



РОСАТОМ

MNTK-2012



ГОСУДАРСТВЕННАЯ КОРПОРАЦИЯ ПО АТОМНОЙ ЭНЕРГИИ «РОСАТОМ»

PERSPECTIVES OF DEVELOPMENT AND INTRODUCTION OF CLOSED FUEL CYCLE

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Challenge

- **Task about transfer of nuclear power generation to the closed fuel cycle is mentioned in almost all programs of nuclear industry development.**
- **At the same time, this issue is non-dedicated and has not got any specific implementation plan for a quarter of century.**

Main causes – lack of necessity, realization program and motivated customer.

Under current circumstances JSC “Concern Rosenergoatom” (further referred as Rosenergoatom) is able and can be such customer, because in 10 – 15 years it will face the thread of competitive ability loss at electricity market.

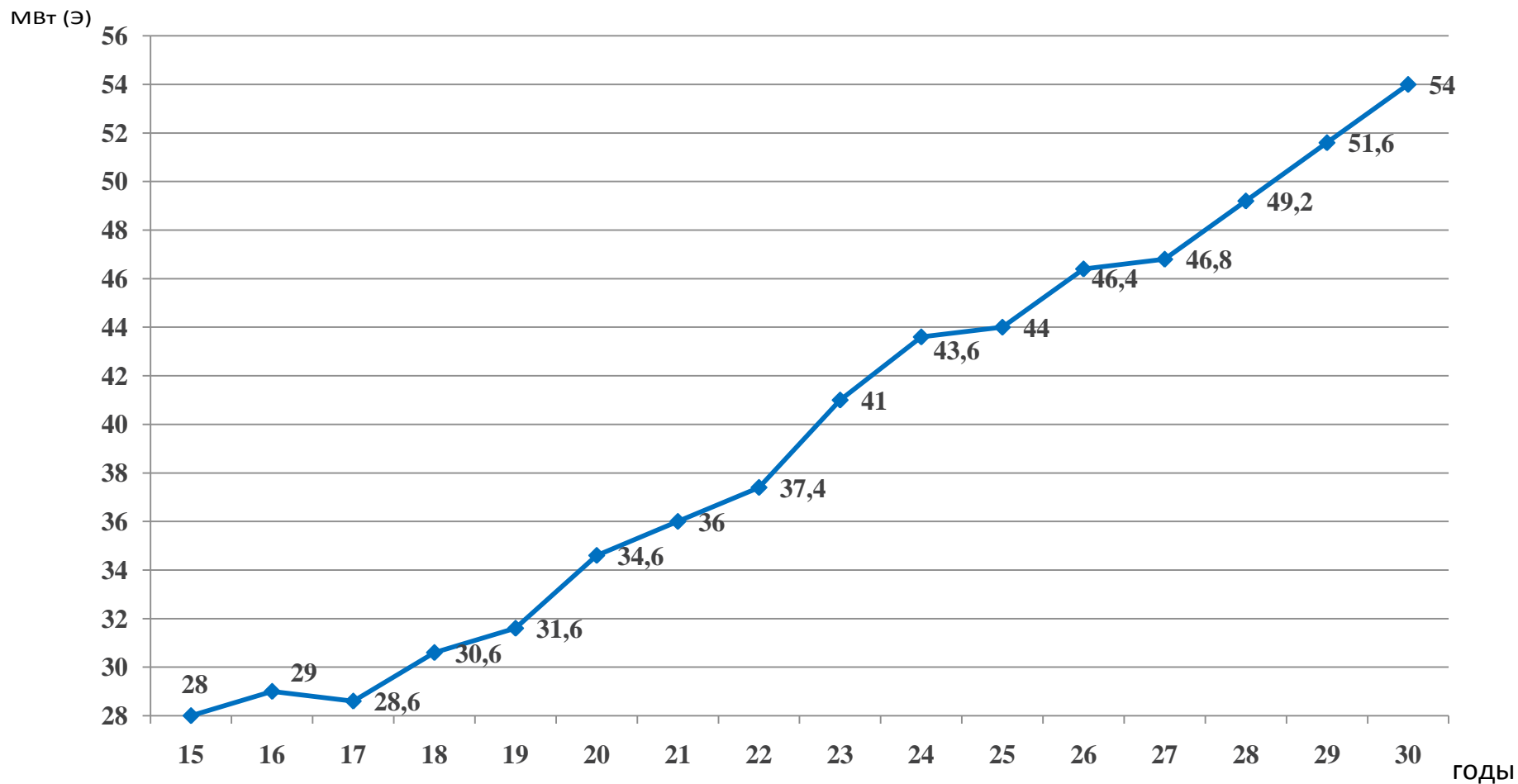
Причины проблемы и способ её решения

- **Substantial obstacle for competitive development of Rosenergoatom are as follows:**
