International academic program in technologies of light-water nuclear reactors. Phases of development and implementation

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Abstract. The results of implementation of European educational projects CORONA and CORONA II dedicated to preserving and further developing nuclear knowledge and competencies in the area of technologies of light-water nuclear reactors are analyzed. Present article addresses issues of design and implementation of the program for specialized training in the branch of technologies of light-water nuclear reactors. The systematic approach has been used to construct the program for students of nuclear specialties, which corresponding to IAEA standards and commonly accepted nuclear principles recognized in the European Union. Possibilities of further development of the international cooperation between countries and educational institutions are analyzed. Special attention is paid to e-learning/distance training, nuclear knowledge preservation and interaction with European Nuclear Education Network.

1. Introduction
One of the basic strategic initiatives advanced by National Research Nuclear University Moscow Engineering Physics Institute (NRNU MEPhI) consists in forming a system of the academic programs and teaching appliances to train high-quality, internationally recognized specialists in nuclear area. Within the frames of this strategic initiative, NRNU MEPhI has participated during the past four years in the European projects CORONA and CORONA-II related with creation and development of the European Centers of Competence on technologies of VVER-type nuclear power reactors.

Technology of VVER-type light-water power reactors has been worked out in the 1950-60s by the USSR specialists. Now, the VVER technology continues upgrading and serves as a basis for many nuclear power plants currently in operation in several European countries [1]. Some innovative projects of VVER-type reactors are currently under implementation in Finland, Hungary, Czech Republic, Turkey, Vietnam, China and India [2]. Multi-year reliable and safe operation of VVER-type reactors has given a foundation to regard the VVER-technology as one of main directions towards further development of nuclear energy systems in European states and in some other countries. Therefore, creation of the European Centers of Competence and their activity in training and qualification upgrading of the specialists involved in operation of VVER-type reactors became an actual task for many countries.

Besides the Russian Federation, the following European countries have participated early and are participating now in the CORONA and CORONA-II Projects because they already apply or interested in future application of the VVER-technology:
• Bulgaria: Kozloduy NPP, Institute for Nuclear Research and Nuclear Energy (INRNE), Risk Engineering Ltd.
2. The CORONA project (2012-2014)
The CORONA and CORONA-II Projects foresee a wide envelopment of many educational and scientific problems related with the VVER-technologies. The works on creating the European Center of Competency were carried out in several large directions. These directions were presented in the form of the Work Packages (WP). Experts from several countries, members of the CORONA Project, participated in performing the Work Packages. For example, within the WP1 frames the works were carried out to define the demands for training of various target groups and the requirements to professional competencies of the specialists graduated from the educational programs. The work packages WP2 (the leading organization - ESIS GmbH, Germany) and WP3 (the leading organization - INRNE, Bulgaria) were related with developing the academic programs and teaching appliances for two target groups, namely for nuclear specialists directly involved into NPP operation and for non-nuclear specialists (sub-contractors, for instance). The work package WP5 was devoted to studying the human factor effects on safe operation of VVER-type reactors and the problems of nuclear security culture. The Consortium Tecnatom (Spain) is the leading organization of this direction, responsible for creation of appropriate training module and further realization of the works under the WP5.

3. The academic program “VVER-technologies for the students of nuclear specialties”
NRNU MEPhI is the leading organization in realization of the work package 4 (WP4) which is related with development and implementation of the academic program in VVER-technology for the students of nuclear specialties (“nuclear” students).

From the very beginning, creation of the academic program in VVER-technology for the “nuclear” students has been based upon the widely used systematic approach to the educational process.

That is why the first phase in developing the academic program in VVER-technology for the “nuclear” students was devoted to analysis of the demands for training (including identification of potential target groups of the “nuclear” students) and exact definition of the educational aims. The educational aims were briefly expressed in the form of competencies acquired by the specialists graduated from the program. Under the CORONA Project the academic program was created for two main target groups, namely for the students of nuclear and non-nuclear specialties. The present paper is limited by consideration of the first target group, i.e. of the “nuclear” students only.

The “nuclear” student group included two target sub-groups: the energy sub-group (“VVER-technology”) and non-energy sub-group (“Technical aspects of NPP with VVER-type reactors”). For both sub-groups the requirements were prepared to the program entrants. In general, preliminary qualification of the program entrants was defined at the level of the Bachelor degree (or above the level of the Bachelor degree) in nuclear specialties. Correspondingly, the sets of the competencies acquired by the specialists graduated from the academic program were formulated for both target sub-groups.

This formulation of the competencies for the graduates from the academic program for the “nuclear” students was essentially a focal point in implementing the systematic educational approach. Just a list of the competencies defines, in the end, full spectrum of knowledge acquired by the graduates, namely what they must be able to do, what methods and equipment units for research, development and designing they must be able to apply. In this connection, it was very important to define the contributions from each training course and from each educational module of the academic
program to forming full spectrum of the graduate’s competencies. These contributions to the competencies formed during the course or the module delivery can demonstrate significance of the courses and modules for accomplishing a final aim of the educational process under the academic program.

