# MULTIPURPOSE FAST RESEARCH FACILITY MBIR

# AS A UNIQUE RESEARCH PLATFORM.

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The State Atomic Energy Corporation ROSATOM is shaping the global trend in the development of a two-component nuclear power industry based on thermal and fast neutron reactors with closed nuclear fuel cycle (CNFC). In order to tackle the scientific challenges arising in connection to the two-component nuclear power industry a modern research infrastructure based on research nuclear reactors is required.

Russia’s strategy of nuclear power development provides for the integration of fast reactors in two-component nuclear energy. The development of the nuclear industry in Russia in respect to the fast reactors can be presented in the following 3 stages:

* Near-term (2020 – 2028) – BN-600 and BN-800 are operated as part of the existing nuclear industry in Russia, the construction of a pilot demonstration reactor BREST OD-300 as well as the development of the first commercial power unit BN-1200 are underway. Reactor tests of innovative materials and prototypes of design elements for nuclear power systems of Generation IV are carried out
at the BOR-60 reactor.
* Medium-term (2028 – 2040) implies the completion of the construction and start of operation of the first commercial power unit BN-1200, as well as the development of a project for the commercial lead-cooled reactor FR(BR)-1200 (subject to demonstrating the safety and competitiveness of the lead-cooled fast reactor BREST OD-300). Reactor testing of innovative materials and prototypes of design elements for nuclear power systems of Generation IV are carried out at the MBIR reactor.
* Long-term (2040 – 2050) calls for the construction of a small series of BN-1200 power units and the construction of the first commercial power unit of FR(BR)-1200. Reactor tests of innovative materials and design prototypes of elements for advanced nuclear energy systems and support for the operation of industrial samples of innovative reactor facilities are carried out at the MBIR reactor.

At the same time, it should be noted that the number of research reactors over the past 20 years has decreased by 15% to 235, among which only BOR-60 provides relevant technical parameters for testing in-reactor materials and core structure elements for fast neutron reactors.

MBIR research reactor which is being constructed at the site of JSC “State Scientific Centre Research Institute of Atomic Reactors” (JSC “SSC RIAR”) in Dimitrovgrad, Ulyanovsk Region, is a unique facility that makes it possible to expand the experimental possibilities for the referential studies for advanced fast reactors, CNFC technologies and technologies for small and medium power reactors. MBIR is a multipurpose sodium-cooled fast neutron research reactor with thermal power of 150 MW and a maximum neutron flux density of 5.3·1015 сm-2s-1.

The MBIR research reactor is intended to replace the world-famous
BOR-60 reactor, which has been operating at the site of JSC “SSC RIAR” for more than 50 years. The construction of MBIR is included in the state program “Development of equipment, technologies and scientific research in the field of the use of atomic energy in the Russian Federation” approved by the Government of the Russian Federation in 2020.

The target date for the launch of the experimental program at the MBIR reactor is 2029. However, the pace of construction achieved during 2021 allows to expect the starting date for experiments in 2028. In 2021, the concreting of the reactor building was completed at the level of +13 meters, the floor slab was installed in the base of the reactor shaft, and the control assembly of the reactor vessel was carried out. Also, as a result of 2021 it is important to highlight that construction of all facilities of the MBIR reactor complex, including a cooling tower, a turbine hall, auxiliary buildings, etc., has started. It is planned to install the reactor vessel in the design position and maintain the construction progress and equipment installation work in 2022.

Innovative technologies and best management practices are applied at the MBIR construction site to maintain and exceed the current rates of construction. Today, the following technologies and systems are fully applied at the MBIR site:

* BIM modelling technologies;
* Lean production technologies;
* System of indices for changes in the estimated cost and a reliable determination of the estimated cost of work;
* Integrated remote monitoring tools: high-resolution satellite imagery, shooting from unmanned aerial vehicles, laser scanning.



