APPLICATION OF UP-FRONT LICENSING

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AECL has been pioneering "up-front" licensing of new reactor designs. The CANDU 3 design has been formally reviewed by AECB staff for a number of years. The CANDU 9 design has just started the up-front licensing process. The process gives designers, regulators and potential customers early confidence in the licensability of future plants.

1. INTRODUCTION

Man-made nuclear power is now into its second half-century, and by the standards of other industries, can be considered a mature technology. Research and development has moved from establishing the basis of reliable operation, to supporting the safety of the operating plants, and now focusses more and more on understanding esoteric phenomena and very rare accidents. The initial thrusts for nuclear energy—an economic competitor to fossil fuels, a source of energy for the indefinite future, and independence of energy supply for countries rich in uranium but not oil—all remain. But the world business climate is changing. Utilities which in former times could take a long-term view, would invest in nuclear power for strategic reasons, and were once willing to share in its development costs, now must compete with independent power producers with access to cheap natural gas. To date nuclear power's inherent advantages—freedom from pollution and greenhouse gases, a renewable energy supply, and minimal use of land and other valuable natural resources—have not been reflected in the price of nuclear power. For fossil fuels, carbon dioxide waste disposal is free, the equivalent of nuclear "licensing" barely exists, and there is no price penalty for exhausting the world's supply of these nonrenewable resources.

Utilities therefore view nuclear power more and more as a commodity—it must compete "today" with current alternatives to attract their investment. With its long construction times, the capital investment is large and vulnerable to delays once the plant has been committed. Delays can come from a number of sources - labour strikes, technical "surprises", poor project management, intervention by self-interest groups, and regulatory licensing. For nuclear power to succeed in the era of cheap fossil fuels, each of these sources of risk must be countered. Reduction of licensing risk is the subject of this paper.

2. CANADIAN PAST EXPERIENCE

The traditional licensing process in Canada has three formal steps. First comes Site Acceptance, initiated by a formal Letter of Intent to the Canadian Regulatory Body, the Atomic Energy Control Board (AECB). From the regulatory viewpoint, Site Acceptance confirms the suitability of the site for a nuclear power plant, whose conceptual design is presented at this point. Environmental Hearings are held as part of Site Acceptance to ensure public knowledge of the proposal and that the environmental effects are acceptable. The next step is Construction Approval, supported by a preliminary design and safety analysis. Key documents reviewed at this stage include all the design requirements documents (for example, Safety Design Guides) and the Preliminary Safety Report. The

third step is granting of an Operating Licence, supported by the detailed design documentation, a Final Safety Report, a commissioning programme, operating policies and principles, emergency plans, authorization of operators, etc.

The Canadian licensing philosophy places the fundamental responsibility for safety on the plant owner, with the AECB acting in an audit role. For designs without a customer, this responsibility is carried by the designer. The AECB sets overall safety objectives which the design must satisfy, but to a large extent leaves the means to satisfy these objectives up to the designer. It does of course exercise independent and informed judgement as to whether the design will meet the overall safety objectives with reasonable confidence. This approach has two benefits: it encourages innovation, and avoids the potential conflict of the regulator sitting in judgement on its own design rules. It has worked well since the Canadian nuclear power industry is focussed on one design, the CANDU. With such a common basis, there was no need to write rules to cover a wide variety of design possibilities. "Accepted practice", negotiated during the licensing and proven during operation of a plant, became the practical basis of much regulation without the need for formal codification. Recently, however, the AECB has moved more toward codification of licensing requirements, although in many areas these confirm the practices accepted on previous projects.

Generally the Canadian licensing philosophy has been beneficial. There are a few disadvantages. Foreign countries normally apply licensability in country of origin as a condition of a reactor purchase. The lack of formally-documented, detailed licensing requirements and the emphasis on informed judgement place a burden on these countries to understand the Canadian philosophy and to apply it. This can be more difficult than comparison of a design with a detailed licensing "check-list". However foreign regulators have risen to the challenge, and CANDUs are being licensed in Romania and Korea. Foreign licensing of CANDU is also easier now that the AECB is documenting more of the basis for licensing.

Another disadvantage is the uncertainty an owner is placed in during a project, when the negotiations on requirements with the AECB, or more specifically on how to satisfy the requirements, are ongoing. There is a potential for licensing delays and/or added costs if there is a misunderstanding of what the requirements mean, or what constitutes an adequate method of meeting them.

