Role and place of the operating organization in implementation of the development strategy of Russian nuclear power industry

Mr. Andrey Yu. Petrov
Director General
Moscow | May 23, 2018
<table>
<thead>
<tr>
<th></th>
<th>Table of Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rosenergoatom today 3</td>
</tr>
<tr>
<td>2</td>
<td>Near-future strategy (10-15 years) 10</td>
</tr>
<tr>
<td>3</td>
<td>Mid-term strategy (15-30 years) 20</td>
</tr>
</tbody>
</table>
1. Rosenergoatom today
Operating organization Rosenergoatom (REA) is as follows:

- **35** operating NPP units at 10 NPP sites
- **27 890 MW** of installed capacity
- **18** VVER NPP units
- **15** channel-type NPP units
- **2** units with fast reactors
- **2** units at the stage of pilot operation (Rostov NPP unit No.4 with VVER-1000 and Leningrad NPP unit No.5 with VVER-1200 (AES 2006))
- **6** units under construction (design capacity more than **7** GW)
- **1** floating nuclear power plant under construction (FNPP **70** MW)
- **3** units in preparation for decommissioning
- **2** units at the stage of decommissioning:
REA is one of the largest electric utilities

in terms of installed capacity 
over the world

<table>
<thead>
<tr>
<th>Rank</th>
<th>Company</th>
<th>Capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EDF (France, 58 units)</td>
<td>65.9</td>
</tr>
<tr>
<td>2</td>
<td>REA (Russia, 35 units)</td>
<td>27.9</td>
</tr>
<tr>
<td>3</td>
<td>KHNP (S.Korea, 24 units)</td>
<td>23.5</td>
</tr>
<tr>
<td>4</td>
<td>EXELON (USA, 22 units)</td>
<td>22.9</td>
</tr>
<tr>
<td>5</td>
<td>NAEK Energoatom (the Ukraine, 15 units)</td>
<td>13.8</td>
</tr>
</tbody>
</table>
The share of electricity production by REA in Russia in 2017 attained 18.9%.

202.9 bln. kW·hr was generated at Russian NPPs in 2017.
In comparison with indicators of WANO regional centers the indicators of sustainability of operation of REA NPP units and personnel injuries are at good level

The indicator of scram actuation per 7000 hours of operation (WANO data) in 2017

<table>
<thead>
<tr>
<th></th>
<th>REA</th>
<th>Moscow Center</th>
<th>Tokyo Center</th>
<th>World average</th>
<th>Atlanta Center</th>
<th>Paris Center</th>
<th>EDF Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scram actuation rate</td>
<td>0.08</td>
<td>0.12</td>
<td>0.17</td>
<td>0.27</td>
<td>0.17</td>
<td>0.34</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Industrial Safety Accident Rate and Contractor Industrial Safety Accident Rate that resulted in personnel injuries (per 200 000 man-hours)

<table>
<thead>
<tr>
<th></th>
<th>REA</th>
<th>Tokyo Center</th>
<th>Moscow Center</th>
<th>World average</th>
<th>EDF Energy (France)</th>
<th>Atlanta Center</th>
<th>Paris Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety accident rate</td>
<td>0.02</td>
<td>0.04</td>
<td>0.05</td>
<td>0.09</td>
<td>0.27</td>
<td>0.38</td>
<td>0.27</td>
</tr>
</tbody>
</table>
Four new NPP units were started up from 2016 to 2018

<table>
<thead>
<tr>
<th>NPP</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beloyarsk NPP</td>
<td>Unit No. 4</td>
<td>NPP unit with fast reactor BN-800 was commissioned in 2016</td>
</tr>
<tr>
<td>Novovoronezh NPP-2 unit</td>
<td>№ 1</td>
<td>Innovative unit of Generation 3+ per design AES-2006 was commissioned in 2017</td>
</tr>
<tr>
<td>Rostov NPP</td>
<td>Unit No. 4</td>
<td>Serial VVER-1000 NPP unit is at the stage of pilot operation</td>
</tr>
<tr>
<td>Leningrad NPP-2 unit</td>
<td>№ 1</td>
<td>Innovative unit of Generation 3+ per design AES-2006 is at the stage of pilot operation</td>
</tr>
</tbody>
</table>
International component is an integral part of REA activities

IAEA
- Convention on Nuclear Safety
- Peer reviews (OSART missions)
- Exchange of experience (improvement of the NPP safety and reliability, technological development and new projects)
- IAEA safety standards