 - **Extremely low efficiency of uranium application, that is in the core of growing costs for upkeep of nuclear heritage;**
 - **Unacceptable growth of cost for nuclear fuel management in connection with decommissioning of old generation units;**
 - **Setting of price for uranium fuel and spent nuclear fuel handling services is irrespective of Rosenergoatom opinion.**
- **Problems arisen in this respect in Rosenergoatom should be countervailed. It is possible solely by means of introduction of new reactor technologies and plutonium share in heat generation that is a point of nuclear fuel closure.**
- **Necessity of accelerated nuclear fuel cycle closure by means of replacement of is uranium-235 with plutonium is overriding in mid-term plans of strategic development of Rosenergoatom till 2030.**

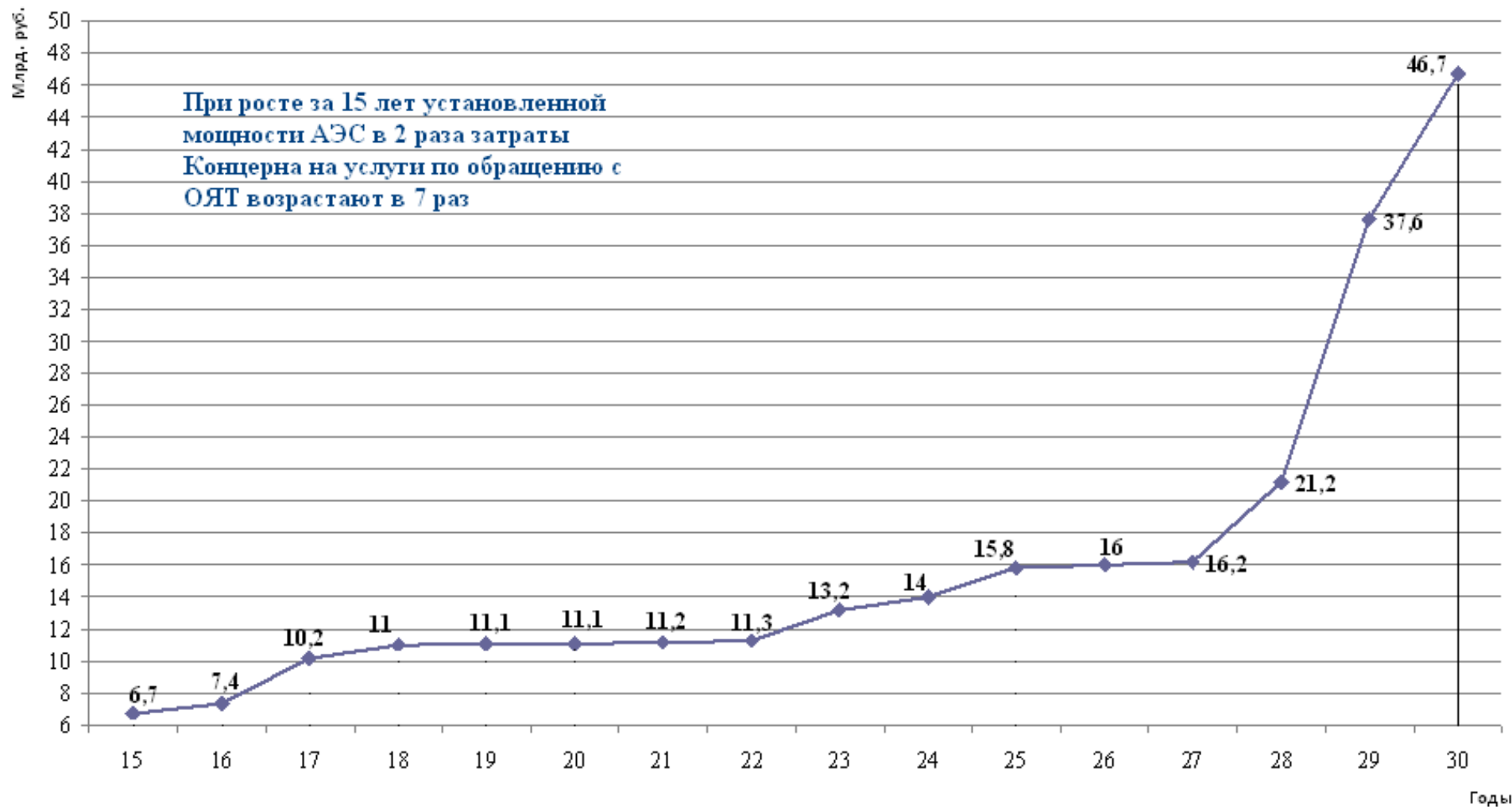
Threat Assessment of competitive ability loss of JSC “Concern Rosenergoatom”

