



РОСЭНЕРГОАТОМ

ЭЛЕКТРОЭНЕРГЕТИЧЕСКИЙ ДИВИЗИОН РОСАТОМА



MHTK-2018

Near-future plans of Rosenergoatom in implementation of the nuclear power development strategy

Alexander Shutikov, Deputy Director General
for operation of nuclear power plants

Moscow | May 23, 2018

NPP performance indicators in 2017:

Electricity generation: **202.9 bln. kW-hr**

at the units that have not expired its lifetime

81.9 bln. kW-hr (40%)

at the units with extended lifetime

121 bln. kW-hr (60%)

Load factor – **83,3%**

Balakovo NPP unit No.3 -
103.2%

Load factor exceeding 90%
(10 NPP units)

Load factor exceeding 85% (7
NPP units)

37 events at power the NPP units

33 - at the units during
commercial operation

4 - at the units during pilot
operation

0.9 events per unit

5 events with scram actuation

4 - at the units during
commercial operation

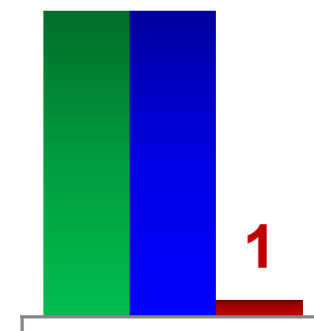
1 - at the units during pilot
operation

0.08 scrams at 7000 hrs. of

operation

CO – commercial operation
PO – pilot operation

18 18



■ Вне ■ ИНЕС-0 ■ ИНЕС-1

The future of the Russian nuclear power industry depends on successful resolution of three main challenges:

1. Maintaining of safe and efficient operation of existing NPPs and its fuel infrastructure.
2. Gradual substitution of the existing NPPs with power units of advanced safety... ensuring based on it the moderate growth of the installed capacity of nuclear power industry and increase of its export capabilities.
3. Development and mastering in industrial scale of nuclear power technologies that meet the requirements of the large-scale energy in terms of economy, safety and fuel balance.

Technical support to safety Enhancement of the commissioning NPP units

parameter	AES-2006			VVER-TOI
	VVER-1000	Novovoronezh NPP-2	Leningrad NPP-2	
NPP unit lifetime, years	30	60	60	60
Channels of active safety systems	4	2	4	2
Thermal capacity, MW	3000	3200	3200	3300
Electric capacity, MW	1000	1195	1198	1255

Pilot Novovoronezh NPP unit No.6 was commissioned for pilot operation in 2017



Leningrad NPP unit No.5 is expected to be commissioned for pilot operation in 2018

Passive safety systems

	VVER-100	AES-2006 Novovoronezh NPP-2	AES-2006 Leningrad NPP-2	VVER-TOI
Passive heat removal system from steam generators	-	+	+	+
Passive heat removal system from the containment	-	-	+	-
Passive part of ECCS (GE-1)	+	+	+	+
Systems of core passive flooding (GE-2)	-	+	-	+
Systems of core passive flooding (GE-3)	-	-	-	+
Molten corium trap	-	+	+	+

