Technical Meeting on Cost Estimation Methodologies for Spent Fuel Management

State atomic energy corporation “Rosatom”

Russian SNFM strategy. Methodologies for Spent Fuel Management cost estimation

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Mission and responsibilities of the State Corporation “Rosatom”

- ROSATOM's mission is to maintain national interests in defence, nuclear safety and nuclear power by achieving global leadership in advanced technologies, competencies and innovations.

- State management in atomic energy use, including:
  - Taking part in the development of the State Policy in the field of atomic energy use.
  - Recognizing organizations as operating organizations.
  - Emergency response.
  - Powers of a competent body for transportation of nuclear materials and radioactive substances.
  - State accounting and control of radioactive substances and RW, accounting nuclear materials.
  - Powers and functions of a state management authority in the field of RW management.
- International cooperation.

Implementation tools of the National Policy

1. **Regulatory framework:**
   - **№170-FZ «On the Use of Atomic Energy»;**
   - **№190-FZ «On the Management of Radioactive Waste…»;**
   - **№3-FZ «On the Radiation Safety of Population»;**
   - **№52-FZ «On Sanitary and Epidemiological Welfare of Population»;**
   - **№7-FZ «On the Environmental Protection»;**
   - **№317-FZ «On the State Atomic Energy Corporation “Rosatom”»**
   - **and etc.**
2. **Powers of management authorities**
3. **State programs and state contracts**
4. **Efforts of operating organizations**

State policy in the field of SNF and RW management

- Development of integrated infrastructure for SNF management
- Transfer of SNF to reprocessing
- Construction of near-surface LL&ILW disposal facilities and deep disposal HLW facility
- Development of innovative technologies for decommissioning and SNF/RW management
- Remediation of contaminated sites
- Dismantling of nuclear service vessels and icebreaker ships

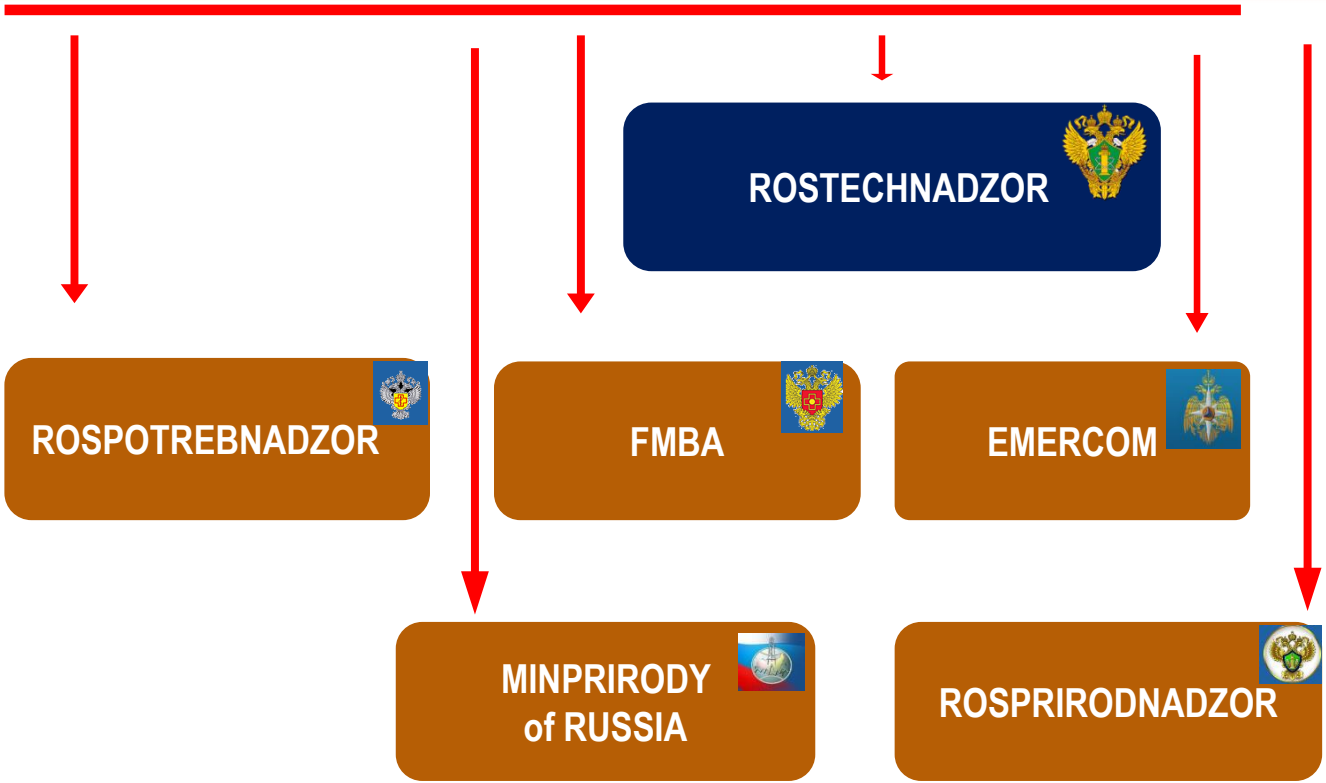
Russian State policy in the field of SNF and RW management (JC matrix- 2018)

Type of Liability	Long Term Management Policy	Funding of Liabilities	Current Practice / Facilities	Planned Facilities
Spent Fuel	Temporary storage Reprocessing	State Operating organisation (operator)	Dry and wet storage (MCC, PA Mayak and at-reactor storage) Reprocessing (RT-1 plant at PA Mayak, the first start-up unit of a Pilot Demonstration Center at MCC site)	The second start-up unit of a Pilot Demonstration Center at MCC
Nuclear Fuel Cycle Waste	Treatment and transfer to the National Operator for disposal Remediation of uranium mining and milling sites Facilities holding special (non-retrievable) RW and disposal facilities for special RW are being upgraded to RW disposal facilities	State Operating organization (operator) Special Reserve Fund	Processing and storage at the sites of operating organizations (operators) Transfer for storage and reprocessing to specialized organizations (FSUE RosRAO, FSUE Radon) RW (LLW and ILW) are disposed of in the first unit of a near-surface disposal facility located at the UECC site Deep well injection of LRW Processing and analysis of the data from the Initial Registration of RW and RW sites, development and approval by the Government of the Russian Federation of lists covering RW disposal facilities, RW long-term storage facilities, facilities holding non-retrievable RW and disposal facilities for non-retrievable RW. Relevant information was filled into the SGUK RV and RAO data base.	Near-surface disposal facility for LLW and ILW located in the restricted administrative and territorial entity Ozersk (Chelyabinsk Region) in the vicinity of PA Mayak Near-surface disposal facility for LLW and ILW located in the restricted administrative and territorial entity Seversk (Tomsk Region) in the vicinity of SCC Underground research laboratory required to investigate the proposed ILW and HLW deep disposal concept

Russian State policy in the field of SNF and RW management (JC matrix-2018) (2)

