U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Backgrounder

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New Nuclear Plant Designs

Background

The NRC has long sought standardization of nuclear power plant designs, and the enhanced safety and licensing reform that standardization could make possible. The Commission expects advanced reactors to be safer and use simplified, passive or other innovative means to accomplish their safety functions. The NRC's regulation (Part 52 to Title 10 of the Code of Federal Regulations) provides a predictable licensing process including certification of new nuclear plant designs. This process reflects decades of experience and research involving reactor design and operation. The design certification process provides for early public participation and resolution of safety issues prior to an application to construct a nuclear power plant.

Pre-Application Review Process

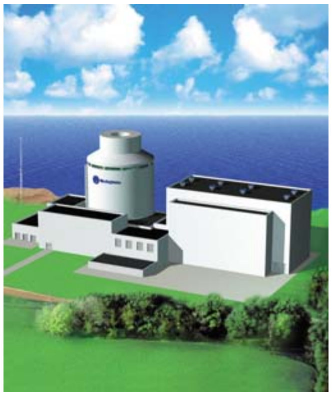
The NRC's "Statement of Policy for Regulation of Advanced Nuclear Power Plants," dated July 8, 1986, encourages early discussions, before a license application is submitted, between NRC and reactor designers to provide licensing guidance. In June 1988, the NRC issued NUREG-1226, "Development and Utilization of the NRC Policy Statement on the Regulation of Advanced Nuclear Power Plants." This document provides guidance on the implementation of the policy and describes the approach used by NRC in its review of advanced reactor design concepts.

In general, the NRC conducts pre-application reviews of advanced reactor designs to indentify:

- major safety issues that could require Commission policy guidance to the staff,
- major technical issues that could be resolved under existing NRC regulations on policy, and
- research needed to resolve identified issues.

Design Certification Review Process

The review process for new reactor designs involves certifying standard reactor designs, independent of a specific site, through a rulemaking (Subpart B of Part 52). This rulemaking can certify a reactor design for 15 years. Design certification applicants must provide the technical information necessary to demonstrate compliance with the safety standards set forth in applicable NRC regulations (10 CFR Parts 20, 50, 73, and 100). Applicants must also provide information to close out unresolved and generic safety issues, as well as issues that arose after the Three Mile Island accident. The application must include a detailed analysis of the design's vulnerability to certain accidents or events, and inspections, tests, analyses, and acceptance criteria to verify the key design features. The NRC is considering a new rule that would require design certification applicants to assess their plant's level of built-in protection for avoiding or mitigating the effects of a large commercial aircraft impact, reducing the need for human intervention to protect public health and safety.



Currently there are four certified reactor designs that can be referenced in an application for a combined license (COL) to build and operate a nuclear power plant. They are:

1. **Advanced Boiling Water Reactor** design by GE Nuclear Energy (May 1997);
2. **System 80+** design by Westinghouse (formerly ABB-Combustion Engineering) (May 1997);
3. **AP600** design by Westinghouse (December 1999); and
4. **AP1000** design (pictured at left) by Westinghouse (January 2006).

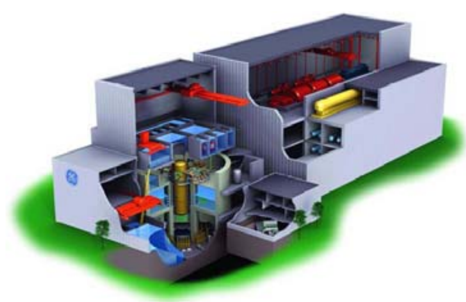
Reactor Design Review Status

The status of advanced reactor applications for both active and inactive design reviews is provided below in alphabetical order. A description of each design follows.