GROWTH DYNAMICS OF INSTALLED CAPACITY

Roadmap of long-term actions of State Corporation "Rosatom"



BEHAVIOUR OF COSTS FOR NUCLEAR FUEL HANDLING SERVICES



Why it will happen?

- Since 2027 all spent nuclear fuel will be property of Rosenergoatom including any kind of encumbrance connected with spent nuclear fuel handling.
- During the period of 2016 to 2027 old generation power units with capacity of 12 GW will be shutdown for subsequent decommissioning. Spent nuclear fuel of these units will be unloaded and sent to industry plants for storage. Weight of fuel from RBMK-type reactors that will be transported till 2030 is 11 876 t.
- Input of new capacities till 30th years will entail even grater gain in spent fuel volume and storage expenses.
- The process concerns the power industry in general, but there are no comprehensive plan for moderation (inhibition) of this process.

Means and ways of compensation of dangerous growth of fuel factor in power production cost of Rosenergoatom ?

It is needed to close fuel cycle on the basis of installed capacity of nuclear power plants of 35GW in package with BN-1200 and VVER-TOI series on the assumption of current and prospective plutonium production and taking into account minimization of costs for creation of infrastructure and time diversity of costs.

The following actions should be taken to implement above stated provision:

- 1. To take decision to construct series consisting of 6 units with fast reactors of BN-1200 type;**
- 2. To take decision to adopt VVER-TOI project for operation with MOX-fuel;**
- 3. To mobilize power station plutonium accumulated from spent nuclear fuel processing ex stock at zero value, for production of MOX-fuel for BN-1200 units (about 55 t by 2020);**
- 4. To mobilize weapon-grade plutonium meant for utilization and in consideration for utilization under agreement with USA at zero value, for manufacturing of MOX-fuel for VVER-TOI power units (35 40 % of the core) up to 38 t. ;**

5. Create facilities for manufacturing of MOX –fuel for BN-1200 in two stages;
6. Create facilities for manufacturing of MOX –fuel for VVER-TOI;
7. Create facilities for processing of spent nuclear fuel from thermal neutrons reactors in 2025 (1-st construction stage of PT-2 plant);
8. Create facilities for processing of MOX –fuel irradiated in BN-1200 reactors;
9. Create facilities for processing of spent nuclear fuel from uranium and MOX-fuel of VVER-TOI in 2028 (2-nd construction stage of PT-2 plant).

**Status of reactor and fuel technologies.
Financial support of their implementation.**

POWER UNIT WITH BREEDER REACTOR BN-1200

- 1. Declaration of Intentions to invest in construction of power unit #5 Beloyarsk NPP with fast neutron reactor BN-1200 was approved by Director General of Rosatom Corporation on 28.09.2011.**
- 2. Action plan for preparation of construction of power unit #5 Beloyarsk NPP with fast neutron reactor BN-1200 was developed and approved by first deputy Director General of JSC “Concern Rosenergoatom” on 28.11.2011.**
- 3. Investment concept of construction of power unit #5 Beloyarsk NPP with fast neutron reactor BN-1200 was approved by Director General of JSC “Concern Rosenergoatom” on 18.01.2012.**
- 4. Design specification of BN-1200 reactor installation and design basis for power unit with BN-1200 reactor with capacity of 1250 thousand kWe are approved by JSC “Concern Rosenergoatom” and are at the stage of issuance.**

5. First priority goal of Rosenergoatom is to finalize design of power unit with BN-1200 reactor, so that to begin construction works in 2012 and to commission it in 2020 as a head unit of series consisting of 6 power units.

