THE ARGENTINE-BRAZILIAN FAST REACTOR PROGRAMME

C.J. GHO
Comisión Nacional de Energía Atómica,
Bariloche, Argentina

A. MAURICIO
Instituto de Engenharia Nuclear,
Comissao Nacional de Energía Nuclear,
Rio de Janeiro, Brazil

Abstract

This paper summarizes the Argentine-Brasilian Fast Reactor Program and gives reasons for the decision of a binational venture.
The work carried out by both countries is described, showing how they complement each other, with the corresponding saving of resources.
The main objectives of the Program and tentative schedules in three progressing integrating stages are given and the present nuclear know-how in each country is identified as a good starting point.
The paper also gives some details regarding the economical and human resources involved.

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1. NEED OF A FAST REACTOR PROGRAM

From the next century on, Brasil and Argentina will depend increasingly on their nucleoelectric resources to face the energy demand connected to the development of both countries.

The Fast Breeder Reactors (FBR) are conceptually the more efficient way to use the uranium reserves.A suitable nuclear program, including FBRs will then assure most of the electric energy production for a long time to both countries and even to all South America.

The central countries are still investing huge economical and other resources in this area, even under joint-ventures, and very probably the technological gap existing between Brasil-Argentina and the developed countries will greatly increased , unless something is done before FBRs are needed.

On the other hand, a binational program of FBRs necessarily involves a better knowledge on the plannings of the other country , sc the mutual relience grows stepwise enabling the distention to appear.

2. BINATIONAL PROGRAM GOALS

The aim of the Argentine-Brasilian Fast Reactor Program (ABFRP) is that both countries obtain through their complementary and joined efforts an adecuate knowledge of FBR technology hopefully before their introduction in the nucleo-electric national grids.

In the middle term the main goal will be the design, construction and operation of an experimental fast reactor (EFR) in the range of 50 MWth, with eventually an electric output, maximazing the indigenous production of components.

This objective will not be reached without the constant efforts of bi-national teams, particularly in the following areas:

- Sodium technology
- FBR Physics
- Safety
- Fuel, Radiochemistry and Materials
- FBR Engineering

Brasil and Argentina are undergoing a difficult economical period related to their high external debts. In addition, many other energy resources alternatives to nuclear energy offer a considerable potentiality. Therefore, the nuclear programs of these two countries are somewhat in recesion, and the conditions for the ABFRP to grow are not the optimum.

However, there exists the political willingness to keep a minimmum of nuclear technology undergoing, including Research and Development in the field of FBRs.

3. ABFRP CONTENTS

Brasil and Argentina have reached an important stage of development in the nuclear field, namely in scientific and technological aspects as well as in the related industries. This means that the starting point is not zero.

However, it will be necessary for the ABFRP to go through two fundamental steps.

- Research and Development of specific technologies.
- EFR Project and Construction

3.1 Research and Development

The first six years of the program will be devoted to strengthen and to increase local knowledge in fundamental items in each of the five areas mentioned above, with clear objectives and goals for each one.

Another not less important aspect will be the formation of human resources.

To acomplish this, both countries will have to resort to self-developed techniques as well as to personnel training in those IWGFR countries willing to help ABFRP.

The main foreseen activities in each area follow:

3.1.1. Sodium Technology

The target here is to get an intense development in the field of liquid metal technology, involving mainly:

- The construction, setting-up and operation of several sodium loops for different purposes (expected completion around 1990).
- Piping design and structural mechanics.
- Sodium Thermal-hydraulics.
- Sodium Physical-Chemistry.
- Instrumentation
- Sodium handling
- Prevention and fight of sodium fires.
- Biological effects of sodium.

3.1.2. FBR Physics

The target in this area is the development of FBR core design capability, involving basically:

- The design, construction and operation of a Fast Critical Facility (FCF), with expected completion in 1995.
- Adaptation of thermal research reactors to fast neutron research.
- Setting-up of a neutronic calculation system.
- Lattice parameters studies, integral experiments.
- Development of specific cross-section libraries.
- Instrumentation and detectors.
- Control and safety in zero power fast reactors.

