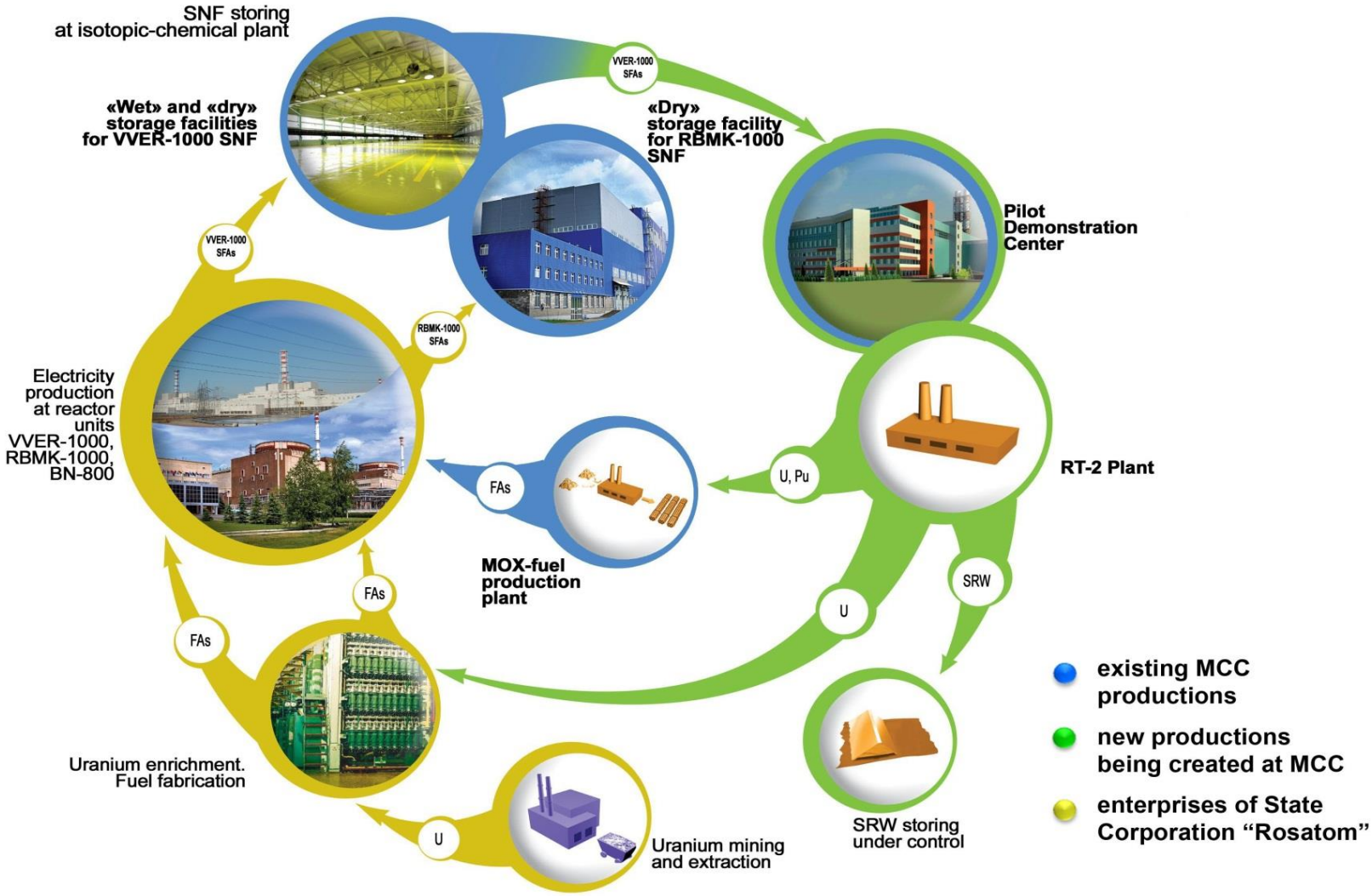
State Atomic Energy Corporation “Rosatom”

FNO FSUE “Mining and Chemical Combine”

Development and implementation of CNFC technologies at FNO FSUE “MCC”

FNO FSUE “MCC”
P.M.Gavrilov

The concept of closing the nuclear fuel cycle at FSUE “MCC”



Implementation of the industrial infrastructure for CNFC at FNO FSUE "MCC"

1. Centralized "wet" storage for SNF from VVER-1000 reactors.
2. Centralized "dry" storage for SNF from RBMK-1000 and VVER-1000 reactors.
3. Pilot Demonstration Center for SNF reprocessing based on innovative technologies (PDC).
4. MOX-fuel production to supply fast neutron reactors with necessary fuel.

