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Roundtable discussion: Innovative process solutions throughout the lifecycle in nuclear power as a prerequisite for sustainable development
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STATE ATOMIC ENERGY CORPORATION "ROSATOM"

Nuclear Fuel Cycle in the Dual-Component Nuclear Power System as a part of Russian Integrated Offer for Foreign Customers

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The objective is to minimize SNF volume

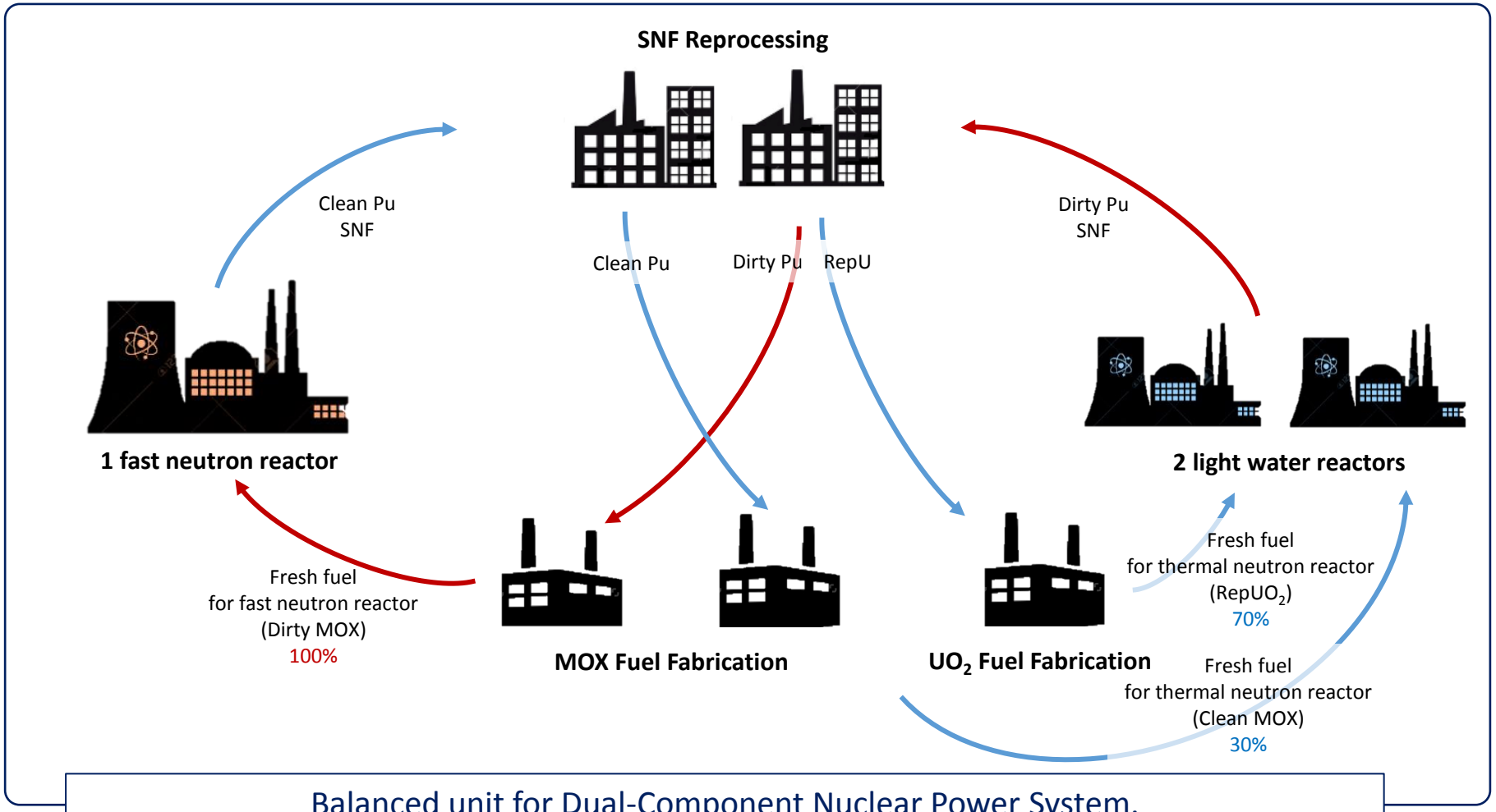
Growing volume of the Spent Nuclear Fuel accumulated becomes the serious impediment for the Nuclear Industry development. Solving this problem is the key factor for the creation of the sustainable Nuclear Power System.

Russia is offering a number of feasible solutions for minimization of the SNF volume with the obligatory fissile materials recycling in all the options. The following solutions are concerned:

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

Being responsible for Russian nuclear industry development Rosatom considers international cooperation in performing the listed solutions.

Dual-Component Nuclear Power System
Definition Chart



Balanced unit for 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).

