Overview of Nuclear Energy in the U.S.

CLEAN AIR TASK FORCE

Nuclear energy is a cornerstone of the U.S. electricity sector, offering reliable, affordable, zero-emission power to meet current and future energy demand. The U.S. Department of Energy estimates the grid will need an additional **700–900 gigawatts (GW)** of clean firm energy capacity by 2050[1] to meet growing energy demand. Nuclear energy, which can provide **24/7 baseload power**, is uniquely positioned to complement variable renewable energy sources like wind and solar, ensuring a stable and diverse energy portfolio.

With significant infrastructure investment and regulatory support, the U.S. could triple its nuclear capacity from **~100 GW to ~300 GW by 2050** resulting in significant contributions to energy security, economic development, and job creation.[2] To expand nuclear capacity, the U.S. must address challenges such as **project risks, licensing delays, workforce gaps, and supply chain fragmentation.**

U.S. nuclear energy by the numbers

30% of the world's nuclear power

The U.S. generates 30% of the world's nuclear power, more than any other country.[3]

48% of U.S. carbon-free electricity

Nuclear accounts for 20% of U.S. electricity generation and 48% of all carbon-free electricity.[4]

775B kWh

In 2023, U.S. nuclear plants produced 775 billion kilowatt-hours of electricity, enough to power over 72 million homes.[4,5]

94 reactors

As of 2023, 94 commercial nuclear reactors operate across 54 power plants in 28 states.[6]

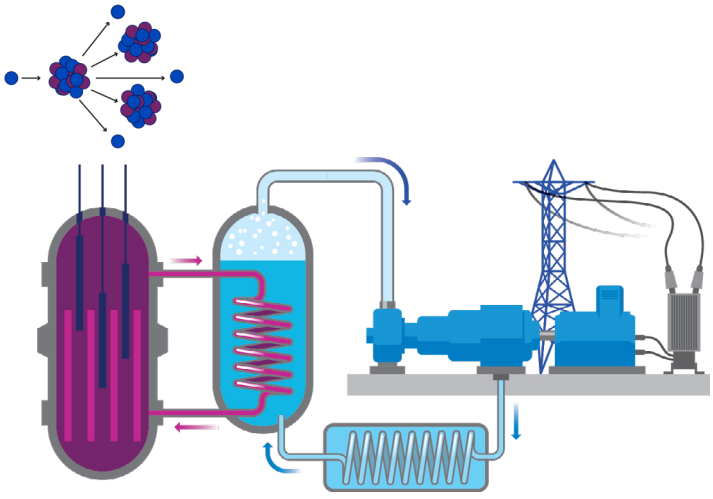
Uses of nuclear energy

Nuclear energy is used to generate heat and electricity for a variety of critical applications, including:

- **Electricity:** Powering homes, businesses, data centers, and national defense infrastructure.
- **Industrial Heat:** Supporting industries like manufacturing, transportation, and chemical production.
- **Coal-repowering:** Replacing fossil generation with clean firm generators, enhancing job creation and retaining economic prosperity in industrial regions.

How nuclear energy works

1. **Fission:** A neutron strikes a uranium atom, splitting it into smaller atoms and releasing energy and additional neutrons.
2. **Heat Generation:** The energy released heats water to produce steam.
3. **Energy Production:** The steam produced can drive a turbine to generate electricity or be used directly in industrial heat applications.



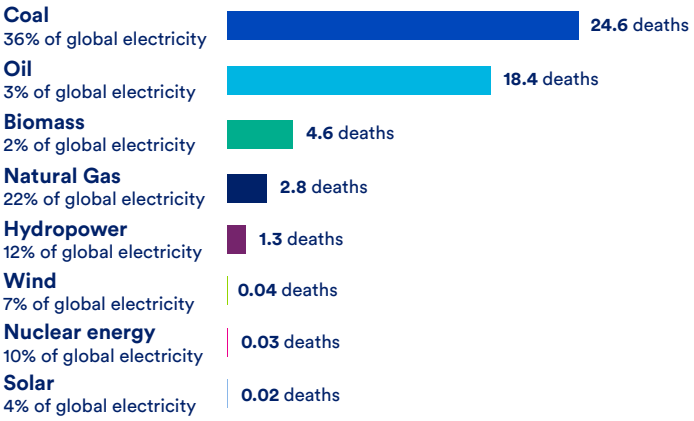
Benefits of nuclear energy

- **Reliability:** Provides 24/7 baseload power, which complements weather dependent renewables and batteries.
- **Energy Density:** Produces a large amount of energy, on a relatively small amount of land.
- **Economic Impact:** Supports high-paying jobs and strengthens domestic energy production.
- **Clean Air:** Emits no greenhouse gas or other air pollution during operation.
- **Flexibility:** New designs are expected to operate with more flexibility to produce heat and electricity as needed, complementing future energy mixes.

Safety and environmental considerations

- **Safety:** Modern nuclear reactors incorporate multiple safety systems, including active and passive systems and containment structures to prevent accidents. Nuclear is shown to be one of the safest forms of energy per unit of electricity generated, similar to wind and solar, considering accidents and deaths produced by air pollution.
- **Federal and State Regulation:** The Nuclear Regulatory Commission (NRC) oversees the safe use of nuclear energy facilities, including plant licensing, construction, operation, and decommissioning. States and local governments manage some siting processes, and many regulate the possession and use of certain radioactive materials through agreements with the NRC.
- **Waste Management:** Spent nuclear fuel is stored short term in dry casks with plans for long-term storage in geologic repositories (the U.S. has yet to build one).
- **Environmental Impact:** Nuclear generation is emissions free with a small land impact (e.g., forests, farms, views). The NRC recently found that the impacts of SMRs are minor or not detectable and will not noticeably alter environmental resources (e.g., water and ecology).[7]

Safest sources of energy



Death rate from accidents and air pollution, measured as deaths per terawatt-hour of electricity production.
Source: OurWorldinData.org/safest-sources-of-energy

Nuclear energy technologies

- **Existing Fleet: Light water reactors** (LWRs) operate in the U.S.
- Advanced Nuclear Technologies:
  - **Small Modular Reactors** (SMRs): Smaller, more flexible reactors that reduce upfront costs and construction timelines.
  - **Microreactors:** Compact reactors for remote or off-grid applications.

Nuclear energy fuel cycle

- **Fuel Production:** Mining, milling, enrichment, and fabrication.
- **Reactor Operation:** Generating electricity through fission.
- **Waste Management:** Storing spent fuel short-medium term in dry casks or long-term geologic repositories.

1 U.S. DOE Liftoff Report: How Clean Energy is the Solution to Rising Electricity Demand, https://liftoff.energy.gov/wp-content/uploads/2024/08/Liftoff-Topic-Brief_Demand-Growth_Aug-26_vF-1.pdf
2 U.S. DOE: U.S. Sets Targets to Triple Nuclear Energy Capacity by 2050, https://www.energy.gov/ne/articles/us-sets-targets-triple-nuclear-energy-capacity-2050
3 World Nuclear Association: Nuclear Power in the USA, https://world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power
4 U.S. DOE: 5 Fast Facts about Nuclear Energy, https://www.energy.gov/ne/articles/5-fast-facts-about-nuclear-energy
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7 U.S. NRC: Environmental Assessment and Finding of No Significant Impact for the Construction Permits and Environmental Review Exemptions for the Kairos Hermes 2 Test Reactors, https://www.nrc.gov/docs/ML2424/ML24240A034.pdf