State Atomic Energy Corporation "Rosatom"

FSUE "Mining and Chemical Combine"

Safety of SNF "wet" and "dry" storage facilities

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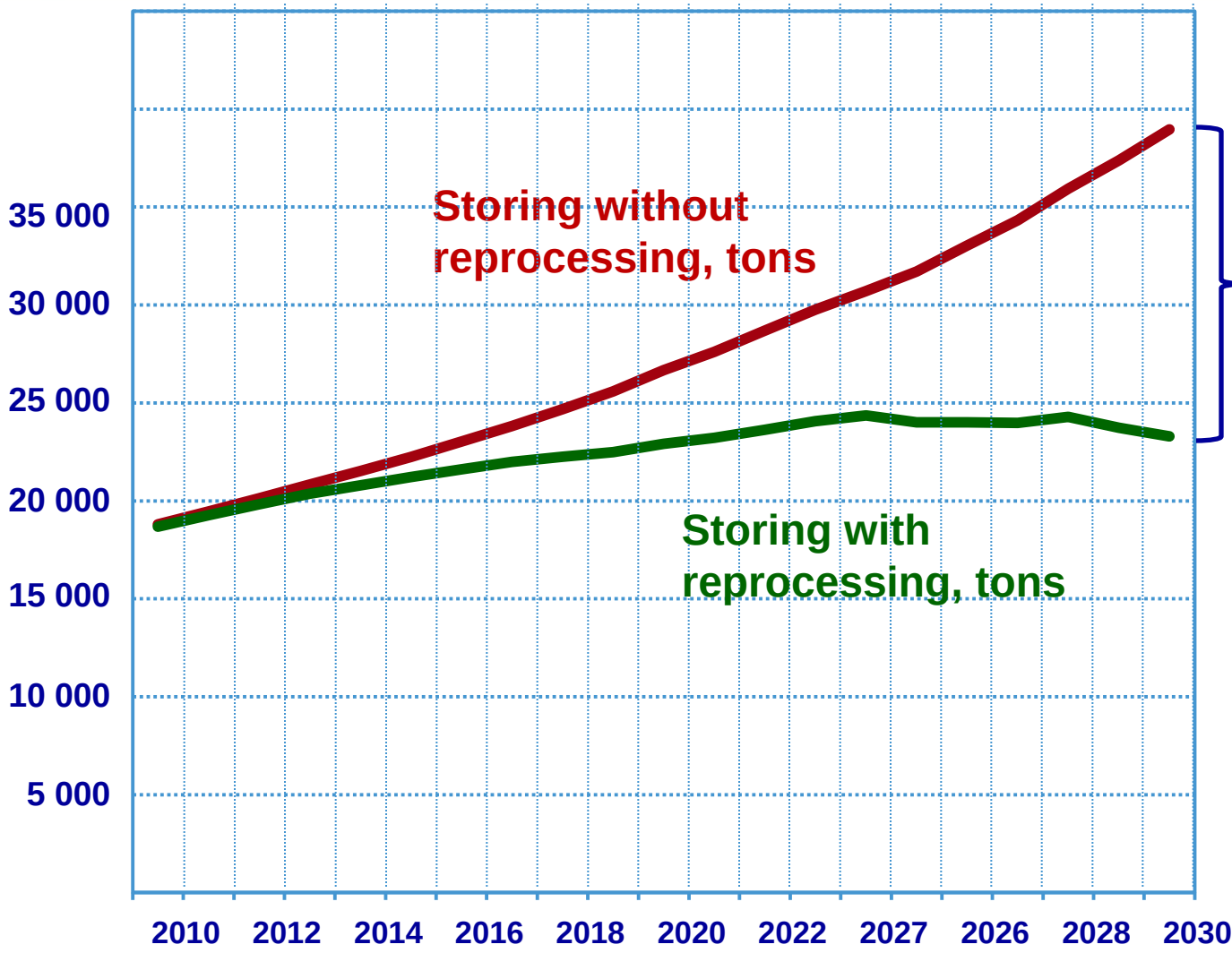
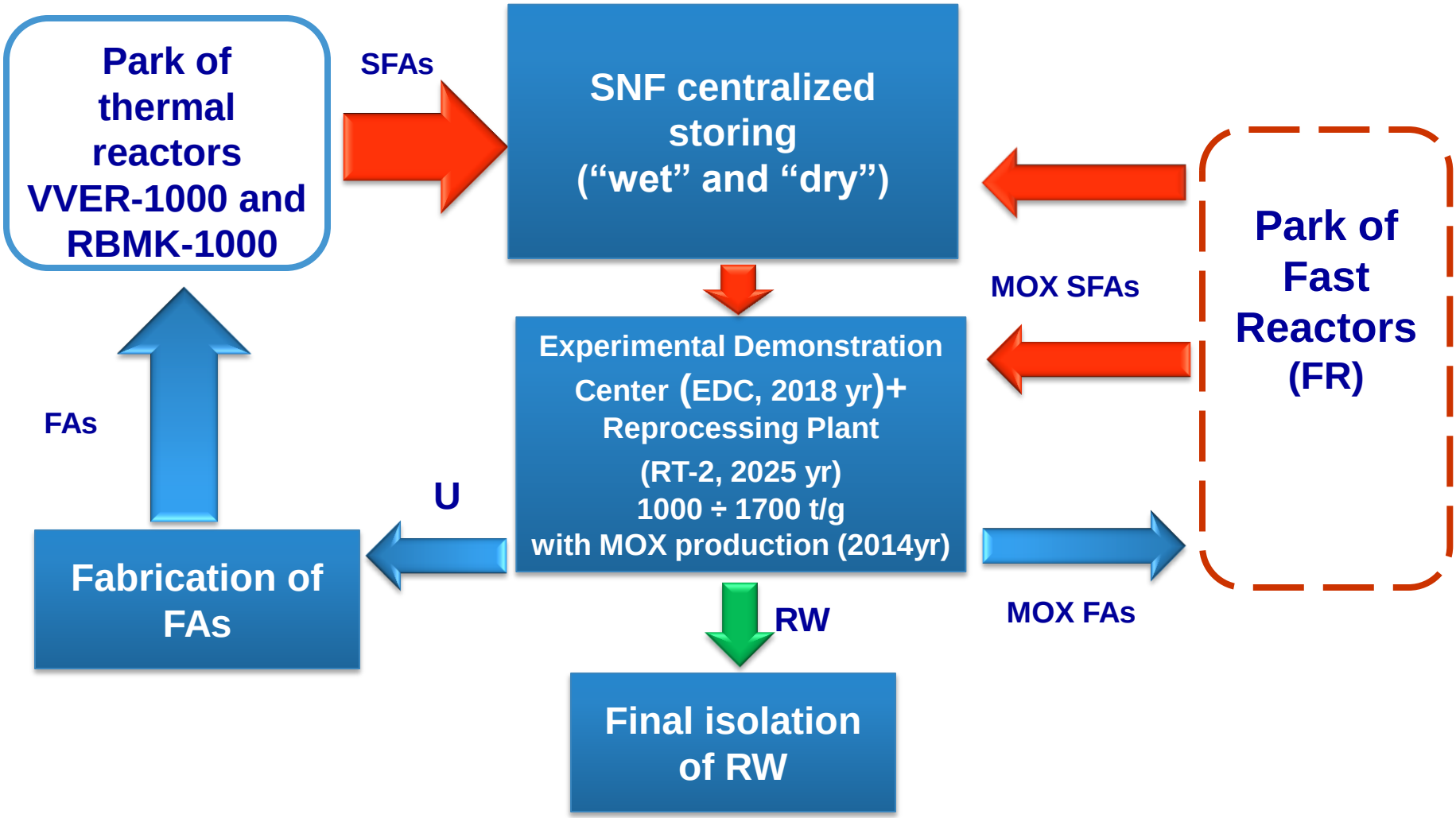
SNF accumulation rate for thermal reactors in Russia



