Uranium (Nuclear)

What Is Nuclear Energy?

Nuclear energy is energy in the **nucleus** of an **atom**. Atoms are building blocks of **elements**. There is enormous energy in the bonds that hold atoms together.

Nuclear energy can be used to make electricity, but first the energy must be released. It can be released from atoms in two ways: nuclear fusion and fission.

In nuclear **fusion**, energy is released when atoms are combined or fused together to form a larger atom. This is how the sun produces energy.

In nuclear **fission**, atoms are split apart to form smaller atoms, releasing energy. Nuclear power plants use nuclear fission to produce electricity.

The fuel most widely used by nuclear plants for nuclear fission is **uranium**. Uranium is **nonrenewable**, though it is a common metal found in rocks all over the world. Nuclear plants use uranium as fuel because its atoms are easily split apart. During nuclear fission, a small particle called a **neutron** hits the uranium atom and the atom splits, releasing a great amount of energy as heat and radiation. More neutrons are also released. These neutrons go on to bombard other uranium atoms, and the process repeats itself over and over again. This is called a **chain reaction**.

History of Nuclear Energy

Compared to other energy sources, fission is a very new way to produce energy. It wasn't until the early 1930s that scientists discovered that the nucleus of an atom is made up of particles called **protons** and neutrons.

A few years later, scientists discovered that the nucleus of an atom could be split apart by bombarding it with a neutron—the process we call fission. Soon they realized that enormous amounts of energy could be produced by nuclear fission.

During World War II, nuclear fission was first used to make a bomb. After the war, nuclear fission was used to generate electricity. Today, it provides 19.7 percent of the electricity used in the United States.

How a Nuclear Plant Works

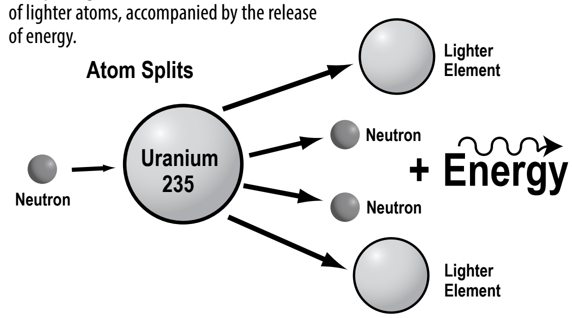
Most power plants burn fuel to produce electricity, but not nuclear power plants. Instead, nuclear plants use the heat given off during fission. Fission takes place inside the **reactor** of a nuclear power plant. At the center of the reactor is the core, which contains the uranium fuel.

The uranium fuel is formed into ceramic pellets. The pellets are about the size of your fingertip, but each one produces about the same amount of energy as 150 gallons (565 L) of oil. These energy-rich pellets are stacked end-to-end in 12-foot (3-4 m) metal **fuel rods**. A bundle of fuel rods is called a fuel assembly.

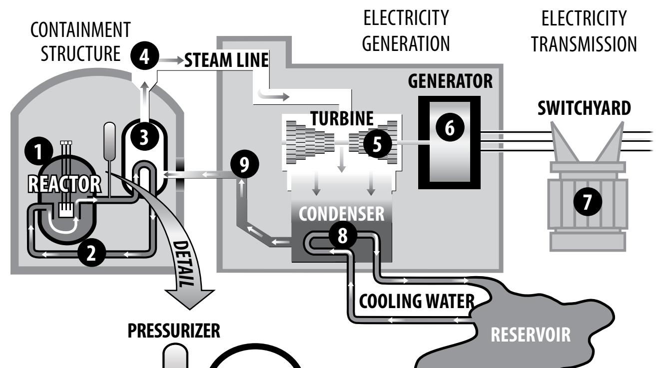
Fission generates thermal energy in a reactor just as coal generates thermal energy in a boiler. The thermal energy is used to boil water into steam. The steam turns huge **turbine** blades. As they turn, they drive **generators** that make electricity.

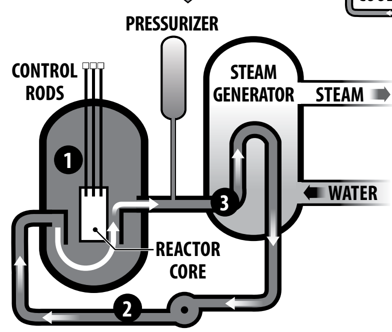
Fission

The splitting of the nucleus of an atom into nuclei of lighter atoms, accompanied by the release of energy.



Pressurized Water Reactor





1. Inside the reactor core are the fuel assemblies, control rods, and water. Fission takes place within the fuel assemblies and heats the water passing through the reactor. Control rods absorb neutrons to control fission.

2. Water is piped through the reactor where it is heated.

3. Water then travels to the steam generator where it heats a secondary system of water.

4. The steam generator keeps the steam at a high pressure. The steam travels through a steam line to the turbine.

5. The high pressure steam turns the turbine as it passes through, which spins a shaft. The steam then travels through the condenser where it is condensed by cooling water and is pumped back into the steam generator to repeat its cycle.

6. The turbine spins a shaft that travels into the generator. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This generates electricity.

7. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

8. The unused steam continues into the condenser where cool water from the environment (river, ocean, lake, reservoir) is used to condense it back into water. The cooling water never comes in direct contact with the steam, so it is safe to return to the environment.

9. The resulting water is pumped out of the condenser with a series of pumps, reheated and pumped back to the reactor vessel.

Afterward, the steam is changed back into water and cooled. Some plants use a local body of water for the cooling process; others use a separate structure at the power plant called a **cooling tower**.

Spent (Used) Nuclear Fuel

Every few years, the fuel rods must be replaced. Fuel that has been removed from the reactor is called **spent fuel**. Nuclear power plants do not produce a large quantity of waste, but this used fuel is highly **radioactive**.

The spent fuel is usually stored near the reactor in a deep pool of water called the spent fuel pool. Here, the spent fuel cools down and begins to lose most of its radioactivity through a natural process called **radioactive decay**.

In three months, the spent fuel will have lost 50 percent of its radiation; in a year, it will have lost about 80 percent; and in ten years, it will have lost 90 percent. Nevertheless, because some radioactivity remains for as long as 1,000 years, the spent fuel must be carefully isolated from people and the environment.

Spent Fuel Repository

Many scientists think the safest place to store nuclear waste is in underground rock formations called **repositories**. In 1982, Congress agreed and passed the Nuclear Waste Policy Act. This law directed the Department of Energy to design and build America's first repository.

The U.S. Department of Energy (DOE) originally looked at Yucca Mountain, Nevada, to be the site of a national spent nuclear fuel repository. Some people supported the site at Yucca Mountain and others did not. The DOE withdrew this location as a possible site, with intentions of pursuing a long-term solution. Until a final storage solution is found, nuclear power plants will continue storing spent fuel at their sites in spent fuel pools or dry cask storage.

Nuclear Energy and the Environment

Nuclear power plants have very little impact on the environment unless there is an accident. Nuclear plants produce no air pollution or carbon dioxide, because no fuel is burned. Using nuclear energy may be one way to solve air pollution problems and reduce **greenhouse gas** emissions that contribute to global **climate change**.

Nuclear power plants do require a lot of water for cooling. If the water is taken from nearby rivers or lakes and returned at a higher temperature, it can disrupt the balance of organisms living in the water habitat.

The major challenge of nuclear power is storage of the radioactive spent fuel. Right now, all of the spent fuel is stored on site at the power plants. People also worry that an accident at a power plant could cause widespread damage and radioactive contamination.

People are using more and more electricity. Some experts predict that we will have to use more nuclear energy to produce the amount of electricity people need at a cost they can afford. The U.S. produces nearly 20% of its total electricity from only 56 nuclear power plants, presently.

Nuclear Safety

The greatest potential risk from nuclear power plants is the release of high-level **radiation** and radioactive material. Radiation is energy given off by some elements and energy transformations. There are natural and man-made sources of radiation that we are exposed to everyday. Very small amounts of radiation are harmless to humans. Very high levels of radiation can damage or destroy the body's cells and can cause serious diseases such as cancer, or even death.

In the United States, plants are specifically designed to contain radiation and radioactive material in the unlikely case of an accident. Emergency plans are in place to alert and advise nearby residents if there is a release of radiation into the local environment. Nuclear power plants have harnessed the energy from the atom for over 50 years in the United States.

In 1979, at the Three Mile Island facility in Pennsylvania, the top half of the uranium fuel rods melted when coolant water to one reactor was cut off in error. A small amount of radioactive material escaped into the immediate area before the error was discovered. Due to the safety and containment features of the plant design, multiple barriers contained almost all of the radiation. No injuries or fatalities occurred as a result of the error. Three Mile Island was safely decommissioned in late 2019 for economical reasons.

In 1986, in the Ukraine (former Soviet Union) at the Chernobyl nuclear power plant, two steam explosions blew the top off of Unit 4. A lack of containment structures and other design flaws caused the release of a large amount of radioactive material into the local community. More than 100,000 people were evacuated from their homes and about 200 workers were treated for radiation sickness and burns. Several people were killed immediately, or died shortly after, with others suffering longer term medical ailments.

On March 11, 2011, an earthquake and resulting tsunami struck Japan, killing and injuring tens of thousands of people. Prior to the earthquake, Japan generated a large percentage of its electricity from nuclear power. In the Fukushima prefecture (community), the Daiichi nuclear plant shut down as a result of the earthquake but suffered extraordinary damage from the tsunami. The damage caused a loss of power that was required to keep the reactor and fuel rods cool. The release of some radioactive material required that residents within a 12 mile radius of the plant be evacuated. Residents living between 12 and 19 miles from the affected power plant were asked to evacuate voluntarily. The Japanese Nuclear and Industrial Safety Agency, the International Atomic Energy Agency, health organizations, and the nuclear energy industry continue to investigate the area and restore it for residents. These groups are also monitoring the impact of the radiation released from the Daiichi nuclear power plant both on the local environment and around the world.

Nuclear energy remains a major source of electricity in the United States and around the globe. The safe operation of nuclear power plants is important to quality of life and to the health and safety of individuals worldwide.