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Reprocessing of SNF from VVER-1000 at Mayak Production Association as an Element of the Nuclear Fuel Cycle Closure. Prospects for Further Development

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Mayak is the leading industrial enterprise in the field of SNF reprocessing in the Russian Federation

ПРОИЗВОДСТВЕННОЕ ОБЪЕДИНЕНИЕ МАЯК
ПРЕДПРИЯТИЕ ГОСКОРПОРАЦИИ «РОСАТОМ»

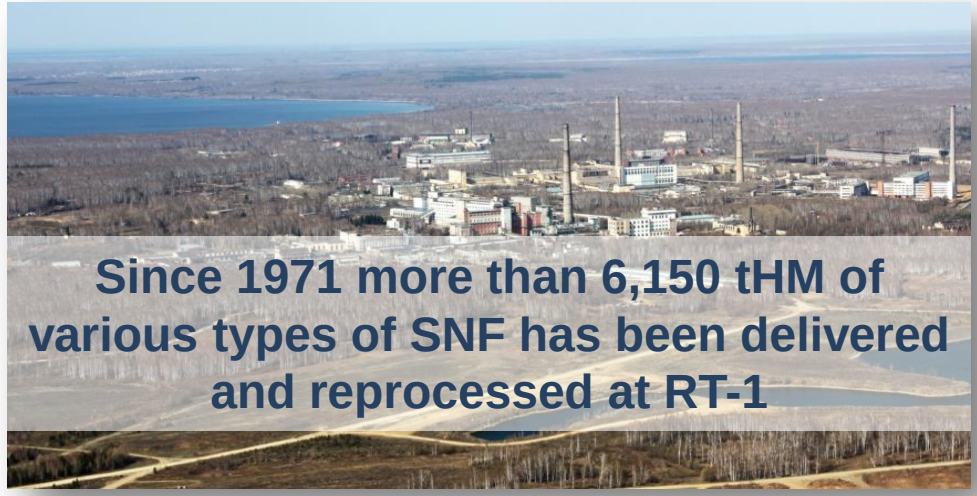
РОСАТОМ

Transportation and reprocessing of practically all types of SNF:

- commercial NPP reactors (VVER-440, BN-600, RBMK-1000, and starting from 2016, VVER-1000)
- navy reactors
- research reactors
- production reactors

and fuel compositions:

- UC, UN, U-Al, U-Be, U-Mo, U_{MET}
- U-Zr starting from 2018



Since 1971 more than 6,150 tHM of various types of SNF has been delivered and reprocessed at RT-1

Shipping SNF from foreign NPPs VVER-440 reactors

Bulgaria
Kozloduy NPP

Hungary
Paks NPP

The Ukraine
Rivne NPP

Czechoslovakia
Bohunice NPP

Finland
Loviisa NPP

GDR
Nord NPP

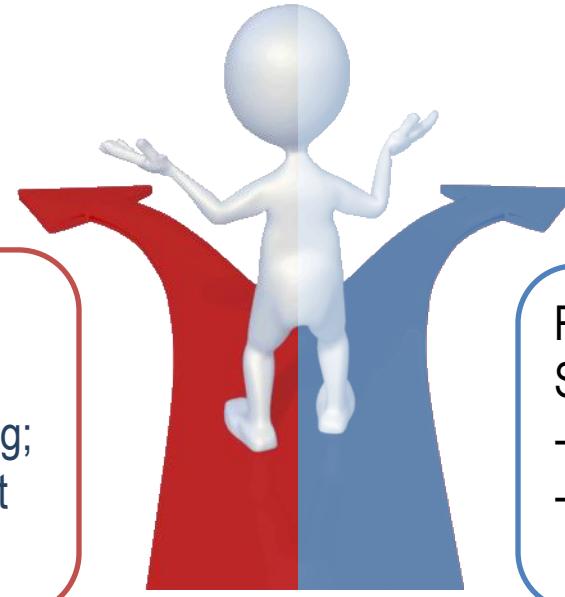
Armenia
Armenian NPP

All reprocessed uranium has been returned into nuclear fuel cycle

SNF management strategy in Russian Federation

Storage

Deferred decision:
- extra costs for storage;
- increase of cost of further reprocessing;
- ecological risks (failure of fuel element claddings)



Reprocessing

Reprocessing is a basic technology of SNF management considering:
- ecological safety;
- economic feasibility and value of reprocessed products

Drivers of decision-making:

- acceptable costs level;
- involvement valuable products recovered from reprocessing into the nuclear fuel cycle; and
- effective solution of RW problem

Background of increase in SNF reprocessing capacity

Volume of accumulated SNF from VVER-1000 in RF:

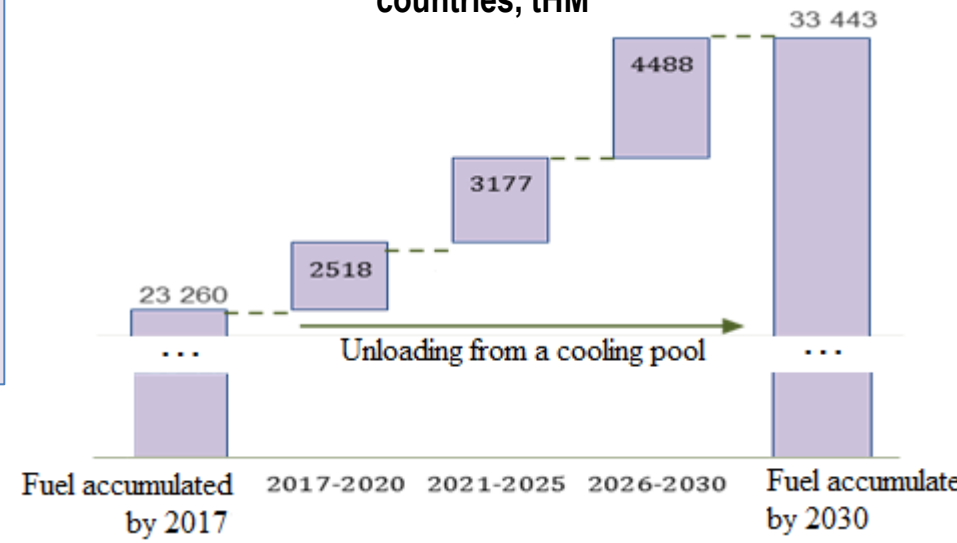
at NPP sites
~ 800 tHM

in interim storage facilities of Mining and Chemical Combine
~ 6,500 tHM

New type of SNF from VVER-1000/1200 reactors in Russia

- **12 units** in operation
- **8 units** under construction

Dynamics of Russian-origin SNF accumulation in foreign countries, tHM



Demand for increase in SNF reprocessing capacity considering new requirements
(costs level, recovered products)

Implementation of VVER-1000 SNF reprocessing at RT-1

2012:

- A decision on RT-1 plant modernization was made.

2016:

- Reconstruction of the third process line was completed.
- The first SNF batch from VVER-1000 (Rostov NPP) was delivered by special train at RT-1.
- 12 SFAs from VVER-1000 (≈ 6 tHM) were delivered and reprocessed.

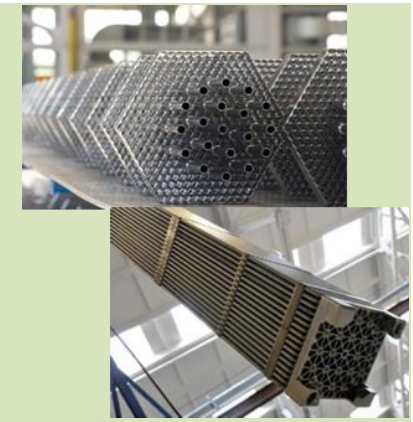
2017:

- Delivery of SNF (20 tHM) from VVER-1000 (Balakovo NPP); evaluation of technical and economic features of VVER-1000 SNF reprocessing at RT-1.
- Feasibility analysis of adopting reprocessing of SNF from VVER-1000 at MAYAK on a regular basis.

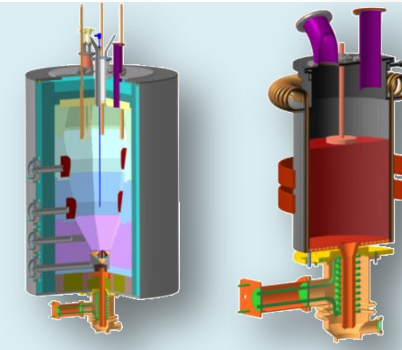
Reprocessing of SNF from VVER-1000 was implemented for the first time in Russia and around the globe

Technological Advances

- SNF reprocessing from the entire range of the present-day thermal reactors (VVER, RBMK, PWR and BWR) is adopted
- Methods of reprocessing of spent MOX-fuel from BN-600 reactor are adopted
  Entire scope of techniques to reprocess SNF from BN-800 reactor is available
- Reprocessing of new fuel compositions (U-Al, UC, UN, U-Be, U-Mo, U_{MET}) is adopted



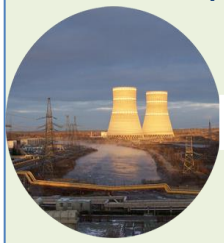
- Innovative solutions for RW management are developed:
  - ✓ Small removable melter (manufacture)
  - ✓ Cold crucible induction melter (bench test)
  - ✓ Facility for long-lived ILW solidification into phosphate compound (commissioning)