Conclusion:
SNF reprocessing and nuclear fuel cycle closing are reasonable factors for the further safety improvement in process of SNF treatment.

Nuclear fuel complex development concept

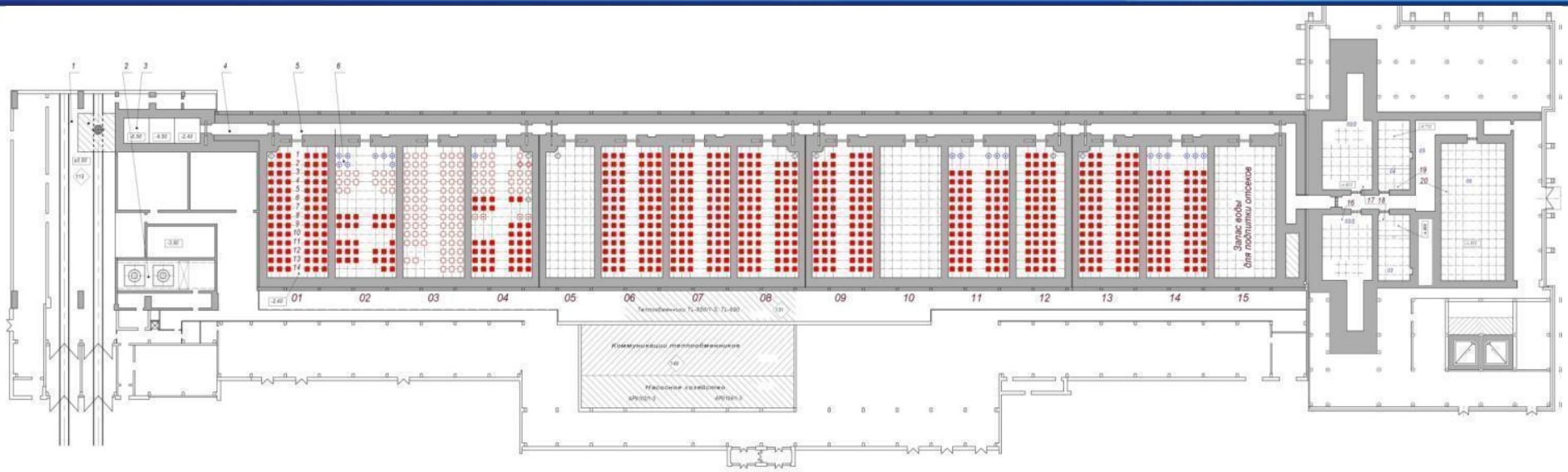


Overall view of the future SNF treatment complex

The main safety parameters while storing SNF

1. Reliable heat and mass transfer from SNF storage.
2. Cladding temperature while storing at levels not more than 300 ºC for RBMK-1000 fuel and 350 ºC for VVER-1000 fuel.
3. Reducing the risk of SFA dropping during the operation.
4. Providing operating life-time of the storage facility for not less than 100 years.
5. Providing reliability of physical security barriers.

VVER-1000 SNF water-cooled (“wet”) storage facility



Storage features:

Capacity − more than 8000 tons of VVER-1000 SNF;

