Nuclear Power: An Overview

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Legislative Research Council

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Introduction

From July 1966 to September 1967, a nuclear power plant known as the Pathfinder Nuclear Generating Station operated in northeast Sioux Falls.[1] Designed as a proof of concept plant with a prototype "superheater" nuclear reactor, Pathfinder had a 60 megawatt generating capacity.[2] Pathfinder operated intermittently at less than peak output during its year of operation, and operated at 100% capacity for a total of thirty minutes, though the power generated by the station was never distributed to the electrical grid.[3] Pathfinder was decommissioned as a nuclear facility in October 1967 and converted into a gas- and coal-powered station.[4] Despite its limited operating lifetime, Pathfinder succeeded as a demonstration project and research facility, and ultimately led to the construction and operation of much larger nuclear power plants still in operation in the Midwest today.[5]

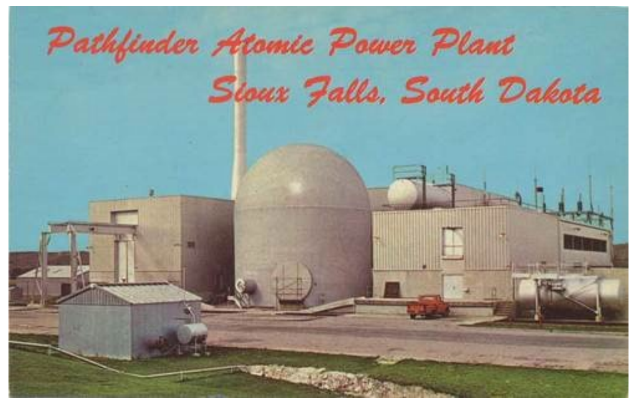

Illustration 1: Pathfinder.[6]

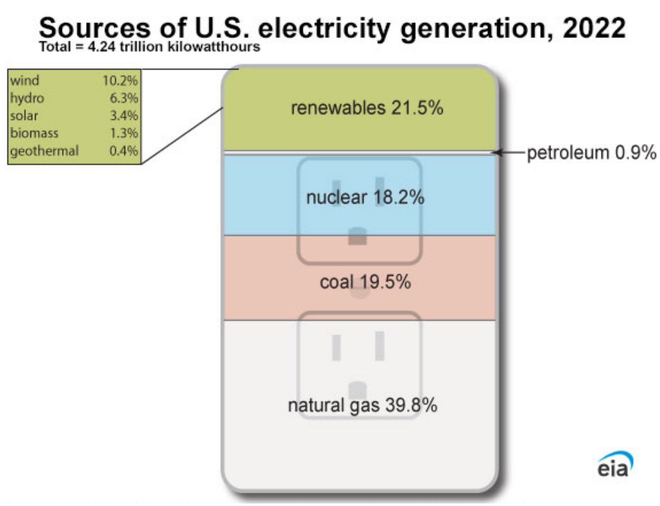

Illustration 2: Breakdown of U.S. electricity sources.[9]

Since the shutdown of Pathfinder, no other nuclear power facility has operated in South Dakota. However, nuclear power remains a vital source of electricity in the United States. There are currently 93 operable nuclear reactors in the United States, with a combined generation capacity of approximately 95,492 megawatts in 2022.[7] Today, nuclear power represents nearly half of all fossil fuel-free electricity and is the source of 18.2% of electricity generation in the United States.[8] To provide context for discussions surrounding the potential for nuclear power in South Dakota, this memorandum summarizes the science and technology behind nuclear power, how nuclear power is utilized across the nation and in neighboring states, and the ways in which nuclear power is legislated.

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[1] *Nuclear Reactor Shutdown List*, U.S. Energy Information Administration, https://www.eia.gov/nuclear/reactors/shutdown/ (last visited Sept. 7, 2023).
[2] Id.; *Pathfinder*, World Nuclear Association, https://www.world-nuclear.org/reactor/default.aspx/PATHFINDER (last visited Sept. 7, 2023).
[3] Eric Renshaw, *City's nuclear age lasted only a year*, Argus Leader (Mar. 29, 2014, 11:00 PM), https://www.argusleader.com/story/life/2014/03/30/citys-nuclear-age-lasted-year/7043837/.
[4] Id.
[5] Tom Hanson, *A rare look at South Dakota's first and only nuclear power plant called Pathfinder*, KELOLAND (Feb. 15, 2021, 10:07 PM), https://www.keloland.com/news/eye-on-keloland/a-rare-look-at-south-dakotas-first-and-only-nuclear-power-plant-called-pathfinder/.
[6] *Pathfinder Nuclear Generating Station*, Greetings From Sioux Falls, https://www.greetingsfromsiouxfalls.com/pathfinder (last visited Sept. 7, 2023).
[7] *Nuclear Reactors in United States of America*, World Nuclear Association, https://www.world-nuclear.org/country/default.aspx/United%20States%20Of%20America (last visited Sept. 7, 2023); *Nuclear explained - U.S. nuclear industry - Basics*, U.S. Energy Information Administration, https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php (last updated Aug. 24, 2023).
[8] *Electricity explained - Electricity generation, capacity, and sales in the United States - Basics*, U.S. Energy Information Administration, https://www.eia.gov/energyexplained/electricity/electricity-in-the-us-generation-capacity-and-sales.php (last updated Jun. 30, 2023).
[9] Id.

