THE RMB PROJECT DEVELOPMENT STATUS

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Abstract

Brazil has four research reactors (RR) in operation: the IEA-R1, a 5 MW pool type RR; the IPR-R1, a 100 kW TRIGA Mark I type RR; the ARGONAUTA, a 500 W Argonaut type RR, all constructed during the 50´s and 60´s and utilized for training, teaching and nuclear research, and a 100 W Brazilian developed critical facility constructed in the 80´s, mainly for the development and qualification of reactor physics. All these RRs are operated by the Brazilian Commission of Nuclear Energy (CNEN) and have been fulfilling their mission along the last 54 years. IEA-R1 is the only one that has been used for radioisotope production, although with limited capacity. The recent international molybdenum-99 supply crisis has affected significantly the Brazilian nuclear medicine services, since 100% of this radioisotope used to be imported from Canada. New molybdenum-99 suppliers were developed, but there is still some concern on the future supply. The recently revisited Brazilian Nuclear Program has decided to establish a national capacity for radioisotope production, the conclusion of the third nuclear power plant (NPP), the construction of at least four more NPPs until 2030, as well as the establishment of a national capacity to supply all the nuclear fuel needed to operate the Brazilian NPPs. This scenario of the nuclear activities in Brazil gave rise to the ***Brazilian Multipurpose Reactor Project (RMB)***, which is being developed by CNEN. A sustainability study costs and benefits related to the development and construction of a new research reactor in Brazil has been accomplished by CNEN, with a favorable conclusion. The RMB will be an open pool multipurpose research reactor, using low enriched uranium fuel, with a power of 30 MW, giving neutron fluxes higher than 2×10^{14} $cm^{-2}s^{-1}$. The RMB is designed to perform three main functions: radioisotope production (mainly molybdenum); fuel and material irradiation testing to support the Brazilian nuclear energy program; and provide neutron beams for scientific and applied research (in complement to the existing synchrotron light laboratory). The project encompasses not only the reactor but also all the laboratories and facilities infrastructure required for the multipurpose applications. The RMB site has already been selected, in the State of Sao Paulo, and is under analysis for environmental licensing. The conceptual design is under development and basic engineering work will start soon. This paper presents the RMB project status, giving some technical and management details on its development and its future perspectives.

1. INTRODUCTION

There is a need to provide the country with a nuclear facility with characteristics and capacity to offer services for the production of radioisotopes, to perform irradiation tests of nuclear fuels and materials with their post-irradiation analysis, and to conduct researches with neutron beams in support to various areas of knowledge. The type of facility that can provide these services consists of a multipurpose research reactor and all the specific laboratories and facilities associated with each one of these services. The “Brazilian Multipurpose Reactor Project (RMB)” will contribute decisively to the country’s strategic objectives related to the increasing production of radioisotopes for medical application, the nuclear energy technology development, the scientific and technological development and to the constitution of human resources for the nuclear sector, meeting the following government’s policies and plans:

— National Energy Plan 2030 from the Ministry of Mines and Energy, which provided for the consolidation of the nuclear option for electricity generation in the country, through the completion of Angra 3 NPP and the construction of up to four new NPPs by the year 2030;
— Technical note of the Ministry of Health regarding the challenges and opportunities of the Brazilian Nuclear Program – Medicine Subgroup. This article highlighted the world market crisis in the radioisotopes production and radiopharmaceuticals due to the

shutdown of reactors in Canada and Europe, and pointed out as a strategic opportunity the expansion of the national productive capacity by installing a more powerful reactor by CNEN, which shall produce the radioisotopes that are currently imported by the country;

— Plan of Action on Science, Technology and Innovation of the Ministry of Science Technology and Innovation (MCTI), which provided actions for the industrial sector in all phases of the nuclear fuel cycle; the need to strengthen the scientific, technological and human resources for the nuclear sector; as well as established RMB as one of its main goals.

Brazil has four operating research reactors and only one, the IEA-R1 of IPEN/CNEN-SP, has limited radioisotope production capacity and materials irradiation. The IEA-R1 reactor has been operating for over fifty years and is supposed to operate for ten years more. After its shutdown, all these activities carried out today will cease if there is no research reactor in operation. At the same time, the Brazilian Nuclear Program (PNB) in its current revision foresees the increase in research and development activities in support for the nuclear energy generation program, as well as the increase in applications of nuclear technology in medicine, industry, agriculture and environment. It’s important to highlight that the demand for electricity leverages the need for nuclear power reactors and all fuel cycle industry, but research, development and training of human resources also need projects as a nuclear research reactor. The old IEA-R1 reactor does not meet the increased requirements demanded by the new PNB, especially regarding the production of radioisotopes for nuclear medicine and material testing for nuclear power plants development. The RMB will attend these demands.

