POLICY ISSUE
(Information)

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SECY-94-079

FOR: The Commissioners

FROM: James M. Taylor
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SUBJECT: SCHEDULE AND RESOURCE ESTIMATES FOR CANDU 3 DESIGN CERTIFICATION REVIEW

PURPOSE:

To inform the Commission of the staff estimate of the Office of Nuclear Regulatory Research (RES) and the Office of Nuclear Reactor Regulation (NRR) resources and review schedules required to certify the CANDU 3 reactor design.

BACKGROUND:

In SECY-93-104, "Program Analysis and Recommendations Concerning the NRC Review of Advanced Reactor and CANDU 3 Designs," dated April 20, 1993, NRC staff summarized the status of NRC preapplication reviews of advanced reactor designs, including CANDU 3. Following its review of SECY-93-104, the Commission, in its staff requirements memorandum (SRM) of June 9, 1993, directed the staff to estimate the RES and NRR resources (staff and funds) that would be required to certify the CANDU 3 reactor design, and to plan the associated certification review schedule. The SRM directed the staff to identify available resources and to determine additional resources it would need to complete certification.

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In order to respond to the SRM, the staff examined the past and projected resource expenditures for reviews of advanced light-water reactor (ALWR) designs, as well as the understanding developed over the past 18 months on the preapplication review for the CANDU 3. The efforts examined as a basis for developing NRR's estimates for the CANDU 3 review included the two nearly completed safety reviews for the evolutionary reactor designs (General Electric's advanced boiling water reactor (ABWR) design and ABB-Combustion Engineering's System 80+ design), as well as the ongoing reviews for the advanced passive designs, Westinghouse's AP600 and General Electric's simplified boiling-water reactor (SBWR).

The RES confirmatory research that is being recommended is based on the identification of important aspects of the CANDU 3 design, a review of existing data bases, and an assessment of modifications needed in NRC's analytical computer codes.

DISCUSSION:

At present, Atomic Energy of Canada Limited Technologies (AECLT) anticipates that it will submit an application for certification for the CANDU 3 design in the summer of 1994. Although there is some uncertainty about when a certification application will be filed, the staff expects submittal in late FY94. NRR is working with AECLT before the formal design certification application is submitted to ensure that the information required by 10 CFR Part 52 Subpart B will be submitted as completely as possible before the staff begins its review. The staff plans to continue working on the advanced designs on schedules that are consistent with the receipt of the applications. That is, the priorities are the ABWR and System 80+ then the AP600 and SBWR for which resources have been budgeted in both NRR and RES. Consistent with previous Commission guidance in the SRM on SECY-93-104, the NRR staff has maintained a low level of effort aimed at maintaining technical cognizance of key technical issues and expanding staff knowledge of the CANDU basic design principles. There are presently two technical staff members and one project manager working essentially full time with the CANDU 3 review. Additionally, NRR has been familiarizing other technical review staff with the CANDU 3 technology.

Since the CANDU 3 application for design certification is expected in 1994, the staff does not plan to continue the previously planned preapplication safety evaluation review identified in SECY-91-161, "Schedules for the Advanced Reactor Reviews and Regulatory Guidance Revisions." Instead, as outlined in the FY 1994-1998 Five Year Plan, the staff is continuing activities to prepare for a CANDU 3 design certification application by: maintaining cognizance of the design; continuing staff familiarization with the design; maintaining technical progress on key issues; and conducting computer code development and benchmarking.

The NRR CANDU review is expected to take longer to complete than the schedule provided in SECY-93-097, "Integrated Schedules for the Evolutionary and Advanced Light Water Reactor Projects." The milestones in SECY-93-097 for the ALWRs are not considered to be applicable to CANDU 3. For reviewing the ALWRs, the staff has had the benefit of years of experience with the design, operating, and licensing characteristics of such plants. Although the passive plants are a departure from current operating plants, they still involve such familiar features as vertical cores and off-line refueling. Therefore, the staff expects that the CANDU 3 review will take about 54 months from the time the detailed certification review begins until the final design approval is issued. The extra time for the review would be consumed by more extensive requests for additional information, resolution of policy issues, and more Advisory Committee on Reactor Safeguards (ACRS) meetings.

