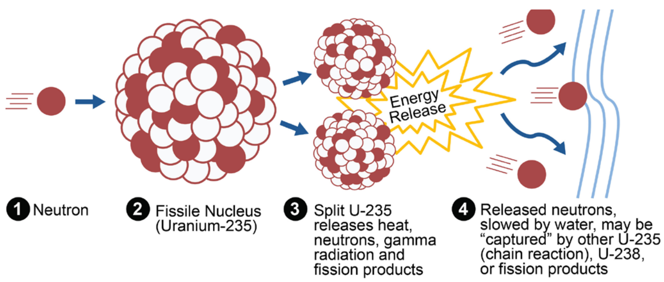
Nuclear Energy

Nuclear power plants generate electricity by using controlled nuclear fission chain reactions to heat water and produce steam that powers turbines. Nuclear is often labeled "clean" energy because no greenhouse gases (GHGs) or air emissions are released from the power plant. It has the highest capacity factor (91% in 2025) of any power plant type,[1,2] in part because they only need to refuel every 1.5-2 years.[3] The capacity factor of nuclear energy has increased from 56% in 1975.[2] As the U.S. and other nations seek low-GHG energy sources, nuclear power's benefits must be weighed against costs, operational risks, and challenges of procuring fuel and managing radioactive waste.

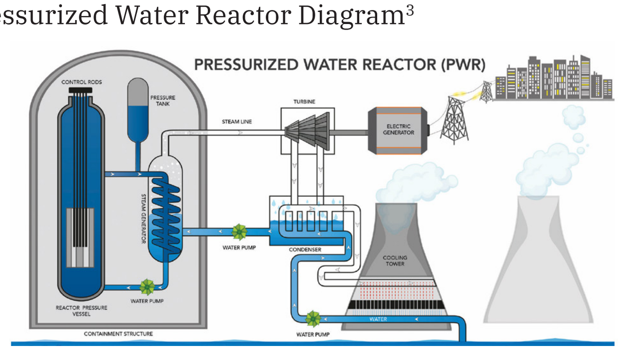
Fission of Uranium-235 in a Nuclear Reactor



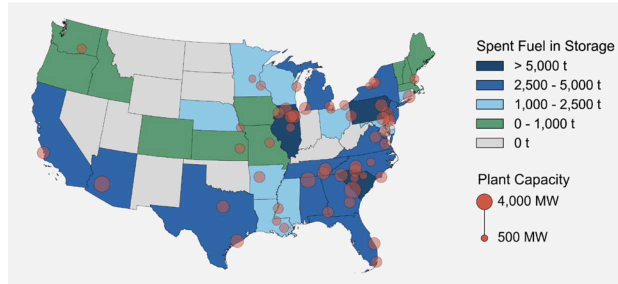
Nuclear Resources and Energy Use

- Most nuclear reactors use enriched uranium with higher concentrations of uranium-235 (U-235) isotopes, which split more easily to produce energy. Mined uranium ore averages less than 1% U-235.[4]
- Total identified recoverable resources exceed 7.9 Mt, with 75% recoverable at reasonable cost (<$130/kg).[31] Only 1% of deposits are in the U.S.[31]
- U.S. nuclear plants purchased 21 kt of uranium in 2025, importing from Kazakhstan (37%), Canada (16%), Australia (15%), and Russia (14%).[39]
- Uranium dioxide (UO_2) fuel is the most common. Mixed oxide fuel combines UO_2 with plutonium and/or other elements.[5]
- The first U.S. nuclear plant began commercial operations in 1958.[1] As of 2026, the U.S. operates 94 reactors with 97 GW net summer capacity.[2]

