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ROSATOM STATE ATOMIC ENERGY CORPORATION

Requirements for Nuclear Power in respect of worldwide trends and challenges

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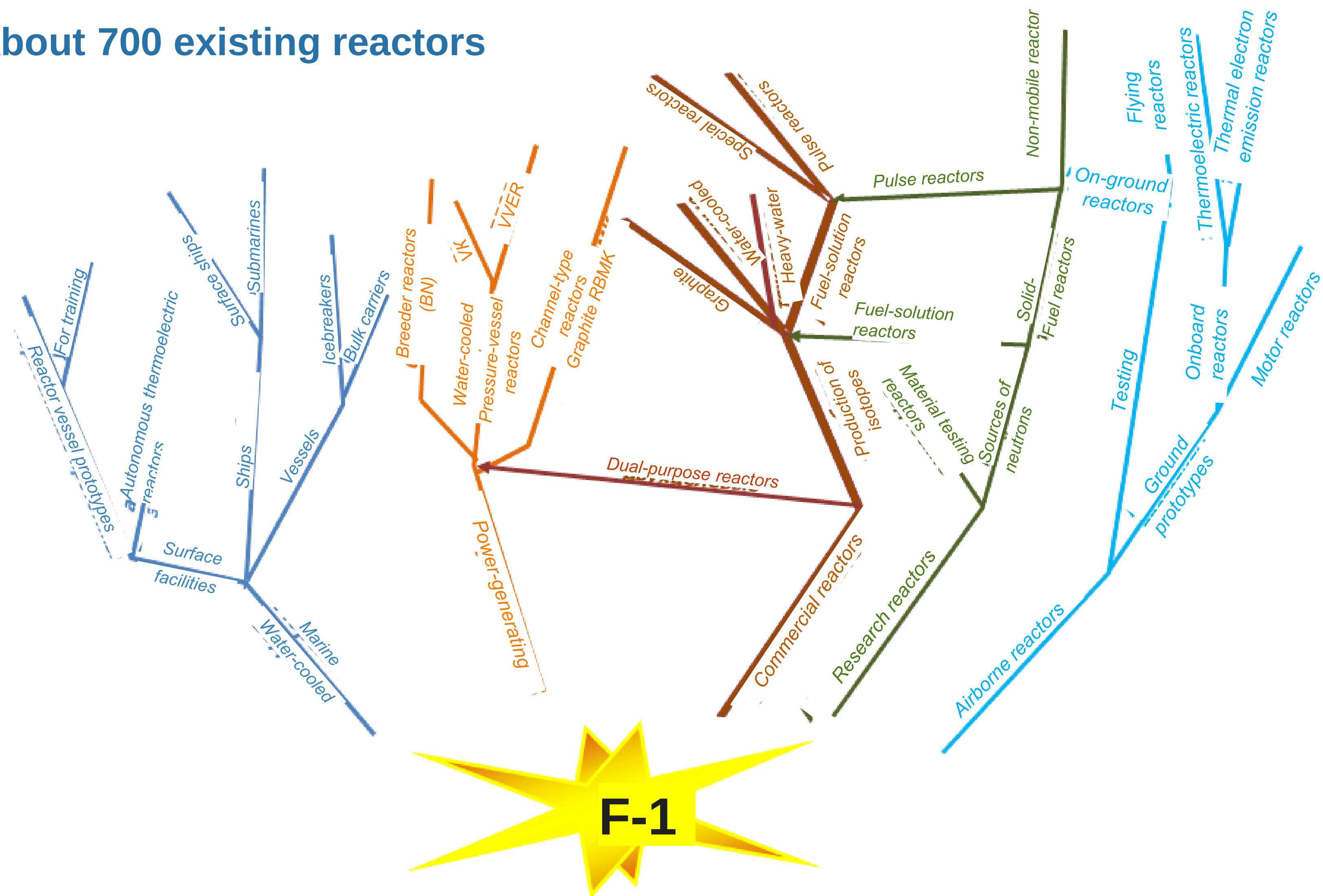
Tree graph of reactors

