# Powering America: Nuclear Energy

With every flick of a light switch, humans contribute to the 5.6 billions tons of carbon dioxide released into the atmosphere each week due to the burning of fossil fuels (Pablo). Only 400 power plants in the world do not add to carbon emissions, all being nuclear (Morgan). Instead, nuclear power plants produce radioactive waste, the major factor impeding the widespread use of nuclear energy. Despite the environmental benefits, the production of radioactive waste causes nuclear energy to be a controversial power source.

**Figure 1.** This map shows all of the nuclear power plant locations in the United States.

## Discovery

**Figure 2.** Marie and Pierre Curie in their laboratory.

The French scientist and professor, Antoine Henri Becquerel, was credited with discovering the radioactivity of Uranium. Becquerel, along with Marie Curie and Pierre Curie (Figure 2), won the Nobel Prize in 1903 for research on the subject of radioactivity. Although the idea of nuclear power was first introduced by Becquerel in the early twentieth century, scientists did not discover the process of nuclear fission until 1939. Through nuclear fission, large amounts of energy can be released from radioactive elements. During the 1940s, United States scientists captured the nuclear reactions and used them to create atomic bombs. Then, in 1951 in Idaho, the properties of radioactive elements were first used for nuclear power. However, commercial nuclear power plants did not open until 1957 in England. Despite promising prospects, nuclear power has never become as popular and wide spread as scientists originally believed it would be.

## The Production of Electricity

The production of nuclear energy takes place within a nuclear reactor. Through the process of nuclear fission, Uranium-235 decays by alpha radiation and releases an alpha particle. Unlike other forms

of Uranium, the alpha radiation of Uranium-235 can be induced by injecting a free neutron into the nucleus. The alpha particle that breaks off consists of two neutrons and two protons. After the original injection of a neutron into the nucleus, the newly created alpha particles can proceed to host more fission reactions. The process of nuclear fission is a chain reaction, and the reactions happen very quickly.

This chain reaction could go on indefinitely, eventually causing a nuclear explosion. In order to keep these chain reactions controlled, Uranium is inserted into the nuclear reactor on thin fuel rods. Between each fuel rod, control rods made of boron absorb some of the neutrons released during fission. Control rods are raised and lowered throughout fission to keep the reaction from causing catastrophe. A moderator surrounds both the fuel rods and the control rods. Made of graphite or another material that does not react during fission, the moderator helps to slow down the neutrons and control the reaction. Then, surrounding the entire nuclear power plant is a concrete liner covered by a steel containment vessel. Encasing the steel containment vessel is a concrete structure that can endure anything from an earthquake to a crashing jet plane (Figure 3).

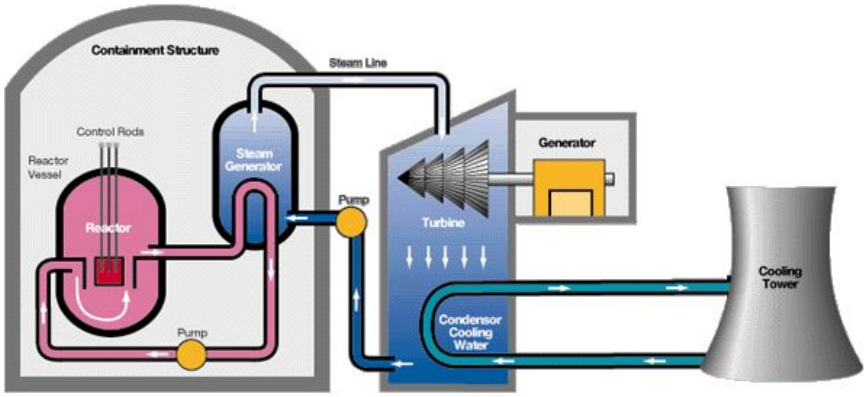


**Figure 3.** The standard model for the structure of a nuclear power plant.

Nuclear fission creates heat. The same amount of heat is produced from 15.5 ounces of Uranium as is released from 1400 tons of coal (Morgan). Carbon dioxide, which is pumped around the reactor, absorbs the heat released from the reaction. Then, the carbon dioxide uses the heat it has absorbed to boil water and make steam. The steam turns a turbine which powers the generator. Through this process, electricity is produced.