3.1.3. FBR Safety

The target here is the development of safety and licencing standards, involving:

- Control and Safety in power FBRs
- Radiological Protection and Shielding
- Accident hypothesis, prevention and preparedness
- Inherently safe designs.
- Environmental impact.
- Siting and Licencing.

3.1.4. Fuel, Radiochemistry and Materials for FBR

The target here is the development of the needed fuel and materials for the whole program and the improvement of uranium enrichment, spent fuel reprocessing and plutonium production technology.

Besides completion of enriching and reprocessing plants, the main Research and Development effort will be oriented to:

- Alternative uranium enrichment techniques
- PHWR and PWR fuel reprocessing
- Fuel development for FCF and EFR
- FBR fuel and blanket reprocessing
- Boron enrichment. Control rods materials
- Erotion, corrotion, mass transfer, radiation damage in sodium exposed steels.
- Thermal isolators and inert gass loops.
- Radiochemistry of activated sodium loops.

3.1.5. FBR Engineering

The target here is the development of engineering tools for design, construction and operation of small power reactors, and also the industrial capacity to produce indigenously most of the components.This involves basically:

- Adaptation of the present experience in small reactor projects management.
- Engineering for heat exchangers, steam generators, pumps, etc.
- Related industrial technology development and components production.
- Setting of specific engineering standards, fitting the program needs with the local modalities.
- Financing channels.

3.2. Experimental Fast Reactor

With a single small experimental reactor (instead of two which should have been the case without the ABFRP) most of the needed know-how for FBR's construction will be acomplished both at an earlier stage and more economically.

The EFR is the main goal of the program and its conceptual design is foreseen to be ready by 1995.

4. ABFRP STARTING POINT

Brasil and Argentina have independent nuclear programs with a total installed power of 1600 MWe plus other 2000 under construction .

The present economic difficulties in both countries have delayed these programs, therefore the development and construction of power Fast Breeder Reactors has low priority. However, Argentine Atomic National Commission (CNEA) and the Brasilian Nuclear Energy Commission (CNEN), which are responsible for nuclear policy in each country, have assesed the importance of these reactors for the future energetic independence and a decision was made to start national Research and Development programs in this field.

4.1. Brasil

Since 1969 the CNEN's Nuclear Engineering Institute (IEN) in Rio de Janeiro has a program of activities and studies related to Fast Reactors Physics and Engineering Research.

4.1.1. Sodium Technology

A 100 Kw sodium loop constructed by a Brasilian company in 1972, CTS-1, is still being used at IEN for heat transfer and basic sodium technology studies, having achieved during this time a solid experience in small and medium loops operation and maintenance as well as in sodium handling, sodium chemistry and safety.

In 1981 CNEN decided to stress IEN's activities in sodium technology through a cooperation agreement with the Italian Ente Nazionale per l'Energie Alternative (ENEA).

A contract was signed with NIRA/ANSALDO for the project and construction of three modern sodium loops for thermal shock analysis studies, tests of locally produced components (pumps, valves, level meters), mechanical and thermalhydraulic test of fuel elements, etc.

4.1.2. FBR Physics

Several thermal experimental reactors exist in Brasil. Some theoretical groups for neutron calculations, are oriented to fast reactor problems.

4.1.3. Safety

Regarding Reactor Safety, Brasil gained experience when in the early seventies started the project of a coupled thermal-fast reactor.

4.1.4. Fuel, Radiochemistry & Materials

The programs on uranium enrichment and fuel reprocessing are in the research and development stage. A small boron enrichment plant is working at IEN.

4.1.5. FBR Engineering

An agreement between France and Brasil in 1970 gave, among many other results, the detailed project of the coupled fast-thermal reactor COBRA. As Brasil could not, at that time produce the fuel and since highly enriched fuel was not commercially available, COBRA construction never started. However, the result of this project was the development of human resources in reactor engineering.

Another source of human resources in this area was the agreement with ENEA, which involved engineering training in Brasil as well as "on the job" training in Italy mainly concerned with structural mechanics (participation on the PEC reactor design).

