ROSATOM

STATE ATOMIC ENERGY CORPORATION "ROSATOM"
ГОСУДАРСТВЕННАЯ КОРПОРАЦИЯ ПО АТОМНОЙ ЭНЕРГИИ «РОСАТОМ»

Rosatom today and overview of its current and prospective Nuclear Power Plant projects

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Outline

- Rosatom today and its global visions
- Rosatom strategy – its strengths and challenges
- Evolution of VVER nuclear power plant fleet
- Emphasis on nuclear safety after Chernobyl accident
- Era of new VVER plants
- Overview of AES-2006 safety

Rosatom today (1)

State Atomic Energy Corporation ROSATOM was founded in accordance with the Order of the President of Russian in December of 2007 and replaced the Federal Nuclear Power Agency (also called Rosatom).

The creation of the corporation was intended to facilitate the performance of federal target program of nuclear industry development approved by the State Duma and the President of Russia.

ROSATOM implements the state nuclear policy by providing

- management of nuclear power use,
- stable functioning of
    - nuclear power and industrial complex and
    - nuclear weapons complex,
- nuclear and radiation safety.

ROSATOM is charged with the tasks of observing Russia's international obligations in the area of peaceful use of nuclear power and nuclear materials nonproliferation regime.

Rosatom today (2)

Enterprises and staff

Rosatom comprises more than

- 250 enterprises and organizations
- 250 000 employees.

Rosatom comprises all elements needed for nuclear power production:

- research institutes,
- nuclear power engineering companies,
- architect engineering companies
- manufacturing industries,
- enterprises of nuclear fuel cycle, and
- all Russian nuclear power plants (40 000 employees)

Rosatom today (2)

Major enterprises under Rosatom

JSC **Atomenergoprom** (AEP) is a holding company, which owns almost 100 enterprises of the nuclear industry. These enterprises provide full production cycle of nuclear power engineering — from uranium production to nuclear power plant construction and energy generation. Atomenergoprom owns such large companies as **Rosenergoatom Concern** (#2 in the world by nuclear electricity generation), **TVEL** (17 % of the world nuclear fuel market), and **TENEX** (40 % of the world uranium enrichment services market).

Enterprises that are main players in the design and construction of new nuclear power plants are the three **Atomenergoproject** companies (**Moscow**, **St.Petersburg** and **Nishni Novgorod**), the VVER reactor island designer **Gidropress**, and **Kurchatov Institute** that provides support to design and safety analysis. **Atomstroyexport** that is now integrated to Nishni Novgorod AEP coordinates design and construction of the exported plants.

Rosenergoatom is the power company that owns all NPPs, and it has a strong **Engineering Department (PKF)** that verifies the design of the new NPPs before approving the construction and submittal of the licensing documentationto the regulatory body.

Rosatom vision for 2020

2020 Targets

- Rosatom is **among Top 3 nuclear companies** (by revenue in key segments)
- More than **50% of revenue** comes from **global operations**
- More than **25% of revenue** is generated by **overseas assets**

Key Actions

- **Localize** all business segments' operations on key markets
- Benefit from **global talents** and **local workforce**
- Establish multiple **alliances and partnerships** with global and local players
- **Source, develop and transfer technologies** to maintain global leadership
- Take full advantage of **global capital market**
- Ensure **business transparency** as a key operating standard