WANO
- Technical support and exchange of technical information
- Performance of peer reviews
- Exchange of operating experience
- Regional crisis centre of WANO Moscow Centre

OECD NEA
- OECD NEA projects and programs
  (International Information System on Occupational Exposure (ISOE), Multi-national design examination program (MDEP))
- Technical committees and Working groups of OECD NEA (operating experience, decommissioning, economy of nuclear power industry etc.)
- Work of REA experts in the Secretariat of OECD NEA

EDF, JNPC, IBERDROLA...
- Bilateral collaboration with leading energy companies of the world
2. Near-future strategy (10-15 years)
In the framework of implementation of the strategy for development of nuclear power industry in Russia to 2030 REA will be transformed from an operating organization into a global energy business company.

- **Increasing the share** at international markets
- **Cost reduction** products and timing performance of processes
- **New products** for Russian and international markets
- **International business development:**
  - services for foreign nuclear power plants,
  - new products and projects
- Development of traditional business **generation of electricity**
- Entry to the market of **non-nuclear facilities**
Development and preservation of the generating capacities (MW) to 2030
## VVER technology development:
AES-2006 - an innovative project with VVER-1200 reactor of Generation 3+

<table>
<thead>
<tr>
<th>Designed lifetime</th>
<th>LTE</th>
<th>Number of personnel</th>
<th>Peculiar features</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 years</td>
<td>20 years</td>
<td>30-40% less than (VVER-1000)</td>
<td>A unique combination of active and passive safety systems that makes the plant resistant to the maximum extent to the external and internal impacts</td>
</tr>
</tbody>
</table>

### Positive experience

- **2017**
  - 1NVNPP-2
- **2018**
  - 1LNPP-2
- **2019**
  - 2HBAЭС-2
- **2020**
  - 2LNPP-2
- **2022**
  - 1KUNPP-2
- **2023**
  - 2KUNPP-2

### VVER-TOI enhancement of VVER-TOI project:

1. Improvement of competitiveness
2. Removal of conservatism in terms of safety
3. Operation in dual-component nuclear power system with BNs
REA is the customer, developer and the operating organization of FNPP with KLT-40S reactor

Completion of FNPU from St.-Petersburg to Murmansk

Loading of nuclear island

Transportation of FNPP to Pevek

Start of integrated mooring tests

Characteristics of FNPU

<table>
<thead>
<tr>
<th>Electric capacity, MW</th>
<th>2x35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal capacity, Gcal / h</td>
<td>50</td>
</tr>
<tr>
<td>LF</td>
<td>0.75</td>
</tr>
<tr>
<td>Periodicity of nuclear refuelling, years</td>
<td>3</td>
</tr>
<tr>
<td>Periodicity of manufacturer overhaul, years</td>
<td>12</td>
</tr>
<tr>
<td>Design lifetime, years</td>
<td>40</td>
</tr>
</tbody>
</table>

Commissioning of FNPP

31.12.2019

Decision-making on the FNPP replacement

2022

First loading of nuclear fuel at the site of location

2023

Medium maintenance of FNPU at the manufacturer premises (16 months)

2030

Commissioning of the substituting source

2032
Development of technologies for dual-component nuclear power system (NPS)

Current status of Nuclear power industry (NPI)

- Optimization systematic research that identify the structure of the dual component nuclear power industry and requirements for the components.
- Development of the requirements for the components. VVER, RBN and CNFC

2020

2024

- Upgrading of the design of the NPP unit with VVER-TOI reactor for work in closed nuclear fuel cycle
- Development of the Improved NPP unit with BN-1200M reactor (BREAKTHROUGH)
- Development of CNFC production: fabrication and reprocessing (BREAKTHROUGH)

2034

- Construction of the pilot unit for dual-component NPS for UOX and MOX (MNUP)
- Construction of the pilot unit
- Construction pilot production facility of U-Pu fuel
- Elaboration of reactor technologies and CNFC

2035 - commercial operation:

- Pilot NPP unit with BN-1200M reactor
- Pilot NPP unit with VVER-TOI reactor
- Plant for fabrication of MOX-fuel for BN-1200M
- Design of reprocessing module for spent BN-1200M MOX fuel in CNFC