Type of Liability	Long Term Management Policy	Funding of Liabilities	Current Practice / Facilities	Planned Facilities
Application Wastes	Treatment and subsequent transfer to the National Operator for disposal	State Operating organization (operator) Special Reserve Fund	Treatment and storage at the sites of specialized organizations (FSUE RosRAO, FSUE Radon)	RW (LLW and ILW) disposal facilities
Decommissioning	Decommissioning Program	State Operating organization (operator) Special Reserve Fund	Two pilot demonstration centres were established: • PDC for production uranium-graphite reactors decommissioning; • PDC for WWER-type NPP unit decommissioning. In 2014 – 2017, a total of 22 NRHFs were decommissioned, including: • PURG EI-2 at SCC; • Building B at VNIINM site (located within Moscow city boundaries).	82 NRHFs are scheduled to be decommissioned by 2025.
Disused Sealed Sources	Treatment and subsequent transfer to the National Operator for disposal	State Operating organization (operator) Special Reserve Fund	Storage at the sites of specialized organizations (FSUE RosRAO – 2,200,000, FSUE Radon – 488,000, PA Mayak – 52,800, MCC – 46,100, RIAR – 29,400, SCC – 21,300)	RW disposal facilities

State nuclear safety regulation authorities



Russian Nuclear Power Plants: 36 nuclear power units, ≈30 GW

They produce ≈19 % of the electricity generated in the country.

- **VVER-1000/1200: 16 units (13 units VVER-1000 + 3 units VVER-1200) in operation**
  - **4 units under construction (Kursk NPP -2 units, Leningrad NPP-1 unit, FNPP)**

•RBMK-1000: 10 units in operation (1-in the course of decommissioning)

•VVER-440: 5 units in operation till 2030, 3 units are in the course of decommissioning

•EGP-6: 3 units in operation, 1- in decom.)

•BN-600 (FR) 1 units in operation

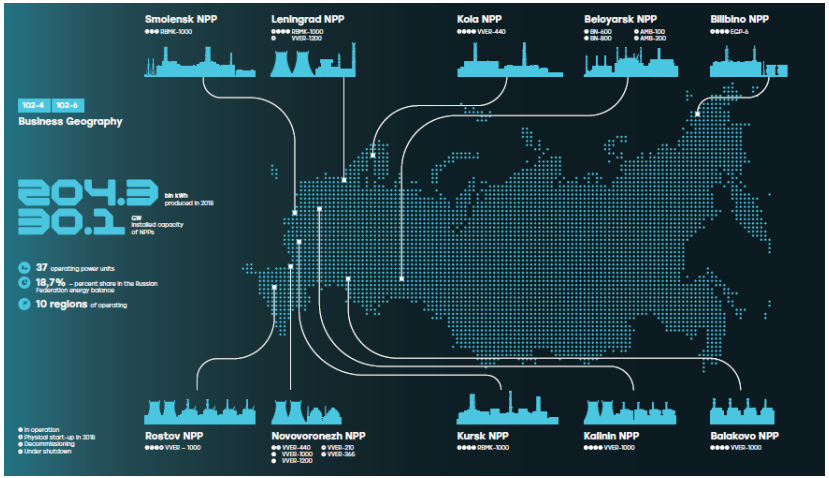
•BN-800(FR) 1 unit in operation

•FTNPP 1 unit - "Academician Lomonosov"

will replace Bilibino NPP (shout down in 2018-2021 years)

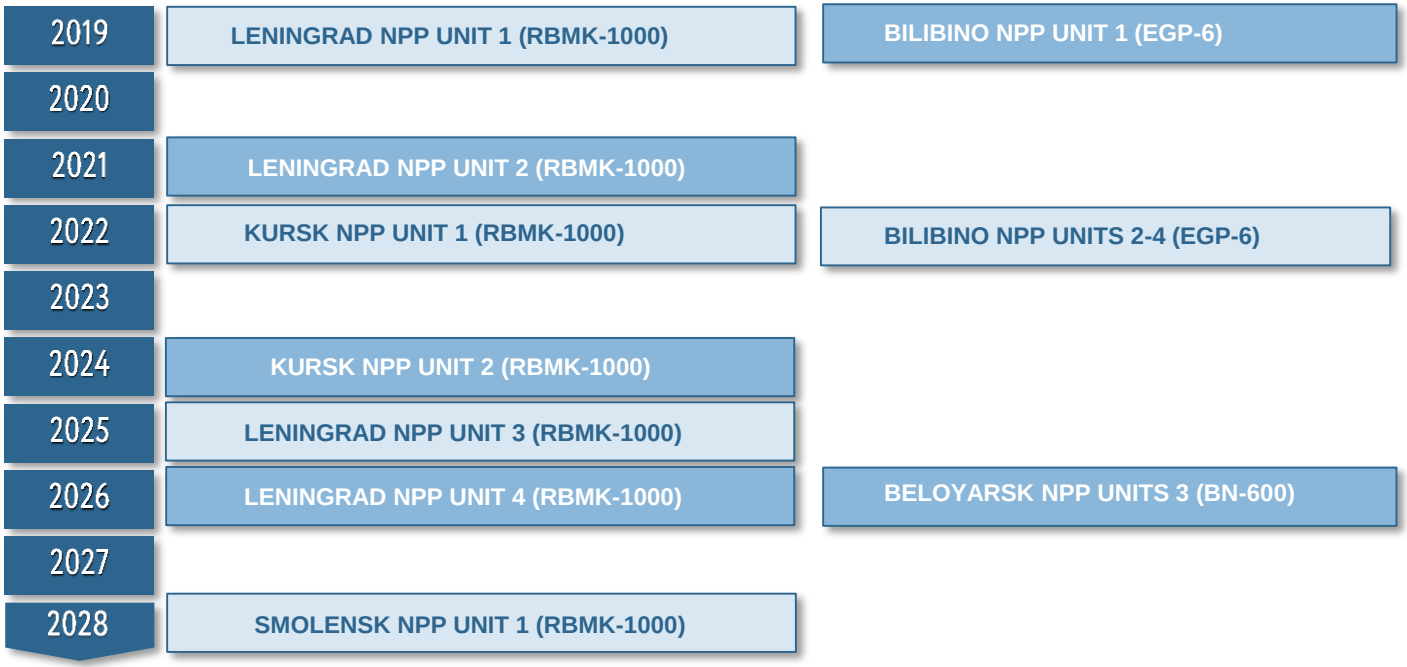
•Research reactors, Ice-breakers

•Submarines



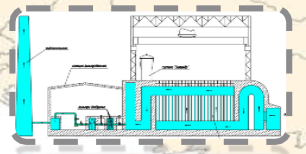
SNF in storage- 23,9 ktHM,
incl. AFR Wet storage on site- 9,8 kt HM,
AFR wet storage (on centralized sites)- 8,2 kt HM, AFR dry storage (on centralized site) – 2,6 kt HM.

