

## NEEDS FOR RESTORATION OF NUCLEAR KNOWLEDGE MANAGEMENT IN SERBIA

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**Abstract:** Nuclear programmes in former Yugoslavia have been supported by comprehensive research and development (R&D), educational programs and pertinent training in country and abroad. Three research reactors and one nuclear power plant (NPP) were constructed and operated with significant participation of domestic experts. Since 1989, the nuclear expertise has been deteriorated considerably in Serbia due to adopted law on ban for NPP construction, isolation of the country due to the UN sanctions and weak economical situation. Major R&D programs were cancelled, nuclear courses at the University revoked, many professionals left the country, and the loss of nuclear knowledge and expertise was inevitable. A new nuclear programme related to remediation of nuclear and radiation safety in Serbia has been launched two years ago. This paper, beside overview of past nuclear knowledge management programmes, emphasizes the need for nuclear expertise and the lack of nuclear professionals to carry out new programme.

### 1. Introduction

Various extensive nuclear programs were carried out in the former Yugoslavia in period from 1955 to 1990. During that period, three research reactors and one nuclear power plant were constructed. The 6.5 MW heavy water RA research reactor, designed in the Institute of Theoretical and Experimental Physics, Moscow, in ex-USSR, had been bought in 1955 as a turn-in-key facility and constructed in the former “Boris Kidrič” (now ‘VINCA’) Institute of Nuclear Sciences, near Vinča village and the Danube river, about 15 km southern-east from Belgrade capital. The reactor was commissioned at December 29, 1959, when it has been brought to the first criticality.

But, the first controlled nuclear fission chain reaction in Yugoslavia was achieved a year and half ago, on April 29, 1958 when the heavy water – natural uranium RB critical assembly, designed and constructed entirely by Yugoslav scientists, reached the first criticality. Nuclear material, natural uranium metal fuel rods and heavy water, was bought in ex-USSR. This achievement was considered as one of the greatest successes of Yugoslav nuclear knowledge. Both Vinča’s research reactors were built according the national plan of development of nuclear energy in the country of that period and were among the first ones in the southern-east part of Europe. They were constructed with the major participation of domestic experts, who successfully operated these facilities in next forty-five years. They were playing a considerable role in the nuclear programmes in the country supporting not only a comprehensive R&D in the institutes, but also appropriate educational programs at the Universities through a part of pertinent training of students and nuclear experts in the country.

### 2. Brief history of nuclear knowledge in Yugoslavia

The first nuclear program, with the ultimate goal to develop nuclear technologies and to introduce nuclear power plants in the country, in Federal Peoples Republics of Yugoslavia (FNRJ) was initiated in mid fifties and was in place for about 10 years. Federal Commission for Nuclear Energy (“SKNE”) was established by the Federal Government decree in March 1955 and operated, fully funded from the federal budget, to 1961. In that period, nuclear programme related laboratories were built at the site of the “Boris Kidrič” Institute of Nuclear

Sciences, including two research reactors, reactor thermodynamics, isotope production and reactor materials research, health physics and medical protection.

Director and founder of the Institute was the famous Serbian scientist Prof. Pavle Savić, who was also founder of the Faculty of the Physical Chemistry at Belgrade University. In the early days of the Institute, good and skilled students from that faculty were recruited to the Institute to work their B.Sc. thesis and later to joint various laboratories. Another main sources of students from the Belgrade University and future Institute's staff were Faculty of Electrical Engineering, Faculty of Mechanical Engineering and Faculties of Natural Sciences (Chemistry and Physics). Programmes at these faculties (especially in the last grades) were adjusted to respond to the national nuclear programme and to needs of the Institute in Vinča. Cooperation between Institute in Vinča and University of Belgrade was very strong in late fifties so the SKNE had plan to buy in the USA and construct a small 15 W 'school reactor' at the Faculty of Electrical Engineering, downtown in Belgrade. On the other hand, the Institute in Vinča was the main source of many experts that had migrated to the University, founding various courses related to nuclear energy utilization and radiation protection, or even took major part in establishing new Institutes.

Education activity in the Institute in Vinča has started very early – already in September 1956 the "School for education of experts in radioisotopes management", known as the "School for radioisotopes" was founded and had conducted various courses related to basics of radioisotopes management, radiation protection and many courses related to application of isotopes, particularly in medicine and industry. Many books, textbooks and scripts related to education activities are published by the school professors.

