Concept for a new research reactor in Ukraine

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Abstract. The Concept substantiates the need for a new multi-purpose research reactor and determines the optimum alternative to meet these needs. The Concept involves considerations about the reactor type and relevant technical parameters, the reactor's main uses, possible locations, and the necessary scientific and technical infrastructure and tentative schedule for implementation.

1. Introduction

Currently in Ukraine there is only one high-power research reactor in operation; this is the WWR-M research reactor at the Institute for Nuclear Research of the National Academy of Sciences of Ukraine. It was commissioned 47 years ago (one of the first research reactors in the former USSR) to implement the program initiated by Academician I.Kurchatov to provide nuclear regional centres with research reactors. From the beginning, the WWR-M research reactor constituted a scientific and technical basis for research not only for scientists of NASU but also for other organizations in Ukraine and the former USSR

The reactor is a heterogeneous water-moderated research reactor operating with thermal neutrons at a power of 10 MWt, giving a maximum neutron flux of 1.5x1014 n·cm-2s-1 at the core centre. The reactor has nine horizontal experimental channels, a thermal column, and 13 vertical isotope channels in the beryllium reflector. It is possible to install 10-12 vertical channels in the core.

This reactor facility plays an important role in Ukrainian nuclear industry infrastructure in the form of fundamental research, namely: nuclear and neutron physics, semiconductor radiation and solid-state physics, radiological material science, nuclear energy, radiochemistry, biology, medicine, and applied science and engineering innovations including neutron-activation analysis, silicon neutron doping, neutronography, testing and development of various sensors for the in-core controls, and radionuclide production.

The final shutdown is expected in 2015 which presents a problem of how to preserve and strengthen the nuclear "know-how" needed for new reactor construction in Ukraine. Ukraine maintains its own nuclear industry constructing new NPPs and expands existing ones. Providing safe and secure NPP operation along with further development of nuclear science and technologies definitely requires a new research reactor and scientific centre.

The construction of a new research reactor is under current consideration. The first stage was to develop a Concept for a new multi-purpose research reactor. If the construction process were started now, reactor commissioning would be expected in 2015. This would help to increase the level of the scientific and engineering research for NPP maintenance, to extend fundamental research and development into providing state-of-the-art radiopharmaceuticals, and to raise as a whole the national nuclear competence. The new

reactor would be utilized by all interested organizations regardless of their departmental affiliation.

2. Basic grounds of Concept

Resolving issues related to the reactor site selection, design and construction should start as soon as possible. Clearly, the first step in resolving this problem should be a decision at the conceptual level with the subsequent adoption of a corresponding Law of Ukraine.

The Institute for Nuclear Research at NASU has prepared the following draft documents: "Concept of the New Multi-Purpose Nuclear Reactor" and "The Concept Backgrounds". These documents determine the conceptual basis and the main requirements for the design, construction and operation of the new Ukrainian research reactor providing accepted protection levels for both humans and the environment along with reducing risks of radiological accidents. The Concept highlights methods for selection of reactor type, reactor characteristics, possible site locations, proposed reactor utilization and the necessary infrastructure for the reactor operation. The Concept approval will permit works related to the reactor design and construction to start.

The following prerequisites underly the Concept:

- the new reactor is intended as a replacement for the existing WWR-M reactor;
- the new reactor will be designed and constructed with the aim of satisfying current and future needs of the State as a power source of neutrons;
- it will have a multi-purpose use for both fundamental and applied investigations;
- the new research reactor will be an integral part of the Ukrainian nuclear power industry;
- the design will follow modern international trends for increased reactor utilization whilst maintaining all nuclear and radiation safety requirements;
- the construction will benefit the domestic industry and economy;
- the new research reactor should be the core installation of a new national nuclear centre.

Positive opinions for the draft Concept were received from a large number of authorities, namely, the Ministry of Fuel and Energy, the Ministry of Emergencies, the Ministry of Science and Education, the Ministry of Environmental Protection, the Ministry of Health Protection, the State Nuclear Regulatory Committee of Ukraine, and the National Atomic Energy-generating Company "Energoatom". Also the draft Concept has been presented and approved by the Assembly of Nuclear Physics and Energy Division of the National Academy of Sciences as well as the Parliament Committee for Nuclear Policy and Security. Considering all positive references and proposals, the Concept has been submitted to the Cabinet of Ministers of Ukraine for their approval.

3.Reactor and laboratories

The Concept encompasses the different types of research reactors. The final decision can be made from the tenders submitted after technical and economic assessment. The most suitable choice in the Concept is considered to be the open pool type reactor design with 20-30 MW thermal power and an average neutron flux of about 4.0×10^{14} $n\cdot cm^{-2}\cdot s^{-1}$. Low-enriched uranium fuel will be used for the reactor operation. Reactor and technological systems will be located in the containment.