Human actions. Development of safety culture

Development of leadership of managers and coaching for the safety purposes

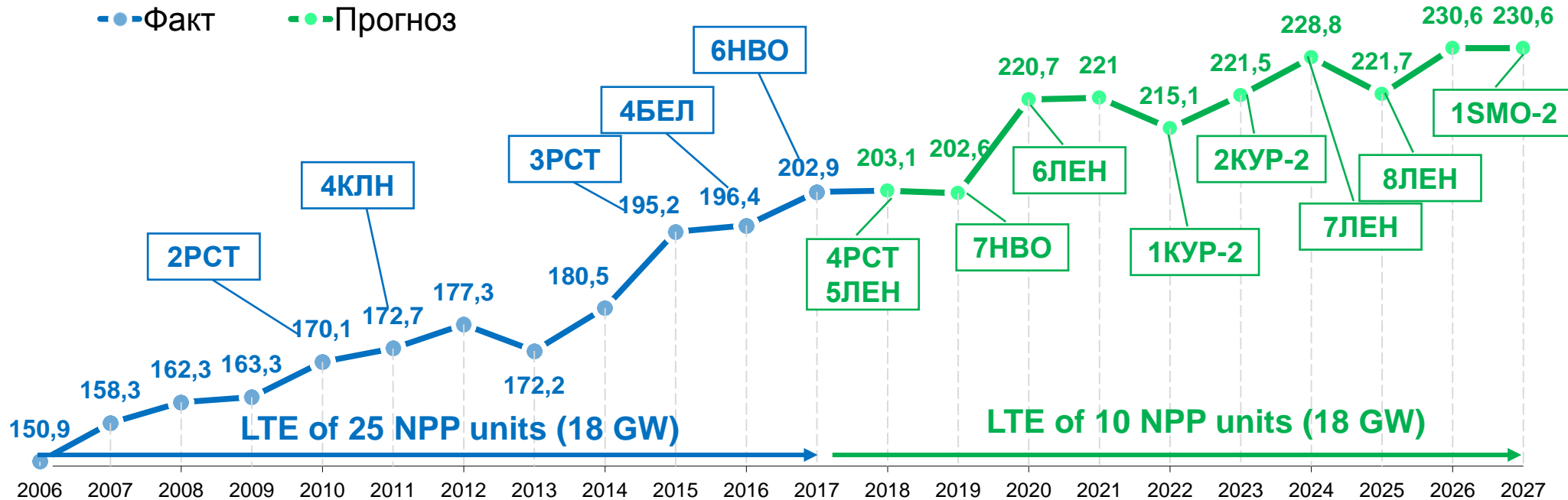
Communication of the managers to the personnel

Establishment of the atmosphere of zero tolerance to violation of the safety requirements by the personnel

Striving for continuous self-improvement

Establishment of the atmosphere of trust by the managers

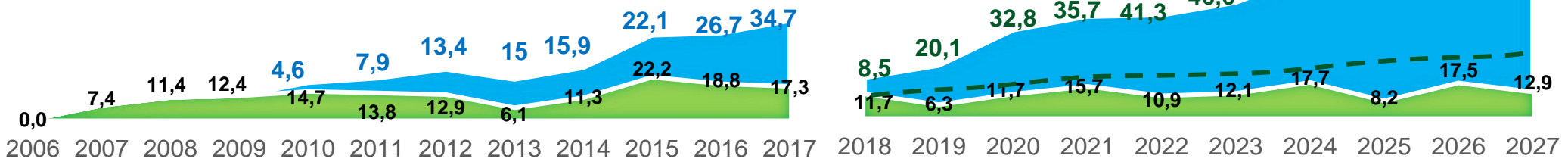
Forecast of the electricity generation bln. kW·hr



- повышение эффективности
 - increase of efficiency factor
 - increase of load factor
 - power upgrade of VVER-1000 reactor units
- ввод новых блоков

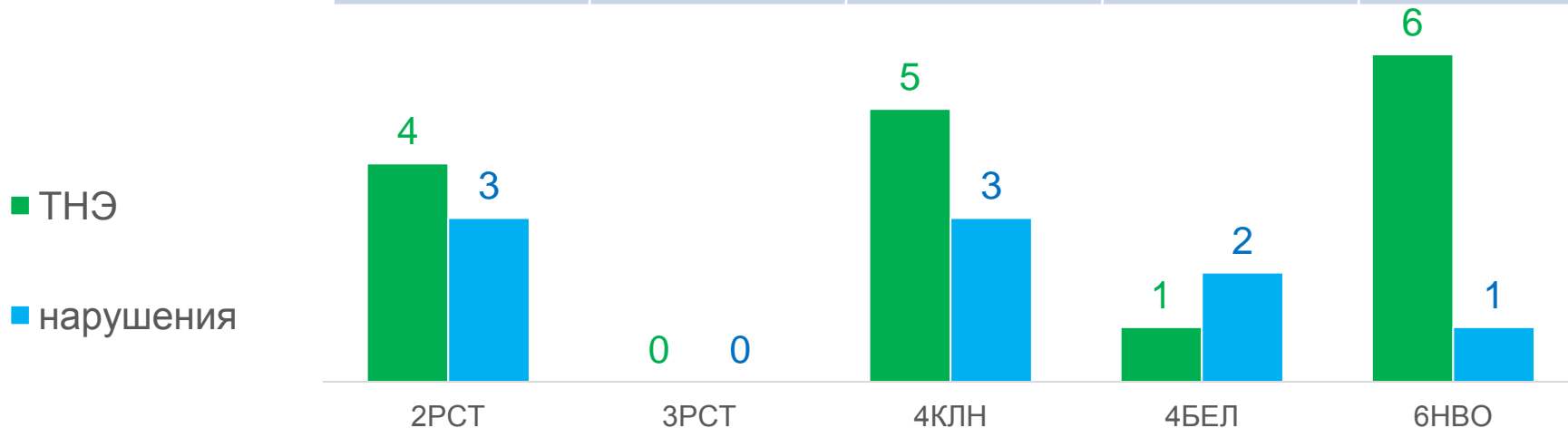
- повышение эффективности за счет ранее реализованных программ
- ввод новых блоков

