ROSATOM

FUEL COMPANY OF ROSATOM TVEL

ГОСУДАРСТВЕННАЯ КОРПОРАЦИЯ ПО АТОМНОЙ ЭНЕРГИИ «РОСАТОМ»

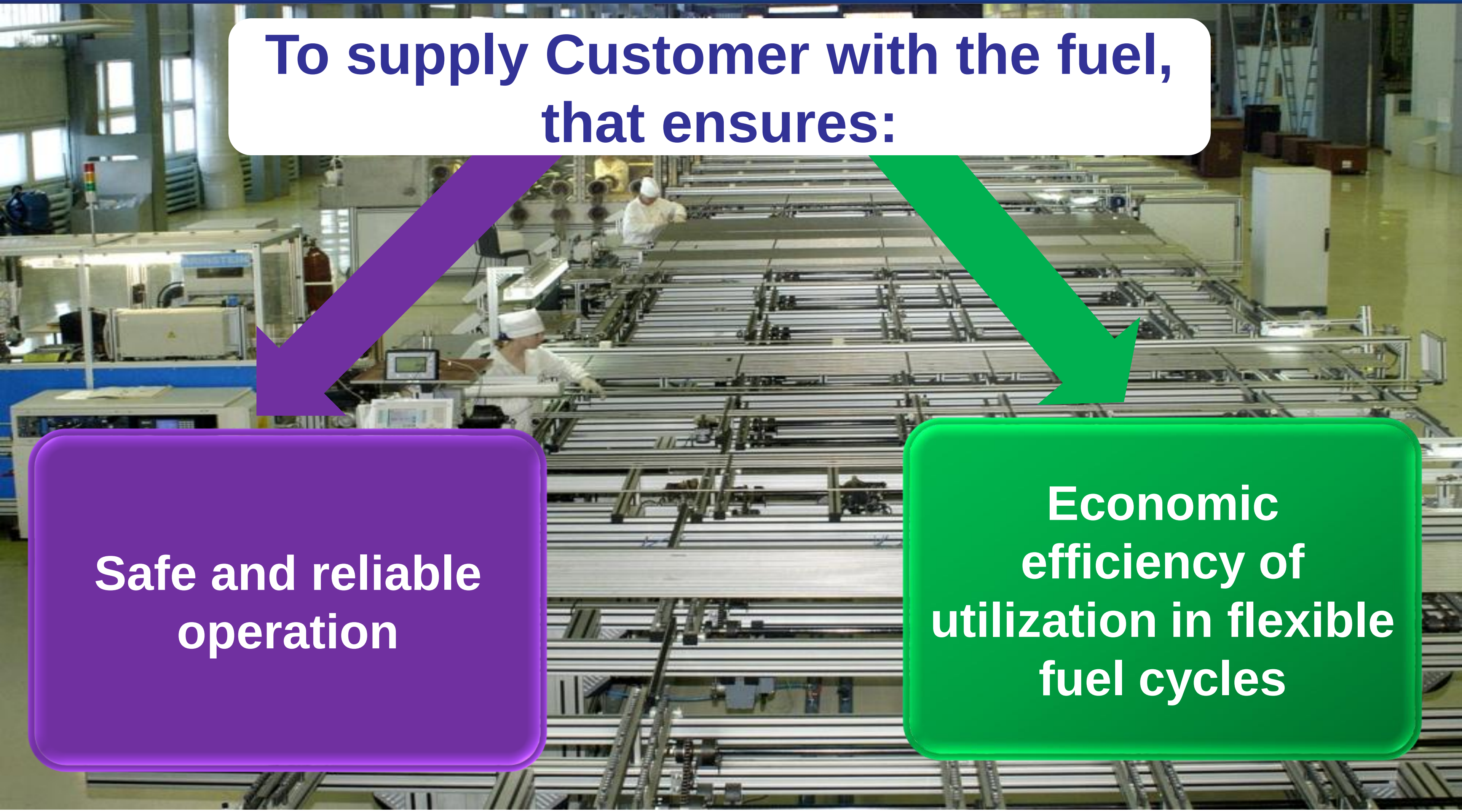
Improving the Reliability and Economic Efficiency of Nuclear Fuel for NPP's. «Driving to Zero Failure».