Globalization of operations is the key priority

Rosatom Global Operations

#1 in key segments

#1

in uranium deposits

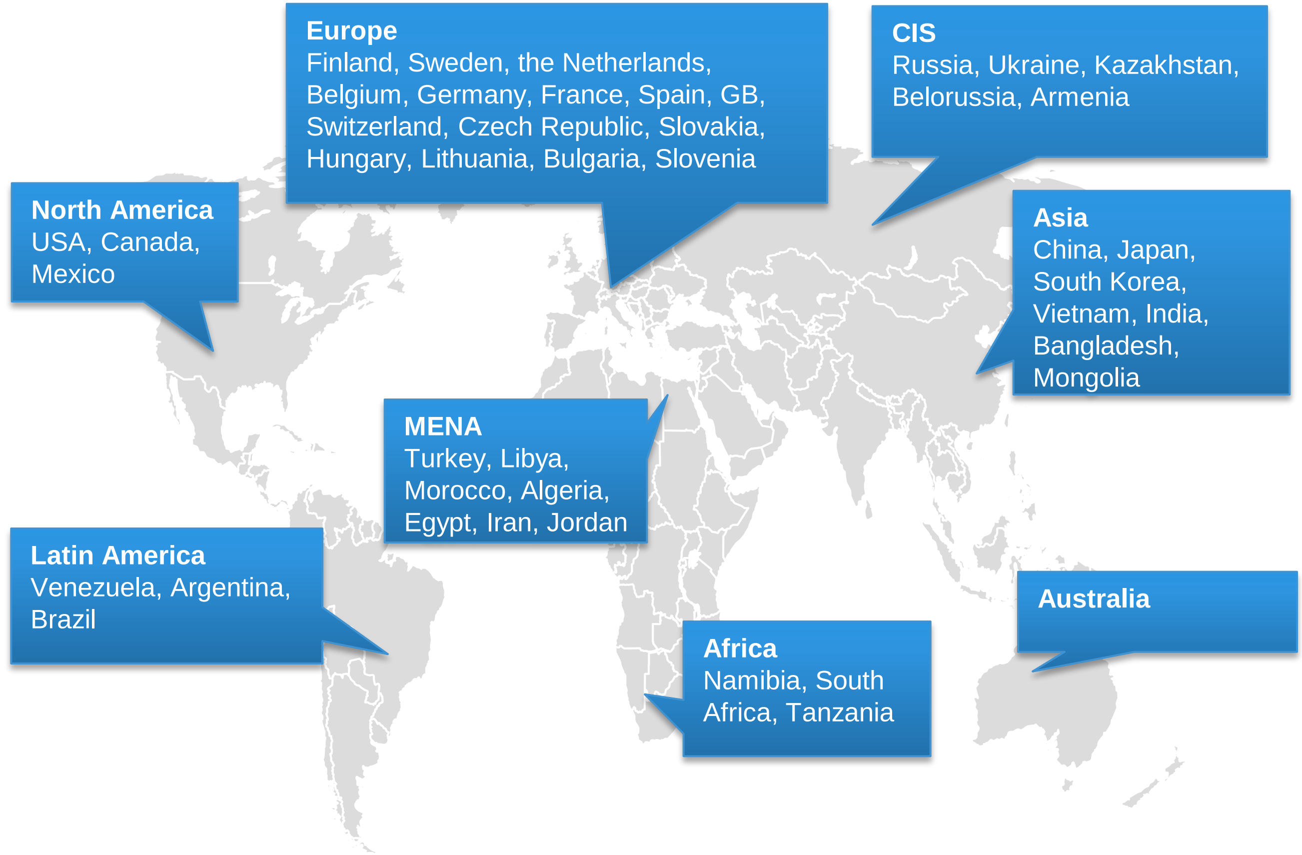
#1

in uranium enrichment

#1

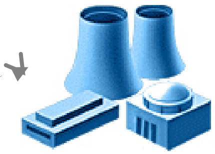
in new NPPs construction

Activities on 5 continents in more than 40 countries.



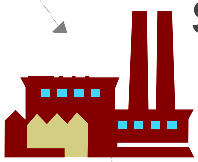
Rosatom integrated NPP construction solution

Energy Solution



- Modern NPP design (Gen III+)
- NPP construction and life cycle management support (fuel, services, modernization)
- Operation & maintenance

Industrial Solution



- Component manufacturing, service & works localization
- Technology transfer
- Certification of local suppliers, participation in third countries projects

Financial Solution

- BOO projects
- State credits
- Partnership projects

Knowledge, skills, human capital

- Academic and vocational basic education & personnel training
- R&D base development

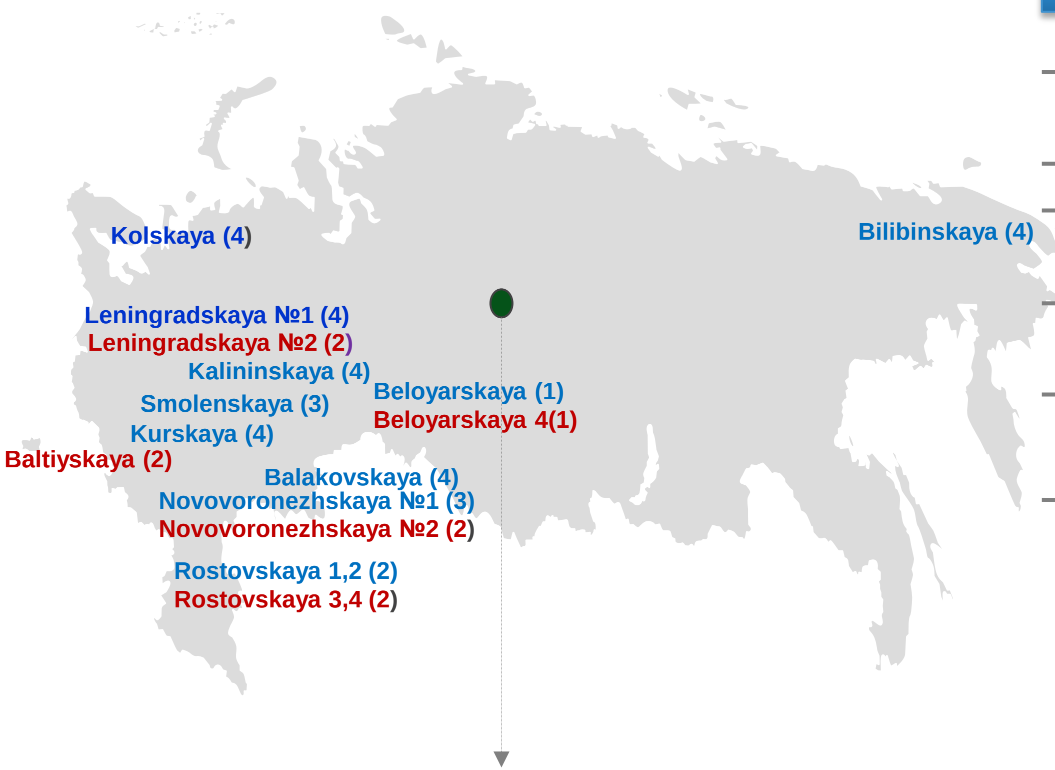
Support to Legislation, Infrastructure and Public communication

Rosatom Integrated Solution

Overriding target : prerequisites and means for safe long-term operation

NPPs construction program in Russia is among the most dynamically developing in the world