The following laboratories and complexes are planned around the reactor:

- a material testing complex for testing and investigating irradiated materials;

- a medical and biological complex to produce medical isoptopes by neutron irradiaition and investigation into the irradiation impact on biological systems;
- a laboratory for the radionuclide production and manufacture of radiation sources;
- a laboratory for the neutron doping of silicon and other materials;
- a neutron-activation laboratory for the multi-element analysis of technological materials and environmental samples;

The research reactor should be the central nuclear facility of a new national nuclear research centre having the following structure:

The National Scientific Centre as an adjunct facility to the new research reactor and as such has to have the following facilities:

- a design office in conjunction with a model machine-shop;
- a laboratory building with the "hot-cells" for work with high-active materials;
- a laboratory building for the preparation of techniques and fundamental research;
- a training centre and conputer service;
- a centre of radiation medicine and a hospital;
- an administrative building;
- auxiliary buildings for the provision of reactor and installations operation;
- miscellaneous.

4.Site selection

The selection of the reactor site will be made according to established procedures at the design stage. Preliminary estimates are that the area of reactor site will be about 40-50 hectares. Taking into account the duration of the reactor's construction, operation and decommissioning, the term of site use will be about 100 years.

The suburbs of the town of Slavutich in the Chernigov region are considered now as the most preferable location; however, some other places should be considered too.

5.Legislative requirements

In accordance with the Law of Ukraine "On decision-making process related to the site location, designing, construction of the nuclear facilities and radioactive waste facilities. Common provisions" issued on September 9, 2005 No 2861-IV, the decision regarding the site location, designing, construction of the nuclear facilities would be approved by Ukrainian Parliament by passing an appropriate law regarding the site location, designing, construction of such nuclear facility.

Additional documents are required to pass the Law:

- technical and economic assessment for both nuclear facility design and site selection;
- state ecology expertise conclusion;
- regional referendum results;
- report on the information distribution among neighboring countries;
- other documents, if foreseen by the legislation.

6.Schedule of Concept implementation

Concept implementation should be performed in separate stages during 2007-2015. The proposed sequence of measures and activities with the corresponding timeframes are given in the table below.

Stage	*Time*	*Measures and activities*
1.	2007	Concept approval by the Cabinet of Ministries of Ukraine and determination of the principal state customer
2.	2008 – 2009	Elaboration of the technical and economical substantiation
3.	2009	State ecology expertise
4.	2009	Local authorities approval
5.	2009	Petition of the law-project "On the site location, designing and construction of the new research reactor with the relevant infrastructure" to Ukrainian Parliament
6.	2009	Requirements specification for the reactor design
7.	2009	Tender for the reactor construction. Deetrmination of the reactor operator.
8.	2010 – 2011	Designing and licensing
9.	2011 – 2015	Reactor and infrastructure construction
10.	2015	First criticality. Commissioning
11.	2008 – 2015	Operational stuff training
12.	2012 – 2015	Purchasing and installation of experimental equipment

7.Expected results from the concept implementation

The main result from the Concept realization will be the creation of a new multi-purpose research reactor with an effective infrastructure yielding significant scientific, economical, social and ecological benefits. The Concept implementation will allow carrying out by means of the reactor, investigations and technological development works in the following areas:

1) nuclear power:

- investigations into the properties of construction materials from the reactor cores, vessels and internals for power reactors;
- material irradiation under controlled conditions and environment for post-irradiation investigation;
- testing of new fuel designs, absorber and construction materials;
- verification and testing of new heat-carriers;
- examination of new start-up, transitional and emergency regimes of heat transfer from the reactor core;
- inspection and testing of new control and diagnostic measures for the reactor core, fuel, and heat-carrier;
- investigation into the radiation durability of the diagnostic system sensors in the reactor core and irradiated construction elements of power reactors.

2) fundamental scientific investigations:

- investigations in the field of nuclear and neutron physics; investigations of interaction of thermal and resonance neutrons with nuclei, including the use of filtered neutron beams; determination of cross-sections for the interaction of neutrons with the stable and radioactive nuclei; investigations into the interaction of poliarized filtered neutrons with the oriented nuclei; investigation of properties of exited states at the neutron capture by nuclei; nuclear fission; neutrino physics;
- structural investigation into the crystals of high-temperature semiconductors, biological systems, liquids, polymers, nanostructures etc;

- investigations of vibration spectra of atoms, molecules, biomolecules, nanostructures;
- investigations into magnetic phenomena; determinations of the magnetic moments of atoms, distribution of magnetization, spectra of magnetic excitations;
- investigations into external impact (irradiation, temperature, pressure etc.) on the materials, increase in stress and deformation;
- investigations in the fields of radiation biology, chemistry, medicine, ecology.

3) nuclear technologies:

- production of radioactive isotopes for medical diagnistics and treatment;
- production of radioactive isotopes for industry (isotope indicators, control instrumentation, sterilization);
- neutron transmutation doping of semiconductors and other materials for electronics;
- development of perspective radiation-thermal technologies for the production of materials and devices with the unique electro-physical properties and high radiation durability;
- irradiation by reactor neutrons for medical purposes;
- activation analysis of admixtures in material and environmental samples;
- modification of different properties of materials, strengthening of materials, polymers, metals and alloys, glass toning;
- sterilization of medical equipment, drugs, food etc.

8.Conclusion

The Concept is based on the assumption that a new research reactor will be an essential element for the provision of a wide-ranging complex of national interests and that the real independence and safety has only the states, which are able to get new knowledge and efficiently use it. Approval of the Concept will allow the design and construction of a new multi-purpose research reactor in Ukraine to begin.