Fission Reactors

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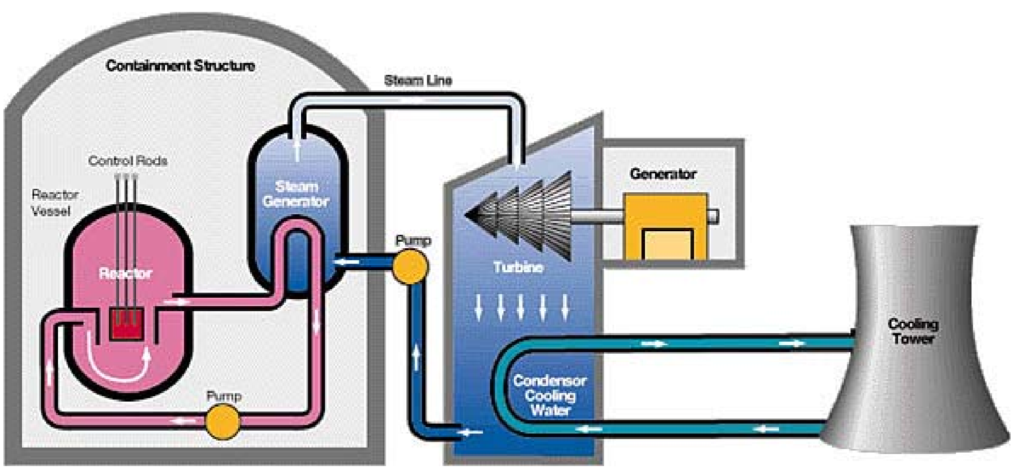
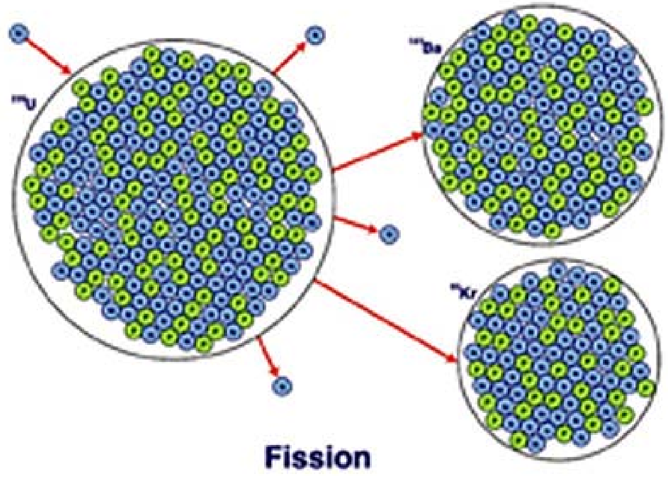
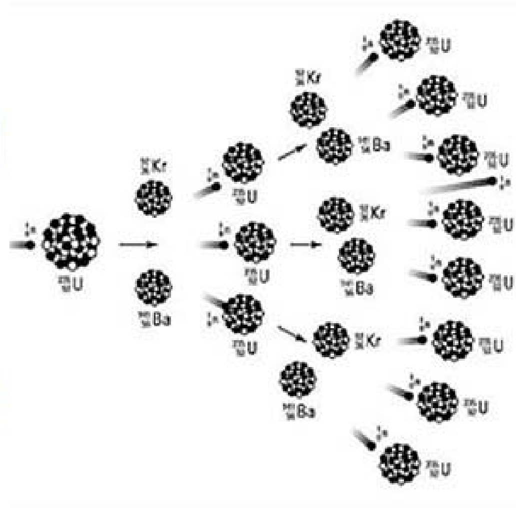
Fission Reactors

There are about 438 **Neutron Fission Power Reactors** (NFPRs) producing commercial electricity in the world today. They use uranium fuel to produce heat, which boils water to make steam, which spins a turbine, which spins a generator to make the electricity.



Neutron Fission Power Reactors (NFPRs) are more often called Nuclear Power Reactors, but this commonly accepted terminology is ambiguous because it does not properly distinguish between fusion and fission; and the difference is important. NFPRs (Neutron Fission Power Reactors) get their energy from uranium fission:





When elements with very large mass numbers such as U236 split apart to make smaller more stable nuclei closer to 56 in mass number, we say that fission has occurred. In the reaction above left, a neutron combines with a U235 nucleus to produce an unstable U236 nucleus. The unstable U236 nucleus fissions to produce 3 neutrons, a Barium nucleus, and a Krypton nucleus. The multiple neutrons produced are very important in sustaining the **chain reaction**, which characterizes NFPRs. In the chain reaction above right, neutrons split uranium nuclei which release more neutrons which split more uranium nuclei which release more neutrons which split more uranium nuclei and so on.