Another two main nuclear oriented research institutes were established in two other republics of former Yugoslavia: The "Jožef Štefan" Institute was established in 1949 in Ljubljana, Slovenia, and the "Rudjer Bosković" Institute was established in 1950 in Zagreb, Croatia.

The commercially available research reactor of US origin made by the Gulf Atomic Co., the 250 kW TRIGA reactor, was bought and set to operation in the "Jožef Štefan" Institute in 1966, as a third nuclear research reactor in the country. Research in the Institute has been reinforced by building strong links to universities, other research institutions and industry. The Institute was closely connected with the two Slovenian universities in Ljubljana and Maribor. Since 1985 to beginning of 1990-es, more than 600 postgraduate students have gained their MSc. and Ph.D. degrees at the Institute. Close contacts were also maintained with secondary schools, providing work practice on research projects in natural sciences and organising regular visits to the laboratories.

The "Ruđer Bošković" Institute was founded as a centre for advanced research and it was, from the very beginning, oriented to fundamental research. The Institute was devoted to pedagogical activities both through lectures at undergraduate and graduate level and by training junior researchers by leading B.Sc., M.Sc. and Ph.D. theses since 1957. International co-operation was very broad and intensive and had played an important role in executing modern scientific research.

Nuclear experts educations in the former Yugoslavia has shown constant growth from 1948 (6 in science, 24 technicians and 15 in administration) to 1959, when 1059 employees were worked in science, supported by 908 technicians and about 2500 in administrative sector. Beside organization of national conferences, the SKNE has also organized the 'Summer school for physics' in Herceg Novi at Adriatic coast since 1956, with foreign participants (about 70) and international lecturers, so that this school has become of regional interest in beginning of sixties of the last century. From 1961 to 1970, the SKNE has funded the country nuclear program through the research projects, since the investment period for establishing major research infrastructure was completed. In 1967 the Yugoslav nuclear program has

comprised 2833 employees. From these, 932 were high educated (about 300 with Ph.D.) that were published about 5000 scientific papers. There were about 100 engineers working in nuclear related fields in R&D organisations, and there were 12 centres for application of isotopes in medicine and 4 centres for application of isotopes in agriculture. Average budget of the SKNE in 1960-ties was equivalent to 6-8 thousands US \$ per researcher and per year for whole nuclear program including research, education, nuclear energy research, radioisotopes production, utilisation and health protection.

The SKNE was cancelled in 1970 and the funding of research programmes in nuclear institutes and companies were transferred to the Republics' ministries of sciences. The nuclear programme was continued and, in the same year, the first contracts to purchase the 630 MW electrical nuclear power plant (NPP) from the Westinghouse, Co., USA was signed and construction started a few years latter. The "Krško" NPP, has been built jointly by funds of Republics of Slovenia and Croatia at Krško site (in Slovenia, about 15 km to Croatian border) and had reached the first criticality in 1981.

In meantime, the Yugoslav Federal Government ("SIV") has founded, in 1978, the new Commission for Nuclear Energy, initiating works on the second nuclear programme on developing nuclear technologies for introducing nuclear energy in the country (1980 – 1988). Organization NUKLIN was founded in 1982 as joint organisation of 10 scientific and R&D nuclear institutes in the country. The same year the "4E Consortium" was founded by four main industry companies in the country involved in the nuclear industry development programme: "Energoprojekt" (Belgrade, Republic Serbia), "Elektroprojekt" (Zagreb, Republic Croatia), "Elektroinženjering" (Sarajevo, Republic Bosnia and Hercegovina) and "Elektroprojekt" (Ljubljana, Republic Slovenia).

Plans for construction up to twenty NPPs in the country by end of the twentieth century were announced in mid-seventies and beginning of eighties. Courses at Universities for experts in nuclear field were adjusted to that plans, and, e.g., at the Faculty of Electrical Engineering at Belgrade University, at regular courses, 5 to 10 students per year are expected to graduate at the Nuclear Engineering grade at the Department of Technical Physics. Topics have covered general knowledge from the basic and applied physics and all basics of reactor physics, engineering, experimental reactor physics, nuclear safety and radiation protection.

