Experience of projects aimed at attraction and development of young experts in the international scientific and technological programs

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Abstract. The report reviews international organizations practices related to attraction of students and young researchers as trainees and participants of contests for implementation of large projects such as Mega-Science. Organizational frameworks are presented, which are used for these purposes in The Nuclear Energy Agency (NEA), the International Atomic Energy Agency (IAEA), European Nuclear Education Network (ENEN), European Nuclear Research Center (Conseil européen pour la recherche nucléaire (CERN)), The Generation IV International Forum (GIF), et. The role of international organizations in formation of scientific personnel with the great potential in arrangement of the international scientific cooperation has been determined. The classification of measures aimed at identification and development of scientific personnel was proposed: from studying at the university till working in the international organization.

1. Introduction
Issues related to HR training are urgent for all scientific organizations and high-tech production associations. Unfortunately, Russian practice of sending young trainees to work in the world centers of science and technologies, including taking part in Mega-Science projects, is based on negative tendencies of last 20 years, when the significant outflow of talented youth was observed to work beyond the borders of the Russian Federation. At the same time, the analysis of the HR policy experience and project practice of international organizations involved in scientific studies show high efficacy of cross-state and cross-project exchange of specialists of any level. Implementation of this very practice and target orientation of specialists training for international organizations and projects may help State Corporate Rosatom and its support universities to use the world nuclear infrastructure efficiently and to form own scientific elite. Application of this practice will make it possible to make up similar programs for our partner states, very interested in the increase of the educational and management levels for their citizens to take part in the inter-state scientific and technical exchange.

2. HR Projects of International Organizations
2.1. Nuclear Energy Agency (NEA)
In 2016 in the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (NEA/OECD), the concept of the Nuclear Education, Skills and Technology (NEST) Framework Project was formulated [1]. The project was aimed at formation of research competencies of European students of nuclear disciplines by means of application of the existing infrastructure of...
European Nuclear Centers. NEST Project was developed based on the analysis of the current situation in European Nuclear Education and formulation of the problem, which implies the real risk of losing experts knowing nuclear technologies and having critical nuclear knowledge, as well as non-formalized knowledge in the sphere of application of these technologies in practice. At this moment, certain countries even with developed nuclear technologies demonstrate a communications gap between the power and scientists, between scientists and business as well as between generations inside nuclear communities.

NEA/OECD documents contain a concern of isolation of the European Nuclear Education from the nuclear infrastructure. It is difficult to obtain skills and practical knowledge in the university if there is no contact with professionals and real technologies. It is difficult to arrange laboratories with nuclear technologies at a separate university, since their exploitation requires maintaining specialized personnel, licenses and special equipment.

NEST Project suggests using simple methods of arrangement of taking by young researchers of internships at European Nuclear Centers. These internships must be undertaken under the control of experienced supervisors and serve as an important stage of training specialists for the nuclear power industry. An important aspect of this project is the task of formation of the network of nuclear leaders, who will become the basis of the international nuclear community in the future.

One more program aimed at young scientists support implemented at NEA, is the program of interns support, who are forwarded to NEA to undertake an internship for the time period of three to six months. In 2017-2018, three post-graduates of NRNU MEPhI took part in this program.

2.2. IAEA

The International Atomic Energy Agency (IAEA) has a number of programs aimed at youth support and its involvement in the nuclear power industry. At IAEA, programs for cooperation in the sphere of nuclear energy use both for experienced nuclear power experts, and young specialists. The technical cooperation program is the mechanism of nuclear technologies promotion in IAEA partner-states (members) [2, 3]. The technical cooperation program includes various mechanisms: capacity building, partnership-building, knowledge-sharing, support for networking. Various events are held to implement the mechanisms listed: technical visits, seminars, training courses, material expertise, etc.

Young specialists of nuclear power industry from various countries take part in the events.