Executive director of JSC TVEL
D. Krylov

atomexpo

Moscow
6 June 2012

Our Goal

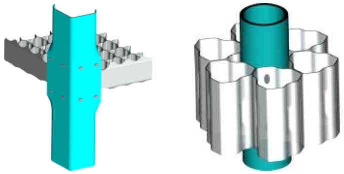


To supply Customer with the fuel, that ensures:

Safe and reliable operation

Economic efficiency of utilization in flexible fuel cycles

Improvement of Nuclear Fuel reliability



Improvement of FA resistance to distortion

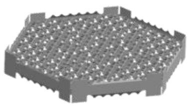
Implementation of FA with robust skeleton

Improvement of protection from foreign materials in the coolant

Implementation of debris filters (DF)

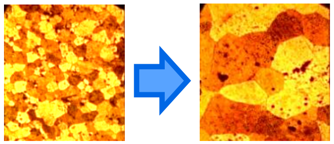
Improvement of resistance to vibration loads

Implementation of antivibration grids (AVG)



Improvement of thermal-hydraulic performance

Implementation of intermediate flow mixers (IFM)



Improvement of PCI behavior,
Decrease in fission gas release

Increase in fuel grain size

Improvement of resistance to corrosion and radiation

Application of new constructional materials

Improvement of economic efficiency of Nuclear Fuel

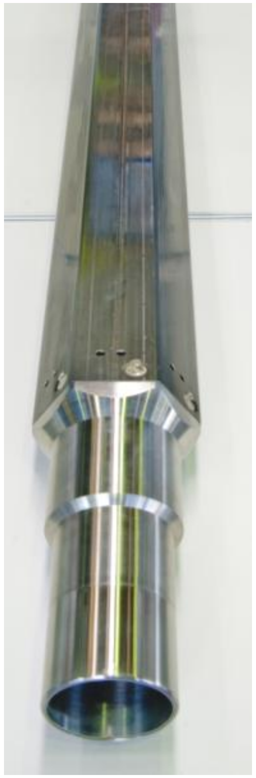
Increase in fuel burnup

Elongation of fuel in-core life-time

Creating conditions for units thermal power uprate

Justification of nuclear fuel operation in load-follow modes

VVER-440 Nuclear Fuel



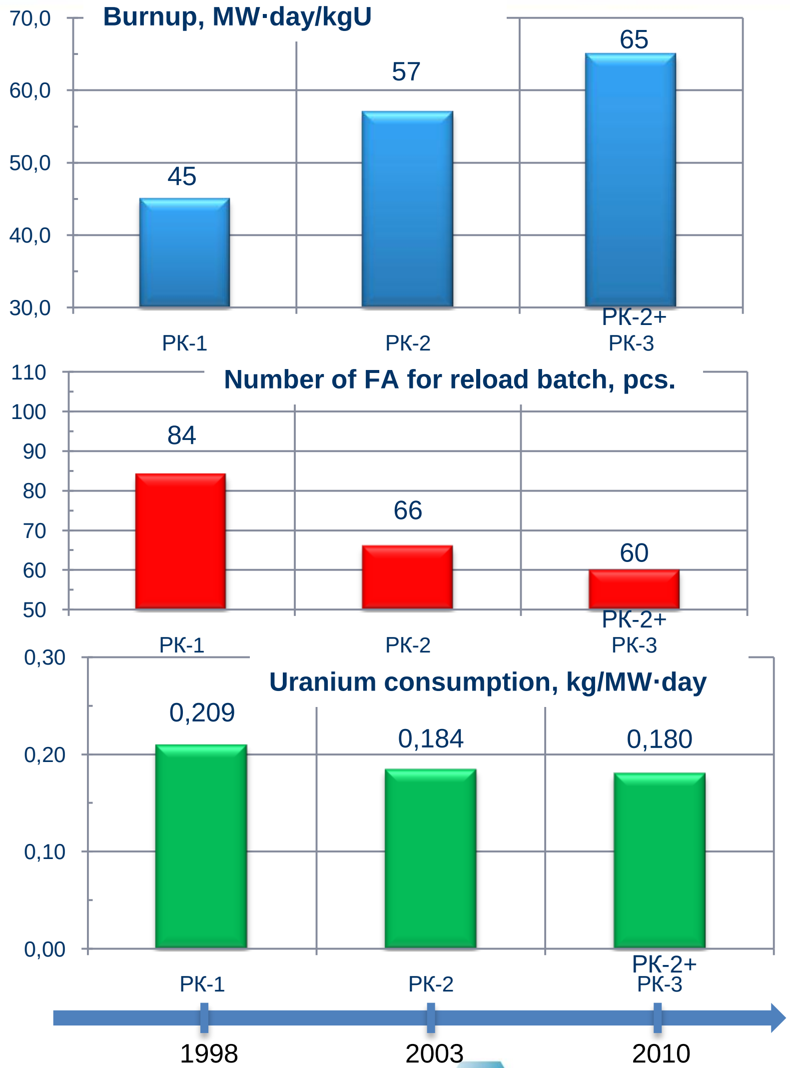
Vibration-resistant design
Average reload batch enrichment 3.82%
Fuel pellet 7.57/1.4
1998