The competency models of the graduates, the educational programs and associated methodological materials were created with application of the experiences gained by NRNU MEPhI in implementing the BS Graduate Programs and the MS Graduate Programs in nuclear physics and technologies. These experiences allowed us, in a lot of aspects, to use professional competencies of the specialists graduated from the BS and MS Graduate Programs which were worked out in tight cooperation and concurred with Russian nuclear employers for many years of joint activity. Of course, the works on formulation of professional competencies for the specialists graduated from the academic program “VVER-technologies for the students of nuclear specialties” were carried out in tight collaboration with other partners of the CORONA Project.

In accordance with the systematic approach to the educational process, the next phase consisted in forming the educational modules, the program as a whole and the curricula for both target sub-groups, namely for the sub-group “VVER-technology” and for the sub-group “Technical aspects of NPP with VVER-type reactors”.

At this phase a modular principle was adopted as a basic methodology for creating the program. Each educational module consisted of a series of the training courses intended to form a certain type of professional competencies including production and technological competencies; research, development and designing competencies; organizational and managerial competencies; expert competencies, for each target sub-group. The modular structure of the academic program has allowed us without any serious difficulties to embody the systematic approach mentioned above because the flexible modular structure is able to satisfy completely all the industrial demands for the graduates with various nuclear specialties and with various professional competencies.

An important final phase in creating the academic program was the establishment of the compliance between the educational results and the problems to be solved by the graduates in their future professional activity. A fund of the evaluating means could be used to control and assess the professional competencies acquired by the program’s trainees. Development of such a fund was the final phase in creating the academic program “VVER-technologies for the students of nuclear specialties”. Assessment of the professional competencies acquired by the students of both target sub-groups (“VVER-technology” and “Technical aspects of NPP with VVER-type reactors”) has demonstrated that the competencies in VVER-technology were in full compliance with the 3-6 levels of the European Qualification Framework [3] depending on the graduate’s specialization.

4. Pilot implementation of the program “VVER-technologies for the students of nuclear specialties”. Analysis of its effectiveness

This phase in realization of the academic program includes the pilot implementation of the educational module devoted to nuclear and radiation safety of VVER-type reactors.

Topical actuality of the educational module “Safety-related aspects of VVER-technologies” aroused a keen interest from the side of potential trainees and instructors of the training course. The number of applications from different countries on participation in the training courses exceeded our capabilities. The entrants who passed selection successfully included the students from Sevastopol National Technical University, Odessa University, Belarus State University, Al-Farabi Kazakh National University, Nizhny Novgorod State Technical University, National Research Nuclear University MEPhI and so on.

The module’s curriculum has been compiled by such a way that, in addition to brief overview of the fundamental principles related with physics and safety of light-water reactors, significant attention was given to some practical aspects of safety ensuring at NPP with power reactors of VVER-1000 type. The lessons on the multi-functional simulator of VVER-1000 [4] at NRNU MEPhI have allowed
the students to feel the real difficulties in safe operation of VVER-1000 and potential consequences from their erroneous actions and deviations from nominal regime of the reactor operation.

The next phase consisted in assessing the results obtained in the pilot education and included the following three significant components:

- Quality assessment of learning the educational materials by the students with application of tests and control tasks from the fund of the evaluating means that was previously worked out.
- Expert assessment of the educational module by the invited specialists from the Open Joint-Stock Company “Concern ROSENERGOATOM”, the National Research Center Kurchatov Institute, Institute of Physics and Power Engineering, Rostechnadzor, Bulgarian NPP “Kozloduy” and Bulgarian Institute for Nuclear Research and Nuclear Energy (Sofia).
- General evaluation and comments on quality of the submitted methodological materials by the students.

When the certificates on successful completion of the educational module, official representative of the Open Joint-Stock Company “Concern ROSENERGOATOM” has marked large quantity of correct answers to the tests and, as a consequence, high level of learning the educational materials. This opinion was supported by other experts.

As it was noted in the student comments, the lessons and practical exercises conducted in the pilot delivery of the educational module have given additional pulse to them and called interest from the standpoint of their future participation in the studies related with safe operation of NPP with VVER-type reactors.

5. The CORONA-II project (2015-2018)

Further development of the European Centers of Competency in VVER-technology foresees creating the International Association of the educational institutions in the area of VVER technologies, so called VVER Academy. The VVER Academy must become not only an organizational basis for rendering the educational services but also the VVER Academy can make it possible to involve many other countries (outside of the European Union, for instance) which are interested in the use of power VVER-type reactors and associated nuclear technologies. Tight collaboration with and further connection of the CORONA Consortium up to the European Nuclear Education Network (ENEN) can play here a significant role. Such an association could form a common approach to the European certificate for Master of Science degree in nuclear engineering. The common approach should be based on the following four main requirements:

- Development of common qualification criteria in the area of nuclear engineering.
- Creation of common system for mutual recognition of the European MS certificates.
- Promotion for more mobility of the professorial staff and trainees throughout the European Union.
- Promotion of more tight collaboration with and feedbacks from nuclear employers.