For specific HEI’s students and young specialists, dedicated projects have been elaborated: internship [4] and the Junior Professional Officer (JPO) Program [5]. The internship program is dedicated for students from specific HEI at the age of 20-25 years old for the time period up to one year. To take part in the contest, a candidate must be a student of the specific HEI (at least year 4) or HEI graduate, who completed study less than one year ago. The participation procedure has been simplified - the candidate shall provide two reference letters and a motivation letter. The objective of the IAEA internship program is to provide students or recent graduates with an opportunity to obtain experience of practical work based on their studies or interests. At the same time this is to the benefit of IAEA and helps to obtain assistance by competent students specialized in various professional areas. According to the statistics, most participants of the program remain in the nuclear industry and many of them return to their states to develop national nuclear programs and technologies.

To be qualified to take part in the JPO program, a young person must not be older than 32 and must have at least two years of experience in the industry. He/she should also receive nomination from his/her country. JPO participant obtains a unique opportunity to work in the international team, which carries out scientific, technical or administrative activity.

2.3. European Nuclear Education Network (ENEN)

European Nuclear Education Network ENEN was founded in 2003 and by now has combined over 50 universities from 20 European countries, where nuclear specialists are being trained and European nuclear companies are located. It has been the member of NRNU MEPhI since 2009. The full participants list can be found at ENEN website [6]. At ENEN various projects aimed at interaction
among specific universities and nuclear organizations are under way. One of the most successful projects is assignment of European Master of Science in Nuclear Engineering (EMSNE), issued under the annual General IAEA Conference events. In 2017, EMSNE certificates were issued to 19 young people [7], who obtained their master’s degrees at the universities being members of ENEN, and continued their career in the nuclear industry.

EMSNE certificates serve as a serious motivation driver of many industrial companies in Europe. Owners of this certificate obtain the opportunity of fast career development. In order to obtain the certificate, it is necessary to: study at the university at least 5 years under the bachelor’s and the master’s degree programs; obtain at least 60 credits in the course of the nuclear discipline studying (nuclear reactors physics, thermohydraulics of nuclear facilities, nuclear fuel cycle, nuclear reactor materials, nuclear facility safety, radioecology, radiation protection, etc.); obtain additionally at least 20 credits at the university, being a member of ENEN from another country, and write a master’s degree dissertation dedicated to the nuclear discipline and obtain the job at the nuclear institution.

Special attention should be given to that the requirement to obtain 20 credits in another country implies a high degree of international mobility in formation of competencies of a nuclear specialist at the opinion of the European nuclear community.

2.4. CERN

European Nuclear Research Organization (CERN) is the most famous and largest inter-governmental organization comprising 22 countries. In addition to the scientific activity, CERN aims at teaching the new generation of scientists and engineers and education of all population layers regarding modern physics issues. The group’s materials on education and communications contain main informational channels of communication to various audiences [8]. CERN has developed various programs for various partner categories: school pupils, teachers, students, reporters, sponsors, regulating authorities officers, potential employees, etc. These programs are often stated as an example of successful practices of attraction of employees and promotion of scientific achievements.

Programs aimed at involvement of pupils, students and young scientists implemented by NRNU MEPhI together with Rosatom SC, often use practices elaborated by CERN. At CERN summer camps and schools, internships, international master classes are arranged. Every summer, around 300 students of the bachelor’s program take part in the internship program (8-13 weeks). Several hundreds of young students in physics and engineering obtain higher degrees at universities based on the results of the work performed at CERN. In the course of the internship, they receive new knowledge and skills, as well as the experience in the international cooperation. Special CERN schools ensure teaching physics of elementary particles, accelerator physics and computer calculations of several hundreds of young researchers each year.

Education of young scientists is the key part of influencing the community. Over 2,400 post-graduates are registered with CERN and around 600 dissertations are defended each year. Around 36% of post-graduates, CERN graduates get their first job at a scientific institute or a university all over the world. In the future, around 80% of graduates transfer their expert knowledge in industry, finances or other spheres. This ensures a continued flow of highly-qualified young people with great technical expertise and international experience to carry out scientific, commercial and investment activities of various organizations.