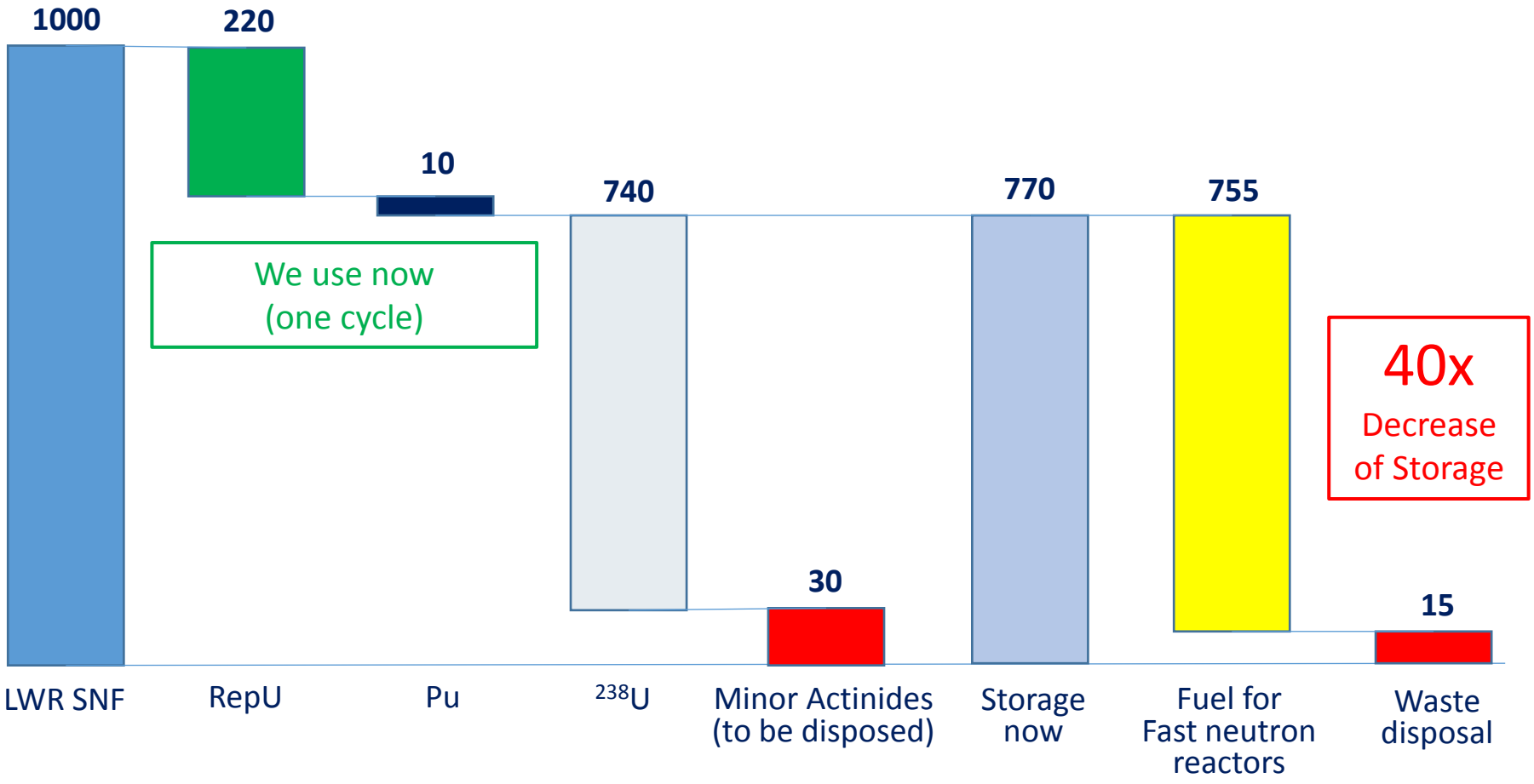
Dual-Component Nuclear Power System
Definition and Description

Dual-Component Power System = reactors on thermal neutrons (VVER, PWR, BWR) + fast neutron reactor (BN) + SNF reprocessing facility + fabrication facility(ies).

- Thermal neutron reactors (should be at least two times more than fast neutron reactors in unit balanced by plutonium quantity) works as the **primary plutonium source**.
- Fast neutron reactor **breeds plutonium** (generates more than burns; reproduction rate ~1,2) and **improves its isotopic composition** (more fissile isotopes content). Natural uranium demand by this system is reduced by 30%.
- Uranium and **plutonium don`t leave Power System**, every time returning to reactor in regenerated fuel (multiple recycling). All accumulated SNF goes to reprocessing; no accumulation and storages.
- Additional advantage of dual-component Energy System – opportunity to **burn minor actinides** in fast neutron reactor (Am, Np, Cm) – the most active and long-lived components in SNF. So, this allows to reduce radioactive wastes amount to be disposed.