A neutron fission chain reaction is the primary distinguishing trait of NFPRs; the chain reaction sets NFPRs apart from other nuclear power devices such as the polywell. People who insist on saying, "Nuclear Power Reactor," when they mean "Neutron **Fission** Power Reactor" are putting all nuclear reactors in the same category, which is a very big mistake. NFPRs have very serious problems, which are not shared by the polywell. It is extremely important that people who are worried about these problems, distinguish between devices that truly have those problems, and other devices that do not. At this time, the polywell is the only device which can promise to safely provide all the energy needs of our civilization. To confuse it with other nuclear devices, is to jeopardize the very future of humankind.

Nomenclature

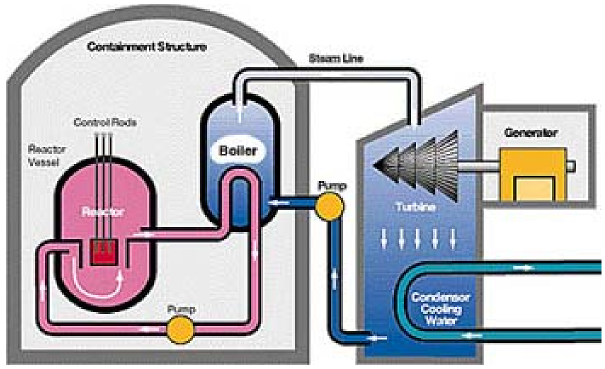
Control Rods absorb neutrons. When the control rods are inserted into a Neutron Fission Power Reactor, the chain reaction stops. As the control rods are gradually removed, the chain reaction (and thus, the energy produced) increases. As the reaction rate increases, the temperature of the reactor increases. The control rods are usually made out of Cadmium, Hafnium, or Boron10 – a neutron absorbing isotope of Boron.

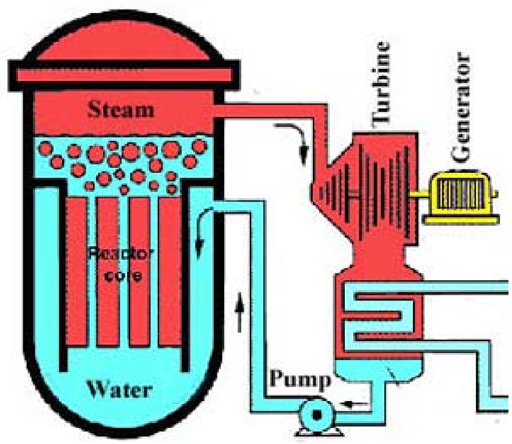
The **Coolant** is a liquid that circulates through the reactor, absorbs the heat, and carries it away to make the steam to drive the turbine. The coolant is usually water or heavy water. (Heavy water is made from deuterium and oxygen.)

The neutrons produced during a chain reaction are moving too fast to split Uranium nucleii. It is necessary to slow the neutrons down enough for them to react. **Nuclear Cross-Section** in **Millibarns** (a measure of reaction probability) varies with the speed of neutrons, just as it varies with the speeds of the hydrogen and barium nucleii in the polywell and the tokamak. **Moderators** slow down the neutrons so the chain reaction can continue. In addition to acting as a coolant, water or heavy water can also act as a moderator. Graphite is also used as a moderator in some reactors.

Types of NFPRs

There are 264 **Pressurized Water Reactors** (PWR) in use today in the United States, France, and Japan. PWRs have two separate water circulation systems. The coolant water reaches a temperature of about 325C in the reactor core, and it is pressurized to 150 atmospheres. This very hot pressurized water passes through a boiler where it heats water from the turbine loop, and boils it to make steam for the turbine.

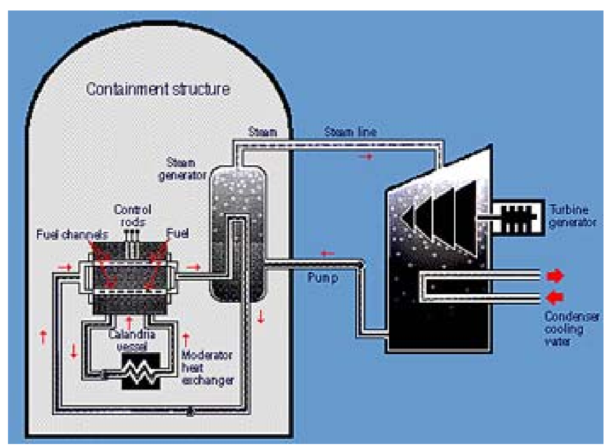




There are 94 **Boiling Water Reactors** (BWR) in use today in the United States, Japan, and Sweden. In a BWR (right), the steam for the turbine is produced by boiling the water in the reactor. Since there is only one loop, a break in the steam line to the turbine could release reactor contaminants; so the turbine is often placed inside the reactor containment.