The NRR review effort required to certify a CANDU 3 design should be roughly commensurate with the effort expended for the ABWR design certification review. The NRR ABWR certification effort has required approximately 70 direct FTE and $1 million in technical support through FY93; this is expected to reach 100 FTE by the time the FDA is issued. The benefits that would normally be anticipated from recent staff experience on other reviews may be offset by the uncertainties associated with a first-of-a-kind review of Canadian heavy-water technology, differences between Canadian and U.S. design philosophies, and construction codes and standards, and the staff's lack of experience with heavy-water designs.

In order for the staff to have a comparable level of confidence in the results of its review, sufficient testing, confirmatory analysis, and analytical code development need to occur. This information needs to be available for the staff to use in its review. The RES confirmatory research recommended for the CANDU 3 review is consistent with what has been done to support the review of the passive designs and is based upon work done over the past 18 months by staff and contractors looking at the design, key safety issues, and the data base of information available to support CANDU 3. The staff recommends that confirmatory research be done in the following areas: (1) severe accidents, (2) source term, (3) thermal hydraulics, (4) reactor physics, (5) probabilistic risk assessment, (6) fuel behavior, and (7) materials and structural methods. This will give the NRR staff an independent capability for assessing the CANDU 3 design in key areas affecting reactor safety. The proposed research program is outlined in Enclosure 1.

RES resource estimates are based upon the need to modify existing NRC codes to enable NRR to perform independent severe accident, thermal hydraulic, and reactor physics analyses of the design, and the potential limited use of the Canadian test facilities to satisfy experimental confirmatory needs. RES estimates that it will take five years to complete the CANDU 3 tests, code development, and analytical support (i.e., plant calculations). It should be noted that AECL will supply all testing and computational analyses required

to support certification. The RES efforts will be limited to confirmatory research. The total RES resource requirements are estimated to be 23 direct FTE and $18 million for contractor support. The year-by-year breakdown of resources to meet the above approach is shown in Enclosure 2. (It should be noted that the staff is preparing a separate submittal in response to a staff requirements memorandum dated January 7, 1994, related to the results of the fee study (SECY-93-342). Information on the cost of research which may benefit a small number of advanced reactor vendors or licensees who are not charged will be included).

NRR resources have not been budgeted for a certification review of the CANDU 3 application. If an application is received in FY94, the staff would propose the following approach for the review:

1. NRR would perform an acceptance review with previously budgeted resources in FY94. This amounts to about 5 direct FTE. These were the resources previously planned for the preapplication efforts.

2. NRR would begin the detailed review with the budgeted resources in areas not impacted by the need to perform testing or code development, such as human factors and electrical power systems. This is about 10 direct FTE in FY-95 (5 FTE are identified in the FY 1994-1998 Five-Year Plan for CANDU 3 - related activities, the remaining 5 FTE will be reprogrammed). To the extent possible, the staff will identify, early in the review, what research needs to be provided by AECLT to support the CANDU 3 certification application. The schedule for the FDA would be based on a start of detailed review in FY96.

3. The remaining detailed review would begin in FY96 and would be consistent with the research, testing, and code development efforts already budgeted in FY96-98 by RES as discussed below.

The RES resource estimates contained in the FY 1994-1998 Five-Year Plan do not include resources for CANDU 3 confirmatory research until FY96. These Five Year Plan values were based on estimates of confirmatory research made prior to completion of the RES preapplication activities on CANDU 3, and current estimates, as shown in Enclosure 2, are somewhat different. The revised resource and FTE estimates in Enclosure 2 are based on the current planned scope of RES activities; the revised estimates confirm the need for approximately a 5 year period in which to complete the research activities. The availability of RES resources in FY96 to begin work on CANDU 3 assumes that the current schedules for completion of the confirmatory ALWR research do not slip.

