REATOR MULTIPROPÓSITO BRASILEIRO

Nuclear Technology in Service of Life

RMB
Reator
Multipropósito
Brasileiro

WHAT IS RMB – THE BRAZILIAN MULTIPURPOSE RESEARCH REACTOR?

In general terms, there are two main types of nuclear reactors: power reactors and research reactors. Nuclear power reactors use the energy released in nuclear reactions to produce electricity. Research reactors use the radiation generated in nuclear reactions for various applications. RMB consists of a research reactor with several purposes: production of radioisotopes for use in medicine and industry; testing of materials and nuclear fuels for power reactors; use of neutron beam for scientific and technological research in different fields of science; neutron activation analysis; production of tracers for application in research in agriculture and the environment; training of human resources in the nuclear area; and personnel training for operation and maintenance of power reactors.

RMB will have, in addition to the nuclear research reactor, an entire infrastructure of laboratories to carry out the proposed activities. The main laboratories are: radioisotope processing and handling laboratory; neutron beam laboratory; post-irradiation analysis laboratory; radiochemistry and activation analysis laboratory, as well as support facilities for researchers. RMB will be the catalyst for the establishment of a new national research centre for the application of radiation for the benefit of society.

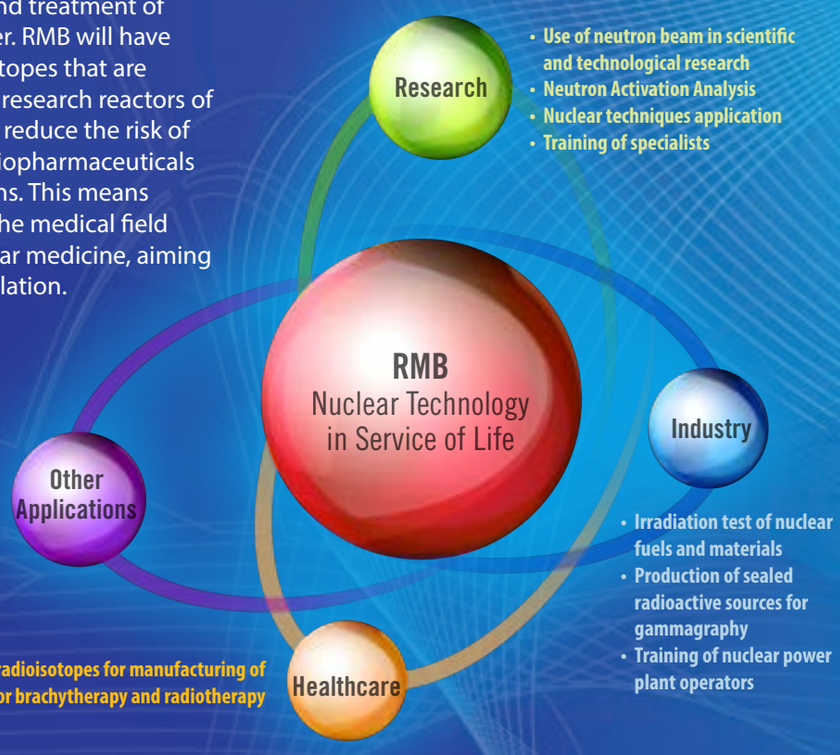
Regarding the healthcare area, radioisotopes are the basis for the manufacture of radiopharmaceuticals, which are drugs composed of some radioactive substances, used for the diagnosis and treatment of diseases and different types of cancer. RMB will have the capacity to produce the radioisotopes that are currently imported and produced in research reactors of other countries. This autonomy shall reduce the risk of shortages, as well as the costs of radiopharmaceuticals production and medical examinations. This means better conditions for investment in the medical field with consequent expansion of nuclear medicine, aiming to assist a larger portion of the population.

