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Understanding Nuclear Energy

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The use of carbon-free energy sources, or energy sources that emit minimal to no greenhouse gases (GHGs) to produce electricity, is increasing. Nuclear energy, which is a carbon-free energy source, already accounts for about 19 percent of the electricity generated in the United States[1], but there are concerns about its potentially harmful health and environmental impacts. This issue brief provides an overview of nuclear energy, its history in Colorado, public health and environmental concerns, and recent technological advancements in nuclear energy.

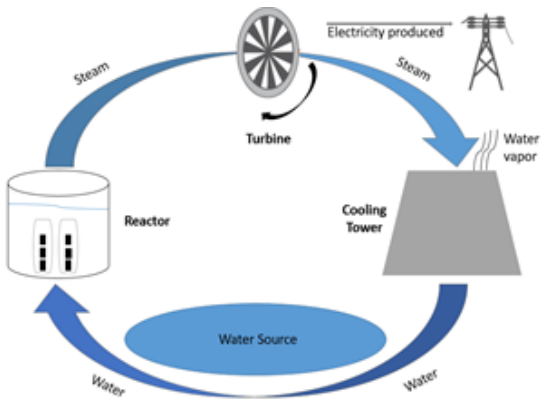
Generating Nuclear Energy

Nuclear power plants use nuclear fission to produce electricity. Fission occurs when atoms are split apart using a high-energy neutron from another atom, which creates large amounts of energy through heat and radiation. According to the U.S. Energy Information Administration (EIA), there are currently 54 commercially operating nuclear power plants with 94 nuclear power reactors in 28 states, with Illinois, Pennsylvania, and South Carolina as the top producers of nuclear energy in the country. The U.S. Nuclear Regulatory Commission is the primary regulator of nuclear power plant operations, while state regulatory authority is limited to need, reliability, and cost. Federal Law limits states' regulatory authority to need, reliability, cost, and other state concerns.

Electricity Production

Nuclear power, like most of the world's electricity generation, uses steam turbines to drive electricity generators. Nuclear reactors—the large domes that house the nuclear fission fuel rods and their containment chambers—are filled with water. When fission occurs within these chambers, the released heat creates steam that is pumped through a turbine, which in turn drives the electricity generator. The steam is then transferred and condensed back into water using a cooling tower. Figure 1 shows how a nuclear reactor generates electricity.

Figure 1
How a Nuclear Reactor Generates Electricity



Source: U.S. Energy Information Administration.

[1] EIA Electricity Generation by Energy Source

Uranium Mining

Uranium is the main fuel for nuclear reactors. Uranium is a naturally occurring element that is found underground and is mined around the world. According to the World Nuclear Association (WNA), Kazakhstan produces 39 percent of the world supply of uranium, followed by Canada at 24 percent, and Namibia at 12 percent in 2024.

The U.S. produces a small amount of uranium for U.S. nuclear power plants, but there has been a recent increase in the amount mined due to the growing nuclear market and demand for energy. According to the EIA, the U.S. produced 677,000 pounds of uranium concentrate in 2024, a significant increase from the 50,000 pounds produced in 2023.[2]

Nuclear Energy in Colorado

Colorado's sole nuclear power plant, Fort St. Vrain, operated from 1979 until 1989. Currently, it is used as a natural gas power plant and stores spent nuclear fuel in an on-site repository.

Uranium was first discovered in Central City, Colorado in 1871 and has been mined throughout the state, with peak activity from the 1950s through the 1970s, and last known production in 2005. While there are existing permits for uranium mining, there are currently no known active mines in the state.

Through House Bill 25-1040, the state defines nuclear energy as a "clean energy source," which allows nuclear energy projects to qualify for clean energy project financing.

Health and Environment Concerns

Although nuclear reactors do not directly emit GHGs, nuclear energy can potentially pose risks to public health and the environment in other ways.

Radioactive Waste

A byproduct of nuclear fission is radioactive waste. Radioactive waste is the spent uranium fuel that is created after nuclear fission. This waste is extremely hazardous because it releases radioactive particles and remains harmful for thousands of years. Radioactive waste must be stored securely to prevent its release. According to the EIA, most radioactive waste is stored underground at the nuclear power plant that produced it. Nuclear power plants are required to have the appropriate safety measures in place to secure radioactive waste.

Nuclear Meltdowns

Nuclear reactors must be continuously cooled with water since nuclear fission generates heat. When a reactor is not properly cooled, the fuel rods can overheat and melt, which then melt the containment chamber in which they are housed. If the containment chamber

[2] EIA: Domestic Uranium Production Report

melts, the entire reactor can overheat in a nuclear meltdown and release the radioactive material stored inside. While nuclear meltdowns are rare, major meltdowns have occurred and have caused irreparable harm to the surrounding environment.

Fresh Water Usage

Another concern with nuclear energy is the amount of fresh water required. Fresh water is necessary to produce the steam that rotates the turbines. Water must also be available to cool nuclear reactors. According to the WNA, nuclear power plants require more water than any other power plant, including coal, natural gas, and solar thermal power plants.

While fresh water is cooled through cooling towers before it is returned to its source, the water used in the power plant can still be hot. Hot water that is released back into the environment can kill numerous aquatic species, affect their health, and harm their habitat.[3] This released water can also contain small amounts of radioactive material.

Technology Advancements

As the demand for carbon-free energy sources to generate electricity grows, the U.S. Department of Energy (DOE) has researched and developed technological advancements to increase the use of nuclear energy, such as advanced small modular reactors. These reactors vary in electricity generation potential, size, and the type of coolant necessary to cool the reactors. These small modular reactors are recognized for their numerous benefits over traditional nuclear power, such as their size and cost relative to nuclear power plants; their ability to operate in more areas; and their potential to use less water and produce less nuclear waste.[4]

Since 2018, DOE has awarded funding to companies across the country to begin researching and developing their own advanced small modular nuclear reactors.

Additional Resources

The following are additional resources that may be of interest:

- A People's Atlas of Nuclear Colorado
- Advanced Nuclear Energy
- Colorado Geological Survey Map and Directory of Colorado Uranium and Vanadium Mining and Mining Activities
- Fort St. Vrain Nuclear Generating Station

[3] U.S Fish & Wildlife Service: Nuclear Power

[4] DOE: Advanced Small Modular Reactors