Second generation fuel
Average reload batch enrichment up to 4.38%
Fuel pellet 7.6/1.2
2003

Second generation fuel
Average reload batch enrichment 4.87%
Fuel pellet 7.6/1.2
2010

RK-3 Average reload batch enrichment 4.87%
Fuel pellet 7.8/0
2010

Second generation fuel
Average reload batch enrichment 4.87%
Fuel pellet 7.8/0
2012

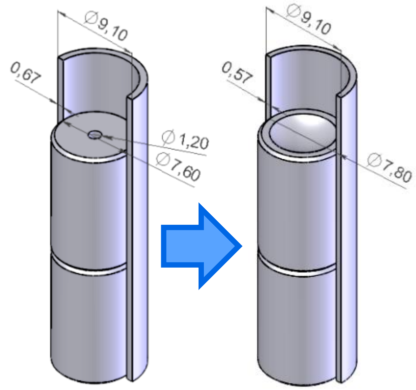


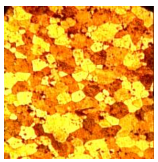
VVER-440 Nuclear Fuel

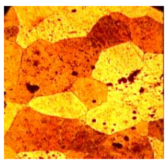
Second generation fuel
Average enrichment 4.87%
Fuel pellet 7.6/1.2 mm

5-year fuel cycle at a power level of 1471 MW(th) (107%).
Profiled fuel rod bundle, U-Gd fuel.
66 FAs in the reload batch.
Burnup of 65 MW·d/kgU.
Load follow operation.

In 2010, pilot operation of reload batch started at Kola NPP Unit 4.







8-10 μm

~ 25 μm

Second generation fuel
Average enrichment 4.87%
Fuel pellet 7.8/0 mm

5-year fuel cycle at a power level of 1540 MW(th) (110%).
Profiled fuel rod bundle, U-Gd fuel.
60 FAs in the reload batch.
Burnup of 65 MW·d/kgU.
Load-follow operation.

Development of design documentation in 2013

VVER-440 Nuclear Fuel

RK-3 design – without the shroud tube, skeleton formed by angels and tubes.
Mass of UO2 - 132 kg (increased by 4.5%).
Fuel rod pitch in the bundle increased from 12,3 to 12,6 mm.

Fuel cycle – 6 x year.
The expected benefit of RK-3 implementation – increase in fuel consumption efficiency about 10%.

Pilot batch operation (12 FAs) started at Kola NPP Unit 4 in 2010

VVER-1000 Nuclear Fuel

Modernization of FA design	Change of geometrical size of pellets and claddings	Uranium enrichment increase	Fuel column length increase

TVSA (1998)

TVS-2 (2003)

Enrichment 4.40%
Pellet 7.57/1.4mm
Core height 3530mm
Mass of UO_2 494.5kg

→

TVSA-ALFA (2006)
Enrichment 4.7%
Pellet 7.8/0mm
Core height 3530 mm
Mass of UO_2 546 kg

→

TVSA-12 (2011)
Enrichment 4.7%
Pellet 7.8/0mm
Core height 3530 mm
Mass of UO_2 546 kg