Active Reviews

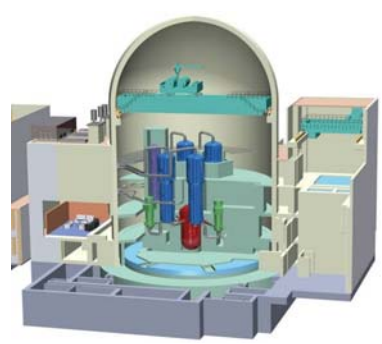
- **AP1000 (Amendment) –** Westinghouse submitted an application to amend the AP1000 design in July 2007, in order to: 1) address several "open items" that would otherwise be dealt with in a COL application, 2) voluntarily comply with the intent of the proposed aircraft impact assessment rule, and 3) modify the reactor's pressurizer design. The staff accepted the amendment for review in January 2008 and expects to complete its review in 2009. The rulemaking is tentatively scheduled for completion in 2010.

- **ESBWR** - General Electric submitted its ESBWR (pictured at right) certification application on Aug. 24, 2005. The staff accepted the application for review in a letter dated Dec. 1, 2005, and expects the certification process to continue through 2010.



- **EPR** - Areva submitted its EPR certification application on Dec. 11, 2007. The staff expects the certification process to continue through 2011.

- **US-APWR** - Mitsubishi Heavy Industries (MHI), a Japanese firm, submitted a design certification application for the U.S.-specific version of its Advanced Pressurized Water Reactor (pictured at right) on Dec. 31, 2007. The staff expects the certification process to continue through 2011.



Pre-Application Reviews

- **PBMR -** A South African firm, Pebble Bed Modular Reactor (PBMR) Pty. Limited notified the NRC in a letter dated Feb. 18, 2004, that it intended to apply for design certification in the near future and requested discussions with the NRC to plan the scope and content of the preapplication review. NRC staff have held several public meetings with PBMR to discuss its activities and plans to submit pre-application information. PBMR has continued to submit pre-application information through 2007 and expects to submit a design certification application in late 2009.

- **Toshiba 4S** - On Feb. 2, 2005, the NRC staff met with the city manager and vice mayor of Galena, Alaska to discuss and answer questions on the city's plans to build a Toshiba 4S reactor to provide its electricity. Toshiba began pre-application discussions with NRC staff in Oct. 2007, and the company expects to submit a design approval application in 2009.

Inactive Reviews

- **IRIS** - In May 2006, Westinghouse and the NRC staff discussed the current status of the International Reactor Innovative and Secure (IRIS). The planned submittal of a design certification application for IRIS has been changed from 2008 to 2010. Westinghouse has submitted topical reports related to the planned test programs and plans to submit additional reportes in support of preapplication interactions. The IRIS design is sometimes mentioned in the context of a grid-appropriate reactor under the Global Nuclear Energy Partnership.

Regulatory Structure for New Plant Licensing

In the longer term, the NRC may be called on to review reactor designs that use a broader range of technology than those currently under review. Therefore, the NRC staff may develop technology-neutral guidelines for plant licensing in the future. These guidelines are intended to encourage future designs to incorporate additional safety and security where possible. The staff issued in Dec. 2007 a "Feasibility Study for a Risk-Informed and Performance-Based Regulatory Structure for Future Plant Licensing" (NUREG-1860).

Design Descriptions

ABWR: The U.S. Advanced Boiling Water Reactor (pictured at left) uses a single-cycle, forced circulation design with a rated power of 1,300 megawatts electric (MWe). The design incorporates features of the BWR designs in Europe, Japan, and the United States, and uses improved electronics, computer, turbine, and fuel technology. Improvements include the use of internal recirculation pumps, control rod drives that can be controlled by a screw mechanism rather than a step process, microprocessor-based digital control and logic systems, and digital safety systems. The design also includes safety enhancements such as protection against overpressurizing the containment, passive core debris flooding capability, an independent water makeup system, three emergency diesels, and a combustion turbine as an alternate power source.