Nuclear Power: How It Works

To understand the science behind nuclear power, it is best to begin with its fuel source: uranium. Uranium, and more specifically, uranium-235—the only isotope of the element capable of sustaining a nuclear chain reaction—is the most widely used fuel in nuclear power plants in the United States.[10] Although uranium is a common metal found across the globe, uranium-235 is relatively rare, occurring in just over 0.7% of natural uranium.[11]

Illustration 3: Fuel assembly.[18]

After uranium is mined, it must be processed and enriched to increase the concentration of uranium-235 to 3.0%-5.0% for use as fuel in nuclear reactors.[12] The enriched uranium is then formed into ceramic pellets, each approximately one inch tall and capable of producing the same amount of energy as 1 ton of coal, 120 gallons of oil, or 17,000 cubic feet of natural gas.[13] The pellets are stacked end-to-end in twelve foot fuel rods, and the fuel rods are bundled together into fuel assemblies.[14] A fuel assembly contains about 179 to 264 fuel rods, depending on the reactor type, and a typical reactor core holds 121 to 193 fuel assemblies.[15] The reactor core containing the bundled fuel assemblies is enclosed in a steel pressure vessel with walls several inches thick.[16] At this stage, with the core of enriched fuel assemblies in place, a nuclear reactor can be "started up" by initiating a nuclear chain reaction called fission.[17]

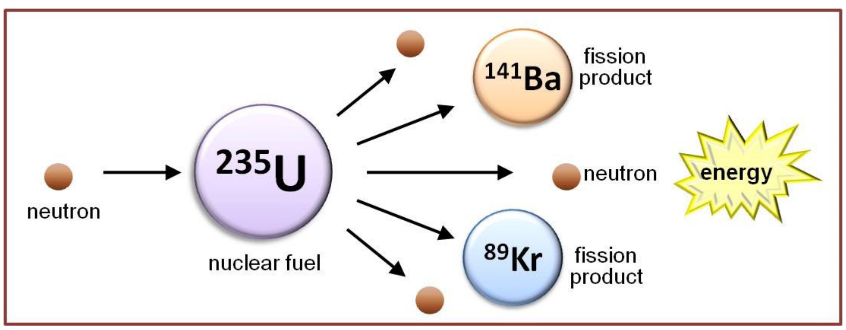

Illustration 4: Schematic representation of nuclear fission.[19]

Nuclear fission is the process by which an atom is split apart to form smaller atoms, releasing energy in the form of heat and radiation. Nuclear fission is initiated inside a nuclear reactor by introducing a "spare" neutron, which collides with a uranium atom and splits it, releasing more neutrons that continue to collide with other uranium atoms, causing the process to repeat itself in a chain reaction.[20] If such a chain reaction were allowed to go unchecked, it would result in a massive and nearly instantaneous release of energy and heat.[21] However, the fundamental purpose of a nuclear reactor is to control the rate of fission to produce and maintain a desired amount of heat. By inserting control rods into the reactor core, a portion of the neutrons released by the fission of the uranium fuel is absorbed.[22]

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[10] *Nuclear explained - The nuclear fuel cycle - Basics*, U.S. Energy Information Administration, https://www.eia.gov/energyexplained/nuclear/the-nuclear-fuel-cycle.php (last updated Jul. 12, 2022).
[11] Id.
[12] Id.
[13] *Nuclear explained - Nuclear power plants - Basics*, U.S. Energy Information Administration, https://www.eia.gov/energyexplained/nuclear/nuclear-power-plants.php (last updated Aug. 21, 2023); *3 Reasons Why Nuclear is Clean and Sustainable*, Office of Nuclear Energy (Mar. 31, 2021), https://www.energy.gov/ne/articles/3-reasons-why-nuclear-clean-and-sustainable (last updated Jun. 2022).
[14] *Nuclear explained - Nuclear power plants - Basics*, supra note 13.
[15] *Nuclear explained - The nuclear fuel cycle - Basics*, supra note 10.
[16] Id.
[17] *Controlling Fission*, Nuclear @ McMaster, https://nuclear.mcmaster.ca/resources/how-does-it-work-2/controlling-fission/ (last visited Sept. 7, 2023).
[18] *Nuclear explained - The nuclear fuel cycle - Basics*, supra note 10.
[19] *The Reactor*, Nuclear @ McMaster, https://nuclear.mcmaster.ca/resources/how-does-it-work-2/the-reactor/ (last visited Sept. 7, 2023).
[20] *Nuclear explained - Basics*, U.S. Energy Information Administration, https://www.eia.gov/energyexplained/nuclear/ (last updated Aug. 21, 2023).
[21] *Controlling Fission*, supra note 17.
[22] Id.

To initiate a chain reaction when a reactor is being started up, the control rods are partially withdrawn so that they absorb fewer neutrons; once a chain reaction is occurring, the control rods are inserted slightly further into the core to slow the rate of fission.[23]

It is the heat produced by the nuclear fission reaction that is key to nuclear power. Once fission is initiated, generating heat and energy, a nuclear power plant functions much like any other natural gas- or coal-powered plant. The heat generated in the reactor core is used to boil water into steam, which spins the blades of a steam turbine, which drives the generators that create electricity.[24] In the U.S., two main types of reactors are utilized for this process. About one-third are boiling water type reactors, which use a single circuit to produce steam directly inside the reactor and feed it to the turbine.[25] The other, more commonly used reactor is the pressurized water type reactor. A pressurized water reactor has a primary circuit that flows water through the core of the reactor under very high pressure, which prevents the water from turning into steam, and a secondary circuit where the heat of that pressurized water is used to vaporize water into steam, which in turn drives the turbine.[26] In both types of reactor, the steam is condensed back into water and recycled through the system to be used in the heating process again.[27]