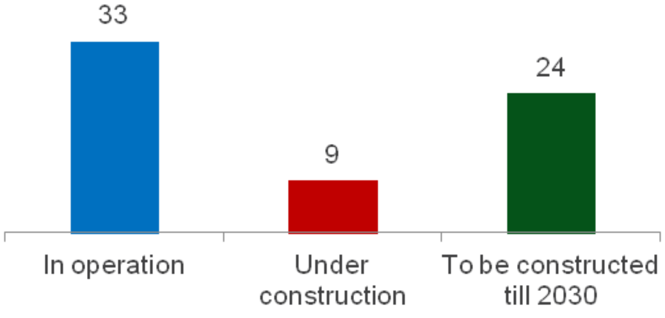
Rosatom NPPs in Russia



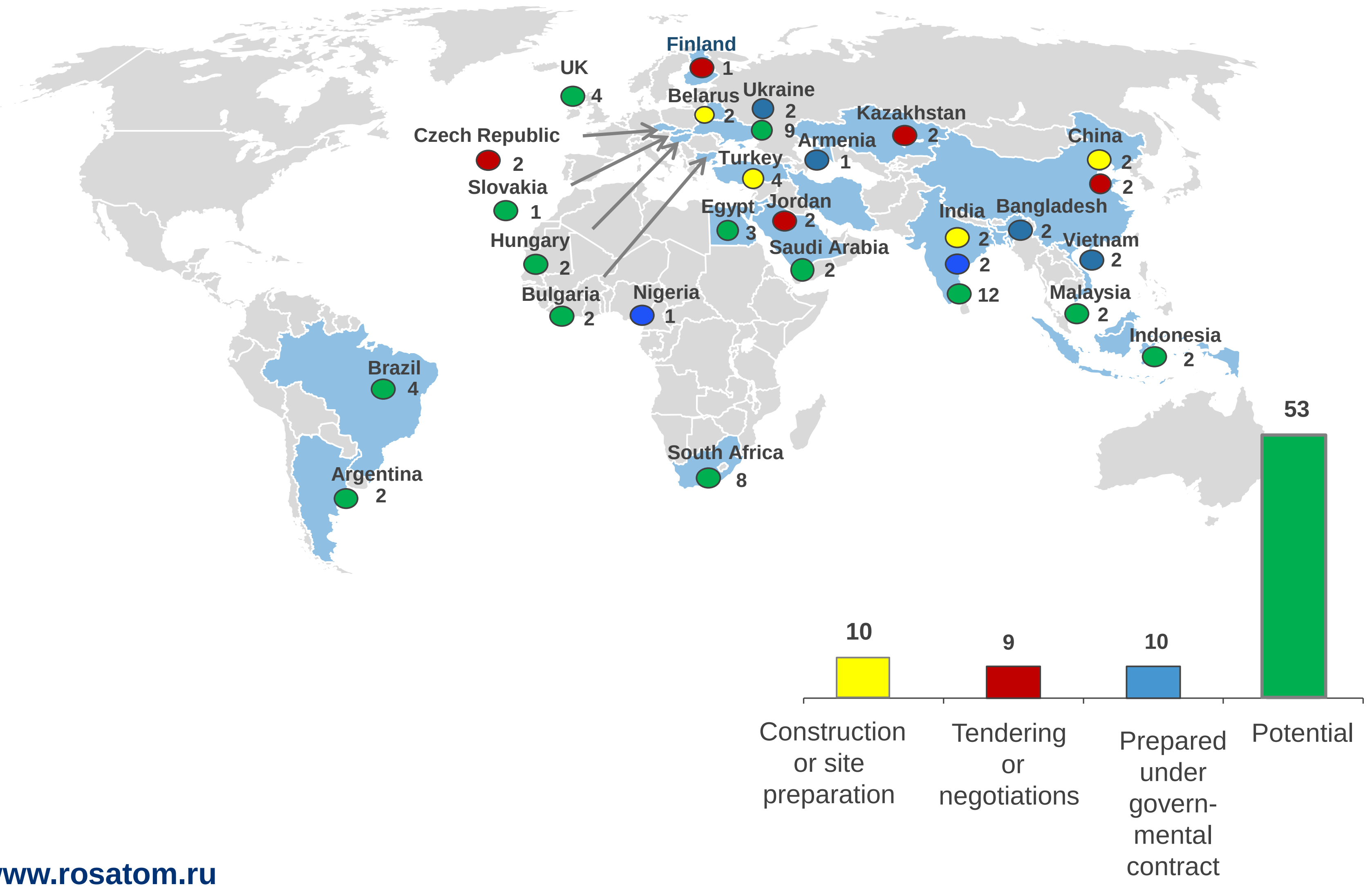
24 new NPP units will be constructed till 2030

Under construction

NPP	Unit	Type
Baltiyskaya	№1	VVER-1200
	№2	VVER-1200
Beloyarskaya	№4	BN-800
Leningradskaya №2	№1	VVER-1200
	№2	VVER-1200
Novovoronezhskaya №2	№1	VVER-1200
	№2	VVER-1200
Rostovskaya	№3	VVER-1000
	№4	VVER-1000



Rosatom's new VVER projects outside Russia



Rosatom strategy in new entrant countries (1)

Long term support to customers is confirmed by making an **Intergovernmental Agreement** with a country that is interested in Rosatom nuclear power plants.

Under that agreement Rosatom can for instance

- provide **support to infrastructure development** (human capital, legislation, scientific base, technology, ...) as requested by the potential customer country – generally this is done in co-operation with the IAEA,
- agree on **financial arrangements** to support nuclear programme development.

Rosatom strategy in new entrant countries (2)

The time from making the Intergovernmental Agreement to start of actual nuclear program development is generally very long.

- Before starting Nuclear Power Plant (NPP) construction **Rosatom wants to ensure** that the new entrant country will have all capabilities and arrangements required **for safe long term operation of nuclear power**.

