IAEA-SM-310/ 74

RATIONALIZATION AND FUTURE PLANNING FOR AECL'S RESEARCH REACTOR CAPABILITY

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ABSTRACT

AECL's research reactor capability has played a crucial role in the development of Canada's nuclear program. All essential concepts for the CANDU reactors were developed and tested in the NRX and NRU reactors, and in parallel, important contributions to basic physics were made. The technical feasibility of advanced fuel cycles and of the organic-cooled option for CANDU reactors were also demonstrated in the two reactors and the WR-1 reactor. In addition, an important and growing radio-isotope production industry was established and marketed on a world-wide basis.

In 1984, however, it was recognized that a review and rationalization of the research reactor capability was required. The commercial success of the CANDU reactor system had reduced the scope and size of the required development program. Limited research and development funding and competition from other research facilities and programs, required that the scope be reduced to a support basis essential to maintain strategic capability.

Currently, AECL is part-way through this rationalization program and completion should be attained during 1992/93 when the MAPLE reactor is operational and decisions on NRX decommissioning will be made. A companion paper describes some of the unique operational and maintenance problems which have resulted from this program and the solutions which have been developed.

Future planning must recognize the age of the NRU reactor (currently 32 years) and the need to plan for eventual replacement. Strategy is being developed and supporting studies include a full technical assessment of the NRU reactor and the required age-related upgrading program, evaluation of the performance characteristics and costs of potential future replacement reactors, particularly the advanced MAPLE concept, and opportunities for international co-operation in developing mutually supportive research programs.

The growth and maturing of the nuclear industry has not reduced the need for a strong and flexible research reactor capability. The Canadian program has been fortunate in developing the NRX/NRU reactor combination, and careful planning will be required to maintain this strength for future application.

1. INTRODUCTION

This paper reviews the current planning and studies being undertaken to secure a future research reactor capability for Atomic Energy of Canada Limited (AECL). This capability also provides an important resource for the Canadian nuclear industry and the University research community.

AECL is currently mid-way through a Research Reactor Rationalization Program which was implemented early in 1985. This program will be completed during the 1992/93 fiscal year and will define AECL's research reactor capability during the 1990's. Current planning and studies are part of a program which will provide the future capability for the early decades of the next century.

2. RESEARCH REACTOR RATIONALIZATION PROGRAM

In the early 1980's AECL owned and operated two zero-power critical facilities (PTR, ZED-2), three prototype power reactors (NPD, Douglas Point, Gentilly-1) and three research reactors (NRX, NRU, WR-1). Table I below gives the characteristics of the three research reactors.

TABLE I

AECL Research Reactors

Reactor	Power (MWt)	Coolant	Moderator	Fuel	First Power
NRX	42	LW	HW	HEU-Al	1947/07
NRU	135	HW	HW	HEU-Al	1957/11
WR-1	60	ORG	HW	UC, 1.8%	1965/11

LW-Light Water, HW-Heavy Water, ORG-Organic Coolant

Since that time, all three prototype power reactors have been shut down and decommissioned. The two critical facilities are still in operation, but the research reactor capability has been reduced as part of a rationalization program.

2.1 Rationalization Program

Development of the program started in 1984, when it was recognized that a review and rationalization of the research reactor capability was required. There were a number of factors important in shaping the program.

1. The successful operating and maintenance record of the CANDU reactor system had reduced the scope and size of the development program required to support the current design of power reactor. In parallel, the slowdown in the world-wide nuclear construction programs had reduced the need for and pace of development of advanced types of reactor and fuel cycles. Consequently, the facilities available in the three reactors were not being utilized to full capability.

2. Funding for fission reactor research and development had peaked and was beginning to decline. It could be foreseen that the operating and maintenance costs for the reactors and other research facilities under construction would consume an increasing fraction of the available funds, and impact adversely on the amount available for direct research and development activities. Consequently, while maintaining an adequate research reactor capability, the associated costs must be reduced.

3. An important and growing radio-isotope production industry was being established to serve a world-wide market. This activity required that at least two reactors were available to provide short-lived isotopes (one as primary producer, and the other reactor as backup to cover primary reactor outages).