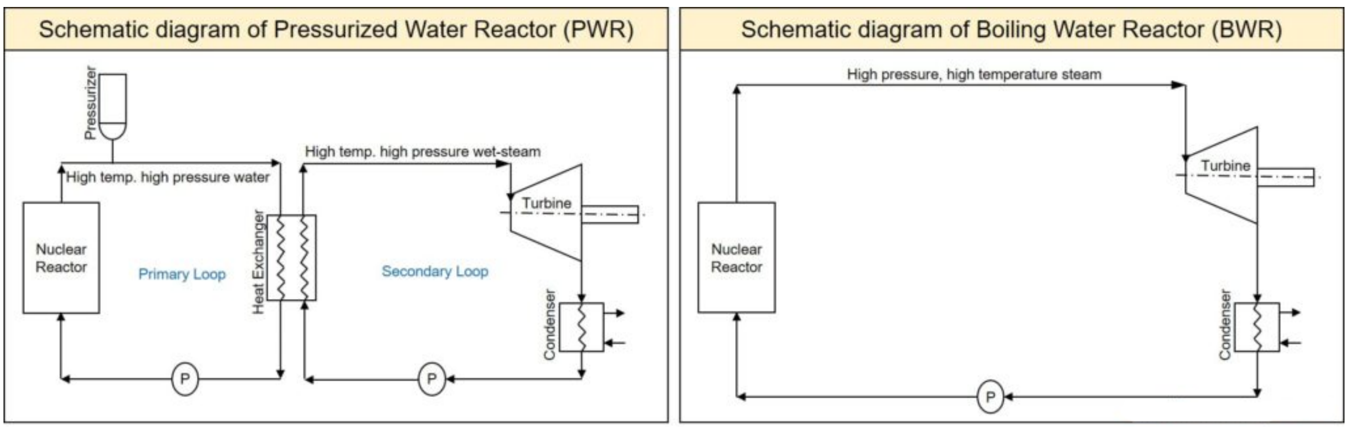

Illustration 5: Two types of nuclear reactor.[28]

The U.S. Department of Energy also supports the commercialization of small modular reactors, which are about one-third the size of a conventional boiling water or pressurized water reactor.[29] Small modular reactors have simple, compact designs that can be assembled in a factory and transported by train or truck to a power plant site.[30] Where a large, conventional reactor produces between 700-1,400 megawatts of electricity, enough to power 500,000 to 1 million homes, a small modular reactor produces up to 300 megawatts of electricity, enough to power 75,000 to 200,000 homes.[31] The size and simplicity of small modular reactors could reduce both the time it takes to build a new facility and the high upfront costs of a nuclear power plant.[32]

[23] Id.
[24] *Energy Portfolio - Nuclear Energy*, Xcel Energy, https://sd.my.xcelenergy.com/s/energy-portfolio/nuclear (last visited Sept. 7, 2023); *Nuclear explained - Nuclear power plants - Basics*, supra note 13.
[25] *Nuclear Power Reactors*, World Nuclear Association, https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/nuclear-power-reactors.aspx (last updated May 2023); *NUCLEAR 101: How Does a Nuclear Reactor Work?*, Office of Nuclear Energy (Aug. 2, 2023), https://www.energy.gov/ne/articles/nuclear-101-how-does-nuclear-reactor-work.
[26] *Nuclear Power Reactors*, supra note 25.
[27] *NUCLEAR 101: How Does a Nuclear Reactor Work?*, supra note 25.
[28] Difference Between PWR and BWR - Pressurized Water Reactor & Boiling Water Reactor, Minaprem.com, https://www.difference.minaprem.com/npp/difference-between-pwr-and-bwr-pressurized-water-reactor-boiling-water-reactor/ (last visited Sept. 7, 2023).
[29] *Nuclear explained - Nuclear power plants - Types of reactors*, U.S. Energy Information Administration, https://www.eia.gov/energyexplained/nuclear/nuclear-power-plants-types-of-reactors.php (last updated Aug. 7, 2023).
[30] Id.
[31] Daniel Shea, *Nuclear Power and the Clean Energy Transition*, National Conference of State Legislatures (Apr. 6, 2023), https://www.ncsl.org/energy/nuclear-power-and-the-clean-energy-transition.
[32] *Nuclear explained - Nuclear power plants - Types of reactors*, supra note 29.

Reliablity, Efficiency, and Cost

Nuclear power has the highest capacity factor of any energy source. A capacity factor indicates the reliability of a power plant, measuring how often the plant is operating at maximum power.[33] For example, a plant with a capacity factor of 100% would mean the plant is producing power at all times.[34] In 2022, the average annual capacity factor of a nuclear power plant was 92.7%.[35] Comparatively, the average annual capacity of a natural gas plant was 54.4%, a coal plant was 49.3%, a wind plant was 34.6%, and a solar plant was 24.6%.[36] Based on these capacity factors, two coal or natural gas plants, or three to four renewable resource-based plants would be required to generate the same amount of electricity onto the grid as one typical nuclear reactor.[37]

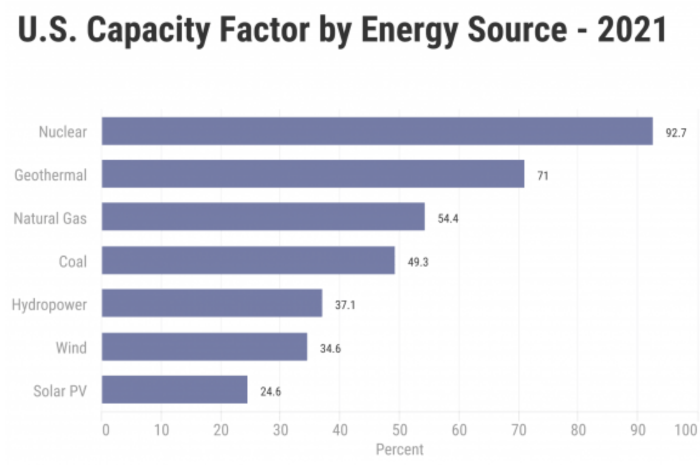

Illustration 6: Capacity factors.[38]