About 700 existing reactors



The first NPP in the World

June 26, 1954 –

Birthday of nuclear-power engineering

Power-producing reactors

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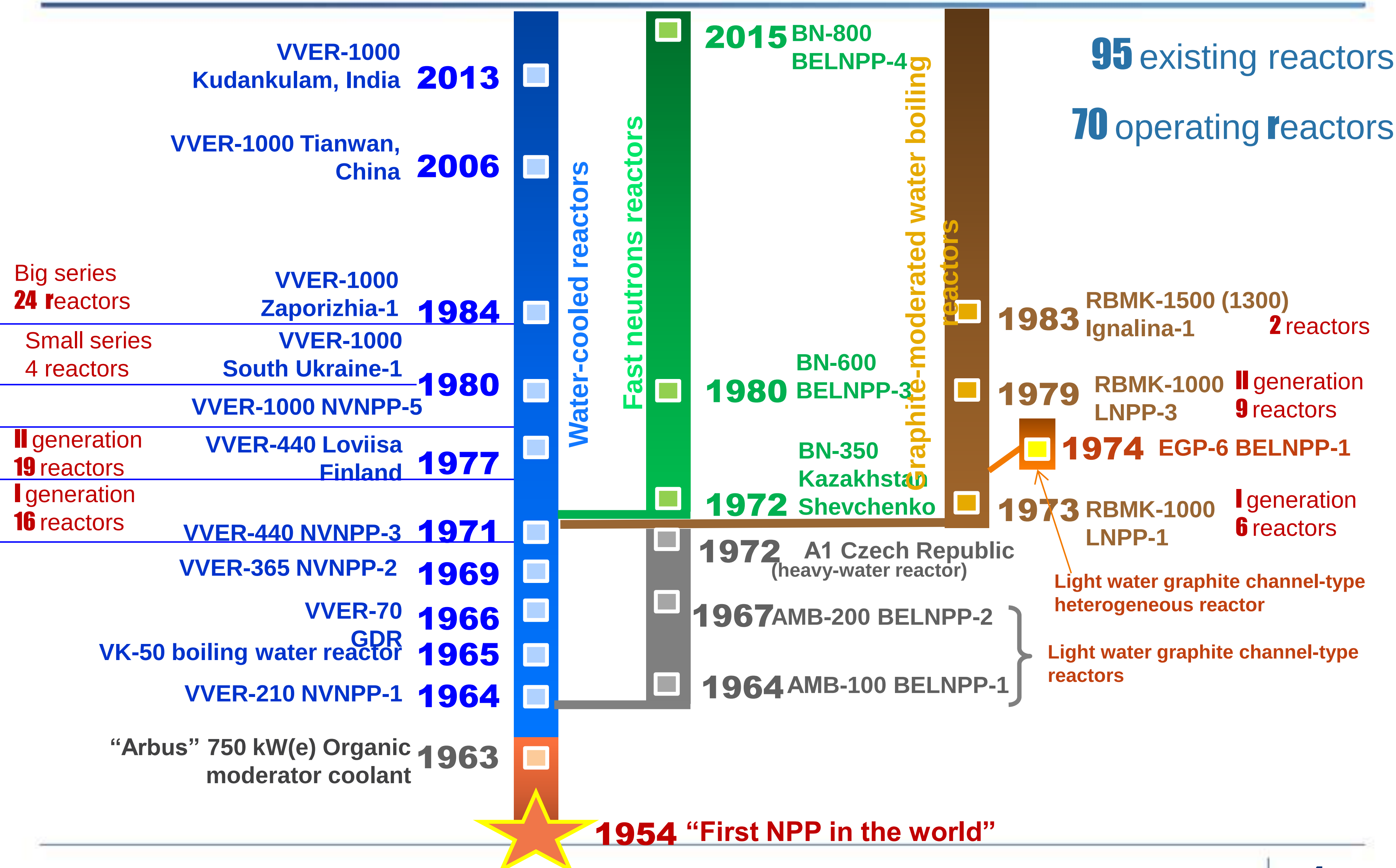
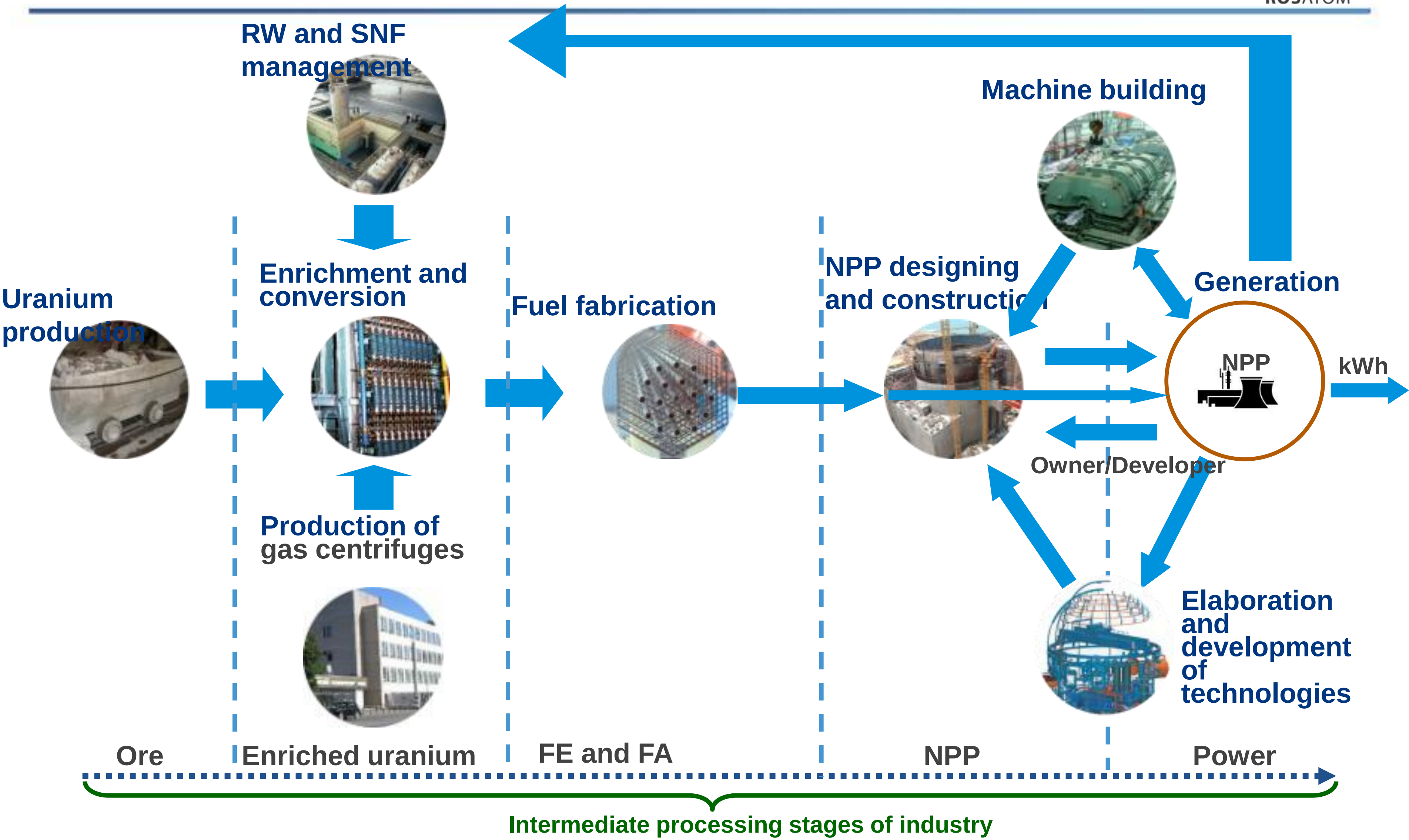
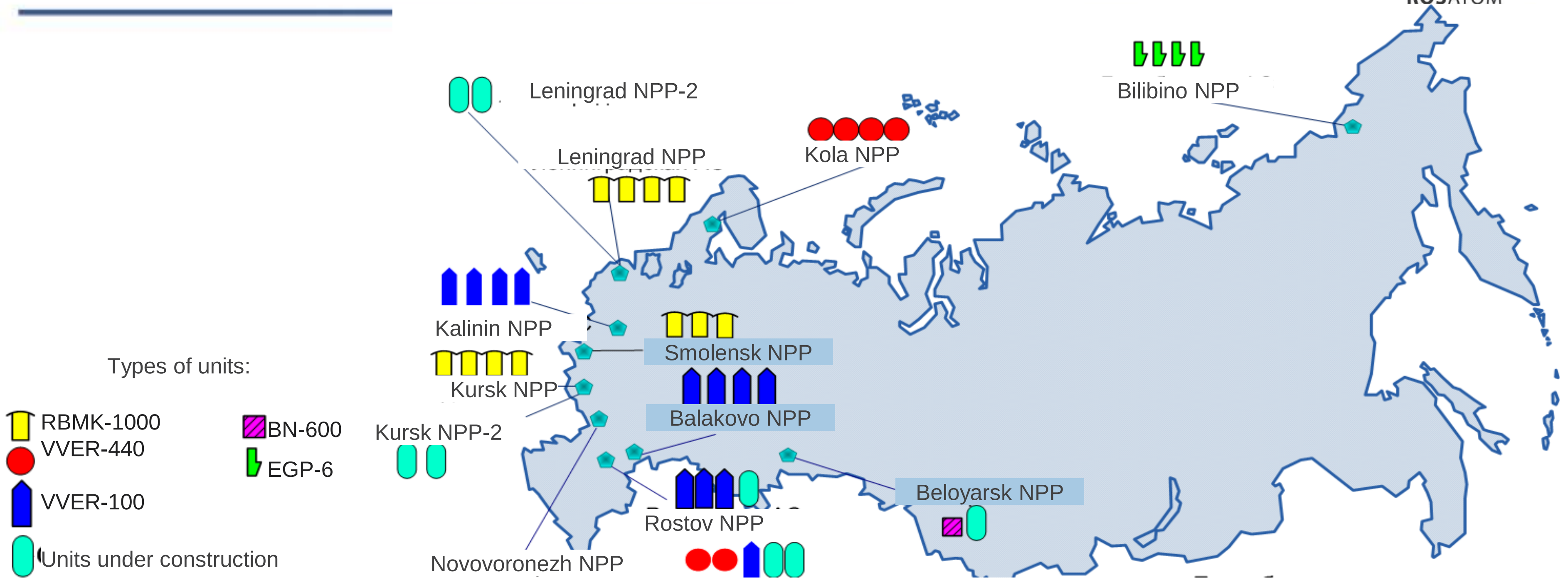


