Chapter 2

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The nuclear industry that has developed in the United States since 19s9 has grown up with a surprising degree of technical diversity. All but a handful of the 72 plants that are currently licensed for operation have been custom-designed and custom-built. A result of this practice is that the plants must also be individually licensed, since the safety analysis of each is inevitably different. When a utility decides to build a plant, it usually first hires an architect-engineering (AE) firm, then contracts with a reactor manufacturer (one of the four existing "nuclear vendors") to build the nuclear core, vessel, and control mechanisms, which represent about 10 percent of the plant investment. Each vendor has a different design for its nuclear system, so there are four different options. Then the AE designs the balance of the plant (BOP):

- cooling systems;
- feedwater systems;
- steam systems;
- control room; and
- generator systems.

There are about 12 AEs presently designing nuclear plants in the United States, and each has its own preferred approach to these various systems. The AE's approach will be tailored by past experience to be consistent with one vendor's nuclear system, but not necessarily compatible with the systems of all four. In addition to the diversity due to the different architect-vendor combinations, there is also a degree of variability due to the different meteorological, seismic, and hydrological conditions at different plant sites.

Further variability is introduced by the length of the process (12 years) and the piecemeal approach that is taken to both design and licensing. Because safety standards have grown up with the nuclear industry rather than being formulated in full and fixed fashion when the industry began, plant builders and designers have taken a "design-as-you-go" approach to new plants in order to be able to meet upgraded safety standards that might be adopted during the period a plant was under construction. For some years, the industry's practice has been to start construction with the design about 15-percent complete. On the regulatory side, the approach taken — to accommodate changing safety standards due to accrued experience and improved analysis — has been to issue plant licenses in two steps, a preliminary step sufficient to start construction and a final step necessary to start operation. Both of these practices have inevitably increased the variation from one plant to another. Even among plants intended to be identical, but started at different times, significant design differences have occurred in the final plants.

Reducing the diversity that now exists in the nuclear industry would allow increased attention to be given to improving each plant design. It would also increase the amount of operating experience that would be available for a particular design and make it possible for improvements at one plant to be immediately applicable to an entire plant family.

Efforts to encourage standardization however, have met with slow acceptance. Some argue that the many deviations from original designs that now occur before plants operate indicate that neither the technology nor the licensing process is sufficiently stabilized to support standardization. Furthermore, the nonstandardization that now exists in the industry is a direct resu lt of the diversity that exists in the marketplace, and a substantial move toward standardization could result in some restructuring of the nuclear industry.

How substantial any move toward standardization should be is one of the topics of this report. There is such a range of possible options that lie between the two logical extremes—that either all plants be different or all be the same— that four different approaches to standardization merit discussion. The different approaches represent greater degrees of standardization, the last option being a single design identical to all others in both its

nuclear and BOP systems. The approaches differ in their technical, institutional, licensing, and safety implications. Some require strong legislative action, while others rely predominantly on trends already underway in the industry.

This study was undertaken by requests of the House Committee on Interior and Insular Affairs and the Senate Subcommittee on Nuclear Regulation. Some committee members expected that standardization would significantly improve the safety of the plants, and help create a stable licensing process in which utilities would have confidence that they would get their reactors approved. The accident at Three Mile Island (TMI) contributed to this expectation because both the local operators and the Nuclear Regulatory Commission (NRC) personnel seemed to lack thorough understanding of the reactor and had failed to learn from similar experiences at related reactors. Ever-increasing licensing delays, especially since TMI, reinforce the need to reexamine the merits of standardization.

Congress is not the only institution interested in standardization. NRC has also encouraged standardization although recent actions indicate that its priority at NRC has been lowered. The NRC Advisory Committee on Reactor Safeguards has maintained a strong interest in the subject. The nuclear industry has also been moving towards standardization as individual companies have filed standardized versions of their own designs with NRC. However, such efforts have been directed more at unifying current practices than at maximizing safety.

Any degree of standardization will require decisions as to the level of specification required. The standard plants that have been filed with NRC specify flow diagrams, design descriptions, and generic information, but does not include all the detailed information required to actually build a plant. Complete standardization would require considerably greater efforts before a design is approved and would allow considerably less flexibility afterwards, but wou Id result in making plants virtually identical.

This is not an exhaustive study of standardization. It is a broad scoping of four kinds of standardizations that could be considered and the major advantages and disadvantages involved in each. In addition, the study examines the standardization of procedures and organizations to see if some advantages can be gained without depending on new designs and plants. The retrofitting of existing plants to enhance standardization or safety has not been considered. OTA had staff and contractors prepare background papers on NRC policy, the U.S. Navy's experience with standardization, several plant systems that could be standardized, and the relation of standardization to safety. These background papers were distributed to the participants of a 2-day workshop held to identify and discuss the issues of standardization. The workshop included representatives of reactor manufacturers, AE companies, utilities, regulators, and concerned observers of nuclear power. This report is the result of the background papers, the conclusions of the workshop, and further information received by the staff. It has been reviewed by the workshop participants and by others.