The Abdus Salam International Centre for Theoretical Physics

2372-18

Joint ICTP-IAEA Workshop on Sustainable Energy Development: Pathways and Strategies after Rio+20

1 - 5 October 2012

Contribution of Nuclear power to Sustainable Energy Development in the RF

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Sustainable energy definition

A central goal of sustainable development is to maintain or increase the overall assets (natural, man-made and human or social assets) available to future generations, while minimizing consumption of finite resources and environmental load .

The development of nuclear power broadens the natural resource base usable for energy production, increases human and man-made capital, and, when safely handled, has little impact on ecosystems.

Russia profile

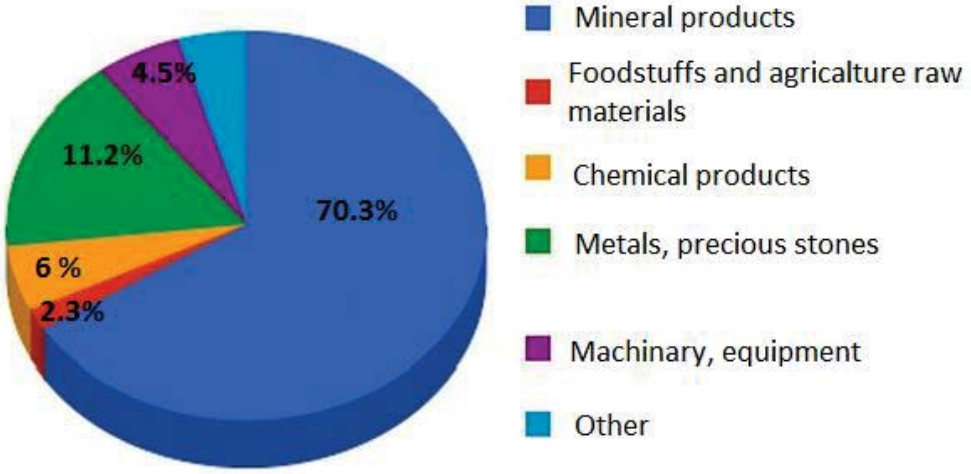
- 12.8% of the world territory,
- 2.8% of the world population and
- 12-13% of the world unexplored resources.
  - 12% of explored reserves of oil,
  - 42% of resources and 34% of reserves of natural gas,
  - about 20% reserves of coal and
  - 32% reserves of brown coal
  - 10% of world reasonably assured resources of U

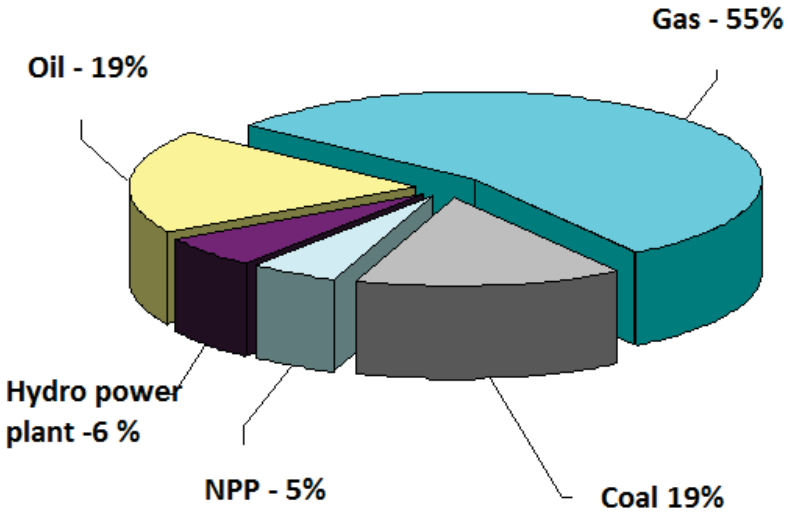
Electricity generation and GDP per capita growth scenarios

scenarios	Annual Growth of GDP for period of 2012-2030
Innovative scenario	4.4 %
Conservative scenario	3.6 %

Problems of the state-level

1. **Too low share of technologies in export structure less 5%.**





2. **Low share of non-carbon resources in total primary energy supply.**

About 11% (nuclear +hydro)

Source : Russia in figures, 2012, Commodity structure of export o the Russian Federation http://www.gks.ru/bgd/regl/b12_11/IssWWW.exe/Stg/d2/26-08.htm