Process chain of nuclear power generation in Russia



Geography of operating and being-built NPP units in Russia



10	Operating NPPs
34	Operating power units
1	Power unit in pilot operation (4BEL)
7	Power units under construction
26,242 MW	Installed capacity
195.2 bln. kWh / 18.6%	Generated electric power in 2015 /NPP share in Russian power industry
40%	Share of NPP power generation in the European part of Russia

Level of nuclear power globalization

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USA
Germany
France
Russia
Japan
5 countries

generate 70% of the world nuclear electricity

France
China
Great Britain
India
Russia
Japan
6 countries

possess capacities for nuclear fuel reprocessing

Russia
India
France
China
Japan
5 countries

possess advanced fast neutron reactor projects

Rosatom
JNFL
URENCO
CNNC
USEC
EURODIF
6 companies

provide industrial enrichment of uranium

PWR
WER
BWR
3 types of light-water reactors

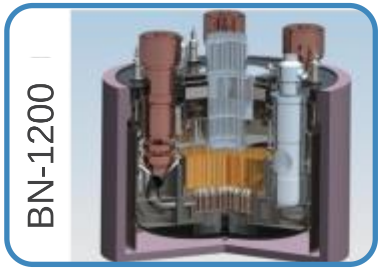
make 80% of the global reactor fleet

Assessing level of technological availability of Russia to ensure innovations in nuclear power-engineering

With respect to reactor technologies:

Evolutionary NPP designs with reactors featuring capacity of 1200 MW have been developed and implemented

