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Nuclear energy strategy of Russia till 2050

Report is developed by expert panel composed of the following experts of National research centre "Kurchatov institute"in 2010 - 2011

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with support of wide circle of Kurchatov institute specialists.

Basic provisions

Scope of nuclear energy

Nuclear energy constitutes an essential part of power generation of Russia nowadays and in foreseeable future. Scope of nuclear generation until mid of current century shaped by the growing power demand is secured by available resources of fissile materials. Technological potential ensures possible breadth of its long-term development .

Basic provisions

Closed nuclear fuel cycle

Forming of large-scale nuclear power industry is linked to organization of closed fuel cycle where resources problem is learneb by means of inclusion of U-238 and Th-232 isotopes in the cycle. Centralized processing of spent nuclear fuel ensures effective control over application of fissile materials for civil purposes and reliable disposal of radioactive waste.

Basic provisions

Multi-components structure

Multi-components structure of nuclear reactors fleet together with evolutional development of any functional area ensures maximal harmony between the structure of nuclear power industry and external energy system, minimizes risks caused by essential uncertainty of perspectives of both resources provision and use of new materials and technologies, suits ultimately economical preferences of market variety.

Basic provisions

Safety tasks and safety assurance

As for further development of nuclear power industry and creation of new generations of nuclear facilities the task of maximal reduction of initial nuclear hazard has to be realized by means of internal self-protection and subsequent implementation of defense in depth strategy.

In order to guarantee nuclear power safety international criteria of protection against external hazards and natural disasters as well as measures on severe accidents management and elimination of their consequences should be formulated and introduced in Russian practices.

Basic provisions

Acceptable economics

Long term of functionality of nuclear power facilities and principal uncertainty of price values exclude possibility to use formal economical criteria as determinant factor of appeal of nuclear cluster structural filling, but allow to take an estimate "from above" as reference value of acceptable cost considering average worldwide cost of primary energy. According to such methodology acceptable for Russian economics cost of installed capacity of NPPs is now about 2000 Dollars/kW, and will increase by 2030 till 4000 Dollars/kW.

Share of expenses for primary energy sources in gross world product

Basic provisions

Near-term outlook

Commercial job of nuclear energy sector of economy in prospect of nearest decades will be focused on improvement of thermal neutrons reactors, first of all on the technics of light-water pressure vessel reactors to ensure capacity series to meet the demand of regional development within the nation and worldwide. Power technology capabilities of high-temperature reactors are promising, including safety issues. Requirements of world market to fast reactor meant for mass manufacturing have not been stated yet.

Basic provisions

Rate of development

Variety of nuclear industry development , considering rated installed capacity of NPPs (including export supply) of 100 GW by 2030 and 300 GW by 2050, taking into account limitations on integral consumption of natural uranium, its annual consumption and scope of separation works, demonstrates necessity of serial construction of fast reactors with expanded fuel recovery from approximately 2030.

Formation of structure of nuclear power sources

Basic design data of nuclear power industry :

- **Installed capacity** **2030 – 100 GW(e)**
  (maximal value with consideration of export.
  Corresponding to conservative scenario of IAEA)
  2050 – 300 GW(e)

- **variants are fuel-balanced:**
  Charges of fast reactors are comprised of plutonium extracted from spent nuclear fuel after processing.