- HLW partitioning method was implemented both in pilot and industrial scale
- Techniques to extract minor actinides were adopted:
  in large scale for Np,
  in pilot scale for Am and Cm

Perfect scheme for SNF management

NPPs



Energy production

SNF cooling in a pool

Radiochemical Plant

SNF reprocessing

HLW

NPPs

Energy production

Extracting Pu for Fast Reactor Park
(To load BN-1200 reactor with MOX-fuel,
~ 720 t SNF from thermal neutron reactors should be reprocessed)

Introducing Rep U into fuel supply scheme for thermal neutron reactors

Partitioning RW

ILW

ILW

LLW

Cs, Sr
cooling

Rare earth metals, precious metals

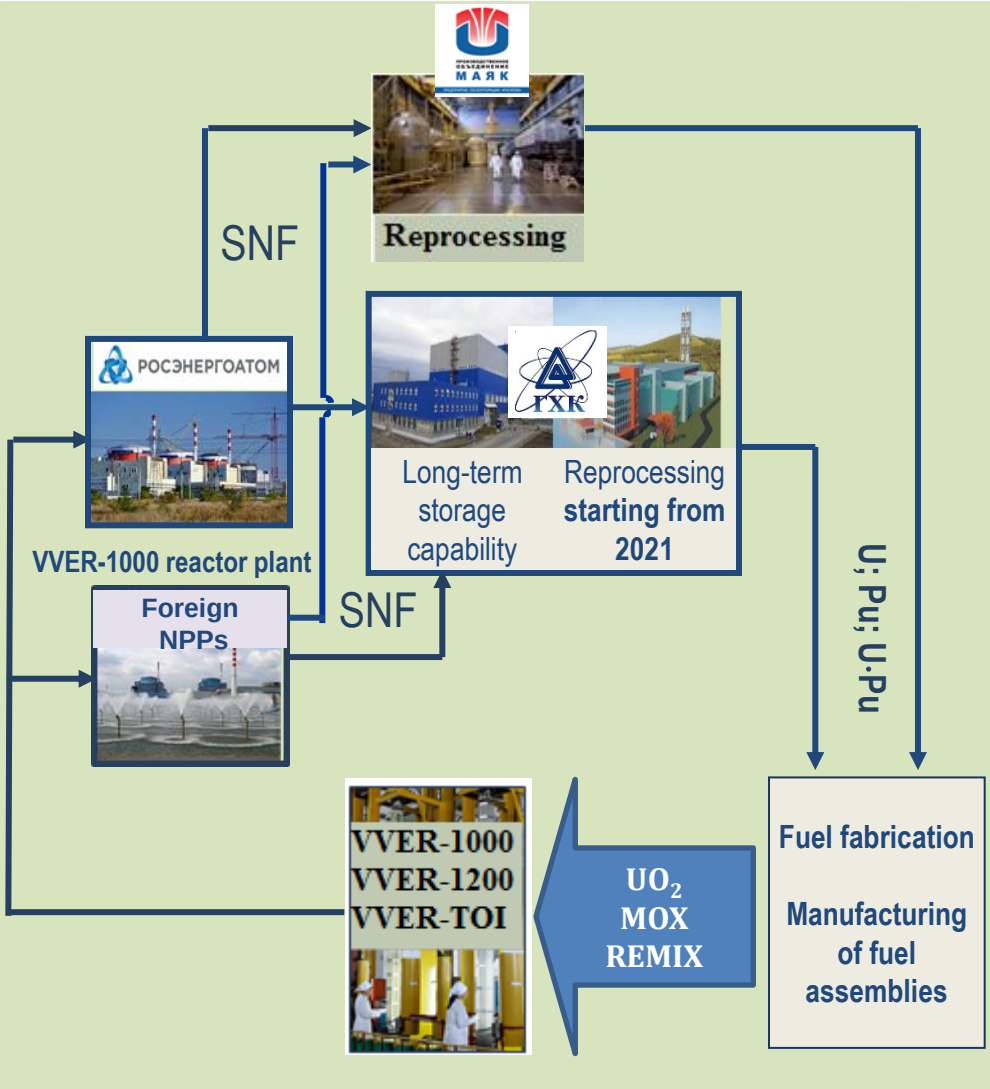
Near surface disposal

Np, Am
burning in fast reactors
(optimal option in terms of neutron balance)

Cm
storage
(decayed to Pu)