Plans for NPP units shut down



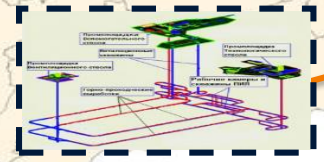
SNFM infrastructure for centralized management in Russia

Reprocessing any type of SNF



Partitioning and isotopes production

Modernization of the HLW management infrastructure



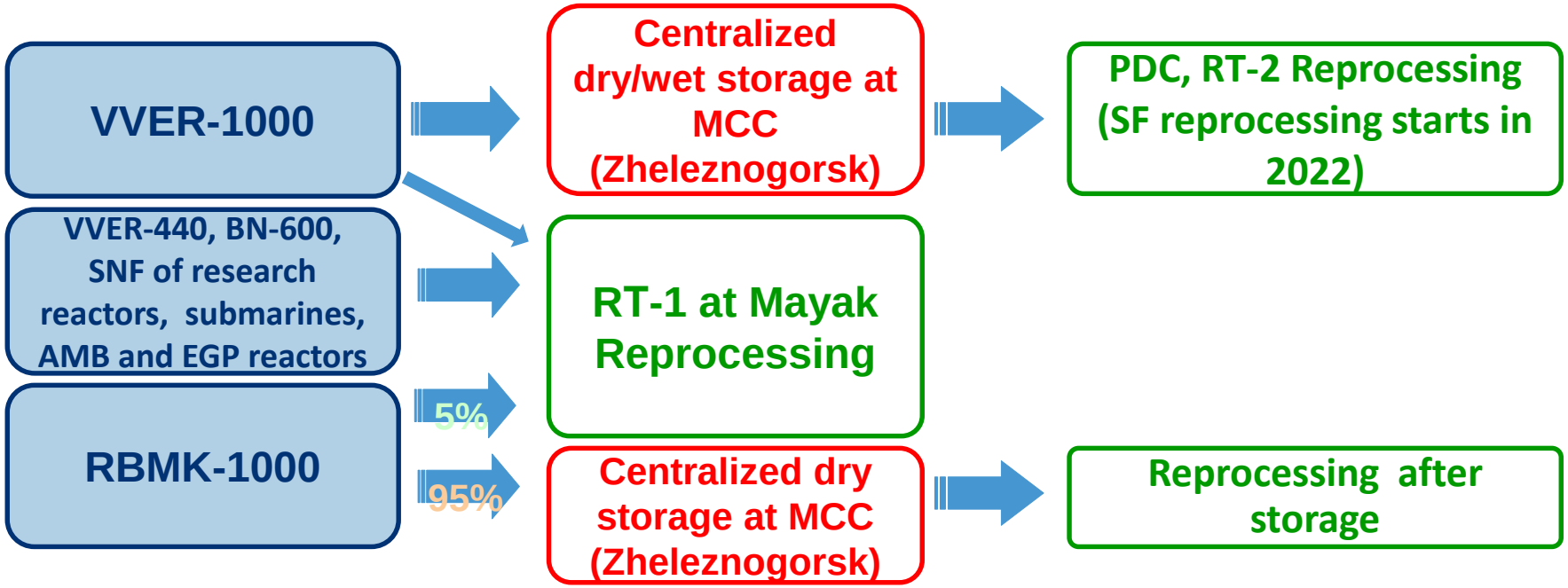
SNF
Centralized wet and dry storage facilities

Test Demonstration Centre for SNF reprocessing (commissioning in 2021)

Underground research laboratory (commissioning in 2024)

MOX-fuel for BN-800 fabrication

Technologic Patterns of SNF Management: Temporal Storage and Reprocessing



Reprocessing is a basic method of SNF management

SNF Reprocessing at PA Mayak

- **Routine reprocessing of** WWER-440, BN-600, nuclear submarine, research and production reactor SNF.
- 2016 – starting the industrial reprocessing of **RBMK-1000 SNF unsuitable for storage**.
- Starting the industrial reprocessing of **WWER-1000 SNF**.
- **AMB SNF:** pilot shipment from Beloyarsk NPP in 2016, regular shipment – since 2017.

- **Research reactor SNF shipment activities**
  - RIAR - Dimitrovgrad
  - IPPE, NIFHI - Obninsk
  - NITI, PNPI - Leningrad
  - MEPhI, NRC Kurchatov Institute - Moscow
  - NIIP - Moscow Region
  - IRM - Ekaterinburg
  - and other

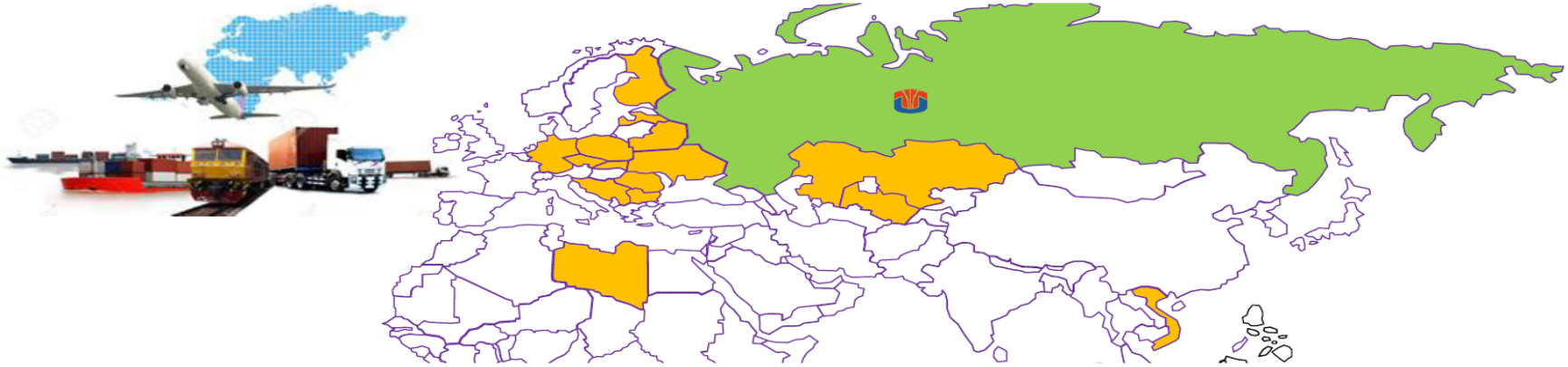
SF from foreign NPP received and reprocessed at Mayak plant

ROSATOM

Bulgaria VVER-440 | Hungary VVER-440 | Ukraine VVER-440 | Kazakhstan BN-350 | Finland VVER-440 | Slovakia KS-150 | Armenia VVER-440 | Germany(GDR) VVER-440

SHIPMENT OF SNF FROM FOREIGN POWER REACTORS OF RUSSIAN ORIGIN

Since 1971 **over 2 400 tU** has been shipped from NPPs of 7 countries



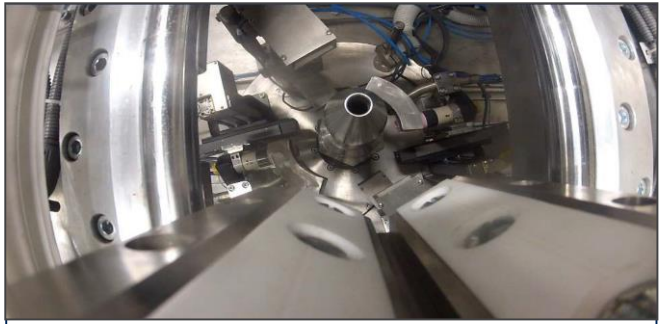
SHIPMENT OF SNF FROM FOREIGN RESEARCH REACTORS OF RUSSIAN ORIGIN

Since 2006 **over 1 200 kg** of high-enriched uranium has been shipped from 13 countries

