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The concept of phased deployment and closure of NFC on the basis of FR under conditions of uncertainty with future scales of NP development

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Outline

1. Overview of FR&CNFC activities in Russia.
2. A proposal for a new paradigm in selection of requirements and priorities with view of uncertainties.
3. A proposal for the first stage of NFC closure in Russia.

Introduction to the problem.

Considerable success in SFR development has been achieved in our country: BN-600;BN-800.

New FTP “Nuclear Power Technologies of the New Generation” has started in 2010 with an objective to select and develop innovative FR&CNFC technologies for large scale NP after 2030.

Meanwhile, it is planned to increase the NP capacity in Russia from present 24 to 40-60 GWe by 2030 by using VVER and OFC technologies.

Solutions concerning the SNF from VVER are usually associated with bunch construction of FRs.

Taking into account future uncertainties and risks with development of innovative technologies, one may expect that policy of temporary storage of VVER SNF will continue long after 2030.

Policy of delaying the solutions for LWR SNF

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Negative consequences:

- Decline of a public support for the;
- Loss of energy potential of Pu (owing to the decay of Pu-241) and, as a consequence, accumulation of considerable quantities of radiotoxic Am-241;
- The need to construct storage facilities for the LWR SNF, without knowing definitive time of storage;
- LWR back-end fuel cost still vague.

Possible solutions:

- Look for VVER SNF decisions based on use of demonstrated technologies.

FR&CNFC activities in Russia.

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A new strategy of a large-scale NP development for the period till 2050 based on development of innovative FR and CNFC was officially approved in 2000.

- **NP development scale – 100 GWe by 2050 and 300 GWe by 2100.**
- **FR mission – large scale NP development.**

FR and CNFC technologies must meet so called "natural safety" requirements:

- **No breeding zones (proliferation resistance);**
- **Core BR =1.05 (safety reason);**
- **External fuel cycle < 1 year (to reduce FM in cycle);**
- **Multiple recycling of U and Pu together with MA (to reduce the RW radiotoxicity).**

Innovative technologies: U-Pu-MA Nitride fuel; On site dry reprocessing. BREST concept; BN-1200 on Nitride.

FR&CNFC activities in Russia.(2)

In 2011, an alternative view from KI on NP strategy for 21st century was published, with alternative vision for NP development scale, FR mission, requirements and technological priorities:

- NP development scale – 300 GWe by 2050;
- FR mission – breed Pu for Super VVER;
- FR requirements – BR =1.4;
- Innovative technologies: Super VVER; BN with heterogeneous core; HTGR; MSR to burn MA.

FR&CNFC activities in Russia.(3)

Meanwhile:

- **The commissioning of production shop for MOX fuel for BN-800 are planned by 2017.**
- **A concept of BN-1200 (MOX) is under development.**
- **FTP “Nuclear Radiation Safety” was accepted with objective to build and Experimental Demonstration Centre (EDC) to modernize PUREX technology for RT-2 plant to be commissioned by 2025.**

The present paradigm

Contradictory views on requirements and technology priorities are based on use of a following approach:

- •Forecast the future large-scale NP;
- •Describe problems and FR role;
- •Define the requirements and develop innovative FR&CNFC technologies (scientific and strategic interest);
- •Promise to resolve the present NP problems, (industry interest) in future.

The extent of justification of requirements depends on the extent of reliability of the concepts of the future, and extent of feasibility of suggested innovative technologies . This approach entails uncertainties and risks. Low interest from industry.

Proposal for a new paradigm:

- Identify the problems of present day NP;
- Define requirements and develop those technologies that would allow to address the present-day problems (industry interest), without creating restrictions for the future;
- In parallel develop new technologies for future large-scale NP – (science and strategic interest);
- Correct the requirements to these technologies, as our concepts of the future are defined more precisely, and the real potential of different technologies are shaped better.

Options for VVER SNF management

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Two possible options:

1. Geological isolation of VVER SNF. Allows a complete solution of the SNF problem, but precludes a any large-scale development of NP in Russia after 2030.

2. Option of VVER SNF reprocessing with MOX recycle in the existing VVER . Helps to resolve the SNF problem only partially. The total quantities of Pu in NP becomes twice as small, and the content of radiotoxic Am-241 is considerably increased. This would complicate large scale NP development in Russia in future.

Proposed third option for VVER SNF management

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3. Reprocess VVER SNF and recycle extracted Pu in MOX form in few BN reactors.

For utilization of all SNF from all VVERs to be build by 2030 it will be necessary to create by 2035 the following infrastructure:

- **RT-2 plant** to reprocess all SNF from VVERs with capacity from 800 t/year to 1200 t/year, depending on total capacity of the VVER serviced from 40 to 60 GW(e);
- **The adjoin MOX production line** to fabricate MOX fuel from all Pu separated;
- **The 4-6 units of BN-1200** to recycle fabricated MOX fuel.

Possible scenarios for BN-1200 MOX SNF management after 2030

1. **In the optimistic scenario,** the MOX SNF from few units of BN-1200 will be reprocessed and Pu will be used for the fabrication of start-up loadings of the innovative FRs operating in the regime of complete closed nuclear fuel cycle.

2. **In the pessimistic scenario,** the MOX SNF from few units of BN-1200 will also be reprocessed, but Pu will be used for the fabrication of MOX fuel for existing VVER reactors. Existence in the system of FRs would permit to realize multiple recycling of Pu in the form of MOX fuel, both in few units of BN-1200 reactors, and in the operating VVER reactors.

Requirements to first BN-1200 on MOX

1. BR - any economically justified value from 1 to 1.3;
2. SNF storage time before reprocessing. For VVER UOX SNF - 4-5 years; For MOX BN-1200 would depend on future scenarios;
3. Proliferation resistance. While reprocessing VVER SNF, separate Pu together with U in equal fractions. Organize the MOX fabrication for BN on the place of RT-2 plant. While exporting VVERs, propose a package – supply of fresh fuel and SNF take-back. Or establish international centre for VVER SNF management;
4. Safety – nothing special;
5. Cost – of proposed infrastructure for VVER SNF management should be acceptable for industry.

Demonstration of feasibility

Within FTP "Nuclear Radiation Safety" Experimental Demonstration Centre EDC (to demonstrate advanced PUREX for VVER SNF reprocessing with a capacity up to 300 t h.m. per year) is planned to be commissioned by 2017.

Our proposal to industry. In addition to the EDC:

1 . Design and build a special line to fabricate MOX fuel for BN-1200 from Pu separated at EDC;

2. Design and build first unit of BN-1200 to recycle fabricated MOX fuel.

Conclusions

A new phase of mastering the FR and CNFC technologies began in Russia with a challenging scientific goal to develop innovative technologies appropriate for large-scale NP development in future.

Meanwhile it is proposed for industry to use demonstrated BN and MOX technologies in addressing present day burning issue of VVER SNF accumulation.

The proposed option would provide possibility to:

- **dispose timely all VVER SNF and by this would minimize time for SNF storage, Am inventory and improve public perception**
- **export VVER with SNF take-back policy;**
- **preserve accumulated in VVER Pu for future;**
- **stabilize Pu inventory in future in case of NP stagnation.**

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Thank you