3. CANDU 3 INITIATIVE

CANDU 3 is a small (450 MWe) evolutionary single-unit plant aimed at utilities with small electrical grids and "first-time" nuclear buyers. It is a Standard Product Design: the goal was to do all the conceptual and most of the detailed design, and obtain assurance of licensability, before a site-specific project was committed. This gave a very strong assurance of low risk to potential customers.

Reduction of licensing risk was addressed from the beginning. Formal contact with the AECB was initiated by AECL to engage in pre-licensing of the CANDU 3 Standard Product Design. We sent them documents describing the design to date and how we thought the licensing process could proceed.

Milestones

It was agreed between AECL and the AECB that pre-licensing of the CANDU 3 design would use a process of 4 Milestones. These Milestones are listed in Table 1 and described further as follows.

Licensing Basis

Fourteen documents in all are required to achieve this first Milestone defining the basis for the licensing requirements.

A single Licensing Basis Document (LBD) is the top level document which identifies, among other things, the codes and standards plus regulatory documents which will govern.

Twelve Safety Design Guides (SDGs) are required for Milestone 1. These documents cover a number of topics such as tornados, fire, seismic, etc. which designers use to ensure proper and systematic application of safety in design. Table 2 lists the titles of the SDGs.

Finally, a single document is also required for Milestone 1 which describes a review of the plant design to identify all possible initiating failures. The requirement for this comes from AECB document[1] C-6 which defines how safety analysis shall be performed.

An agreement on the licensing basis, and achievement of licensing Milestone 1, is obtained once all 14 documents are approved by AECB staff. Achieving Milestone 1 is also conditional upon a number of future activities:

- AECB acceptance of Safety Analysis Basis (SAB) documents, which describe the assumptions and methods to be used in safety analysis, and

- consideration or incorporation of any new and significant findings from safety-related Research and Development (R&D), safety analysis or experience from operating plants.

The SABs are formally required for licensing Milestone 2, but the AECB has tied milestones 1 and 2 together through acceptance of the SABs. AECB staff did not specify any R&D which must be done to support CANDU 3, but indicated that Milestone 1 could be affected by the on-going generic safety R&D program run by the CANDU Owners Group.

Identify Potential Problems

This milestone is essentially achieved by AECB staff review of our design. The design is described in a Technical Description document, which consists of two volumes. Most of the CANDU 3 design is a straight-forward evolution from CANDU 6s operating throughout the world. AECB review concentrated on new design features in CANDU 3, which represent simplification over operating CANDUs. The following items were chosen by the AECB for particular attention:

- process and safety systems grouping philosophy

- unidirectional core flow and single-ended refuelling

- steel-lined containment without dousing

- distributed control system, and

- computerized safety systems.

When AECB Staff are satisfied they have identified all significant design and safety issues, Milestone 2 is achieved. The safety issues are reviewed through a compliance document, prepared by AECL, which describes the methods used to show compliance with three key safety regulatory documents R-7[2], R-8[3] and R-9[4], and the SABs.

No Major Problems Foreseen

During the process of achieving Milestones 1 and 2, AECB staff opened actions against the CANDU 3 project to provide more design information or safety analysis. When these actions have been addressed to the satisfaction of the AECB, by more information, or if necessary, by design changes, Milestone 3 is achieved.

There is still discussion on the amount of safety analysis required. AECL expected that a "conceptual" report of analysis, covering the traditional cases which have affected CANDU design, will suffice. AECB staff have indicated that if the analysis is sufficient, achieving Milestone 3 will also represent the equivalence of a construction license for the design. When a site is selected for a CANDU 3, only site specific licensing would be required in order to obtain the actual construction license.

Accept Standard Design

AECB staff need to do a thorough review of the detailed design and safety analysis in order to achieve Milestone 4. This review is expected to take two years. The scope of information required is still under discussion. AECL expects that a safety report containing analysis of about the same scope as a Preliminary Safety Report (PSAR) for a real plant, would be required. Along the same lines, the detailed design scope has also not been defined. AECL expects that the design requirements and description of all the safety related systems will be required.