possible ways of enhancing the effectiveness



Operational reliability and efficiency of new NPP units

NPP units of the power supply contract:	Rostov NPP unit No.2	Rostov NPP unit No.3	Kalinin NPP unit No.4	Beloyarsk NPP unit No.4	Novovoronezh NPP unit No.6
Scope of unpreparedness for power delivery in 2017 (MW)	1199.3	372.5	262.6	343.6	2435.9



DEVELOPED

«Plan of activities to ensure safe and reliable operation of the NPP units engaged in power supply contracts»

Outage-2017	Outage-2018	Outage-2019	Outage-2020
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Primary lifetime extension

Results of 2017

- maintaining of the generation **25** NPP units
- **18** GW of generating capacities
- Contribution to the generation attained:
121 bln kW hr (~**60%** of total electricity generation)

Necessity for resolution of the additional tasks

Annealing of the reactor vessel at Balakovo NPP unit No.1.

+

performance of additional calculation substantiations for core internals of VVER-1000

+

Kalinin NPP units Nos. 1, 2 - replacement of the cables and upgrading of instrumentation and control systems

Balakovo NPP unit No.2 VVER-100

Balakovo NPP unit No.3 VVER-1000

Smolensk NPP unit No.3 RBMK-1000

Balakovo NPP unit No.4 VVER-1000

2017

2018

2019

2020

2021

2022

2023

2024

2025

2026

2027

Balakovo NPP unit No.3

Balakovo NPP unit No.4

Smolensk NPP unit No.3

Reactor type

VVER-1000

VVER-1000

RBMK-1000

Expiry of design lifetime, year

2018

2023

2019

Anticipated year of extended lifetime completion

2048

2053

2034

Repeated lifetime extension

Removal of conservatism in decision-making on repeated lifetime extension of the NPP units (revision on NP-017, approval in Rostekhnadzor)

	Completion of the first extended lifetime period	Anticipated duration of the second lifetime extension	Current state of the works
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Novovoronezh NPP unit No.4

2017

2032

1. Expansion of the range of the design-basis accidents from Dnom100 to Dnom500 (rupture of the main circulation pipeline due to:

- implementation of the passive core cooling system (4 ECCS hydraulic tanks);
- upgrading of low- and high-pressure ECCS systems;
- upgrading of the reactor containment to ensure its integrity in case of a maximum design basis accident.)

Kola NPP unit No.1

2018

2033

2. Lifetime extension of the irreplaceable equipment, buildings and structures taking into account:

- annealing of the reactor vessel;
- Introduction of the water heating system in the circular tank.