4.2. Argentina

Although the many research activities on fuel enrichment and reprocessing had as a sideline goal their future use in FBRs technology, it is only in the 80's that specifically oriented activities are started in spite of a failed attempt to start an FBR program during the 70's.

4.2.1. Sodium Technology

There is a scarce experience in NaK handling, sodium purification and analysis.

4.2.2. FBR Physics

During the seventies the design of a coupled thermal-fast facility was started but abandoned soon afterwards. There exists a large experience in thermal reactor physics, which hopefully will be used for this program. A small inherently safe thermal power reactor (CAREN) is under development and an important Research and Development related program to use is now underway. Research on Instrumentation and Control enabled to use locally designed systems for both the recently started 10 Mw research reactor in Peru and the 1 MW Algerian reactor. Several core physics research groups are presently working with locally built thermal experimental reactors.

4.2.3. Safety

The construction of several experimental reactors (in Argentina and abroad) has served to gain a good experience in this area, which could be transferred to FBRs.

4.2.4. Fuel, Radiochemistry and Materials

This is Argentina's strongest field. The Radiochemical Processes Laboratory (LPR), small and heavily instrumented reprocessing plant, is in advanced construction; once completed it will produce about 15 Kg Pu/year. The Pilcaniyeu Enrichment Plant is increasing its capacity to 100.000 SWU/y .Two fuel factories (for MTR and PHWR fuel) are operative and research on mox fuel is performed. A factory for zircalloy cladding production was developed indigenously. All related research groups in CNEA are very active.

4.2.5. FBR Engineering

CNEA has designed and built many research reactors, having recently exported two of them. It has also taken an important part in the construction of power reactors. There is also experience on design of small power reactors as for example CAREN(15MWe) an ARGOS-PHWR(380MWe). This know-how is being re-oriented to the FCF and EFR design and construction, specially regarding core design. However, as opposed to Brasil, there is a lack of knowledge in sodium piping and components engineering.

5. ABFRP DIRECTION

The Brasilian Nuclear Energy Commission (CNEN) and the Argentine Atomic Energy Commission (CNEA) hold the direction of the ABFPR through a "Steering Commitee" (SC).

The SC President is either the head of Research and Development at CNEA or the head of Reactor Research at CNEN, both switching with annual periodicity The SC President will officialy represent ABFRP .

The SC is completed with two technical delegates from each country, one of them being the Executive Coordinator, who is in charge of the coordination of tasks between two succesive SC meetings.

The Executive Coordinator, who will have a different citizenship from that of the President, and the past-Executive Coordinator are the natural delegates to the IWGFR.

The SC will meet twice a year analysing the advance of the program during the preceeding period, setting the objectives for the following one and distributing the tasks to the participants under the requirements of a general chronogram.

The agreements and/or associations with institutions or enterprises from other countries or with international organizations in the field of FBRs, will be directed through this SC from now on.

6. ABFRP STAGES

From the work organization point of view, three different stages of progressive integration will respectively start in 1989, 1995 and 2000 as it is shown in graph N° 1.

Since up to now the independent programs of Brasil and Argentina have been rather complementary, in the first stage each country will continue with the tasks already started. However, during this period there will exist a free and complete exchange of results and use of the facilities to be built under the ABFRP auspices, promoting the active participation of experts and technicians of each country in the tasks performed at the other.