## Nuclear Waste

Almost every form of energy releases carbon dioxide into the environment. Today scientists link these carbon emissions to climate change. The carbon dioxide absorbs the solar radiation that enters the atmosphere, traps the heat, and in turn, causes the earth to become warmer. This phenomenon is known

more commonly as global warming. However, nuclear power does not release nearly as much carbon dioxide as do other energy sources.

Even though carbon emissions are not released into the atmosphere from nuclear power plants, another form of waste is produced, which is just as, if not more hazardous, than carbon dioxide. When a neutron hits a Uranium atom and causes it to break down, a radioactive particle breaks off from the atom. Radiation exists in the nuclear waste that is left over from nuclear fission. Anything that has come into contact with the reaction is considered radioactive and therefore, harmful. This includes the fuel and control rods, the reactor, and mining sites. Radioactive materials continue to release radiation for thousands of years.

## Radiation

There are two types of radiation: primary radiation and secondary radiation. Primary radiation can be blocked from entering a cell whereas secondary radiation is more subtle and cannot be stopped, making it more dangerous. When humans are near radioactive materials, they run the risk of receiving this secondary radiation. Secondary radiation enters into living tissue and takes valence electrons from the elements in the tissue. This process is called ionization, and it can cause the chemical reactivity of an element to change. Inside living tissue are water, hydrogen, carbon, nitrogen, oxygen, phosphorus, and sulfur. Some of the ionized atoms will react and make substances that are life threatening.

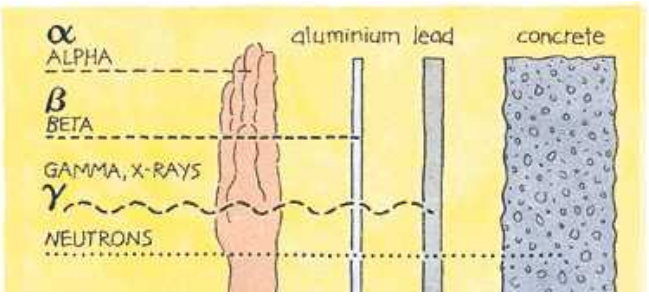


**Figure 4.** Gamma rays penetrate the farthest of the three forms of radiation particles.

The radiation released from nuclear waste comes in the form of gamma rays (Figure 4). It is easy for gamma rays to penetrate a substance because they have a neutral charge. Their neutral charge makes the radiation from nuclear waste very dangerous since it can easily enter humans. If the radiation hits molecules such as proteins or nucleic acids, the molecules can be damaged to the point where they cannot function properly. Damaged molecules can decrease enzyme production, initiate cancer, or mutate genes. Radiation can cause cell membranes to rupture which then causes cells to die. If radiation kills enough cells, organs will stop

functioning and then lead to the death of the human. The breakdown of cells caused by radiation can also affect the immune system, leaving the human vulnerable to sicknesses.

Radiation caused by nuclear energy can come in two forms: high-level radioactive waste and low-level radioactive waste. High- level waste comes directly from the nuclear reactions. Low- level waste comes from the parts, equipment, and mining sites that have come in contact with the radioactive material. Though both are dangerous, low- level waste does not continue to release radioactive particles for as long as high- level waste.

## Nuclear Accidents

In locations where there have been nuclear explosions, it has been proven that there is an increase in cancer after the release of the radiation. For example, in Chernobyl, Ukraine, the lid of a nuclear reactor blew off when the reactor overheated. Radioactive particles entered the atmosphere leading to the evacuation of 135, 000 people, the death of 30 people, and a 20 mile radius of high-level radiation (Kelly and Mast). Due to the radiation, 300,000 people had to be permanently moved from the location and an increasing number of Ukrainian children have been diagnosed with thyroid cancer since the accident (Kelly and Mast).

The Navajo Indians, who reside in the Colorado Plateau, have also experienced the effects of radiation. They agreed to mine for Uranium on their land in hopes of earning large amounts of money. However, their plan backfired when their water became contaminated and their people began to suffer from cancer and birth defects. Though there was no nuclear power plant or nuclear explosion, the tailings, which are the rest of the ore that cannot be used for nuclear reactions, were enough to contaminate the environment. When the Navajos mined for ore, one ton of ore created only three kilograms of Uranium ("The Nuclear Waste"). As a result, a large magnitude of tailings was left behind that contained low-level radiation. There have also been many accidents in the transportation of Uranium from the mines to the nuclear power plants. When Uranium spills, it is harmful to the surrounding environment and population.

