Lithuanian activities in the nuclear competence building

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Abstract. The Technical and scientific Support Organisations (TSOs) are gaining increased importance by providing the technical and scientific basis for decisions and activities regarding nuclear and radiation safety. In Lithuania, after declaration of independence, the technical support organisations in Lithuania grows and develops into institution, capable to perform all necessary safety analyses for Ignalina NPP. However, the preparation for the construction of new nuclear power plant showed that Lithuania lacks the nuclear energy specialists. To solve this task, following the National Energy Strategy and Nuclear Power Law of the Republic of Lithuania, the "National Plan for preparation of specialists in the nuclear energy field" was developed. According this plan, several measures (establishing of new study programs, modernization of educational and scientific laboratories, creation of preconditions for nuclear education training and retraining, skills improvement, preservation of knowledge and competence) are planned. It is very difficult to develop necessary nuclear research infrastructure and to gain the competence in the small country with limited recourses. Thus the Lithuania, Latvia, Estonia, Poland and Sweden trying to join the "forces" and work together. The information about the creation and growing up of Lithuanian TSOs and initiatives for building of nuclear competence in Lithuania is presented in this paper.

1. Introduction

Ignalina NPP is the only nuclear power plant in Lithuania consisting of two units, commissioned in 1983 and 1987. Both units are equipped with channel-type graphite-moderated boiling water reactors RBMK-1500. Since 1984 Ignalina NPP produced up to 82% of electric energy for Lithuania. In 1993 INPP produced record amount of electricity – 12.26 billion kWh or 88.1 percent of electricity necessary for the state. This figure was recorded in the Guinness Book of Records as the largest contribution to the common electricity production in the world's nuclear history. During the 26 years of operation Ignalina NPP has produced 307,9 billion kWh of electricity: Unit 1 – 136.9 billion kWh and Unit 2 – 170.2 billion kWh. The total amount of electricity sold is 279.8 billion kWh. Unit 1 of Ignalina NPP was shutdown for decommissioning at the end of 2004 and Unit 2 – at the end of 2009.

After 1990 Lithuania declared its independence, Ignalina NPP with two largest in the world RBMK-1500 reactors came under authority of the Lithuania Republic. The primary national institution, responsible for the regulation of nuclear energy, VATESI was established by Government resolution in October 1991. VATESI approves nuclear safety rules and guides, issues licences for the activities related to nuclear safety and controls adherence to the requirements set out in licences and safety rules. At the same time the creation of Lithuanian Technical and scientific Support Organisations (TSOs) starts. In March 1992 at the Lithuanian Energy Institute in Kaunas the Ignalina Safety Analysis Group (ISAG) was established. The goals of ISAG were to gain a thorough understanding of the basic processes of RBMK-1500 reactors; to gather and analyze design and operational data; to record and rank safety issues at

Ignalina; to analyze the consequences of simulated accidents at the plant; and to provide professional technical and scientific consultation to the VATESI, the government and the international community. Later this group overgrows into Laboratory of Nuclear Installation Safety.

The Lithuanian Energy Institute (LEI, established in 1956) is a technical research centre dealing with energy related research in analysis of security of energy supply, development of energy planning methods, fuel cells and hydrogen, renewable energy, thermal physics and fluid mechanics, nuclear safety, structural integrity assessment of components and structures, simulation of complex energy systems. Few laboratories, including the mentioned Laboratory of Nuclear Installation Safety, are dealing with the nuclear safety and nuclear energy research. The main research areas, related to the nuclear energy are: numerical simulations of thermal-hydraulic processes during design, beyond design and severe accidents in nuclear reactors, spent fuel pools, containments and experimental facilities; simulation of aerosols and Fission Products transport in the compartments of NPP; assessment of reactor core modifications and analysis of postulated reactivity accidents; structural analysis of NPP buildings, components and piping. Also the specialists of Laboratory of Nuclear Installation Safety are performing Level 1 and Level 2 Probabilistic Safety Assessment of NPP and sensitivity and uncertainty analysis of modelling parameters and results. In this paper, only the activities in the area of nuclear safety and nuclear energy research are taken into account. The specialists, working in these areas, are assumed as the TSO from LEI.

The other organizations also took income into creation of TSOs - Kaunas University of Technology (KTU), Vytautas Magnus University (VMU), Faculty of Physics of Vilnius University (VU) and the Institute of Physics (IP). In these institutions (in separate departments) also the groups of specialists were established, which are performing the functions of TSO.