→

TVSA-PLUS (2010)

TVS-2M (2006)

Enrichment 4.95%
Pellet 7.6/1.2mm
Core height 3680 mm
Mass of UO_2 525 kg

→

TVS-4A
Skeleton of angle brackets & SG

TVS-4M
Skeleton of GC & SG

Enrichment 4.95%
Pellet 7.8/0mm
Core height 3680mm
Mass of UO_2 568 kg

Design development in 2012

VVER-1000 Nuclear Fuel

FA of 4th generation for VVER-1000

Fuel column length 3680 mm

Fuel pellet size 7.8x0 mm

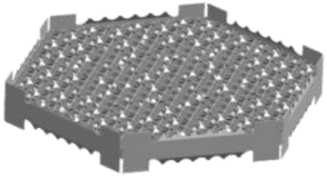
12 spacer grids

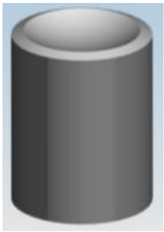
Intermediate flow mixers

Bottom nozzle with debris filter

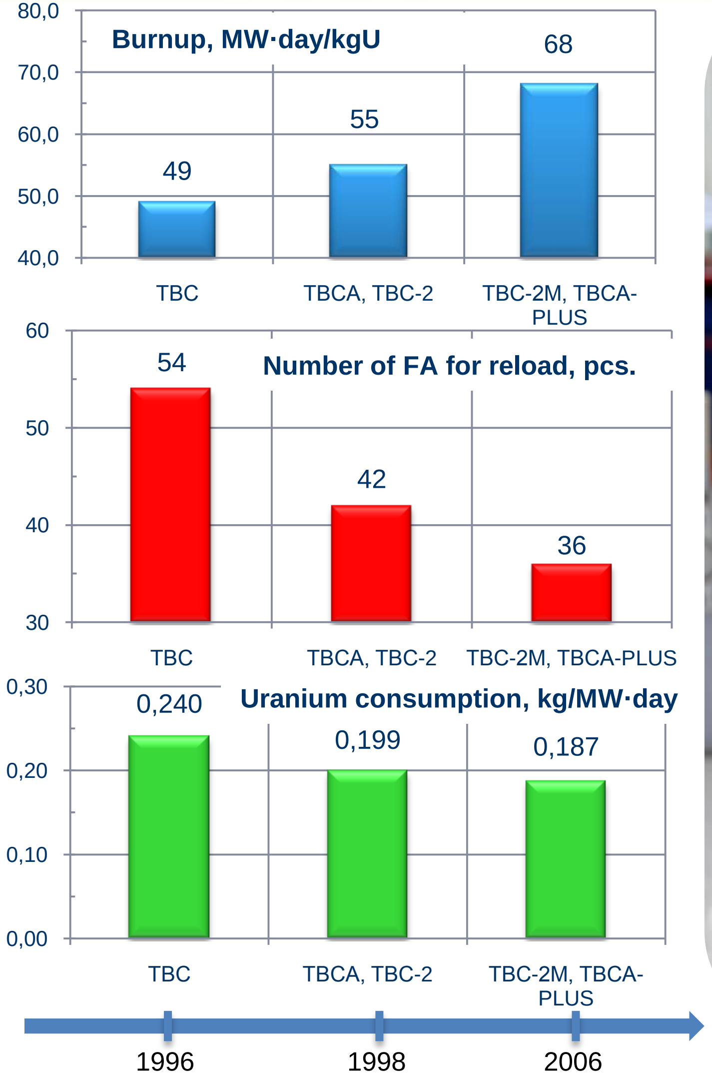
Antivibration support unit