4. A new type of multipurpose research reactor was under development. This MAPLE reactor (Multipurpose Applied Physics Lattice Experimental) combined the advantages of a pool-type compact core associated with light-water cooling, with a large volume of irradiation space resulting from the use of a heavy water radial reflector. (This reactor is described in a companion paper [1]). Construction of an initial reactor could meet some of AECL's future needs, as well as providing a demonstration facility which may interest other organizations who were also replacing or expanding their research capability.

The result of the studies was a rationalization program with four components;

- mothball the WR-1 reactor (with the potential to restart or eventually decommission),
- maintain the NRU reactor as the prime research reactor capability,
- construct a MAPLE reactor to demonstration the technology and provide the prime capability for production of short-lived isotopes,
- maintain the NRX reactor in a hot standby mode to provide backup isotope production capability while the MAPLE reactor was being constructed and then decommission.

2.2 Current Status

Currently AECL is part-way through this program and completion should be attained during the fiscal year 1992/93.

- The WR-1 reactor was shut down during 1985, and a recent decision has been made to decommission the facility.

- NRU is operating at high operating efficiency, providing research and development services as well as being the prime isotope producer.

- Design of the MAPLE reactor is more than 75% complete and procurement of the major components is underway. Major construction will start in spring of next year. The project has been the subject of two major reviews (1987 and recently in 1989) and a recent decision of the Board of Directors has confirmed the decision to complete the program.

- The NRX reactor is being maintained in a hot, standby condition to provide backup isotope production capability. A companion paper [2] describes the operational methods which have been developed to deal with the problems of an aging reactor and maintain low operating costs.

Overall, the program is meeting the strategy and objectives developed in 1984. This program and other steps have resulted in a reduction in operating costs of approximately $16 million [2] and they are now 58% (in constant dollars) of the 1985 level.

3. FUTURE REQUIREMENTS

The impact of the rationalization program has been to reduce the AECL research reactor capability from three facilities to one. The capabilities of the NRU reactor will satisfy most of the needs of the pure and applied research community in the 1990's together with support for other associated commercial activities.

The reactor, however, is aging (over 32 years old) and will require future repair and refurbishment to maintain safe and efficient operation. Future upgrading will also be required to meet the changing and more demanding needs of the researchers, as well as keep abreast of current licensing requirements. While NRU can meet AECL's requirement during the 1990's, a major issue is whether the reactor is a suitable vehicle on which to plan AECL's capability for the early decades of the next century. Part of the answer to this question lies in the expected future role of research reactors in the next century.

3.1 The Environment in 2010

Long-range planning requires that the expected future environment be analyzed to provide direction for both strategy and investment. Currently a 20-year perspective is being developed, and by 2010 it is expected that there will be a strong resurgence in the pace of nuclear power installation and use. This will be fuelled, not only by economic considerations, but also by environmental concerns about alternative energy sources, and the perception that fission power is a long-term sustainable technology.

Arising from this environment, it is expected that AECL's activities will be influenced by three dominant features,

- a continuing strong nuclear technology focus,
- a strong associated pure research program, and
- commercial exploitation of the technologies developed.

In turn, these features will require that the researchers have access to major facilities with world-class characteristics and designed to be beneficial to a broad range of R&D programs ranging from pure scientific research to applied R&D.

3.2 Research Reactor Characteristics

With a continuing strong focus on fission power, it is expected that future facilities will require capabilities similar to those available today. The needs can be grouped into seven major areas:

- the ability to provide tailored beams of neutrons for pure research work in condensed matter physics and also commercial applications (e.g. neutron radiography),
- facilities to investigate the behaviour of new materials in the Advanced CANDU nuclear environment (e.g. to study corrosion, deuterium uptake, water chemistry, material fracture properties and deformation),
- facilities in which to test new advanced fuels and their behaviour under power manoeuvering conditions,
- facilities in which to test new components (e.g. pressure tubes),
- facilities in which to test new fusion breeder blanket materials,
- facilities to test fuel behaviour under abnormal conditions (e.g. Blowdown Test Facility [4]),
- facilities to produce radio-isotopes.