6. BN-1200 project development is a result of evolutionary development of sodium fast neutrons based on convincing reference, with capital expenditures proximal to costs of equal in terms of power VVER reactor and safety level not less than safety level of generation 3+. More appropriate breeder reactor for proposed plan of nuclear fuel cycle is not available at the moment and will not be available till 2030.

7. Project development is financed from Federal budget funds allocated for federal special-purpose program «ЯЭНП», with involvement of Rosenergoatom in co-financing of this program. Construction will be realized at the cost of investment program of long-term activities of State corporation “Rosatom”.

VVER-TOI NPP

- 1. Justification should be done for and consideration in the design should be foreseen of operating ability of power unit using MOX-fuel constituting 30 to 40 percent of core charge.**
- 2. Program of experimental proof of possibility and conditions of MOX-fuel operation at 1- 2 operating VVER-1000 within the period till 2016 should be developed.**
- 3. Design and construct plants for manufacturing of MOX-fuel for VVER-TOI using weapon-grade plutonium under agreement with USA about utilization not later than in 2018. Plutonium with reduced background (glove plutonium) in comparison with nuclear power plutonium retrieved from breeder blanket and core of BN-1200 should be considered as basic material in the course of designing, that will be fuel for VVER after finalization of utilization.**
- 4. MOX-fuel should be used in VVER-TOI since 2020. Appropriate decisions should be taken to ensure it.**
- 5. Source of financing of such activities is not defined.**

Requirements for production of mixed uranium-plutonium fuel for BN-1200 series

- 1. In order to diversify the costs in time and taking into account reference equipment of limited capacity and possible improvement of technology it is feasible to create fuel manufacturing plants for BN-1200 in to stages:**
 - 1-st construction stage with capacity of 50 t/year in 2018;**
 - 2-nd construction stage with capacity of ≥ 50 t/year in 2024.**
- 2. Mixed dioxide uranium-plutonium fuel (MOX fuel) with use of nuclear power plutonium after spent nuclear fuel processing from thermal reactors should be taken as basic fuel composition.**
- 3. Stages design should make provisions for possibility of adaptation to mixed nitride uranium-plutonium fuel production.**
- 4. Appropriate decisions should be taken for creation of fuel manufacturing plant for BN-1200 series.**

Requirements for production of mixed uranium-plutonium fuel (MOX-fuel) for VVER-TOI

- 1. In order to diversify the costs in time and taking into account that a part of reactor cores of VVER-TOI should be urgently put to MOX-fuel, and considering possible significant improvement of technology by 2025, it is feasible to create fuel manufacturing plants in to stages :**
 - 1-st construction stage with capacity of 50 t/year in 2018;**
 - 2-nd construction stage with capacity of ≥ 50 t/year in 2024.2.**
- 2. Design of manufacturing plants should be carried out based on the provision that plutonium will be used after spent nuclear fuel processing from BN-1200 with reduced background (glove plutonium) in comparison with nuclear power plutonium.**
- 3. Appropriate decisions should be taken for creation of fuel manufacturing plant for VVER-TOI units.**

PROCESSING PLANTS OF SF OF VVER

1. RT-1 plant is functioning at PO “Mayak” that is dealing with VVER-440 and BN-600 spent fuel processing with output of power plutonium up to 1t/year.

2. Experimental and demonstrational center of spent nuclear fuel processing from VVER with capacity up to 250t/year and output of power plutonium till 2,5 t/year will be functioning at FSUE “GChK” (mining-and-chemical plant) since 2018 r.

3. In 2012, first construction stage of RT-2 plant will be erected for processing of spent nuclear fuel of VVER-1000 with capacity of ≥ 700 t/year of heavy metal with output of power plutonium of about 7t/year for subsequent charge of BN-1200 units.

- In 2028, second construction stage of RT-2 plant will be erected for processing of spent nuclear fuel of VVER-TOI and VVER-1000 with capacity of ≥ 800 t/year of heavy metal with output of power plutonium of about 8t/year (in accordance with nuclear power industry development program after 2030)

Construction of RT-2 and its financing is foreseen in the special - purpose program “Spent Nuclear Fuel management” governed by Nuclear and Radiation safety direction of Rosatom State corporation.

