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Closing up Nuclear Fuel Cycle in a Two Component System with Thermal and Fast Neutron Reactors

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Purpose and Need for Closing the Nuclear Fuel Cycle (NFC) in Nuclear Generation

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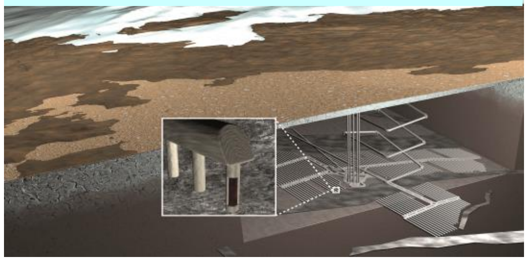
1. Ousting U-235 from nuclear generation as the underlying reason of low commercial efficiency, growing environmental unacceptability and limiting scale-up of open NFC
2. Creating a closed NFC in a two component NPP with thermal and fast neutron reactors with prevailing use of recycled fuel and Pu produced in the cycle to address in an economically and environmentally acceptable manner the deferred issues in used nuclear fuel (UNF) management
3. Reducing the volume and time of radwaste transition to the radiation safe condition
4. Creating favorable conditions for international cooperation to improve the efficiency of nuclear generation and UNF management
5. Technological and resource support to sustainable existence and development of nuclear generation

Global Options for UNF Management

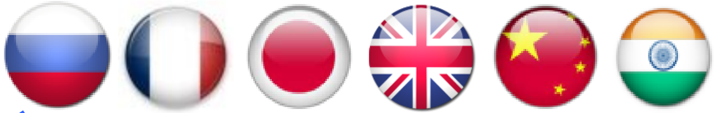
UNF Management

Long-term controlled storage and disposal – open NFC



UNF is considered as waste that should be disposed

Reprocessing & recycling – closed NFC



UNF is considered as feed to be extracted and returned to NFC as U-235 and Pu

The existing in Russia system of UNF management is a unified technological complex including storage, transportation, reprocessing of UNF and recycling of secondary product

Comparison of UNF Management Options Worldwide

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Open Nuclear Fuel Cycle	Closed Nuclear Fuel Cycle
+ No need to immediately address the issues of final isolation of UNF	− Needs improving technology of radiochemical reprocessing of UNF aimed at: (i) reducing the process costs, and (ii) mitigating the risks of proliferation of UNF reprocessing products
− High cost of construction & maintenance of landfills & long-term storage sites	
+ Low price of natural U at the current market situation (production exceeds the demand)	+ Zero dependence on sources of fuel resources and market situation
− Low efficiency of using the energy potential of natural U	+ Return to the NFC of non-burnt out & reactor generated products of UNF reprocessing (U-235, Pu, MA) reduces the need for natural U
− No solution regarding long-term isolation of radionuclides contained in UNF	+ Minimizing activity, volume and mass of waste intended for final disposal

Summary: Advantages of open NFC are of short-term nature; drawbacks of closed NFC can be eliminated

By the end of 2015 r. total accumulated ~ 285 thousand MT of UNF, and ~ 11 thousand MT of UNF unloaded from world reactor fleet annually

Global UNF Accumulation is Growing

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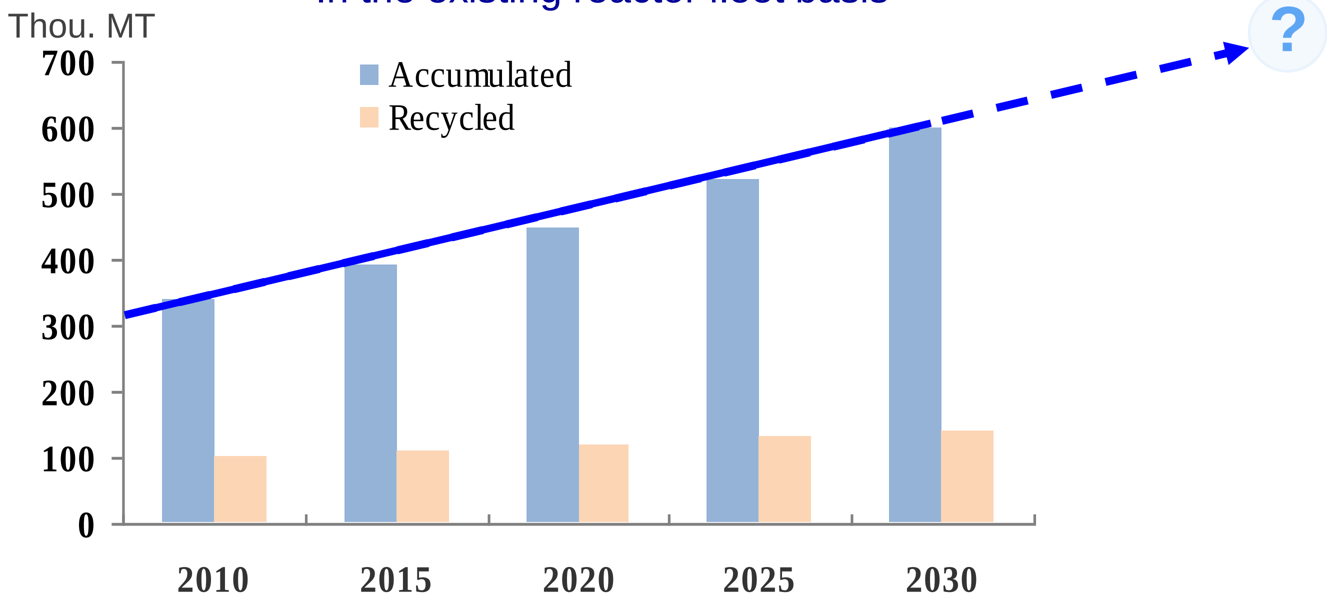
In the existing reactor fleet basis