Because nuclear fission produces a much greater amount of energy than fossil fuels—fission being nearly 8,000 times more efficient than burning natural gas, oil, or coal—a nuclear power plant also requires less fuel and less frequent refueling than a traditional fossil fuel-based plant.[39] A typical nuclear reactor requires about 27 tons of fresh fuel each year, while a similarly sized coal-powered plant would require more than 2.5 million tons of coal to produce an equal amount of electricity.[40] This results in an estimated fuel cost of 0.61 cents per kilowatt-hour for nuclear power, and 2.46 cents per kilowatt-hour for fossil fuel power.[41]

Despite low fuel costs, nuclear power remains a capital-intensive technology. Capital costs such as site preparation, engineering, manufacturing, construction, and financing are much higher for a nuclear power plant than for a fossil fuel-based plant.[42] For example, the two new reactors at the Alvin W. Vogtle Electric Generating Plant in Georgia, discussed further below, have a projected combined cost of $30 billion—more than double the original estimates.[43] Though the requirements of the Nuclear Regulatory Commission are necessary to ensure safety in the design, construction, and operation of nuclear power plants, the average annual cost of regulation for a nuclear plant is estimated to be at least $60 million.[44] The regulation of nuclear power can also result in delays in the approval of construction and operation licenses for new nuclear facilities, with an average wait time of 80 months.[45]

To determine the true cost of nuclear power, each of these factors must be considered. The basic economics metric for any power plant is the levelized cost of electricity (LCOE), which is the lifetime total cost to build and

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[33] *What is Generation Capacity?*, Office of Nuclear Energy (May 1, 2020), https://www.energy.gov/ne/articles/what-generation-capacity.
[34] Id.
[35] *Nuclear explained - U.S. nuclear industry - Basics*, supra note 7.
[36] *What is Generation Capacity?*, supra note 33.
[37] *Nuclear Power is the Most Reliable Energy Source and It's Not Even Close*, Office of Nuclear Energy (Mar. 24, 2021), https://www.energy.gov/ne/articles/nuclear-power-most-reliable-energy-source-and-its-not-even-close.
[38] *What is Generation Capacity?*, supra note 33.
[39] *The Pros & Cons of Nuclear Energy: Is it safe?*, Spring Power & Gas (Dec. 5, 2018), https://springpowerandgas.us/the-pros-cons-of-nuclear-energy-is-it-safe.
[40] *How does a nuclear reactor work?*, World Nuclear Association, https://world-nuclear.org/nuclear-essentials/how-does-a-nuclear-reactor-work.aspx (last visited Sept. 7, 2023).
[41] *Nuclear explained - Data & statistics*, U.S. Energy Information Administration, https://www.eia.gov/energyexplained/nuclear/data-and-statistics.php (last updated Nov. 18, 2022).
[42] Daria Iurshina, et al., *Why nuclear power plants cost so much—and what can be done about it*, Bulletin of the Atomic Scientists (Jun. 20, 2019), https://thebulletin.org/2019/06/why-nuclear-power-plants-cost-so-much-and-what-can-be-done-about-it/.
[43] Shea, supra note 31.
[44] *Regulations Hurt Economics of Nuclear Power*, Institute for Energy Research (Jan. 19, 2018), https://www.instituteforenergyresearch.org/nuclear/regulations-hurt-economics-nuclear-power/.
[45] Id.

operate a power plant, divided by the lifetime total electricity output of the plant.[46] This metric accounts for the high capacity factor, low fuel costs, and high upfront capital costs of a nuclear power plant to determine the cost per unit of electricity produced. In 2023, the unsubsidized LCOE is estimated to be $141-$221 per megawatt-hour for nuclear. Comparatively, the LCOE is $68-$166 per megawatt-hour for coal; $39-$101 per megawatt-hour for natural gas; and $42-$114 per megawatt-hour for onshore wind.[47]

