STATUS OF FAST REACTOR ACTIVITIES IN BRAZIL

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Abstract

This text describes the present status of fast reactor activities in Brazil, emphasizing the strategies being used to preserve this reactor concept as a viable alternative for future electricity generation in the country. The program is mostly research-oriented and has the objective of establishing a consistent knowledge basis which can serve as a support for the transition to the activities more directly related to design, construction and operation of an experimental fast reactor. Due to the present economic difficulties, the program is still modest but it is gradually growing. A report which has been finalized in December, 1995 and submitted to the authorities indicates the existence of the grounds for enlarging and consolidating the program.

1- Introduction

Brazil is a large country, with a population of a little more than 150 million distributed on its 8,5 million square kilometers. The "per capita" electricity consumption is of the order of 1500 kWh, a value which is low when compared to most advanced countries. Around 95% of the electricity come from hydric resources, most of them located in the southeast region of the country. The estimated hydroelectric potential is 260 GW, from which around 60 GW is being used. A recent study made by the Brazilian Federal Energy Board -ELETROBRÁS-, which takes into consideration different scenarios for economic growth, the resources available today and also the possibility of exploiting new resources, indicates that in the second decade of the next century the hydroelectric potential will be exhausted and, from that time on, the demand will have to be supplied by a growing number of thermoelectric power plants, either conventional or nuclear.

Brazil has presently one reactor (PWR/Westinghouse, 626 MWe) in operation and a second one (PWR/Siemens, 1300 MWe) has recently received authorization for completion, which is planned for 1999. A third reactor (PWR/Siemens, 1300 MWe), originally planned to be assembled in the same site as the other two is still awaiting for a government decision to its construction, amidst discussions related to construction costs and the benefits of nuclear energy. Although the participation of nuclear energy in the electricity grid is still very small (less than 1%) and hydroelectricity is potentially abundant, our view of the future indicates that a fast reactor program should be consolidated in order to provide a consistent basis for discussing the utilization of fast reactors for future electricity generation in the country.

Only recently the Brazilian economy is giving signs of stabilization, after a long period of very high inflation rates. Also, both internal and external national debts resulted, among other things, in a reduction of the investments in nuclear power Research and Development (R&D) activities. Considering the future importance of fast reactors, all efforts have been made in order to keep this option alive, in spite of the tight budgets. As a result, the fast reactor program is small and the plans for its growth (which is to be gradual) envision to avoid an excessive demand on the already scarce financial resources, which could increase the risk of its discontinuation, as it happened with the past fast reactor activities in Brazil.

2- Historical Background

In 1969, the Instituto de Engenharia Nuclear-IEN (Nuclear Engineering Institute) initiated its activities related to fast reactors. As part of a contract with TECHNICATOME (France), a thermal-fast reactor has been designed, but it was not constructed due to problems with fuel supply. In 1972, a small sodium loop (100 kW) was inaugurated for studying heat transfer and several aspects of sodium technology and is still in operation.

In 1981 a decision to intensify the activities in fast reactors resulted in a cooperation agreement with ENEA (Italy), mainly for training in several areas. Also a contract with ANSALDO/NIRA (Italy) was signed to design and construct three modern sodium loops and auxiliary systems. Due to insufficient funding the loops were never constructed. Discussions are presently taking place with the aim of assembling one of the loops, which is capable of serving as a bed for experiments related to sodium purification and transferring.

In 1985, a new technical cooperation agreement was signed, now with Argentina, for a joint work in the fast reactor area. Many discussions took place, but nothing has been done, mainly due to the fact that discussions were too focused on the design and construction of an experimental fast reactor, which neither Brazil nor Argentina needed at that time.

At the Instituto de Estudos Avancados-IEAv (Advanced Studies Institute), fast reactor activities were initiated in 1979, when a technical group has been created with the objective of doing research on the utilization of nuclear reactors for space applications, with the main focus on neutronics and thermal-hydraulics. That work gave the group a better understanding of the importance of fast reactors for electricity generation. It was then decided to re-direct the work towards investigating different fast reactor core and blanket configurations for efficient utilization of Thorium, due to its large resources in Brazil (estimated: one million tons). Several ideas came up and a good number of technical papers have been published. In 1988, fast reactor activities at IEAv were discontinued not only because of the lack of an well-defined long term program, but also due to the many difficulties in having the participation of other research institutions in Brazil, mostly involved with thermal reactor work.