How acceptable is preserving the trend ?

When & where will the accumulated UNF create an obstacle to scale-up of nuclear generation?

Two Component Nuclear Power Generation is a Way to Address Deferred Issues

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Two component nuclear power generation is a synergic coexistence of fleets of fast neutron & thermal neutron reactors

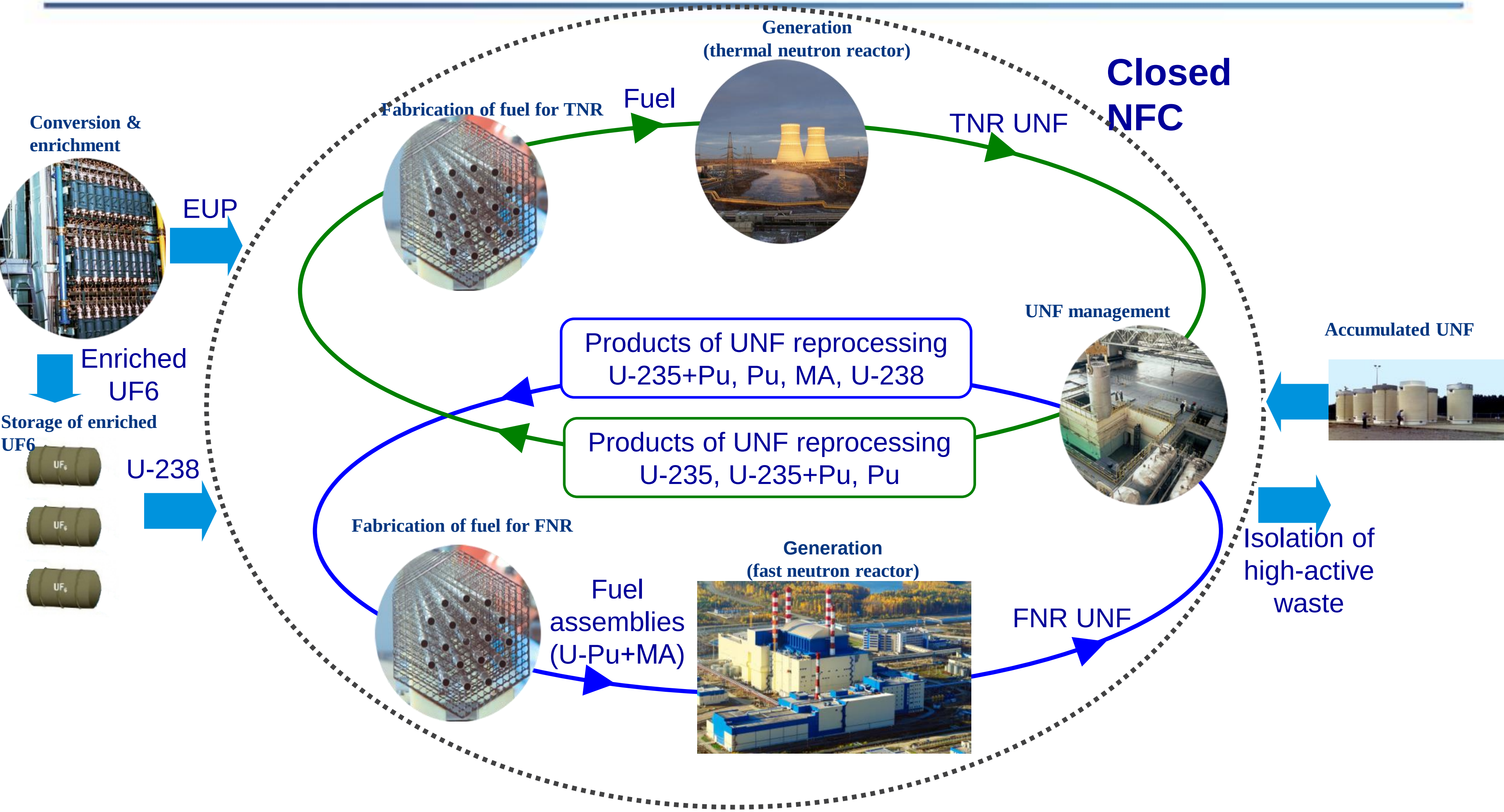
Fleet of thermal neutron reactors

Fleet of fast neutron reactors

- Addressing the issue of management of UNF accumulated worldwide;