The two basic modes Rosatom is offering to customer countries for building an nuclear power plant are

- BOO – Build, Own, Operate
- EPC – Engineering, Procurement, Construction

Rosatom strategy in new entrant countries (3)

In the BOO approach, such as agreed in Turkey for Akkuyu project:

- Rosatom establishes an Operating Company in the customer country and makes a Power Puchase Agreement to **sell power in the customer country at fixed price for a certain time period**.
- The Operating Company applies for necessary permits and licenses from the national authorities and thus assumes full responsibility for safety of its operations.

The Operating Company is an independent intelligent customer towards the Rosatom supplier consortium.

- The Operating Company maintains close technical co-operaration with Russian nuclear operator Rosenergoatom.

Rosatom strategy in new entrant countries (4)

The **BOO** approach can evidently provide the **fastest track to nuclear operation** in a new entrant county.

- In this approach the construction and commissioning will be implemented by an experienced organization.
- Safe operation is ensured by the Russian staff that has similar competences as at NPPs in Russia.
- In parallel, Russia is training local staff to gradually take over the responsibility for plant operations,
  - *For instance, in preparation for Akkuyu NPP operation stage about 150 Turkish students are already studying in university in Moscow and will be graduated as nuclear engineers around the time when first unit of Akkuyu NPP is ready for commissioning.*

Rosatom strategy in new entrant countries (5)

The **BOO** approach is a major **challenge for the national regulatory body** of the customer country.

Rosatom recommends that the national regulatory body acquires

- general support and advice from the IAEA,
- co-operation with Russian nuclear regulator and other regulatory bodies with experience from VVER type nuclear power plants, and
- specific support from foreign expert organizations for developing and implementing safety review, licensing, and inspection activities.

Rosatom emphasizes that the national regulatory body must be ready for independent regulation when the NPP starts to operate.

Rosatom strategy in new entrant countries (6)

The **EPC (Engineer, Purchase, Construct) approach** may be more approriate for countries where

- a **power company** has adequate **financial resources** and a **strong engineering staff** and is **interested to invest** in NPP construction
- existing university education on nuclear energy and a research program including a research reactor facilitate start of NPP construction programme.

Also in the EPC model the new entrant needs support and advice in development of the nuclear infrastructure and regulation.

- Rosatom is prepared to help development in the country before launching the actual nuclear construction programme.

Strengths of Rosatom (1)

Backbone of Rosatom's global business today is front end of the fuel cycle.

- Rosatom is strong in all parts of the front end and can thus **guarantee security of fuel supply in long term contracts**, even for the life time of a nuclear power plant.
- Companies with strong quality management have excellent operating experience from Rosatom fuel: for instance, the two units of Loviisa NPP in Finland operated for more than ten consecutive cycles without any leaking rod.

All steps of the **fuel cycle back end (including waste management)** are today being **developed in a determined manner** as part of Russian national nuclear waste management program.

- A variety of back end services can be negotiated with those customers that will buy both an NPP and fuel from Rosatom.

Strengths of Rosatom (2)

Design of new VVER plants is based on **advanced general safety regulations**.

- Version ”1997” used as basis of current designs was ahead of respective IAEA Safety Standards when it was issued.
- Version ”2012” (draft is still out for comments) complies with the latest IAEA safety standards and in addition takes into account lessons from Fukushima Daiichi accident.

High quality of main components is proven in reliable VVER type NPP operation for about 1500 reactor years.

Strengths of Rosatom (3)

Only one Licensee, **Rosenergoatom** (REA) operates the entire Russian NPP fleet, and its extensive construction and operating **experience gives a sound basis for exporting NPPs**

- REA has strong engineering staff that has made a critical review of the new designs offered for export.
- Large NPP construction programme is ongoing in Russia: eight VVER plants and one fast breeder are under construction.
- Final refinement of standard Generation III VVER plant design is to be completed this year, and a large construction program based on that design is planned to start in Russia in 2016.

REA is actively learning from experiences of foreign NPP operators via WANO network and is transferring those lessons to designers.

Strengths of Rosatom (4)

Design organizations have nuclear experience since 1950´s and thermal power plant experience since 1920's.

- Competition is maintained between design organizations.
- **Experts in design organizations have life-long careers** and dedication to continuously improve and maintain their professional competence.

Several scientific institutes support the design work and verify the safety of NPP's, in addition to the Licensee and the Regulatory body.

- Scientific institutes provide a possibility to do large scale R&D and testing.
- Institutes have been part of international network via OECD/NEA since early 1990's.

Strengths of Rosatom (5)

Rosatom has international partners and subsidiaries with good brand names

- Partners: Rolls Royce, Alstom, Fortum, …
- Subsidiaries: Skoda JS, Nukem Technologies, …

Rosatom has an advanced data management system for finding potential subcontractors/component manufacturers and for keeping current records on them and on their products **[http://zakupki.rosatom.ru]**

- The system is accessible to both Russian and foreign companies that are interested to offer their products to Rosatom's NPP projects and meet the specified quality criteria.
- This system is used as a framework for purchases; it facilitates implementation of the localization strategy in customer countries.

Rosatom challenges in entering global NPP export markets (1)

Generally bad image of Russian nuclear technology seems still to be evident in many countries, both in advanced nuclear countries and in new entrant countries.

- **Chernobyl accident is casting a shadow on Russian nuclear image, although it was a turning point towards major progress**.
- Rosatom has not been able to communicate successfully on developments that have taken place in the Russian nuclear industry in the last 25 years.