Kola NPP unit No.2

2019

2034

Bilibino NPP units

2019-2020

2021

- development of the technology, production of the robotics and sampling from the lower support plate and biological shield tank of the reactor plant;
- study of the metal properties, substantiation of residual lifetime of the irreplaceable elements (lower support plate, biological shield tank)

Annealing of the reactor vessel

1

To ensure the repeated lifetime extension of the NPPs with reactor installations of VVER-440 of the first generation

“Integrated program of works on material study substantiation of LTE of the equipment of the NPPs with VVER-440 up to 60 years”

Executed

- annealing of the reactor vessels at Kola NPP units Nos. 1-2
- cutting and study of templates from the reactor vessels at Kola NPP units Nos. 1-2 and Novovoronezh NPP unit No.4
- annealing of Novovoronezh NPP unit No.4 reactor vessel with expanded area of the main metal heating and temperature control

2

Restoration annealing of VVER-1000 reactor vessels (with high content of nickel (1,88%) in the weld joint No.3 of the reactor vessels)

ENSURES full restoration of the structural property and features of the steels in the reactor vessels of VVER-1000 type, possible lifetime extension to 60 years and more

- Restores the mechanical properties and resistance to brittle fracture parameters of the base and weld metal;
- In irradiation after the annealing the embrittlement of the VVER-1000 materials is going on with the pace not exceeding the embrittlement pace during primary irradiation.

Pilot NPP unit: Balakovo NPP unit No.1 (Outage-

2018)

Transition of the VVER-1000 unit to operation at 107% of nominal capacity.

Pilot unit is Balakovo NPP unit No.1

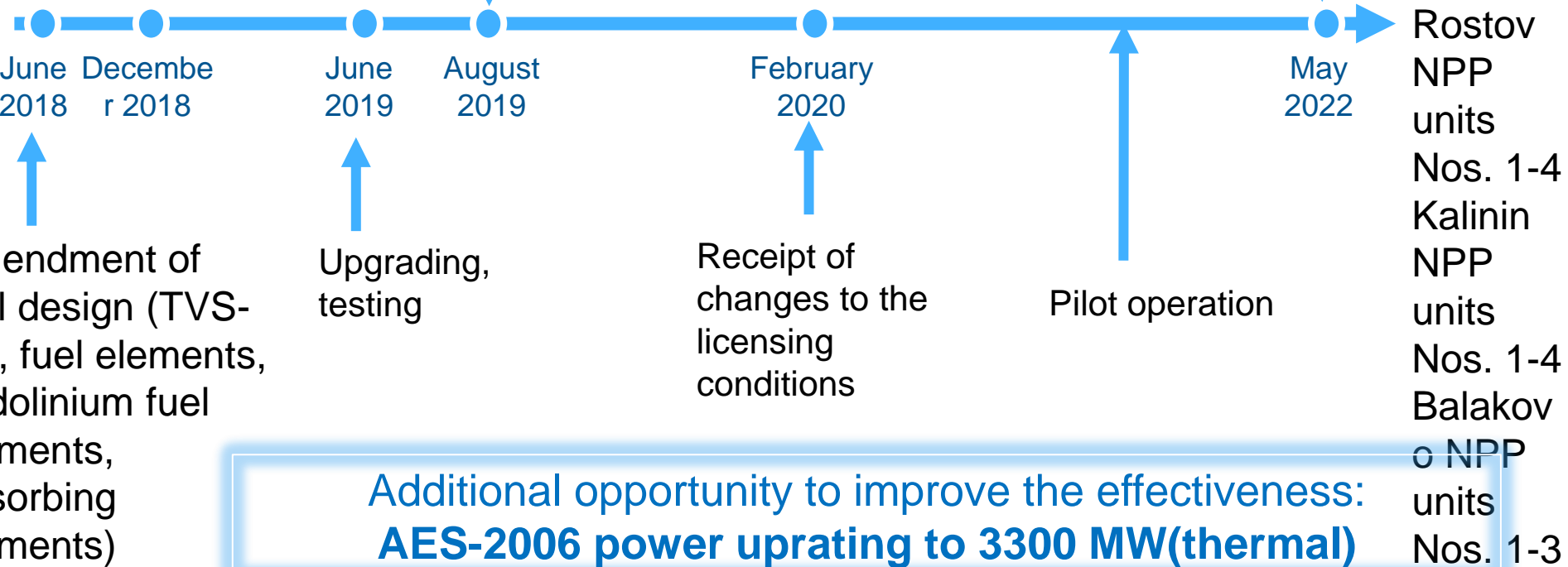
11 VVER-1000 NPP units are in commercial operation or in pilot operation at the capacity of 104%Nnom