What is SNF
And how to use it

Spent Nuclear Fuel Composition, reference kg*



The main effect is complete involvement of Pu and ^{238}U into the Nuclear Fuel Cycle

*Expert Estimation

Fractioning & After-Burning of Minor Actinides

The way to reduce Time and Danger of High-Activity Radwaste

Today: SNF is recycled with no waste fractioning

- Rep U, Pu – useful products
- Vitrified high-active waste (MA, Sr, Cs)

~ 2 cub.m per 1 GW annual nuclear generation
Activity decay period = 10,000 years

Prospective: SNF reprocessing with waste fractioning

- Rep U, Pu – useful products
- Minor actinides (Np, Am, Cm) – to be burn in fast neutron reactors
- Valuable nuclides (Cs, Sr, Tc) - to be sold
- Vitrified high-active waste (Sb, Eu)

~ 0,5 cub.m per 1 GW annual nuclear generation
Activity decay period = 300 years

Dual-Component Nuclear Power System
Main Advantages

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Environmental

- Waste amount reduction in Energy System with corresponding risk decrease.
- Minimize demand of natural uranium by maximum use of SNF energy potential and breeding ability of fast reactors.
- Involvement existing light-water NPPs into closed NFC.

Economic

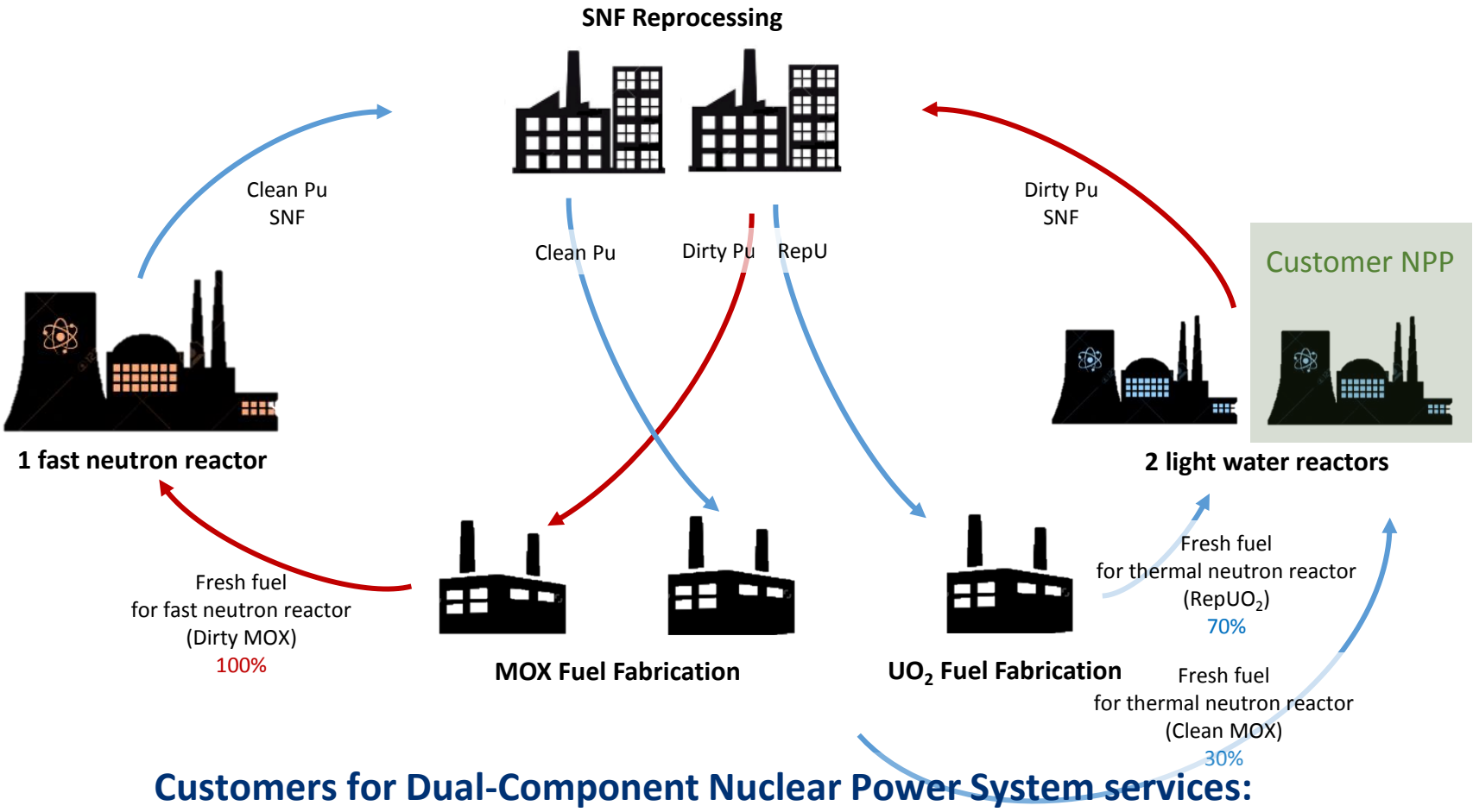
- Burning of the existing SNF including MOX SNF.
- Avoiding appearance of new SNF burden (interim storage, taxes, deferred payments).
- Savings in the cost of natural components of the nuclear fuel cycle and separative work units.

