Power Reactors in Widespread Use

About 80% of the world's nuclear reactors used for generating electricity are either boiling water reactors or pressurized water reactors. All power reactors currently in use in the United States are of these two types and have been very successfully used for reliable, on-demand, emissions-free electricity generation for decades.

Most common – Boiling Water and Pressurized Water Reactors

About 80% of the world's nuclear reactors used for generating electricity are either boiling water reactors or pressurized water reactors. Of these, about 30% are boiling water reactors and 70% are pressurized water reactors. All power reactors currently in use in the United States are of these two types.

How does a boiling water reactor work?

Water flows from the bottom to the top of the fuel, and as it moves past, it carries away the heat produced by the nuclear fission process. Shortly before it flows past the top end of the fuel, the water begins to boil, creating steam. Once the steam leaves the end of the fuel region, any remaining moisture in it is removed by moisture separators and dryers, and then the steam flows directly to the turbine blades, causing the turbine to spin. The turbine is attached to a generator shaft that spins a large coil of wire inside a strong magnetic field, producing electricity.

How does a pressurized water reactor work?

As with the boiling water reactor, water enters the bottom of the fuel region and exits at the top of the fuel, again carrying away heat from the fission process in the fuel. In a pressurized water reactor, however, the water is kept at a high pressure so that boiling does not occur in the reactor. Instead, this very hot water flows into tubes in a steam generator – a heat exchanger a bit like a car radiator. The hot water from the reactor heats cooler water that flows in a separate piping loop within the steam generator and makes that water boil, creating steam. This steam then flows to the turbine, resulting in electricity generation, just as in a boiling water reactor plant.

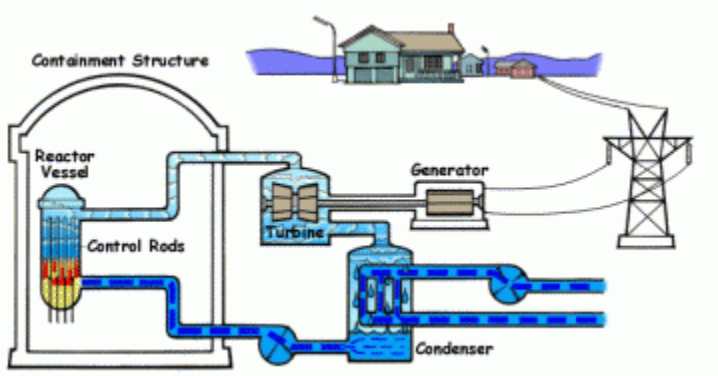

Diagram of a boiling water reactor plant (courtesy of the US Nuclear Regulatory Commission)

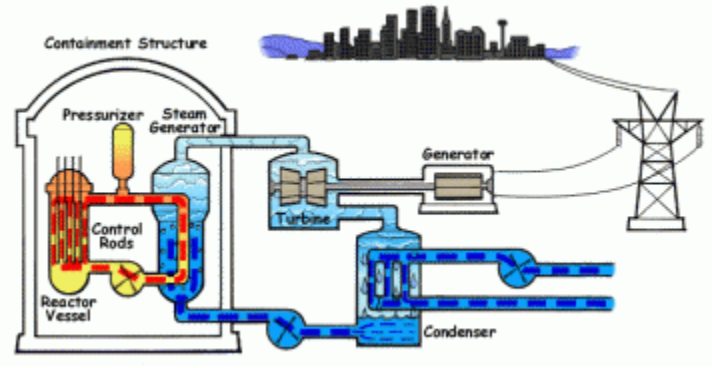

Diagram of a pressurized water reactor plant (courtesy of the US Nuclear Regulatory Commission)

What are the main features boiling and pressurized water reactor plants have in common?

- Both use water to carry heat away from the fuel and produce steam
- Both use water to slow down the neutrons produced in the fission process and use these low-energy neutrons to continue the fission chain reaction
- Both types of reactors have been operating in commercial electricity generating stations since the 1960's and so have an extensive history of operating experience
- Both send the steam that has passed through the turbine to a device called a condenser, where the steam is cooled down and changes back into water that is reused in the process of generating steam
- Both use fuel made of uranium oxide (or, in a few plants, a mixture of uranium and plutonium oxide), formed into pellets that are stacked in sealed metal tubes, with the tubes arranged in rectangular bundles called assemblies.
- Both have large water-filled storage areas called spent fuel pools where used fuel that has been removed from the reactor is stored while the decay heat in the fuel decreases with time.

What are the main differences between boiling and pressurized water reactor plants?

- **Plant design**
  - Boiling water reactor plants have a simpler design, since no steam generator is needed. However, because the water/steam that passes through the reactor core becomes slightly radioactive, the steam entering the turbine is slightly radioactive and so the turbine and condenser must be shielded to keep plant workers from being exposed to radiation.
  - Pressurized water reactor plants must include a steam generator, which is an expensive additional piece of equipment that must fit within the primary containment building, so the containment must be larger than for a boiling water reactor. However, the radioactive water stays within the containment, so the turbine and condenser do not need the added expense of shielding.
- **Control rods**
  - In a boiling water reactor, the control rods are pushed into the fuel region from the bottom of the fuel, meaning they are moving in the direction of the water flow but against gravity. Inserted control rods are automatically mechanically locked in place and thus will stay in the reactor even if electrical power is lost.
  - In a pressurized water reactor, the control rods are driven in from the top of the fuel region, so although the rods are moving against the direction of the water flow, gravity works to aid insertion of the rods.
- **Reactor pressure**
  - High in a pressurized water reactor
  - Significantly lower in a boiling water reactor (about half that of a pressurized water reactor)
- **Location of spent fuel pools**
  - At the level of the top of the reactor for all currently built boiling water reactor plants
  - At ground level for pressurized water reactor plants

Improvements in BWR and PWR designs

Reactor vendors have built on their experience with the power reactor designs described above, collectively known as Generation-II designs, to create improved reactors that are known as Generation-III/III+ designs. These reactors are superior to their predecessors in a number of ways:

- **Simpler design**
  - Fewer valves, less piping, less control cable
  - Fewer pumps throughout the plant
- **Increased safety**
  - Both types of reactors include passive safety features – actions that occur automatically and naturally to keep the reactor cooled, without operator action and without electricity being available
  - The most advanced boiling water reactor design does not need any pumps to move the water through the reactor
- **Lower cost**
  - Smaller buildings and therefore much less concrete and rebar
  - An overall smaller footprint

Several of these newest pressurized water reactors are currently being built in the United States and China.