Centralized water-cooled (“wet”) storage for SNF from VVER-1000, storing hall

Successful acceptance and safe storing of VVER-1000 SNF for more than 30 years.

Water-cooled (“wet”) storage of VVER-1000 SNF

The storage is reconstructed drastically with results as follows:

- The seismic stability of the storage has been considerably increased due to the foundation and building structures reinforced and the roof lightened.
- The cooling system of the storage bays has become more effective and reliable.
- For the further increase of SNF storing safety the passive irrigation system is being commissioned against dewatering of SNF bays.

As the result:

- **The lifetime of the water-cooled SNF storage is extended for 30 years till 20145;**
- **The storage represents the atomic energy use facility based on the modern technology platform with high level of safety and seismic stability to ensure uninterrupted operation of NPPs in Russia.**

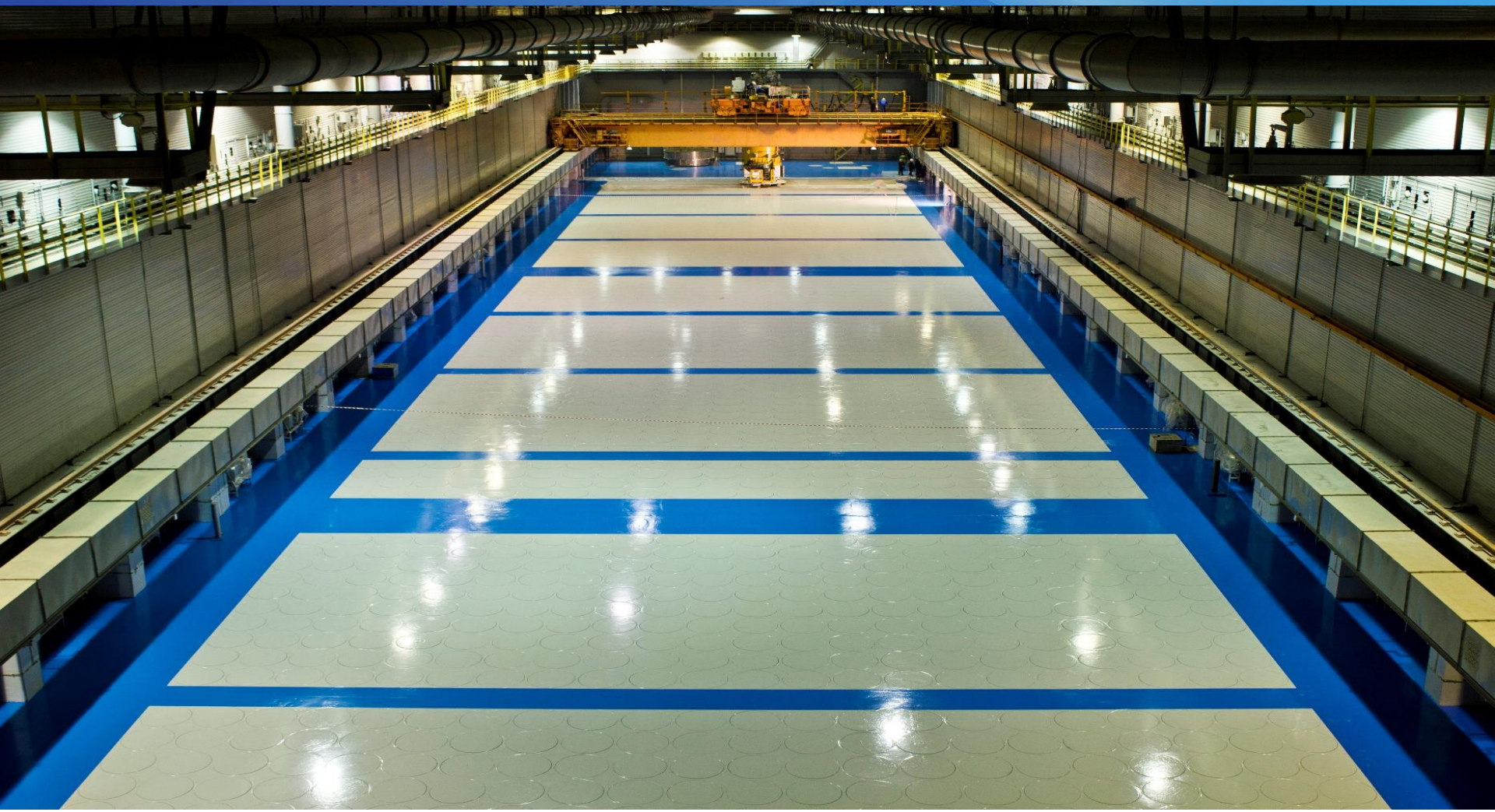
Centralized air-cooled storage for SNF from RBMK-1000 reactors