Non-proliferation

- Relief control of nuclear materials due to their localization within Energy System unit.
- Rejection of RepU and Pu warehouses due to their flows balance in Energy System.
- Opportunity of effective utilization of accumulated plutonium (power and weapon-grade).

The Dual-Component Nuclear Power System has distinct advantages from an ecological, economic and non-proliferational standpoints.

Dual-Component Nuclear Power System
Customer's Slot



Customers for Dual-Component Nuclear Power System services:

- NPP operator with LWR on thermal neutrons operating MOX fuel;
- NPP operator with LWR on thermal neutrons operating REMIX fuel;
- Energy companies and national agencies who already have plutonium stockpiles.

Russian infrastructure
for Dual-Component Nuclear Power System

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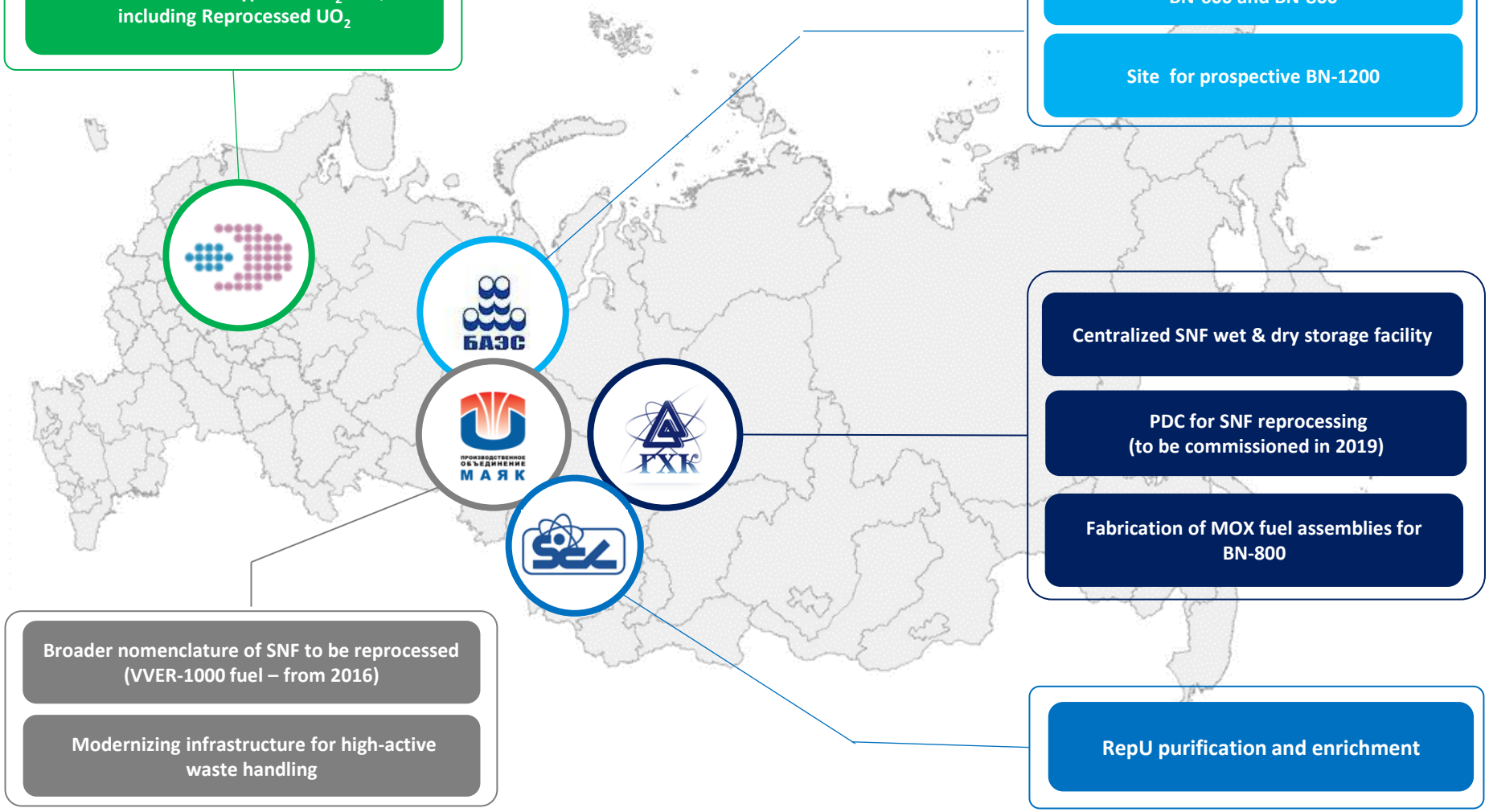
Fabrication of all types of UO_2 fuel, including Reprocessed UO_2