2. Activities of Lithuanian TSOs during Ignalina NPP operation in 1994 – 2009

In 1994 Lithuania signed the agreement with the European Bank for Reconstruction and Development (EBRD) Account of Nuclear Safety. According this Account, in 1995 – 1996 was prepared In-depth Ignalina NPP Unit 1 Safety Analysis Report, using USA and Western Europe methodology and computer codes. This study has been performed by specialists from the Ignalina NPP, Russia (RDIPE), Canada and Sweden. The created group of Lithuanian TSO (ISAG) has been participated in preparation of independent Review of the Ignalina NPP Safety Analysis Report. This Review was performed in 1995–1997, together by the experts from USA, Great Britain, France, Germany, Italy and Russia. Such first very significant international project was the good school for the young Lithuanian TSO.

Based on the findings, developed in the Ignalina Nuclear Power Plant Safety Analysis Report and independent Review, the few significant modifications were recommended: the new algorithms for reactor shutdown and activation of emergency core cooling system in the case of low flow through group of fuel channels and on pressure decrease rate in drum separators; modification of reactor shutdown system and others. The first modifications protected the reactor from flow stagnation and overheating of fuel in the group of fuel channels. Safety justifications of these modifications have been performed in Lithuanian Energy Institute (LEI). The modifications of activation algorithms for reactor shutdown and emergency core cooling systems activation were installed in power plant unit 1 in 1999, and unit 2 – 2000 m. The second modification (modification of reactor shutdown system) was necessary, because in the case of failure of reactor shutdown function the consequences can be dramatic enough.

Therefore the priority recommendation has been formulated: to implement the second, based on other principles of operation, diverse shutdown system for reactors of Ignalina NPP. However development, designing and implementation of such system needed few years, so at first the compensating mean (named „Additional emergency protection“), has been implemented. For this system, which was used in transition period while second diverse shutdown system was developed, LEI selected the set points for activation and performed the safety justification. The additional emergency protection was installed in Unit 1 in 1999, in Unit 2 – in 2000. The Second Diverse Shutdown System (DSS) has been designed and installed in Ignalina NPP Unit 2 in 2004. In the first unit of Ignalina NPP this system has not been installed because reactor has been shutdown in 2004. Specialists from LEI together with experts from the countries of the Western Europe checked and have assessed the design documentation, carried out independent calculations, thus helping Lithuanian regulatory body (VATESI) to make the appropriating decisions concerning implementation of mentioned system at Ignalina NPP.

On 2002 the safety analysis report for Ignalina NPP Unit 2 has been developed. This report contains the description of systems, list of postulated accidents, engineering assessment of reactor cooling system, accident analysis, assessment of fuel channels structural integrity, assessment of reactor safety acceptability and other chapters. The accident analysis in this report, was performed using best-estimate approach with uncertainty and sensitivity analysis. The safety analysis report and its review were the main documents, required for license for Ignalina NPP Unit 2. LEI performed the accident analysis part, including the external events (earthquake, strong wind, aircraft crash, flooding, external fire and etc.) analysis, see FIG. 1. The other Lithuanian TSOs (KTU, IP) performed the independent review of such report.

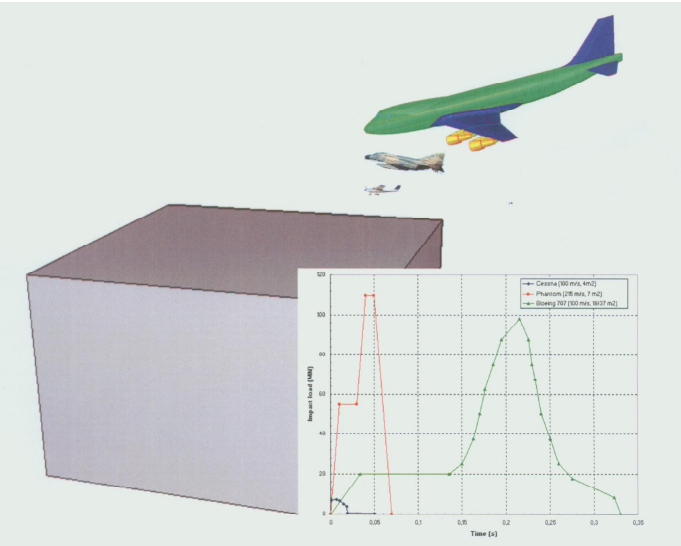

FIG. 1 Analysis of Aircraft Crash: Loads on the buildings due to crash of different aircrafts

In parallel to deterministic analyses Lithuanian TSOs performed the Probabilistic Safety Assessment (PSA). The Ignalina NPP first level PSA “BARSELINA” project was initiated in 1991. It was first PSA for nuclear power plants with RBMK type reactors. From the beginning this project was carried out by nuclear energy experts from Lithuanian, Russian and Swedish institutions, and since 1995 it was carried out by efforts of experts from Lithuania (Ignalina NPP, LEI) and Sweden. The performed PSA 1 level analysis has shown that in Ignalina NPP probability of core damage is about $6 \cdot 10^{-6}$. Thus, Ignalina NPP fulfilled the requirements for new NPPs, which are in process of construction.