Milestone 4 is essentially the equivalent of the operating license for the standard design. All actual operating requirements, such as operator training, would have to be reviewed and approved by AECB staff for a real plant.

Progress to Date

Currently Milestones 1 and 2 are almost complete. All documents, except for a number of SABs, have been submitted and reviewed. Almost all of the documents for Milestone 1 have been approved.

The conceptual reports, for accident analysis and probabilistic analysis, have been submitted for Milestone 3. AECB staff have been reviewing these along with the Technical Description, which resulted in a number of actions against the CANDU 3 project. AECL has closed a few of these actions but most remain open currently.

For Milestone 4, AECL has produced much of the detailed design description necessary for AECB review, but has not submitted this material yet. AECL's priority has been on the first three milestones.

Currently, AECL is devoting much more of the design effort to CANDU 9 and CANDU 6. The progress to date for CANDU 3 is unlikely to change significantly in the next few years.

Successes and Lessons Learned

The process has worked reasonably well. It has allowed AECL to maintain a current and detailed understanding of AECB licensing requirements as they evolved through the 1980s and 1990s. The experience AECL gained from this process was applied directly to the Wolsong 2,3,&4 plants currently being constructed in Korea. They are being licensed in Korea to Canadian requirements as of December 1989. Therefore, working on CANDU 3 licensing Milestones 1 and 2 has produced a direct benefit already.

The CANDU 3 licensing basis document required a number of revisions to reach an agreement between the two parties. Many of the AECB's safety requirements documents were introduced as consultative documents after AECL had last licensed a CANDU in Canada. It wasn't clear if these "C" documents should be followed for CANDU 3. In time, many of the "C" documents became regulatory documents ("R" documents) and the issue is now resolved.

In the early days, there was competition for AECB resources between licensing of a new design and licensing operating stations or those under construction. CANDU 3 generally tended to get lower priority than "actual" plants due to AECB resource limitations. Consequently, AECL submitted many documents which did not see AECB staff review for years in some cases. With the completion of the Darlington nuclear power station, this conflict was resolved.

Later, AECL resources on CANDU 3 were reduced as the Wolsong 2, 3 and 4 projects started. This allowed AECB staff to catch up in document reviews and open a number of actions on AECL as a result of those reviews. AECL has not responded quickly to close the actions as resources have shifted again to the CANDU 9 program.

There were, of course, technical disputes, but the whole idea of the process is to resolve these before the plant is committed and/or being built. In many cases, design changes were implemented or committed to the design to accommodate AECB concerns. Of course, making these changes during design rather than during construction is a benefit to be realized when the first CANDU 3 is built.

In general, the way up-front licensing worked in detail could only be defined by trying to do it. Much was learned on both sides. In that respect the CANDU 3 experience points the way for future up-front licensing initiatives, such as CANDU 9.

4. CANDU 9

CANDU 9 is a large evolutionary single-unit plant, being developed for those utilities with a larger electrical grid and/or higher growth rates. It incorporates the economies of scale of units in the 900 MWe range and above. The CANDU 9/480NU core is based on the Darlington reactor core, and the remainder of the plant is based on already operating CANDUs, with improvements in the areas of constructability, economics, plant layout, and safety, many of which were developed on CANDU 3.

Any domestic purchaser of CANDU 9 will require evidence of licensability in Canada, sufficient to assure them of low licensing-induced risk during a project phase. A foreign purchaser of CANDU 9 will likewise require such assurance, so they know that the host country "stands behind" the product. The "up-front" licensing process of CANDU 3 has therefore been adapted to suit CANDU 9.

CANDU 9 is not a Standard Product Design. Should a CANDU 9 be sold overseas, the foreign regulator would award a construction licence, not the AECB. Thus much of the detailed licensing would be done overseas after the commitment of the project. The CANDU 9 licensing objective is therefore to get assurance from the AECB, before a project is committed, that CANDU 9 is licensable in Canada; and that this assurance is in sufficient detail, with sufficient work done to back it up, that a foreign regulator could proceed with confidence. The finding by the AECB should therefore be one of "no fundamental barriers" to licensability in Canada, equivalent to Milestone 3 on the CANDU 3 programme.