Two fast neutron reactors are working BN-600 and BN-800

Site for prospective BN-1200

Centralized SNF wet & dry storage facility

PDC for SNF reprocessing (to be commissioned in 2019)

Fabrication of MOX fuel assemblies for BN-800

RepU purification and enrichment

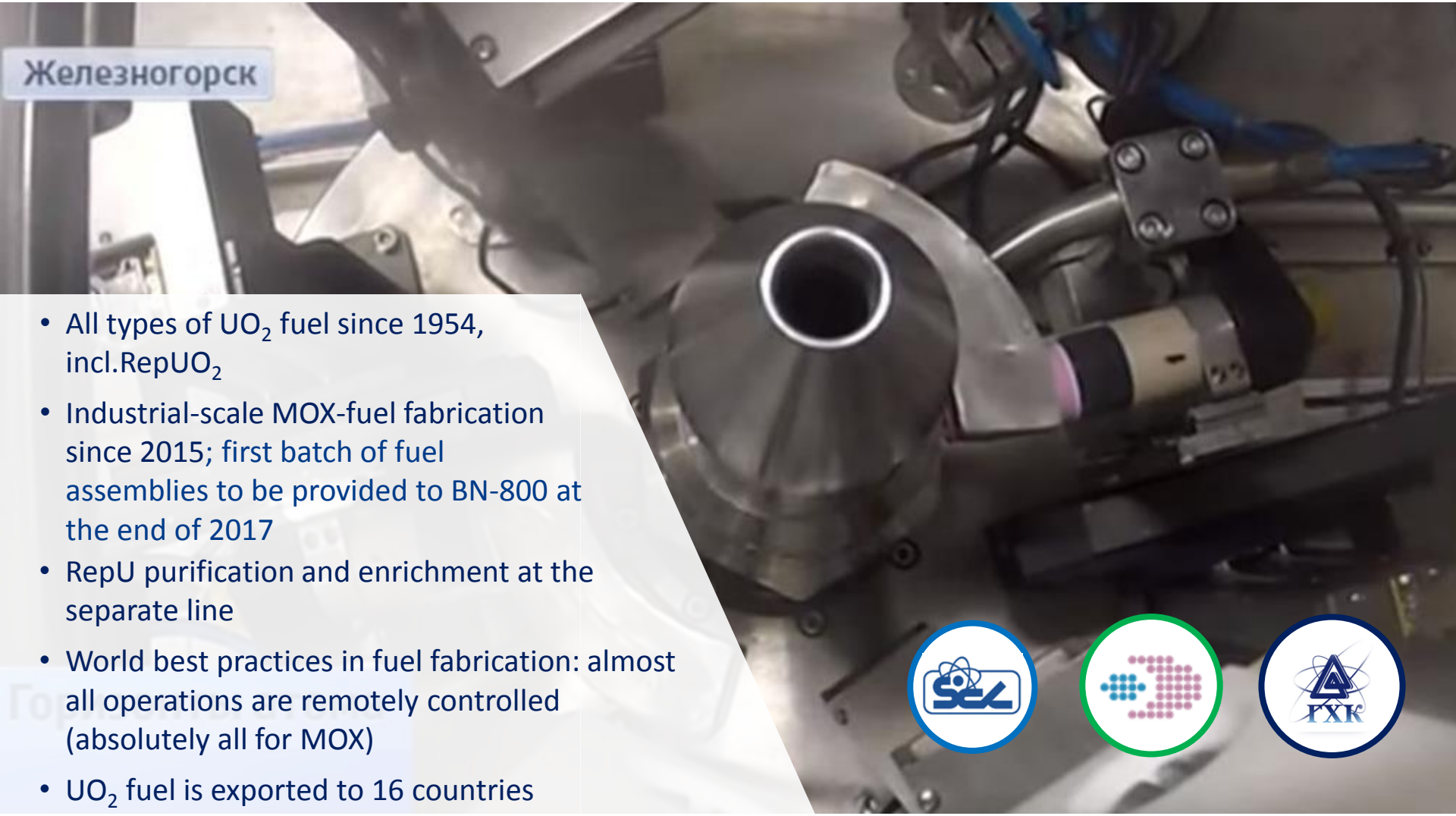
Broader nomenclature of SNF to be reprocessed (VVER-1000 fuel – from 2016)

Modernizing infrastructure for high-active waste handling

SNF Reprocessing
Non-stop Development

- Since 1977 as commercial service
- Two main sites: Mayak (Ural) and MCC (Siberia); total capacity 400 t/y now, 800 t/y since 2020
- All types of light-water reactor and fast neutron reactor SNF could be reprocessed, incl. failed and defected
- up-to date ecologically-advanced technology (no liquid RW)
- HLW fractionating; radioisotope production: Cs-137, Kr-85, Am-241, Pu-238, Sr-90, Pm-147