ADVANCES IN PUBLIC HEALTHCARE IN BRAZIL

Radiopharmaceuticals allow physicians to visualize the functioning of living organs and tissues through images such as CT scans and scintigraphy. Therefore, RMB deployment shall bring many gains to the healthcare area and, in particular, to the users of the Public Healthcare System who normally do not have access to these types of procedures. Nowadays, they correspond to 30% of the users of nuclear medicine procedures in Brazil.

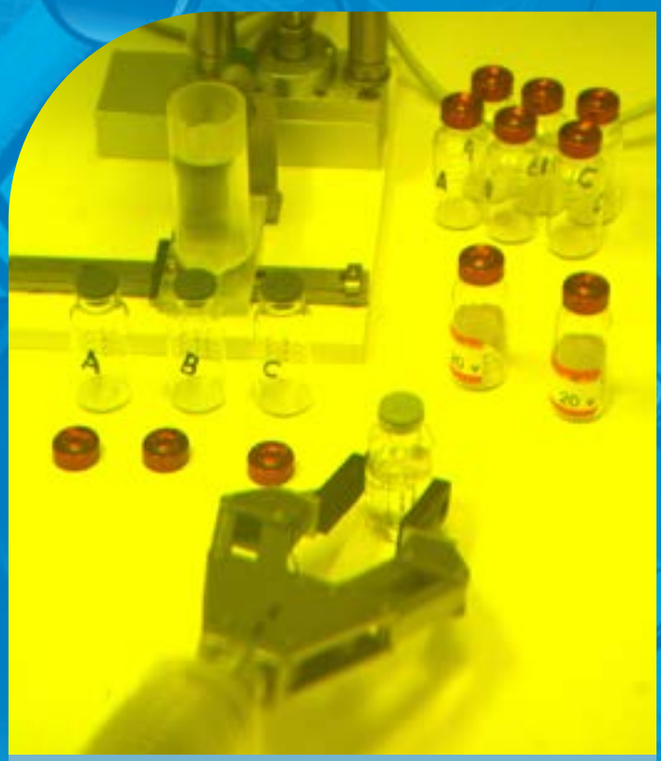
This technology is present in several medical areas such as cardiology, oncology, haematology and neurology. It allows the performance of accurate diagnoses of diseases and complications such as pulmonary embolism, acute infections, myocardial infarction, renal obstructions, and dementia. It is one of the best and most efficient ways to detect cancer, as it defines the type and extent of a tumour in the body, which helps choosing the most appropriate treatment for each case.

However, since 2009, Brazil has experienced difficulties in supplying 99mTc (technetium 99 isotope), which is the radioisotope used in about 80% of the nuclear medicine procedures. This supply difficulty began when the Canadian reactor responsible for 40% of 99Mo (molybdenum 99) world production, and for all Brazilian demand, stopped operating. Brazil has diversified its suppliers, but its dependence on supplying hospitals and clinics with this basic input for tests applied in current health treatments has become evident.



What are radioisotopes?

Radioisotopes are the radioactive isotopes of an atom, that is, atoms that have the same atomic number but different mass number and that emit radiation. Radiopharmaceuticals have radioisotopes in their composition in order to fulfil their diagnostic and/or therapeutic activity. The radioisotopes used in radiopharmaceuticals manufacturing must have a short half-life (time in which their quantity is reduced by half), a level of radiation suitable for the procedure in which they will be used and, in principle, they must not be toxic.



What are radiopharmaceuticals?

Radiopharmaceuticals are substances with known biological affinity, whose molecules have at least one radioactive atom (radioisotope), and on which their pharmacological action will depend. They can be used for diagnostic purposes, identifying diseases, tumours and malfunctioning of an organ through imaging tests such as scintigraphy and tomography, or for therapeutic purposes, being important aids in oncological treatments.

WHAT ARE THE BENEFITS OF RMB FOR LOCAL AND REGIONAL POPULATION?