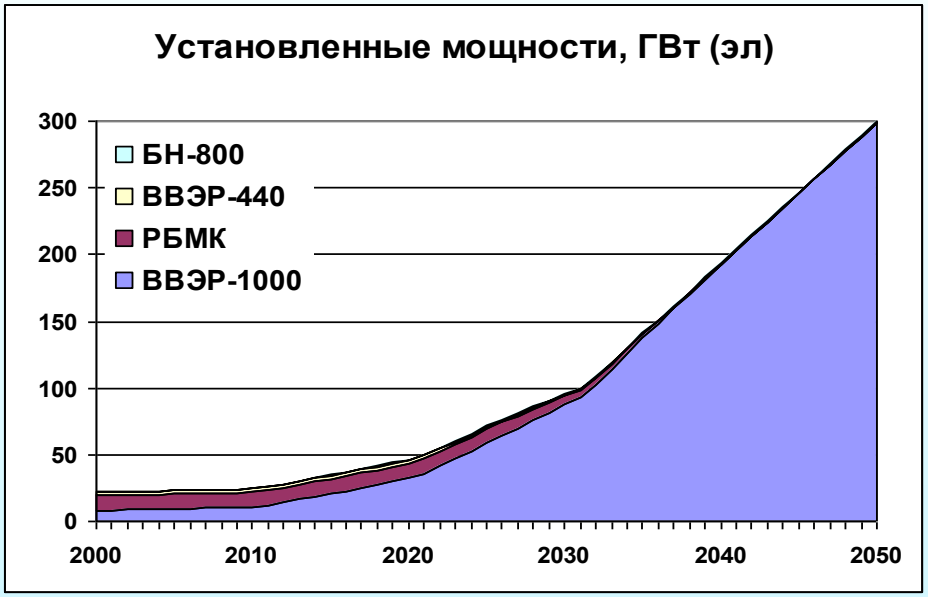
Formation of structure of nuclear power sources

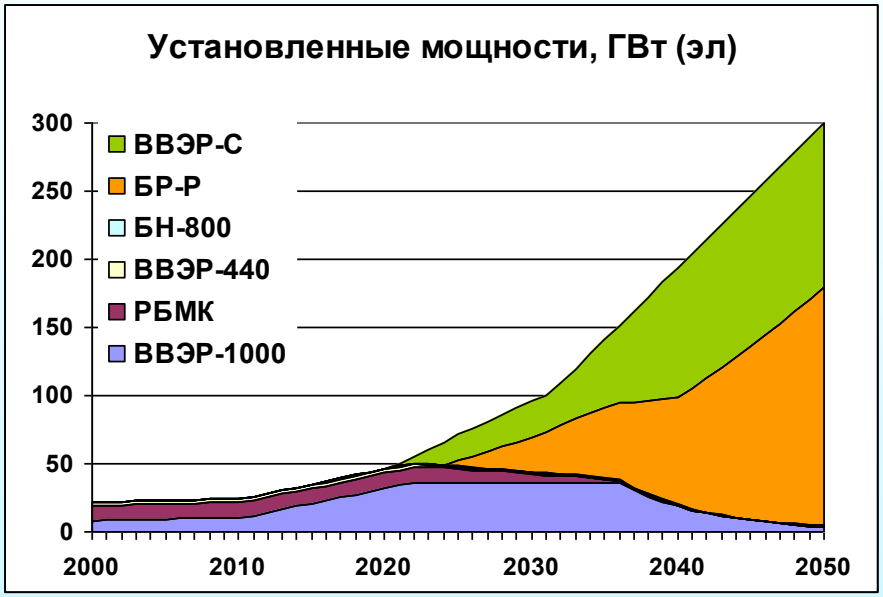
Main characteristics of reactors in terms of fuel utilization

Reactor	Specific consumption of natural uranium, t/GW	Specific lifetime of plutonium, kg/(GW·year)	Specific initial charging of plutonium (fissile isotope), t/GW	Specific excessive performance period of plutonium, kg/(GW·year)
VVER	170	245		
VVER-C	135	219		
HTGR	140			
VVER-MOX		711	2,7	
FN-1200			4,17	145
FR-K			5,0	56
FR-K (U)	1610 (initial charge)			50
FR-P			2,83	345

