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Understanding Nuclear Energy's Role in an Energy Portfolio

By Andrea Denka

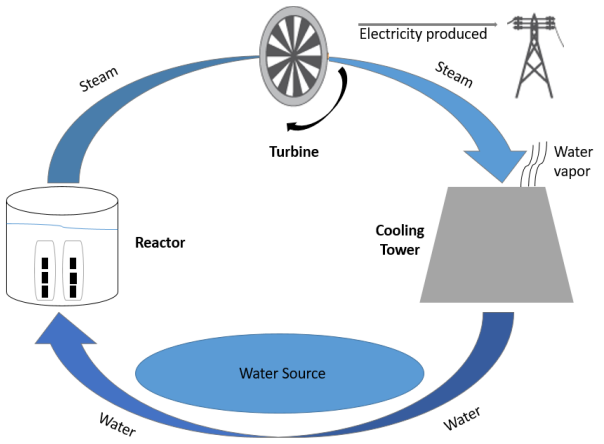
The use of carbon-free energy sources, or energy sources that emit minimal to no greenhouse gases (GHGs) to produce electricity, is increasing. Nuclear energy, which is a carbon-free energy source, already accounts for about 20 percent of the electricity generated in the United States, but there are 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 safety concerns, and recent technology advancements.

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 (U.S. EIA), there are currently 57 commercially operating nuclear power plants in 29 U.S. states. Most of these power plants are located on the East Coast. The U.S. Nuclear Regulatory Commission regulates nuclear power plant operations.

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.

Nuclear energy has accounted for about 20 percent of the total U.S. electricity generation since 1990. The U.S. EIA outlook estimates that nuclear energy will become a smaller part of the U.S. energy portfolio in the future, and will fall to 13 percent in 2050 due to: low natural gas prices, limited growth in electricity demand, retiring nuclear power plants, and increasing competition from other renewable energy sources.

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), most uranium is mined in Australia, Canada, and Kazakhstan. The U.S. produces a small amount of uranium for U.S. nuclear power plants from mines located in Nebraska, Texas, and Wyoming.

Nuclear Energy in Colorado

Currently, Colorado does not have any nuclear power plants or any plans for future power plants. According to the Colorado Energy Office (CEO), the state's only nuclear generating facility, Fort St. Vrain, generated electricity from 1976 to 1989. Today the facility, which is located near Platteville, is used as a natural gas electricity generating plant.

Uranium was discovered in Colorado in Central City in 1871. Uranium was mined in Colorado as other states began building nuclear power plants in the 1950s. CEO states that the market for uranium declined in the 1970s due to health and environmental concerns with nuclear energy. Uranium mining has been completely halted in Colorado since 2009.

Health and Environmental 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 U.S. 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 will then melt the containment chamber in which they are housed. If the containment chamber 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 also must be available to cool nuclear reactors. According to the WNA, nuclear power plants require more water than any other power plant, including: coal power plants, natural gas power plants, or 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[1]. This released water can also contain small amounts of radioactive material.

Technology Advancements

As the use of 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. DOE states that small modular reactors offer 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[2]. Since 2018, DOE has awarded funding to companies across the country to begin researching and developing their own advanced small modular nuclear reactors.

[1]U.S Fish & Wildlife Services: Energy Development, Energy Technologies and Impacts – Nuclear Power: https://www.fws.gov/ecological-services/energy-development/nuclear.html.

[2]Office of Nuclear Energy: Advanced Small Modular Reactors (SMRs) https://www.energy.gov/ne/nuclear-reactor-technologies/small-modular-nuclear-reactors