The technology of sodium-cooled fast neutron reactors has been successfully demonstrated



Development of new NPP designs with fast sodium-cooled reactors, with fast reactors featuring heavy metal coolant and a set of designs for small and medium power engineering are at different stages of availability

Assessing level of technological availability of Russia to ensure innovations in nuclear power-engineering

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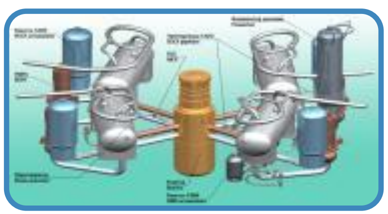
With respect to the closed nuclear fuel cycle technology:

The technology of wet reprocessing of SNF with plutonium separation and vitrification of high-level RW (RT-1) has been demonstrated at the industrial level

The pellet- and vibro-technologies of MOX fuel fabrication for fast reactors with sodium coolant have been demonstrated at the experimental production level

Development of alternative fuel-cycle technologies with fast reactors (nitride fuel, dry methods of SNF reprocessing, minor actinides transmutation in fast neutron reactors, uranium-thorium cycle technology elements) is underway now



Consideration is given to the concepts of hybrid accelerator-driven units and molten salt reactors for burning-out long-lived RW

Assessing level of technological availability of Russia to ensure innovations of nuclear power-engineering

- With respect to the technologies of nuclear power sources for non-electrical use:

The possibility of using nuclear-power technologies for the purposes of sea water desalination (BN-350) and of regional heat supply (Bilibino NPP) has been demonstrated

The technologies of power generation for non-electrical use and power unit designs for implementing these technologies are at different stages of completion

Basic principles of development of the Russian nuclear power complex

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I. Integrity

Requirements for development of every key technological element of the NPC are developed in response to a request from the NPS with the aim of integral optimization of all its parameters

II. Stages

Safe and efficient NPP operation is ensured by gradual implementation of all required stages of development and mastering new technologies:

- conceptual research project
- R&D
- pilot operation of a prototype model
- commercialization
- mass commercial use

III. Steps

Development of short-term and long-term targets is based on the iterative process of analyzing problems arising at every current stage of NPP development

Requirements for a large-scale XXI-century Russian NPS

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Consumer appeal	• guaranteed safety • economic efficiency
Scale of production in electric power market	• At least 30% by mid-century
Power-generation structure	• It shall ensure multi-purpose use by the fields of application, i.e. expansion of sales markets, and complexity as the flexibility and risk-tolerance factor
Raw materials base	• It shall not have limitations for historically significant period of time (hundreds of years)
Handling waste	• It shall provide for safe final RW isolation

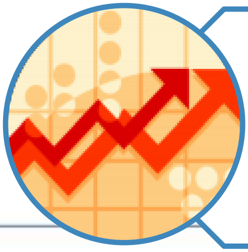
Tactics and strategy of the NPS development in Russia

Current stage:

building-up power-generating capacities based on the development of VVER technology as the practical basis for long-term industrial nuclear power engineering

Establishment and optimization of the basic elements of a new technological platform for closing the nuclear fuel cycle ensuring the minimization of radiation load in the course of nuclear fuel reprocessing and RW ultimate disposal

ensuring growth of export of reference nuclear power-generation technologies



investigating market demand for regional nuclear power engineering of low and medium capacity and its non-electrical use

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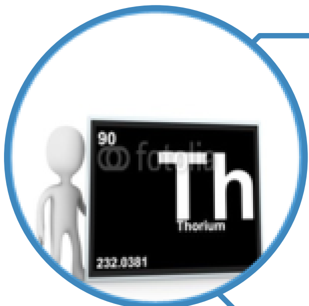
Subsequent stages:

development and deployment of a large-scale NPS closed with respect to uranium and plutonium as the basis for sustainable development of Russia in the third millenium