The performed by LEI and Ignalina NPP specialists PSA studies demonstrated, that the risk of core damage most of all increases transients with loss of long-term core cooling. It is the positive fact meaning that up to consequences of severe accidents there is enough time. Based on these findings, the procedures and means on severe accident management were developed by international team from England, United States of America and Lithuania. LEI bring the significant contribution in development of Severe Accident Management Guidelines for the Unit 2 of Ignalina NPP. These guidelines were implemented two years before final shutdown of plant. The works do not stop even on forthcoming final shutdown of the plant – just before the shutdown, the Severe Accident Management Guidelines were harmonised with the Symptom-Oriented Emergency Operating Procedures at Ignalina NPP. This work, performed by LEI, allowed to provide safe elimination of accident consequences in all range of accidents.

As it was already mentioned, after Lithuania declared its independence, the technical support organisations in Lithuania grows and develops into institution, capable to perform all necessary safety analyses for Ignalina NPP. The Lithuanian TSOs provided the supports to the Lithuanian State nuclear power safety inspectorate (VATESI) in the form of consultations, design, research, expertise and other works requiring high scientific-technical qualification, competence, special knowledge and skills.

3. Lithuanian TSOs activities after the shutdown of Ignalina NPP

The closure of Ignalina NPP in Lithuania at the end of 2009 brought to an end the previous nuclear energy generation period of Lithuania. After being a net exporter of electricity for more than two decades, from the beginning of 2010 Lithuania changed its status overnight to that of importer. The closure of Ignalina NPP also had significant impact on the balance of energy distribution in remaining Baltic States (Latvia and Estonia). The Lithuanian energy system after closure of Ignalina NPP is dependent on Russia, because Lithuania energy sources, supply of gas and power, are tied to that country. At the same time in the Poland the situation in the energy market (due to constantly rising demand) changed also – the country assumed that nuclear power might be included in the energy mix. Just before the closure of the Ignalina NPP, the deterioration of energy situation was expected. The prime Ministers of Lithuania, Latvia and Estonia signed Communique regarding cooperation in construction of the new NPP in Lithuania in February 2006. A decree endorsed by Lithuanian Parliament in June, 2007 about construction of a new NPP in Lithuania in cooperation with Latvia, Estonia and Poland.

In relation with plans to construct new NPP in Baltic region, the task of competence building in the nuclear safety field arose for the nuclear safety institutions. Education and training of nuclear energy engineers in Lithuania is split among institutions with a longstanding experience in complementary fields. Academic education is provided by the Kaunas University of Technology and the Lithuanian Energy Institute, specialized in nuclear facilities and evaluation of NPP safety. The Faculty of Physics of Vilnius University specialized in physics. In the Centre for Physical Sciences and Technology (former Institute of Physics) the nuclear fuel physics and radiation protection are taught. When the Ignalina NPP was in operation, the training of operating personnel was implemented at the Ignalina NPP Training centre, using a full-scale simulator. The KTU and LEI are oriented to engineering, VU and the Centre for Physical Sciences and Technology (CPST) – to education of the physicists. At present KTU is offering nuclear power bachelor (BSc) and masters (MSc) studies. Annually 5 – 10 BSc and 2 – 5 MSc degree nuclear energy specialists are educated in the KTU (in the Department of Thermal and Nuclear Energy). KTU also educates annually 20 BSc and 10 MSc degree nuclear

energy specialists in physics according to the "Applied Physics" programme. In 2008 a four-year bachelor study programme “Nuclear Physics” was launched in VU.

However, such educational program is not enough - the preparation for the construction of new nuclear power plant showed that Lithuania lacks the nuclear energy specialists, and other energy-related professions. During the development of the new nuclear power plant projects in the Baltic region, the need for qualified personnel will only increase. According the Lithuanian National Plan for preparation of specialists in the nuclear energy field, during the licensing and construction of new NPP at least 100 nuclear energy specialists of different fields will be required. Later, during the operation of new NPP, approximately 300 specialists will be required, and in addition about 60 specialists will be needed for the governmental, educational and scientific research institutions.