Constructions maintain integrity under earthquake load up to 10 points and withstand direct plane crash.

SNF storing technologies

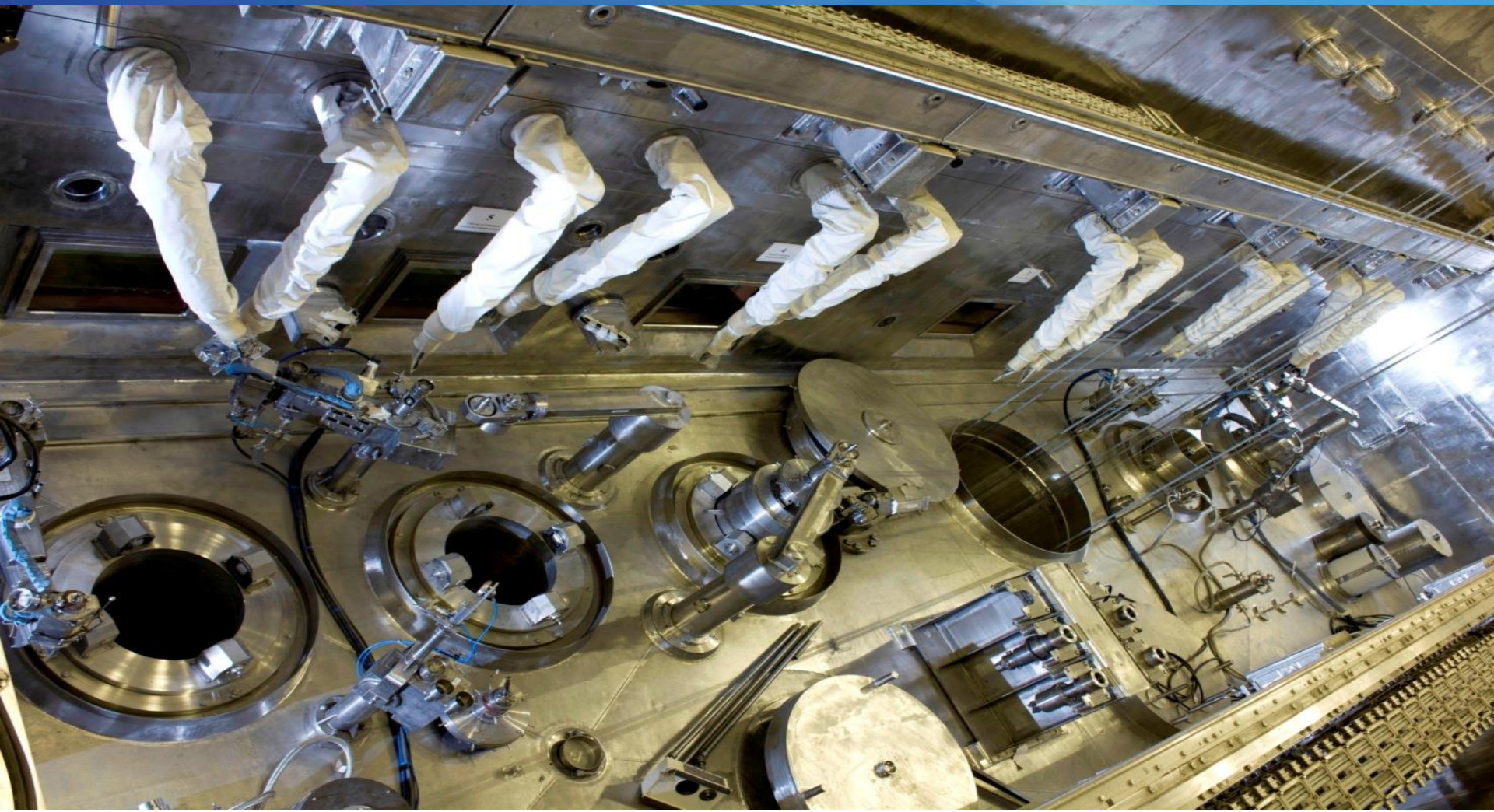
The new operational principles of SFAs automatic reloading have been developed to provide reloading safety improvement and complex productivity duplication along with cutting SNF storing costs.