Russian achievements in the nuclear field are not generally known to the outside world:

- Advanced safety features and innovations in the new generation of VVER plants
- Current high priority on safety and quality throughout the Russian nuclear industry.

Rosatom challenges in entering global NPP export markets (2)

Open and easily accessible information on Russian NPPs should be provided following the good examples of other NPP vendors:

- Differentiated information to the general public, to the global community of nuclear experts, and to the potential customers and regulators.

Rosatom should also increase significantly its active expert level participation and contributions in the co-operation networks of the global nuclear industry and operators.

- Russian experts would have much to give to their foreign colleagues but the language barrier is still an obstacle.

Rosatom challenges in entering global NPP export markets (3)

The **structure and internal co-operation** of Rosatom Corporation is yet to be **better geared for entering the global markets**.

- A new entity, JSC Rusatom Overseas (RAOS) was established in August 2011 to consolidate Rosatom contacts with foreign customers but its integration to the Corporation structure is still seeking its forms.
- **Improved information flow between all Rosatom entities** is needed for efficient work in the entire Corporation.
- Practical arrangements are needed for allocating **technical resources** of all Rosatom entities **to export project preparation**, in cooperation with RAOS.

VVER nuclear power plant fleet (1)

- Today there are 68 VVER plants in operation or under construction in 11 countries
  - total operating experience is 1500 reactor-years
- Eleven VVER-440 units were closed prematurely after 11-18 years of operation at political decisions, without any serious safety evaluation
  - in connection with the German unification
  - when Slovakia and Bulgaria joined the EU.

VVER nuclear power plant fleet (2)

		Operation			Construction		
		VVER1000	VVER440		VVER1200	VVER1000	VVER440
Russia		11	6		6	2	
Ukraine		13	2				
Czech Republic		2	4				
Slovakia			4				2
Hungary			4				
Bulgaria		2					
Armenia			1				
Finland			2				
China		2				2	
India						2	
Iran		1					
Total		31	23		6	6	2

Evolution from operating VVER plants (1)

- Since designing Loviisa NPP in Finland, all currently operating VVER plants have been designed to meet the safety principles used in the USA.

- The US criteria were a reference for all "*Generation II* " PWR plants
  - the safety features of currently operating VVER and PWR plants are therefore quite similar.

Evolution from operating VVER plants (2)

Design of the VVER-1000 plants, was completed in the early 1980’s but construction of most units was completed after Chernobyl accident.

- two last units (Rostov 3,4) of the VVER-1000 plants of ”*Generation II*” are still under construction.

The new VVER plants representing ”*Generation III*” are evolution of the operating VVER-1000 plants.

Evolution from operating VVER plants (3)

- **The safety record** of VVER-1000 plants **is good** and no incidents with significant safety impact have taken place.
- Operational **reliability** of VVER-1000 plants was **not satisfactory in the first operating years**, mostly because of the poor reliability of many control equipment.
- Based on the operating experience, I&C systems and certain mechanical control equipment such as control rod drives and control valves have been replaced with more reliable technology. **After the modernizations the reliability** of the entire VVER-1000 fleet in different countries **has achieved a good level**.
- **Reliable and stable operation is important also for safety** of the plants because it keeps the frequency of potential accident initiating events low.

Emphasis on nuclear safety after Chernobyl accident (1)

Safety research with international contacts

- Already in the first weeks after the Chernobyl accident new safety studies were started in the USSR, especially with the aim to **better understand the phenomena occurring during a severe accident**.
- It was also decided to start as an urgent matter participation to the **international cooperation in safety research, including access to the foreign computer codes and their adaptation to the features of the USSR plants**.

Emphasis on nuclear safety after Chernobyl accident (2)

Safety research with international contacts (cont.)

- A systematic safety research program was started, inluding **transfer of the foreign research results** to the USSR and development of equivalent domestic skills. The program was supported by **experimental research** as needed to obtain adequate data base **for correct modelling of the specific features of USSR designed plants**.
- The computer codes received from abroad and adapted to Soviet plants were provided to the use of designers and a certification process for the codes and their users was established.
- Research knowledge was used also in development of regulatory requirements.

Emphasis on nuclear safety after Chernobyl accident (3)

Safety research with international contacts (cont.)

In the **1990's Russia played a leading role in the international safety research** and participated actively to the OECD/NEA programs.

Many important research programs were planned and implemented under the umbrella of OECD/NEA. **Large tests** were conducted **in Russian research laboratories** and the **results were assessed jointly with highest level international experts**.

Emphasis on nuclear safety after Chernobyl accident (4)

Soviet/Russian participation to international co-operation

- Within a ten year period after Chernobyl accident, the USSR/Russia invited the **international** nuclear community to participate to the **safety evaluation of both VVER and RBMK type reactors.**
- A number of international peer reviews of operational safety and safety design features were conducted in 1988-91 to assess the safety of NPPs operated in the USSR
- **IAEA issued guidebooks for enhancing safety** of the NPPs designed in the USSR.
- **Soviet / Russian experts started to contribute strongly to the international development of safety principles, regulations and standards.**

Emphasis on nuclear safety after Chernobyl accident (5)

Enhancing safety of operating NPPs in Russia

Plant specific **safety analysis** were conducted using analysis methods and computer programs that had been acquired through international cooperation. **Russian experts developed quickly high skills in safety analysis techniques**.

Regular bilateral co-operation was started with NPPs in other countries, aiming to **learn from foreign safety practices**. The lessons were applied in innovative manner to operation of Russian NPPs.