To meet these needs, following the National Energy Strategy and Nuclear Power Law of the Republic of Lithuania, the “National Plan for preparation of specialists in the nuclear energy field” was developed and approved by Minister of Education Science and Minister of Energy of the Republic of Lithuania. In order to implement the objectives of National Plan for preparation of specialists in the nuclear energy field, several measures (establishing of new study programs, the modernization of educational and scientific laboratories in KTU, VU, CPST and LEI, creation of preconditions for Nuclear Education training, retraining, skills improvement, preservation of knowledge and competence) are planned.

LEI and KTU have united doctorate in area of technological sciences “Energetics and Power Engineering”. The specialists of KTU and LEI together participated in process of study. KTU doctoral graduates performed their internships in the Lithuanian Energy Institute. Students have the possibility to use the LEI experimental facilities, hardware and software. The examples of doctoral dissertations in nuclear energy and nuclear safety areas, defended in LEI are presented below:

- Egidijus Babilas “Analysis of Hydrogen Distribution in Containments of Nuclear Power Plants” (2008);
- Ernestas Narkūnas “Investigations of the Change of Nuclides’ Content in the RBMK-1500 Reactor Structural Components” (2009);
- Ausra Marao “Simulation of Processes in Fuel Rods of RBMK Type Reactors” (2010);
- Raimondas Kilda “Analysis of Radionuclide Migration from Near-Surface Repositories for Radioactive Waste” (2010);
- Asta Narkuniene “The Investigation of Radionuclide Release from the Hypothetical Repository for RBMK Spent Nuclear Fuel Disposal” (2011);
- Audrius Šimonis “Investigation of Personnel Exposure During Dismantling of Nuclear Facilities” (2011);
- Aurimas Kontautas “The Numerical Study of Aerosol and Radionuclide Transport in the Containments of Nuclear Power Plants (2013);
- Darius Justinavičius “Investigation of Gas Migration in a Geological Repository (2014).

In the last years the Lithuanian nuclear regulator VATESI continue cooperation with the Center for Physical Sciences and Technology, LEI, KTU, Vilnius Gediminas Technical University; the State Institute of Information Technologies, UAB ITECHA, Research Centre

of Electromagnetic Compatibility and other organisations. The main performed works are in the areas of preparation of working design for decontamination and dismantling of equipment of Ignalina NPP, assessment of environmental impact and safety of interim storage facilities for spent nuclear fuel under construction and radioactive waste processing and storage facilities as well as the Landfill type repository for low and very low activity radioactive waste.

The main current goals of Lithuanian TSOs at the moment, waiting for the Lithuanian Government's final decision regarding building of new NPP, are the preservation of knowledge and competence and creation of new necessary nuclear competence. The last goal is very important, because during the Ignalina NPP operation the high level of competence was achieved regarding safety of channel type boiling water reactors. Now the Lithuania is choosing between the latest state of the art nuclear technologies. Thus the adequate competence should be achieved. One of the way to reach this is the participation of Lithuanian TSOs in the international projects.

FIG. 2 Discussion regarding testing of special equipment for the spent fuel transportation at LEI experimental setup with VATESI experts

Lithuanian TSOs (especially experts from LEI) actively participated in the different project of EU Framework Programme for Research and Innovation FP6 – FP7 and are preparing to participate in the Horizon 2020. Unfortunately, the experience of Lithuanian activities in the nuclear competence building, demonstrated, that it is very difficult to develop necessary nuclear research infrastructure and to gain the competence in the country with limited recourses, without significant support from the "more experienced" countries. The only way for the "new" EU states to compete / cooperate on equal basis with "old" EU members is to join forces and work together. One of the last initiative of Lithuanian TSOs is the cooperation with the scientific institutions and industrial partners in Latvia, Estonia, Poland and Sweden to form a Baltic Region Initiative for the Long Lasting InnovAtive Nuclear Technologies (BRILLIANT). This foreseen cooperation would help with finding of optimal regional solution to create cooperation platform for modern electrical power solutions and give better synergies with on-going and future EU research and innovation projects in particular those offering access to research infrastructures in conjunction with education and training.

4. Conclusions

- After Lithuania declared its independence, the technical support organisations in Lithuania grows and develops into institution, capable to perform all necessary safety analyses for Ignalina NPP.
- The preparation for the construction of new (Visaginas) NPP showed that the available at the moment educational programs are not sufficient to develop the sustainable infrastructure for the nuclear technical and scientific support. The nuclear energy and nuclear safety related knowledge and competence is an issue of high importance for planning, construction, operation and decommissioning of nuclear installations in the Baltic region.
- The experience of Lithuanian activities in the nuclear competence building, demonstrated, that it is very difficult to develop necessary nuclear research infrastructure and to gain the competence in the small country with limited recourses. Thus, the Lithuanian TSOs are trying to join forces and work together with the scientific institutions and industrial partners in Latvia, Estonia, Poland and Sweden.