Storing hall of the air-cooled storage for RBMK-1000 SNF



The passive safety approach is applied as the basis of the “dry” storing in order to cool SNF due to the natural air convection.

Hot cell for packaging RBMK-1000 SNF canisters



The centralized air-cooled chamber-type storage is the safest and the most cost-efficient.

SNF centralized storing complex at FNO FSUE “MCC”

The full-scale storage complex for SNF from RBMK-1000 and VVER-1000 was built in December 2015.

Pilot Demonstration Center on SNF reprocessing based on innovative technologies

The purpose of creating PDC at FSUE "MCC" is in industrial demonstration of possibility to solve the problem of SNF accumulation effectively and ecologically safely.

That purpose will be implemented if the following is ensured:

1. **Safe SNF reprocessing (nuclear, radiation and fire-explosive safety).**

2. **Absence of negative environmental impact**

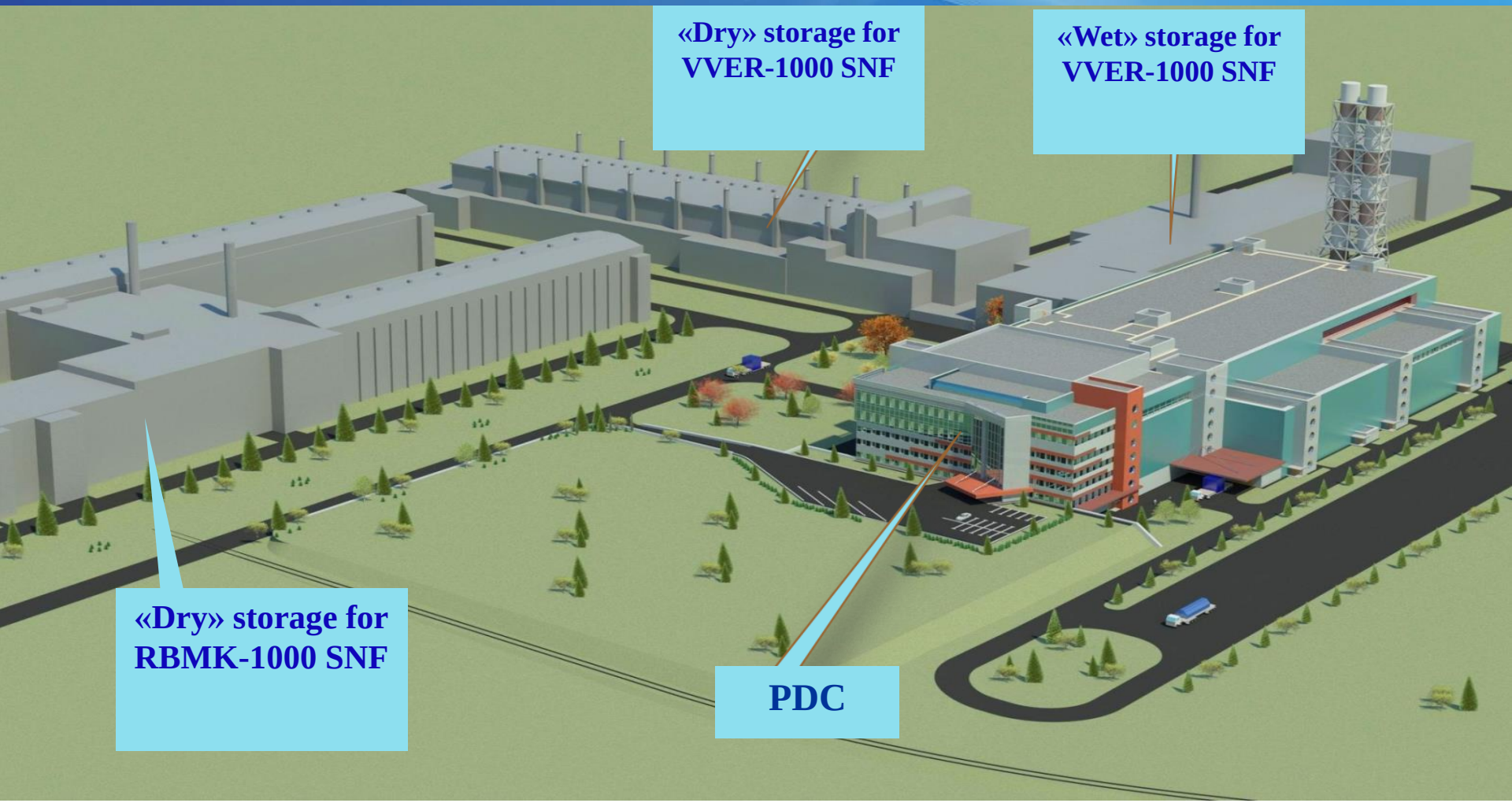
3. **Cost effectiveness of SNF reprocessing.**