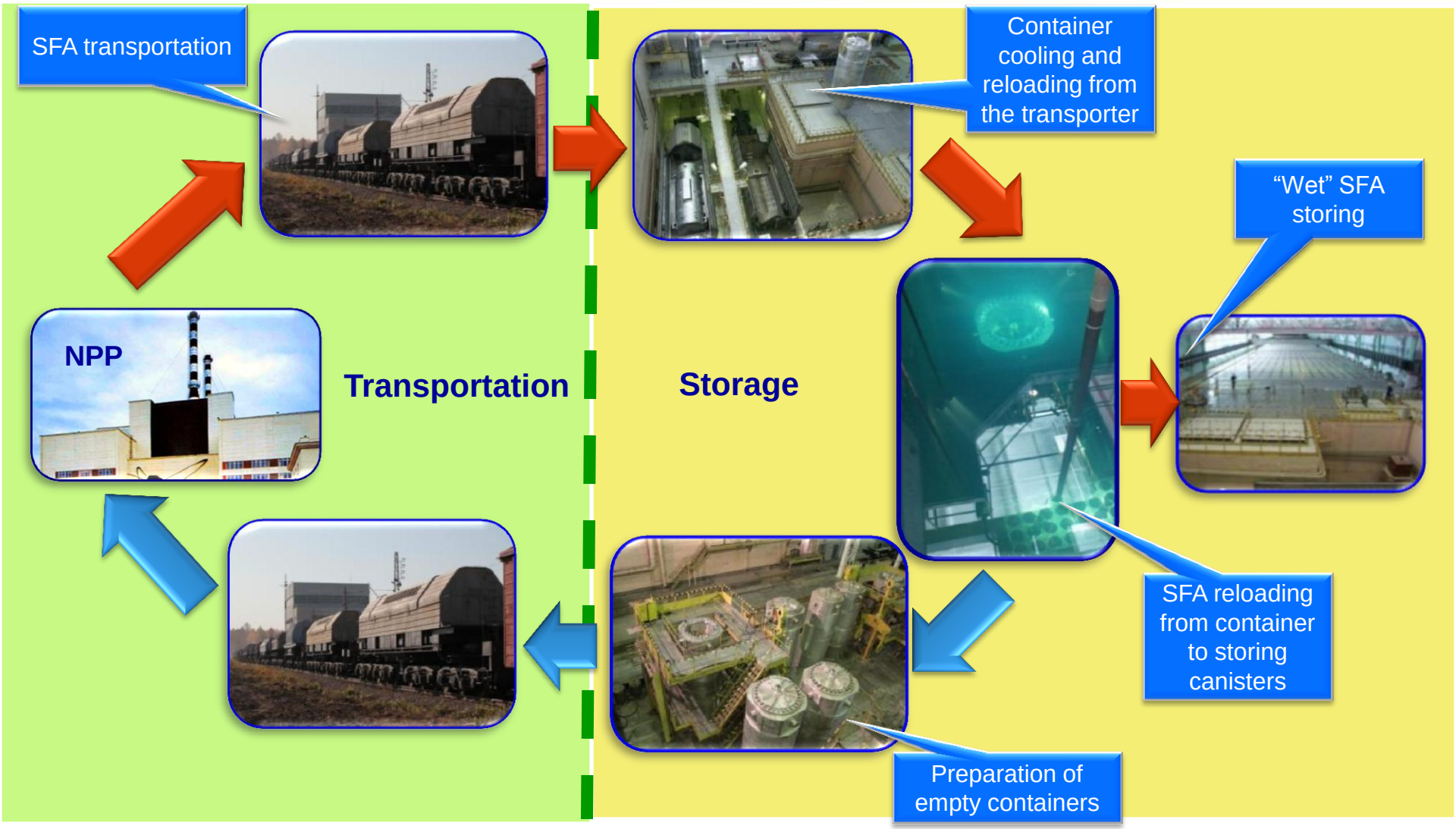
Total amount of water in cooling system − 40000 m^3;

Water temperature in bays − max 50 °C;

Load-lifters availability;

Standby water tank.

VVER-1000 SNF treatment process



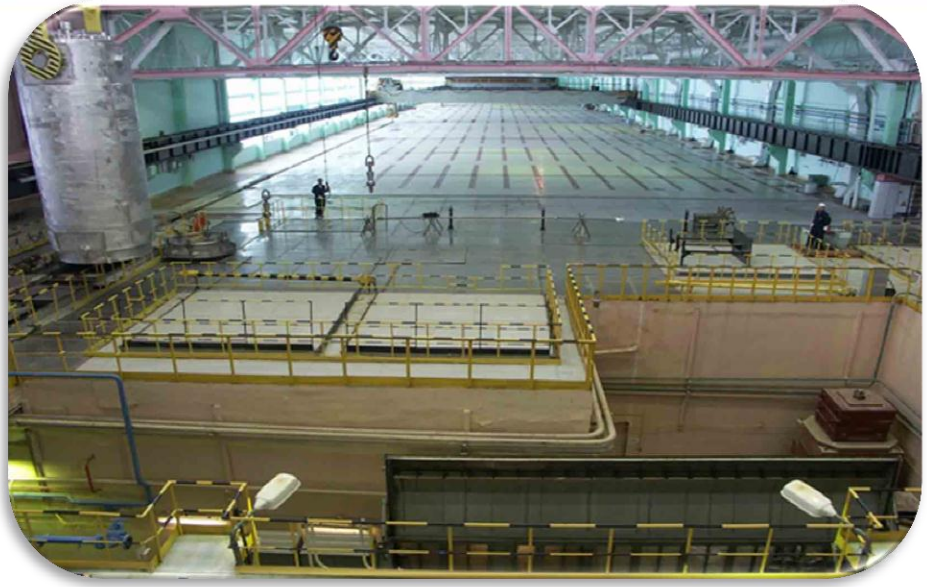
VVER-1000 SNF water-cooled (“wet”) storage facility, the hall of storing

Reloading machine in “wet” storage

“Wet” storage reconstruction

Reconstruction improvements had been started 3 years before Fukushima accident:

- Anti-seismic stability was forced;
- Four cranes were replaced;
- Cooling system has become more effective by now.



