledge and tools for its transfer should be guaranteed in order to ensure the safe operation of NPPs. Last but not least the nowadays relative independence of the EU Member States in view of regulations and standards in the nuclear sector makes it different compared to the other super-states in the world and is most probably both economical and safety issue.

3 Innovative Approaches

The shortage of qualified professionals for nuclear facilities will be one of the problems in a foreseeable future. Although this problem is not tangible yet, considering the number of students studying nuclear technology, it will be a fact in about two decades. The development of nuclear projects is unthinkable without sufficient and highly skilled professionals in the area. Training on the various disciplines related to the use of nuclear energy and nuclear applications requires a strong motivation from all stakeholders, especially from future students. In a world where the possibilities for rapid development and professional realization are virtually countless, nuclear technologies, which requiring a long and profound occupation, have serious competition in the face of areas that are developing the use of digital technologies at a faster rate. To reach prospective students we need to use their social networks, by creating appropriate content for the each one of the available digital channels.

By addressing young people with clear, brief and concrete content, we will convey to them the key messages that nuclear technology is part of high technology, offering opportunities for innovation and professional growth, and its use is safety under certain rules. The most important thing, however, is what we will offer the young people as training. In this respect, standard universities are facing serious challenges regarding teaching methods because the young generation is learning in another way. They require online access, online platforms not only during their university studies, but also to maintain and optimize their knowledge. This, in turn, gives a unique chance to unify the training objectives and training goals related to nuclear energy (Radioactive waste, Decommissioning, Safe Operation). In this way, another serious problem faced by EU countries - the necessity of common standards and criteria for the regulation framework in the nuclear field in the EU - will be addressed in an evolutionary way, which indirectly hinders the free movement of specialists within the community.

The current paper proposes the establishment of common platform for education on specific topics connected with the safe use of nuclear energy. Those may include reactor operation regimes, reactor safety analyses, structural materials properties, radiation monitoring and control, emergency planning and emergency preparedness, and other relevant selected by the nuclear professionals as important for establishment of common European standards.

There are examples [9] of such common EU platforms for education on specific matters in the nuclear area, that has arisen from the two parallel intergovernmental "soft law" processes - Bologna and Copenhagen. Moreover different Community frameworks [10] are formed within the European Union to facilitate the processes related to the peaceful use of the nuclear energy. Each one of them may serve as a model for a pan-European platform for distant training and education. Under the 7th and HORIZON 2020 Framework Programs of the European Commission the CORONA and CORONA II Projects were funded with the goal to create state-of-the-art regional training center for WWER competence [11]. The training may be provided by means of direct teaching on-site by the different training centers that form the regional one or via distance training, implemented by e-learning system that contains specially adapted e-courses. The opportunity to carry on some of the courses via the specially created platform for on-line training and education is essentially the reflection of the possibility for design of a greater platform that encompasses a greater knowledge. The content of the training modules, as well as the training needs, training objectives and training goals have been internationally agreed among the project partners, that have a proven excellence in teaching WWER technology [12]. The participation of the European Nuclear Education Network is additional guaranty for the relevancy of the selected training topics. However, the biggest parts of the topics covered may be easily applied for any kind of nowadays power reactor technology besides the WWER type. This is easily seen from the pilot trainings [13] performed in the earlier CORONA project. Additional interest for the researched matter is found in the presence in the pilot trainings of an Online Multimedia Training Course on WWER Reactor Pressure Vessel Embrittlement and Integrity Assessment [14]. This is available through the website of the Joint Research Centre of the European Commission. It may be accepted, that such tool can be easily expanded to encompass broader range of reactor technologies that include pressure vessels, like EPR, AP, [15] or to be interconnected with other such multimedia tools that deal with similar topics like other structural materials wearing out, etc.

With such fleet of digital tools and developed topics agreed between the most acknowledged European experts in each area related to the nuclear safety, it will be then possible to attract the targeted audience from across Europe to use a common source of knowledge (Figure 1) on this matter of pan-European importance.

The online learning platform has to be hosted on a European Commission server. It has to be developed on proprietary e-learning software as CLP4NET [16] in close collaboration between software developers, content providers and nuclear inspectors from the European Commission. International advisors from the IAEA, WANO, etc. have to be invited. The content should be collected and put together from the state-of-the-art results from

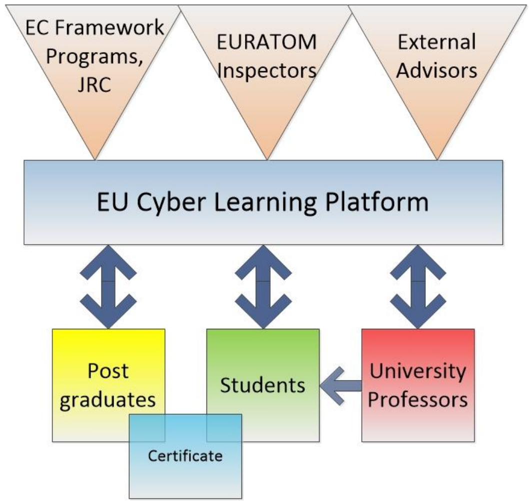

Figure 1. Stakeholders of the European Cyber Learning Platform.

EU funded projects and complemented with community agreed knowledge where necessary. It may be easily included in the European Commission Joint Research Center clearinghouse activities [17].

The platform should consists of a number of modules, each containing online lectures, presentations, demonstrative graphical content, digital tools for training like simulators of real situations. Opportunity for asking questions regarding the viewed material have to be provided in terms of for example online forum or Sli.do [18] and experts has to be engaged in answering these questions within 24 hours. Opportunity to perform test on the viewed content in order to check the competence level of the trainee will be included. A certificate for holding the European Union recommended minimum knowledge on the relevant specific area will be issued upon successful completion of the test.

The platform should be targeted to Radiation protection specialists, Reactor Physics and Thermo-hydraulics specialists, Nuclear reactor operators, Radiochemists, Students in Nuclear Engineering and Radiochemistry and others and presented in a proper manner to the targeted audience. To reach this audience the key online and offline channels have to be used (Figure 2).

Figure 2. Communication channels for audience targeting.

The appropriate online channels are at least the following:

- Publication on the Website of the European Commission
- European Commission accounts in the most popular social media – Facebook, Linked In, Instagram, Twitter, YouTube, etc. Content relevant to each media specifics should be created. Such could be short posts, shared publications, video tutorials, and so on.
- E-mail campaign through the European Commission's database toward the stakeholders

The offline key channels are at least the following:

- Press release for European Commission's statement regarding the platform and the benefits it brings to the European Union
- Press conference for presenting the platform to media specialized in the nuclear field
- Conference for demonstration of the platform to Universities, NPP Operators, Regulators and Technical Support Organizations

The platform will bring at least the following benefits to the European Union:

- Modern means of knowledge reception, including multimedia examples, simulations, platform for online discussions, most recent open access articles.
- Opportunity for Cross-border education
- Access to the most relevant expertize available within EU on each training subject
- European level recognition of the obtained knowledge
- Common European rules and standards in evaluation of the radiation and nuclear safety

4 Conclusion

The establishment of common European platform for transfer of knowledge on safe NPP operation, Radioactive waste management, Decommissioning and spent fuel management is proposed in the paper. The necessity for such platform is defined. The prerequisites are analyzed and approaches are proposed based on the existing common European tools and knowledge in the area. The platform is described and the channels to fulfill its goals as a common European knowledge source are defined. The benefits toward free movement of people within the Union and increased safety of NPP operation are justified. A long term benefit of establishment of common standards for nuclear safety evaluation in the European Union has been foreseen.

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