Major investments have been made to enhance safety of NPPs on the basis of safety analysis and international co-operation: installing new safety systems and training simulators, improving operator training, and improving maintenance and NDT (non-destructive testing) of safety equipment.

Emphasis on nuclear safety after Chernobyl accident (6)

Developing a central management system in Rosenergoatom (REA), owner of all NPPs

- REA recruited a strong **scientific and engineering staff** to the company, tasked to **assess the technical and safety aspects of the back-fittings and modernizations** proposed by the design organizations, as well as to assess new designs.
- Advanced video-conference facilities were installed at all NPPs and at REA headquarters. Conduct of **weekly video conferences among all NPPs** was started to discuss experiences and actions to ensure safety of all plants.
- Communication and data collection systems were installed in the REA headquarters for **continuous monitoring of operational state of all NPPs** and for ensuring prompt response to abnormal events and emergencies.

Era of new VVER plants (1)

<u>Safety principles for new NPPs</u>

- The first set of General Regulations on Ensuring Safety of Nuclear Power Plants was issued in 1988 and revised in 1997.
- The **safety requirements were based** on the discussions in the IAEA's International Safety Advisory Group (INSAG) since 1986 and **on the INSAG reports that led to development of "*Generation III*" NPPs.**
- INSAG reports issued between 1988 and 1996, with strong contribution of Russian experts, presented state-of-the art in global nuclear safety and were ahead of development of the IAEA Safety Standards and of most of the national safety requirements.
- Russian general regulations gave thus a sound basis for designing new "*Generation III*" NPPs already in 1990's.

Era of new VVER plants (2)

Designing and construction of new advanced VVER-1000 plants

- **Design** started around 1990 in co-operation **with the Finnish utility Fortum** that wanted to build an **advanced VVER-1000** plant on its Loviisa site where two smaller VVER units have been in operation since 1977. However, the Finnish Parliament stopped plans for any new NPP in 1993.
- The same concept was further developed for **China** (Tianwan), and the IAEA safety evaluation of the concept in 1995 gave it very positive marks; contract on plant was made in 1997.
- A slightly different design providing more passive safety features was developed for **India**.

Era of new VVER plants (3)

Designing and construction of new advanced VVER-1000 plants

- The main changes of Tianwan from the standard V-320 series of plants were following
  - the plant lay-out provides systematic physical separation of redundant safety systems and reduces significantly the volume and need for concrete and steel in the construction.
  - double containment and 4 x 100% redundancy in the main safety systems
  - severe accident design features: core catcher, passive hydrogen recombination
- **First advanced VVER-1000 plants, Tianwan 1&2**, were constructed in China and have operated with good performance record since **2007**.
- Another advanced plant in India, Kudankulam 1 had its reactor loaded in October 2012 but it was not started up until in July 2013 due to a delay caused by a legal process.

Era of new VVER plants (4)

<u>Launching the design and construction of AES-2006 plants</u>

Design of VVER-1200 plants called as AES-2006 was started after the year 2000 and completed in 2006. Besides the increased size of 1200 MW power, the **AES-2006 plant has additional safety features when compared with the advanced VVER-1000 plants**.

Design of AES-2006 benefitted from the experiences from the construction of plants built in China and India.

Six AES-2006 units are currently under construction in Russia:

- Leningrad 1&2 since 2008 (unit 1 start 2016 ?),
- Novovoronesh 1&2 since 2008 (unit 1 start 2015 ?), and
- Baltic NPP 1&2 since 2011.

Era of new VVER plants (5)

The first proposal for a standard VVER design of Generation III was thoroughly reviewed in the fall 2012 by the engineering department of Rosenergoatom, and a large number of comments were made during that review to the design organizations.

The first version was also submitted to the regulator's preliminary review to expedite the forthcoming licensing.

An improved design version taking into account the comments by Rosenergoatom and Rostechnadzor will be ready for applying construction license probably at the end of this year.

Construction of the series of standard 1200 MW VVER plants is planned to start in January 2016, first unit will be built at Kursk.

Ensuring AES-2006 safety (1)

Reliable provision of the three fundamental safety functions has been the leading principle in the design of the AES-2006 plants.

1. Control of reactivity
   - preventing uncontrolled reactor power increase
   - ensuring fast safe shutdown of the reactor when needed,

2. Removal of decay heat to the ultimate heat sink
   - cooling of shutdown reactor
   - cooling of used nuclear fuel

3. Containment of radioactive materials
   - preventing significant radioactive releases to the environment

Ensuring AES-2006 safety (2)

All new VVER plants that are under construction have already design features that take properly into account the main ”Fukushima issues”:

- long term cooling of reactor core without electrical power,
- long term decay heat removal that is not relying on primary ultimate heat sink (sea, river, cooling tower, ...), and
- protection of reactor containment integrity with dedicated systems after a potential core meltdown accident.

Ensuring AES-2006 safety (3)

In the international meetings in the aftermath of Fukushima, the key word emphasized for further safety enhancement of NPP designs is availability of **diverse systems for providing fundamental safety functions.**

In the AES-2006, the fundamental safety functions are provided by diverse safety systems that can be used independently of each other and in a flexible manner, depending on the accident scenario.

The safety philosophy emphasized in the AES-2006 design is clear: both active and passive systems are available to provide reliable protection of fundamental safety functions.

Reactivity control (1)

All AES-2006 reactors have a unique safety feature, when compared with all PWR or older VVER type plants:

If the control rods are inserted to the core the reactor will stay in shutdown state also in low temperatures and in long term.