The main reasons for all these setbacks can be also associated to the following: a) the initiatives were isolated, with no search for institutional cooperation; b) the country has been, for a long time, going through economic problems; c) the public opposition to nuclear energy was high and; d) there has been too much emphasis on the reactor itself, with no emphasis at all on the scientific and technological gains which would result from a fast reactor program with multi-disciplinary characteristics. These factors, and maybe some others, have never stimulated the "decision makers" to take seriously a long term and certainly costly R&D fast reactor program.

In 1992, after many discussions, we succeeded in convincing the authorities that a long term fast reactor program should be maintained, even with modest proportions, if the country wished to keep this reactor concept as an alternative for a future use. A long term R&D project was then established with the objective of having, within 25-30 years, an experimental reactor in operation, in which relevant experiments could be performed. For this program, the cooperation among institutions would be a key factor.

Between 1992 and 1995 efforts have been directed to what we called <u>Feasibility Phase</u>, which had, among others, the objective of submitting to the Brazilian authorities a detailed report composed of six parts: 1) Global View; 2) Reference Design (Primary Circuit) for an Experimental Fast Reactor; 3) Survey of Brazilian Research Institutions; 4) Survey of Brazilian Industrial Park; 5) Survey of Brazilian Universities and; 6) Preliminary Planning for Next Phases. This report, which has been finalized in December, 1995 and is presently being analyzed by the authorities, shows the potential for enlarging the present group of activities and also for including others which have been left aside, mainly due to the shortage of people.

3- Managerial Strategies

As a general rule, countries with fast reactor programs justify them based on the fact that this class of reactors, among other things, utilize more efficiently the uranium resources. For those countries this represents a good argument, because it is supported by the considerable participation of thermal reactors (which lead to a rather inefficient uranium utilization) in their electricity grids. The arguments related to the generation of less waste (in fast vs. thermal reactors) follow the same line of reasoning. Although these arguments may be consistent for some countries, for Brazil they sound a bit anachronic, due to the present very low participation (less than 1%) of nuclear energy in the electricity grid, with an insignificant demand on our uranium resources, estimated in 200,000 tons.

For some years we have tried to consolidate a fast reactor program using the arguments of Japan, United States, France and others: the main focus was on the reactor and the efforts were almost uniquely devoted to the development of conceptual designs, some of them very interesting but incapable of strongly motivating the Brazilian "decision-makers" and also a large part of the nuclear community. The reason for this is very simple to understand and can be attributed to the generalized perception that the only "product" of the program would be the reactor, whose necessity is, in principle, distant in the future. The belief that "decision-makers" are more efficiently convinced by facts rather than by arguments which certainly will be irrefutable in the future but sound vague and difficult to be evaluated today, have made us switch, in 1992, to a strategy in which the efforts towards the materialization of the reactor would be temporarily de-emphasized in favor of research-oriented activities in areas such as safety analysis, materials, fuel recycling and others, in order to show that a fast reactor program can produce, along its way, important scientific and technological gains for the country. This strategy should be associated to the generation of the maximum number of important and easy to be evaluated results which could be useful not only for the fast reactor program itself but also to other sectors.

The "environment" which prevailed at the beginning of the Feasibility Phase was characterized by tight budgets and also by a strong disbelief from a large portion of the Brazilian nuclear community with respect to big projects. In order to minimize the chances of a new setback, we also decided to establish the following group of strategies:

- **For motivating the internal technical team:** the project is to be conducted in phases of duration no longer than 3-4 years, with the objectives for each phase being defined in such way as to create a feeling that they can be reached, even with the present economic difficulties.