Unfortunately, water is the moderator in both the PWR and BWR reactors. Because water does not moderate the neutrons to optimum speed (cross-section), it is necessary to **enrich** the uranium fuel used in these reactors. Natural Uranium, as it comes out of the ground, is only about 0.7% (seven tenths of one percent) U235. It is necessary to increase that percentage to about 3.5 to 5.0%, through enrichment, in order to sustain a chain reaction using water as a moderator.

There are 43 **CANDU** reactors in use today in Canada. The CANDU uses heavy water as a coolant and moderator but, except as noted below, it is other-wise essentially the same as the PWR.



There are 12 **Реактор Большой Мощности Канальный** (RBMKs) in use today in Russia. Like the BWR, the RBMK has only one water circulation system, and the steam for the turbine is produced by boiling the water in the reactor. The RBMK, however, uses graphite as a moderator. *Both the CANDU and the RBMK are able to use natural Uranium as a fuel, rather than enriched Uranium*. Using heavy water or graphite as a moderator to better optimize the speeds (cross-sections) of the neutrons makes this possible. With only two notable exceptions, most of these reactors have functioned for many years without incident. Nevertheless, many people have serious concerns about them.

Concerns

1. **Meltdowns**: NFPRs depend upon chain reactions to make neutrons. The chain reaction is controlled by the control rods, which can be gradually inserted into and removed from the reactor. If a malfunction causes the control rods to be removed and they cannot be re-inserted, the chain reaction can go out of control and release too much energy, causing critical parts of the reactor to melt down or otherwise selrf-destruct. Also, in some reactors, failure of the reactor coolant system can cause a meltdown. Such events have already happened three times: in 2011 at the Fukushima Daiichi Plant in Japan; 1986 in Chernobyl, Ukraine; and 1979 at Three Mile Island, United States. In both Japan and the Ukraine, these meltdowns breached the reactor containment, releasing substantial amounts of radioactive substances into the biosphere.

2. **Nuclear Weapons**: Some NFPRs can be used to produce fuels such as plutonium for nuclear weapons. Plutonium can also be extracted from the nuclear waste of some reactors. There is concern that unscrupulous nations may take advantage of their NFPRs to produce nuclear weapons. Indeed, such threats have already been implied by North Korea and Iran. Also, there is the concern that as plutonium becomes more readily available, it will somehow be acquired by a terrorist group and used to make nuclear weapons.

3. **Limited Fuel**: NFPRs use uranium as their fuel. Uranium may be a limited resource. It has been estimated that the world supply of uranium will be depleted in about 50 years at the current rate of consumption and the present price of uranium.

4. **Nuclear Waste**: An operating NFPR produces some radioactive isotopes, which cannot conveniently be recycled. Many of these isotopes are hazardous because of their emissions, and some are toxic as well. At present, there is no safe, cost-effective way to dispose of them. Such dangerous nuclear waste has been accumulating for more than 30 years at various locations world-wide.

So, while it is true that NFPRs do not produce greenhouse gases, the above concerns, when taken together with the following information, would seem to suggest the need for a safer source of energy such as the polywell device.

For Future Cost Comparison

How many 1,000,000,000 watt (1000 mW) Boiling Water NFPRs would be required to replace just half of the 12,900,000,000,000 watts (12.9 Terawatts), presently produced from carbon-based fuels every hour here on Earth, assuming that the Boiling Water NFPRs are operating at 90% (0.9) efficiency? And how much would it cost for that many Boiling Water NFPRs?

6,450,000,000,000 watts/(1,000,000,000 watts per NFPR x 0.9) = 7,167 NFPRs

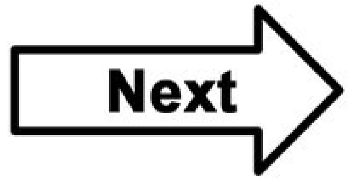
Each 1000 mW NFPR costs $4 billion to $8 billion installed. (Call it $6 billion.)

$6,000,000,000/NFPR x 7,167 NFPRs = $43,002,000,000,000

Excuse me? **More** than $43 TRILLION dollars????

It's a pretty scary number, but just for future comparison purposes, to eventually put this number into perspective, let's calculate the cost per Terawatt:

$43 Trillion/6.45 Terawatts = **$6.66 Trillion/Terawatt**
(remember this number!)



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