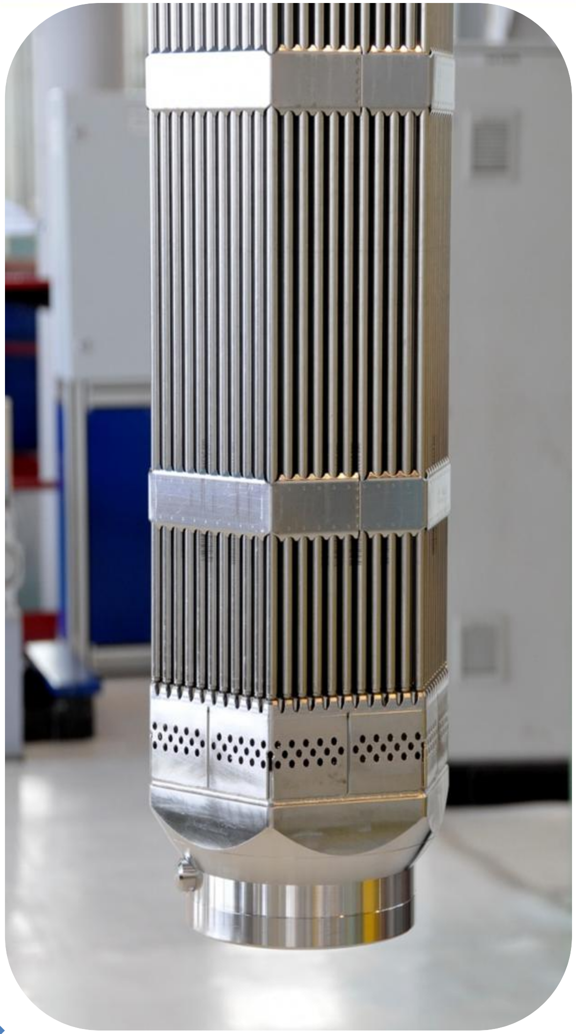
Stages of development	
Design documentation	2012
Pilot operation	2014
Regular reloads	2016





VVER-1000 Nuclear Fuel





VVER-1000 fuel cycles, thermal power 104 % N_{nom}

TVS-2M	Operation in fuel cycle 3×18 months	 Balakovo NPP Rostov NPP Tyanvan NPP (planned)
TVSA-PLUS	Operation in fuel cycle 3×18 months	 Kalinin NPP
TVSA-T TVSA-12	Operation in fuel cycle 5×12 months	 Temelin NPP NPP of Ukraine (planned) Kozloduy NPP (planned)

Load follow modes at NPPs with VVER-1000

VVER-1000 FAs allow to operate in load-follow modes

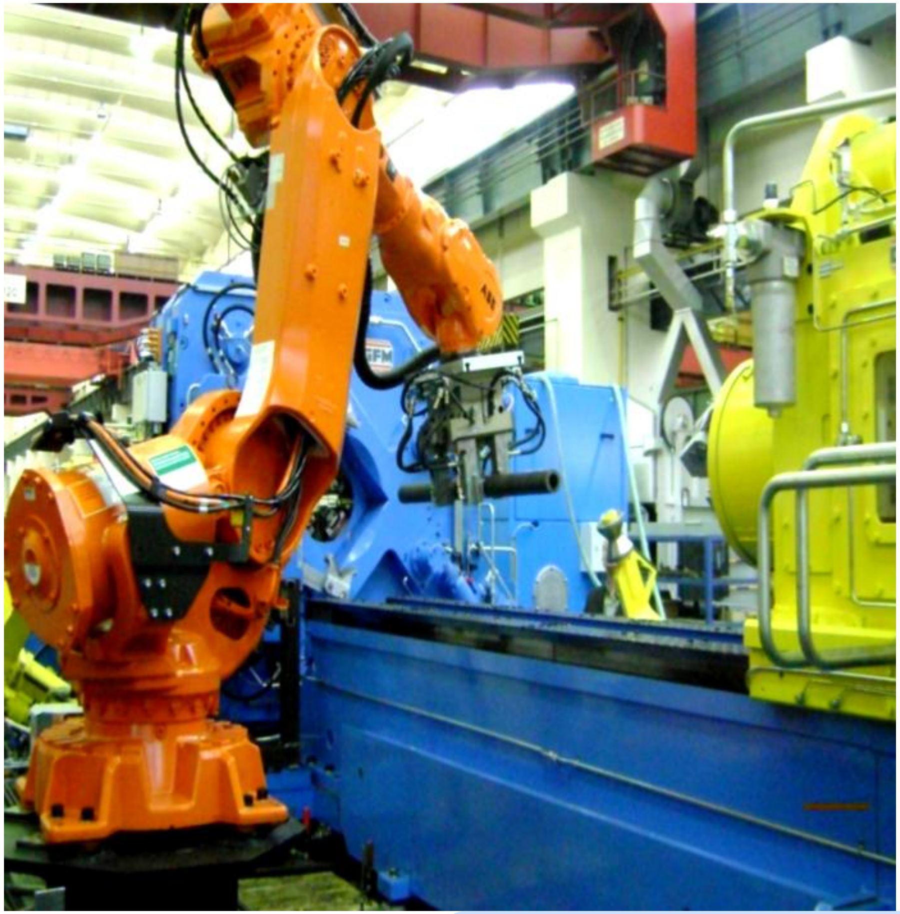
Experiment-calculated justification is performed