Fig. 1. The MBIR site model

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In accordance with the Concept and Terms of Reference, one of the main areas of application of the multipurpose fast research reactor MBIR is to conduct mass reactor tests of innovative materials for nuclear power systems of Generation IV, including fast neutron reactors integrated into a closed fuel cycle along with thermal reactors, including small and medium power reactors. The design of the MBIR reactor facility includes a vast number of experimental capabilities for conducting research under programs for the development of the Russian nuclear industry, as well as performing work for foreign customers within the framework of the international consortium of users which is being created on the basis of MBIR.

The MBIR reactor complex consists of a reactor facility with two sodium cooling circuits and a third steam-water circuit, a steam turbine plant, technological systems including hot cells, vertical and horizontal channels and independent loops.

TABLE 1. TECHNICAL PARAMETERS OF MBIR REACTOR

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| --- | --- |
| Parameter | Value |
| Thermal power | 150 MW |
| Electric power | Up to 50 MW |
| Maximum neutron flux density | 5.3⋅1015 cm-2s-1 |
| Parameter | Value |
| Fuel | Vibrocompacted-MOX |
| Core height | 550 mm |
| Maximum fluence per year | 1⋅1023 cm-2 (40 dpa) |
| Number of autonomous loops with various coolants | 3 |
| Number of experimental assemblies and irradiators for radioisotope production | 14 in the coreUnlimited in in the radial reflector |
| Number of instrumented channels | 3 |
| Lifetime | 50 years |

The design of the MBIR reactor facility provides for the availability of autonomous / independent loop channels for simulating the operating conditions of cores with various coolants to perform a wide range of studies.

In 2021, the Scientific and Technical Council of the State Atomic Energy Corporation ROSATOM has decided to equip the MBIR reactor with autonomous loop devices containing three different coolants: sodium, lead/lead-bismuth, and helium. Such autonomous loops will allow to obtain experimental data to determine the limits of safe operation of fuel elements, as well as their behavior and damage under conditions of variable loads and exceeding the limits of safe operation in various coolants. In addition, with the help of autonomous loop devices, experimental information on the behavior of fuel under conditions of severe and beyond design accidents with cladding damage, fuel melting, coolant boiling, as well as during a heat transfer crisis, etc. can be obtained for verification of computer codes.

The unique physical characteristics of MBIR will allow not only to carry out a full cycle of research into advanced materials and equipment for Generation IV reactor technologies but also to simultaneously carry out a wide range of work in the field of non-power applications, in particular, to produce radioisotopes and develop modified materials, conduct medical and basic research. MBIR will become one of the most demanded research reactors in the world and the most powerful of the existing and under construction research facilities, will provide the nuclear industry with a modern and technologically advanced research infrastructure for the next 50 years.

An important event in 2021 was the approval of the national scientific research program for advanced experimental research at MBIR for the period 2028-2040, which shows that the need of Russian organizations for the MBIR reactor resource exceeds 50% of the total irradiation capabilities of MBIR.

Implementation of the scientific research program, including in-reactor research, is necessary to justify the technologies for closing the fuel cycle at the experimental technological level and justify the use of structural, fuel and absorbing materials for fast neutron reactors. This is one of the key tasks of the scientific program at the fast neutron research reactor MBIR.

The creation of safe and competitive nuclear power units of Generation IV requires a large amount of in-reactor research of new materials and structures of reactor elements in special experimental devices and loops equipped with modern control and management tools. Structural materials should ensure reliable operation of core elements at least until damaging doses of 170 dpa and even higher values in the future. The safety of reactors must be experimentally substantiated in transient, power cycling and emergency modes of reactor operation.

The main areas of research within the scientific research programme are:

1. Research into characteristics of advanced fuel materials;
2. Tests of fuel elements with advanced fuel types in transient, power cycling and emergency modes;
3. Tests of advanced structural materials;
4. Tests of absorbing, moderating and composite materials for innovative nuclear reactors;
5. Research into new and modified liquid metal coolants and molten salt compositions;
6. Life tests of new types of equipment for innovative nuclear reactors;
7. Conducting of reactor physics, materials, thermal hydraulics and other research for computer code verification;
8. Applied experimental work with the use of reactor radiation.