2.5. The Generation IV International Forum (GIF)

The Generation IV International Forum (GIF) is the international projects aimed at conduction of scientific research to study the potential of nuclear and energy systems of the next generation [9]. With the view of that, the projects in question will be implemented by further generations of researchers, the educational projects Education and Training Task Force (ETTF) was founded under the GIF project in 2015. One of key ETTF group’s project was the project on international webinars in GIF subjects [10]. Webinars elaboration was aimed at stimulating not only the interest of young scientists, but also of
managers, key persons taking decisions and the wide public of perspective reactors with the pre-
determined advantages, but also key studies in the sphere of their development.

Each webinar represents short (60-90 minutes) lectures in GIF study subjects, which materials are
being developed in cooperation with universities and organizational partners. Webinars are registered
and archived to become a library or a collection of the information with online access at the GIF’s
website. Students of NRNU MEPhI in specific area have participated in webinars since 2017, not only
developing their professional competencies, but also improving their knowledge of English.

GIF webinars provide an opportunity of this resource to inform the wide public and the scientific
community of achievements in the sphere of perspective reactor technologies. Besides, due to the
interest of a wide public, from professionals to teachers, the ETTF group’s objective, i.e. to make an
archive of webinars, has been fulfilled. Webinars are available in two formats: audio-video record and
PDF slides. This is free access, which makes webinar records more attractive for the scientific
community.

3. General approaches to formation of research competencies

3.1. The classification of measures aimed at formation of research competencies in the nuclear
industry

The analysis of international projects on attraction and development of young professionals in the
nuclear sphere, shows that the following general approaches can be distinguished:

• continuous works with youth: from a pupil to a student, from a student to an intern, from an
  intern to a young expert;
• use of various event measures from group tours to the individual work under internships and
  contracts;
• selection of candidates based on the competition process;
• facilitating of youth international mobility as the necessary element of integration into the
  international nuclear community;

At the stage of formation of interest in the nuclear industry (pupils and bachelor students),
informational events usually prevail: excursions, summer schools, lecture courses, webinars.

At the stage of formation of professional competencies (master students and post-graduates),
individual events are added to the group forms: internships and contests.

At the stage of commitment to the nuclear industry (postdoctoral fellows, young employees at
nuclear facilities), individual events are mainly used and implemented as the work in the international
team.

3.2. Portrait of a modern young nuclear scientist

By summing up the above mentioned, a portrait of a modern young nuclear scientist can be presented
and the stages of necessary competencies formation described. Table 1 contains characteristics of a
young scientist, which correspond well to the general competencies formulated in the documents of
the Bologna process. The basic materials of the Bologna process have [11] three distinguished types of
general competencies: instrumental, inter-personal and systemic. All competencies start to form in the
course of studying at the university and continue to form throughout the whole professional activity.
This is closely associated with a wider education concept: there is a certain education continuum
existing during the whole life, and a person is capable of using knowledge, expand it, select what is
consistent with the given situation, continue to learn and understand how the obtained knowledge can
be adapted to the new, quickly changing situations.
### Table 1. Characteristics of nuclear professionals.

| Characteristic | Bologna process competencies | Events, projects |
|----------------|------------------------------|-----------------|
| Basic knowledge (erudition) | Analysis and synthesis capabilities<br>Basic general knowledge<br>Learning Ability | Studying at the university | |
| Professional knowledge | Basic occupational knowledge<br>Ability to apply knowledge in practice | Studying at the university<br>Internships, practical trainings<br>Participation in research projects | Work experience<br>Internships, practical trainings<br>Participation in research projects |
| English language | Communication skills in foreign language<br>Ability to work at the international level | Studying at the university<br>Professional webinars in English | International internships<br>Professional webinars in English |
| Integration into the professional community | Ability to teamwork<br>Inter-personal skills<br>Ability to adaptation to new situations | Professional internships<br>Participation in professional conferences | |
| Experience of participation in international projects | Ability to work in the interdisciplinary team<br>Ability to perceive diversity and inter-cultural differences<br>Ability to work at the international level | | International internships |
| Organizational work experience | Ability to work in the interdisciplinary team<br>Ability to interact with experts in other subject areas<br>Leadership Ability | Studying at the university<br>(participation in events arrangement)<br>Experience of organizational work (participation in arrangement of events) | |

Competence formation is a long process and sometimes not linear with parallel processes and interactions among various directions in knowledge, skills and expertise learning. The international organizations experience shows that continuous formation of competencies may be ensured with events for various categories of young people: pupils bachelor students, master students and post-graduates, young specialists.