The worst nuclear accident in the history of the United States occurred near Harrisburg, Pennsylvania on March 28, 1979, and is known as Three Mile Island. One of the two reactors in the area depleted its coolant, causing the reactor to overheat and melting some of the uranium core. Radioactive

water and gases were released into the environment, but there are no records of health issues linked to the accident.

## The Controversy

Nuclear waste continues to pose a problem due to its release of radiation. The radiation factor has caused controversy throughout the government and scientific community. The government has suggested storing waste in Yucca Mountain, Nevada, but scientists fear that the surrounding area will become unfit for human habitation due to radioactive pollution (Figure 5).

There are four parts of Yucca Mountain. Part one of the diagram shows nuclear waste arriving at Yucca Mountain via train or truck in special storage casks. Then in part two, the inner tube containing the waste is removed from the shipping container and placed into a multilayered storage container. Those storage containers are automatically transported in step three to tunnels where they will be permanently kept in step four.

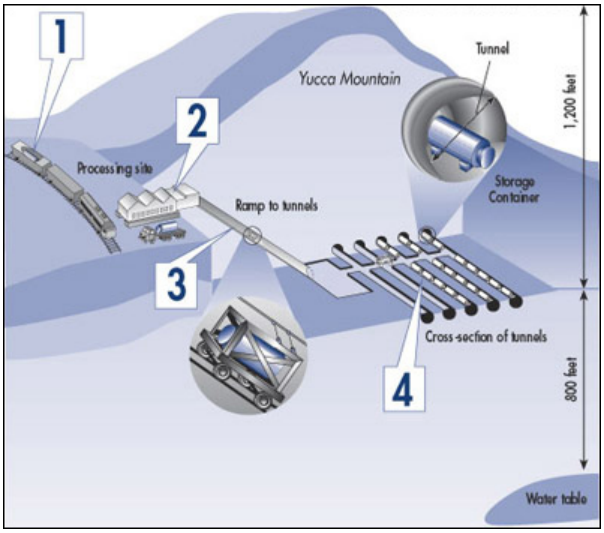


**Figure 5.** Yucca Mountain would store nuclear waste as shown in the model.

The waste would reach humans mainly through the water cycle. Vegetation absorbs water holding radionuclides and then animals ingest the vegetation. Radiation can also reach humans when it is transported through the air and lands upon a human, animal, or plant.

Not only is nuclear waste dangerous, but a large quantity of waste is also produced from nuclear power plants. In the United States alone, three thousand tons of high-level radioactive waste is produced each year (Nuclear Waste. Oracle). That is enough waste to cover an entire football field in a layer one foot deep ("Nuclear Waste." Oracle). As a result, space has become a prime issue as to how to dispose of waste.

## Waste Storage

Up until the 1970s, containers holding high-level waste were dumped into the ocean, but scientists then discovered the containers were leaking. Currently, waste is often stored in pools. The waste is put

**Figure 6.** Nuclear waste containers are stored in cooling pools to contain radiation.

into a steel rod that is then placed in a pool and covered with 13 feet of water (Figure 6). The pools help to contain gamma radiation because the rods are kept cool and they stop fission. However, after the rods are placed within the pools, it is very dangerous to move the rods from their original position. Another common form of waste disposal is called geologic disposal. This is when mines are built within the Earth and the waste is put into the mine.

Nuclear waste can be contained in casks, which are steel containers that are believed to be able to withstand almost any collision or natural disaster. Some scientists are not convinced that the casks are as indestructible as they are believed to be, and would prefer to have the casks tested more thoroughly for failure. Scientists are also looking into burying high-level waste in the sea bed at the bottom of the ocean or constructing specially shaped containers that will sink to the bottom of the ocean.

Some nuclear waste can be recycled and reused rather than stored. Spent fuel is reprocessed by cutting up the fuel rods and placing the pieces into a tank of nitric acid. The addition of solvent into the tank release Uranium and Plutonium. The fission products are then separated and concentrated. Concentrated fission products are considered high-level nuclear waste and are then stored in cooling tanks.

## Future of Nuclear Power

Ever since the late 1900s, nuclear energy has been discussed as an energy source in the United States. Apart from the controversies prohibiting nuclear energy from being a major energy source, it continues to be an option for future electricity. The disposal of nuclear waste and the potential release of radiation into the environment have been the prevailing reasons for the delay of the use of nuclear energy. Regardless, scientists are still exploring the phenomenon of nuclear reactions as a more environmentally friendly and oil independent source of energy.

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Figure 2
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Figure 6
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