GEN IV International Forum
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Scientific and Technical Problems of Closed Nuclear Fuel Cycle in Two-Component Nuclear Energetics

Summary / Objectives:

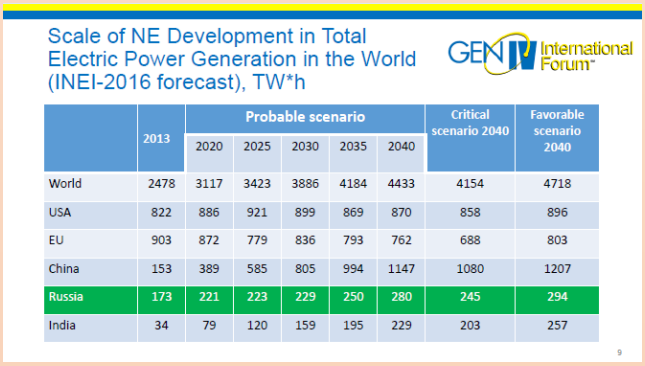
The webinar presents the overview of scientific and technical problems of closed nuclear fuel cycle in two-component nuclear energetics. The presentation will highlight the existing problems of the current technological platform of NE (thermal reactors in an open nuclear fuel cycle) and the advantages of the new technological platform (fast reactors with closed nuclear fuel cycle). Latest developments associated with the use of mixed UN fuel & spent nuclear fuel reprocessing are briefly presented as well. The remaining research challenges of the new technological platform being developed within the “Proryv” Project framework are summarized in the light of the present technology understanding.

Meet the Presenter:

Mr. Alexander Orlov, Ph.D. is the advisor to the Scientific Director of R&D of the “Proryv” Project. Since 2012, he has been a member of the fast reactors with lead and sodium coolants, a new type of reactor fuel (mixed U-Pu nitride), and technologies to reprocess spent nuclear fuel in order to return it into the fuel cycle. These technologies combined are known as the “Proryv” Project.

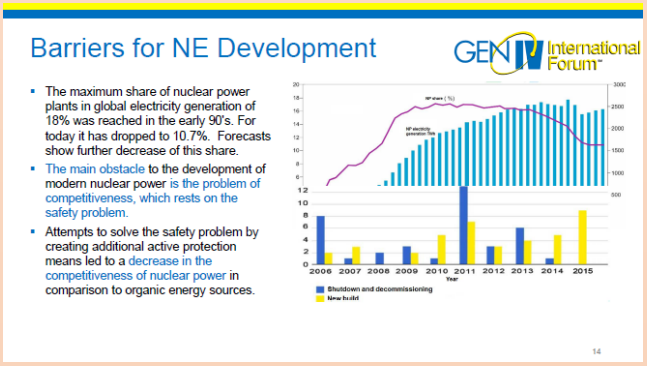
Pessimistic forecast of future NE deployment and its obstacles:

In accordance with the analysis of world deployment scenario of nuclear power, all scenario showed pessimistic growth of nuclear deployment except China. The obstacle of nuclear deployment is lack of competitiveness by additional safety measures. The current and/or old open nuclear fuel cycle would be sufficient to mid-term fuel supply, but have limitation for use in longer-term due to low utilization efficiency of uranium, lack of environmentally acceptance, and proliferation risk.



Scale of NE Development in Total Electric Power Generation in the World (INEI-2016 forecast), TW*h

	2013	Probable scenario					Critical scenario 2040	Favorable scenario 2040
		2020	2025	2030	2035	2040		
World	2478	3117	3423	3886	4184	4433	4154	4718
USA	822	886	921	899	869	870	858	896
EU	903	872	779	836	793	762	688	803
China	153	389	585	805	994	1147	1080	1207
Russia	173	221	223	229	250	280	245	294
India	34	79	120	159	195	229	203	257



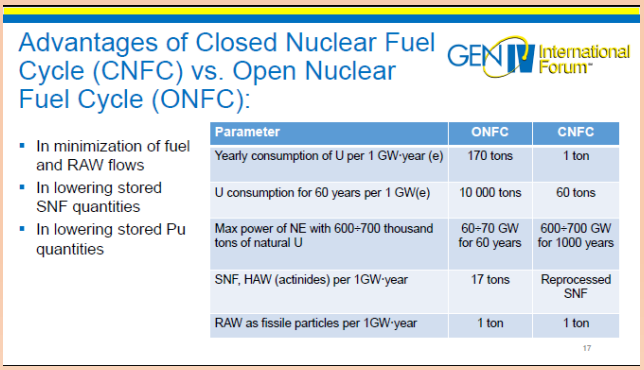
Barriers for NE Development

- The maximum share of nuclear power plants in global electricity generation of 18% was reached in the early 90's. For today it has dropped to 10.7%. Forecasts show further decrease of this share.
- The main obstacle to the development of modern nuclear power is the problem of competitiveness, which rests on the safety problem.
- Attempts to solve the safety problem by creating additional active protection means led to a decrease in the competitiveness of nuclear power in comparison to organic energy sources.