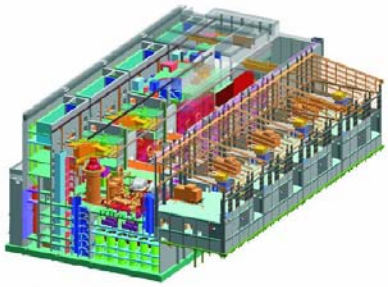
AP600: The Advanced Passive 600 is a 600 MWe advanced pressurized water reactor that incorporates passive safety systems and simplified system designs. The passive systems use natural driving forces without active pumps, diesels, and other support systems after actuation. Use of redundant, non-safety-related, active equipment and systems minimizes unnecessary use of safety-related systems.

AP1000: The Advanced Passive 1000 is a larger version of the previously approved AP600 design. This 1,100 MWe advanced pressurized water reactor incorporates passive safety systems and simplified system designs. It is similar to the AP600 design but uses a longer reactor vessel to accommodate longer fuel, and also includes larger steam generators and a larger pressurizer.

EPR: The Evolutionary Power Reactor (pictured at right) is a 1,600 MWe pressurized water reactor of evolutionary design. Design features include four 100% capacity trains of engineered safety features, a double-walled containment, and a "core catcher" for containment and cooling of core materials for severe accidents resulting in reactor vessel failure. The design does not rely on passive safety features. The first EPR is under construction at the Olkiluoto site in Finland, with another planned for the Flammanville site in France.

ESBWR: The Economic and Simplified Boiling Water Reactor is a 1,500 MWe, natural circulation boiling water reactor that incorporates passive safety features. This design is based on its predecessor, the 670 MWe Simplified BWR (SBWR) and also utilizes features of the certified ABWR. The ESBWR enhances natural circulation by using a taller vessel, a shorter core, and by reducing the flow restrictions. The design utilizes an isolation condenser system for high-pressure water level control and decay heat removal during isolated conditions. After the automatic depressurization system operates, a gravity-driven cooling system provides low-pressure water level control. Containment cooling is provided by a passive system.

IRIS: The International Reactor Innovative and Secure is a pressurized light water cooled, medium-power (335 MWe) reactor that has been under development for several years by an international consortium. The IRIS design utilizes an integral reactor coolant system layout. The IRIS reactor vessel houses not only the nuclear fuel, control rods and neutron reflector, but also all the major reactor coolant system components including pumps, steam generators and pressurizer. The IRIS integral vessel is larger than a traditional PWR pressure vessel, but the size of the IRIS containment is a fraction of the size of corresponding loop reactors.



PBMR: The Pebble Bed Modular Reactor (pictured at left) is a modular high-temperature gas reactor that uses helium as its coolant. PBMR design consists of eight reactor modules, 165

MWe per module, with capacity to store 10 years of spent fuel in the plant (there is additional storage capability in onsite concrete silos). The PBMR core is based on German high-temperature gas-cooled reactor technology and uses spherical graphite elements containing ceramic-coated fuel particles.

System 80+: This standard plant design uses a 1,300 MWe pressurized water reactor. It is based upon evolutionary improvements to the standard CE System 80 nuclear steam supply system and a balance-of-plant design developed by Duke Power Co. The System 80+ design has safety systems that provide emergency core cooling, feedwater and decay heat removal. The new design also has a safety depressurization system for the reactor, a combustion turbine as an alternate AC power source, and an in-containment refueling water storage tank to enhance the safety and reliability of the reactor system.

Toshiba 4S: The Toshiba 4S reactor design has an output of about 10 MWe. The reactor has a compact core design, with steel-clad metal-alloy fuel. The core design does not require refueling over the 30-year lifetime of the plant. A three-loop configuration is used: primary system (sodium-cooled), an intermediate sodium loop between the radioactive primary system and the steam generators, and the water loop used to generate steam for the turbine. The basic layout is a "pool" configuration, with the pumps and intermediate heat exchanger inside the primary vessel.

US-APWR: The Mitsubishi Heavy Industry US-APWR design is an evolutionary 1,700 MWe pressurized water reactor currently being licensed and built in Japan. The design includes high-performance steam generators, a neutron reflector around the core to increase fuel economy, redundant core cooling systems and refueling water storage inside the containment building, and fully digital instrumentation and control systems.

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