2. TECHNICAL CHARACTERISTICS

The technical characteristics of the RMB were determined based on the data and conclusions obtained in the technical discussions of working groups composed of CNEN experts. Fig.1 presents in a concise way items that need to be addressed within the scope of the RMB Project. “Products” of the RMB operation are shown on the left of Fig.1, especially the production of radioisotopes, irradiation and testing of fuels and materials, and some of the possible applications with neutron beams. On the right side of the figure are placed the "needs" for the design, construction, commissioning, licensing, fuel supply and operation. The reactor itself and the physical infrastructure that will be needed to meet the various applications are presented in the central part of the figure.

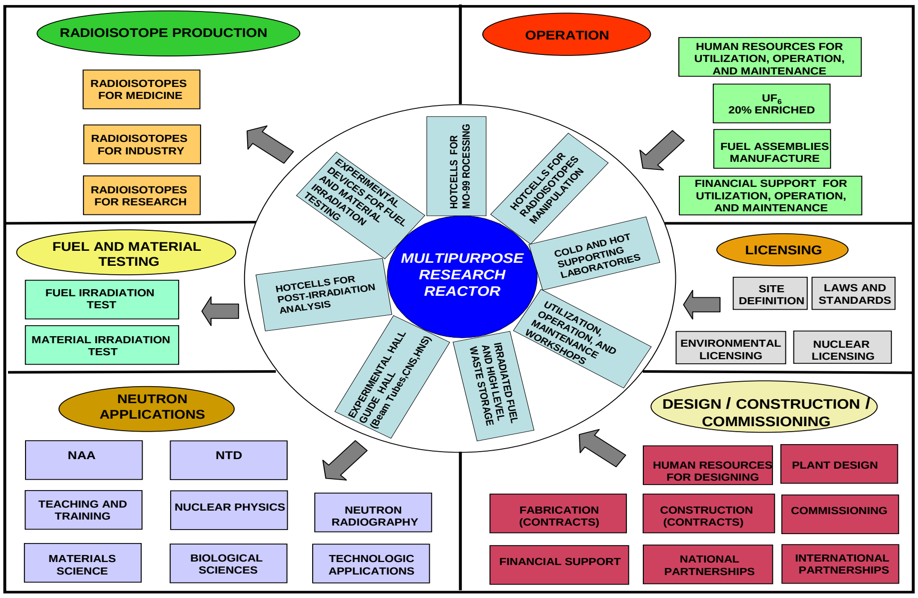

FIG. 1. General features of the RMB project.

2.1. Reactor description

Among the various types of research reactors, the pool type is the most common and most widely used due to its versatility, ease of operation and safety. The RMB project will be a multipurpose open-pool-type, with a maximum thermal power of 30 MW. The reactor core should be compact, with fuel elements such as MTR-type fuel of U_3Si_2-Al with a plate meat density of up to 4.8 gU/cm^3 and U-235 enrichment of 19.75 wt%. The thermal flux shall be greater than 2x10^{14} n/cm^{2}s in defined irradiation positions, and the flux of fast neutrons shall also be above 2x10^{14} n/cm^{2}s in material irradiation positions. The reactor core will be cooled and moderated by light water and reflected by heavy water except from one side where beryllium and light water are used. The optimization of the core design will take into account strategic factors such as: in-core materials irradiation devices; ex-core fuel irradiation devices allowing adjustment of the neutron fluxes and the irradiation devices shall have independent cooling systems; radioisotope production in the reflector; and proper positioning of the beam-holes for the extraction of neutron beams with adequate fluxes.

All the core structure will be located within a square cross section called "chimney" that will form part of the primary cooling circuit. The cooling of the reactor core will be promoted by forced circulation of demineralized water in upward direction. In normal operation, the refrigerant will be pumped through the channels of the core and then, through pipes, to the heat exchanger before returning to the reactor core. A removable grid is placed on top of the chimney to do the calibration of water flow and to protect the core of any falling objects. The core will be surrounded by a heavy water tank, where devices will be positioned for radioisotope production except from one side where beryllium and light water are used for fuel material testing. The region of the reflector will include a facility to accommodate the cold neutron source. The core (and chimney) and the reflector are located within a pool of demineralized light water, which will provide cooling and radiation shielding in all conditions of reactor operation. The pool water also cools the outer region of the core during normal operation and removes the residual heat after shutdown.