Daily load-follow in the range 100-75-100 % N_{nom}
Up to 200 cycles per year

Primary load-follow in the range ± 2 % N_{nom}

The calculation analysis of power ramp from 50% to nominal power without 3-hours delay step was carried out.
The result is positive

Development of Nuclear Fuel fabrication technology



Radial forging machine

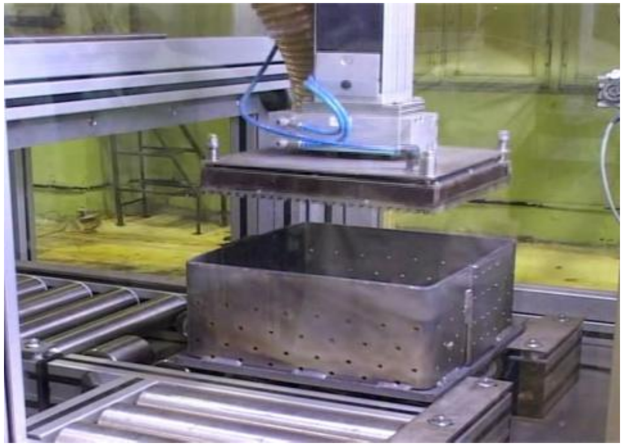
Rolling mills

✓Tolerance for outer diameter ± 0,04 mm (previously ± 0,05 мм)
✓Polythickness less than 0,05 mm (new requirement)
✓Roughness less than 0,6 mkm (previously 1mkm)

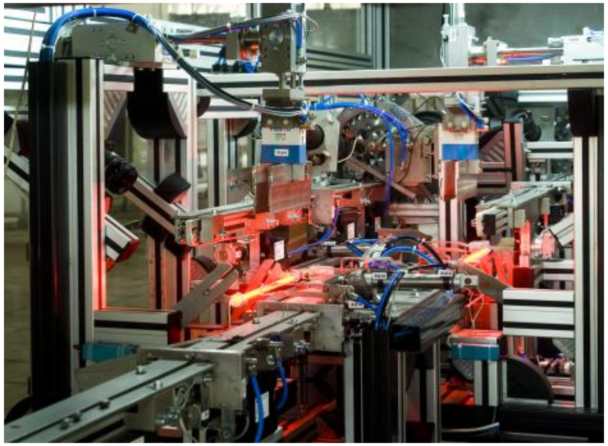
Development of Nuclear Fuel fabrication technology