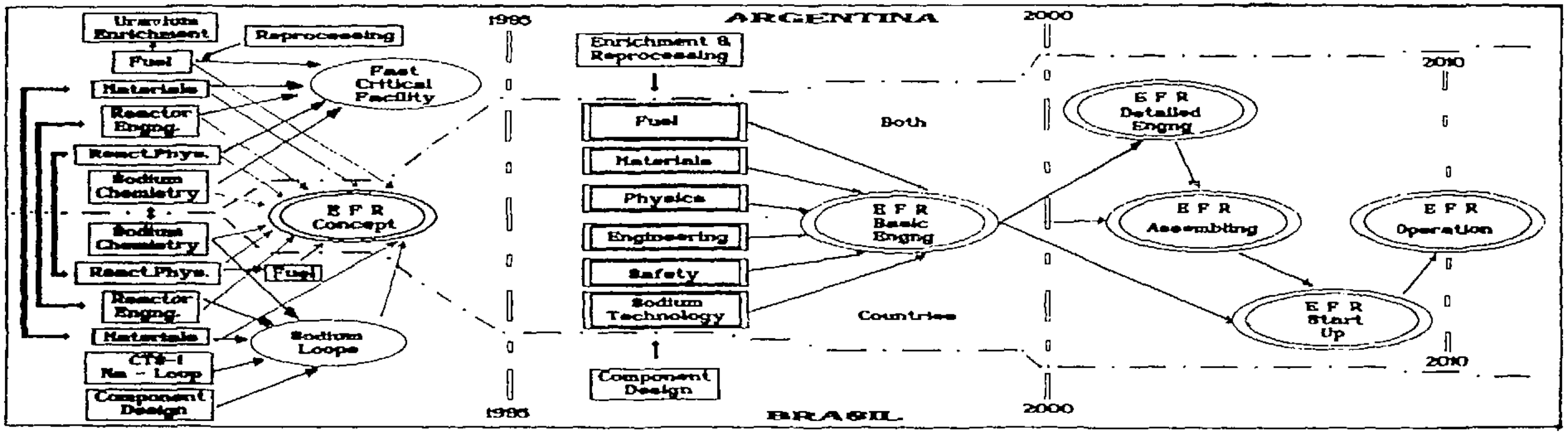
Brasil will then give priority to the "Sodium Technology" and "FBR Engineering", and a less important attention to the other areas, whereas Argentina will concentrate efforts on "Reactor Physics" and "Fuel, Radiochemistry and Materials", with little activity in the other areas.

Therefore, during this first stage, Argentina will carry-on the project and construction of a Fast Critical Facility with expected start-up by the end of 1995.

To achieve this objective Argentina is improving and developing neutronic calculation methods, nuclear instrumentation, fuel, control algorithms, materials for control rods, safety analysis, metallurgy of stainless steel in contact with sodium , all these items related to the FCF.

Meanwhile Brasil is concerned with mounting, testing and operation of several sodium circuits, (with a foreseen startup in 1990). Related to these facilities will be sodium thermalhydraulics, processes instrumentation, phase transitions, sodium analysis and purification, components cleaning, sodium handling, sodium-water reactions and fire prevention and fight, structural mechanics, pumps and valves performance. Boron enrichment, reactor calculations and other less related activities are also foreseen.

These tasks will be financed by the home country, including the costs arising from the cooperation of technicians from the other one.



Graph No. 1 Progressive Integrating Stages

The organization of tasks is also a decision of the home country during the first stage.

For instance in Argentina it was decided to adopt a matrix system where the Research and Development tasks are assigned to already existing groups and labs inside or outside CNEA by means of work contracts. The managing of the program is itself a part-time task.

In Brasil, rather differently, the Reactor Dept. (DERE) of IEN executes most of tasks. DERE is divided in five Divisions, namely: Physics Div. (DIFIR), Sodium Division Technology (DITRA); Thermalhydraulics Division (DITRE); Liquid Metal Division (DIMEL) and Structural Analysis (DIMEC).

There is however some work to be started and performed in common during this first stage, which is the concept design of the EFR. This will be the first step towards the stronger integration which is expected to take place during the second stage of ABFRP as indicated in graph N° 1. In the second stage most of the work will be performed by binational teams.

A complete definition of the 2nd and 3rd stages will be written in the future, based on the evolution of the first one.

7. SCHEDULED TASKS FOR 1989/1990

7.1. Argentina

a) Concept design of FCF, including fuel, core,control rods, instrumentation and control.
b) Development of Instrumentation and detectors.
c) Implementation of B_4C sinterizing techniques.
d) Preliminary siting analysis.
e) Safety standards adaptation.
f) Experimental training.
g) Speed-up of LPR mounting.
h) Mox fuel development, increasing Pu content in presently developed fuel for Pu recycling.
i) Research on carbide, nitride and metallic fuels.
j) Implementation of sodium purification and analysis techniques.
k) Completion of enrichment capacity, which is the major target, because U235 (at probably 40%) is needed for the FCF initial core.