Preliminary tests of the reactor installations at 107% of power

Submission of the pilot operation substantiation documents to Rostechнадзор

Decision-making on power uprating to 107% Nnom at VVER-1000 NPPs

Transfer to commercial operation



Additional opportunity to improve the effectiveness: **AES-2006 power uprating to 3300 MW(thermal)**

Transition to 18-months fuel cycle of AES-2006 NPP units

12-months fuel cycle (4X1) has been substantiated and implemented for AES-2006 (VVER-1000) NPP units

Perspective until 2022

VVER-1200 Substantiation and transition to the 18-months fuel cycle

Decision on transition to the 18-months fuel cycle.

	FUEL LOADINGS:			
	I	II	III	IV
Novovoronezh NPP unit No.6				2020
Novovoronezh NPP unit No.7			2021	
Leningrad NPP unit No.5			2020	
Leningrad NPP unit No.6	2020			

Additional opportunity to improve the effectiveness:
Performance of R&D to substantiate the transition of VVER-1000 and VVER-1200 NPP units to 24-months fuel campaign

Directions of the NPP turbines upgrading

1. Improvement of efficiency and power

10
turbines K-1000-60
/ 1500-1 (2) VVER-
1000



replacement of the high-pressure cylinder blades



gain of capacity - 38 MW/unit under
TOTAL: 380 MW

The upgrading of the turbines is performed simultaneously with upgrading or replacement of the generators

2. Ensuring of reliability

Fast turbine produced by
PSC Silovye mashiny



Upgrading of control and protection system by
implementation of electro-mechanical drives

production and the introduction of more
environmentally friendly Russian fire-resistant liquids

3. Identification and removal of non-design losses

Evaporation cooling tower

Project “Zero failure level”

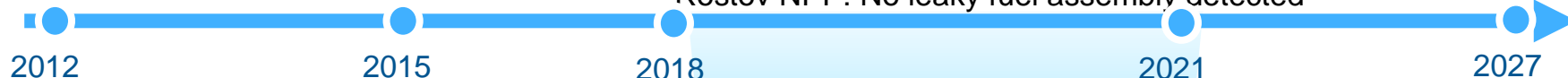
The project is of significant importance in view of improvement of the fuel operation

Detection of high level of the fuel integrity failures (10 pcs. at VVER NPPs).

The best results:

Balakovo NPP: One leaky fuel assembly detected

Rostov NPP: No leaky fuel assembly detected



2012

2015

2018

2021

2027

Signature of the Memorandum between SC TVEL and SC Concern Rosenergoatom on joint actions to receive the zero level of the fuel failure

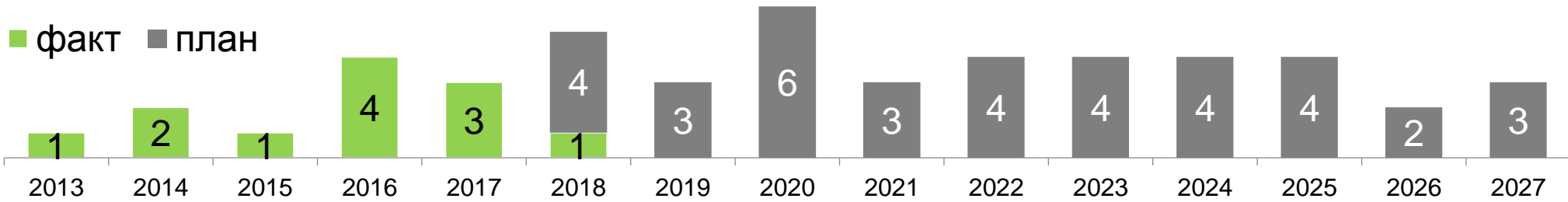
Implementation of the activities aimed at improvement of the quality of the FA production and operation