Formation of structure of nuclear power sources

Structural variety of nuclear industry development

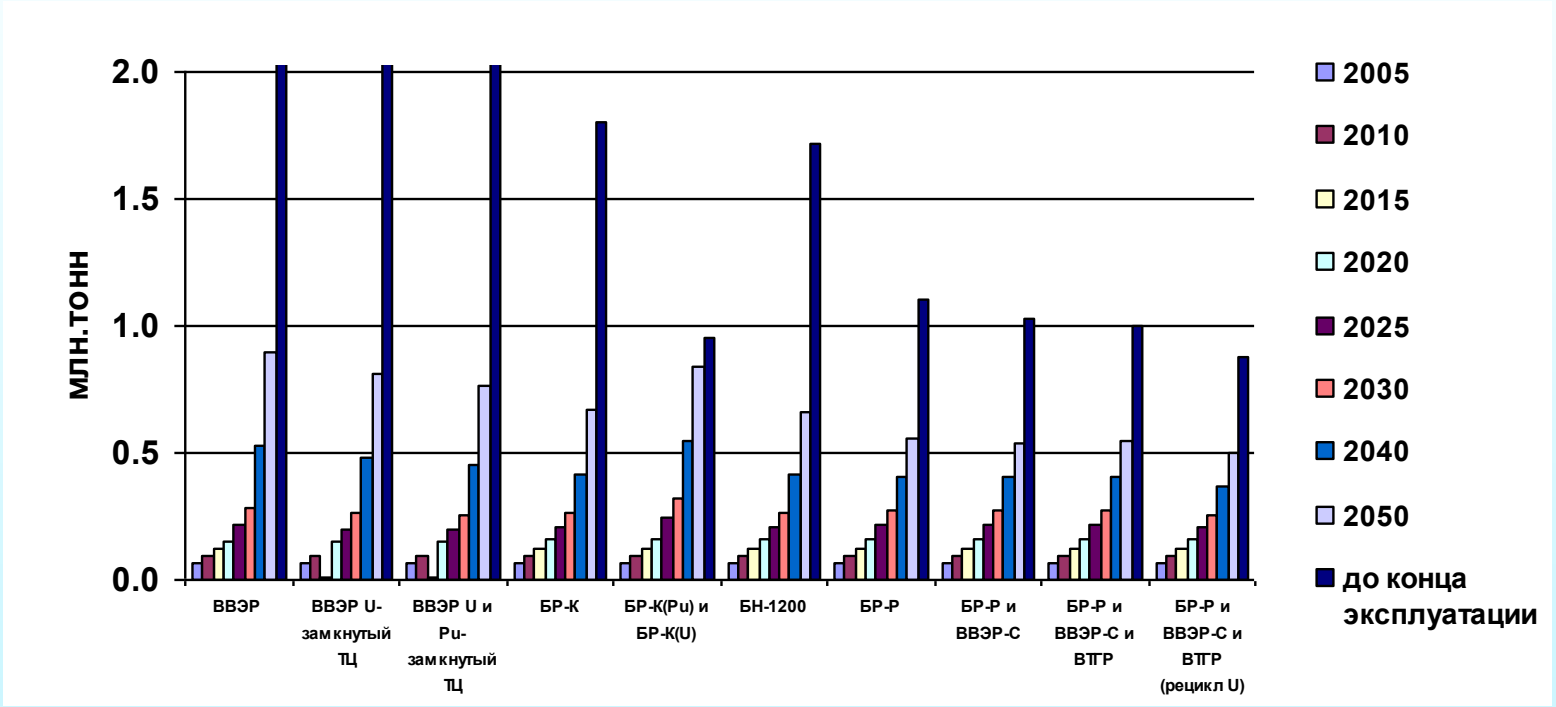




Open fuel cycle without spent nuclear fuel processing. New construction – VVER reactors.