Uzbekistan | Czech Rep. | Bulgaria | Ukraine | Libya | Hungary | Belarus | Kazakhstan | Poland | Latvia | Vietnam | Romania | Serbia

SNFM infrastructure in Mining &Chemical Combine

Centralized wet and dry RBMK &VVER-1000 SNF storage facilities

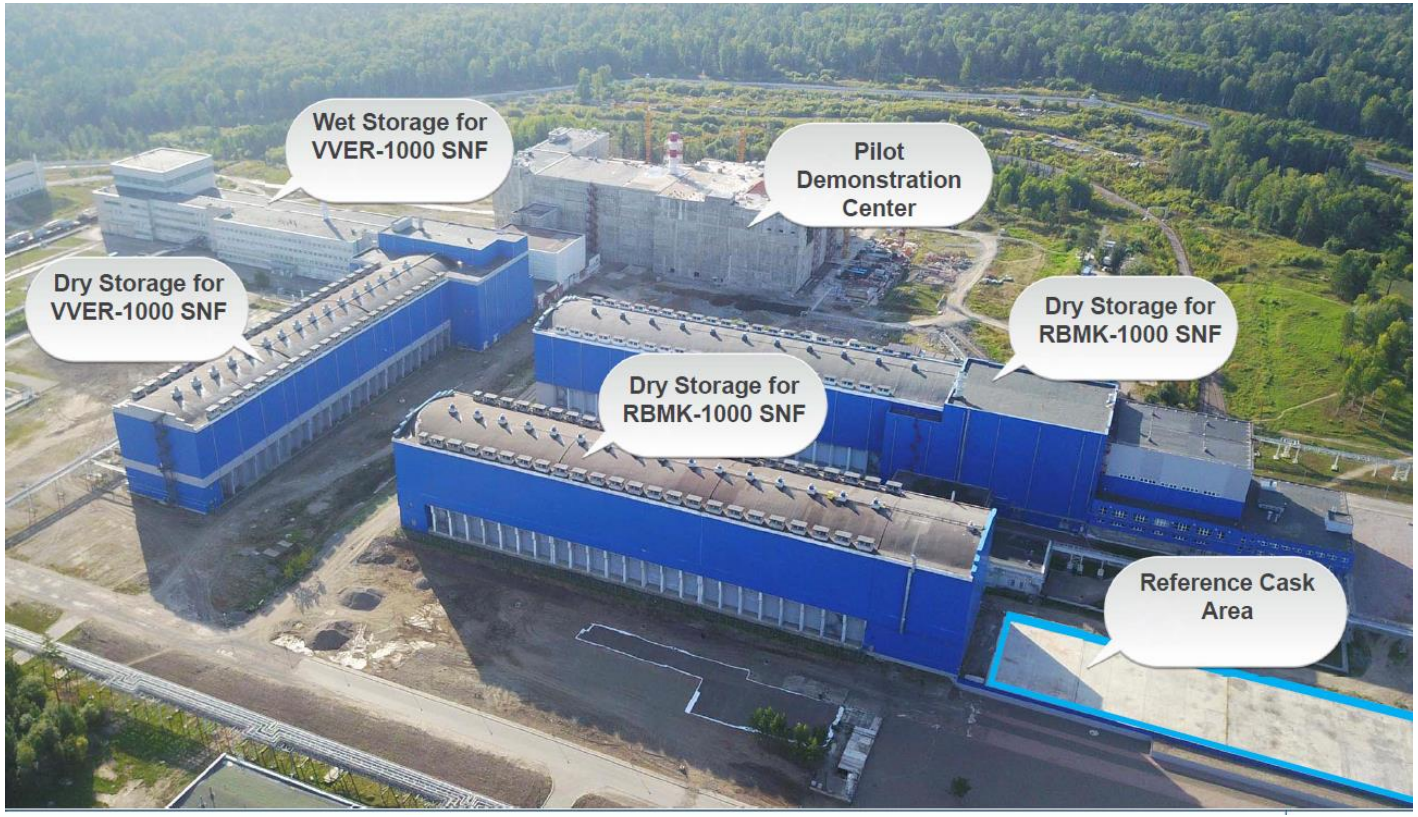


MOX-fuel for BN-800 fabrication

Centralized wet SNF storage facilities

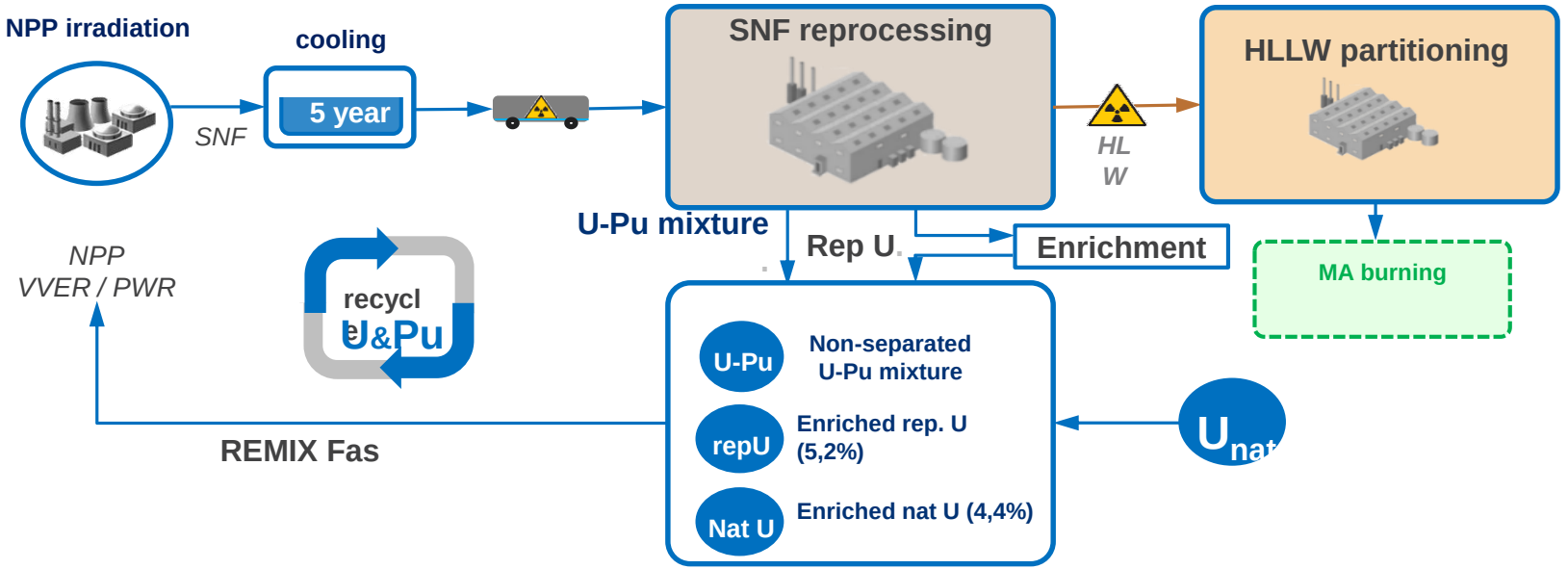
Test Demonstration Centre for SNF reprocessing

SNFM infrastructure in MCC (2)