This means that reactor can be cooled down to safe shutdown condition without a concern that it becomes critical again and without a mandatory need to inject boron to the reactor coolant system.

Reactivity control (2)

Nevertheless, AES-2006 reactor has also reliable **boron injection** systems. These can add liquid with high boron concentration to the reactor coolant in case that the control rods would not drop to the reactor core for any reason.

Boron injection system has **four identical parallel pumps.** Operation of **two pumps is enough for fast shutdown of the reactor so that the reactor fuel is not damaged in any accident scenario** (this is a true ATWS protection!).

If there is no urgent reason requiring fast shutdown of the reactor, operation of one pump is enough.

Decay heat removal

In the AES-2006 plants, decay heat can be removed in three different ways:

1) by active systems to the main ultimate heat sink or to a separate dedicated "spray pond",
2) by active systems to the atmosphere (feed and bleed from steam generators), or
3) **by passive systems to the atmosphere**.

Active systems of type 1) and 2) are standard features found in most PWRs in operation today, including older VVERs.

Passive system for decay heat removal is an important advanced feature for ensuring safety of the the new VVER plants.

Passive decay heat removal at LNPP-2 (1)

Passive system for decay heat removal from reactor via steam generators to atmosphere (PSHR-SG)

1 – emergency heat removal tanks (EHRT) outside containment ; heat is removed by boiling of water in EHRTs in atmospheric pressure

2 – steam lines

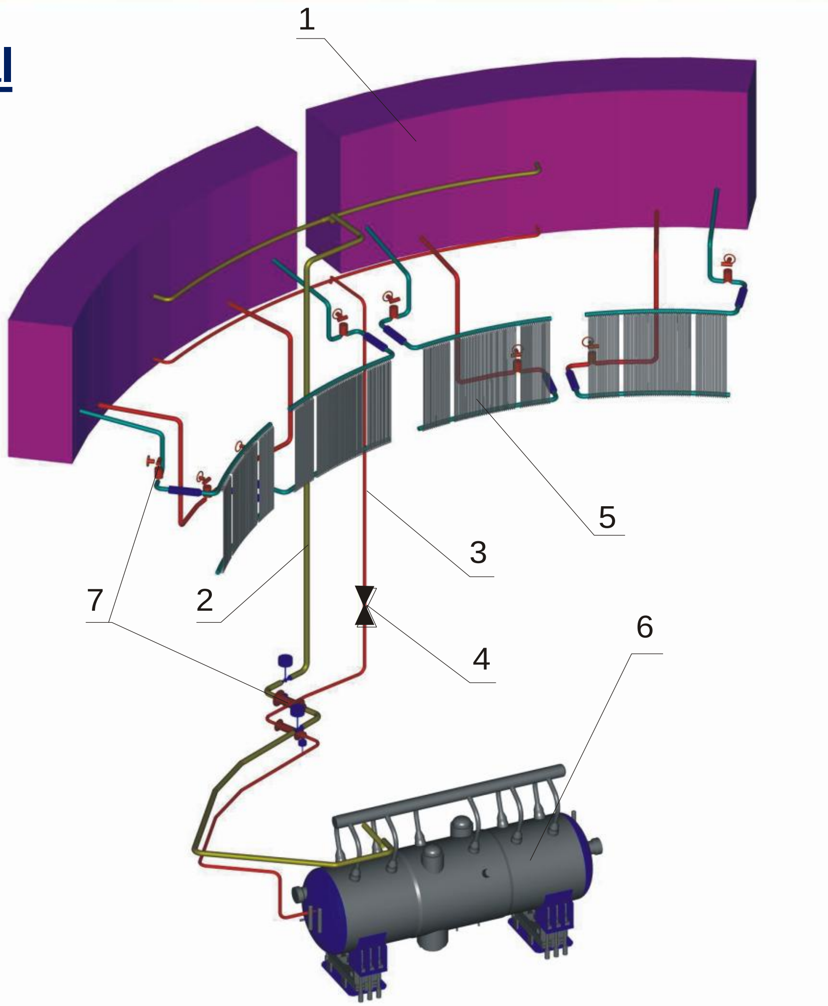
3 – condensate pipelines

4 – PSHR-SG valves

[**5** – heat exchangers of containment heat removal system PSHR-C; *it is a separate system but uses same EHRTs*]

6 – steam generators

7 – cutoff valves



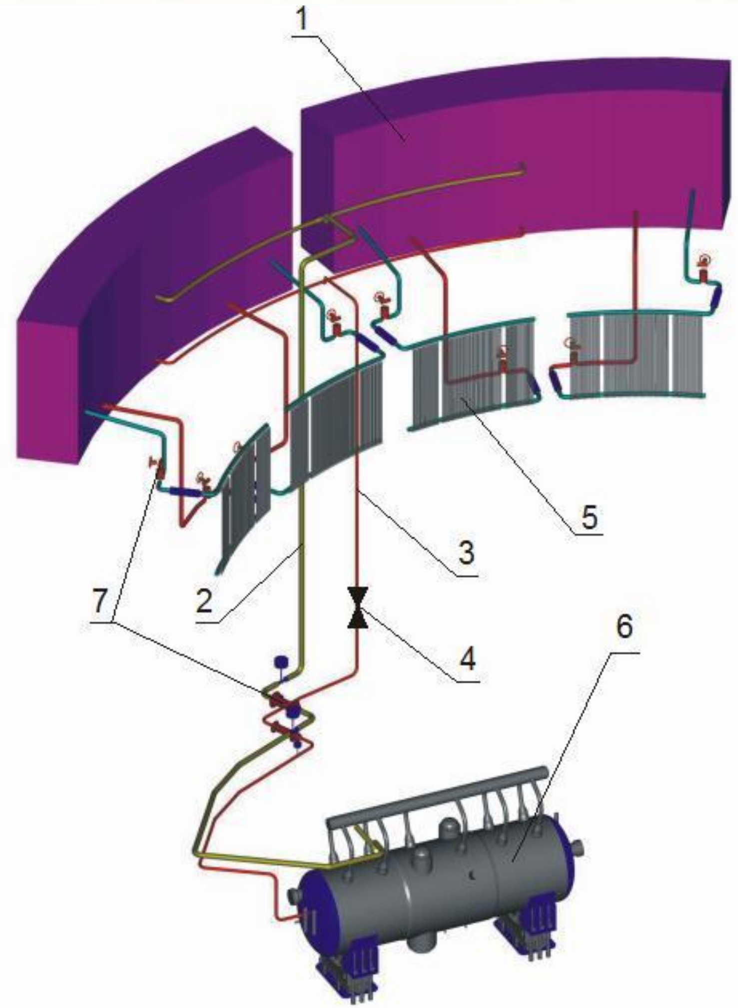
Passive decay heat removal at LNPP-2 (2)