In that period, the Parliament of the Socialistic Federative Republics of Yugoslavia has brought various policy documents related the nuclear programme. These documents were also supported by various actions carried out in the Institutes and Universities with the aim to prepare necessary experts in the field. A special study on available experts in the whole country, their topics of research and expertise, was prepared by the Faculty of the Electrical Engineering, of the Belgrade University in mid-eighties. 'Nuclear Safety Commission' was formed and operated as the Regulatory body in the country in mid-eighties, issuing appropriate permissions and licences for operation and use of nuclear facilities.

During that time significant knowledge and operating experience have been gained, and high nuclear and radiation safety standards were achieved, while the manpower was appropriate to the programmes initiated. The most important results were accomplished in R&D within the research institutes. Research and Development has also provided valuable courses for postgraduate studies. As a result, sufficient number and diversity of experts were available for various assignments in nuclear technology and related fields.

At the same decade (1978 - 1991 period) few important events related to nuclear energy were happened in the world and in the ex-Yugoslavia:

- Three Mile Island NPP accident (1979) influenced many countries' regulation bodies to strengthen demands for increased safety of nuclear installations;

- Consequences of the Chernobyl NPP accident (1986) influenced the whole world nuclear community to review safety analysis reports, and to forward research to new, advanced NPP with increased inherent safety features. Yugoslav Government regulatory body adopted a set of new regulations related to safety of nuclear installations (1988):
- Green-peace groups, all over the world including Yugoslavia, increased their activities to amplify environmental protection and made influence at public general opinion against NPP and nuclear and/or radioactive waste;
- As a consequence of these three previous mentioned events, the Yugoslav Parliament brought the law against construction of new NPPs, nuclear fuel production or spent fuel reprocessing and radioactive waste storage in the country: ‘Law on ban of construction of nuclear power plants’ (1989).

### 3. Last fifteen years of the nuclear programme in the country

Since 1989, and especially during the past decade, the nuclear expertise has been deteriorated significantly in Serbia due to several peculiar reasons:

- Adoption of the ordinance of ban for nuclear power plants construction and related activities;
- Isolation of the country due to the embargo of the Security Counsel of the United Nations Organisation, and
- Weak economical situation in the country.

In parallel with processes of technology degradation, another deteriorating tendency has been advancing – losing both experts and technicians qualified to operate the reactor and carry out the research in the nuclear field. Management of human resources within the “Vinča” Institute failed to retain these personnel, and management of human resources at the governmental level didn’t exist for the nuclear field. Consequently, undergraduate and postgraduate studies, research courses and training in nuclear science and engineering were cancelled and there has been no renewing of human resources. That resulted in a dramatic ageing of nuclear workforce in the country.

But, during last two years (2001 to 2003) three significant nuclear projects within a new country nuclear programme have been launched with the support of the IAEA. They emphasized the need for nuclear expertise and the lack of nuclear professionals in the country to carry out these projects.

### 4. New nuclear programme in the country

As consequences of the general non-favourable energy situation in the country mentioned above, and particularly to the existing nuclear and radiation safety problems in the Vinča Institute, that have been arisen as results of previous nuclear programmes, research and developments in nuclear safety, radiation and environmental protection must be stimulated.

For these reasons, the “Vinča” Institute of Nuclear Sciences has proposed to the Government of the Republic Serbia a new nuclear programme, supported also by the IAEA technical co-operation programme, in 2001. This programme is known as the Vinča Institute Nuclear Decommissioning – VIND (or the “Green Vinča”) Programme. The first support to the VIND programme was given by the Government of the Republic Serbia in July 2002 by following conclusions:

- (1) RA research reactor will be permanently shutdown after 18 years of extended shutdown status and will go to decommissioning;
- (2) Fresh high-enriched uranium fuel elements from the RA and RB research reactors will be shipped back to Russian Federation;
- (3) Spent nuclear fuel of the RA research reactor should be prepared for safely storage or, preferably, for shipment back to the country of origin (Russian Federation);

(4) Radioactive temporary storage of the LLW and MLW in the Vinča Institute should be refurbished and/or upgraded in a such way to accept all radioactive waste that would arise from the spent fuel shipment and decommissioning of the RA research reactor;

(5) Final disposal site in the country for LLW and MLW should be selected according to the study prepared in 2001 and the final design including construction phase should start in near future;

(6) RB critical assembly in the “Vinča” Institute will continue to operate with the Government support, and

(7) The “Vinča” Institute will be in charge of the VIND Programme while the necessary experts education at the Universities and in the country institutes will be stimulated by adequate stipends given by the Ministry of science of the Republic Serbia.