The works implemented have made the following possible:

- Storage capacity has increased by 2600 tons of SNF;
- Storage operation life-time has expanded up to a minimum of 20 years.

Preliminary results of the beyond-design-basis accident analysis for the “wet” SNF storage

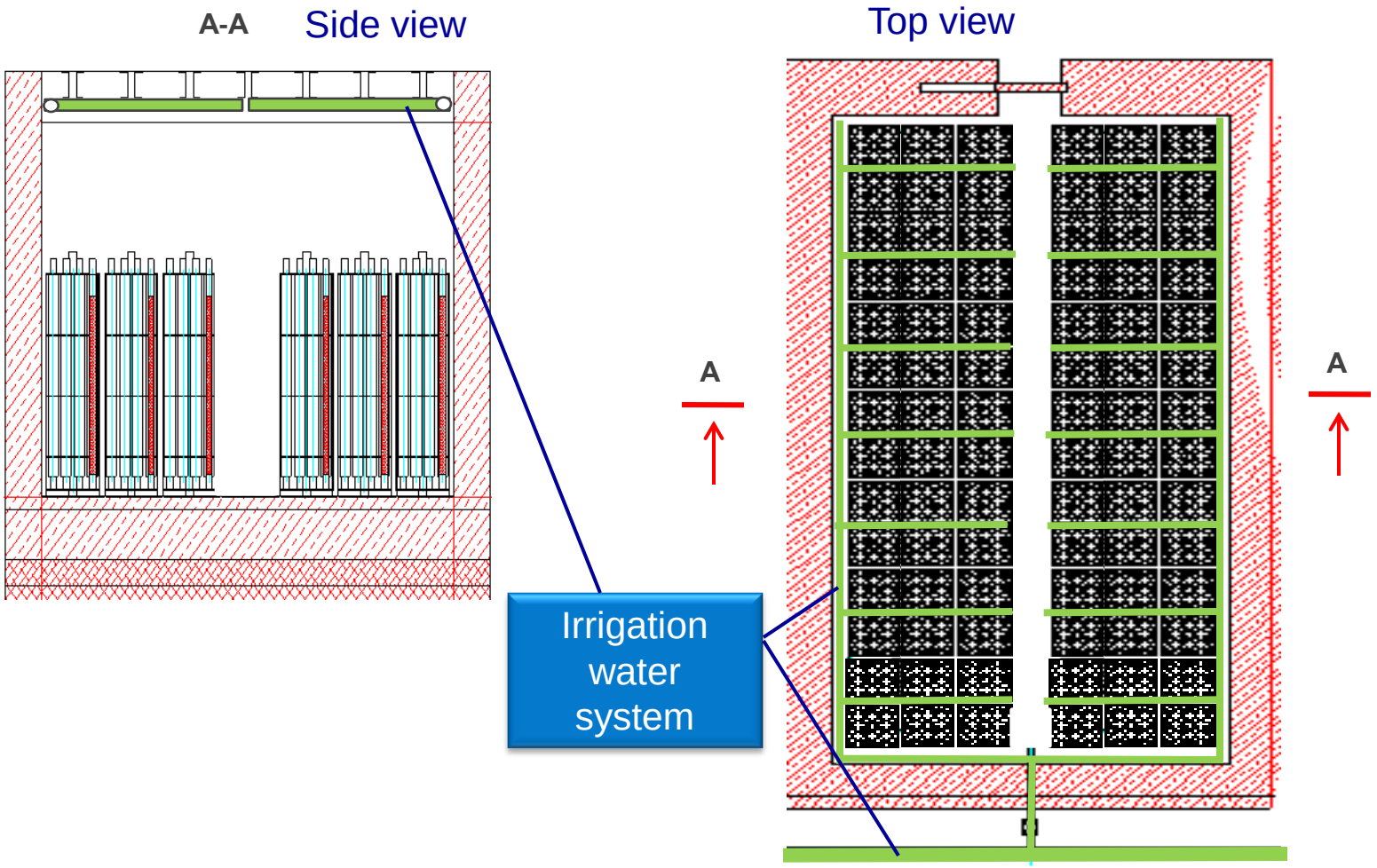
Deterministic analysis of the beyond-design-basis accidents was performed in 2011 with application of 3D models of storage bay (ANSYS, VIBROS2.1, CILINDR-KOMPLE etc.).