7.2. Brasil

a) Sodium Chemistry
b) Components cleaning
c) Sodium handling and safety
d) Operation of CTS-1 sodium loop
e) Enriched boron production
f) Reactor physics studies
g) Structural analysis for high temperatures
h) Instrumentation development
i) Assembling and set-up of the three sodium loops and auxiliary systems, namely:

SS 10 - Sodium feeder
SS 10 T - Sodium liquifier
SS 20 - Equipment for component cleaning
SS 30 - Handling chamber under argon atmosphere
SS 40 - Static sodium loop
SS 50 - Small component testing loop
SS 60 - Medium and large component testing loop

The civil works for housing these loops are ready, all the components are stocked there, and their assembling will start as soon as financial support is obtained. This will be IEN'S major goal during the next period.

8. RESOURCES

8.1. Economic Resources

It is expected that the total budget for the three stages would be around 500 Million dollars, to which Brasil and Argentina will contribute equally .

This amount will be divided in 50, 100 and 350 million dollars for the first, second and third stages of the program respectively. However, both goverments must make successive decisions regarding the allocation of these amounts.

As it has been mentioned before, the financial situation of both countries is far from healthy, therefore making it difficult to give a clear definition on this aspect.

8.2. Human Resources

The organization of work in Brasil makes it easy to define the involved human resources. Presently there are at DERE more than 30 senior level scientists and engineers and 15 trained technicians directly involved with the Fast Reactor Program. Most of them have been trained through agreements with Germany, France and Italy. Two other Departments. of IEN (Instrumentation and Control and Metallurgy) also contribute a substantial number of part-time personnel.

Outside CNEN, the ABFRP may be assisted by the following institutions:

a) Advanced Studies Institute (IEAv) at San José dos Campos, where about 8 senior scientists work on basic studies related to fast core reactor physics. Here exists a very good nuclear data bank.

b) Scientific Computation Laboratory (LCC), at Rio de Janeiro, specialized in structural analysis and non linear phenomena.

c) Post-Graduate Coordination Programs (COPPE) at Rio de Janeiro Federal University. Master and PhD theses in nuclear engineering.

d) Post Graduate Courses at the Military Engineering Institute (IME) and at the Pontifical Catholic University (PUC), both at Rio de Janeiro, with students doing thesis work on related subjects.

In Argentina, as mentioned above, work organization is rather different. The participation of the personnel in this program is on a part-time basis, that is, there are no fast reactor specialists in the strict meaning of the word. However, there are specialists in core reactor physics. Most of the participating groups have senior technicians.

The program is headed by a team of five PhD's. from the Bariloche Atomic Center (CAB) allocating work contracts to mainly the Nuclear Engineering Dept and the Applied Research Dept (at CAB); the Processes Development Dept, the Fuel Dept and the Materials Dept at Constituyentes Atomic Center; the Instrumentation and Control Dept and the Safety and Radiological Protection Directorate at Ezeiza Atomic Center. There are also other CNEA Departments occasionally involved in the program. There are about 50 senior scientists and about 30 trained technicians involved part-time with FBRs research.

In addition, the Instituto Balseiro in Bariloche will contribute to the enlargement of personnel through Master and PhD theses programs in Nuclear Engineering.

Two subsidiary companies from CNEA group, ENACE (nuclear engineering), and INVAP (applied research and technology) are planned to take part in the program, the latter being the architect-constructor of the recently inaugurated Algerian reactor and the main contractor of the CAREN project.

9. CONCLUSIONS

The ABFRP is just born and, as all binational programs, its first years are expected to generate adaptation problems. Overcoming these is an endeavour for which Brasil and Argentina have great hopes.

This is an important enterprise for both countries and therefore for South America, due to reasons of very diverse nature, i.e. industrial development, future primary resources savings, energetic sovereignty, regional distention and peace, etc.

These facts, and the possible opening of future markets, should be noted by the IWGFR countries. Their help and support could be important for the ABFRP success. The mere acceptance of ABFRP as an observer in this Forum has been seen as very promising.