New Technology Platform (NTP) with Fast Reactor:

The closed fuel cycle with Fast Reactor have advantage in minimization of radioactive waste, lowering spent nuclear fuel (SNF) and stored plutonium. The government of Russia constructed the development strategy of NTP, Strategy-2000, and proceeded it based on the milestones by 2020.

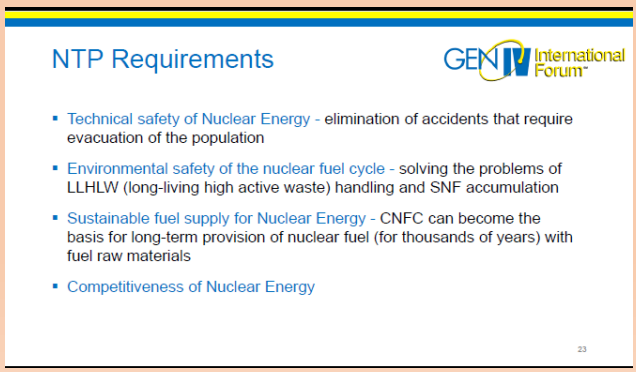
Resolve four major challenges are required to NPT, 1) technology safety, 2) environment safety, 3) sustainable fuel supply, and 4) competitiveness.



Advantages of Closed Nuclear Fuel Cycle (CNFC) vs. Open Nuclear Fuel Cycle (ONFC):

- In minimization of fuel and RAW flows
- In lowering stored SNF quantities
- In lowering stored Pu quantities

Parameter	ONFC	CNFC
Yearly consumption of U per 1 GW·year (e)	170 tons	1 ton
U consumption for 60 years per 1 GW(e)	10 000 tons	60 tons
Max power of NE with 600÷700 thousand tons of natural U	60÷70 GW for 60 years	600÷700 GW for 1000 years
SNF, HAW (actinides) per 1GW·year	17 tons	Reprocessed SNF
RAW as fissile particles per 1GW·year	1 ton	1 ton



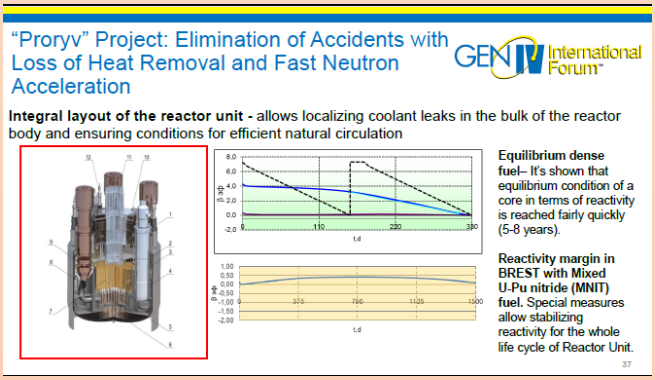
NTP Requirements

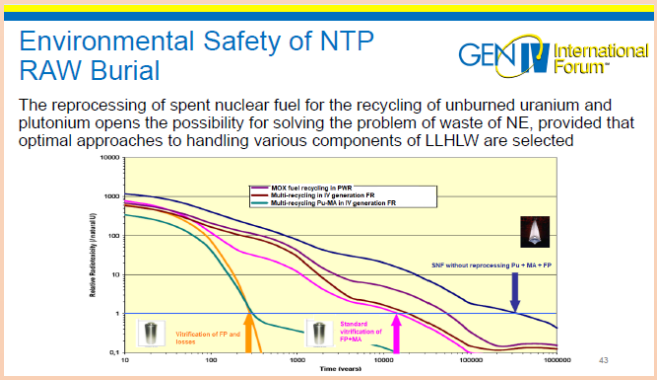
- Technical safety of Nuclear Energy - elimination of accidents that require evacuation of the population
- Environmental safety of the nuclear fuel cycle - solving the problems of LLHLW (long-living high active waste) handling and SNF accumulation
- Sustainable fuel supply for Nuclear Energy - CNFC can become the basis for long-term provision of nuclear fuel (for thousands of years) with fuel raw materials
- Competitiveness of Nuclear Energy

1) Technology safety and 2) Environmental safety:

The goal to achieve technological safety is elimination of accident that requires evacuation of the population at nuclear power plant and other nuclear facilities. The dense fuel in reactor core with zero reactivity margin for burnup, lead coolant, air heat exchanger for natural circulation are possible measures to eliminate reactivity accidents and accident with loss of heat removal.

For environmental safety, the goals are publicly acceptable treatment of LLHLW and avoidance of SNF accumulation. Processing SNF, MA transmutation and disposal of radioactive waste are identified as measures to prohibit RW disposal containing ecologically significant amount, reduce the amount of SNF, and isolate RW.