Effective measures on off-design accidents management are determined including the following:

- Water irrigation of SFAs in damaged bays;
- Cooling arrangement for undamaged basin bays;
- Operating of normal ventilation;
- Leak elimination with sealing compounds (sealing technology is under development).

The most effective way to reduce the cladding temperature of SFA and concrete walls of storage bays is cooling by water irrigation, so that the temperature would not exceed 550 °C for cladding and 50 °C for walls.

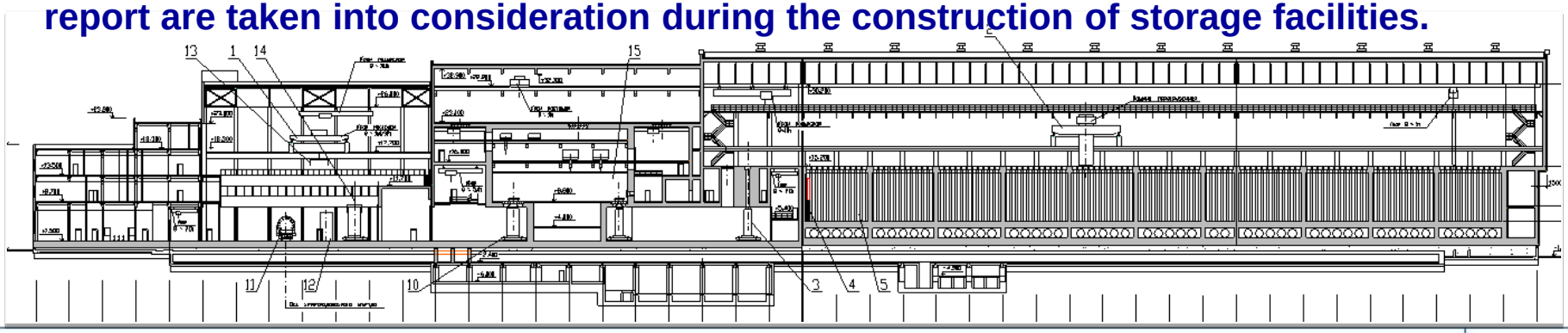
Emergency irrigation system by example of a storing bay



Water discharge necessary for one storing bay − 20 m^3 /hour.

Overall view of the centralized air-cooled “dry” storage for RBMK-1000 SNF

The project of “dry” storage has successfully passed international expert examination at the SGN company (France). Suggestions performed in the expert report are taken into consideration during the construction of storage facilities.



Process of SNF arrangement for the “dry” storing

Container transfer

1

2

Unloading SNF from container

3

Case completion

4

Case sealing. Welding quality check.