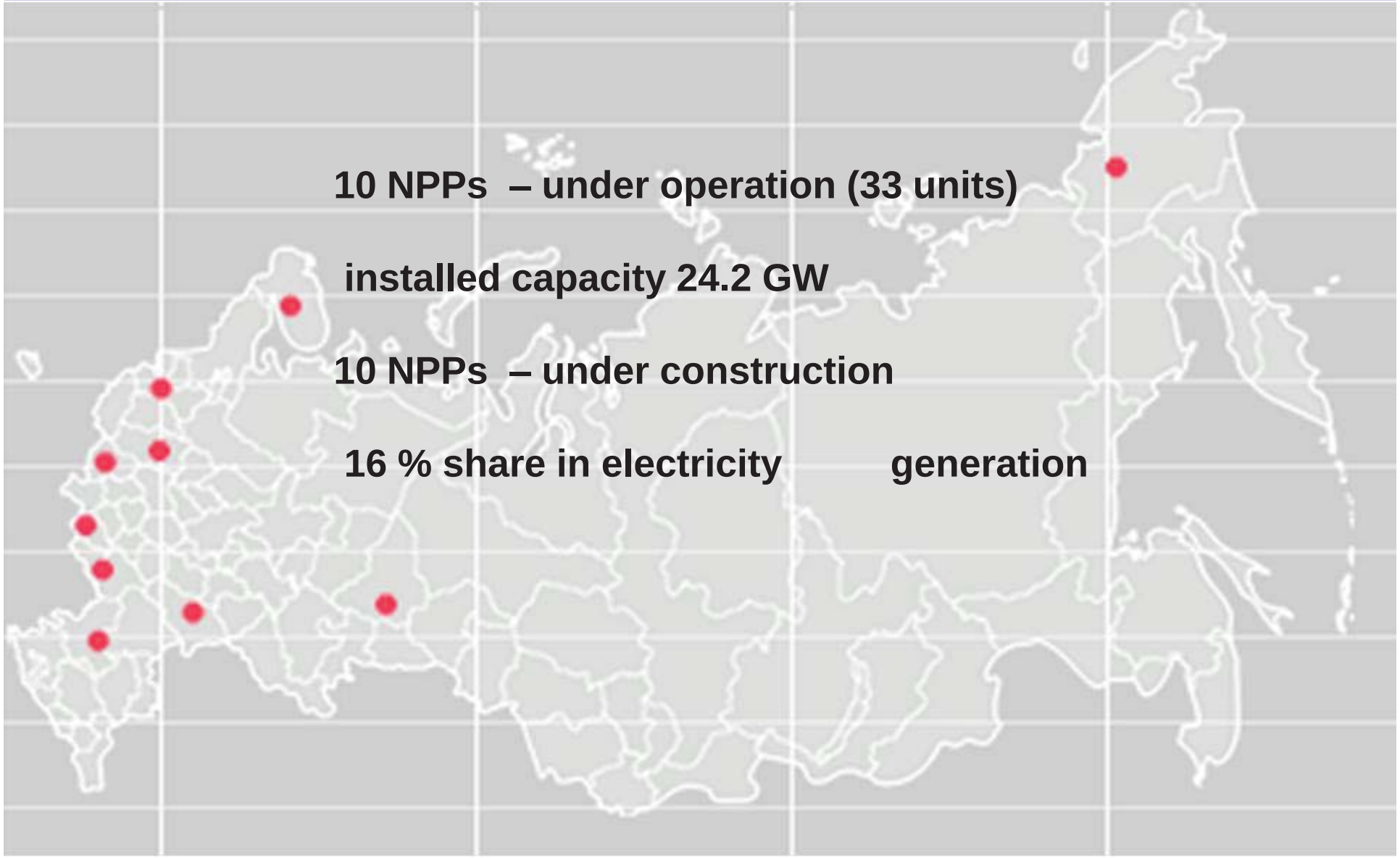
Why is nuclear?

Today Russia is the world's largest exporter of gas and oil.

Growing Russian economy is in a dilemma: should it continue to rely on increasing use of natural resources or should it move to high technology?

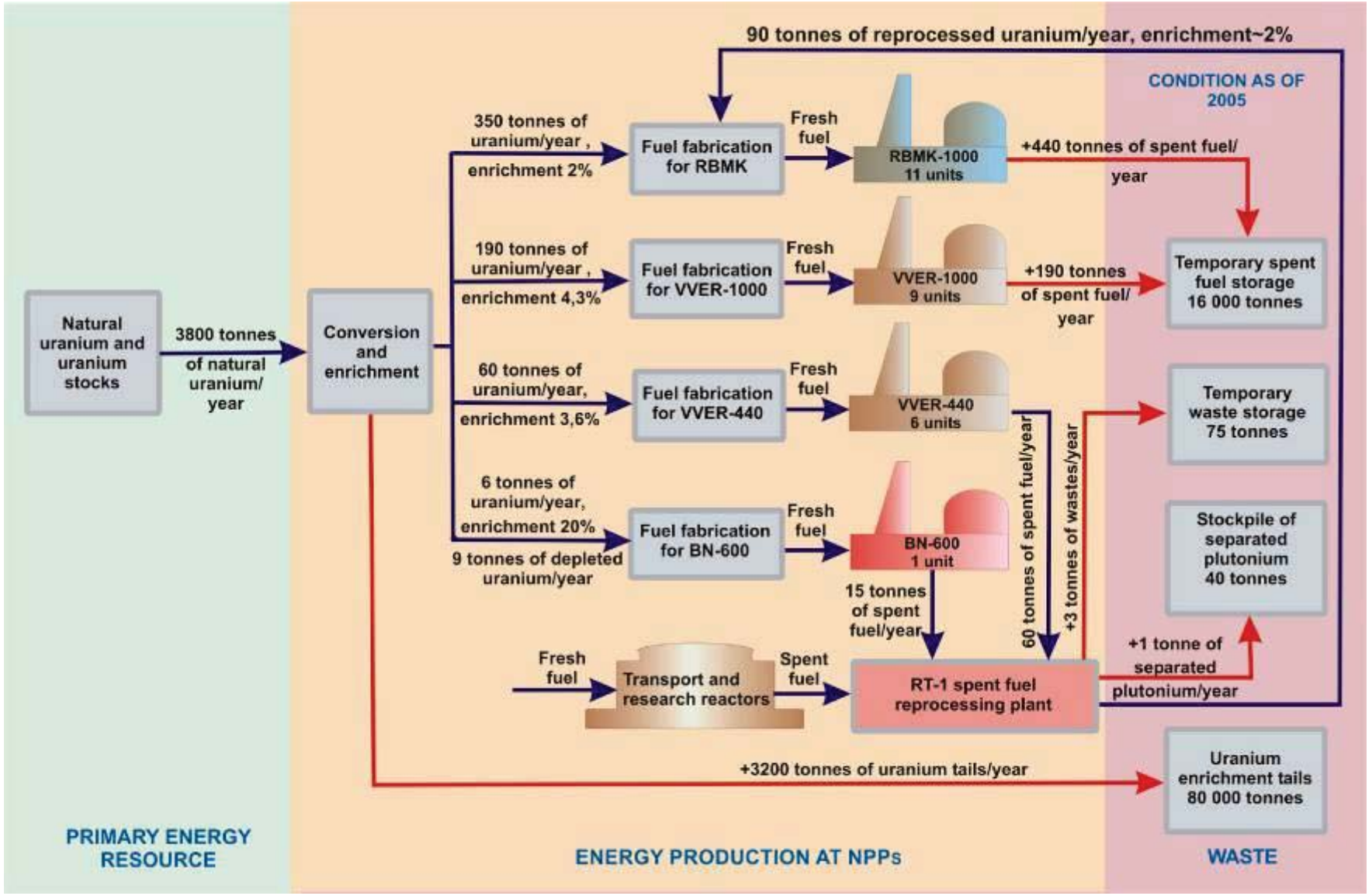
"Business as usual case" would lead to serious problems for the Russian economy, its energy security and environment.