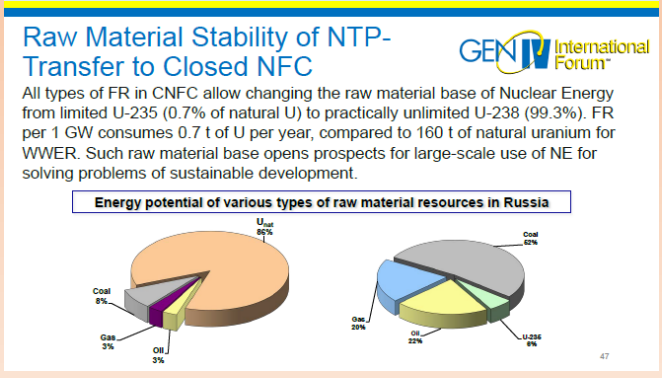


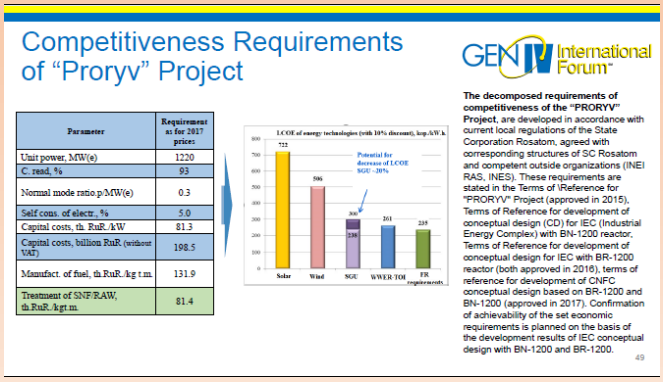


3) sustainable fuel supply, and 4) competitiveness

Having long-term provision of nuclear fuel with raw materials is the goals for sustainable fuel supply. The full reproduction of fissile nuclides in the core and transition to a closed NFC, using FR with B.R.~1, SNF reprocessing and fuel fabrication with recycled materials, are possible ways to reach the goals.

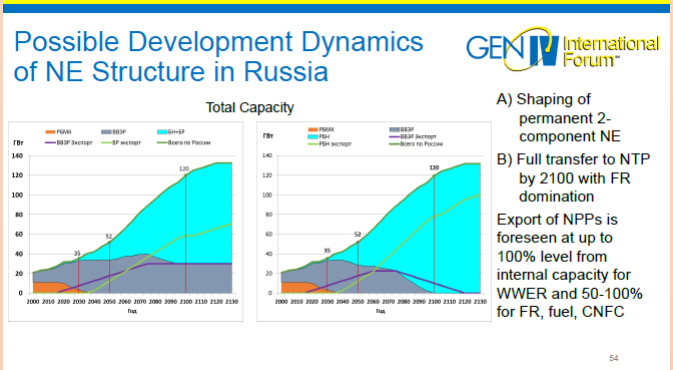
Competitiveness could be achieved by elimination and simplification of number of NPP safety systems and design of the reactor, and reduction of the fuel component, and transportation costs using on-site fuel cycle systems.

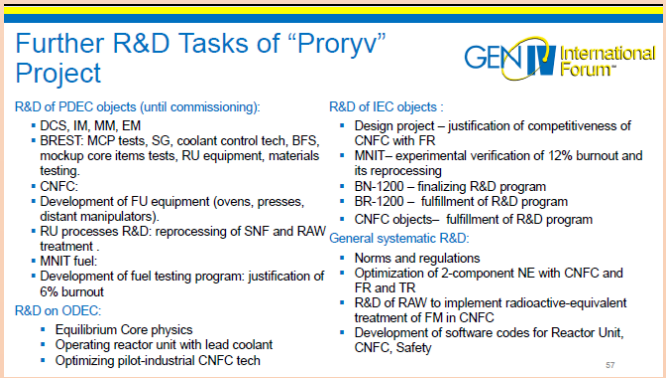




Proryv Project :

The Proryv Project have been implemented by the State Atomic Energy Corporation ROSATOM which is aimed at achieving these challenges. The seven solutions for technical safety have been studied and developed the lead coolant reactor with nitride fuel, BREST-OD-300. The multiple software evaluation and test-reactor irradiation of nitride fuel has been carried out for the development. The pyro-chemical reprocessing, no blanket design and transmutation of MA also studied for the solution of environmental safety. Preliminary results of scenario study in Russia assumed pilot energy complex, BREST-OD-300 with dense nuclear fuel and reprocessing, BN-1200 and design project of industrial energy, shows full transfer to closed fuel cycle with FR will be achieved 120 GW by the end of this Century.





Conclusion:

"PRORYV" Project provides leadership in the studies for major challenges required to NPT.

The crisis of world nuclear power can be overcome by the creation between 2018-2035 of the first industrial Energy Complex based on Fast Reactors.