An international scientific research program at the MBIR reactor will be formed on the basis of the national scientific research program. For this purpose, an Advisory Board is being set up, which is supposed to include leading Russian and foreign experts in the nuclear industry, working on Generation 4 technologies, SNF and other areas that will be researched at MBIR reactor. At the moment, the experts of the Advisory Board are representatives of 3 countries (including Russia) and two international organization.

Already at the construction stage, the International Research Center (IRC) is being created in Dimitrovgrad, where scientists from all over the world will be able to receive a full cycle of science-intensive, high-tech services for the study of advanced nuclear reactors and closing the nuclear fuel cycle.

The access of Russian and foreign partners to the MBIR reactor is implemented through a unique legal platform for the Russian market and scientific projects – the Consortium Agreement. This approach creates the possibility of flexible use of the reactor resource that meets the needs of all members of the scientific community. The consortium structure also facilitates the conduct of multilateral scientific research programs.

The initial signing of the Consortium Agreement took place in July 2021. Such a model makes it possible to use a mixed financing structure, including attracting foreign participants to the project already at the construction stage, since foreign participants own the reactor resource (a derivative value of the neutron flux density for the purpose of distributing the rights to conduct experiments in the MBIR reactor between the Consortium members), and not the reactor facility, which belongs to JSC “SSC RIAR”.

In February 2019, the company "Leader of the Consortium "IC MBIR" LLC was established in order to manage the Consortium “IRC MBIR”. The main functions of Leader of the Consortium “IRC MBIR” are:

– Set up of the Consortium “IRC MBIR”;

– Administration of Consortium activities;

– Facilitating the operation of Consortium management bodies, including the Advisory Board and the Management Committee;

– Attraction of external funding;

* Implementation of a multilateral scientific research program at MBIR reactor.

The Consortium Agreement provides for the following roles of project participants:

JSC “SSC RIAR” is an operating company in charge of MBIR reactor construction and commissioning. After MBIR is put into commercial operation, JSC “SSC RIAR” undertakes to remain the owner of the reactor facility and, on a priority basis, conclude contracts for the provision of services with the use of MBIR reactor resource with the members of the Consortium “IRC MBIR”;

“Leader of the Consortium “IRC MBIR” LLC is the administrator of the Consortium “IRC MBIR” responsible for the overall coordination and management of the activities of the Consortium “IRC MBIR”, as well as for raising financing for the construction of MBIR and attracting new key participants by reselling the right to access the reactor resource. For this purpose, all rights to use the MBIR resource as of the date of signing the Consortium Agreement are transferred to “Leader of the Consortium “IRC MBIR” LLC;

The State Atomic Energy Corporation ROSATOM is the guarantor of certain obligations of the JSC “SSC RIAR” and Leader of the Consortium “IRC MBIR”.

The Consortium Agreement determines the possibility of other participants to join it and establishes two forms of participation – Principal Members (joining at the construction stage with the condition of financing capital costs for the construction of MBIR) and Associated Members (joining at the operation stage). Members of the Consortium “IRC MBIR” receive the right to use the MBIR reactor resource in an amount proportional to their participation in the project.

In accordance with the provisions of the Consortium Agreement, three governing bodies will be formed – the IRC MBIR Council (the highest governing body), the Management Committee (managerial and administrative issues), the Advisory Board (scientific advisory body).

In 2021, Memorandums of Understanding were signed with three foreign organizations from China, Czech Republic and France. Memorandums of Understanding reflect the intention of foreign partners to participate in the project and specific terms of such participation.

The discussions on terms and conditions of participation in the Consortium “IRC MBIR” are at various stages with government institutions and scientific organizations form around the world.