pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

NUCLEAR ENERGY

Introduction

There are about 93 nuclear power reactors operating across the United States providing electricity to homes and businesses. About 20 percent of the electricity in the United States is provided by nuclear energy. Pennsylvania has eight operating nuclear power reactors on four sites. In 2017, Pennsylvania ranked second in the nation in electricity generation, obtaining 42 percent of its net electricity generation from nuclear power-more than from any other source. The megawatt electricity (MWe) generated by the eight nuclear power plants ranges from 933 to 1,324 MWe per plant, with an average for all eight plants of 1,176 MWe each.

How Does a Nuclear Reactor Work?

Think of a boiling tea kettle: the energy from the steam coming out of the spout can be directed at a toy pinwheel that then spins. What causes the water to boil? The heat from the stove. Steam electric power plants produce electricity in the same way. Steam is produced and used to turn large fan-like blades located inside a turbine. The turbine is attached to a generator that, through the use of coils of wire and magnetic fields, creates electricity. In a steam electric power plant, the steam is generated by burning coal, natural gas, oil, or by using nuclear energy.

Nuclear energy does not require anything to be burned; instead, splitting atoms of uranium create the heat that turns the water into steam. Splitting atoms is called fission. Uranium comes in the form of ceramic pellets about the size of the end of the pinky finger. The pellets are inserted into long, vertical tubes, which are bundled together as fuel assemblies and placed inside the plant's reactor, where fission takes place.

When a plant starts up, neutrons are released to strike the uranium atoms. When the neutrons hit some of the uranium atoms in the pellets, the atoms split (fission) to release neutrons of their own, along with heat. One fission triggers others, which trigger still more until you have a chain reaction. When that happens, the plant is up and running, splitting atoms to create the heat that will turn water into steam.

This chain reaction is controlled by inserting long rods among the tubes holding the fuel. These long rods, called "control rods," are made of a material that absorbs neutrons-so the neutrons can no longer hit atoms and make them split. To slow down the chain reaction, control rods are inserted into the core. To speed up the chain reaction, control rods are withdrawn from the core. The reactor's "core" cooling is maintained with chemically controlled water.

Are Nuclear Power Plants Safe?

To understand why nuclear power plants are safe, we need to remember how they work. Nuclear power plants are fueled with uranium. The uranium atoms split, producing heat that boils water to steam. The steam is used to spin a turbine to produce electricity.

The leftover radioactive materials-by-products of fission-are carefully controlled to be sure that no dangerous levels of radiation get outside the plant.

To protect the public from a release of radiation, the plant design takes advantage of natural processes and incorporates backup safety systems-safety in depth.

Nuclear plant designers also assume that equipment will fail and that operators will make errors, so nuclear power plants have multiple backup systems to cope with equipment failure and human error. In addition to backup systems that monitor and regulate what goes on inside a nuclear reactor, there are also a series of physical barriers to prevent the escape of radioactive material.

- The first barrier is the fuel itself. The uranium fuel is in the form of solid ceramic pellets, which resist the effects of high temperature and corrosion. Most of the fission particles remain locked inside the fuel pellets.
- The next barrier is the fuel rods that hold the fuel pellets. The pellets are stacked end-to-end in 12-foot-long tubes made of a special metal called zirconium. Zirconium resists heat, radiation, and corrosion.
- The next barrier is the large, steel pressure vessel (called the reactor vessel), with walls about eight inches thick.
- Finally, these barriers are enclosed in a massive reinforced concrete structure—called the containment structure—with walls that are about four feet thick.

To reach the environment, radioactive material would have to escape from each of these barriers in succession.

Regulatory Oversight of Nuclear Power Plants

U.S. Nuclear Regulatory Commission (NRC)

The radiological health and safety regulation of the nuclear facilities is under the exclusive authority of the NRC. The NRC is particularly tasked with the licensing of the site, the power plant, and the qualifications of its operators. Additionally, the NRC is tasked with the constant oversight of the operation of these reactors. Two resident inspectors are stationed at each power plant site to perform this task. The resident inspectors provide the major on-site NRC presence for direct observation and verification of plant activities. Additionally, various inspections are periodically conducted by NRC Regional offices and NRC Headquarters.

Department of Environmental Protection's (DEP) Bureau of Radiation Protection (BRP)

In compliance with the Pennsylvania Radiation Protection Act of 1984, DEP's BRP has implemented a comprehensive nuclear safety and environmental monitoring program at the nuclear power plants in Pennsylvania. BRP's Nuclear Safety Oversight Review Program consists of Nuclear Safety Specialists, Radiological Health Physicists, Radiation Protection Specialists, and Environmental Technicians. An experienced Nuclear Safety Specialist is assigned to each of the four nuclear plant sites. Staff conduct nuclear power plant evaluations and participate in inspections with the NRC inspectors. BRP has a major responsibility in providing technical support and assistance to the Pennsylvania Emergency Management Agency during a nuclear event or emergency. All BRP staff are trained to respond and protect the public during emergencies.

Location of Nuclear Power Plants in Pennsylvania

Nuclear power plants are located in the following areas: Limerick Generating Station Unit 1 and Unit 2 in Pottstown, Montgomery County; Peach Bottom Atomic Power Station Unit 2 and Unit 3 in Peach Bottom, York County; Susquehanna Steam Electric Station Unit 1 and Unit 2 in Berwick, Luzerne County; and Beaver Valley Power Station Unit 1 and Unit 2 in Shipping port, Beaver County.

Further Information

To obtain additional information on nuclear reactor operations, safety, emergency planning, licensing, etc., please contact any one of the organizations listed below.

Nuclear Regulatory Commission (NRC), www.nrc.gov;

Federal Emergency Management Agency (FEMA), www.fema.gov;

American Nuclear Society (ANS), www.ans.org; and

Nuclear Energy Institute (NEI), www.nei.org.

For more information, visit www.dep.pa.gov.