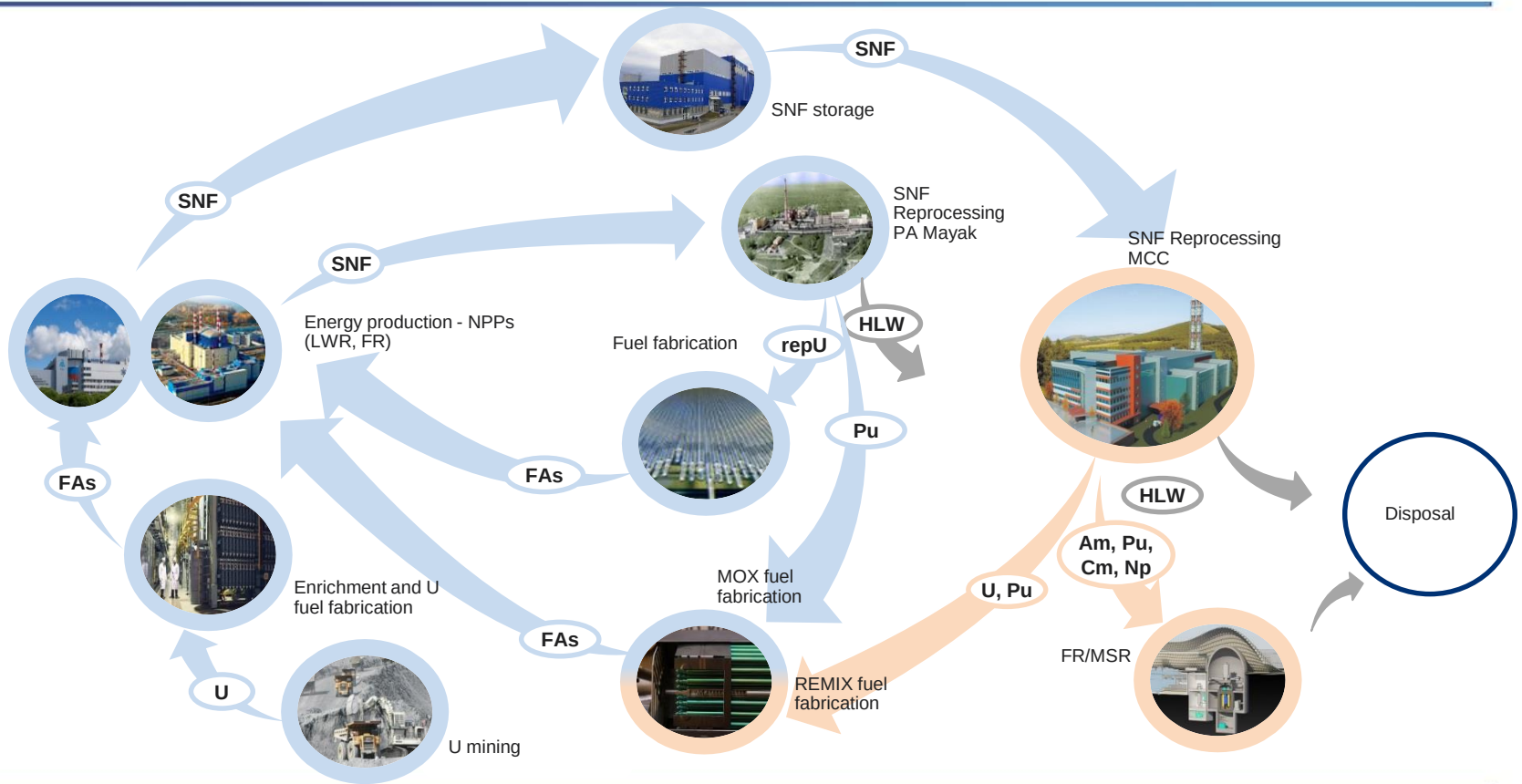


REMIX fuel – U& Pu multi - recycling in LWR reactors

REMIX fuel is the mixture of U and Pu from LWR SNF reprocessing, with the addition of enriched uranium (natural or rep. U) .
REMIX fuel enables multiple recycling of the entire quantity of U and Pu from SNF, with the 100% core charge and 20%- saving of natural uranium in each cycle.



Infrastructure of Advanced Fuel Cycles in Russia



Unified State System for RW Management

2011-2014 | **2015-2017** | **2018-2025**

1st stage

Legal framework development

Establishment of the «National Operator on RW Management»

Proposals on RW repository candidate sites

Disposal tariffs approval

RW inventorying

RW reserve fund establishment

2nd stage

Establishing LLW & ILW disposal system

Federal district/region	Site	Status
Urals / Sverdlovsk	Uralsk Electrochemical Combine	1st unit was commissioned, 2nd unit is under construction
Urals / Cheliyabinsk	PA Mayak	Design development
Siberian/ Tomsk	Siberian Chemical Combine	Design development
Central	-	Siting process in progress
Volga	-	
Southern	-	
North-Western	-	

3rd stage

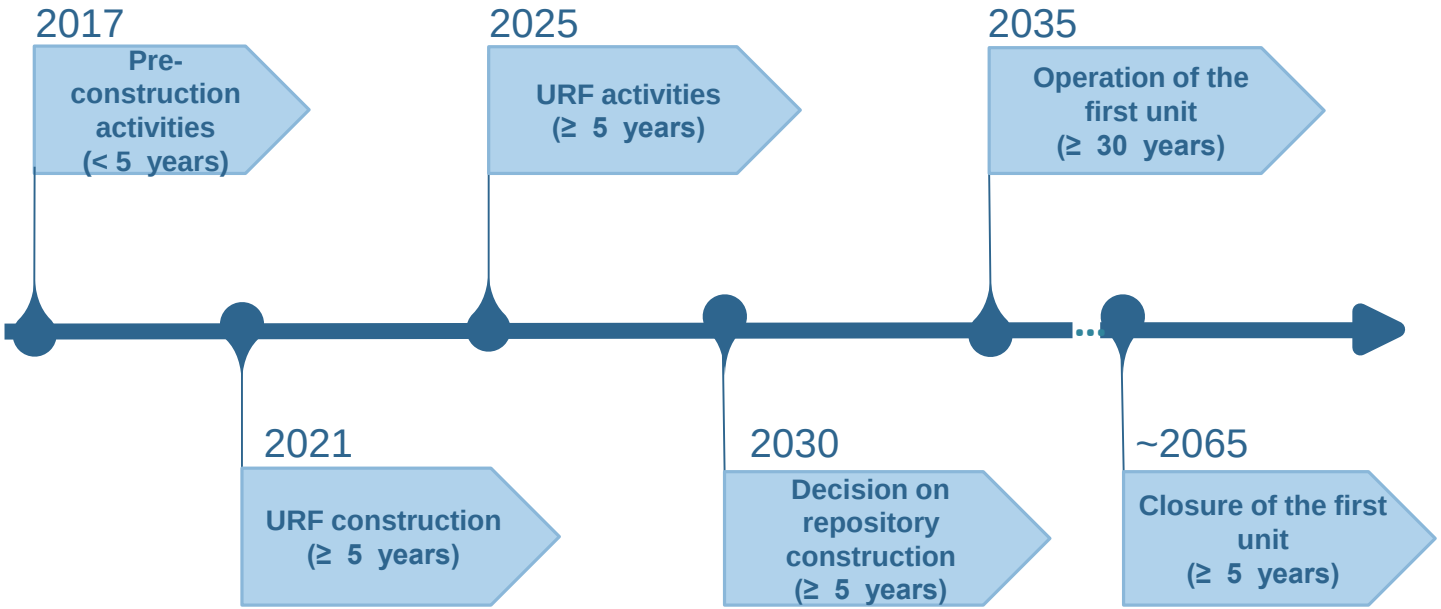
Underground research facility (laboratory) construction

Commissioning of **LLW & ILW** repositories (up to **200,000 m³**)

Additional capacities for RW processing

Closure of non-retrievable RW **storage facilities**

Geological Disposal: the Strategy



The model for assessing SNF management financial obligations in the framework of International Financial Reporting Standards.