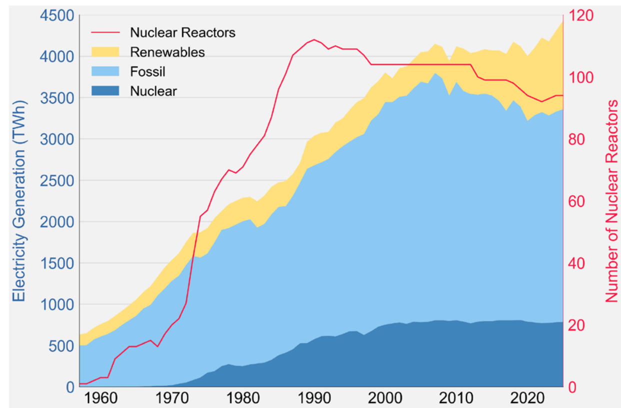
Pressurized Water Reactor Diagram[3]



U.S. Nuclear Plants and Spent Fuel Sites[4,8]



U.S. Electricity Generation by Source[2]



- Pressurized water reactors (PWRs) account for 68% of U.S. reactors; the water in PWRs in contact with the core is pressurized to prevent boiling.[3,6] The rest of U.S. reactors are boiling water reactors (BWRs), where steam from the core directly turns a turbine.[3]
- Nuclear provided 9% of global electricity in 2024, with the U.S. generating nearly 30% of this.[7] Nuclear has provided about 18% of U.S. electricity annually since 1990.[2]

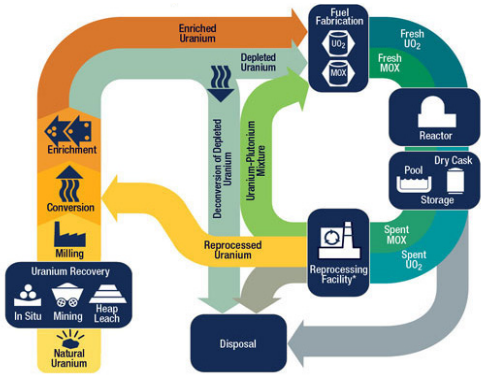
Economic Impacts

- Nuclear has high levelized costs of electricity (LCOE)—about twice that of combined cycle natural gas, 3x that of utility solar or onshore wind, and 48% more expensive than coal.[9]
- Final construction costs for U.S. nuclear plants typically exceed original estimates by 2-3 times due to delays.[10]
- Only two new U.S. nuclear projects have begun since 1990, both requiring federal subsidies. The VC Summer dual reactor project was abandoned in 2017 with $9B in sunk costs.[10] The Vogtle reactors in Georgia began operation in 2023 and 2024, with total costs reaching $35B.[10,11]
- Recent projects in the U.K., France, and Finland have experienced similar delays and cost overruns, while China, Japan, and South Korea have completed plants faster and closer to budget.[10,12]

Energy and Environmental Impacts

- A uranium fuel pellet (~0.5" in height and diameter) contains energy equivalent to 1 t of coal or 149 gal of oil.[14] A typical 1 GW reactor holds 18M pellets.[15]

Nuclear Fuel Cycle[13]