Fuel Fabrication
Broadest Experience

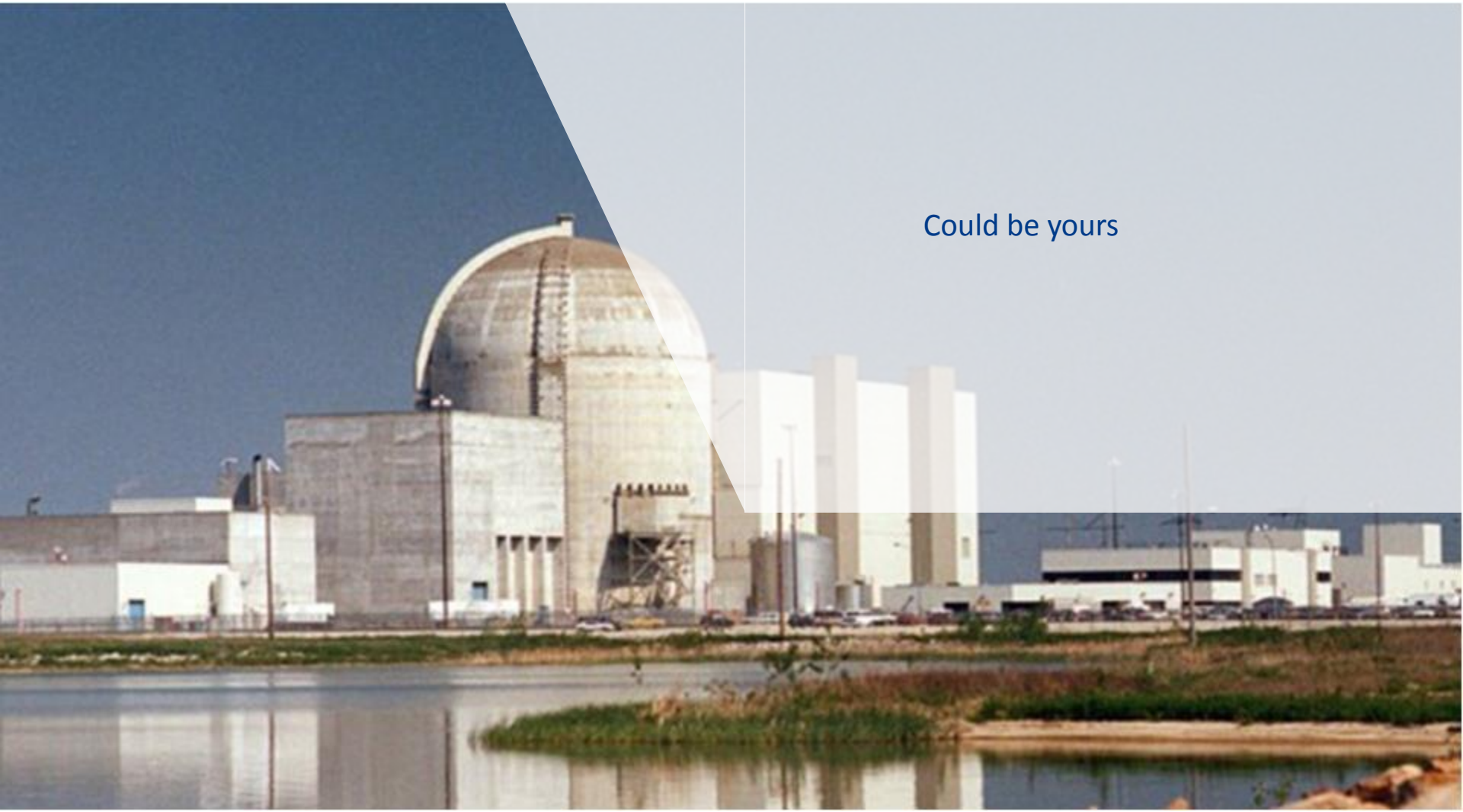


- All types of UO_2 fuel since 1954, incl.RepUO_2
- Industrial-scale MOX-fuel fabrication since 2015; first batch of fuel assemblies to be provided to BN-800 at the end of 2017
- RepU purification and enrichment at the separate line
- World best practices in fuel fabrication: almost all operations are remotely controlled (absolutely all for MOX)
- UO_2 fuel is exported to 16 countries