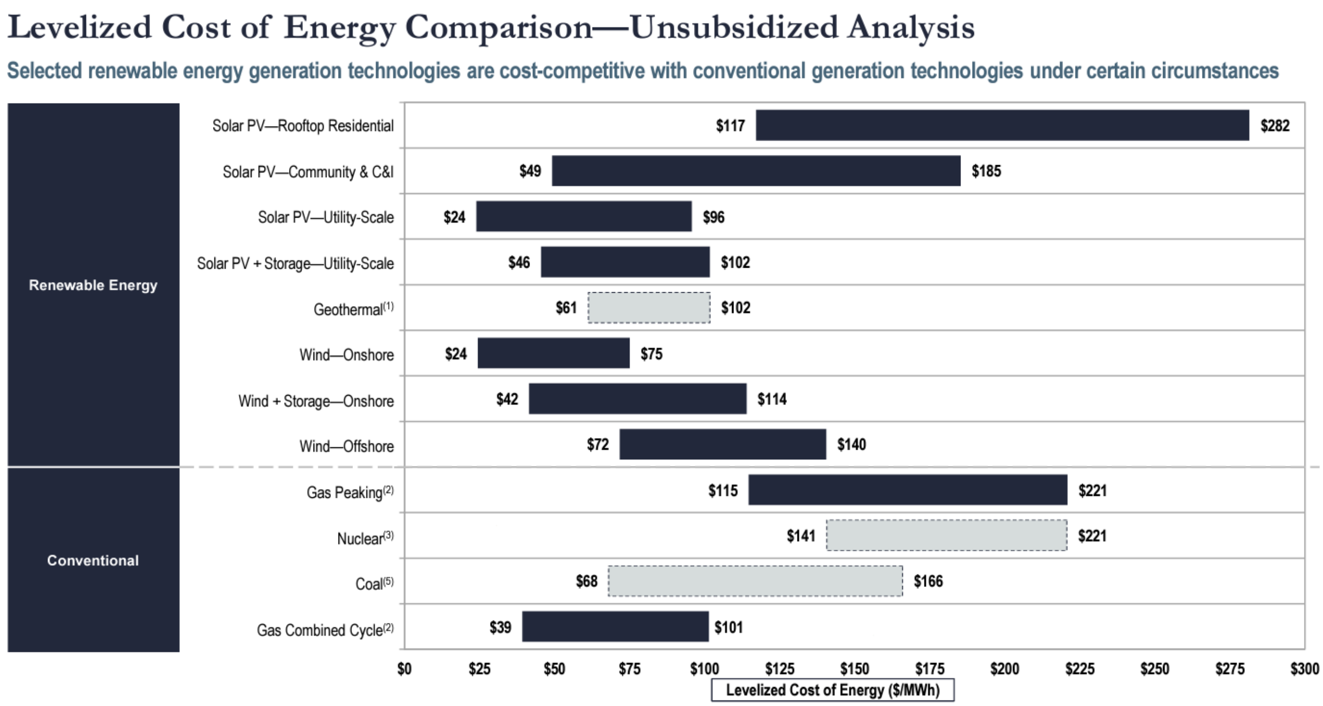

Illustration 7: Unsubsidized LCOEs.[48]

Nuclear Facilities in the United States

The U.S. generates more nuclear power than any other country, producing 29.9% of the total nuclear electricity generated in the world.[49] As of August 1, 2023, there are 93 nuclear reactors operating in 54 commercial nuclear power facilities in 28 states.[50]

Illinois ranks highest among all states, with eleven reactors located at six plants, generating approximately 11,582 megawatts of electricity—equal to about 12% of the total U.S. nuclear generation capacity.[51] The Palo Verde nuclear power plant in Arizona is the largest nuclear power plant, with three nuclear reactors and a generating capacity of 4,210 megawatts.[52] The R.E. Ginna Nuclear Power Plant in New York is the smallest nuclear power plant, with one nuclear reactor and a generating capacity of 614 megawatts.[53] The newest nuclear reactor in the U.S., Vogtle Unit 3, entered service on July 31, 2023, at the Alvin W. Vogtle Electric Generating Plant in Georgia, with a generating capacity of 1,114 megawatts.[54] An additional reactor, Vogtle Unit 4, is near completion and

[46] *Economics of Nuclear Power*, World Nuclear Association, https://world-nuclear.org/information-library/economic-aspects/economics-of-nuclear-power.aspx (last updated Aug. 2022).
[47] George Bilicic & Samuel Scroggins, *2023 Levelized Cost of Energy+*, Lazard (Apr. 12, 2023), https://www.lazard.com/media/2ozoovyg/lazards-lcoeplus-april-2023.pdf.
[48] Id.
[49] *Nuclear explained - Data & statistics*, supra note 41.
[50] *Nuclear Reactors in United States of America*, supra note 7; *FAQ - How many nuclear power plants are in the United States, and where are they located?*, U.S. Energy Information Administration, https://www.eia.gov/tools/faqs/faq.php?id=207&t=21 (last updated Aug. 3, 2023).
[51] Id.
[52] Id.
[53] Id.
[54] Id.

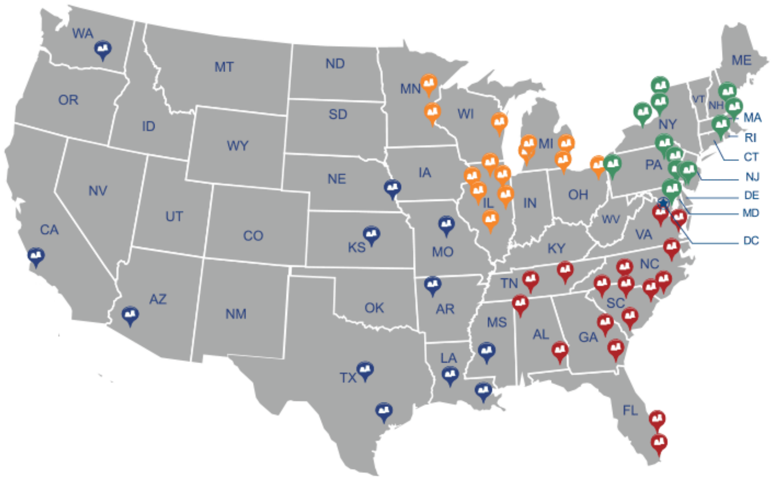

Illustration 8: Map of U.S. nuclear power plants. Marker colors indicate respective administrative regions of the Nuclear Regulatory Commission.[60]

projected to enter service in 2024.[55] Once Unit 4 is operational, Vogtle will become the largest nuclear power plant operating in the U.S., with four reactors and a total generating capacity of 4,660 megawatts.[56]