Main activities

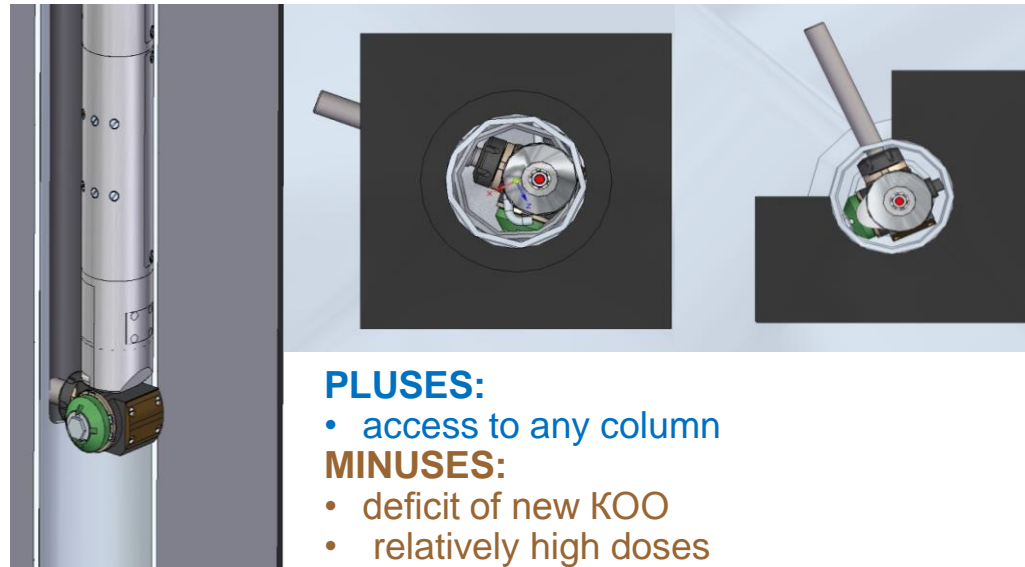
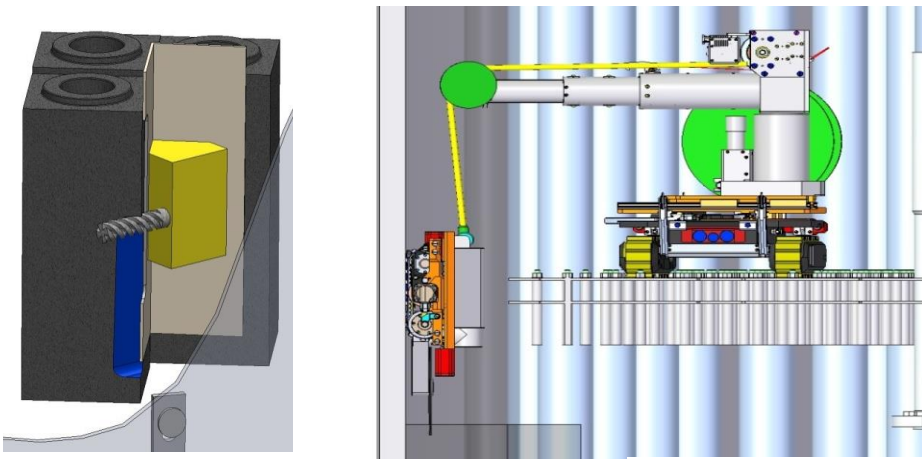
1. Performance of the commission investigations of the causes of leakage of the fuel assemblies at nuclear power plants, audits of nuclear fuel manufacturers;
2. Performance of post-reactor research of the leaky fuel assemblies;
3. Improvement of the activities to prevent the ingress of foreign objects during the works with opening of the equipment at nuclear power plants and production at factories.

1. Introduction of ADF-2 in design of the fuel assemblies for VVER-440, VVER-1000 and VVER-1200
2. Introduction of the equipment for extraction of the foreign objects from fuel assemblies and equipment of the reactor plants.

