NUCLEAR INNOVATION IN SPENT FUEL MANAGEMENT

Liudmila Zalimskaya
ROSATOM
Growing Nuclear:
More Spent Nuclear Fuel Generation

Example of SNF volume worldwide accumulation calculated for current NPP fleet size and SNF reprocessing rate

ROSATOM expert estimation, 2017
Main Nuclear Fuel Cycle Trends and Brazilian example

Most NPP operators’ choice in favor of **referred solution** (interim SNF storage) by cause of absence of better scenarios

Lowering **public acceptance** and support issues in some countries, caused by – among others – lack of safe and reliable solutions in back end

Angra 1 and 2 in operation. SNF is stored in the existing spent fuel pools in each NPP. ELETRONUCLEAR choses solution based on SNF cask storage facility. This will save time till 2045. Final decision on SNF disposal is still to be made.

World Nuclear Industry and Brazilian one as well need new nuclear fuel cycle based on innovative solutions and integrated approaches
Key Requirements for New Nuclear Fuel Cycle

✓ To decrease considerably amount and danger of waste to be disposed
  - Obligatory SNF reprocessing
  - High level waste partitioning with the separate treatment of the different fractions
  - Minor actinides transmutation in fast reactors

✓ To enhance fissile materials consumption
  - Recycling of the U and Pu
  - Multi-recycling of U and Pu
  - Pu ‘cleaning’ in the fast reactors

✓ To comply with non-proliferation regime

✓ To be appropriate to reactor fleet
  Taking into account specifics of LWR, PHWR and F
Spent Nuclear Fuel is Quite Specific to be Disposed Better to split it and manage by fractions

Nuclear Waste components radiotoxicity decrease
ROSATOM expert estimation, 2017
What to do with the different SNF fractions
After its partitioning

SNF components possible usage
ROSATOM Vision, 2019

*in the spent nuclear fuel of PWR-1000 reactor after 10 years of cooling
SNF Partitioning
Allows to Minimize NatU Consumption and Amount of Waste

We use now (one cycle)

Spent Nuclear Fuel Composition, reference kg*
ROSATOM Expert Estimation, 2019

*Expert estimation for SNF after 10 years of cooling  **As reprocessed uranium in UO₂ fuel  ***In MOX fuel
The objective is to minimize nuclear waste volume

ROSATOM is offering a number of feasible solutions for minimization of the SNF volume based on the up-to-date innovations.

All the options consider fissile materials recycling:

- Recycling of the reprocessed U and Pu in existing NPP fleet
- REMIX Nuclear Fuel Cycle
- Dual-Component Nuclear Power System
Recycling of the reprocessed U and Pu in existing NPP fleet

**RepU Treatment Chart**

- Reprocessed U3O8
  - Dilution/Purification
  - Conversion
  - Enrichment
  - ERU/UF6
  - Reconversion
  - ERU/UO2 powder
  - Fabrication

**PuO2 based MOX Fuel Fabrication Chart**

- Power reactor grade PuO2
  - MOX-fuel pellet fabrication line
  - Components (spacers, tubes, heads)
  - Fuel assemblies fabrication line

- Depleted UO2
  - MOX-fuel pellet fabrication line
  - Fuel rods fabrication line

- MOX Fuel Fabrication Facility in Zheleznogorsk

- Plutonium blending and affinage unit

- BN-800
Possible Solutions. Rosatom Approach (2/3)

REMIX Nuclear Fuel Cycle

Customer

NPP Irradiation

NPP Cooling Pool

Cooling

5 years

Transportation

SNF Reprocessing

U & Pu Mix

All uranium and plutonium generated during reprocessing

HLW partitioning

Valuable Isotopes Selling

Minor Actinides Burning in Fast Neutron Reactors

RW returning back to Customer for disposal

Customer

NPP VVER/PWR

U & Pu Recycling

U-Pu Fabrication*

80% U-Pu

20% U

Enriched Uranium

Fuel supply (enriched uranium)

NPP Cooling Pool

SNF

RW

RW
Possible Solutions. Rosatom Approach (3/3)

Dual-Component Nuclear Power System

**Dual-Component Power System** = reactors on thermal neutrons (VVER, PWR, BWR) + fast neutron reactor (BN) + SNF reprocessing facility + fabrication facility(ies).
“We are certain that the future of world atomic energy is intrinsically linked to closing of the nuclear fuel cycle, and fast reactor technologies constitute an integral part of it…Considering the scientific and technological backlog we are convinced that the closed fuel cycle is no longer a distant prospect. And we are basically witnessing the first stage of this project’s implementation today. Closing of the fuel cycle will allow peaceful atom to become an environmentally safe source of energy with practically inexhaustible resources for millennia to come. There are all grounds to believe that such a comprehensive product will be offered to the market within the next 10-12 years. In terms of nuclear energy, it is almost tomorrow.”

Alexey Likhachev, ROSATOM CEO
IAEA Ministerial Conference
“Nuclear Power in the XXI century”
17-21.09.2018
Nuclear Fuel Cycle needs to be Smart

<table>
<thead>
<tr>
<th>Customizing: ability to offer the Customer optimal NFC options</th>
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<tr>
<td>Comprehensiveness: readiness to offer NFC solutions, that includes utilization of recovered products, waste volume reduction and its safe disposal</td>
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<tr>
<td>Emphasis on advanced scientific and engineering achievements: involving the partitioning technologies, fast reactors, the best practices in the field of geological disposal of radioactive waste treatment</td>
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<td>International cooperation enhancement in different forms</td>
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- **Most NPP operators’ choice in favor of referred solution** (interim SNF storage) by cause of absence of better scenarios

- **Lowering public acceptance** and support issues in some countries, caused by – among others – lack of safe and reliable solutions in back end

- **Let-up of SNF reprocessing** by some big players, caused by – among others – inefficiency of the solutions in SNF reprocessing itself, in recycling of the RepU and Pu and in waste treatment

- **Delay in performance** of promising international projects due to the infrastructure construction barriers

**Further development of Nuclear is possible only with the new Nuclear Fuel Cycle**
THANK YOU FOR YOUR ATTENTION!