PROCESSING PLANTS OF SF OF BN-1200

Necessity of specialized line for manufacturing of MOX-fuel for VVER-TOI will arise in 2025 which will be created with capacity of ≥ 100 t/year on heavy metal with output of glove plutonium > 14 t/year after finalization of weapon-grade plutonium utilization program by 2027.

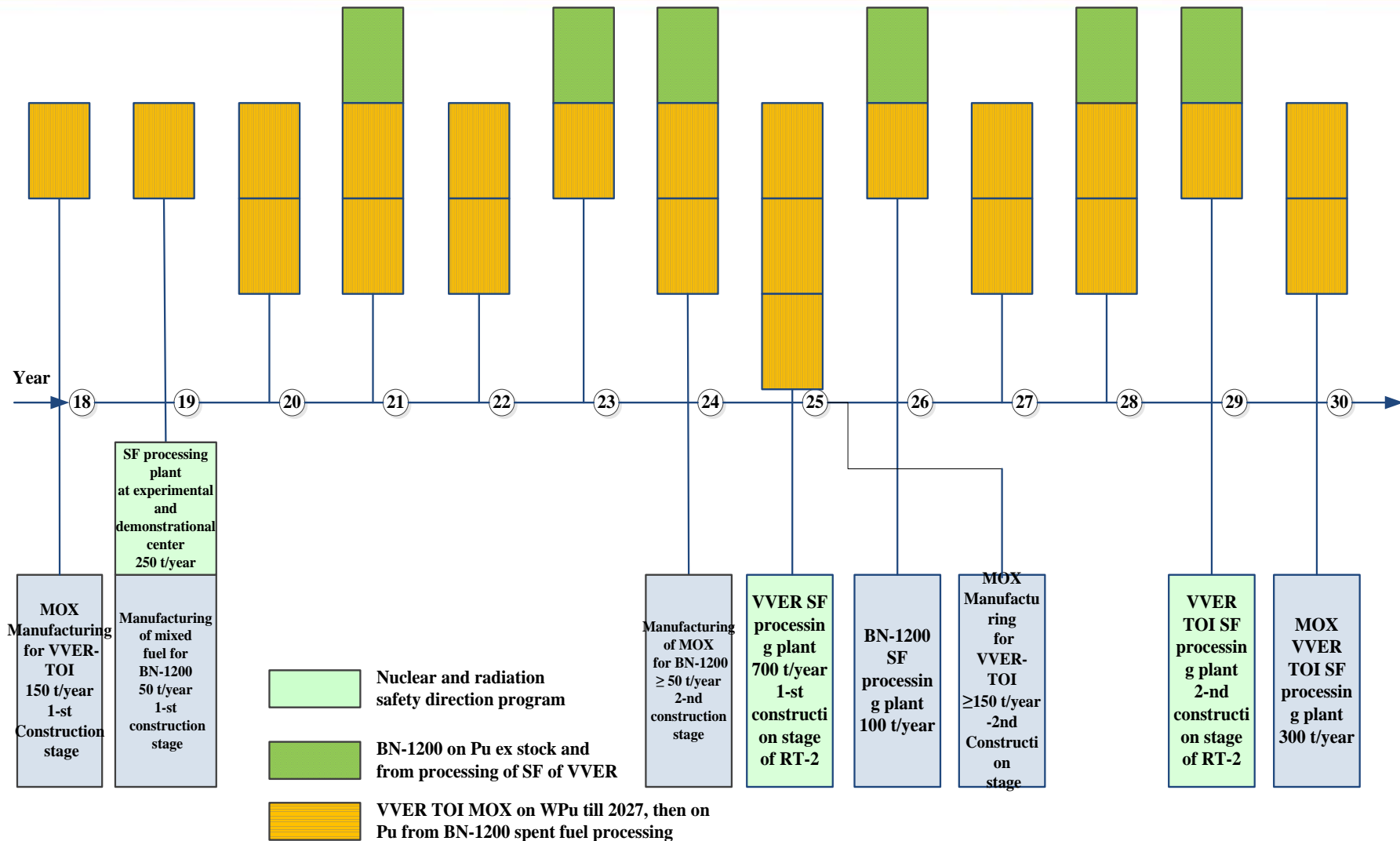
By now 3 possible technologies of such manufacturing are studied. Decision should be taken to continue activities on program of NRS Direction of “Rosatom”.