The schedule and resource projections assume that the NRR staff will not encounter unanticipated problems in the course of the review that might require additional testing or computational analysis by the vendor or additional confirmatory research by RES. The projections also assume there will be no unanticipated difficulties in completing the confirmatory research as

planned. Should such additional issues arise, additional time and resources could be required.

The above analysis leads the staff to conclude that:

1. The CANDU 3 certification review can begin at a low level upon receipt of the application utilizing resources previously budgeted for the pre-application review.

2 The scheduled review should be expanded to 54 months from the start of the intensive detailed review in FY96.

3. Confirmatory research and code development efforts would begin in FY96 with previously budgeted resources and be completed consistent with the schedules for final staff safety decisions.

4. Delaying the start of the detailed certification review until FY96 would allow resources to be included in the FY96 budget request for NRR, and would not require an increase in or reprogramming of RES resources. Nevertheless, it would allow the needed confirmatory and analytical tools to be developed and available consistent with the schedule for safety decisions.

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Enclosures:
1. Proposed Confirmatory Research in Support of CANDU Certification
2. NRR/RES Resource Estimates for CANDU 3 Design Review

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Proposed Confirmatory Research in Support of CANDU Certification

Based upon staff experience and precedent with the advanced light water reactor (ALWR) reviews and based upon the work done during the preapplication review of CANDU 3 looking at safety issues and the supporting data base for the CANDU design, the staff is proposing confirmatory research in the areas of severe accidents, source term, thermal-hydraulics, reactor physics, probabilistic risk assessment (PRA), fuel behavior, materials and structural methods. This research will be used to provide independent confirmation of CANDU 3 behavior and to explore design margins in those areas key to CANDU 3 safety. The proposed confirmatory analytical and experimental research work is summarized below:

- Severe Accidents

Modify the MELCOR and SCDAP codes to model CANDU 3. Use these codes to analyze core melt accidents in CANDU 3, relying heavily on sensitivity studies in lieu of experiments to predict core melt progression and fuel coolant interaction. Although such an approach may lead to conservatism in the staff's positions, it is the only practical solution considering the cost and time required to generate a severe accident experimental data base equivalent to that for U.S. light-water reactors (greater than $100 million and 10 years). However, it should be recognized that some small-scale ex-reactor experiments may be desirable, if the sensitivity studies show a high sensitivity to certain parameters or severe accidents phenomena. No allowance has been included in the resource or schedule estimates for these small scale experiments, since it is not clear what would be required and as discussed further below, it is possible that AECL would be requested to provide the information.

The extent of severe accident analysis and experimental work to be done by the Canadians is not yet clear. It will depend upon staff review of the CANDU 3 application, resolution of severe accident issues following a process similar to what has been done on the ALWRs (e.g., SECY-90-016) and could eventually be influenced by any requirements which may come out of the rulemaking described in the September 28, 1992, Advance Notice of Proposed Rulemaking on the "Acceptability of Plant Performance for Severe Accident., Scope of Consideration in Safety Regulation" (57 FR 44513). As described in SECY-93-226, dated August 18, 1992, the need for and approach of this rulemaking will be decided upon completion of the final safety evaluation reports for the advanced boiling water reactor and CE System 80+.

It should also be noted that no experimental work on the consequences of severe reactivity accidents (i.e., positive void reactivity) is proposed. It is the staff's view that if such

accidents are not eliminated from consideration by either making their likelihood acceptably remote or by reducing the magnitude of the positive void reactivity feedback to a value which is not of concern, then they will be analyzed using bounding analysis to assess the consequences. The analytical and experimental work which would be needed to predict with greater confidence the consequences of large reactivity insertion events in CANDU 3 would be expensive and time consuming and, as such, is not proposed at this time.

* Source Term

Develop a mechanistic source term for CANDU in a fashion similar to that developed for light-water reactors and documented in NUREG-1465. This would involve a review of the CANDU 3 PRA, identification of the dominant sequences and a determination of the timing, magnitude and chemical form of radioactive material released as a result of these sequences. Also, the credit to be given for removal mechanisms (e.g., containment sprays, aerosol settling, etc.) would need to be determined.