RMB will be built in Iperó, which is a municipality in the interior of the State of São Paulo, near CINA, the Nuclear Industrial Centre of ARAMAR, where the prototype of the Brazilian nuclear submarine is being developed by the Brazilian Navy. RMB and CINA may contribute for Iperó to become the largest nuclear technology development hub in Brazil.

RMB will occupy an area of two million square meters in which the reactor and all its infrastructure will be installed. In the future, it is expected that RMB site will also comprise laboratories concerning research in nuclear fusion, particle accelerators and high-power lasers as well as laboratories for radiopharmaceuticals development and production.

There will be numerous benefits for regional population, as enterprises of this magnitude attract new companies and industries, create job opportunities for all levels of education and qualifications, and increase local economic activity. RMB will promote more investment in the areas of healthcare and education, bringing hospitals and medical clinics, facilitating the launch of new courses and universities, as well as attracting Brazilian and foreign students and researchers.

RMB is being planned to be a future-proof workplace, fully equipped to turn into a lively campus and to attract companies, research facilities and top talent in the field of nuclear technology applications and healthcare.

The project will also bring development to the urban infrastructure with the improvement of public roads and local highways.

SOROCABA

Sorocaba River - Photo: Paulo Ochandio

IPERÓ

WHAT ARE THE BENEFITS OF RMB FOR BRAZIL?

Annually, in Brazil, approximately 2 million medical procedures using radiopharmaceuticals are performed. This represents a third of the country necessities and means millions of dollars spent on importing the radioisotopes necessary for the production of these radiopharmaceuticals.

With the implementation and entry into operation of RMB facilities, the country shall achieve self-sufficiency in the sector, leading to significant foreign exchange savings. In addition, RMB surplus production may be exported, as there are few reactors of this size in the world, while the demand for radioisotopes is continuously growing.

Thus, Brazil will be able to become a reference centre in nuclear medicine, attracting investments from the areas of healthcare, education and research. Researchers, students and professionals from several areas should look for opportunities to participate in RMB, which will naturally promote the formation of a new generation of specialized labour for the nuclear area and related areas.

RMB shall facilitate the development of new radiopharmaceuticals, expanding the possibilities of medical treatment for a greater number of diseases, for a greater number of people and at a lower cost.