- Tenfold improvement of efficient use of initial feed uranium;
- Minimizing volume & mass of nuclear generation wastes and reducing time for radioactivity decay through after-burning of minor actinides in fast neutron reactors

Closing up NFC needs efficient solutions for improving technologies of UNF reprocessing and including minor actinides in the composition of fuel for fast neutron power generation

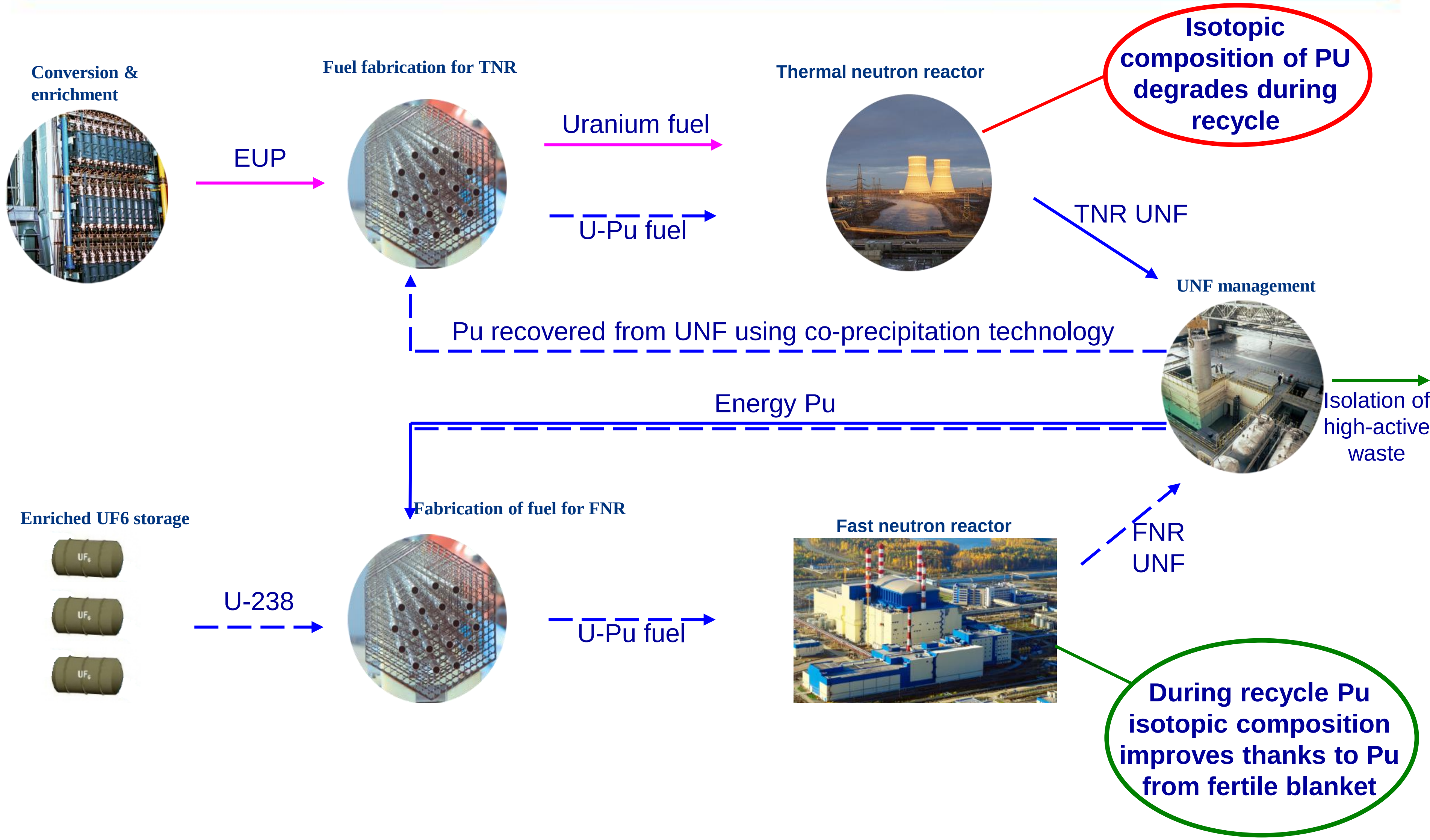
Principal Chart of Two Component Nuclear Power Generation (System of Fast Neutron & Thermal Neutron Reactors)