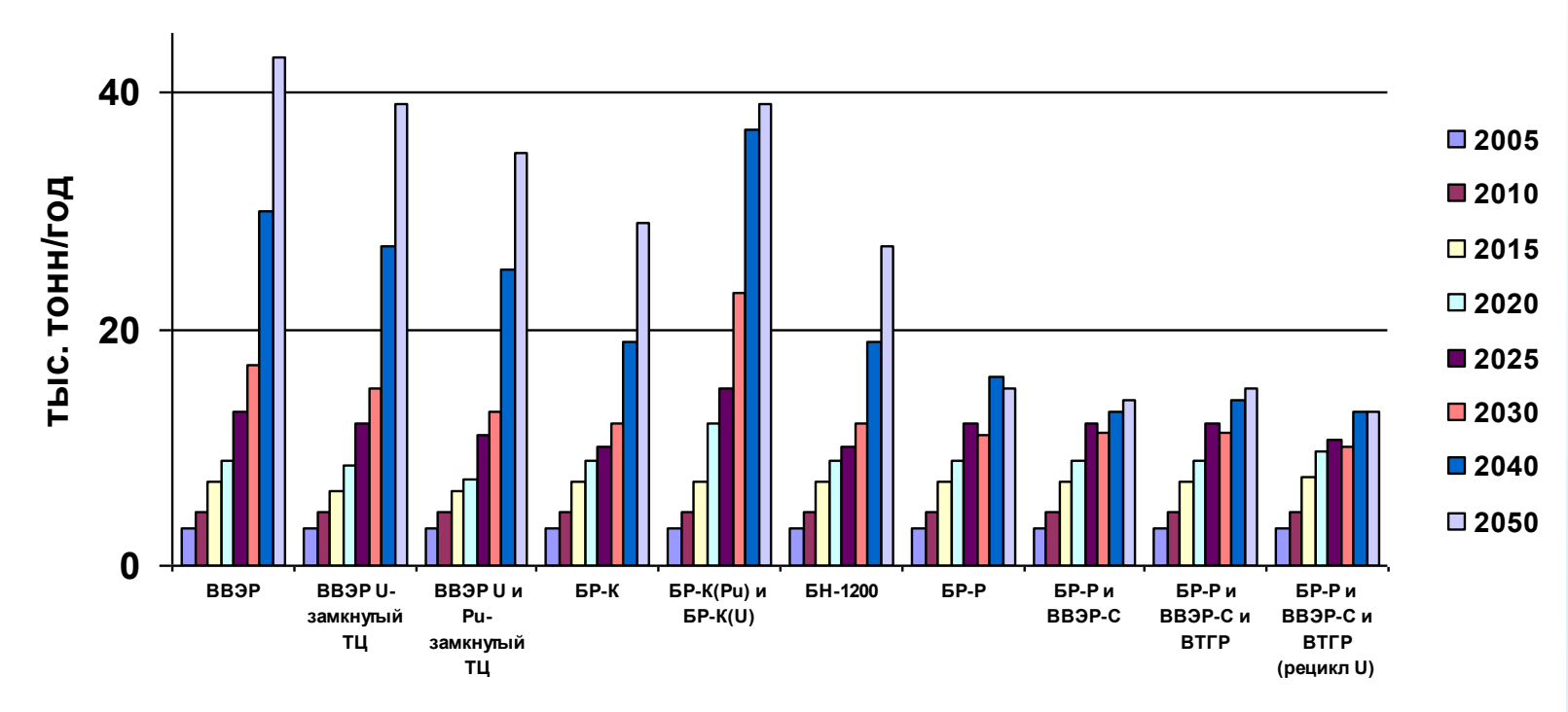
Closed fuel cycle. New construction – VVER reactors, fast reactors FR-P, from 2020 upgraded VVER-C with increased conversion (up to 0,8).