The average age of a nuclear reactor in the U.S. is 42 years, with the oldest operating reactor having entered service in December 1969.[57] In 2019, two units at the Turkey Point plant in Florida were licensed for eighty years of operation, the first in the world.[58] A total of 32 nuclear reactors have been closed and decommissioned in the U.S., and 21 commercial nuclear reactors are currently in various stages of decommissioning.[59]

Nuclear Facilities in the Region

Minnesota has two nuclear power facilities that have been in operation since the early 1970s.[61] The Prairie Island Nuclear Generating Plant, located in Welch, operates two units with pressurized water type reactors.[62] The plant generates approximately 1,100 megawatts of electricity total, enough to power about 1 million homes.[63] The Prairie Island units are the smallest individual reactors in the U.S.[64] The Monticello Nuclear Generating Plant, located in Monticello, operates one unit with a boiling water type reactor.[65] The plant generates approximately 671 megawatts of electricity, enough to power about 500,000 homes.[66] In 2022, nuclear power supplied 24% of the total in-state electricity net generation in Minnesota.[67]

Illustration 9: Wolf Creek reactor refueling and maintenance.[68]

Nebraska has one nuclear power facility that has been in operation since 1974.[69] The Cooper Nuclear Station, located in Brownville, operates one unit with a boiling

[55] Id.
[56] Id.
[57] *FAQ - How old are U.S. nuclear power plants, and when was the newest one built?*, U.S. Energy Information Administration, https://www.eia.gov/tools/faqs/faq.php?id=228&t=21 (last updated Aug. 3, 2023).
[58] *How does a nuclear reactor work?*, supra note 40.
[59] *Decommissioning Nuclear Facilities*, World Nuclear Association, https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/decommissioning-nuclear-facilities.aspx (last updated May 2022); *Locations of Power Reactor Sites Undergoing Decommissioning*, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/info-finder/decommissioning/power-reactor/index.html (last updated Sept. 5, 2023).
[60] *Map of Power Reactor Sites*, U.S. Nuclear Regulator Commission, https://www.nrc.gov/reactors/operating/map-power-reactors.html (last updated Feb. 2023).
[61] *Nuclear Waste Storage in Minnesota*, Minnesota Legislature, https://www.lrl.mn.gov/guides/guides?issue=nuclearwaste (last updated Mar. 2023).
[62] Id.; *Prairie Island Nuclear Generating Plant, Unit 1*, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/info-finder/reactors/prai1.html (last updated May 6, 2022); *Prairie Island Nuclear Generating Plant, Unit 2*, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/info-finder/reactors/prai2.html (last updated May 6, 2022).
[63] *Energy Portfolio - Nuclear Energy*, supra note 24.
[64] *FAQ - How many nuclear power plants are in the United States, and where are they located?*, supra note 50.
[65] *Monticello Nuclear Generating Plant, Unit 1*, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/info-finder/reactors/mont.html (last updated Jul. 14, 2023).
[66] *Energy Portfolio - Nuclear Energy*, supra note 24.
[67] *Minnesota State Profile and Energy Estimates - Analysis*, U.S. Energy Information Administration, https://www.eia.gov/state/analysis.php?sid=MN (last updated Aug. 17, 2023).
[68] Evergy, Facebook (May 27, 2021), https://www.facebook.com/EvergyPower/posts/congrats-to-our-wolf-creek-nuclear-generating-station-employees-for-completing-t/10159629679480680/.
[69] *Cooper Nuclear Station*, U.S. Energy Information Administration, https://www.nrc.gov/info-finder/reactors/cns.html (last updated May 6, 2022).

water type reactor.[70] The station generates about 835 megawatts of electricity, capable of providing power to more than 385,000 residential customers.[71] In 2022, nuclear power supplied 14% of the total in-state electricity net generation in Nebraska.[72] A second nuclear power plant in Nebraska, the Fort Calhoun Nuclear Station, was powered down in 2016.[73]

Kansas has one nuclear power facility that has been in operation since 1985.[74] The Wolf Creek Generating Station, located in Burlington, operates one unit with a pressurized water type reactor.[75] The station generates about 1,200 megawatts of electricity, which is enough energy to power more than 800,000 homes.[76] In 2022, nuclear power supplied 14% of the total in-state electricity net generation in Kansas.[77]

Illustration 10: Callaway Plant site and cooling tower.[80]

Missouri has one nuclear power plant that has been in operation since 1984. The Callaway Plant, located in Fulton, operates one unit with a pressurized water type reactor. The station generates approximately 1,190 megawatts of electricity, which is enough to power over 800,000 households.[78] In 2022, nuclear power supplied 11% of the total in-state electricity net generation in Missouri.[79]

Iowa has no operating nuclear power plants. The Duane Arnold Energy Center, located in Palo, was decommissioned in October 2020 following extensive weather-related damage to the plant cooling towers.[81] The plant had one boiling water type reactor and generated approximately 615 megawatts of electricity, enough to power 600,000 homes.[82]

Federal Regulation

The Atomic Energy Act of 1954 is the fundamental law governing the development, regulation, and disposal of nuclear materials and facilities in the U.S.[83] The Act and its related legislation delegate control over nuclear energy primarily to the U.S. Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), and the Environmental Protection Agency (EPA).[84] The Act requires the civilian use of nuclear materials and facilities to be