Status of Nuclear power in Russia



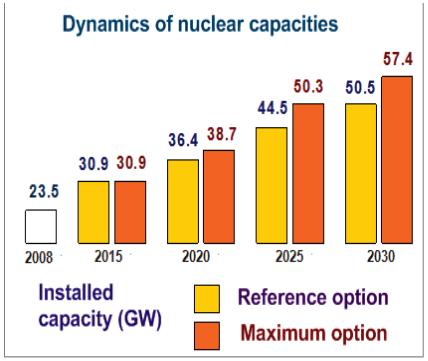
Source: www.roenergoatom.ru

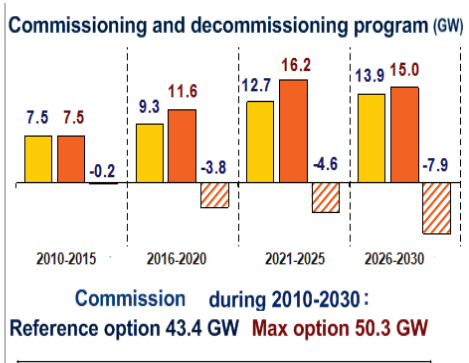
Technological scheme of existing NP of Russia



Prospects of Nuclear Power development in Russia

Dynamics of nuclear power development according to the Energy Strategy of Russia up to 2030





Commission during 2010-2030:
Reference option 43.4 GW Max option 50.3 GW

Deployment geography

Decommissioning list

NPP	Decommissioning year
Novovoronezh NPP	2016, 2017, 2021-2025
Kola NPP	2018, 2019, 2026-2030
Leningrad NPP	2018, 2020, 2021-2025, 2026-2030
Bilibino NPP	2019, 2020, 2021-2025
Beloyarsk NPP	2021-2025
Kursk NPP	2021-2025, 2026-2030
Smolensk NPP	2026-2030
Kalinin NPP	2026-2030
Balakovo NPP	2026-2030

Russia plans by 2030 to increase total NP power capacity:

- **50 GW in moderate option,**
- **57 GW in maximum option**

increase share of NP up to 30 %

General arrangement of energy generating facilities up to 2030, information from website of the Agency for forecasting energy balances (ZAO «APBE»): http://www.e-apbe.ru/scheme/

Long-term development of NP

At present long-term Strategy of nuclear power up to 2050 is under development.

The following ambitious goals are set up to the nuclear power sector of Russia:

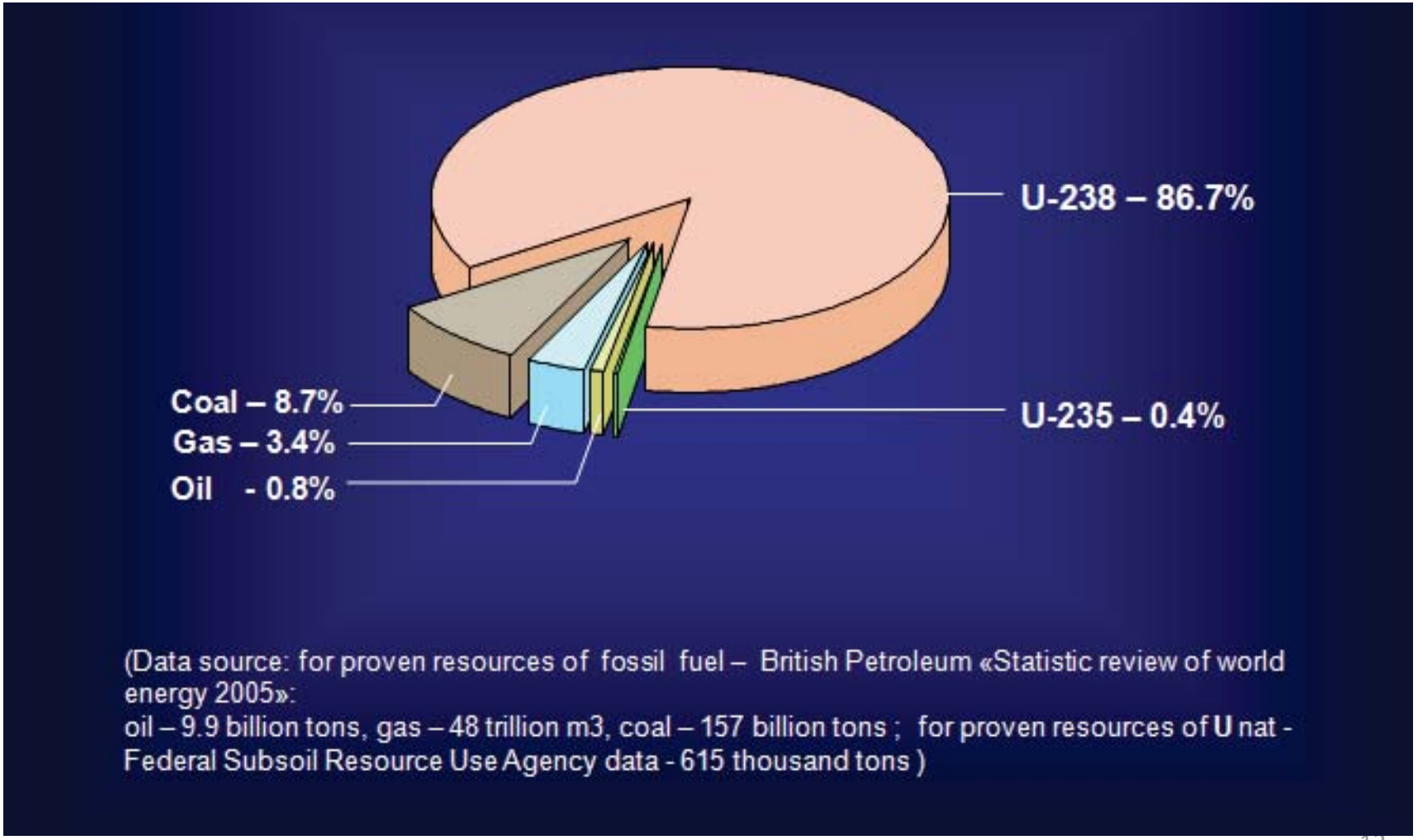
- to increase the share of nuclear electricity up to 30% and more with achievement of NPPs total installed capacity up to 100 GWe and more by 2050 and continue to operate at this level for further long-term (hundreds of years) period;
- to assure extension of export potential of Russia with achievement of as much as 25% of the world's export of nuclear energy technologies.

Major challenges of existing nuclear power in Russia:

- Increasing quantities of spent nuclear fuel
- Insufficient nuclear raw material resources for large scale nuclear power growth

Why is fast neutron reactors and closed fuel cycle?