5

Passing the case for storage

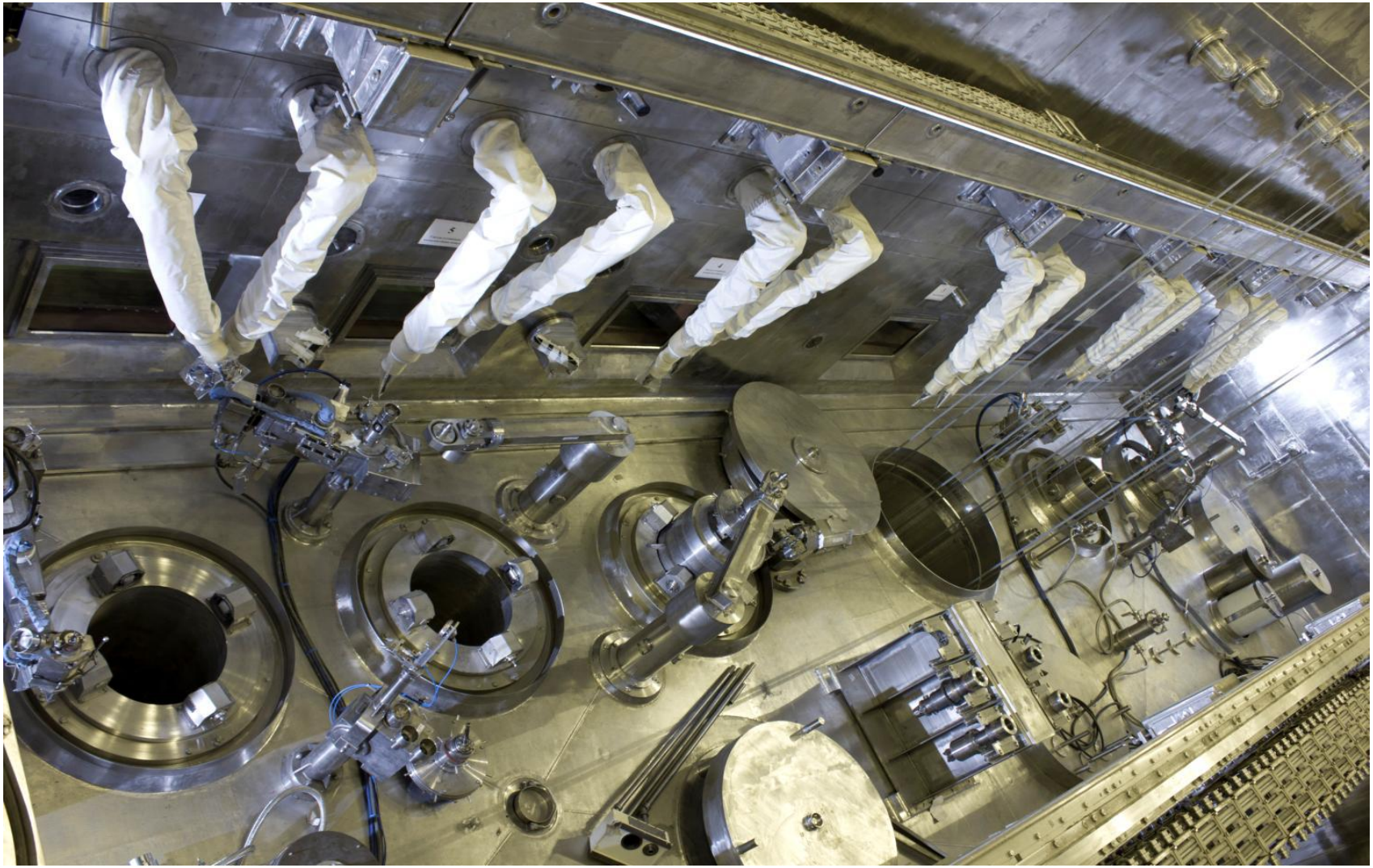
6

Case arrangement for storage

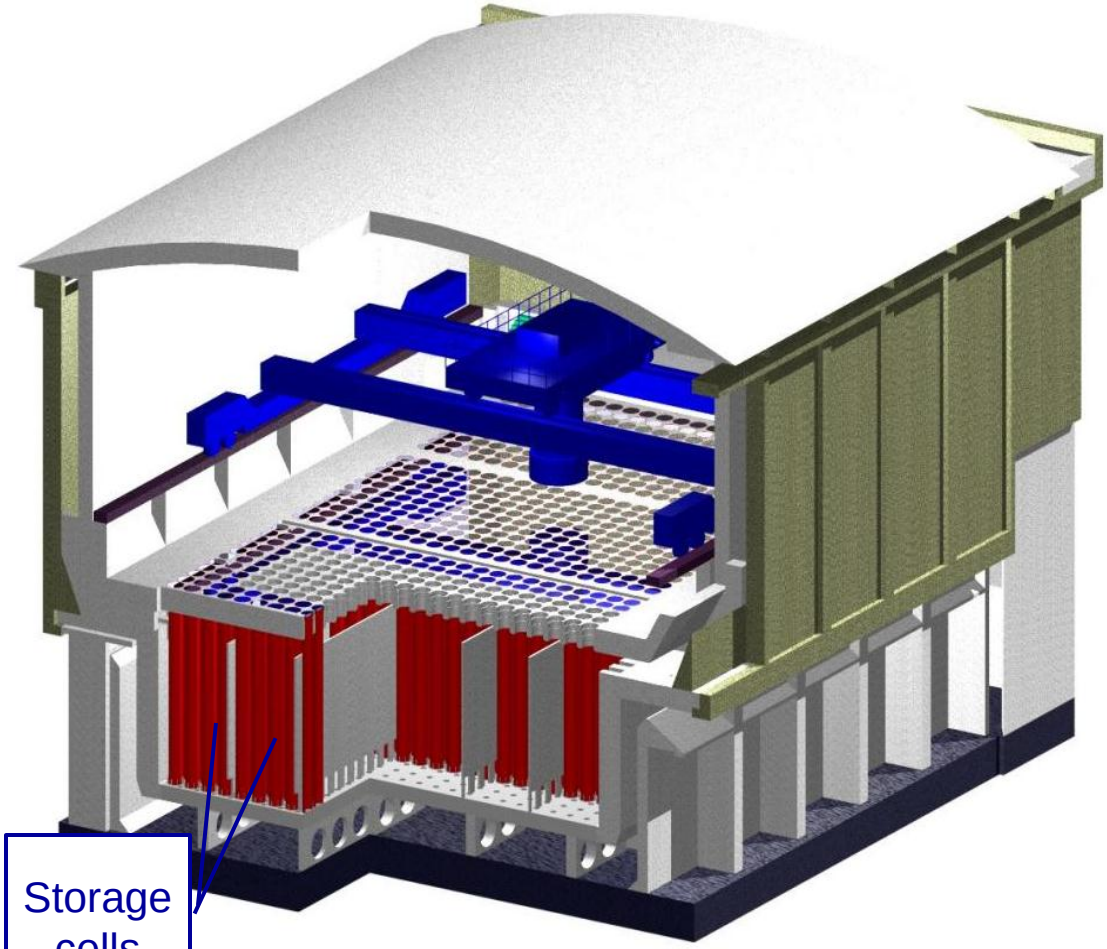
7

The hall of cases storing

Hot cell of the “dry” storage

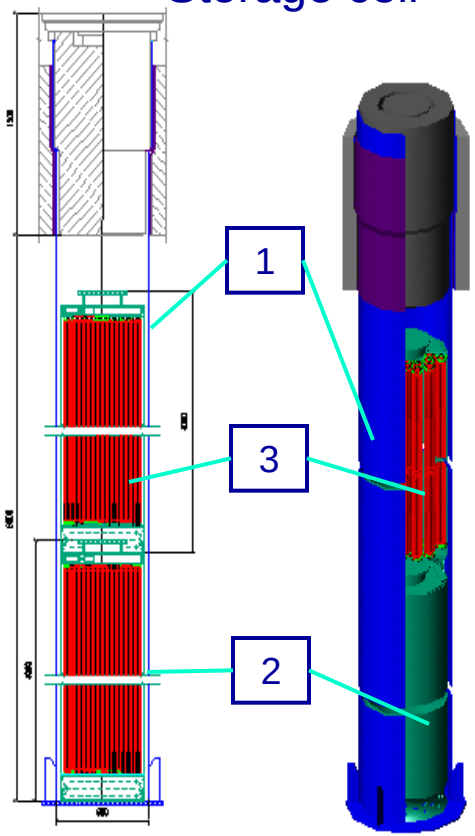


“Dry” centralized storage



Storage cells

Storage cell



1 − storing seat;
2 − case with gas (N_2+He_2);
3 − fuel element of assembly

Parameters of “dry” storage

	RBMK-1000	VVER-1000
Cooling environment	Outer air	Outer air
Storing environment	N_2+He_2	N_2+He_2
Outside air temperature, °C	+38	+38
Air temperature at the chamber outlet, °C	+94	+94
Temperature at the surface of a storing seat, °C	+145	+147
Maximum temperature of the fuel element cladding,°C	+248	+308

Probability of the basic accidents

System	Initiating events	Failure probability, year^{-1}
External events	8-point earthquake load (MSK-64 magnitude)	$2 \cdot 10^{-4}$
	Airplane crash	$1.37 \cdot 10^{-13}$
Internal events	Case fall	$1.23 \cdot 10^{-4}$
	Fall of fuel elements inside the hot cell	$4.47 \cdot 10^{-1}$

According to probable risk assessment all those events will not lead to environmental radiation discharge.

Conclusions

Comprehensive SNF storing safety is to be improved by the following:

- SNF removal from NPP sites and placing at the centralized SNF storage facilities.
- Application of passive heat and mass transfer systems (“dry” storing).
- Application of multi-barrier systems of SFA isolation inside pressurized cases and storing cells.
- Creation of systems to operate beyond-design-basis accidents and localize consequences.

Summary

SNF reprocessing and nuclear fuel cycle closing are reasonable factors for the further safety improvement in the back-end.