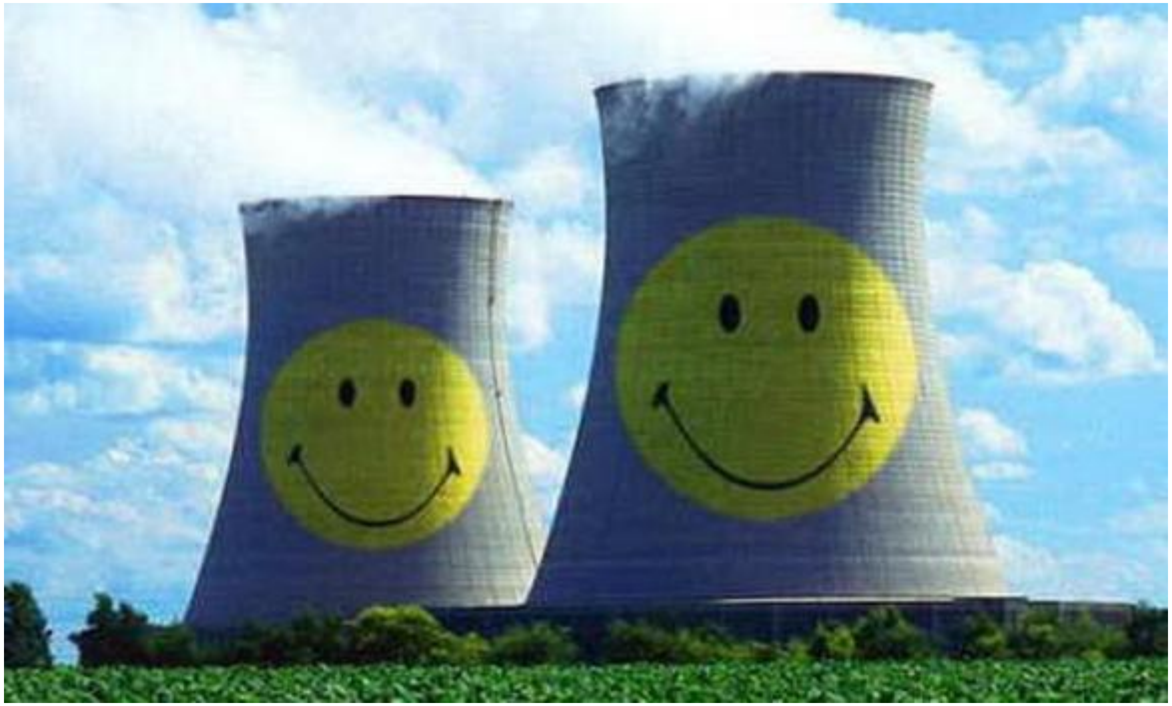
determining perspectives for incorporating thorium into the nuclear fuel cycle

justification of necessity and possibility of using the thermonuclear (fusion) source for nuclear fuel breeding

Priority tasks of the Russian NPC

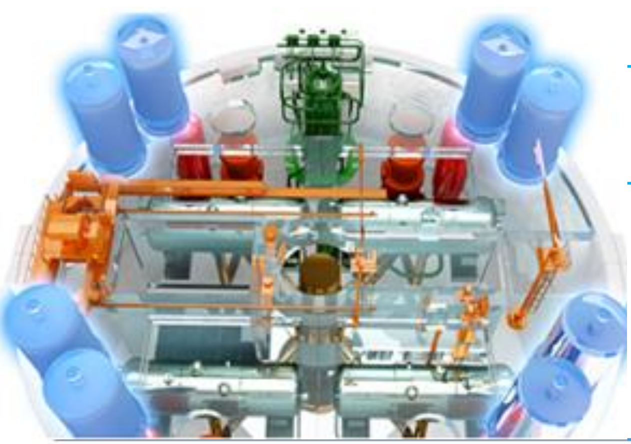
Increasing safety and efficiency of operating NPPs and NPPs under construction

- development and implementation of performance targets for decreasing expenses and increasing safety at all stages of the lifecycle of nuclear power engineering and their justification on the basis of optimization analysis