The Government of the Republic Serbia has reconfirmed these main conclusions in February 2004, underlining the decision for the spent fuel shipment back to Russian Federation and strategy of immediate dismantling of the RA research reactor as the only acceptable options.

#### 5. Restoration of nuclear knowledge

The newly launched nuclear programme in the country has promoted the importance to establish as soon as possible appropriate engineering education and training and prevent further loss of nuclear expertise. It is necessary to commence several co-ordinated activities:

- Preparation of educational programs and concepts of networking academic/university and the R&D institutions where the nuclear experts have remained;
- Promotion of nuclear technologies through the existing professional association (Yugoslav Nuclear Society), with the special accent on the role of nuclear in sustainable development;
- Promotion of environmental responsibility of nuclear technologies in the frame of Kyoto protocol principles;
- Enhancement of public understanding and acceptance of nuclear technology.

The contribution of all relevant parties capable to organise and carry out the above actions is necessary to restore the nuclear knowledge in Serbia and Montenegro and provide the basis for establishing an appropriate management of this knowledge in the future.

Reduced activities in nuclear educations in last decade have led to the present circumstances in Serbia and Montenegro, in which university courses related to nuclear engineering and radiation protection exist only at few faculties of the Belgrade University. Unfortunately, number of students graduated at the courses is only few per year in last decade and does not show any considerable increase. Reasons are already mentioned:

- Poor salaries of researchers and engineers employed in research institutes and faculties,
- Deficiency of appropriate posts in industry,
- Country is without serious nuclear programme that could guarantee a stable, perspective long-term job for young employees in the country.

Such country policy, materialised in the ban on the NPPs option and natural ageing of the staff at the institutes and universities has led to the expert's brain drain of the country reducing nuclear knowledge and could be summarised in the students saying ‘*to graduate and to emigrate*’. Recent interviews (made in June 2004) with students of University of Belgrade have shown that 80 % of students have plans to leave the country after graduation, looking for appropriate jobs and better salaries in foreign countries.

#### 6. Prospects for a change

In order to move towards development of the knowledge in nuclear sciences and technology in the country, it is necessary to ponder several principal issues and accordingly deduce adequate measures. The prospects for a change could be created if a sound organisation is provided to:

- Examine existing and identify needed initiatives for the knowledge revival
- Promote the nuclear sector to encourage recruitment
- Underpin learning pathways
- Create vigorous education institutions capable to meet changing requirements
- Enable sharing of existing technological infrastructure and foster wide dissemination of information.

The goal of recovering the nuclear knowledge, and subsequently in developing preserving it, can be achieved thorough thoughtfully and efficiently performed activities:

- *Preservation of the existing nuclear knowledge.* That seeks to establish a comprehensive, inventory of existing data and knowledge in the country, that would be sufficient to form the basis for development 20 to 40 years from now.
- *Revision of the existing university programs and courses related to nuclear and radiation field.*
- *Identification of the new projects needs.* Management should foster certain policy for recruitment and selection of staff, and define requirements for qualification, educational basis and experience which staff has to fulfil.
- *Identification of the appropriate scientific and engineering education and training* that has to be organized as soon as possible.

## 7. Conclusions

The main conclusions regarding the needs for restoration, development and preservation of the nuclear knowledge in Serbia can be summarized as follows:

- If the Serbian education system does not quickly respond to the demand for developing nuclear skills, the impact on nuclear and radiation safety, and the damage to national technological performance and will be considerable.
- The pertinent way to extend options available to students is through collaboration between science and engineering faculties, R&D institutions and training providers, as well as involving employers. Industry and the science-based professional institutions could make a very important contribution in this regard.
- The aim should be to change the perceptions of young people, parents and teachers about the many opportunities that could be open to people with scientific qualifications, both at the technical level and through higher education. The ongoing reforms in the educational system could prove beneficial for achieving this objective.

As a summary, we can estimate that the current situation in the nuclear knowledge in Serbia is alarming, and moves forward a critical phase. Measures that should be taken to improve the situation and provide the basis for establishing the nuclear knowledge management are proposed. Otherwise, if the existing trend would continue within the next few years, the only remaining experts in the nuclear field in Serbia, will be – journalists.

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