**Nuclear power plant**

A nuclear power plant is a thermal power station in which the heat source is a nuclear reactor. As is typical in all conventional thermal power stations the heat is used to generate steam which drives a steam turbine connected to an electric generator which produces electricity.

Nuclear plants are very often used for base load.  However, building a nuclear power plant often spans five to ten years, which can accrue to significant financial costs.

Nuclear power plants have a [carbon footprint](https://en.wikipedia.org/wiki/Carbon_footprint) comparable to that of [renewable energy](https://en.wikipedia.org/wiki/Renewable_energy) such as [solar farms](https://en.wikipedia.org/wiki/Photovoltaic_power_station) and [wind farms](https://en.wikipedia.org/wiki/Wind_farm), and much lower than [fossil fuels](https://en.wikipedia.org/wiki/Fossil_fuel) such as [natural gas](https://en.wikipedia.org/wiki/Gas-fired_power_plant) and [coal](https://en.wikipedia.org/wiki/Coal-fired_power_station). Despite some spectacular catastrophes, nuclear power plants are among the safest mode of electricity generation comparable to solar and wind power plants.

**History**

Nuclear energy history

The idea of nuclear power [began in the 1930s](https://www.energy.gov/sites/prod/files/The%20History%20of%20Nuclear%20Energy_0.pdf), when physicist Enrico Fermi first showed that neutrons could split atoms. Fermi led a team that in 1942 achieved the first nuclear chain reaction, under a stadium at the University of Chicago. This was followed by a series of milestones in the 1950s: the [first electricity produced from atomic energy](https://inl.gov/experimental-breeder-reactor-i/) at Idaho's Experimental Breeder Reactor I in 1951; the [first nuclear power plant](http://www.world-nuclear.org/information-library/current-and-future-generation/outline-history-of-nuclear-energy.aspx) in the city of Obninsk in the former Soviet Union in 1954; and the first commercial nuclear power plant in Shippingport, Pennsylvania, in 1957.

Nuclear power, climate change, and future designs

Nuclear power isn't [renewable energy.](https://www.nationalgeographic.com/environment/article/renewable-energy) National Geographic emerging explorer Leslie Dewan, for example, [wants to resurrect the molten salt reactor](https://www.nationalgeographic.com/magazine/article/nuclear-engineer-leslie-dewan-clean-energy-plan), which uses liquid uranium dissolved in molten salt as fuel, arguing it could be safer and less costly than reactors in use today.

The conversion to electrical energy takes place indirectly, as in conventional thermal power plants. The fission in a nuclear reactor heats the reactor coolant. The coolant may be water or gas or even liquid metal depending on the type of reactor. The reactor coolant then goes to a steam generator and heats water to produce steam. The pressurized steam is then usually fed to a multi-stage steam turbine. After the steam turbine has expanded and partially condensed the steam, the remaining vapor is condensed in a condenser. The condenser is a heat exchanger which is connected to a secondary side such as a river or a cooling tower. The water is then pumped back into the steam generator and the cycle begins again.

**Economics**

[Bruce Nuclear Generating Station](https://en.wikipedia.org/wiki/Bruce_Nuclear_Generating_Station) (Canada), one of the [largest operational nuclear power facility in the world](https://en.wikipedia.org/wiki/List_of_nuclear_power_stations).

The [economics of nuclear power plants](https://en.wikipedia.org/wiki/Economics_of_nuclear_power_plants) is a controversial subject, and multibillion-dollar investments ride on the choice of an energy source. Nuclear power stations typically have high capital costs, but low direct fuel costs, with the costs of fuel extraction, processing, use and spent fuel storage internalized costs.[[20]](https://en.wikipedia.org/wiki/Nuclear_power_plant#cite_note-20) Therefore, comparison with other power generation methods is strongly dependent on assumptions about construction timescales and capital financing for nuclear stations. Cost estimates take into account [station decommissioning](https://en.wikipedia.org/wiki/Nuclear_decommissioning) and [nuclear waste](https://en.wikipedia.org/wiki/Nuclear_waste) storage or recycling costs in the United States due to the [Price Anderson Act](https://en.wikipedia.org/wiki/Price_Anderson_Act).

With the prospect that all [spent nuclear fuel](https://en.wikipedia.org/wiki/Spent_nuclear_fuel) could potentially be recycled by using future reactors, [generation IV reactors](https://en.wikipedia.org/wiki/Generation_IV_reactor) are being designed to completely close the [nuclear fuel cycle](https://en.wikipedia.org/wiki/Nuclear_fuel_cycle). However, up to now, there has not been any actual bulk recycling of waste from a NPP, and on-site temporary storage is still being used at almost all plant sites due to construction problems for [deep geological repositories](https://en.wikipedia.org/wiki/Deep_geological_repository). Only [Finland](https://en.wikipedia.org/wiki/Finland) has stable repository plans, therefore from a worldwide perspective, long-term waste storage costs are uncertain.