Environmental issues, deferred for a long term, are not included into scheme

Developing infrastructure for VVER SNF management



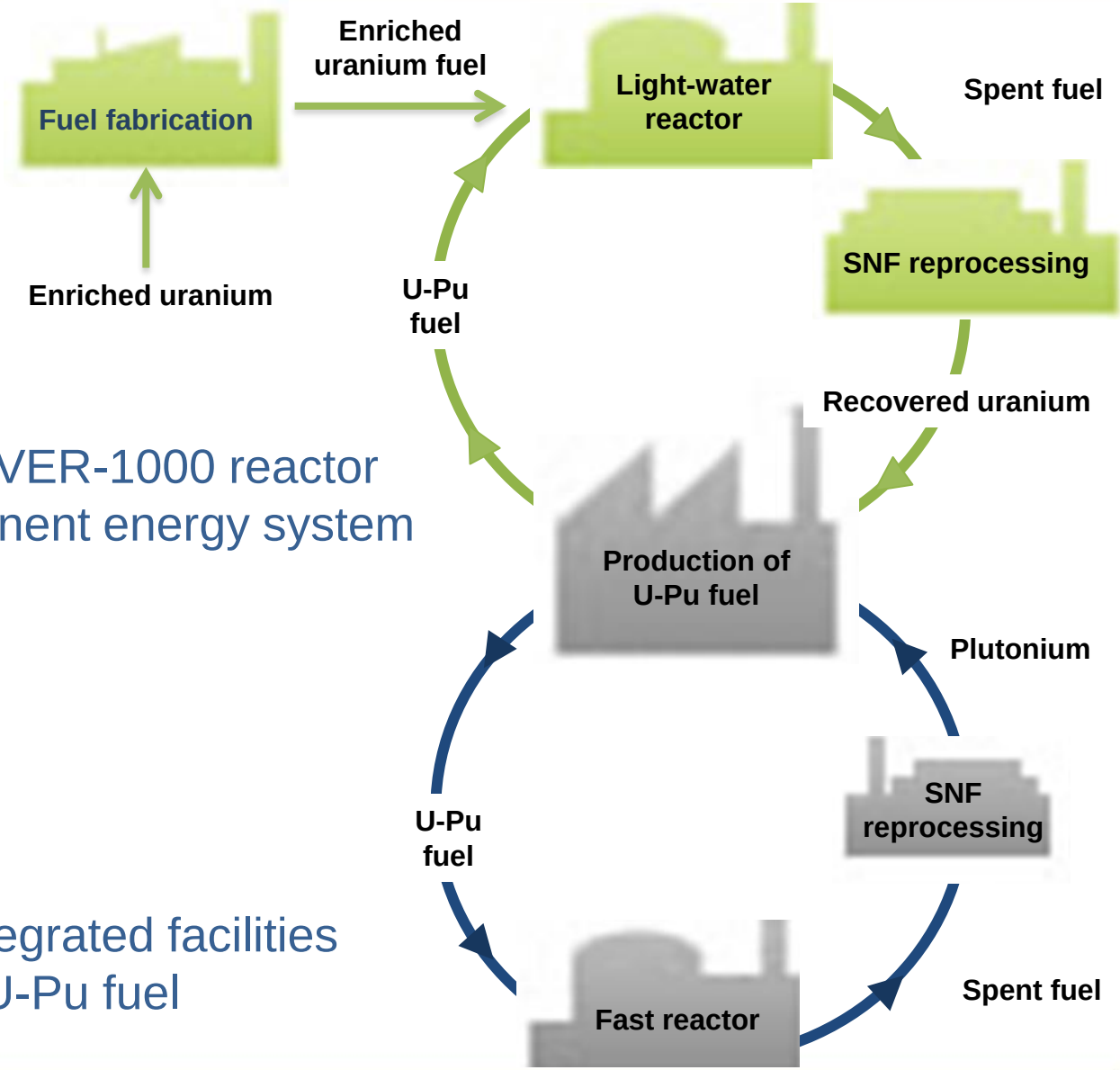
- ✓ Loading of reprocessing capacity of Mayak Radiochemical Plant
- ✓ ability to reprocess the whole range of SFAs from VVER-1000 and 1200 (including SFAs of foreign design, i.e. PWR and BWR):
  - defective SNF
  - SFAs with higher enrichment and burnup
  - standard (experimental and serial) SFAs
- ✓ capability to decrease rates of SNF accumulation

The infrastructure developed creates a possibility to close the nuclear fuel cycle within two-component system

Two-component energy system

Reprocessing of SNF from VVER-1000 reactor is the first step to a two-component energy system

The next step is: to establish integrated facilities for production of mixed U-Pu fuel



Conclusion

Reprocessing VVER-1000 SNF at Mayak will provide:

Closure of nuclear fuel cycle for the main types of power units

Flexibility of SNF management system *(storage – reprocessing)*

Capability to develop over Russian atomic energy sector to two-component energy system