The European Nuclear Education Network, within the frames of the EUROATOM – ROSATOM agreement, implements already several projects with Russian organizations for developing the joint educational programs under the conditions on mutual recognition of the acquired qualifications and credits.

The integration of the CORONA Consortium with the European Nuclear Education Network could promote the wider implementation of the educational programs in VVER technology to the EU countries and outside. The CORONA-II Project foresees developing a structural scheme of the VVER Academy and mechanisms for the CORONA-ENEN cooperation. It is presumed that intense activity of the VVER Academy and ENEN work teams will form a foundation for further well-planned and fruitful functioning of the interacting bodies.

One of main directions towards further perfection of the academic program “VVER-technologies for the students of nuclear specialties” consists in performing the approbation (pilot implementation) of the program for different target groups. Application of the remote education techniques can offer the larger prospects for the wider dissemination and use of the program in practical training activities.
As is planned, the nearest task of the VVER Academy included the works on final development and pilot implementation of the academic program with application of electronic and remote educational forms under the work package WP5 of the CORONA-II Project. This task was entrusted to National Research Nuclear University MEPhI, as the leading organization of the work package WP5, and to its partners in the Project.

The pilot implementation of the academic program with application of electronic or remote educational forms is complicated by needs to resolve some methodological, organizational and technical problems. Amongst them, the demands for technical educational appliances should be mentioned in the first turn.

In the CORONA-II Project the Cyber Learning Platform for Nuclear Education and Training (CLP4NET) [5] was selected as a main instrument for conduction of remote (distant) lessons. The CLP4NET platform is currently and successfully used to solve some problems of the University.

In addition to the implementation of technical appliances for remote education, the work package WP5 foresees forming a library of the educational modules and their pilot application for electronic or remote education of foreign students. Here, like previously, National Research Nuclear University MEPhI is the leading institution responsible for creating the educational module in tight collaboration with foreign partners. The educational module for “nuclear” professionals is under joint development now with the Engineering Support Company (Germany), for “non-nuclear” professionals – with experts from Institute for Nuclear Research and Nuclear Energy (Bulgaria).

It should be noted that, under the previous CORONA Project, each educational module has passed a detailed analysis performed by all participants of the Project. Such a multilateral analysis gave an objective estimate to the modules in the term of their efficiency or helped to elaborate some concrete corrective measures. It is planned to use a corporative approach for analysis and estimation of the education quality for the modules with remote educational forms.

One else significant factor for successful mission of the academic program “VVER-technologies for the students of nuclear specialties” consists in wide disseminating the best practices developed under the Project. The specialized informative portal of the CORONA and CORONA-II Projects can serve as a quite suitable instrument for the best practice dissemination. In this connection the work package WP5 stands before National Research Nuclear University MEPhI the task on rendering support and future advancement of the Project’s informative portal http://vverportal.com [6].

Performance of this task includes the following steps:

- Integration of the CLP4NET platform and the informative portal http://vverportal.com.
- Informational support to the portal.
- Extension of the portal’s functional capabilities and provision of its reliable operation.

Currently, partners of National Research Nuclear University MEPhI from Czech Republic, Hungary, Germany and Bulgaria are rendering assistance in further development of the Project’s informative portal.

**References**

[1] Nuclear power in the European Union, section: EU nuclear generation capacity 2016, mhttp://www.world-nuclear.org/information-library/country-profiles/others/european-union.aspx accessed: 03.11.2016

[2] Ershov G A The Project NPP-2006 – Technology and Philosophy of Safety 2015, http://nuklearis.hu/sites/default/files/docs/Jersov_MNT_2015september10.pdf accessed: 02.11.2016.

[3] Descriptors defining levels in the European qualifications Framework, https://ec.europa.eu/ptyeus/content/descriptors-page 2016 accessed: 02.11.2016.

[4] Chernov E Utilization of WWER-1000 Reactor Department Multi-Functional Analyzer (MFA-RD) as Advanced Educational Tool 2014, https://www.iaea.org/NuclearPower/Downloadable/Meetings/2014/2014-05-19-05-22-TMNPTD/Session1/Chernov_MEPhI_Simulator_Part_2.pdf accessed: 03.11.2016.
[5] Sbaffoni M CLP4NET Introduction to a cyber-learning platform for nuclear education and training, https://www.iaea.org/NuclearPower/Downloadable/Meetings/2012/2012-01-TM-WS-Vienna/Day-2/11.IntroductiontoCyberLearningPlatform-MSbaffoni.pdf accessed: 03.11.2016.

[6] Dedicated training on VVER technology, http://vverportal.com accessed: 03.11.2016.