← Iperó
Sorocaba →
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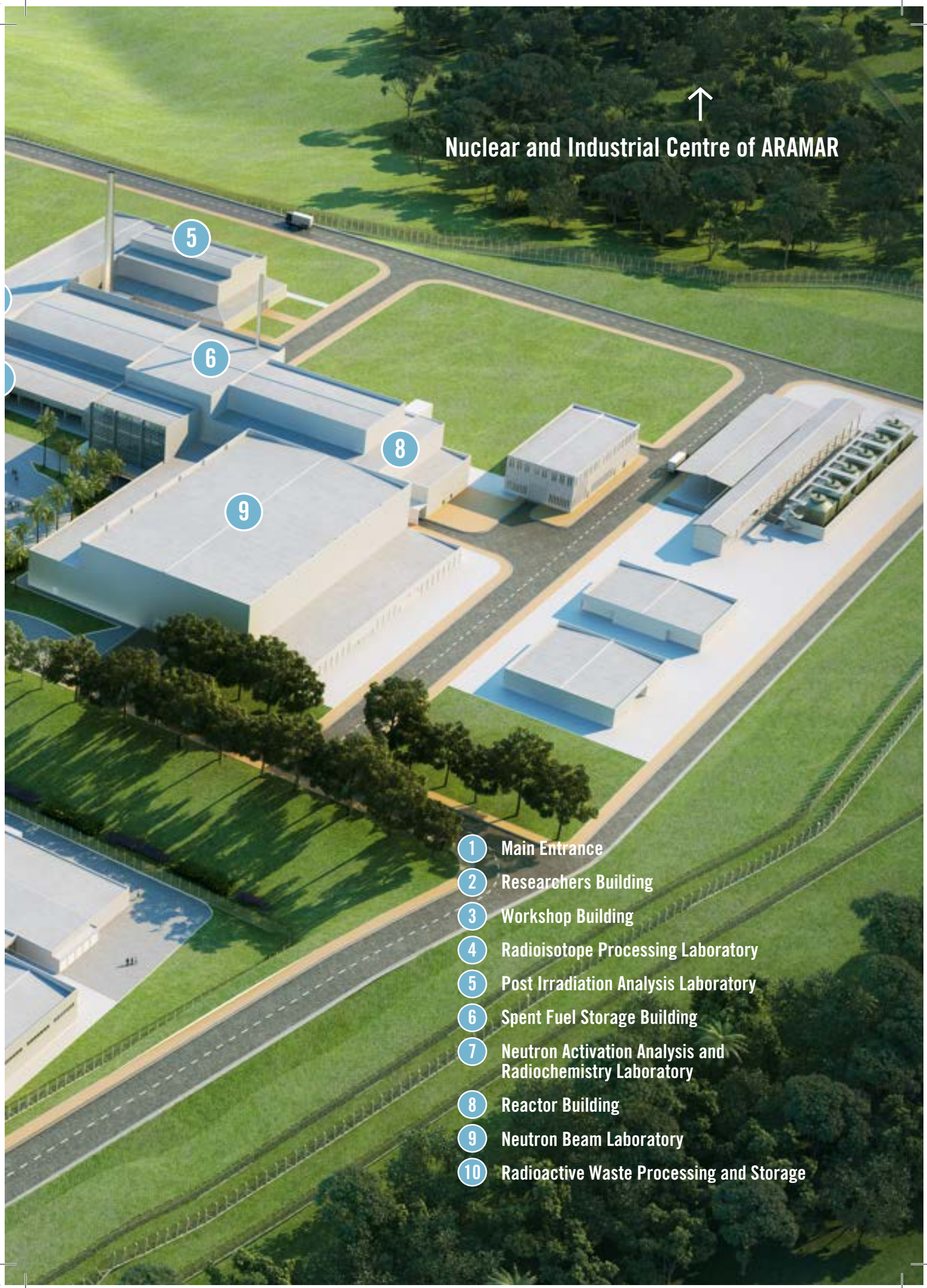
RMB Master Plan


Nuclear and Industrial Centre of ARAMAR
5
6
8
9
1 Main Entrance
2 Researchers Building
3 Workshop Building
4 Radioisotope Processing Laboratory
5 Post Irradiation Analysis Laboratory
6 Spent Fuel Storage Building
7 Neutron Activation Analysis and Radiochemistry Laboratory
8 Reactor Building
9 Neutron Beam Laboratory
10 Radioactive Waste Processing and Storage

Is RMB safe?

Throughout RMB planning phase there was a great concern on the safety of workers and facilities, the population, and the environment. Therefore, from the conception and design phases, the safety criteria to be followed in the construction and operation of RMB are already defined, to comply with all the nuclear and environmental legislation in force in the country, which are the codes and standards of the National Commission for Nuclear Energy (CNEN) of Brazil as well as the resolutions of the Brazilian environmental authority, named IBAMA. In addition, the International Atomic Energy Agency (IAEA) procedures and guides are considered.

RMB in numbers

- **Investment of US$500 million**
- **Production of radioisotopes for more than 30 distinct types of radiopharmaceuticals**
- **Possibility of doubling the number of annual procedures in nuclear medicine in Brazil**
- **Guarantee of stability in radioisotopes supply**
- **Contribution to the expansion of national clinics and hospitals that offer nuclear medicine services**
- **Saving of over US$ 15 million in radioisotopes import costs per year**
- **Two million m^2 is the site area available to the deployment of the largest and most important centre for research and innovation in nuclear technology application in Brazil**

RMB is being developed under the responsibility of the National Commission of Nuclear Energy (CNEN) of Brazil, which is an autarchy linked to the Ministry of Science, Technology and Innovation – MCTI of the Brazilian Government.