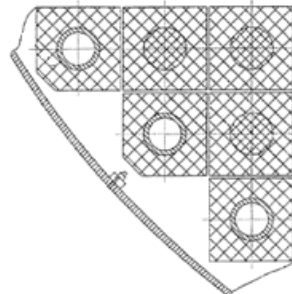
History and forecast plan for the restoration of the lifetime characteristics of graphite lay-out at RBMK-1000 reactors



Restoration of the gap between the graphite and fuel by routine technology with application of the robotics. Completion of the works at Kursk NPP unit No.1



- PLUSES:**
- relatively low radiation dose
- MINUSES:**
- no guarantee of access to all columns
 - probability of inadvertent situation with the accessories



The technology for cutting the graphite bricks inside the KOO is developed for handling the inaccessible for RTK graphite columns (September 2018, Kursk NPP)



Decommissioning of NPP units

	Shutdown units	Decommissioning units
2018	6	2 (Novovoronezh NPP units Nos. 1-2)
2030	19	8 (1-2NVO, 1-2LEN, 1-2KUR, 1-2BEL)

- There was determined the "Immediate dismantling" option for all operating NPP units;
- Transition to "Immediate dismantling" option at Novovoronezh NPP units Nos. 1-2 (pilot project) with completion in 2035;
- Performance of the decommissioning activities at the first stage of Beloyarsk and Leningrad NPPs
- Establishment within the perimeter of State Corporation Rosatom of a new model of the decommissioning that allows to concentrate the obtained reference experience for entering to the international market.

"Immediate dismantlement"	
Preparation for elimination	Elimination
≈ 5 years	≈ 15 years



Reduced operating costs for maintaining of the units shutdown for decommissioning due to the decommissioning duration

Maximum use of the residual life of the equipment and structures of the shutdown units

Use of the capabilities of the existing facilities for management of solid and liquid radioactive waste, decontamination facilities

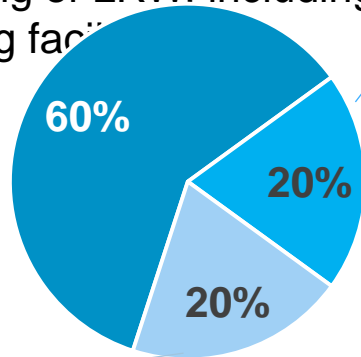
Use of the competences of the personnel engaged in the unit operation



Competences in decommissioning of the NPP units

Available competences

- Dismantling of turbines and turbine building large-scale equipment,
- Dismantling and fragmentation of RCP, PCP, MIV,
- Decontamination of the dismantled equipment,
- Reprocessing of RAW, including RAW reprocessing facility,
- Reprocessing of LRW. including ion-selective reprocessing facility



Missing competences*

- Fragmentation of core internals of the vessel-type reactors,
- Dismantling of the reactor vessel and circular tank,
- Elimination of operating RAW storage facilities,
- Dismantling of metal structures of the channel-type reactors,
- Rehabilitation of the territory of the site and dismantling

Competence to be received in the near future (up to 2020)

- Dismantling and fragmentation of SG, pressurizer, superstructures,
- Remote cutting of the screens and absorbing extensions,
- Release of materials from the radiation oversight,
- Reprocessing of ion-exchange resins,
- Treatment of graphite including its conditioning,
- High-active waste conditioning.