The following represent the types of documents that would be submitted to the AECB for review, to support such a conclusion:

Technical Description
Licensing Basis
Systematic Plant Review Methodology
Systematic Plant Review
Compliance with Regulatory Documents
Disposition of Generic Safety Issues
Preliminary PSA Rev. 0
Preliminary Safety Report Rev. 0
Safety Design Guides
Design Requirements and Flowsheets of Major Safety-Related Systems
Quality Assurance Programme for Design
Human Factors Plan
PSA Methodology Document
External Events Protection
Periodic Inspection
Code Classification
Grouping & Separation Design Philosophy Assessment
Programme to Address Severe Accidents
Process for Feedback from Operational Experience,
etc.

This is a comprehensive scope. It includes a preponderance of requirements documents (in italics) as well as the actual design. The emphasis on agreed requirements is of course consistent with the aim of pre-licensing: if the requirements are agreed, and well-defined, then it should be relatively easy to review the design and the safety analysis against them.

Some particular documents warrant attention. The Licensing Plan records the deliverables to be submitted to the AECB, and the submittal schedule. When agreed to by the AECB, along with a review schedule, it acts as the road-map through the pre-licensing. The Licensing Basis Document now includes both AECB requirements and the requirements of the foreign regulatory. A document on Generic Safety Issues is a new requirement. AECB staff expect designers to make significant progress in clearing these issues.

This process is similar in many ways to Standard Design Certification. The objective is the same—reduction of risk arising from licensing. Much of the scope of work is the same. The philosophy of mutual commitments on the designer and regulator is the same. There are also

differences. Licensing in Canada is not as legalistic as in the U.S., so that the commitments made by the regulator are not legally binding; that is, the regulator can in principle withdraw agreement at any time, although if the up-front process is thorough, this is unlikely. The detail in the design information reviewed is not as extensive as in the NRC process in some areas, particular in the non-nuclear portions of the plant, consistent with the objective of clearing major hurdles away before a detailed review. It is also faster—CANDU 9 plans to reach the objective of "no fundamental barriers" to licensability in Canada within two years.

Such a fast schedule is possible due in part to the understanding AECL has derived from the CANDU 3 licensing. The licensing basis, systematic plant review and safety design requirements documents should take a fraction of the time to prepare and receive approval for CANDU 9. In addition, AECB comments on other CANDU 3 documents will be factored into CANDU 9 documents, which should also reduce AECB review time.

Agreements reached with the AECB on CANDU 9 will then have a spin-off effect back to CANDU 3. AECL expects that many of the unclosed licensing actions on CANDU 3 will be easy to close when the CANDU 3 documents are revised with due regard to the approved CANDU 9 equivalent.

5. CONCLUSIONS

Up-front licensing was pioneered in Canada by AECL with the CANDU 3 standard product design. The success to date of up-front licensing on CANDU 3 will now be exercised on CANDU 9 in a shorter time-scale. The result, if successful, will assure both domestic and foreign customers that they can embark on a project licensing with acceptable risk.

TABLE 1. CANDU 3 UP-FRONT LICENSING IN CANADA

Milestones and Deliverables

Milestone 1	Milestone 2	Milestone 3	Milestone 4
Licensing Basis	*Identify Potential Problems*	*No Major Problems Foreseen*	*Accept Standard Design*
Licensing Basis Document 12 SDGs Systematic Plant Review	Technical Description Compliance with R-7, R-8 and R-9 SABs	Conceptual Safety Report Conceptual PSA Report Resolve Major Problems	General Safety Report Detailed design

TABLE 2. CANDU 3 SAFETY DESIGN GUIDES

Safety Related Systems
Seismic Requirements
Environmental Qualification
Grouping and Separation
Fire Protection
Code Classification
Periodic Inspection
Radiation Protection
Tornado Protection
Pipe Rupture Protection
Decommissioning
External Flooding

6. REFERENCES

(1) "Requirements for the Safety Analysis of CANDU Nuclear Power Plants", AECB Regulatory Document C-6, June 1980.

(2) "Requirements for Containment Systems for CANDU Nuclear Power Plants", AECB Regulatory Document R-7, February 21, 1991.

(3) "Requirements for Shutdown Systems for CANDU Nuclear Power Plants", AECB Regulatory Document R-8, February 21, 1991.

(4) "Requirements for Emergency Core Cooling Systems for CANDU Nuclear Power Plants", AECB Regulatory Document R-9, February 21, 1991.