The structures of the reactor will be designed and built according to safety requirements established by appropriated standards. The structural materials that are most used are stainless steel, zircaloy and aluminum, widely used in the nuclear industry. The fuel elements will be of type MTR U_3Si_2-Al, with 19.75wt% enrichment of U-235 and density up to 4.8gU/cm^3, with the process/manufacturing technology developed by IPEN/CNEN-SP for the manufacture of fuel elements of the IEA-R1 research reactor. The reactivity control will be done by neutron-absorbing plates (Ag-In-Cd or Hf alloy). The control plates will be moved by a drive mechanism located in a room below the reactor pool. The shutdown of the reactor will be guaranteed by the simultaneous insertion of control and safety plates by gravity, although the insertion of the set of safety plates or the set of control plates, independently, is sufficient to ensure shutdown. As a design criterion, this drive system mechanism shall provide a fail-safe condition. A second independent safety shutdown system is given by removing the heavy water from the reflector tank. For the instrumentation and control system it should be used, in principle, an analogue system to protect the reactor, and a digital system to control the plant.

The technological evolution of the automation systems and the licensing requirements on safety will be taken in consideration during the plant design. The safety requirements to be adopted in the design of RMB project are based mainly on the requirements set forth in the IAEA document NS-R-4 Safety of Research Reactors.

2.2. Radioisotope production

Table I presents a summary of radioisotopes proposed to be produced at RMB. The project team needs to identify priorities and quantities within the production of radioisotopes in order to verify the technical feasibility in the design of the reactor as the core size, its constituent materials, the reactor power and the actual values of fluxes in various irradiation positions. It is noteworthy that the production of radiopharmaceuticals will continue to be held in facilities that exist today at IPEN-CNEN/SP.

TABLE I. MAIN RADIOISOTOPES PRODUCTION PROPOSED FOR THE RMB PROJECT

Radioisotope for Injectable Radiopharmaceuticals
^{99}Mo , ^{131}I, ^{51}Cr, ^{153}Sm, ^{177}Lu, ^{166}Ho, ^{90}Y, ^{188}W, ^{32}P
^{99}Mo obtained by LEU target irradiation and processing - 1000 Ci/week $^{(*)}$ (*Today 350 Ci/week are imported by IPEN and 450 Ci/week were imported before the international crisis in 2009)
Radioisotope for Brachtherapy
^{125}I, ^{192}Ir
Radioisotope for Industry Application
^{192}Ir, ^{60}Co
Tracers
^{203}Hg , ^{131}I, ^{82}Br

Mo-99 and I-131 are the main radioisotopes for medicine application and should be the priority of irradiation in the reactor. Mo-99 and I-131 should be produced from irradiated targets. The targets consist of miniature LEU fuel plates, made of metallic uranium or uranium-aluminum alloy, depending on the technique used in processing after irradiation. The RMB design should include the following facilities and specific components necessary for the production of radioisotopes:

- Hot cells for processing irradiated uranium targets in obtaining Mo-99 and I-131;
- Hot cells for handling radioisotopes and preparation for transport off-site;
- Hot cells for special processing of radioisotopes and encapsulation of radioactive sources;
- A hot cell, or a special shielded device for the production of I-125;

- Shields for handling and for off-site transport of radioisotopes;
- Various irradiation devices for radioisotopes production;

Among the facilities listed above, the more complex is the hot cell for processing irradiated uranium targets for the production of Mo-99 and I-131. This technology is not yet controlled in Brazil and it will be necessary, throughout the RMB project development, to build a test cell for the development of processes and associated systems.

