Sierra Presentation

Topics chosen by awareness of issues of concern I have seen in press and online.

Topics to be covered

- •Basic Steam Power Plant
- •Current Reactors
- •Advanced Reactors
- •Licensing Activities
- •Small Modular Reactors
- •License Extension
- •Power Uprates
- •Post Fukishima Requirements
- •Nuclear Waste
- •Current Events
- •Worldwide Status

Basic power plants

Steam source - turbine generator - Condenser/Cooling water

Steam source could be a boiler burning coal oil gas, exhaust from a combustion turbine, geothermal or steam from a nuclear reactor

Current Reactors Operating today

Boiling water reactors, steam directly from the reactor

Pressurized Water Reactors - steam from an intermediary steam generator (more efficient because operate at higher pressures)

Reactors "near here" within 100 miles

Susquehanna- 2 BWR

Oyster Creek - 1 BWR

Salem - 2 PWR

Hope Creek - 1 BWR

Limerick - 2 BWR

Peach Bottom - 2 BWR

TMI - 1 PWR

Advanced reactor Generation 3+ These designs are evolutionary from current designs. They have generally reduced the number of components, improved safety systems, depend on natural forces (gravity), increased redundancy and have improved digital controls.

Gen3+ goals from Commission

- a diverse system to ensure shutdown of the reactor even if the main system fails
- design features to ensure high reliability of the shutdown decay heat removal system
- an alternate ac power source to mitigate station blackout
- additional requirements for fire protection, including ensuring safe shutdown without operator intervention, even if a fire disables all equipment in one fire area
- methods for core debris spreading and cooling if a severe accident were to occur
- a depressurization system and reactor cavity design features to contain ejected core debris if a severe accident were to occur

AP1000; 1,100 MWe advanced pressurized water reactor

> The passive systems respond to emergencies by relying on gravity and other natural forces rather than electric-powered pumps and other support systems. The system uses redundant, non-safety-related equipment and systems where possible to avoid unnecessary safety-related system activation.

ESBWR: The Economic and Simplified Boiling Water Reactor is a 1,500 MWe

> The ESBWR enhances natural heat transport by using a taller vessel, a shorter core, and by enhancing water flow. The design's isolation condenser system controls high-pressure water levels and removes decay heat when active systems are unavailable. After the automatic depressurization system operates, a gravity-driven cooling system controls low-pressure water levels. Another passive system cools the reactor containment.

US-APWR: The Mitsubishi Heavy Industry US-APWR design is a 1,700 MWe pressurized water reactor.

> It 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.

The ABWR: with a rated power of 1,300 megawatts electric (MWe) has internal recirc pumps.

The design's safety enhancements include protection against overpressurizing the containment, passive methods to cool accident debris, an independent water resupply system, three emergency diesels and a combustion turbine as an alternate emergency power source

Licensing Activities:

Combined Operating License: In a COL application, the NRC staff reviews the applicant's qualifications, design safety, environmental impacts, operational programs, site safety, and verification of construction with ITAAC.

Early Site Permits: In reviewing an ESP application, the NRC staff will address site safety issues, environmental protection issues, and plans for coping with emergencies, independent of the review of a specific nuclear plant design.

Current status

Construction activities at both Vogtle and Summer

Note also that construction activities have resumed for Watts Bar Unit 2 and in a Jan 15 press release the Tennessee Valley Authority's efforts to begin operation of its Watts Bar 2 nuclear power plant this fall are on schedule. 1,100-megawatt pressurized water reactor.

Small Modular Reactors (Less than 300 MWe) Characteristics

- Greater simplicity of design, economy of mass production, and reduced siting costs.

- High level of passive or inherent safety in the event of malfunction
- Additional considerations
- Firstly, SMRs can reduce radiation dangers because a smaller reactor core produces less.
- Secondly, due to their small size, SMRs are better able to incorporate passive safety features; those that do not require human or electronic actions to function properly, including cooling systems that use gravity instead of relying on access to power, natural convection systems, and passive heat removal .
- Thirdly, SMRs benefit from a simplification in design as they use fewer components, resulting in a more compact reactor. SMRs designs eliminate the need for coolant pipes. An integral design, in which the primary reactor core, steam generator, and pressurizer are incorporated into a single, common-pressure vessel, is only possible in a small design.
- Fourthly, unlike larger reactors, SMRs are designed to be in an underground configuration, which would limit the risk for aboveground sabotage or radioactive release.