Formation of structure of nuclear power sources



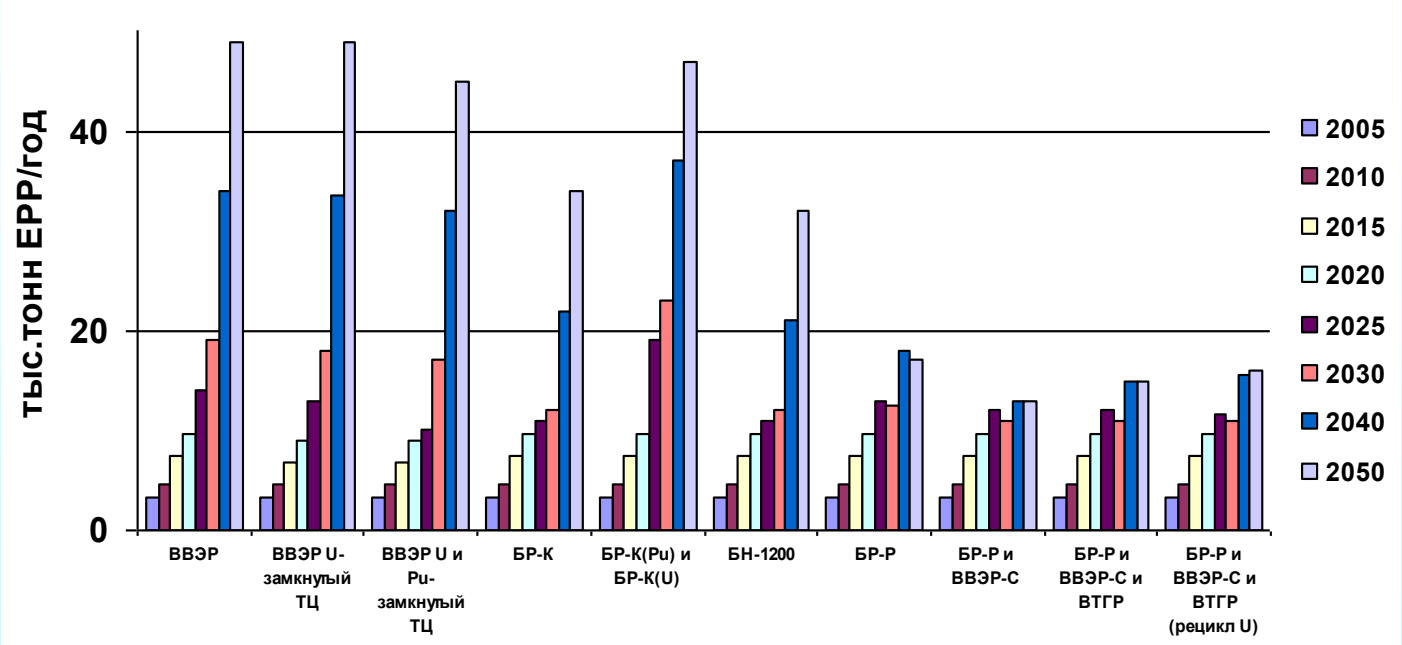
Integral demand for natural uranium

Formation of structure of nuclear power sources



Annual consumption of natural uranium

Formation of structure of nuclear power sources



Annual scope of separation works

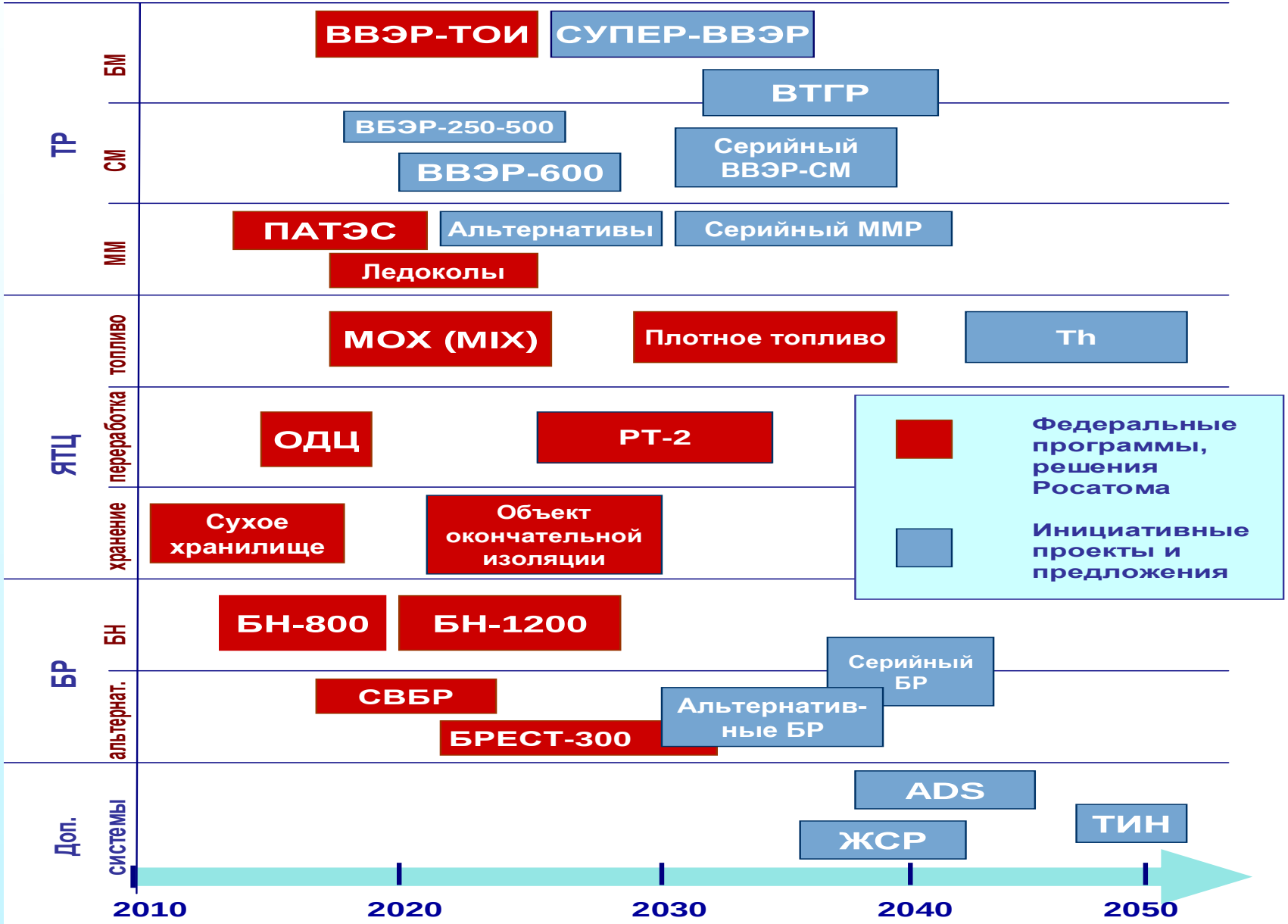
Existing and prospective reactor technologies till mid of 21-st century