2.3. Irradiation testing of nuclear fuels and materials

Considering the general and specific needs of the Brazilian projects in the area of PWR type power reactors, it is suggested that the RMB project should include as objectives: (i) to study the behavior of nuclear fuels under irradiation and experimental basic data collection of performance (ii) the study of damage due to irradiation ("ageing") in reactor of structural materials, and the study of the behavior of reactor core materials under the combined effects of water chemistry and the environment of high radiation and temperature. The following irradiation devices will be designed to the RMB:

- Pressurized circuits of irradiation for nuclear fuels. The Pressurized circuits ("loops") of irradiation should allow the irradiation of mini rods or mini plates in representative environments of those of operation in the reactor (pressure, temperature, power density, burn up limit, the chemical environment, etc.);
- Use of Horizontal Displacement Devices (HDD) to allow irradiation under stationary and transient conditions. This device allows controlled positioning of the irradiation capsule in neutronic conditions required by the test, variable power levels and power cycling, and ensures the automatic removal of the irradiation capsule in relation to the reactor core as a safety condition;
- Irradiation capsules for structural materials testing within the reactor core. The capsules should allow the irradiation of the specimens of structural materials (e.g. steels of PWR pressure vessels, steel of structures inside the reactor, zirconium alloy cladding, etc.) at representative temperatures of those operating in PWR reactor. The distribution of neutron fluxes and temperature in the irradiation capsule should be well known. The time to achieve the desired fluency can be long depending on the neutron flux at the irradiation position, and the specimens must remain inside the reactor during the entire irradiation. It is desirable a fast neutron flux above 2.10^{14} n/cm^{2}s to perform the irradiation tests in an appropriate time.

To perform the irradiations the following facilities will be needed: control room for the irradiation experiments; experimental systems; computer software for collecting experimental data; hot cell for specimens transfer; stand for visual examination at the pool; space in the pool area of the reactor to support devices; laboratories and workshops; laboratory for chemical analysis; mechanical workshop and welding.

When performing irradiation testing of fuels and structural materials, that are highly activated, requires handling to be carried out in facilities with adequate shielding and environmental control. All equipment for characterization and testing should be within these special systems. Non-destructive analysis of physical characterization of the irradiated items should be performed, punching and fission gases (combustible materials) collection, characterization of mechanical and physical properties (structural materials), preparation of samples for optical and scanning / transmission electron microscopy, etc.

A hot cell laboratory with three hot cells for testing fuel samples with reduced dimensions is already being constructed close to the RMB site. This infrastructure will be used in conjunction with the RMB. The installation is not yet fully built, but will be operational at the time of the RMB operation. The laboratory with hot cells for testing structural materials shall be designed and built by the RMB project. The laboratory will be devoted to physical and mechanical characterization of irradiated structural materials. The materials may have its origin both in RMB as in the power reactors in operation in Brazil, with the possibility of receiving testimony coupons of materials from the reactor vessel of nuclear power plants in Brazil, which now are sent abroad for analysis. The laboratory will consist of several hot cells, being able to perform the following tests:

- Physical tests: dimensional analysis, electrical resistivity, density;
- Mechanical tests: uniaxial tension and compression, uniaxial creep, biaxial creep; tube pressure test, hardness, impact test, fatigue test, fracture toughness test;
- Microscopy: optical microscopy, scanning electron microscopy, transmission electron microscopy.

2.4. Neutron beam applications

We can divide the neutron applications in two forms: neutron applications in the reactor itself (core or reflector); and neutrons applications with neutron beams extracted from the reactor. The two characteristics are presented below.

The neutron activation analysis (NAA) is a multielement chemical analysis method, characterized by high precision, accuracy and sensitivity and their multi-disciplinary ability, and can be applied to a great diversity of research fields such as geology, archaeology, biology, medicine, environment, industry, nutrition, agriculture and others. It is one of the relevant applications of nuclear research reactors worldwide. The method is based on the interaction of neutrons with stable isotopes through nuclear reactions, producing radioactive isotopes whose emitted radiation is analyzed by adequate equipment, in most cases the gamma-ray spectrometers. The ideal position is to provide irradiation with fluxes typically between 10^{11} to 10^{13} n/cm^2.s and well thermalized neutrons. You can also make use of irradiation with epithermal neutrons, which particularly favors the analysis of some elements such as uranium and the elements of the lanthanides group or rare earth elements..When short irradiations are performed to determine the isotopes of short half-lives, typically of a few seconds to minutes, it is essential to build pneumatic irradiation stations to transport samples from laboratories to irradiation positions. Pneumatic stations are proposed with transit time of 10 seconds, but also an ultra-fast station with time of less than 10 seconds to allow the analysis of radioactive elements that generate isotopes of very short half-lives, such as selenium and fluoride. An alternative to the traditional method of that has been used in reactors of various countries is PGAA ("prompt gamma activation analysis"), which opens the possibility to determine elements that are unfavorable to the NAA such as hydrogen, carbon, silicon, phosphorus, sulfur. The arrangement for PGAA is located near the exit of the neutron beam. Other devices can be used in the reactor. Some of these applications are:

- Arrangements for irradiation of large samples ("large sample activation analysis"), to shed samples of a few kilograms for in the usual analysis the samples are very small, in the order of milligrams;
- Device for the irradiation with monocrystalline silicon for doping with phosphorus ("Neutron Transmutation Doping") with up to 10 inches in diameter. These devices are on the periphery of the reflector, and may have several pounds produced routinely;
- Device for irradiation of gemstones such as topaz, for induction of color, which increases its commercial value;
- The infrastructure needed for neutrons applications in the reactor is as follows:

laboratory of Radiochemistry to work with different levels of radioactivity; chemical laboratories for processing of samples and standards; laboratories for gamma-ray spectrometry; hot cells for handling irradiated samples; and teaching laboratories.

The fundamental and applied research with neutrons beams in the RMB project will be made possible, since these activities, often complementary to studies with synchrotron radiation, are little used in Brazil due to the low neutron flux of research reactors in the country today. Brazil has an excellent laboratory of Synchrotron Light (NSLL – National Synchrotron Light Laboratory) and the RMB project will come to complement this lab with neutrons beams. In order to use neutrons beams, the reactor will have five tubes to extract the neutrons out of the reactor core (called "beam-holes"). The RMB project's purpose is to make available four beam holes for neutron guides: two for the thermal guides (thermal neutrons) and two for the cold guides (cold neutrons), each with capacity for up to three neutron guides. The technical characteristics of each beam-hole (size and position) should be established during the conceptual design of the reactor. Also the technical choice for the cold neutron source shall be established during the conceptual design. It is important that each beam-hole be tangential to the reactor core, and that the thermal neutron flux outside the shielding of the reactor has at least the order of 1×10^{9} $cm^{-2}s^{-1}$, a value that requires a minimum flux of approximately 1×10^{14} $cm^{-2}s^{-1}$ in a position tangential to the core. There will be a fifth beam hole, with thermal neutrons, dedicated to neutrongraphy.

The RMB Project proposes the existence of two areas for experiments. One called "experimental room" that surrounds the main shield of the reactor, and another called "neutron guide building" where equipment will be settle and experiments will be developed using neutron guides. Table II presents a list of equipment that is the initial proposal to be installed for research using neutron beams. During the conceptual design we shall define which equipment will actually be installed and their positions compared to the neutron beams. For this a Technical Advisory Group should be established to define and prioritize the equipment to be installed.

TABLE II. INITIAL EQUIPMENT AND APPLICATIONS OF NEUTRON BEAMS

Guide Hall	Experimental Hall
Thermal Neutrons	
High Resolution Diffractometer High Intensity Diffractometer Laue Diffractometer Residual Stress Diffractometer	Three Axis Spectrometer Neutrongraphy
Cold Neutrons	
Small Angle Neutron Scattering Prompt Gamma Analysis	Neutrongraphy

2.5. Radioactive waste management

The following policy shall be adopted in the management of radioactive waste (MRW) at the site of RMB:

— All steps of radioactive waste management shall be performed "in situ", except the final disposition that depends on the repository to be defined by CNEN;
— At all stages of the MRW, the relevant national laws and regulations must be obeyed and the recommendations of relevant international bodies should be observed;

- Spent fuel elements (SF) should be stored as radioactive waste of high activity (WHA), in a recoverable way to, at any time, be recycled in accordance with the policy that will be adopted in the country regarding the waste processing; the SF shall be stored in pool for initial decay and stored in dry flasks for long term storage. These storages will be done in the SF building connected to the reactor building.
- High level waste produced in the processing cells of Mo-99 and in laboratories with hot cells should, in principle remain in storages in the cells and, then, be transferred to a special container to be stored in the SF building.
- The management of low activity waste of the site should be performed in a central processing unit, in a separate building from the reactor and production facilities. Laboratories devoted to physical-chemical and radiological wastes characterization should be included in the central unit of treatment.

2.6. Fuel elements supply

The Centre for Nuclear Fuels (CCN) of IPEN-CNEN/SP usually produces fuel elements of the Al-U_3Si_2 for the IEA-R1 reactor, which is the same fuel technology to be used in RMB. The CCN is expanding its current production capacity to attend RMB in the future. The required annual amount of enriched UF_6 at 19.75 wt% will be provided by the Brazilian fuel cycle facilities (conversion and enrichment) in Sao Paulo.