Relative energy potential of natural resources of Russia



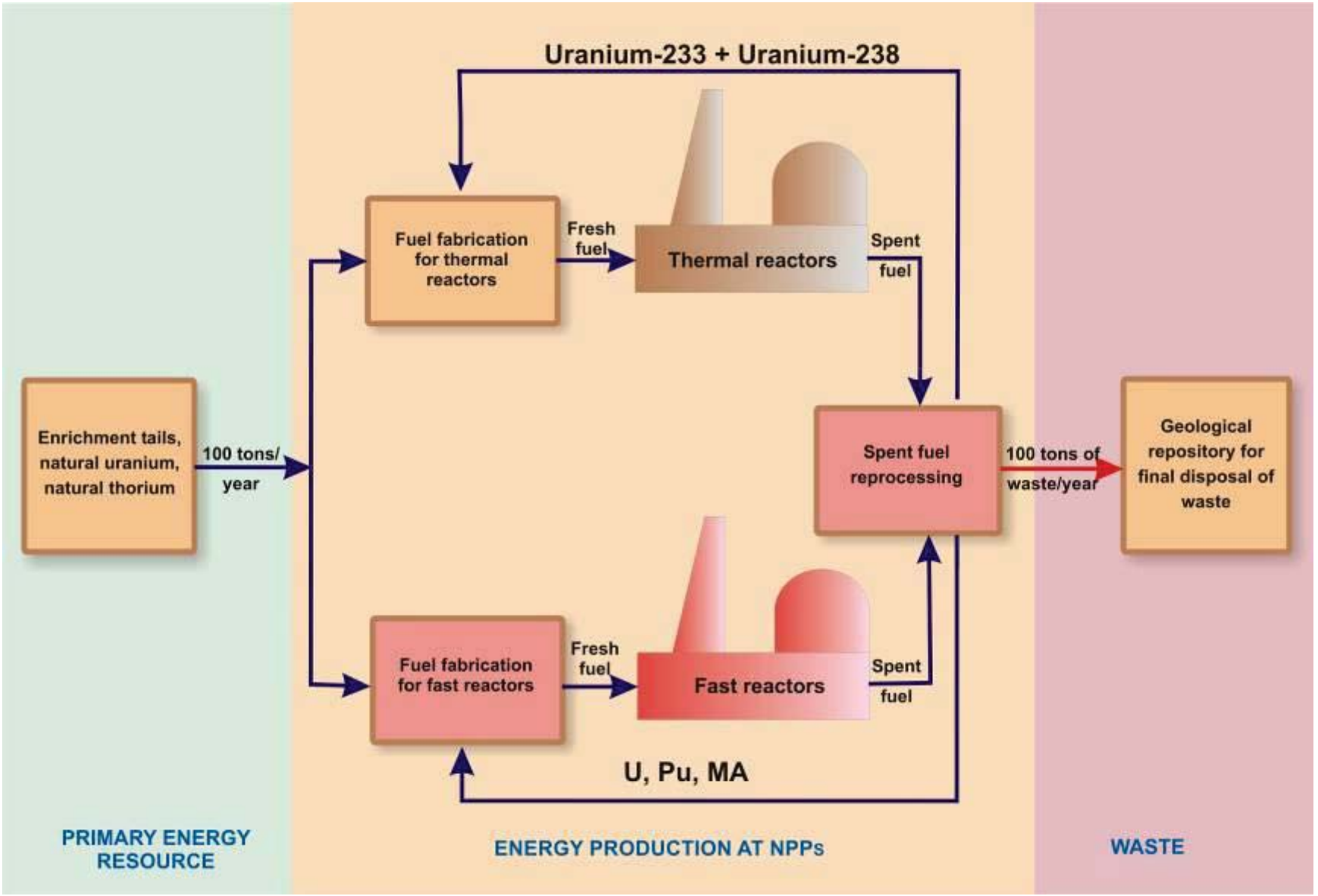
New Technological Platform Goal

Transition to a New Technological Platform opens the possibility for nuclear power to play the key role in achieving sustainability goals

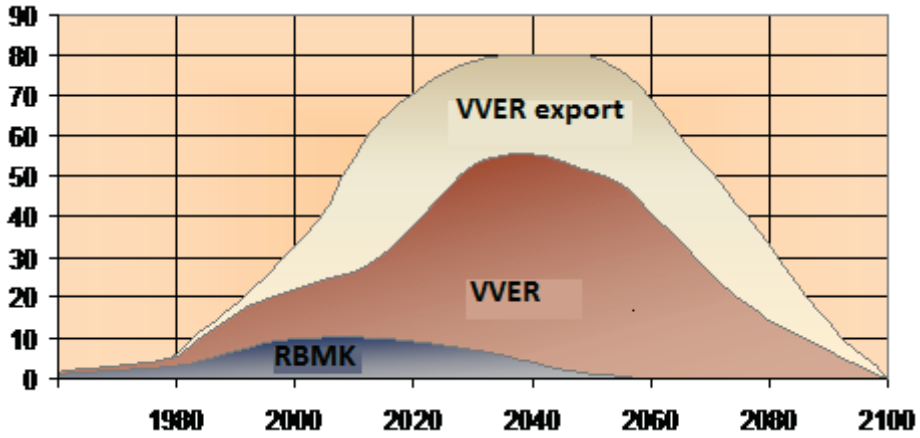
Main tasks for New Technological Platform

1. **Resource.** Essential broadening the natural resource base of nuclear power (more than an order of magnitude);
2. **Waste.** Significant reduce of volume and radiotoxicity of HLW per unit of electricity generated;
3. **Application.** Broadening the sphere of nuclear power applications.
4. **Export.** The possibility of essential increase (several times) of Russian exports of nuclear technologies and NFC services within non-proliferation regime;

Principal scheme of innovative NP in Russia (installed capacity 100 GW as an example)

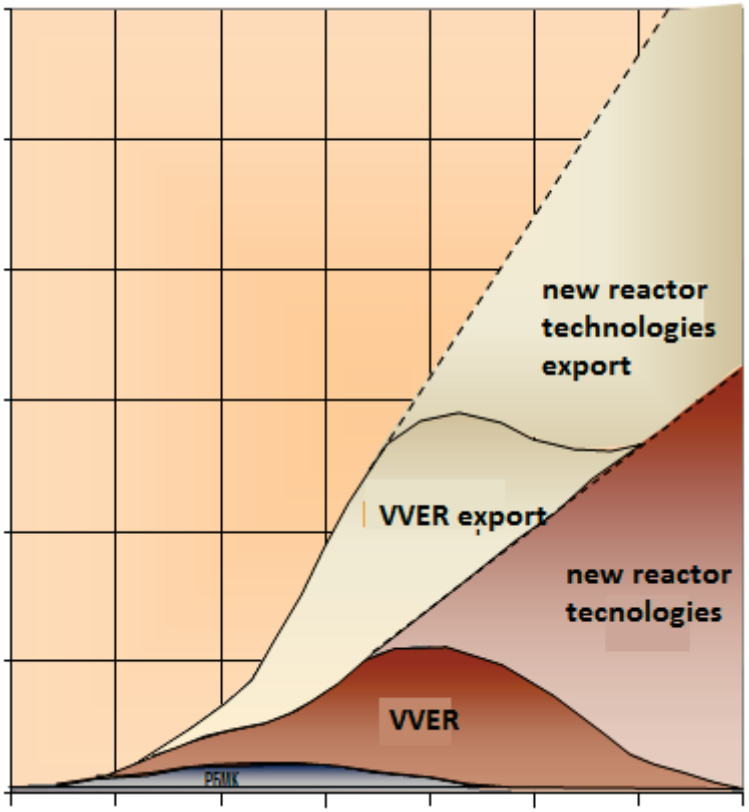


Resource restriction of NP development



Resource: U natural - 1 000 000 t.

Waste: U depleted - 900 000 t.
SNF - 100 000 t.
incl. Pu - 1 000 t., f.p.- 5 000 t.