The process of competencies formation is closely associated with the process of the personality development. It is obvious that there is time for everything, and at various stages of the personality development, personal priorities and learning abilities change. We will attempt to evaluate main timeline and milestones of this process.

Table 2 describes stages of formation of competencies required by nuclear professionals, who may represent State Corporation in international projects. Several key moments should be noted in this process: 1) selection of master program or work after the bachelor program; 2) selection of the post-graduate education or work; 3) selection of work place after post-graduate education. Each selection closes certain opportunities and opens other ones. E.g. current post-graduate education programs provide for the internship at an international scientific organization or a university for several months. Taking such internship is almost impossible for a person working at an enterprise. At the same time, it
is obvious that no practical experience at an enterprise prevents from obtaining professional skills and competencies required to work in a different-aged inter-disciplinary team.

Table 2. Stages of Competencies Formation.

| Stage                          | Age, years | Term, years | Competencies                                                                 |
|--------------------------------|------------|-------------|------------------------------------------------------------------------------|
| Studying under the bachelor’s program | 17-22      | 4           | Analysis and synthesis capabilities, Basic general knowledge, Learning Ability, Inter-personal skills |
| Master program                 | 21-24      | 2           | Basic occupational knowledge, Ability to teamwork, Ability to apply knowledge in practice, Inter-personal skills |
| Master program                 | 23-28      | 4           | Communication skills in foreign language, Ability to work at the international level, Inter-personal skills, Ability to perceive diversity and inter-cultural differences, Leadership Ability |
| Experience of work in an organization | 23-32      | 3-5         | Professional occupational knowledge, Ability to teamwork, Inter-personal skills, Ability to adapt to new situations, Ability to interact with experts in other subject areas, Ability to work in the inter-disciplinary team |

Another problem is that knowledge and skills if not used tend to deteriorate. The half-period of unused knowledge deterioration is assessed by psychiatrists at the level of several months to one year. Therefore, very specific activity prevents from development and maintenance of numerous competencies required for working in international projects.

Table 2 also shows that it takes 12-15 years to train a specialist with the PhD degree and experience of work in international projects. These are young people with great potential of personality growth and who will be able to implement it in various companies, including international ones. To hold such young people in Rosatom State Corporation, a special program must be developed including various events and the data base of the HR reserve. In this case, a lot of work should be performed with the heads of facilities of the State Corporation in order to increase the priority of events aimed at professional training in specific universities, practical training of students and sending young employees to international conferences and to take internships.

In this regard, a positive experience of the joint program of Rosatom State corporation and Skolkovo Business school for innovations should be noted. Main target of this program is formation of HR of leaders in innovations within the industry. The result of implementation of the five-year program was training of 200 people, which formed the innovational community at the innovation management facilities, and creation of the pool of innovational projects, several of which have been already implemented in practice. During the whole period of this educational program implementation, all hearers remained within the industry and at least 50% of participants were assigned a higher status thank to new knowledge and formation of new competencies.
4. Conclusion
Study of projects on involvement and holding youth within the nuclear industry demonstrates uniform approaches in various international organizations. Key forms are: programs of interaction with specific universities, proposal of internships on a competition basis, holding dedicated seminars, trainings and technical tours at the international organizations. It should be noted that the mandatory condition of participation in similar events is fluent English, which has currently become the language of the nuclear science.

Formation of research competencies is not completed after university graduation, however learning at the specific HEI is the key stage for their formation. Therefore, programs of nuclear facilities interaction with specific HEI must be a mandatory component of formation of HR of Rosatom State Corporation.

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