DOE currently supporting two designs mPower and NuScale

High Temperature (Small Modular) Reactors

With negative temperature coefficient of reactivity (the fission reaction slows as temperature increases) and passive decay heat removal, the reactors are inherently safe

HTRs can potentially use thorium-based fuels and burn spent fuel

License Extension

Economic and antitrust considerations, not limitations of nuclear technology, determined the original 40-year term for reactor licenses.

However, because of this selected time period, some systems, structures, and components may have been engineered on the basis of an expected 40-year service life.

Extensive analysis of the entire plant and components and establishment of aging management programs which will detail maintenance and/or replacement of components.

Uprates 3 types

- Measurement uncertainty recapture power uprates increase the licensed power level by less than 2 percent. They are achieved by implementing improved techniques for calculating reactor power. This involves the use of state-of-the-art devices to more precisely measure the feedwater flow used to calculate reactor power. More precise measurements reduce the degree of uncertainty in the power level, helping analysts predict the ability of the reactor to be safely shut down under possible accident conditions.
- Stretch power uprates are typically between 2 percent and 7 percent, with the actual increase depending on a plant design's specific operating margin. Stretch power uprates

usually involve changes to instrumentation settings but do not involve major plant modifications.

- Extended power uprates are greater than stretch power uprates and have been approved for increases as high as 20 percent. Extended power uprates usually require significant modifications to major pieces of non-nuclear equipment such as high-pressure turbines, condensate pumps and motors, main generators, and transformers.

The NRC has approved 154 uprates and typically has several applications for power uprates under review at any given time. Licensees responding to a December 2012 NRC survey indicated they plan to submit 3 applications for measurement uncertainty recapture uprates in the next five years. If these applications are approved, the resulting uprates would add another 172 MWt (58 MWe) to the nation's generating capacity. Lists of uprate applications approved, under review, and anticipated can be found in the three tables on the NRC's website. (Source NRC)

Peach Bottom 2 E, 3 E (12.4%)

Limerick 1S, 2S

Salem 1 S, 2 MU

Hope Creek E (15%)

Susquehanna 1E, 2E (13%)

TMI S

Approved Uprates Total MWt 21978.8 Total MWe 7326

Pending Applications Total MWt 184 Total MWe 61

Expected Applications Total MWt 1674 Total MWe 558

Post Fukishima Requirements

Flooding and Seismic Reanalysis

Obtain and protect additional emergency equipment, such as pumps and generators, to support all reactors at a given site simultaneously following a natural disaster (pictured below).

Install enhanced equipment for monitoring water levels in each plant's spent fuel pool.

Improve/install emergency venting systems that can relieve pressure in the event of a serious accident (only for reactors with designs similar to the Fukushima plant).

NRC Required Emergency Preparedness Staffing and Communications Assessments

Nuclear Waste

Currently (2013) more than 68,000 metric tons heavy metal (MTHM) of used nuclear fuel are stored at 72 commercial power plants around the country with approximately 2,000 MTHM added to that amount every year.

- Sites, designs and licenses, constructs and begins operations of a pilot interim storage facility by 2021 with an initial focus on accepting used nuclear fuel from shut-down reactor sites;
- Advances toward the siting and licensing of a larger interim storage facility to be available by 2025 that will have sufficient capacity to provide flexibility in the waste

management system and allows for acceptance of enough used nuclear fuel to reduce expected government liabilities; and

- Makes demonstrable progress on the siting and characterization of repository sites to facilitate the availability of a geologic repository by 2048.

Dry cask storage is safe and environmentally sound. Cask systems are designed to contain radiation, manage heat and prevent nuclear fission. They must resist earthquakes, projectiles, tornadoes, floods, temperature extremes and other scenarios. The heat generated by a loaded spent fuel cask is typically less than is given off by a home-heating system. The heat and radioactivity decrease over time without the need for fans or pumps. The casks are under constant monitoring and surveillance.

Generation 4

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