Resourse: waste of existing NP
Pu from TR SNF, depleted uranium ОЯТ

Waste: fission products 1t/GW(e)y

Solving the problem of Spent nuclear fuel

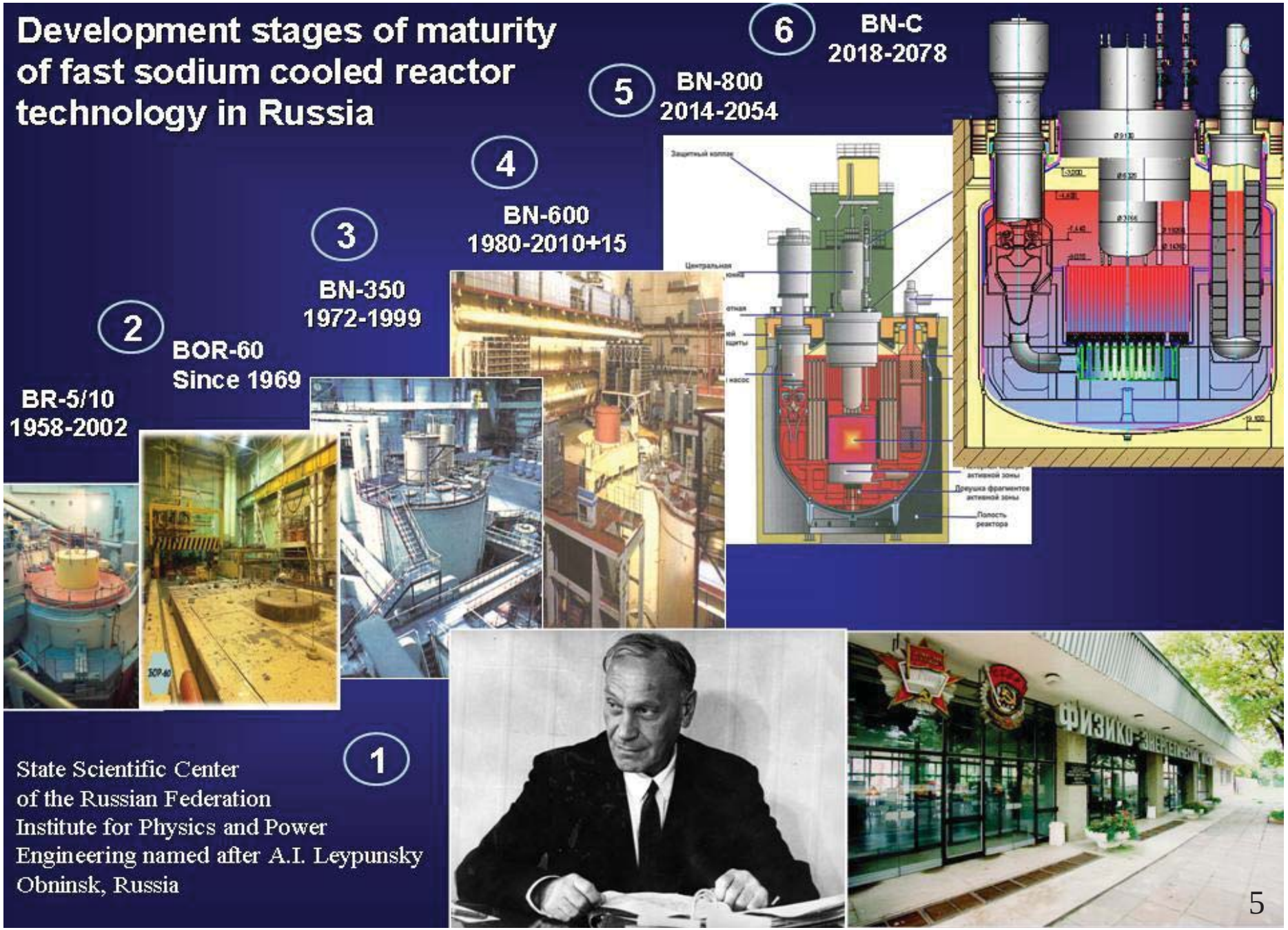
Reprocessing of SNF coming from thermal and fast reactors open wide possibilities reliable and effective solution of waste in NP :

- **Multi recycling of Pu in the nuclear energy system with fast reactors and closed nuclear fuel cycle allows to reduce HLW several times as compared with existing NP with open NFC**
- **Minor actinides incineration in FR will allow to reduce load of geological repositories.**

New Technological Platform

Technological platforms	Raw resource	Fuel origin	Energy generation	SNF and RAW
Existing, once-through cycle	U-235	Mining	Thermal reactors	Long-term storage
New, closed fuel cycle	U-238 Th-232	Reactor-based	Fast &thermal reactors	SNF reprocessing and RAW final disposal

2. Retrospective view on fast reactor technology development in Russia



Role of BN-600 in Mastering FR Technology

Concentration of experience has been gained in carrying out R&D works and operation of BR-5/10, BOR-60 and BN-350