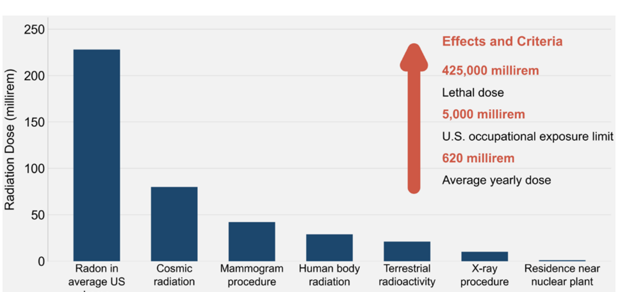


- The nuclear fuel cycle encompasses producing, using, and disposing of uranium fuel. Powering a 1 GW plant requires mining 20-40 kt of ore annually, processing it into uranium fuel, and disposing of spent fuel.[16] 3% of this waste requires cooling and shielding.[17]
- Each kWh of nuclear electricity requires 0.1-0.3 kWh of life cycle energy inputs.[18]
- Although nuclear electricity generation itself produces no GHG emissions, other fuel cycle activities produce emissions. Lifecycle GHG intensity averages 6.1 g CO_2e/kWh,[19] far below other baseload sources like coal (1,001 g CO_2e/kWh)[20] or natural gas (450 - 670 g CO_2e/kWh).[21]
- Nuclear power plants use 270-670 gal/MWh of water, depending on operating efficiency and site conditions.[22] For U.S. nuclear reactors, most environmental impacts stem from fuel element extraction and production.[3,23]

Nuclear Waste

- The U.S. generated 89,178 t of commercial spent fuel and reprocessing waste, stored at over 100 sites in 39 states as of 2021.[24] Reprocessing used nuclear fuel can reduce waste and extract 25-30% more energy,[25] although the U.S. has a policy of not reprocessing used fuel.[5]
- Spent nuclear fuel is stored in wet pools or dry casks in the U.S. While wet pools were more common, many sites are reaching capacity. Dry cask storage is increasingly used, storing 50% of spent nuclear fuel in 2021, up from 27% in 2011.[24,26] Steel cylinders called dry casks contain spent nuclear fuel in inert gas and can be used after years of cooling the fuel in a wet pool.[27]

Dose from Common Radiation Sources (mrem)[32,33,34,35]



- Managing nuclear waste requires very long-term planning. U.S. EPA set radiation exposure limits in permanent storage facilities over an unprecedented 1 million-year timeframe.[28]
- The U.S. has no permanent storage. Nevada's Yucca Mountain was proposed to hold 70 kt of waste,[29] but is no longer under consideration due to political pressure and local opposition.[30]

Advanced Nuclear Reactors

- Small modular reactors (SMRs) are advanced reactors producing up to 300 MW of electricity per module, offering flexible power generation with cost and construction time savings due to smaller and identical reactors.[36,37]
- AI datacenters operations are incentivizing new reactors that can quickly enter the market and provide on-site power, securing >10 GW of conventional and novel nuclear power.[38]
- Many SMRs and microreactors (<20 MWe) in development use novel cooling and fueling methods that could improve efficiency. These include high-temperature gas reactors (HTGRs) that use helium gas as a coolant, molten-salt reactors (MSRs) that use molten salts as coolant (in some cases the fuel is dissolved in the salt), and sodium-cooled reactors (SCRs) that use liquid sodium as a coolant.[37]

Safety

- In 1986, explosions at the Chernobyl nuclear plant in Ukraine resulted in 134 workers and emergency responders diagnosed with acute radiation syndrome. 28 died within weeks. 350k people were evacuated and/or permanently resettled, and a 1,000 mi^2 Chernobyl Exclusion Zone was established to restrict public access.[40]
- On March 11, 2011, an M9.0 earthquake near Fukushima, Japan triggered a tsunami that damaged reactor cooling systems, causing meltdowns. Radiation releases were lower than Chernobyl and mostly deposited in the Pacific Ocean. About 150k people were evacuated, with no deaths or radiation sickness directly linked to the accident.[41]
- The U.S. Price-Anderson Act limits nuclear plant owner liability to $500M for individual plants and $16.3B across all plants for radioactive releases.[42]

Public Policy

- The Infrastructure Investment and Jobs Act (IIJA) of 2021 allocated $6B for the Civilian Nuclear Credit program to prevent premature retirement of existing nuclear plants.[43,44]
- Federal incentives for new nuclear plants include insurance against regulatory delays, a production tax credit (PTC), and federal loan guarantees.[45,46,47] Nuclear plants still quality for PTC through 2032 despite recent legislation.[48,49]
- In 2026, the Department of Energy committed to provide $17.5B in loans for 10 new reactors, generating 11 GW of total baseload power.[50]

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Sources for this factsheet are here, help with units and abbreviations is here.