Concerning RMB, CNEN established a technical partnership with CTMSP, a technology centre of the Brazilian Navy, for the nuclear fuel production, and with AMAZUL, a defence technology company of Brazil for the development of the detailed engineering design of conventional systems of RMB reactor. In addition, CNEN signed a cooperation agreement with the Comisión Nacional de Energía Atómica – CNEA from Argentina.

RMB coordination office is located at the Nuclear Energy and Research Institute – IPEN, which is one of the technical-scientific units of CNEN and is located 130 km from the Municipality of Iperó, São Paulo, Brazil.

RMB
Reator Multipropósito Brasileiro

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CNEN
National Commission for Nuclear Energy

MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION

BRAZILIAN GOVERNMENT
BRASIL
UNITING AND REBUILDING

RMB – THE BRAZILIAN MULTIPURPOSE RESEARCH REACTOR

FREQUENTLY ASKED QUESTIONS (FAQ)

What is the current stage of RMB?

RMB is structured in three phases: deployment, operation and decommissioning.

The current phase, deployment, will have as final product the reactor and all its ancillary facilities licensed by the regulatory bodies of the environmental and nuclear areas in Brazil, so that they can be commissioned to start operating. The second phase begins with the operation of the reactor and its ancillary facilities, whose final product consists of making products and services available to the Brazilian population. After being commissioned, RMB shall operate for 50 years, with the possibility of having its useful life extended for another 20 years, after which it must be decommissioned, which is the third phase.

RMB deployment phase consists of the following steps:

1. Site setup

2. Elaboration of conceptual design and development of preliminary engineering design of the reactor, laboratories and infrastructure

3. Elaboration of the detailed engineering design of the reactor, laboratories and infrastructure

4. Procurement and acquisition of equipment and components

5. Item manufacturing and electromechanical assembly

6. Civil construction of RMB buildings and ancillaries

7. Development and supply of nuclear fuel

8. Environmental Licensing with IBAMA (Brazilian Environmental Authority)

9. Nuclear Licensing with the Directorate of Radioprotection and Safety of CNEN (Nuclear Regulatory Authority)

10. Commissioning.

Steps 1, 2, 3, and 7 are partially or fully completed.

An ***installation license*** has already been ***granted by the Brazilian environmental authority*** and ***site approval*** has been ***granted by the nuclear regulatory authority***. The ***construction license*** is ***under assessment*** by the Directorate of Radioprotection and Safety of CNEN based on the submission of the Preliminary Safety Analysis Report.

Steps 4, 5, 6 and 10 have not yet started.

When is RMB construction scheduled to start?

It is planned for 2024 the start of civil works related to the general infrastructure of RMB site, including land levelling services and construction of a bridge over a river that crosses this site.

What is the deadline for completion of RMB deployment phase?

The estimated period for completing RMB deployment phase is 5 years, considering that an adequate flow of budgetary resources has been established.

What is the budgetary forecast for RMB deployment?

With regard to the allocation of budgetary resources for the construction of RMB enterprise, a plausible proposal is presented in the table below, covering a 5-year period, which is the estimated time to the completion of RMB deployment phase:

The project will need resources of around **USD 500 million** for its construction, divided over 5 years. RMB construction shall start as soon as the necessary budget funds are released.

It is essential for the government to take the necessary steps with the Ministry of Science, Technology and Innovation in the coming period, in order to encourage the competent authorities to give the green light to the construction of RMB.

How much has already been invested in the RMB project?

RMB feasibility has occurred in accordance with the release of public resources, which have been far below what is necessary for the effective implementation of the enterprise. So far, funds of around **USD 63 million** have been released and effectively used.

The realization of the next steps of RMB deployment phase requires continuation of funds, which, in turn, requires a decision from the governmental authorities. CNEN is making all efforts possible to convince the government of the strong position that RMB holds in the development of the Brazilian nuclear sector, and of its potential. Meanwhile, CNEN is applying for the required permits and licenses, as well as assessing the most appropriate and effective organizational model to deploy this project.