Operation of 3 out of 4 EHRT tanks provides cooling for 24 hours, all 4 tanks for 72 hours. All tanks can be connected as communicating vessels and then all water is available.

After Fukushima, a fixed battery driven pump was added to design that can refill the EHRT tanks and spent fuel pools from a separate storage tank, batteries have a capacity for 72 hours.

Also, connections were made for transportable small diesel generator for dedicated recharging of batteries and thus for providing water without time limit.

Furthermore, connections were made for two transportable diesel driven pump units that can also refill EHRT tanks and spent fuel pools.



Containment of radioactive material (1)

A target set already after Chernobyl accident was that dedicated systems have to be developed for the new generation of VVER plants for protecting the reactor containment after possible core meltdown accident.

After Fukushima Daiichi accident, this target was generally concluded to be well founded and the respective requirements have been included in the new IAEA Safety Standard SSR2.1 “Safety of Nuclear Power Plants: Design,” issued in 2012.

Protection of the reactor containment even in connection with a core meltdown accident has been one of the original design principles used for AES-2006 plants, and respective experimental research has been done for more than 20 years.

Containment of radioactive material (2)

The strategy for protection of the AES-2006 containment after possible reactor core meltdown is that all physical phenomena that could occur in connection with core meltdown and endanger the containment integrity are taken into account and dedicated means are provided to ensure containment integrity.

Protection of the AES-2006 containment integrity against all those physical phenomena is based on passive systems that do not need electrical power.

Containment of radioactive material (3)

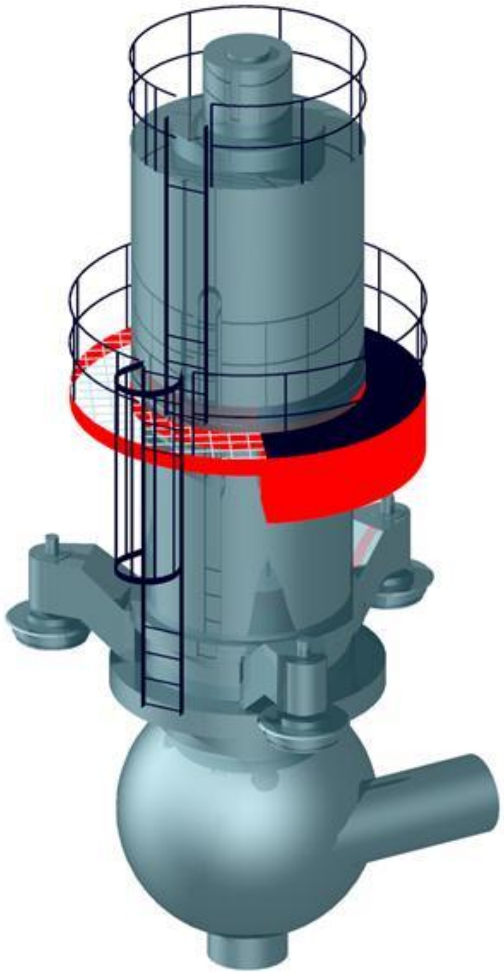
The physical phenomena addressed in the AES-2006 design include:

- reactor core meltdown in high primary circuit pressure,
- containment overpressure due to the steam generated inside the containment,
- accumulation of hydrogen inside the containment and consequent hydrogen explosion,
- steam explosion,
- penetration of the molten reactor core through the containment bottom, and
- recriticality of the molten reactor core

Advanced features of AES-2006 main coolant pumps

Two special safety features of MCPs:

1. Primary circuit main circulations pumps and their motors have **water cooling** and **water lubricated bearings**, while most PWR plants have oil cooling that entails elevated risk of large fire inside the reactor building.
2. An issue that is important in connection with the complete loss of electrical power is the potential leak from the primary circuit main circulation pump seals. AES-2006 pumps have **a seal structure that ensures very small leak** in all conceivable circumstances.



Conclusions

Rosatom has a target to globalize its operations and to become a leading company in the field.

- Rosatom has necessary intellectual, financial, and technology resources to meet its globalization targets.
- Current operating fleet of VVER fleet has good record of safe and reliable power production
- The AES-2006 plants offered for export have safety design features that take into account the latest development of safety requirements and safety technology.
- However, there are strong challenges that have to be overcome to succeed in technologically advanced countries