↓

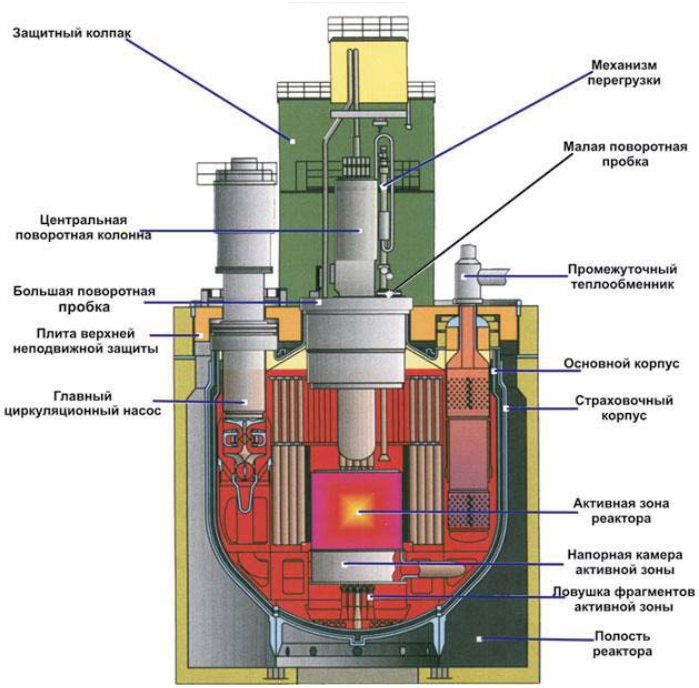
BN-600

↓

The only fast reactor in the world now effectively being operated during 30 years and behind

BN-600 nuclear energy unit is operated in commercial mode producing electricity and heat. Additionally the reactor is used as source of fast neutrons for irradiation of new fuels and structural materials.

BN-800

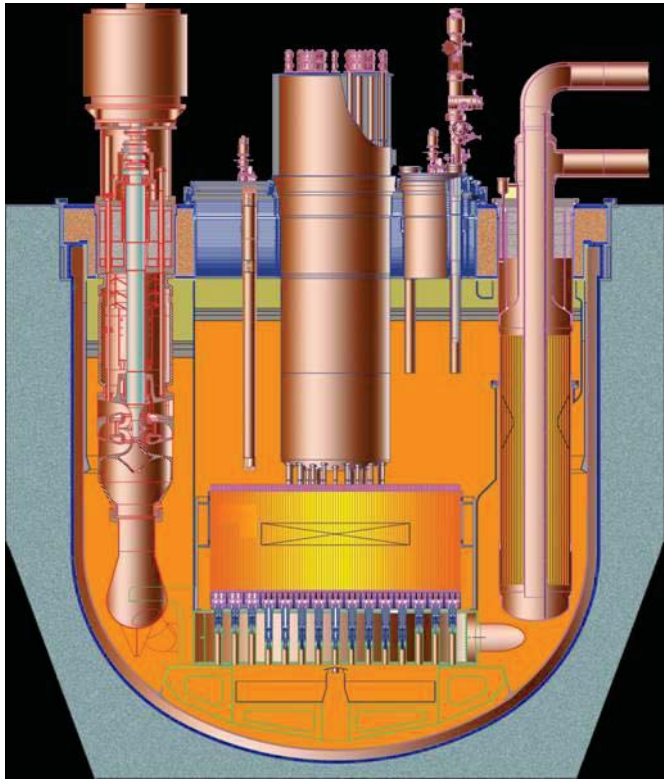


The main goal of the BN-800 is to achieve commercial level of technologies of sodium cooled fast reactors and closed fuel cycle including:

- fabrication of MOX fuel;

- reprocessing of SNF;

BN-K - advanced sodium cooled fast reactor



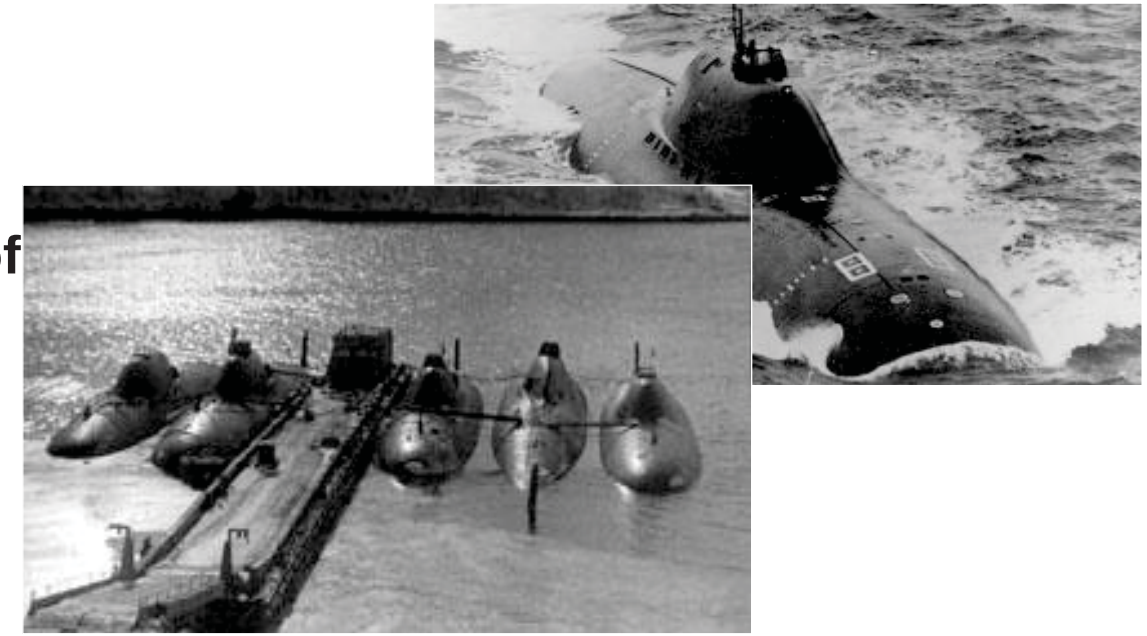
BN-K reactor

Main goal

- to develop basic design of commercial NPP with fast reactor allowing solution of SNF accumulation problem and switching nuclear power to uranium-238 resource base.