* Thermal Hydraulics

Modify the TRAC code to model the CANDU 3 horizontal pressure tube geometry and link it with NESTLE to be able to analyze design-basis and beyond-design-basis transients with and without reactivity excursions. Some limited NRC funded testing using the Canadian RD 14M loop in Whiteshell, Canada may be desired to obtain information on plant response to beyond-design-basis events (e.g., more than single failure) so as to help validate TRAC and better understand the design and its margins.

* Reactor Physics

Modify an existing 3-D reactor physics code developed by DOE (NESTLE) to analyze CANDU transients involving reactivity excursions. This capability would be good for transients up to the point of fuel melting and loss of core geometry, and would be used in conjunction with the thermal-hydraulics code for transient analysis as described below.

* Probabilistic Risk Assessment

Provide limited assessment in specific areas to support NRR's reviews of the applicant's PRA and to support the source term development discussed above.

- Fuel Behavior

Modify existing NRC fuels codes (FRAPCON and FRAP-T) to predict CANDU 3 fuel behavior during steady state and design-basis transient conditions. No independent experimental data would be generated, since the applicant is responsible for generating design basis information.

- Materials and Structures

There are significant differences between U.S. industry codes and standards and those used in the design, construction, testing, and inspection of CANDU-series reactors in Canada. Further, some different alloys and construction techniques are used in those designs such that radiation embrittlement and thermal aging might be different than in U.S. LWRs. Selected studies will be performed to provide the NRC reviewers with some independent bases for reviews in these areas.

NRR/RES Resource Estimates for CANDU 3 Design Review

(direct FTE; dollars in thousands)*

	FY94	FY95	FY96	FY97	FY98	FY99**	FY200**	TOTAL
NRR								
FTE in FY94-98 FYP	5	10***	5	5	5	0	0	
Additional FTE Needed	0	0	10	15	15	20	15	
Total FTE	5	10	15	20	20	20	15	105
Program Support in FYP	400	400	400	400	250	0	0	
Additional Funding Needed	0	0	0	0	0	250	100	
Total Funding	400	400	400	400	250	250	100	2200
RES								
FTE in FY94-98 FYP	0	0	2	5	6.5	0	0	
Additional FTE Needed	0	0	0	0	0	6.5	3	
Total FTE	0	0	2	5	6.5	6.5	3	23
Program Support in FYP	0	0	900	4100	5600	0	0	
Additional Funding Needed	0	0	0	0	0	5500	1900	
Total Funding	0	0	900	4100	5600	5500	1900	18000

The RES resource and schedule estimate to accomplish the proposed research discussed in Enclosure 1 is presented above. NRR resources are also identified in the table. The RES estimates are based upon the use of NRC codes (modified to model CANDU 3) to perform the independent analysis of CANDU 3. It is recognized that Canadian codes were used by the staff during the preapplication review phase (without any staff assessment of their validity) to do preliminary assessments of certain CANDU 3 features; however, for the actual application review, the staff recommends maintaining a more independent review process (similar to that being used on the ALWRs) using NRC codes. The increased resource needs in following this approach are small (approximately $2 million) as compared to using, assessing and ensuring validation of the Canadian codes.

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*The traditional overhead loading factor for advanced reactor activities averaged 1.5 for NRR and RES over the FY94-95 time period. Based on this loading factor, the total FTE resources through the year 2000 for the CANDU 3 review are estimated to be approximately 155 FTE for NRR and 35 FTE for RES. The actual loading factor will depend on the agency's handling of a number of issues including the streamlining effort.

**FYP does not extend through this period.

***5 FTE are identified in the FY94-98 Five-Year Plan for CANDU 3 - related activities, the remaining 5 FTE will be reprogrammed.

NOTE: Resources reflect direct FTEs and program support funds only. Dollars have not been adjusted for inflation.