Fast Neutron Reactors
Generation IV in practice

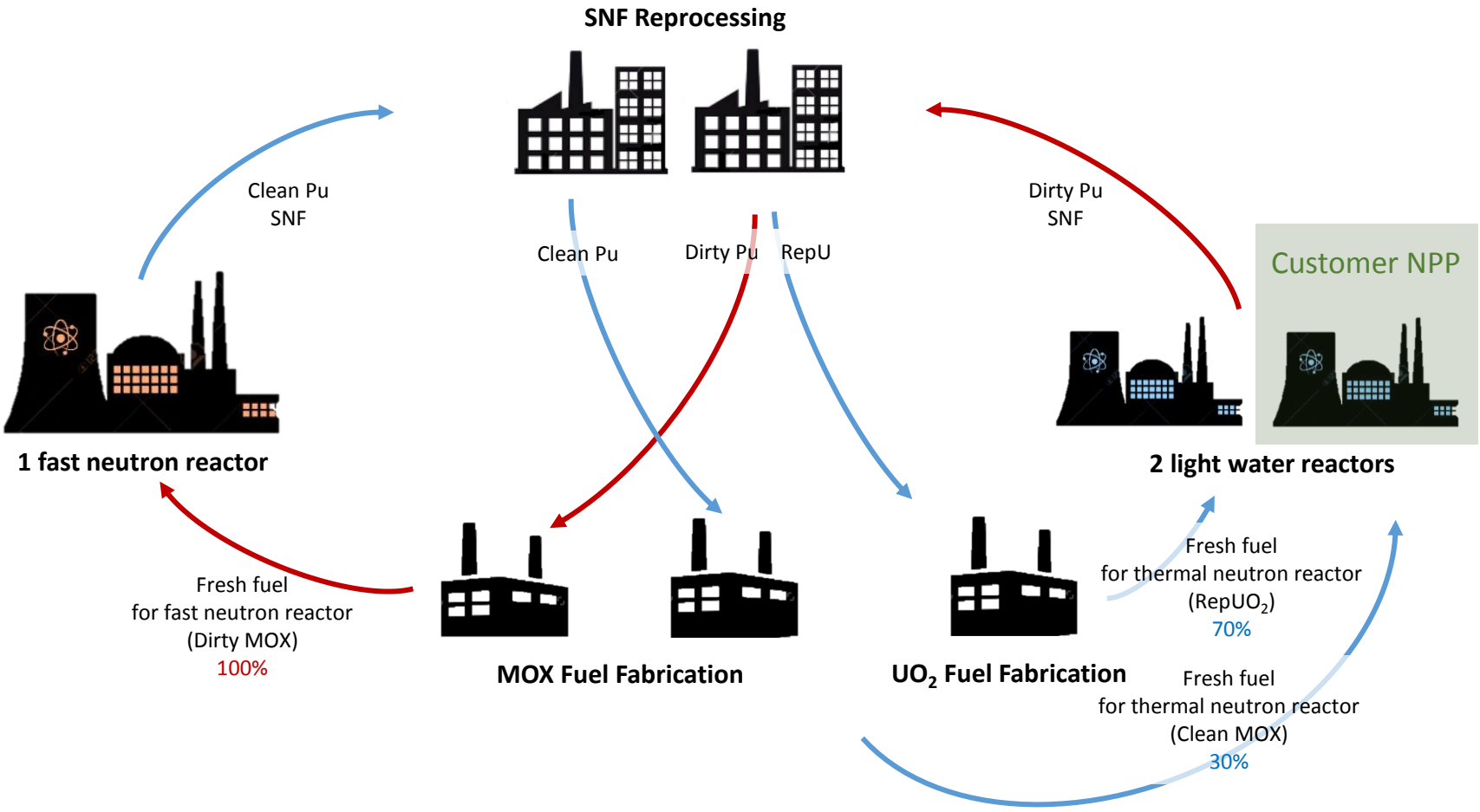
- In 2016 the Beloyarsk NPP's BN-800 fast neutron reactor has been connected to the national grid.
- BN-800 uses MOX fuel.
- For a year of reactor's operation 1,84 t of plutonium is required. It is produced from 190 t of reprocessed SNF of thermal-neutron reactors.
- Plutonium recovered from BN-800's SNF is to be used in VVER-1000 reactors.
- Next generation of the Fast Neutron Reactor, BN-1200, is already designed; to be put into operation in ~2027.

Light Water Reactors
are welcome!