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[70] Id.
[71] *Nuclear Energy*, Nebraska Public Power District, https://www.nppd.com/powering-nebraska/energy-resources/nuclear?locale=en (last visited Sept. 7, 2023).
[72] *Nebraska State Profile and Energy Estimates - Analysis*, U.S. Energy Information Administration, https://www.eia.gov/state/analysis.php?sid=NE (last updated Jul. 20, 2023).
[73] Id.
[74] *Wolf Creek Generating Station, Unit 1*, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/info-finder/reactors/wc.html (last updated May 6, 2022).
[75] Id.
[76] Wolf Creek Nuclear Operating Corporation, http://www.wolfcreeknuclear.com/ (last visited Sept. 7, 2023).
[77] *Kansas State Profile and Energy Estimates - Analysis*, U.S. Energy Information Administration, https://www.eia.gov/state/analysis.php?sid=KS (last updated Jun. 15, 2023).
[78] *Callaway Energy Center*, Ameren Missouri, https://www.ameren.com/missouri/company/environment-and-sustainability/nuclear (last visited Sept. 7, 2023).
[79] *Missouri State Profile and Energy Estimates - Analysis*, U.S. Energy Information Administration, https://www.eia.gov/state/analysis.php?sid=MO (Jul. 20, 2023).
[80] Rod Walton, *Ameren Missouri's 1.19-GW Callaway nuclear plant back in operation after generator rewind*, Power Engineering (Aug. 10, 2021), https://www.power-eng.com/om/ameren-missouris-1-19-gw-callaway-nuclear-plant-back-in-operation-after-generator-rewind/.
[81] *Duane Arnold Energy Center*, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/info-finder/reactors/duan.html (last updated Aug. 17, 2022).
[82] Lee Hermiston, *Duane Arnold nuclear plant's new beginning as a solar farm* (Sept. 14, 2021, 9:00 AM), https://www.thegazette.com/iowa-ideas/duane-arnold-nuclear-plants-new-beginning-as-a-solar-farm/.
[83] Atomic Energy Act of 1954, 42 U.S.C. §§ 2011–2021, 2022-2286i, 2296a-2297h-13.
[84] *Atomic Energy Act and Related Legislation*, Office of Environment, Health, Safety & Security, https://www.energy.gov/ehss/atomic-energy-act-and-related-legislation (last visited Sept. 7, 2023).

licensed and empowers the NRC to establish and enforce rules that govern the use of nuclear materials and facilities.[85]

In 1959, the Act was amended to provide a statutory basis for the federal government to relinquish portions of its nuclear regulatory authority, allowing a state to license and regulate nuclear materials within its borders.[86] The mechanism for the transfer of the NRC's authority to a state is an Agreement signed by the governor of the state and the NRC, once the state is found to have a compatible radiation control program.[87] South Dakota is not an NRC Agreement State and therefore currently has jurisdiction only over x-ray equipment, naturally occurring radioactive materials, and certain radioactive materials that are not produced in a nuclear reactor.[88]

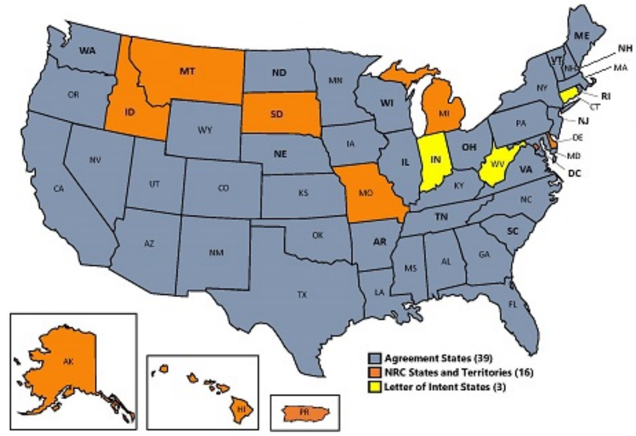

Illustration 11: Map of NRC Agreement States.[89]

To become an NRC Agreement State, the Legislature may issue enabling legislation authorizing the governor to pursue Agreement State status with the NRC. The governor must then file a Letter of Intent with the NRC stating that the state plans to request an Agreement.[90] With guidance and technical assistance from the NRC, the state would then work to develop an appropriate nuclear program and implement the necessary regulations, policies, and procedures to meet NRC compatibility standards and complete the application process.[91] Once all program requirements are met and the state is prepared to assume regulatory responsibility, the Agreement is finalized and signed by the governor and the NRC, and regulatory authority is transferred to the state.[92] For a complete walkthrough of the Agreement State process, a detailed policy statement from the NRC may be accessed here.

Other Federal Legislation

Recent federal legislation has largely sought to promote the expansion of nuclear power in the U.S. The Energy Policy Act of 2005 provides several incentives for domestic nuclear power, including federal risk insurance of $2 billion to cover regulatory delays, a production tax credit of 1.8 cents per kilowatt-hour for the first 6,000 megawatts of new nuclear capacity, and $10.9 billion in federal loan guarantees.[93] These incentives were extended in 2018 and remain in effect today.[94]

The Infrastructure Investment and Jobs Act of 2021 provides further incentives for nuclear power. The Act allocates $6 billion to the DOE to financially support existing nuclear power plants under economic threat of premature closure, authorizing supplemental payments for every megawatt of power generated by the plant.[95] To accelerate the commercialization of advanced nuclear technology, the Act also appropriates $2.4 billion in