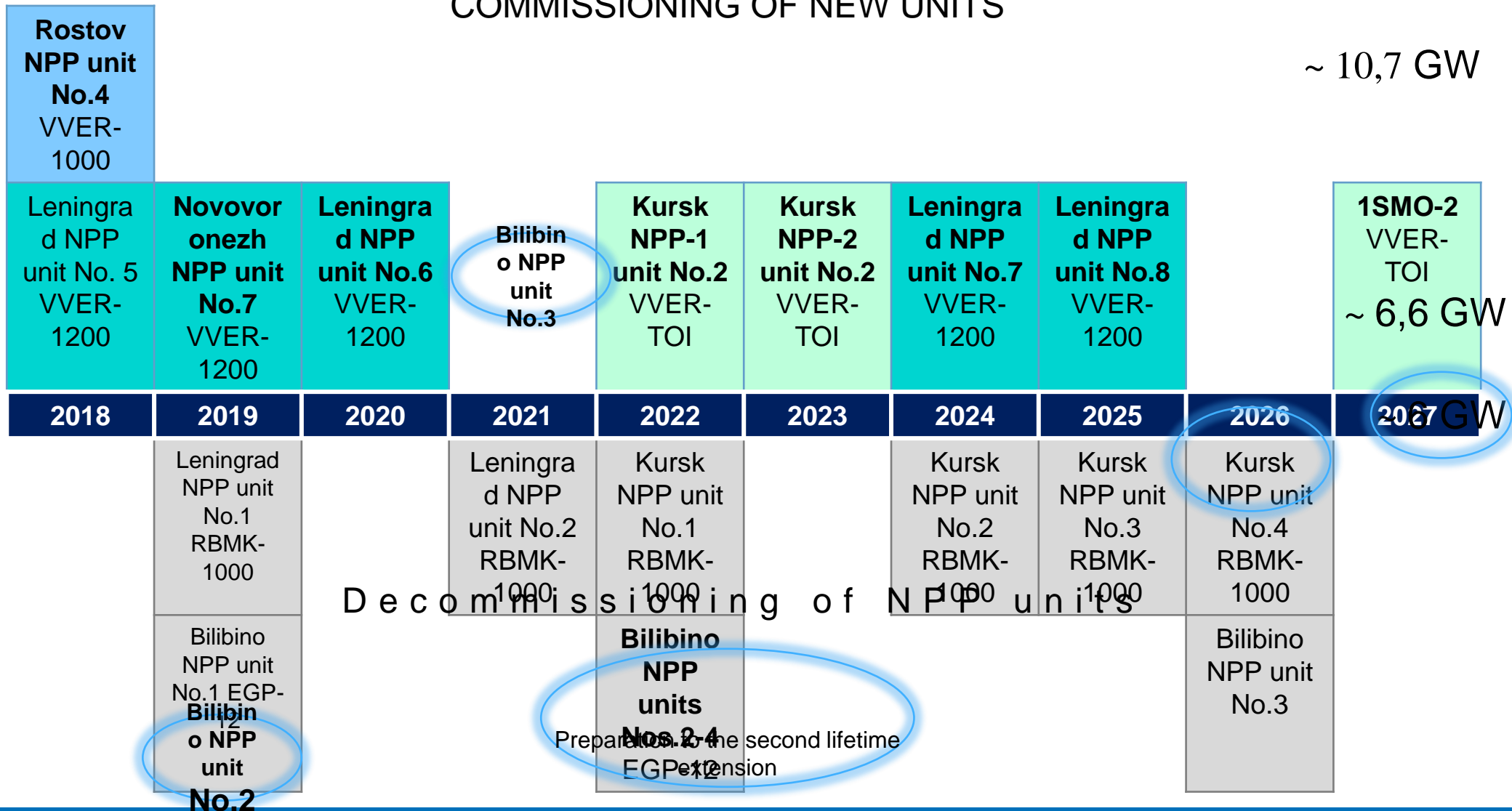
	RSS*	M&A
	2022	2020
	2024	2021
	2025	2021
	2030	2021
	years	
	2026	2020

RSS* - implementation using own resources;

Roadmap for development of the generating capabilities

COMMISSIONING OF NEW UNITS

~ 10,7 GW



Enhancement of VVER-TOI project:



Key directions for the project improvement:

Removal of excessive conservatism with respect to the safety systems (for example, substantiation of the 3-rd stage GE-3)

Improvement of the unit dynamic sustainability by application of the enhances algorithms of the accelerated prevention protection;

Optimization of the information flows at the control and emergency control rooms

Improvement of the unit equipment and systems:

- DOK structures in the scheme of the 2-nd stage GE;
- improvement of RTO efficiency in SG blow-down system;
- systems of heat-exchanger heating for steam-generator cooling system;
- maintainability of the hydraulic tanks valves of the first stage;
- cooling of the pressurizer electric-driven pumps;
- application of the ejector-pumps etc.

Optimization of the list of tests including dynamic ones in the course of the power development at VVER-TOI NPP units

The main objective of Rosenergoatom for the next decade

Create a foundation for development and mastering of new power technologies in the industrial scale



Improvement of the NPP safety



with unconditional search for and implementation of new ways for improvement of the reliability and efficiency of nuclear power units

THANK YOU FOR YOUR ATTENTION!