Innovations in PDC technology

- PDC technology is constructed according to the approach of minimizing production steps along with application of the unique peerless equipment.

- As opposed to the existing similar radiochemical productions the PDC technology applies the processes to avoid tritium discharge to the environment in the form of low-level radioactive wastes.

PDC within SNF management complex



2015 – Construction of PDC's first start-up complex is finished.

2020 – Full-scale PDC commissioning with productivity of 250 tons of SNF annually. Initial data to be received for the large-scale commercial plant for SNF reprocessing.

PDC construction and operation milestones

2008 - 2015

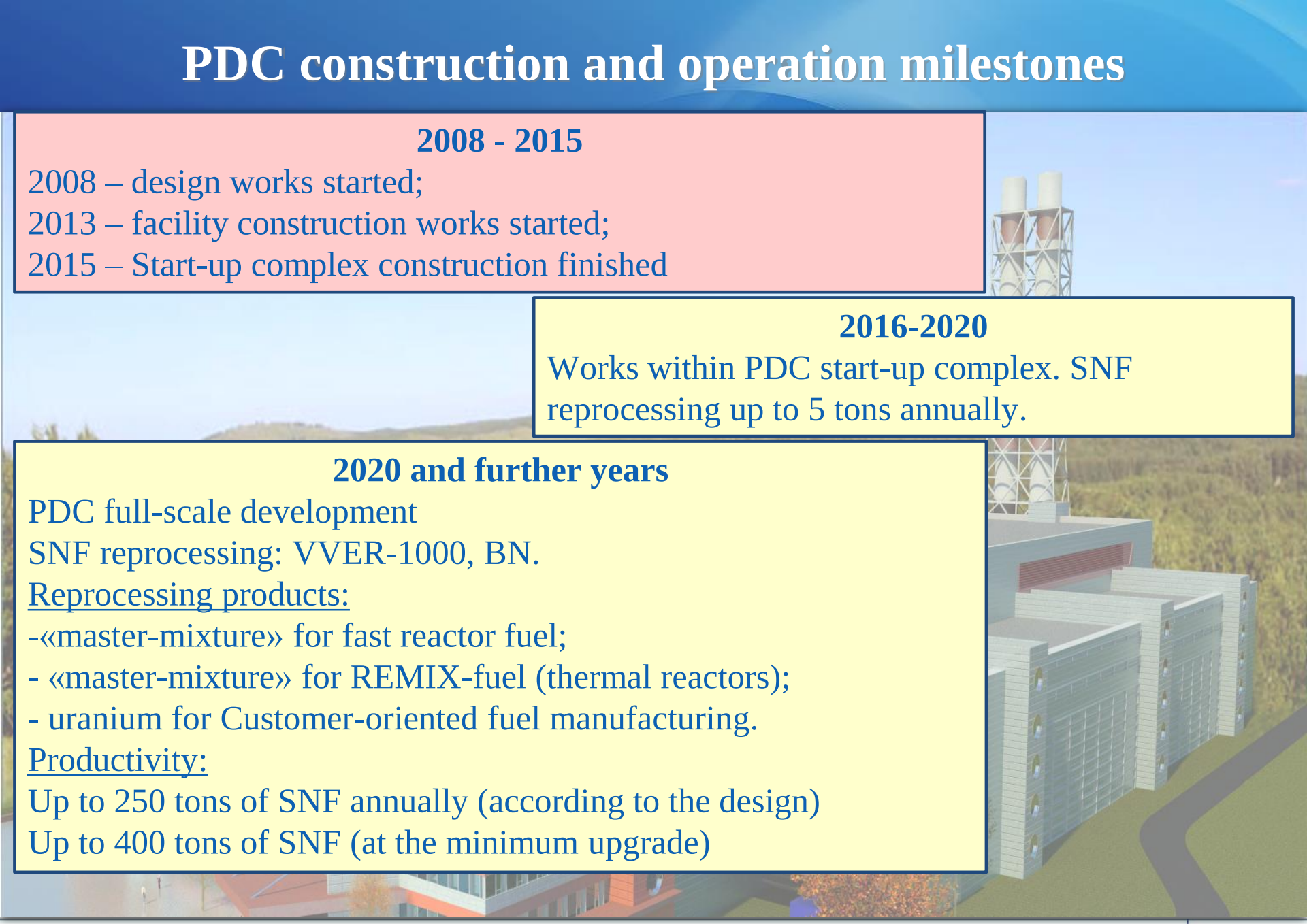
2008 – design works started;
2013 – facility construction works started;
2015 – Start-up complex construction finished