Section for producing uranium dioxide powder by "dry" conversion technology

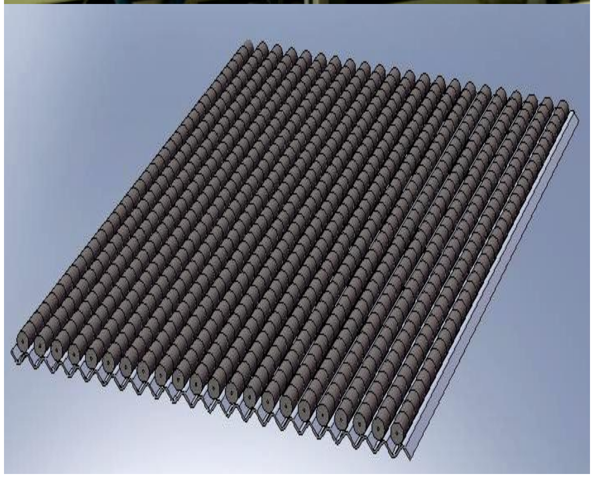
Line for producing pellets



Stacker of pressed pellets in trough for sintering



Equipment for optical inspection of pellets appearance

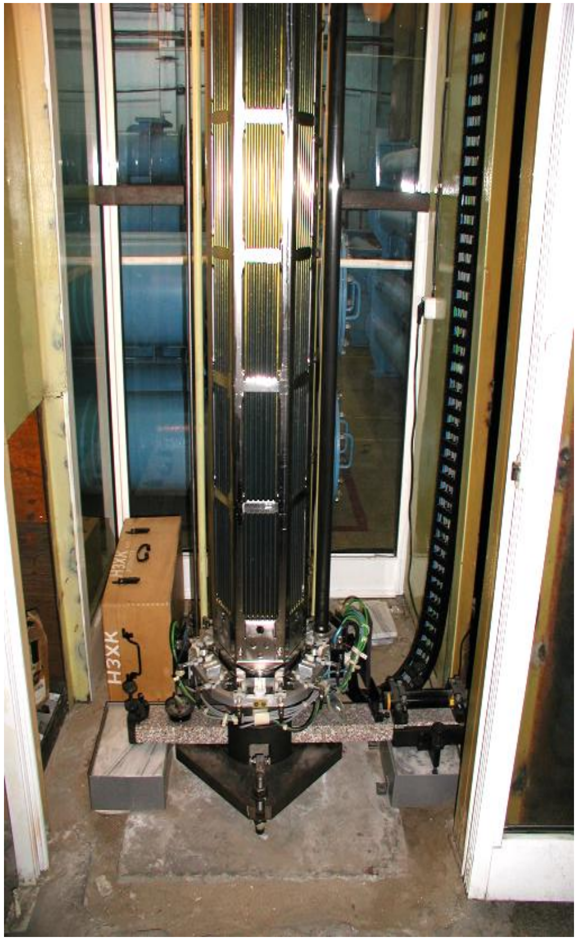


Fuel pellets on pallets

Development of Nuclear Fuel fabrication technology

Line for fuel rod fabrication

Robotized complex for assembly and welding of FA skeletons



Optical bench for FA geometry inspection

Automated bench for fuel bundle assembly

Robotized complex for spot welding of spacer grids

Driving to Zero Failure

Target:

Achieving Zero Fuel Failure and operation of "clean" cores.

Task:

Development and implementation of a scope of scientific-technical and technological measures, aimed at detection and elimination of fuel failure causes for VVER-1000.

Result:

Decrease in radiation dose on the staff, better ecological environment, decrease in NPP expenses for fresh nuclear fuel purchase and treatment with spent fuel, shorter outage length.

Driving to Zero Failure

Design

1. Qualified personal
2. Proven technical solutions
3. Resistance to operational damaging factors (debris, vibration, water chemistry, handling, etc.)

\+

Fabrication

1. Qualified personal
2. Components quality
3. Fabrication culture
4. Automated manufacturing procedures
5. Quality control of the product

\+

Operation

1. Qualified personal
2. Non-violation of operational procedures
3. Exclusion of foreign materials from the primary circuit
4. Smart handling procedures