2.7. Operation

The dimension of the RMB project and infrastructure with the reactor and related facilities justifies the creation of a new CNEN Centre. For definition of the RMB operation staff it is assumed that the reactor will operate 24 hours a day (3 shifts) for a cycle of at least 25 consecutive days, and 12 cycles per year. Each shift will consist of working teams with senior operators (supervisor), operators, and personnel of radiation protection. Support groups for the operation of the reactor (mechanical, electrical, electronic, chemical, quality and administrative) will work during business hours. At least one team member of the mechanical, electrical and electronic maintenance (instrumentation) will be on guard (beep) to meet possible emergencies in the shifts. Work teams will also be formed for operation and maintenance of support facilities (labs with hot cells, molybdenum processing, radiochemistry, waste treatment and building of the neutron guide). Other groups of engineering support for the continued operation of the reactor will be needed such as: risk analysis; neutronic and thermo hydraulic calculations; engineering projects; shielding calculation; fuel inspection; study of ageing; documentary support, etc. An important point is the one that addresses the need to predict the initial formation of the RMB team of operators with some anticipation. This is to ensure that, in its final formation, operators have the opportunity to follow the assembling of the various reactor systems during construction and commissioning.. The expertise of the operation teams from the four research reactors in CNEN will contribute for the training and formation of the new team.

2.8. Licensing

The RMB project will be subjected to environmental and nuclear licensing processes, in accordance to the corresponding Brazilian regulatory authorities’ codes. The steps for environmental license are: preliminary license and emission of the environmental Impact Analysis Report; installation license; and operating license. For the nuclear licensing the steps are: approval of site and emission of the Site Report; construction license with emission of the preliminary safety report; authorization of nuclear material use before core loading; authorization for operation after the approval of the final safety report; and the permanent operation authorization after the commissioning of initial operation approval.

3. SITE SELECTION

The site selection for the RMB project was driven by the following main requirements:

— Have sufficient area for the Emergency Planning Zone (EPZ) to be within the boundaries of the chosen site. Avoid having this site near to major population centers;
— Be close to the radiopharmaceuticals manufacturing laboratories;
— Be close to good road access and proximity to the airport for shipment of radioactive material to several cities of the country;
— Provide good access to the various researchers of national institutions for them to use the RMB project in a constant and intense way;
— Be close to technology centers and advanced industries in order to facilitate the technical exchange and supply of inputs to the reactor.

The coordination of the project, taking into account the sites of the research institutes of CNEN and the nuclear sites in Brazil and due to the requirements given above, suggested the site of the Aramar Experimental Center, in Iperó, Sao Paulo. The reason for this suggestion is based on the following main favorable conditions presented by this site:

— The site has an appropriate size and out of densely populated region with nuclear facilities (reactors) to be installed, with the exclusion radius compatible to the required for the EPZ;
— The site already has an environmental license, public hearings done, environmental laboratory monitoring in operation, environmental measurement historical data, etc. This will greatly facilitate the licensing aspects of the RMB;
— As the environmental licensing, nuclear licensing would be facilitated in the aspect of location approval;
— The site of Aramar, in Ipero, near Sorocaba is 100 km from IPEN/CNEN in Sao Paulo, and connected by good roads. It is close to the Viracopos airport in Campinas, which facilitates the transport aspects of radioisotopes;
— The location puts RMB near major technology centers and advanced industries centers like Sorocaba, Campinas and São Paulo, as well as the major university centers in the country;

4. PROJECT ORGANIZATION AND MANAGEMENT

The RMB project is managed by the Research and Development Directorate of the Brazilian Nuclear Energy Commission (DPD/CNEN), and technically developed by the CNEN research institutes: IPEN (which leads the technical coordination of the project), IEN, CDTN, IRD and CRCN-NE. These institutes have extensive experience in the areas of reactor engineering, nuclear physics, radioisotopes production and nuclear fuel fabrication. Within the groups there are doctors with over twenty years of experience in the nuclear area, as well as teachers, engineers, and technicians who have always given support to the national nuclear programs and projects. The RMB project has also partnership with other national nuclear organizations, laboratories and universities.