The calculation of the cost of SNF management in the framework of International Financial Reporting Standards is carried out in the following sequence

- selection of a standard of International Financial Reporting Standards, within the framework of which the calculation is made
- selection of the type of ownership of spent nuclear fuel to be evaluated
- selection of the technological chain for the management of spent nuclear fuel and the management of radioactive waste generated during the processing of spent nuclear fuel
- selection of the prices corresponding to the given chain and the stage of SNF management, as well as the duration of the stages for this chain
- calculation of the cost of each stage of the SNF handling chain, taking into account the duration of the stage
- calculation of the cost of the spent nuclear fuel management at the prices of the reporting period;
- calculation of the cost of the entire chain of stages of spent nuclear fuel management, taking into account the schedule of obligations (taking into account inflation);
- calculation of the current cost of spent nuclear fuel management (including discounting).

The basic formula of the discount method

- The basic formula of the discount method is as follows:

- $V = \sum_{k=1}^{n} PV_k = \sum \frac{(CF)_k}{(1+q)^k} = CF_0 + \frac{CF_1}{1+q} + \frac{CF_2}{(1+q)^2} + \cdots + \frac{CF_n}{(1+q)^n}$

- V is the value of the object;
  PV_k– current value of the k-th cash flow;
  CF_k– income received by the owner in the k-th year;
  q -is the discount rate;
  n -is the number of forecast periods.

The selection of the technological chain for the SNF management and RW management (generated during the SF reprocessing)

SNF management technological chain represents a technological scheme (set of stages) for SNF management.

Each stage in the structure of the technological chain corresponds to a specific cost and stage duration

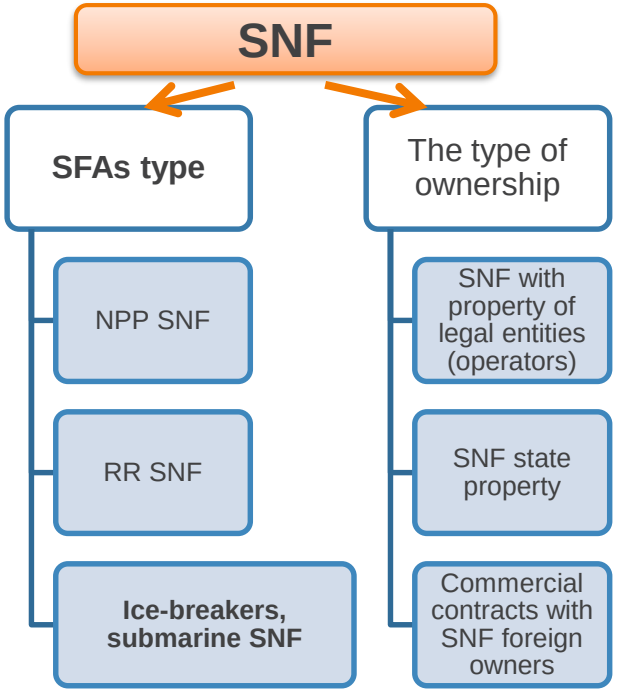
- preparation for SNF transportation;
- SNF transportation and accommodation in SNFM centralized site;
- centralized storage of spent nuclear fuel;
- reprocessing of spent nuclear fuel (including vitrification of highly active LRW);
- storage of vitrified HLW;
- conditioning of radioactive waste of other classes;
- transportation of all radioactive waste to the disposal site
- disposal of all types RW

RW management

Determination of the cost of long-term storage, transportation and disposal of radioactive waste

- The storage schedule for vitrified HLW from spent nuclear fuel reprocessing was based on the assumption that such radioactive waste is stored for 20 years starting from the next year after spent nuclear fuel reprocessing and their formation.
- The volumes of HLW are determined in accordance with the coefficients established by the Methodological approach for calculating the costs of RW management from spent nuclear fuel reprocessing (in dependence of SNF type).
- The cost of all classes RW conditioning is included in the cost of reprocessing spent nuclear fuel
- The cost of HLW shipment to the repository is determined at 15% of the cost of the disposal of radioactive waste in the repository for HLW.
- The cost of LLW and MLW transportation, formed from the reprocessing of spent nuclear fuel at Mayak PA, will be equal to 0 ; for MCC - 5% of the cost of disposal of LL&MLW.
- The cost of RW disposal in the disposal site is estimated at the disposal tariff applicable in the year of SNF shipment from NPP.

Approach to assessing SNF management financial liability

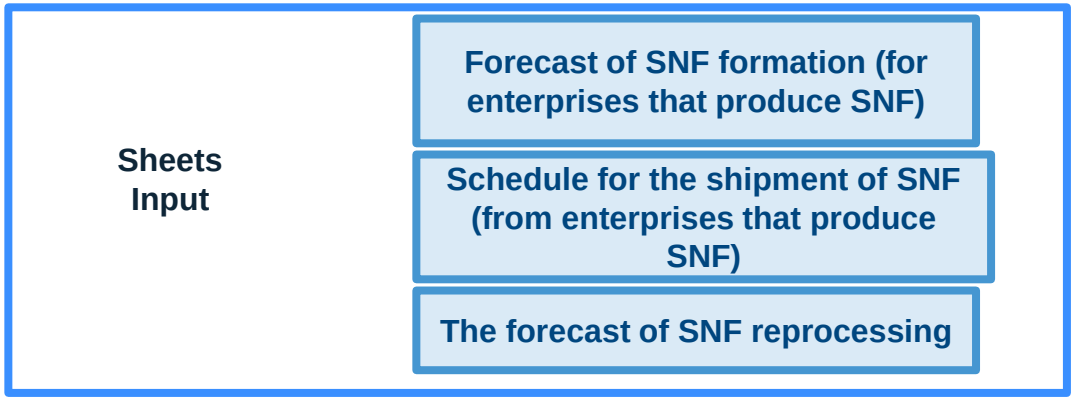


The concept of SNF management including the transport and technological scheme are developed:
for each type of fuel assembly
for each type of ownership of spent nuclear fuel