Nuclear energy technologies of fast reactors with heavy liquid metal coolants (led-bismuth, lead)

Lead-bismuth technology has been mastered only in Russia under conditions of operation of reactors of nuclear submarines (NS)

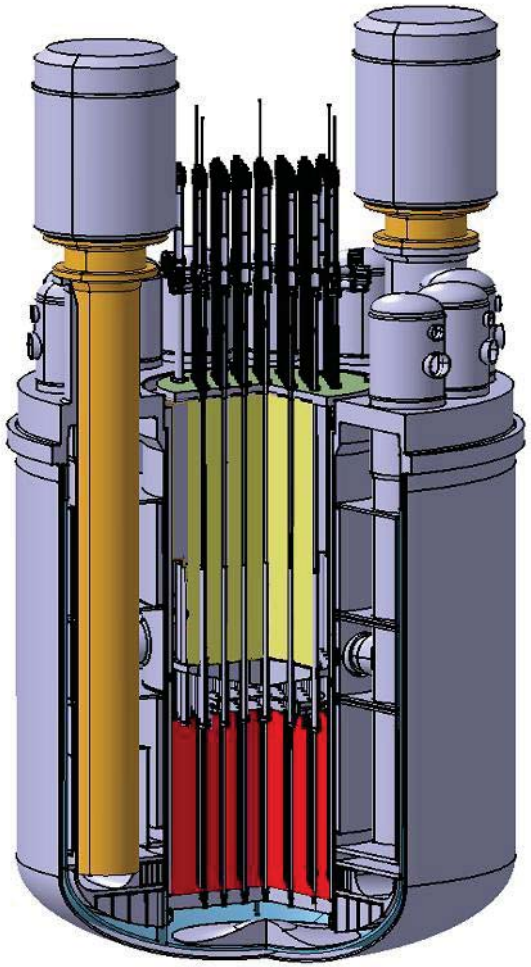


In total, 8 NS and two ground-based prototype facilities were constructed. 12 reactors were in operation. Total reactor-years is 80

Studies are carried out on lead coolant technology

Modular fast reactors with lead-bismuth coolant - SVBR-100

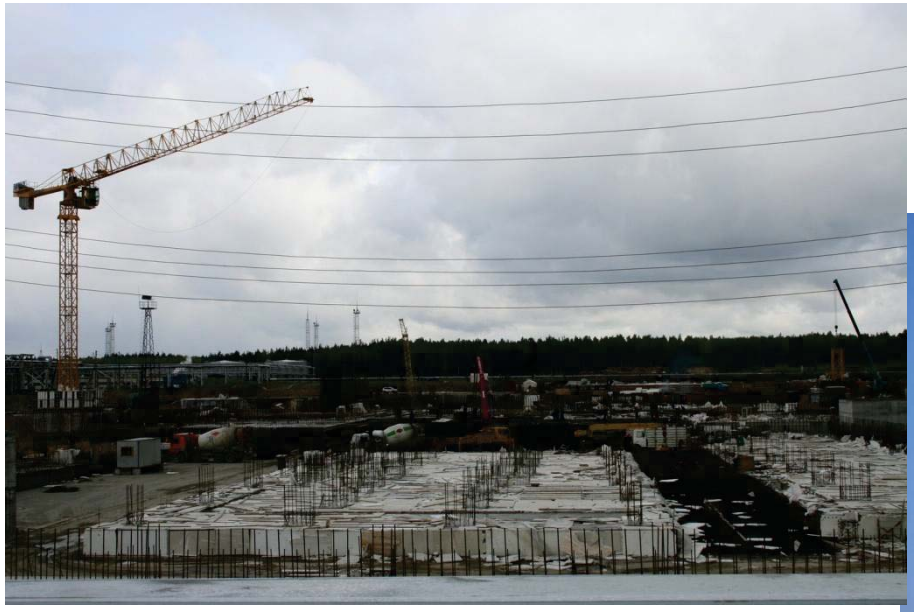
- High level of inherent safety
- Serial supply of pre-assembled reactor modules by railway and other transport means
- Multi-purpose use of unified module in 100-600 MWe power systems:
  - regional co-generation plants;
  - independent electricity and heat sources;
  - transportable energy sources.



New Technological Platform – transition to inexhaustible energy resources

- Sodium fast reactor technology has reached stage of commercialization.
- BN-600 displays good performance parameters.
- Alternative coolants may facilitate improvement of safety and economics of fast reactors:
    - R&D, experiments, demonstrations.
- BN-800 is a new machine to gain knowledge and experience to justify closed fuel cycle technologies.
- BN-1200 is supposed to be commercialized by construction of small series.
- Pilot-industrial infrastructure of CFC – during 2020th:
    - Pilot-demonstration center at MCC;
    - Improved aqueous reprocessing technology.
    - Clean palletized MOX-fuel at the 1st stage of commercialization.
    - Small series of BN-1200;
    - Vibro-packed fuel with MA.
    - R&D on non-aqueous technology.
- Construction of head units of SVBR-100 and BREST-300 is planned too by Federal Target Program.

BN-800 construction



BN-800 site picture. June, 2007

BN-800 site picture. July, 2012

Thanks for your attention!

Grazie per la vostra attenzione!