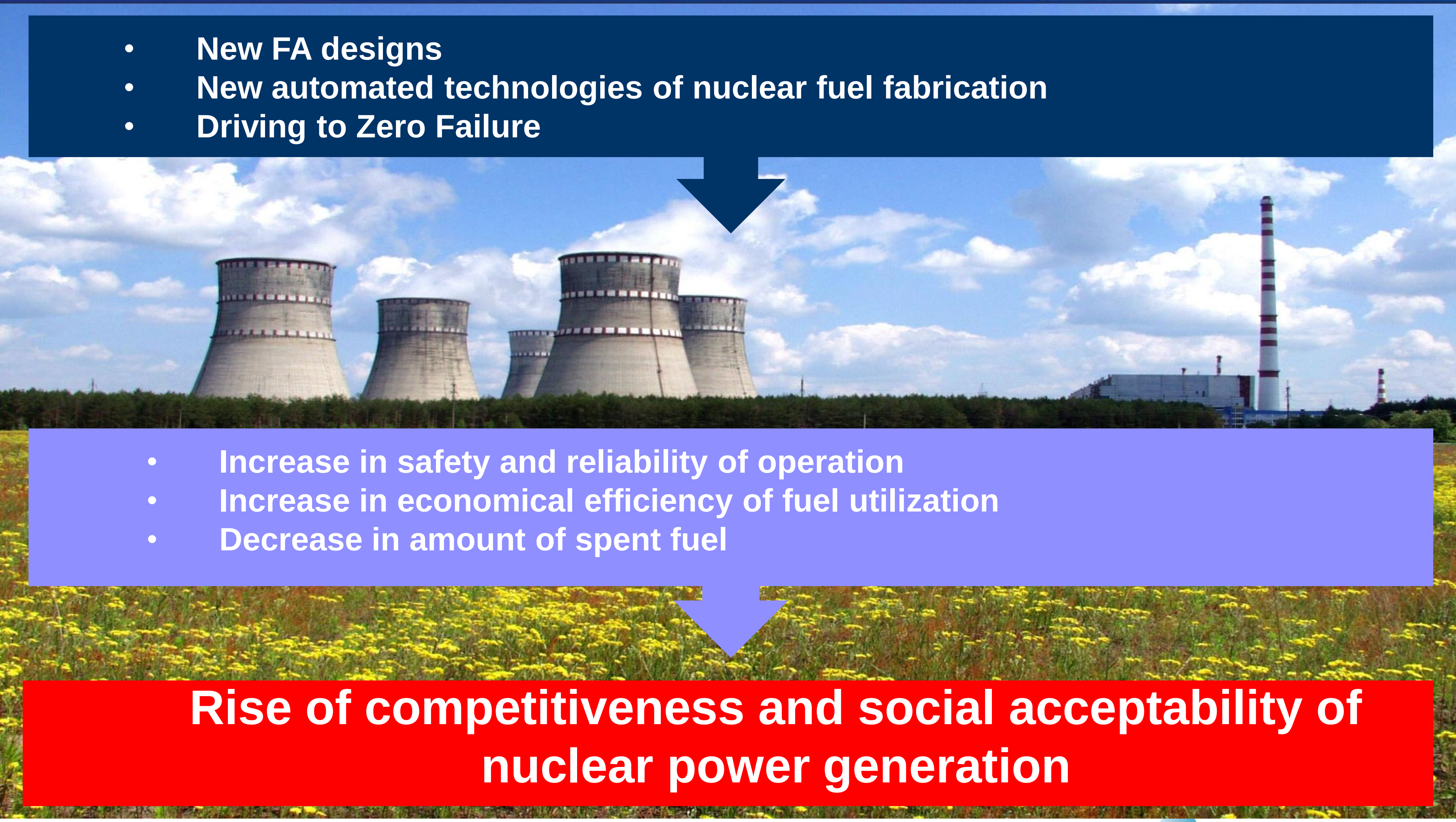
Zero Fuel Failure

Driving to Zero Failure

The Memorandum between JSC «TVEL» and JSC «Concern Rosenergoatom» about intentions on carrying out joint actions for achievement of zero level of nuclear fuel failures is prepared for signing

1	2	3	4	5
Memorandum signing	**Creation of the Working groups**	**Analysis of the causes**	**Recommendations development**	**Implementation into practice**
At the first stage the Memorandum will be signed by JSC «Concern Rosenergoatom» and by JSC «TVEL». Further other NPP Operators can join it	Four working groups will be created: 1) design; 2) manufacture; 3) operation; 4) SNF management.	The working groups will: - Perform the analysis of NF failure causes, design, technological, and operational documentation; - Carry out audits in the enterprises.	The working groups will: - Perform the analysis of NF failure causes, design, technological, and operational documentation; - Carry out audits in the enterprises.	Performance and control of implementation of the actions plan at the enterprises of JSC «Concern Rosenergoatom», JSC «TVEL» and enterprises that are developing nuclear fuel.

Conclusion



- New FA designs
- New automated technologies of nuclear fuel fabrication
- Driving to Zero Failure

- Increase in safety and reliability of operation
- Increase in economical efficiency of fuel utilization
- Decrease in amount of spent fuel

Rise of competitiveness and social acceptability of nuclear power generation