- **For motivating the participation of other research institutions:** the approximation with the institutions must emphasize the several technical challenges in areas such as reactor safety, fuel, materials and so on, and to avoid (at least until the program is entirely consolidated) discussing merits of fast reactors with a community biased towards thermal reactors.

4- Present Status

Research activities are being underway in the following areas:

1. U-Zr alloys are being studied in cooperation with the Instituto de Pesquisas Energéticas e Nucleares-IPEN (Nuclear Research Institute), with the objective of learning how to fabricate and characterize them, in laboratorial scale;
2. Also with the same Institute, metal fuel recycling is being investigated using electrorefining techniques. We expect very soon to have a first sample of actinide electrodeposited;
3. A laboratorial scale direct current electromagnetic pump has been developed and it is being tested at IEAv, using mercury as working fluid. Work is continuing towards its optimization and also towards the development of a small scale alternating current pump;
4. Activities related to HT-9 ferritic steel have been initiated in cooperation with IPEN and with the Instituto de Pesquisas Tecnológicas-IPT (Technological Research Institute). A first sample is presently being characterized;
5. A small thermal-hydraulic nuclear laboratory was set within a collaboration between IEAv and the Instituto Tecnológico de Aeronáutica-ITA (Aeronautic Technological Institute), in order to perform experiments related to natural convection phenomena. ITA is an engineering school, which implies that beyond the technological research aspects, also the educational ones are involved. An

experiment for validation of the thermal-hydraulic code NACISS is planned to be initiated in the first semester of 1996;

6. A reference design for the primary circuit of a 60 MWt experimental fast reactor is completed. Some parameters and characteristics have been selected mostly based on the Integral Fast Reactor (IFR) concept. Fuel pin dimensions and other data were used for calculations which lead to a general core configuration. Some calculations were also independently performed at IEN, and the differences in methodologies are being evaluated.

Together with the above activities there are some others related to shielding analysis, actinide burning calculations, electromagnetic pumps and the development of a software for simulating the fast reactor circuits.

5- Final Remarks

The consolidation of the present fast reactor activities in Brazil must contemplate both the achievement of important technical results and also a step-by-step dissemination of a "fast reactor culture", with the objective of increasing the number of people who can evaluate the importance of fast reactors on a more rational basis. In order to establish a fast reactor "culture" we have been, among other things, stimulating the participation in as many technical meetings as possible, even in the ones which are not entirely devoted to nuclear energy. From 1992 to 1995, about 25 articles have been either published or presented in those meetings, with good receptivity.

So far, we have been successful in getting the cooperation of excellent technical groups, from different research institutions, by proposing their involvement in activities which may represent a challenge to their technical expertise. We are aware that there is still a lot to be done and also a lot to be learned, mainly from the countries with more advanced fast reactor programs. In this respect, the recently signed technical cooperation agreement between Brazil and India may represent an important starting point.

It is our feeling that continuation of fast reactor activities in Brazil depends upon the strengthening of the cooperative work already initiated, and also on the generation of observable results which can easily be evaluated by our "decision makers". All efforts have also been made to convince them that an operating reactor is not the only relevant outcome of a fast reactor program. This is the main reason why we have decided to consolidate it on the basis of research-oriented activities rather than on activities strongly directed towards reactor design.

Following the Feasibility Phase, which ended in December, 1995 we intend to increase the level of details of the Reference Design. Considering that an operating experimental reactor is still distant in the future, for all purposes the Reference Design is our "experimental installation" and is to be used as the basis for calculations related to safety analysis, neutronics, thermal-hydraulics and so on. Experimental and theoretical research activities are also to be continued in a few areas, in order to produce results that can used both for the long term objectives and also as assets for larger medium term funding.

Finally, it must be emphasized that even modest or small programs from developing countries may give an important contribution to the fast reactor field, mainly through intellectual work and also through the execution of a few experiments. Our long-term objective is to establish a basic know-how which can be useful for an eventual transition to fast power reactors in Brazil. The interaction with the more advanced programs can serve as a guide, allowing us to reach a degree of maturity which will result in benefits both to Brazil and also to the international fast reactor community.