- FR – fast reactors with primary sodium;
- VVER – evolutional and innovative development;
- Medium yield reactors for regional power generation and public power supply based on VVER technology and ship reactor building;
- Low yield reactors for local power supply;
- Gas-cooled reactors for high-temperature industrial technics.

Alternatives of nuclear energy

- **Fast reactors with heavy coolants;**
- **non-chemistry breeders;**
- **Electric nuclear facilities;**
- **Thermonuclear sources of neutrons.**

Дорожная карта освоения ядерных технологий в России



Basic provisions of alternative concept (*differences from proposed above concept)*

- **Negation of development prospects of nuclear power based on light water pressure vessel reactors; necessity of purposeful cutting of this development line (expedited decommissioning of LWR and urgent commissioning of FR with breeding factor ~ 1);**
- **Negation of necessity of high breeding in FR; sufficiency of nuclear generation till the year 2100, provided by such reactors with breeding factor ~ 1 considering available uranium resources.**
- **Basic condition of given concept is construction of NPPs solely with reactors of "natural safety".**
- **Non-acceptance of multicomponent structure of nuclear industry (based on purpose and type of reactor).**

Review of these provisions

1. **Inacceptability of application as basic condition of concept selection: application of solely solution – conditionally safe reactor (characterized as “naturally safe”») without any practical confirmation of declared features.**
2. **Artificial constraint of scale and areas of application of nuclear energy not only in the first part of 21-st century and also beyond it, ignoring of unique opportunities of nuclear fuel breeding in FR taking into account that it is impossible to realize mentioned basic goals under conditions of real practice of future decades.**

Closing provisions

1. **Strategy goals and basic criteria of nuclear facilities selection in the course of nuclear energy development strategy formation:**
   - **Practical feasibility;**
   - **Acceptability from the point of view of economy and by consumer;**
   - **Minimization of nuclear weapon proliferation threat;**
   - **Assurance of nuclear safety of civil purpose.**

Closing provisions

2. **Well-considered comparison of different approaches and choice of practical ways and technical solutions should be a subject of forming of national strategy of nuclear power industry development, ensuring realization of fundamental advantages of nuclear technology application in power supply, as well as real flexibility and bright room for manoeuvres in the structure of nuclear fuel cycle and in overcoming of economic risks under mandatory assurance of nuclear safety and ecological suitability – in commitment with international trends and practical approaches.**