Priority tasks of the Russian NPC

Further development of VVER technology

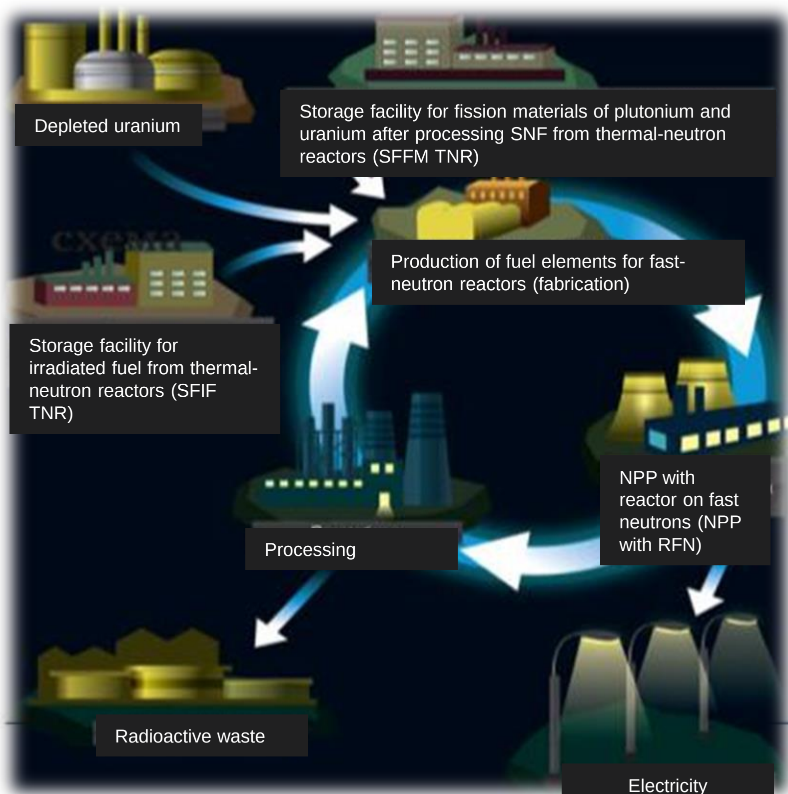


Justification and implementation of proposals on:

- increasing consumer appeal (reliability, safety, maneuverability, etc.)
- extending the capacity range (from 100 to 1800 MW)
- building VVER with spectral regulation for efficient operation in open and closed fuel cycle
- building SCWR with supercritical coolant parameters
- development of new structural materials for the reactor internals and fuel cladding
- incorporation of new burnable absorbers
- implementation of fuel and resource support with developing of optimal structure of nuclear fuel cycle (improvement of fuel usage, increasing of breeding factor, involvement of thorium reserves)

Priority tasks of the Russian NPC

Building basic elements of technological advances in closing NFC



- **development of requirements and justifications, selection of fast neutrons reactor(s) as the basic element for a closed NFC (fuel breeding, time of external fuel cycle regarding plutonium, safety, economy, stage-by-stage approach, implementation dates);**

- **R&D in new NFC technologies (fuel, methods of NF fabrication and reprocessing, minor actinide transmutation, elaboration of the thorium-uranium cycle technology)**

Priority tasks of the Russian NPC

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Expanding sales markets of electric power from nuclear power sources

Justification and implementation of proposals on**:**

- **production of low- and high-temperature process nuclear heat;**
- **production of new energy carriers;**
- **sea water desalination**

Priority tasks of the Russian NPC

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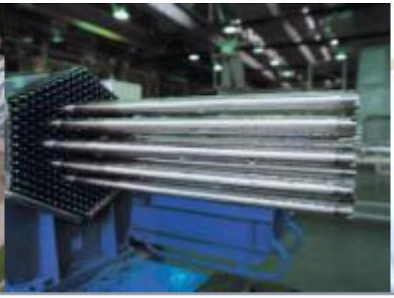
Elaboration of medium- and long-term development strategy

- system modeling of development of the global and Russian nuclear power industry for assessing priority focus areas for innovations (deadlines, scale, technical requirements);
- developing methods of assessment of neutron efficiency of nuclear power engineering system, forecast of neutron efficiency of fuel accessible in future;
- development of methods of efficient control of the nuclear fuel nuclide inventory at all process stages of a closed NFC;
- preparing proposals on efficient transition to the thorium-uranium fuel cycle



Thank you for your attention