2016-2020

Works within PDC start-up complex. SNF reprocessing up to 5 tons annually.

2020 and further years

PDC full-scale development
SNF reprocessing: VVER-1000, BN.
Reprocessing products:
-«master-mixture» for fast reactor fuel;
- «master-mixture» for REMIX-fuel (thermal reactors);
- uranium for Customer-oriented fuel manufacturing.
Productivity:
Up to 250 tons of SNF annually (according to the design)
Up to 400 tons of SNF (at the minimum upgrade)



Radiochemical Plants before Generation 4

RT-1 ("Mayak" Production Association) Generation 1

UP3 (France) Generation 2

PDC (MCC) Generation 3 prototype

RT-2 (MCC) Generation 4 alternative

Certain parameters for plants of different generations

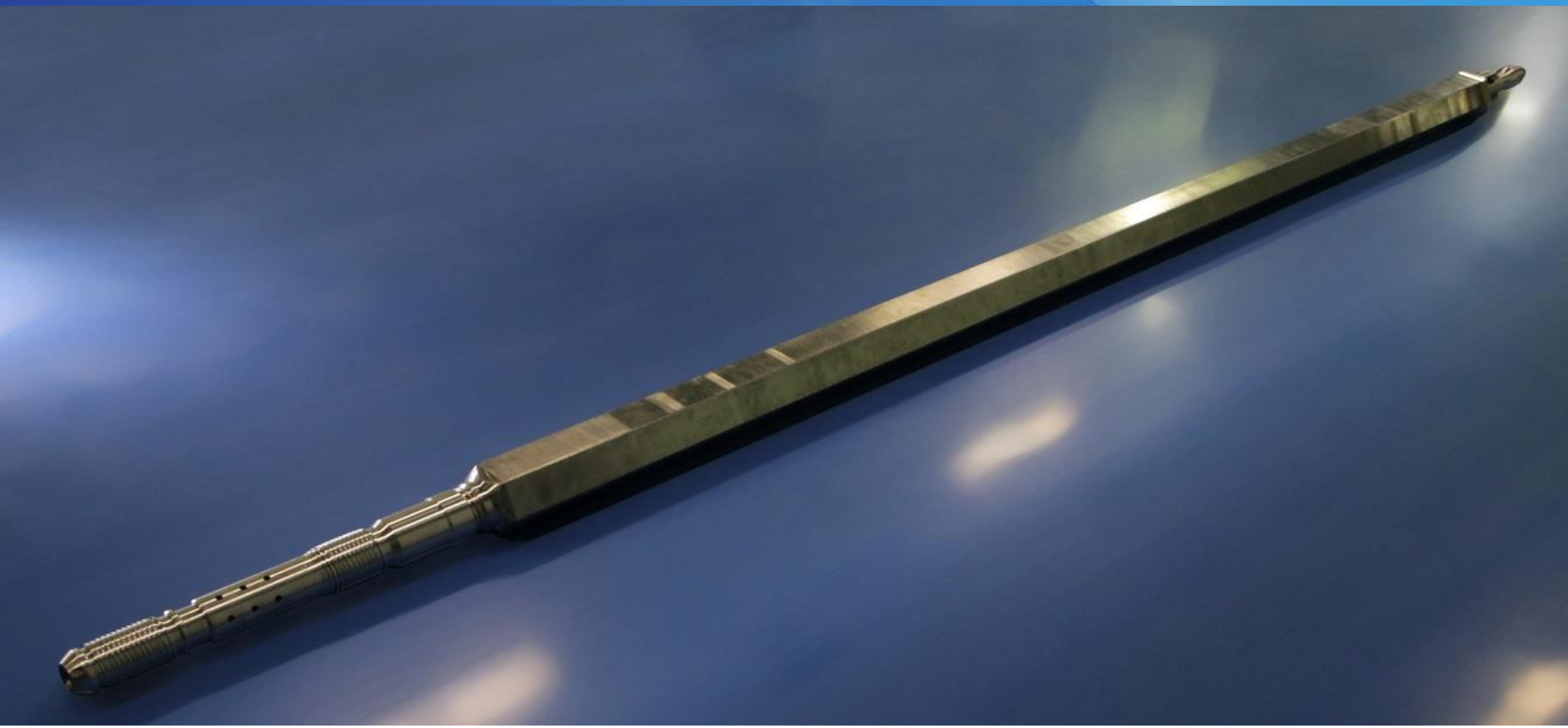
Plant Generation	SNF reprocessing plant	Liquid RW management	Solid HLW management
1st Generation	PT-1 (PA«Mayak»)	Liquid ILW discharge (about 50 m^3/t of SNF) and LLW	0.80 m^3/t of SNF
2nd Generation	UP2,3 (France), Rokkasho (Japan)	Liquid LLW discharge (100 m^3/t of SNF)	0.15 m^3/t of SNF
3d generation	PDC (MCC)	No liquid discharges	0.1 m^3/t of SNF
4th generation	RT-2 (MCC)	No liquid discharges	Transplutonium elements' transmutation, HLW storage to ILW and near-surface disposal. No HLW; ILW - 4 m^3/t of SNF

MOX-fuel production to supply BN-800 Reactor Facility

- The production is constructed in the underground facilities of MCC within the record time-frame – 2.5 years.
- The rock is a natural powerful containment to protect from any outside natural (meteorites) and anthropogenic impacts
- All operations are automated with remote control applied; equipment has no equals all over the world.