Participation in Dual-Component Nuclear Power System

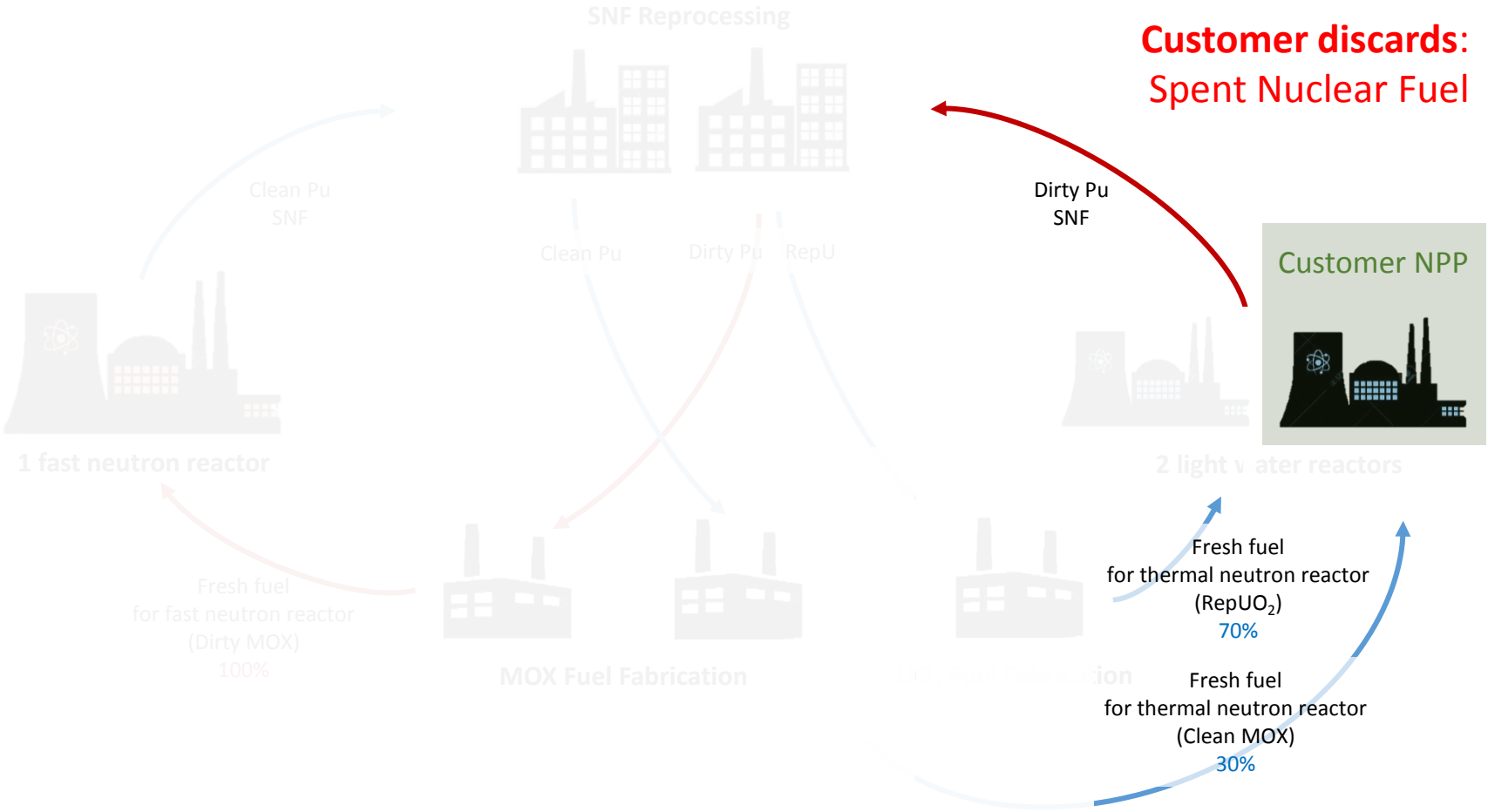
Once again



Participation in Dual-Component Nuclear Power System

Could be considered as a kind of fuel exchange

Customer discards:
Spent Nuclear Fuel



Customer gets:
Fresh fuel ($RepUO_2$ + Clean MOX)
Vitrified Waste to dispose*

*About two times less than now due to the minor actinides removal

Different options for participation in Dual-Component System

Customer

Service for SNF utilization:

- Eliminates Customer's SNF stock
- Reduces cost for SNF storage/disposal
- Saves NatU and SWU
- Reduces level of risks (ecological, financial) concerned to the SNF and RW storage/disposal

Partner

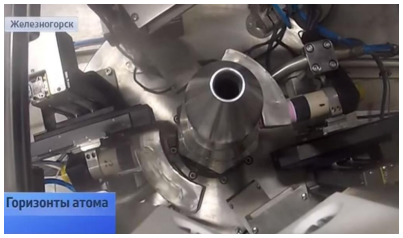
Joint development of the DCNFS:

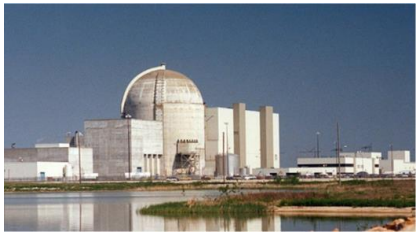
- Develops Partner's Energy System
- Grants access to the advanced Nuclear Fuel Cycle technologies
- Shares the profit from the services provided

TENEX is the integrator from the Russian side.
www.tenex.ru

Conclusions

1. Dual-Component Nuclear Power System uses all the best features of the thermal neutron (light water) reactors and fast neutrons (plutonium breeder) reactors.
2. Such the system allows to recycle all the nuclear fuel and to significantly minimize the volume of radioactive waste.
3. All the components of the Dual-Component System are already proved in Russia.
4. The main commercial peculiarity of the Dual-Component Nuclear Power System is an opportunity to perform a kind of fuel exchange.
5. There are different options for the Dual-Component Nuclear Power System realization by international cooperation.





Thank you very much for you kind attention!
Questions are welcome!

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