Closed NFC efficiency grows along with ousting U-235-based fuel by U-Pu fuel

FNR – fast neutron reactor
TNR – thermal neutron reactor

Fast Neutron Reactor Allows Multiple Pu Recycling in Two Component Nuclear Generation by Restoring Degraded Isotopic Pu Composition from Fertile Blanket (Pu из FB)



FNR – fast neutron reactor
TNR – thermal neutron reactor

Fractioning & After-Burning of Minor Actinides – Way to Reduce Time of High-Activity Radwaste Management

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1. Today: UNF is recycled with no fractioning

Rep U, Pu – useful products

Vitrified high-active waste (MA, Sr, Cs) **~ 2 cub.m per 1 GWt annual nuclear generation per annum**
Activity decay period = 10,000 years

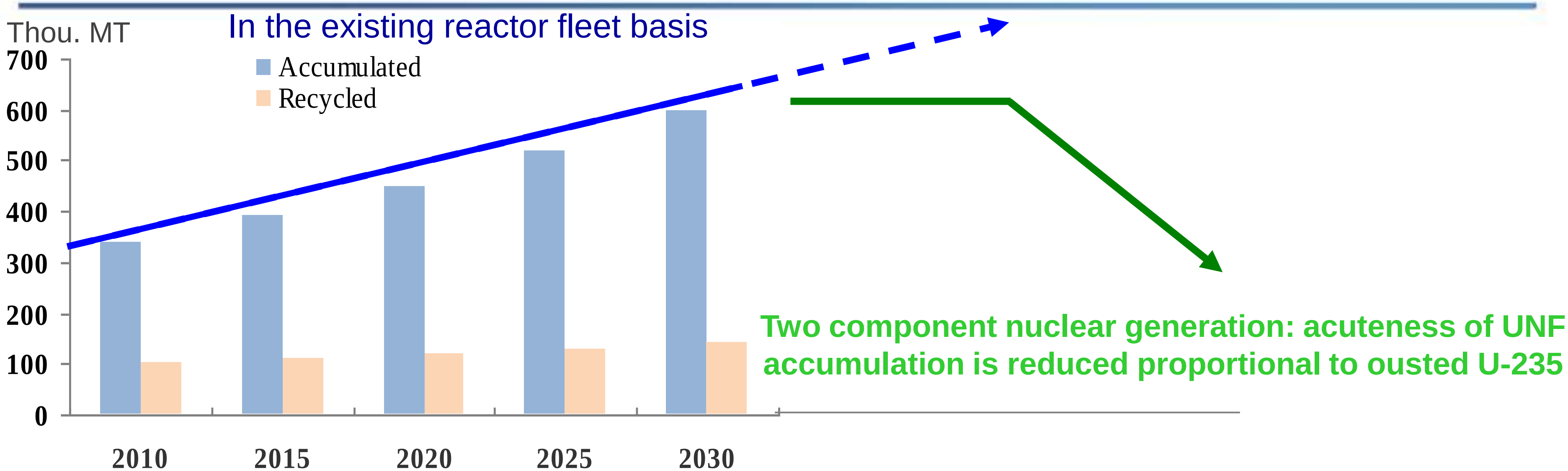
2. Prospective: UNF reprocessing with fractioning

Rep U, Pu – useful products

Minor actinides (Np, Am) after-burning in fast neutron reactors

Vitrified high-active waste (MA, Sr, Cs) **~ 2 cub.m per 1 GWt nuclear generation per annum**
Activity decay period = 300 years

Fleet of Fast Neutron Reactors – a Component of Closed NFC (Fast Neutron + Thermal Neutron Reactors)



Transition to a novel two component nuclear generation is possible through:

-Including FNR in national energy networks;

-Cooperation between utilities operating FNR with utilities operating TNR;

-Establishing international centers.

Russia's success in developing technologies, construction & operation of FNR's has created a tangible basis for closing NFC in the Russian Federation. As far as other countries are concerned, we are ready to discuss international cooperation options

Immediate Steps in Closing NFC in Russia

In December 2015 the Beloyarsk NPP launched a 880 MW fast neutron reactor unit with liquid sodium coolant. The reactor fuel is a mixture of U oxides from tails and Pu (MOX-fuel).

The annual requirement is 1.84 MT of Pu produced from ~ 190 MT of UNF from thermal reactors, and reduces the annual requirements of U-235 for VVER-type reactors with equivalent capacity of ~1600 MW.

Using BN-800 & BN-600 reactors at the demonstration stage of closing NFC up to 2025 is envisaged by the programs of Rosatom State Corporation.

THANK YOU FOR YOUR ATTENTION !