The production provides an opportunity for automated manufacturing of FAs with energy-grade plutonium dioxide content up to 30 %.

MOX-fuel production to supply BN-800 Reactor Facility



The production was commissioned for pilot operation in 2015. FAs with MOX-fuel based on uranium and plutonium mixed oxides have been manufactured since December 2015.

MOX-fuel production operation

- In the year 2015, according to S.V.Kirienko's order, All-Russian Scientific Research Institute of Experimental Physics in cooperation with MCC developed functional-logistic model of MOX-fuel production to evaluate complex productivity and indicate rate-controlling steps.
- The results obtained indicated additional possibilities to improve productivity up to 800 FAs annually.

The existing possibilities of productivity increase will admit prompt arrangements for manufacturing of FAs for the reactors of other designs, including foreign types as well.

Conclusions

- SNF reprocessing and NFC closing shall improve SNF management safety due to the qualitative reduction of spent nuclear fuel volumes and decrease of generated RW manyfold.

- Thus, the Strategy of “Rosatom” State Corporation to establish CNFC industrial infrastructure at FNO FSUE “MCC” site, which is under implementation within Federal Target Programs, allowed locating three jointly-operated industrial production stages at the only site of the MCC: SNF storing, SNF reprocessing and MOX-fuel production.

- Holding sufficient functional flexibility, such a complex shall ensure storing, large-capacity reprocessing of SNF along with “fresh” fuel fabrication for both thermal and fast neutron power reactors of different domestic and foreign designs.