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[85] *Governing Legislation*, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/about-nrc/governing-laws.html (last updated Sept. 10, 2021).
[86] *Atomic Energy Act and Related Legislation*, supra note 84.
[87] Id.; *Governing Legislation*, supra note 85.
[88] *South Dakota: Non-Agreement State Information*, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/agreement-states/south-dakota.html (last updated Jul. 1, 2022).
[89] *Agreement States*, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/agreement-states.html (last updated May 18, 2023).
[90] *Backgrounder on Agreement States*, U.S. Nuclear Regulatory Commission, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/agreement-states.html (last updated Sept. 24, 2020).
[91] Id.
[92] Id.
[93] *Nuclear Energy Factsheet*, University of Michigan Center for Sustainable Systems (Sept. 2022), https://css.umich.edu/publications/factsheets/energy/nuclear-energy-factsheet; *US Nuclear Power Policy*, World Nuclear Association, https://world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power-policy.aspx (last updated Feb. 2023).
[94] Id.
[95] *Biden signs infrastructure bill into law*, Nuclear Newswire (Nov. 16, 2021, 9:30 AM), https://www.ans.org/news/article-3436/biden-signs-infrastructure-bill-into-law/.

funding for microreactors, small modular reactors, and other advanced nuclear reactors, with a further $3.2 billion authorized through 2027.[96]

The Inflation Reduction Act of 2022 provides additional tax credits for existing nuclear plants as well as developers of new nuclear facilities.[97] These incentives include investment tax credits worth 30% of the amount paid to build a facility, a tax credit worth at least $25 per megawatt of electricity generated at any plant beginning construction in 2025 or later, and a tax credit for existing nuclear reactors of up to $15 per megawatt of electricity generated.[98]

Recent State Legislation

Every state has a different approach to nuclear power. States with already established nuclear facilities like California, Connecticut, Illinois, New Jersey, and New York have enacted policies to preserve their existing nuclear power fleet.[99] In states without nuclear facilities, like South Dakota, recent bills have sought to support new nuclear development.

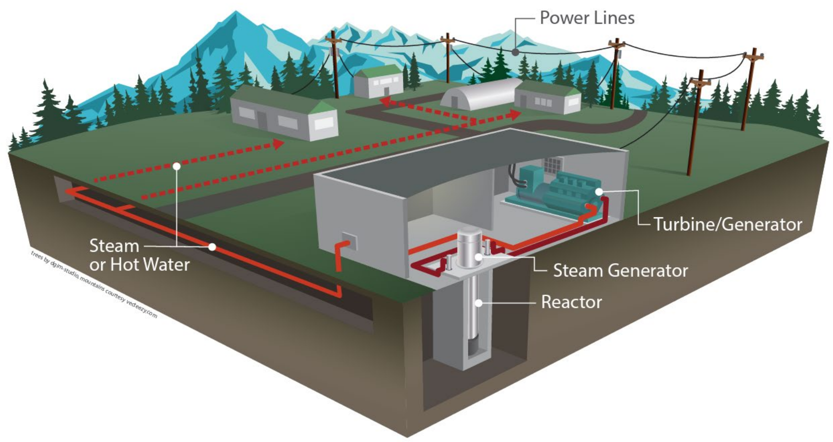

Illustration 12: Conceptual layout of a small modular reactor or microreactor plant.[101]

In 2022, Alaska enacted a bill seeking to streamline the permitting process for microreactors, *i.e.*, those with a generating capacity of less than 50 megawatts, requiring the state to develop regulations overseeing the permitting process and empowering municipal governments to approve microreactors.[100]

Since 2020, Wyoming and Indiana have passed legislation directing state regulators to develop rules and regulations related to the repurposing of retired coal- and natural gas-powered plants for nuclear power.[102] This "coal-to-nuclear" approach is seen as an increasingly viable path for the implementation of nuclear power. Because nuclear and fossil fuel generators are both thermoelectric in nature, many small modular reactors would fit into the existing footprint of a plant, allowing developers to leverage already established infrastructure such as transmission lines and water rights to reduce project costs and regulatory issues for new nuclear reactors.[103] Resolutions to study the feasibility of coal-to-nuclear have also been adopted in Maryland and Montana.[104]

Since 2016, Kentucky, Montana, West Virginia, and Wisconsin have all repealed restrictions on new nuclear development.[105] Minnesota is the only state with a total ban on new nuclear.[106]

A comprehensive status report of all recently enacted state legislation and regulations supporting nuclear energy was published by the Nuclear Energy Institute in January 2023 and may be accessed here.

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[96] Id.
[97] Shea, supra note 31; Daniel Shea, *Nuclear Policy in the States: A National Review*, 3 J. Critical Infrastructure Policy 13 (2023).
[98] Id.
[99] Shea, supra note 31.
[100] Shea, supra note 97.
[101] *Small Scale Nuclear Power: An option for Alaska?, Alaska Center for Energy and Power* (Jan. 2021), https://www.uaf.edu/acep/files/working-groups/nuclear-energy/ACEP_Nuclear_Report_2020.pdf.
[102] Shea, supra note 97.
[103] Id.
[104] Shea, supra note 31.
[105] Id.
[106] Id.

Conclusion

Nuclear power is an efficient energy source utilized in many states across the U.S., including several states neighboring South Dakota. It is the source of nearly one-fifth of all electricity generated in the U.S. and is increasingly cost-competitive with traditional energy sources such as coal and natural gas. States both with and without existing nuclear facilities have enacted legislation to support and expand nuclear power. No nuclear power facility has operated in South Dakota since the decommissioning of the Pathfinder Nuclear Generating Station in 1967. Given this, the Legislature may wish to further consider studying the extent to which technology advances and innovative policymaking offer potential avenues for South Dakota to integrate nuclear power onto the electric grid in the future.

This issue memorandum was written by Melanie Dumdei, Legislative Attorney, on October 17, 2023, for the Legislative Research Council. It is designed to provide background information on the subject and is not a policy statement made by the Legislative Research Council.