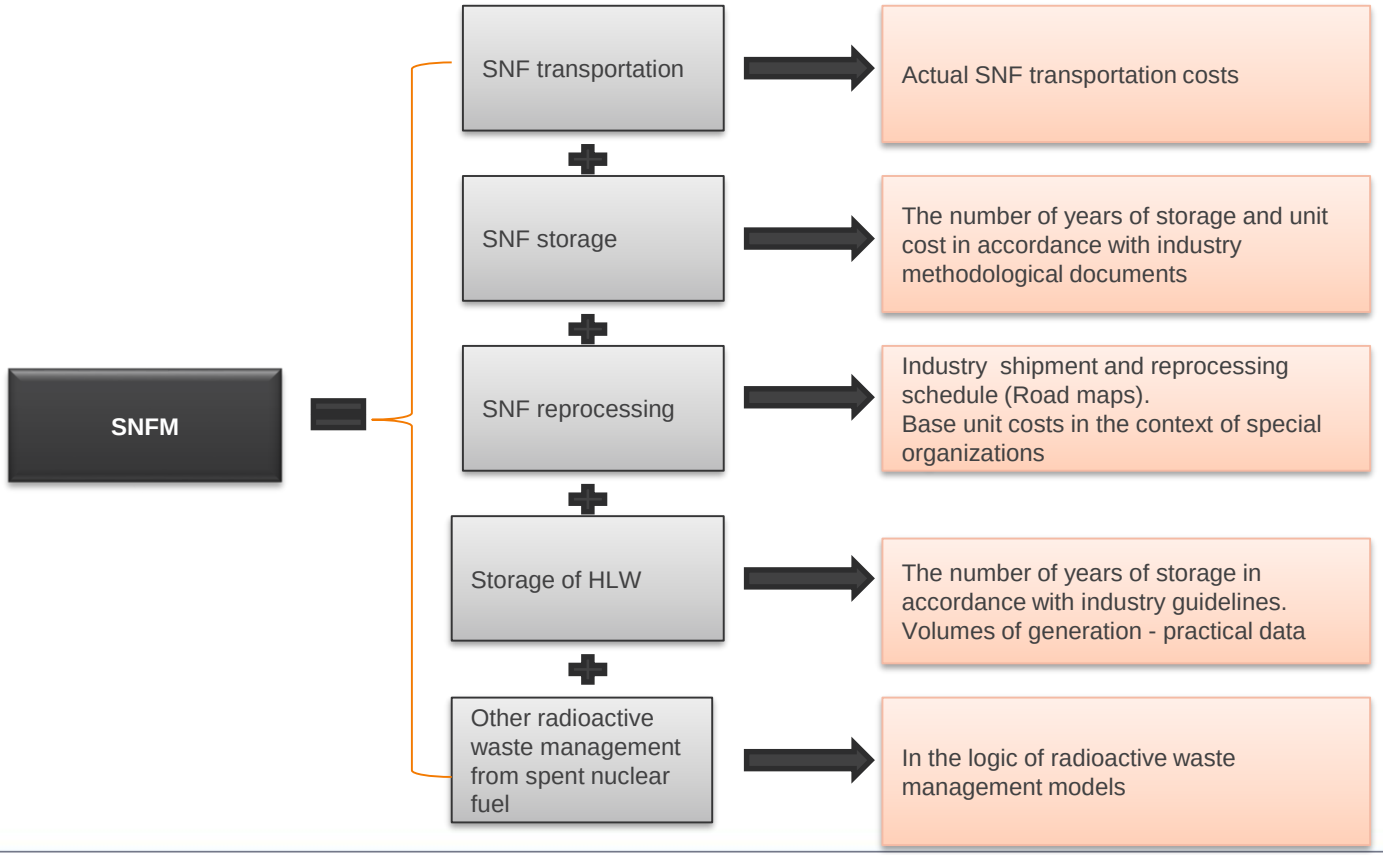
Road maps in the field of SNF management

1. Road maps in the field of SNF management contain data on the amount of SNF generation, SNF shipment to the SNF reprocessors site schedules, as well as a forecast schedule for SNF reprocessing

2. Road maps are designed as a survey form in MS Excel:



Approach to assessing SNF management financial liability(2)

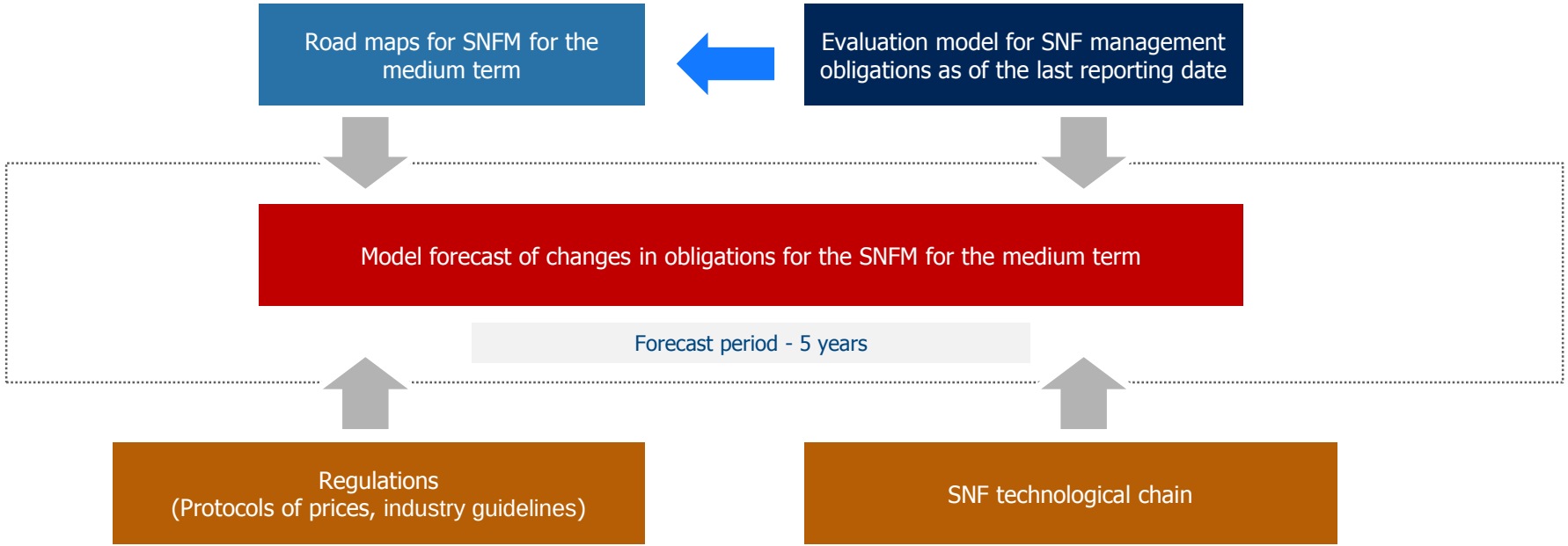


Comparative analysis. The model for assessing SNF management financial liability and the forecasting model of changes in SNFM financial liability

Comparative analysis . The model for assessing SNF management financial liability and the forecasting model of changes in SNFM liability

