# 19.13 Summary of Insights Gained from the PRA

The PRA was conducted with several objectives in mind:

(1) To ensure that the PRA-related goals in the ABWR Licensing Review Bases established in 1987 were satisfied.

(2) To review and improve the design capability for potential weaknesses or relative vulnerabilities, not withstanding the achievement of the Licensing Review Bases goals.

(3) To identify the most important aspects of the design and its operation so that particular attention can be placed on these aspects during certification, detailed design and plant operation.

(4) To provide additional basic studies which were not anticipated when the Licensing Review Bases was established.

(5) To provide uncertainty/sensitivity studies of key results.

The objectives were achieved as noted in the following subsections.

## 19.13.1 Licensing Review Bases Goals

These goals were established to ensure that an appropriate balance between accident prevention and accident mitigation is achieved by ABWR. The goals (Table 19.6-1 provides a summary) focus on prevention (core damage frequency), mitigation (avoiding containment failure from several potential threats) and offsite consequences (as measured by offsite doses, consequences, conditional containment failure probability, and the Safety Goal Policy Statement).

Measurement against these goals and the features which are important in achieving the goals are discussed in detail in Section 19.6. The goals are satisfied, indicating a very robust design with an excellent balance between accident prevention and mitigation features.

## 19.13.2 The Search for Vulnerabilities

As noted in detail in Section 19.7, the PRA process was used extensively to improve the design, even though it could be argued that satisfying the goals of Section 19.6 was sufficient. Improvements were made in many areas, including for example: the automation of several accident prevention functions, the addition of a combustion turbine generator to improve power supply diversity, the addition of an AC-independent Water Addition System to improve accident prevention and mitigation, and the addition of two passive accident mitigation features (the lower drywell flooder and the containment overpressure protection system) which substantially address uncertainties associated with severe accident progression. Procedural improvements were also identified. Many other examples are cited in Section 19.7 to illustrate the manner in which PRA techniques or PRA considerations were used throughout the design process to improve the design.

### 19.13.3 The Most Important Aspects of the Design

The ABWR design and its operation was reviewed to determine the features and operator actions which are most important from a PRA perspective. Applying additional focus in these aspects can provide confidence that ABWR operation will be as accident resistant as characterized by the PRA. The most important features of the design are identified in Section 19.8.

The potential for human error was reviewed extensively (Section 19.11) to ensure that "CRITICAL TASKS" were identified for the human factors Design Acceptance Criteria and to ensure that human actions are covered by the emergency procedures guidelines or other, more specific procedures.

The PRA results were reviewed to determine which surveillance and maintenance activities are most important with respect to assuring that PRA assumptions will be valid throughout plant life (Section 19.12).

### 19.13.4 Additional Studies

Several additional studies which were not anticipated in the original Licensing Review Bases were conducted to further review and enhance the robustness of the ABWR design.

The potential for internal fires to lead to core damage is studied in Appendix 19M. The basic ABWR features of separating the three safety divisions into individual fire zones and the ability to control key systems from outside the control room are the major reasons that very low core damage frequencies are calculated.

Internal flooding is investigated in detail from both a deterministic and probabilistic perspective in Appendix 19R. Divisional and building separation along with other key flooding mitigation features are identified which lead to the conclusion that there is a very small threat posed by internal flooding. General guidelines for addressing the potential for severe external flooding are provided in Subsection 19.9.3.

A seismic analysis (Appendix 19I) was conducted to assess the potential for seismic events beyond the design basis to lead to core damage. It was determined that there is high confidence in a low failure probability, even at ground accelerations approximately two times the plant seismic design basis. Key components and their seismic capacities are identified so that the COL applicant can review the design capability against those assumed in this margins analysis.

An assessment of the potential for core damage to result from ABWR operations while shutdown is documented in Appendix 19Q. Potential precursor events are reviewed for their applicability to ABWR and several ABWR features are noted which reduce the risk from activities conducted while shutdown. A decay heat removal reliability study is conducted to provide input to the COL applicant as to which complements of decay heat removal and water addition systems could be kept available while shutdown to reduce the risk of core damage resulting from the loss of an operating RHR system.

## 19.13.5 Uncertainty and Sensitivity Studies

Following quantification of the level 1 PRA, a data uncertainty study was performed (Subsection 19D.10). The effect of data uncertainty is relatively minor. The most important contribution to the uncertainty is the RCIC maintenance activity. This activity is addressed in the PRA input to reliability assurance (Appendix 19K).

A comparison of the level 1 quantified results to those for Grand Gulf was also developed to document the major reasons for reductions in the frequency of the various accident classes (Subsection 19D.11). The sensitivity of the results to equipment outage times and surveillance intervals was also considered (Subsection 19D.9). The contribution of human errors was compared to the contribution from an operating plant in Subsection 19D.7.

Uncertainties associated with severe accident progression were examined in detail through the use of containment event trees supplemented by decomposition event trees. The latter were used to study the potential for different outcomes of various severe accident events. The results show that the ABWR design is very robust. Analysis of phenomena such as direct containment heating were performed which indicate that the probability of occurrence with significant magnitude to fail the containment is very small. The design is not sensitive to assumptions affecting debris coolability due to the high strength of the containment and the lower drywell pedestal design. The studies also demonstrated that the features of the ABWR design substantially reduced the uncertainty associated with many severe accident phenomena. In many areas, these studies were conducted in greater depth than studies with similar objectives reported in NUREG-1150 and its supporting documents. In addition, the basis for the judgments made is described in detail.

## 19.13.6 Systems and Effects Not Modeled in the PRA

### 19.13.6.1 Equipment Aging

Aging or other deterioration of cables, pipes, walls and structures is not directly addressed in the analysis or in the Reliability Assurance Program (RAP). It is expected that routine maintenance and inspection of equipment for in service inspection requirements and plant walkdowns will identify deterioration of cables, pipes, walls and support structures to the extent that such deterioration would reduce the safety of the plant. It is assumed that detection of any deterioration of this equipment will lead to prompt corrective action to return the equipment to its as-designed condition.

### 19.13.6.2 Plant Control System and Control Room

The plant control systems and control room are not directly modeled in the PRA, although the RPS and other risk significant systems are modeled. The control system impact on safety will be primarily through the potential to cause transients as initiating events. The ABWR control system is expected to be more reliable than control systems of operating BWRs, because of additional redundancy and frequent self-checking of control circuits and components. Therefore, it should not be a significant contributor to plant transients.

The control room is being designed with human factors considerations, so the ability of operators to take proper corrective action in abnormal situations will be greater than that in operating plants. The analyses have considered conservative values for operator actions, so the enhanced control room design is not expected to negatively impact plant safety and does not have to be explicitly modeled in the PRA.

### 19.13.6.3 Equipment Lubrication Systems

Equipment lubrication by active subsystems, including lube oil pumps, has been reviewed with regard to the possibility that several different loops or divisions of safety related equipment could be simultaneously disabled by a single failure. If lube oil pumps are used within a given division of a safety-related system, such as in the RHR System, they must be powered by the same electrical division that powers the pumps or they must require no power. Thus, loss of one electrical division would only disable one division of the RHR system or another multi-division system. It is judged that detailed modeling of lubrication systems is not necessary, since the failure rate for a given equipment item includes the failure of its lubricating system.