The design of the RMB project provides a strong national component in its implementation, both from research institutes and national companies. The institutes of CNEN are responsible for the nuclear conceptual design, licensing and commissioning. In these phases partnerships with other research institutes and universities in the country for specific studies will also be developed. The basic and detailed design, manufacturing, construction and assembly will be carried out by national and international companies.

Of particular relevance is the cooperation of Brazil and Argentina in the COBEN (Nuclear Energy Binational Commission) which develops agreements and technical cooperation in many areas of mutual interest. One of the areas is research reactor. As Brazil, Argentina is developing a new research reactor project. CNEN and CNEA (Atomic Energy Commission of Argentina) have agreed through COBEN that both reactors would have similar basic nuclear projects and would have as much as possible complementary functions for partnership strengthening. Both reactors will have OPAL as a reference model design and CNEN and CNEA agreed in contracting INVAP for this development.

At the present stage it is difficult to determine the cost of the RMB project due to remaining uncertainties regarding the reactor characteristics such as size of structures, devices, values of the items of experiments, etc. It is initially estimated an overall cost of US$500 million based on similar reactor projects in the world. The estimated implementation time of the project is at least six years according to the schedule in Figure 2, once all the required resources are guaranteed by the government.

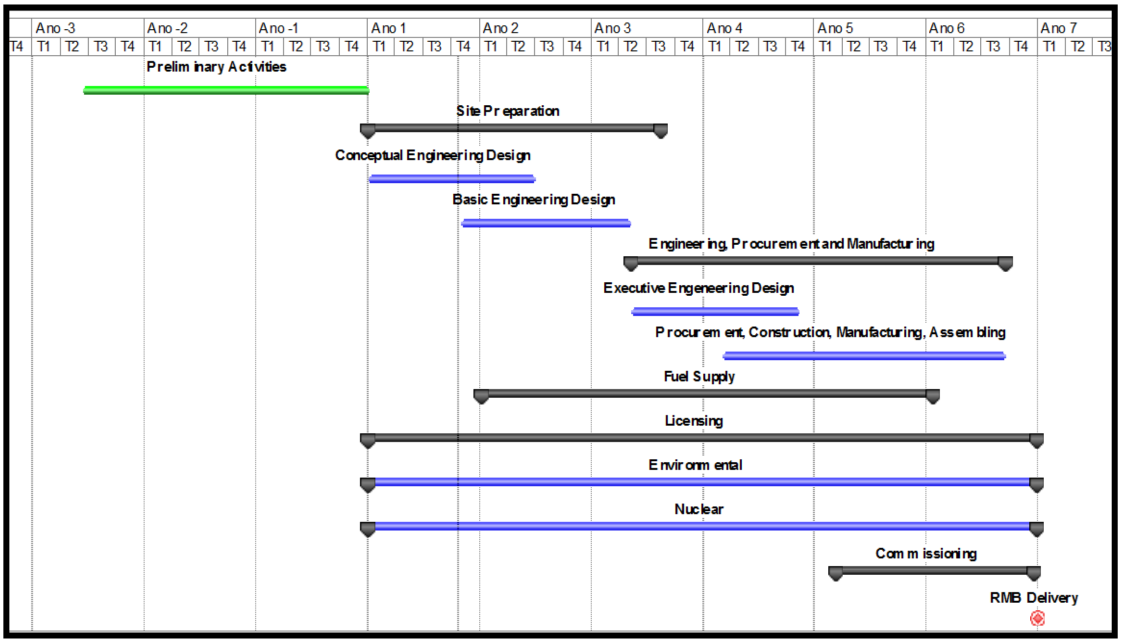

FIG 2. RMB project schedule.

5. FINAL REMARKS

CNEN Institutes technicians are developing the conceptual engineering design of the reactor systems and main facilities. R$ 30 million (US$ 17,5 million) have been provided to contract the basic engineering design of systems, buildings and infrastructure of the RMB (except basic engineering design of nuclear systems and components). The work contract is under development and will be completed in November this year. The contract of the basic engineering design of the nuclear systems, under the CNEN/CNEA Agreement is scheduled to the beginning of next year with the provision of financial resources by the Brazilian government. The Environmental licensing process started and the Term of Reference for Environmental Impact Analysis Report was approved by the Environmental Regulatory Authority (IBAMA) and the work contract is under development, which will be completed by the end of this year. The government included the RMB project in the four year governmental budget planning (2012-2015) ensuring the continuity of the project for these years.

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