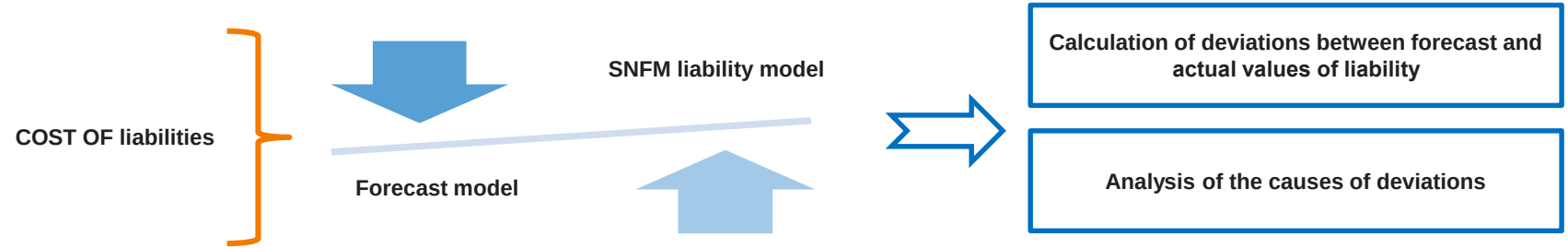
The model for assessing SNF management financial obligations is a tool for generating financial statements taking into account their actual performance

The forecasting model of changes in obligations in the field of SNF management – is a tool for identifying and analyzing potential changes in estimated commitments for SNFM in the medium term

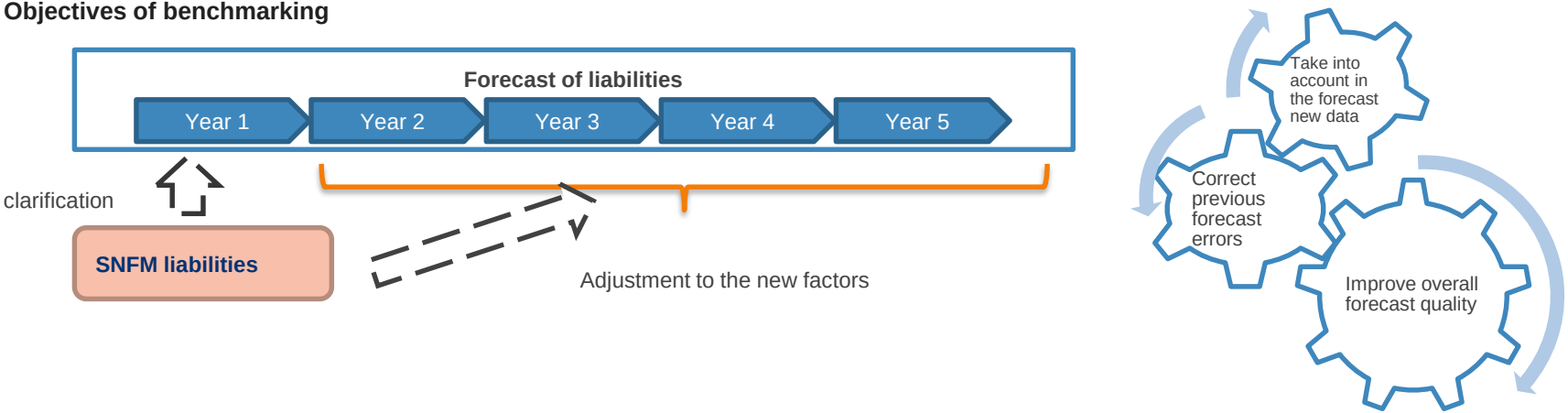


The forecasting model of changes in SNF management liabilities

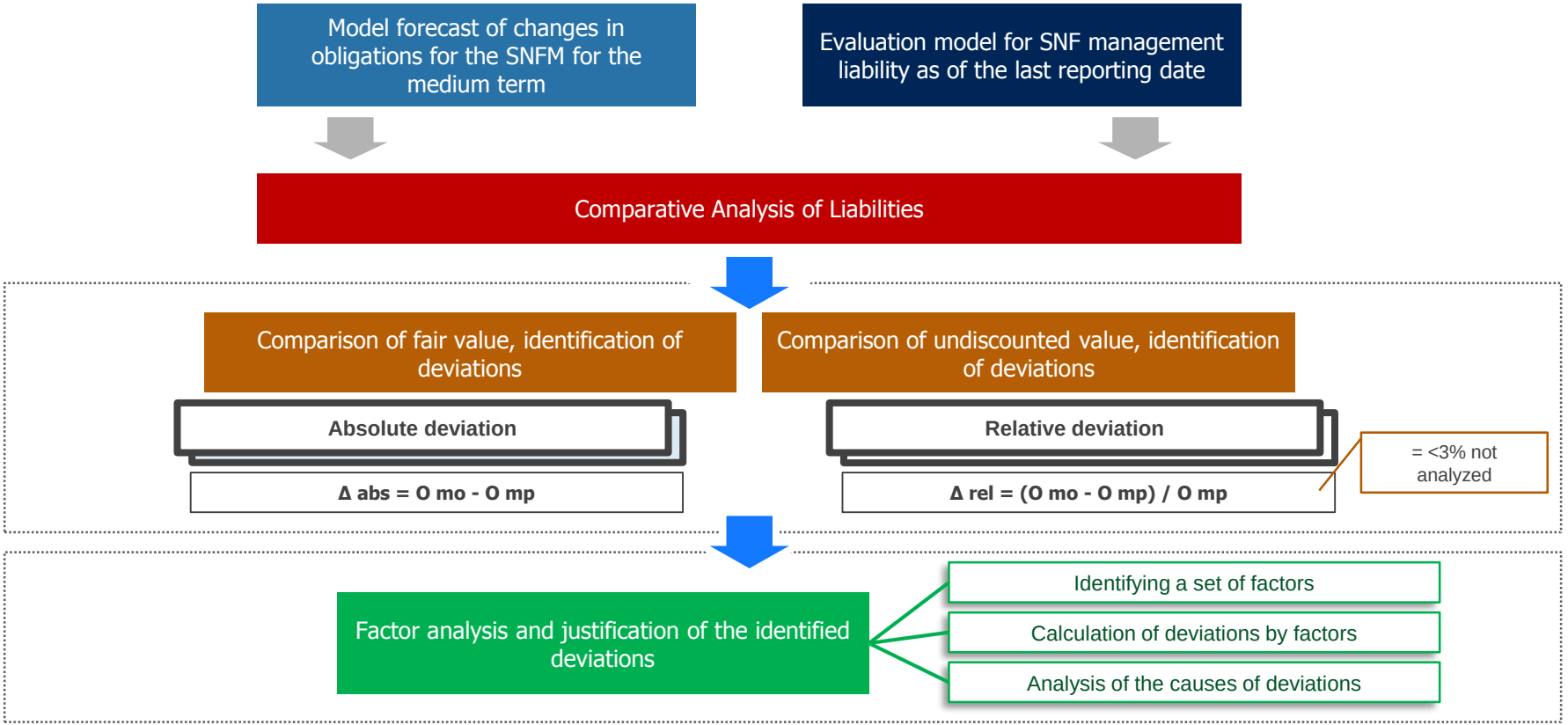
Objects of comparative analysis



Objectives of benchmarking



Approach to benchmarking



Factor analysis

Factor set for SNF obligations

External factors

- Change in inflation forecast
- Change in discount rate

Internal factors

- Change in SNF volumes
- Change in cost of the stages
- Change of the SNF shipment schedule

Analysis of the causes of deviations

Due to what arose?

Was it possible to immediately take into account equally?

How to justify and adjust the model?

Important: based on the comparison and selection of factors
forecasting model for the following periods is specified

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