When RMB come into operation, will Brazil be able to become self-sufficient in the production of radioisotopes?

As it can be observed in the table below, there is a complete list of radioisotopes preliminarily defined to be produced in RMB facilities to accomplish the demand being presented by medical, industrial and environmental protection sectors in Brazil.

Among the main objectives of RMB operation is the production of molybdenum-99 (99Mo), which is a radioisotope obtained from the fission of uranium-235 (235U). 99Mo enables the generation of technetium-99m (99mTc, "m" of metastable), a radioisotope that can be used in the production of more than 30 distinct radiopharmaceuticals, applied in almost 80% of diagnostic procedures in nuclear medicine in Brazil.

RMB RADIOISOTOPE PRODUCTION – PRELIMINARY PROPOSAL

APPLICATION	RADIOISOTOPE	PRODUCTION MODE - IRRADIATION	PRODUCTION FREQUENCY	ANNUAL PRODUCTION (Ci)(1)
Injectable Radiopharmaceuticals	99Mo	235U	Weekly	54000
	131I	235U	Weekly	5400
	131I	130Te	Weekly	2700
	51Cr	50Cr	Bimonthly	5,4i
	153Sm	152Sm	Bimonthly	108
	177Lu	176Lu	Weekly	270
	166Ho	165Ho	Weekly	5,4
	90Y	89Y	Weekly	5,4
	188W	186W	Monthly	1,2
	32P	32S	Bimonthly	5,4
Brachytherapy	125I	124Xe	Weekly	120
	192Ir	191Ir (seeds)	Weekly	12000
	192Ir	191Ir (wires)	Weekly	20 wires (variable activity)
Radiotherapy	60Co	59Co	Annually	15
Industry	192Ir	191Ir	Bimonthly	30000
	60Co	59Co	Quarterly	2,5
Tracers	82Br	81Br	Quarterly	0,2
	203Hg	202Hg	Quarterly	15
	131I	130Te	Weekly	on demand

(1) 1 Ci = 3,7 x 10^{10} disintegrations per second (Becquerel – Bq)

How is sustainability being taken into consideration in the development of RMB project?

According to the International Atomic Energy Agency - IAEA and the United Nations Environment Programme - UNEP, to be sustainable an enterprise must be economically viable, environmentally friendly and socially fair. RMB meets all these assumptions.

Economically Viable: Nationalization of the radioisotopes production used in nuclear medicine and industry, which are currently imported. Brazil shall become an important supplier in Latin America through the export of its surplus production.

Environmentally Friendly: RMB is concerned with the safety of its employees, installations, the public and the environment. Therefore, since the conception and engineering design phase, the criteria to be adopted in RMB construction and operation have already been defined in order to comply with the nuclear and environmental legislation in force in Brazil, as well as the IAEA guides and procedures.

Socially Fair: Job creation, increase in local economy activities and investments in healthcare and education. Production of radioisotopes for use in nuclear medicine, production of radioactive sources for use in healthcare, industry, agriculture and environment sectors, performance of irradiation tests on fuel and nuclear materials and development of scientific and technological research with neutron beams. Currently, only 30% of the two million procedures with radiopharmaceuticals produced in Brazil are performed by the Public Healthcare System (SUS). That number may be immediately doubled or even quadruplicated in the medium term when RMB production will be in full operation.

Despite being an investment strongly aimed at the population well-being, RMB adopted a fourth assumption, the cultural one, in order to be legitimized by public opinion, seeking its acceptance through various assertive actions.

Culturally Accepted: Nuclear area disclosure to local residents based on the principle that knowledge is the best way to eradicate prejudice. Assessment of risk perception and preparation of publicity material based on the results of opinion polls conducted with local population. Creation of RMB Visitor Centre. Implementation of a visit programme to schools and colleges in the region. Monitoring programme carried out by students/scholarship holders to promote nuclear energy acceptance activities.