PROCESSING PLANT FOR SF OF MOX VVER-TOI

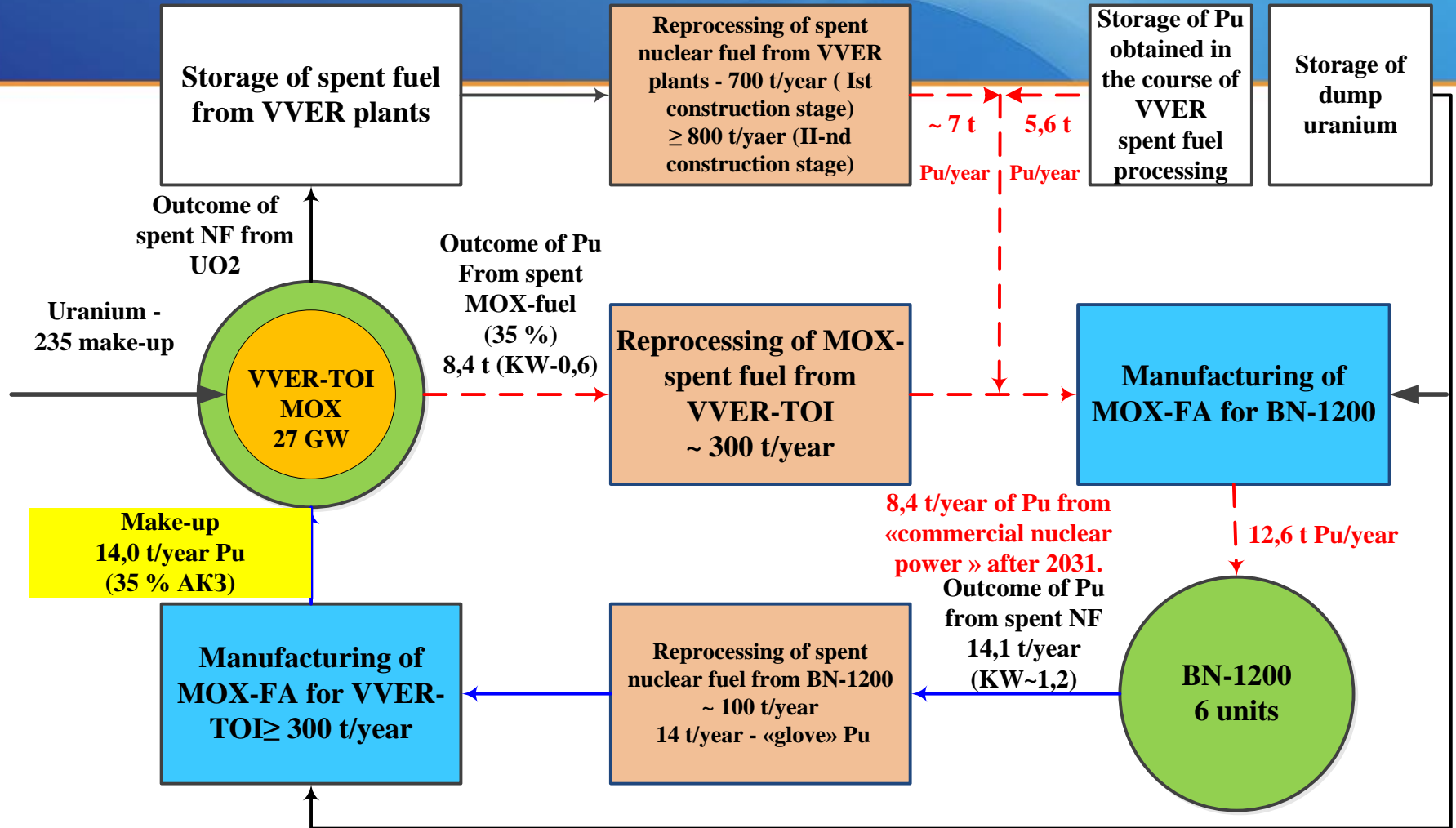
Necessity of such plant will arise in early 30-th that will be created to extend RT-2 plant for plutonium output needed for charging of BN-1200 power units.