Abbreviations used: CNFC - closed nuclear fuel cycle, RBN - fast reactor, NPS - nuclear power system, UOX - uranium fuel, MNUP - mixed nitride uranium-plutonium

www.rosenergoatom.ru
# Decommissioning of NPP units in Russia and abroad

<table>
<thead>
<tr>
<th>Shutdown</th>
<th>Decommissioning</th>
<th>NPP units</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>6</td>
<td>NVNPP № 1,2</td>
</tr>
<tr>
<td>2030</td>
<td>19</td>
<td>NVNPP №1,2, LNPP №1,2, KUNPP №1,2, BELNPP №1,2</td>
</tr>
</tbody>
</table>

- Pilot project: decommissioning of Novovoronezh NPP units Nos. 1-2 with completion in 2035;
- The proven experience will be replicated at other nuclear power plants

## TO OBTAIN A REFERENCE OF EXPERIENCE AND ENTRY TO THE INTERNATIONAL MARKET:

- Performance of the decommissioning activities at the first stage of Beloyarsk and Leningrad NPPs (by individual decisions from the time of shutdown);
- 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.
New businesses of Electric power division Product and geographic diversification

- Nuclear infrastructure
- Sales of electricity
- Personnel training
- Production of isotopes
- Technical customer services
- Conduct of operations
- Commissioning activities
- Support to operations
- Decommissioning and radioactive waste management
- Service, LTE, Upgrading

**In 17 countries**
- Contracts signed
- Leaders of the service market

**In 3 countries**
- Portfolio of new products for the period of 10 years outside the circuit of State Corporation Rosatom
- > 200 bln. roubles
One of strategic development directions is the personnel training

1. Recruitment of young, qualified personnel to the industry
Annual demand for young specialists at the NPPs of REA is 360 individuals.

<table>
<thead>
<tr>
<th>NRNU MEPhI</th>
<th>Ivanovo State Energy University</th>
<th>Tomsk State Polytechnic Institute</th>
<th>Ural Physiscal University in Ekaterinburg</th>
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<tbody>
<tr>
<td>100</td>
<td>143</td>
<td>160</td>
<td>204</td>
</tr>
<tr>
<td>2018</td>
<td>261</td>
<td>816</td>
<td>270</td>
</tr>
<tr>
<td>2019</td>
<td>484</td>
<td>1109</td>
<td>824</td>
</tr>
<tr>
<td>2020</td>
<td>1109</td>
<td>961</td>
<td>220</td>
</tr>
<tr>
<td>2021</td>
<td>210</td>
<td>1103</td>
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</tr>
<tr>
<td>2022</td>
<td>220</td>
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<td>2023</td>
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Establishment of Technical Academy Rosatom (in 2017), an autonomous non-profit organization of vocational professional training:

2. Training of personnel for foreign NPPs

3. Continuous training and qualification improvement of the specialists from REA and foreign customers
Strategic business indicators on the horizon until 2030

Current level

Share in the electricity market of the Russian Federation

+10%

Electricity generation

13

Commissioning of new NPP units

11

Lifetime extension of the NPP units

↑ in 3 times

Revenue from new businesses

↑ in 3 times

Foreign revenues (services of the NPPs abroad)

↑ in 2 times minimum

Growth of the revenues
3. Mid-term strategy (15-30 years)
Further development of reactor technologies

**Reactor VVER-S**
- Reduction of natural uranium consumption;
- Reduction of capital costs;
- Full refusal from liquid boron control;
- Operation in dual-component nuclear power system with BNs

**Commercial RBN**
- Development of commercial RBN units for optimization of the dual-component NPS within a united CNFC;
- Optimization of the technologies of Pu application produced from VVER and uranium-238;
- Testing of technologies of application of nuclear fuel cycle with minor actinides for its burn-out in RBNs

**Nuclear hydrogen energy**
- Large-scale hydrogen production based on technologies of high-temperature gas-cooled reactors (HTGCR);
- Improvement of the technologies;
- Hydrogen energy infrastructure development

**Small and mid capacity NPPs**
- Development of reference competitive nuclear plants of small and mid capacity (ASMM and ASSM) and testing of key technologies
Role of REA in implementation of the nuclear energy development strategy of State Corporation Rosatom

**Current state**
Operator of nuclear power plants in the Russian Federation and the head organization of the developing Electric power division

**Near-future strategy (to 2034)**
Operator of nuclear power plants in the Russian Federation and global energy market company with a significant share of revenues from the sale of new products and businesses in the foreign markets

**Mid-term strategy (to 2045)**
Global energy market company and a potential customer for strategic and cost effective projects in the mid-term stage of the nuclear energy development strategy in Russia