Many of these needs can be satisfied by similar research reactor capabilities (e.g. high fast and thermal neutron fluxes) but can also place differing emphasis on reactor operating characteristics and schedules.

4. CURRENT PLANNING AND STUDIES

To develop a long-range plan to meet future needs, a number of activities are currently underway.

4.1 Technical and Safety Assessment of NRU

Planning for a major technical and safety assessment of NRU is currently underway. The objectives are to:

- determine what safety improvements are required and to provide a safety justification that will enable the reactor to remain licensable at least to the year 2010,

- establish what refurbishment and upgrading needs to be done, and the associated schedule, to enable continued operation of NRU until at least 2010,

- estimate the associated costs (capital, operating and maintenance).

It is expected that the full assessment will take three years and requires a dedicated effort of approximately 60 person-years. The program, however, is divided into three phases and after phase 1 has been completed (towards the end of 1990) it is expected that sufficient information will have been collected to start comparison with other options (described below) and make decisions whether to proceed with the later phases.

4.2 Evaluation of Potential Replacement Reactors

Alternatives to continuing with the NRU reactor are also being evaluated. In particular, attention is being focussed on a 50 MWt advanced MAPLE concept, [3] which builds on the technology being developed by AECL for the current MAPLE-X10 project.

Studies include investigating the ability of the reactor to supply the multipurpose functions described earlier in Section 3. Both capital and operating costs will also be estimated with a target for completion by late 1990. These data, and information on other alternatives will then be compared with similar information being developed by the NRU technical assessment, described above.

4.3 International Cooperation

AECL is already utilizing the capabilities of other reactors to meet those needs which cannot be supplied by NRU, particularly ultra-high fast neutron irradiation of materials. Other areas being investigated include,

- joint studies with other countries, who also need replacement reactors, to explore the possibilities of a common development program,

- participation in international groups studying the development of advanced neutron sources,

- studies on enhanced utilization of off-shore reactors or development of mutually supportive reactor programs.

Results of these studies cannot currently be scheduled, but the status will also be factored into the decision-making process.

4.4 Factors

The future program will be shaped by a number of factors including the perceived needs, the overall costs and potential for attracting a broad range of funding support, and the opportunities available for international cooperation. Two other factors will also influence the nature of the program.

National review - currently a national review is being conducted by both federal and provincial agencies with a view to rationalization of the Canadian nuclear industry. This is similar to reviews being conducted in other countries. It is expected that the review will confirm the commitment to retention of the CANDU nuclear option and, hence, the need to maintain a strong major facility capability. It may also, however, broaden the range of participants in the decision-making process.

Multi-versus single-purpose facilities - past Canadian perspectives on research reactors have been shaped by the design use of heavy water as a moderator in the core design. Prior reactors have been relatively large both in terms of power output, core length and overall core volumes. This has facilitated the development of multi-purpose use. However, future designs based on the MAPLE concept will have more compact, shorter cores and there is an economic incentive to keep core power as low as possible to minimize fuelling costs. For the future, more emphasis will be placed on evaluating the relative merits of a large multipurpose facility relative to a number of smaller, limited-purpose ones.

5. SUMMARY

AECL is mid-way through a research reactor rationalization program initiated in 1985. The net result has been to effectively reduce the number of operating reactors in support of R&D from 3 to 1. A new reactor, based on the MAPLE concept, is currently being constructed, which could provide the basis for future replacement reactors. Completion of the rationalization program will occur in the early 1990's, and AECL will rely on the NRU reactor to support the R&D program for the rest of this century.

Planning and investigations are currently underway to define the long-range program for AECL's research reactor capability in the early decades of the next century. Options include continuing with the NRU reactor; constructing a replacement reactor based on the Advanced MAPLE concept, and the opportunities provided by international cooperation. Results from these studies should start to become available in late 1990 and the major features of the long-range program should then begin to emerge.

6. REFERENCES

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[3] LIDSTONE, R.F. et al., The Advanced Maple Reactor Concept, Rep. AECL-9870, Atomic Energy of Canada Limited, 1989 January.

[4] MacDONALD, R.D., The Canadian In-reactor Test Program in Support of Reactor Safety, IAEA-SM-310/102, 1989 October.