Plant creation is planned by Rosatom within the framework of special-purpose program “Spent nuclear fuel management».

ROADMAP OF I STAGE OF NUCLAR FUEL CYCLE CLOSURE



Block diagram of the I stage of closed nuclear fuel cycle (without BN-800)



- - - - - → Pu from «commercial nuclear power»
————— → Pu with reduced background

Note:

- 1) Till 2027 weapon-grade plutonium is used for production of MOX-fuel for VVER-TOI, then - low level plutonium from BN-1200.
- 2) Since 2028 BN-800 is a part of the cycle as weapon-grade plutonium utilization will stop.

PROSPECTIVE COSTS INCURRED

1. Up to 27 billion Rubles will be needed to create plant for manufacturing of MOX-fuel for BN-1200.
2. 15 billion Rubles will be needed to create plant for manufacturing of MOX-fuel for VVER-TOI.
3. Federal budget funds allocated for federal special-purpose program of nuclear and radiation safety will be used for creation of 1-st construction stage of RT-2 for processing of uranium fuel from VVER.
4. Up to 10 billion Rubles will be required to create processing plant for MOX-fuel from BN-1200.
5. Creation of II-nd construction stage of RT-2 for processing of VVER-TOI SF will be needed in 2028, its capacity should be not less than 800 t/year. They will be created according to programs of NRS direction of Rosatom.
6. Expenses for construction of BN-1200 and VVER-TOI units will be covered in accordance with investment program for ensuring roadmap of nuclear power industry development.
7. Summary additional costs of infrastructure development of the 1-st stage of closure ~ 52 billion Rubles.

Rosenergoatom benefits from the 1-st stage of nuclear fuel cycle closure

- Application of MOX-fuel will invoke VVER installed capacity of 27 GWe (in the amount of 35 % of the core) equivalent to ~ 9,5 GW of installed capacity of conditionally charged with 100 % MOX-fuel.
- Installed capacity of BN-1200 (6 units) and BN-800 (1 unit) on MOX fuel will be invoked equivalent to 8 GW.
- Provided that plutonium has zero price, component price and outfitting cost is equal to 50 % of FA cost, considering forecast of U_3O_8 price growth saving from replacement of Uranium - 235 with Plutonium for installed capacity of 17,5 GW in 2030 will be not less than 12 billion rubles per year.
- Saving from replacement of Uranium -235 with Plutonium will be visible since 2020 and will constitute at least 60 billion rubles by 2030 considering that expenses for infrastructure development at given stage of nuclear fuel circle closure are 52 billion rubles.
- Construction of new spent fuel storages for nuclear power fleet with capacity of 54 GW will not be required since 2030.
- Based on experience gained and considering new breakthrough technologies next stage of nuclear fuel circle closure can be launched in 2030.
- Realization of I-st stage of nuclear fuel circle closure is a highly effective commercial project (pay back in the course of implementation).

NFC CLOSURE RELATED TASKS HAVING NO SOLUTION PRECEDENTS

DECISIONS SHOULD BE TAKEN AT THE GOVERNMENTAL LEVEL CONCERNING

- **PRICE AND PROCEDURE FOR UTILIZATION OF PLUTONIUM EXTRACTED FROM SPENT NUCLEAR FUEL RESULTED FROM NUCLEAR POWER PLANTS OPERATION;**
- **USE OF COSTS SAVED THANK TO REPLACEMENT OF URANIUM -235 WITH PLUTONIUM IN NUCLEAR FUEL FOR THE PURPOSE OF NUCLEAR FUEL CICLE CLOSURE.**

THANK YOU FOR ATTENTION

FORECAST OF URANIUM PRICE GROWTH WITHIN THE PERIOD OF 2013 TO 2025

(Department of production cost calculation and price estimates ,JSC «TVEL», 26.03.2012)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
\$/pound U3O8	55,50	58,13	61,20	63,65	65,70	67,45	68,75	70,05	73,00	75,10	78,55	80,73	83,15
\$/kgU	144,29	151,13	159,11	165,48	170,81	175,36	178,74	182,12	189,79	195,25	204,22	209,88	216,18