[Olkiluoto Nuclear Power Plant](https://en.wikipedia.org/wiki/Olkiluoto_Nuclear_Power_Plant) in [Eurajoki](https://en.wikipedia.org/wiki/Eurajoki), Finland. The site houses of one of the most powerful reactors known as EPR.

Construction, or capital cost aside, measures to [mitigate global warming](https://en.wikipedia.org/wiki/Mitigation_of_global_warming) such as a [carbon tax](https://en.wikipedia.org/wiki/Carbon_tax) or [carbon emissions trading](https://en.wikipedia.org/wiki/Carbon_emissions_trading), increasingly favor the economics of nuclear power. Further efficiencies are hoped to be achieved through more advanced reactor designs, [Generation III reactors](https://en.wikipedia.org/wiki/Generation_III_reactor) promise to be at least 17% more fuel efficient, and have lower capital costs, while [Generation IV reactors](https://en.wikipedia.org/wiki/Generation_IV_reactors) promise further gains in [fuel efficiency](https://en.wikipedia.org/wiki/Fuel_efficiency) and significant reductions in nuclear waste.

Unit 1 of the [Cernavodă Nuclear Power Plant](https://en.wikipedia.org/wiki/Cernavod%C4%83_Nuclear_Power_Plant) in Romania

In Eastern Europe, a number of long-established projects are struggling to find financing, notably [Belene](https://en.wikipedia.org/wiki/Belene_Nuclear_Power_Plant) in [Bulgaria](https://en.wikipedia.org/wiki/Bulgaria) and the additional reactors at [Cernavodă](https://en.wikipedia.org/wiki/Cernavod%C4%83_Nuclear_Power_Plant) in [Romania](https://en.wikipedia.org/wiki/Romania), and some potential backers have pulled out.[[21]](https://en.wikipedia.org/wiki/Nuclear_power_plant#cite_note-kidd2011-21) Where cheap gas is available and its future supply relatively secure, this also poses a major problem for nuclear projects.[[21]](https://en.wikipedia.org/wiki/Nuclear_power_plant#cite_note-kidd2011-21)

Analysis of the economics of nuclear power must take into account who bears the risks of future uncertainties. To date all operating nuclear power stations were developed by [state-owned](https://en.wikipedia.org/wiki/Nationalized) or [regulated](https://en.wikipedia.org/wiki/Regulated_market) utilities where many of the risks associated with construction costs, operating performance, fuel price, and other factors were borne by consumers rather than suppliers.[[22]](https://en.wikipedia.org/wiki/Nuclear_power_plant#cite_note-ft-20100912-22) Many countries have now liberalized the [electricity market](https://en.wikipedia.org/wiki/Electricity_market) where these risks and the risk of cheaper competitors emerging before capital costs are recovered, are borne by station suppliers and operators rather than consumers, which leads to a significantly different evaluation of the economics of new nuclear power stations.[[23]](https://en.wikipedia.org/wiki/Nuclear_power_plant#cite_note-MIT-2003-23)

Following the 2011 [Fukushima nuclear accident](https://en.wikipedia.org/wiki/Fukushima_nuclear_accident) in [Japan](https://en.wikipedia.org/wiki/Japan), costs are likely to go up for currently operating and new nuclear power stations, due to increased requirements for on-site spent fuel management and elevated design basis threats.[[24]](https://en.wikipedia.org/wiki/Nuclear_power_plant#cite_note-Massachusetts_Institute_of_Technology_2011_xv-24) However many designs, such as the currently under construction AP1000, use [passive nuclear safety](https://en.wikipedia.org/wiki/Passive_nuclear_safety) cooling systems, unlike those of [Fukushima I](https://en.wikipedia.org/wiki/Fukushima_I) which required active cooling systems, which largely eliminates the need to spend more on redundant back up safety equipment.

**Workers in a nuclear power plant**

Nuclear engineers

Reactor operators

Health physicists

Emergency response team personnel

Nuclear Regulatory Commission Resident Inspectors

In the United States and Canada, workers except for management, professional (such as engineers) and security personnel are likely to be members of either the International Brotherhood of Electrical Workers (IBEW) or the Utility Workers Union of America (UWUA), or one of the various trades and labor unions representing Machinist, laborers, boilermakers, millwrights, iron workers etc.

**Economics**

The economics of new nuclear power plants is a controversial subject, and multibillion-dollar investments ride on the choice of an energy source. Nuclear power plants typically have high capital costs, but low direct fuel costs, with the costs of fuel extraction, processing, use and spent fuel storage internalized costs. Therefore, comparison with other power generation methods is strongly dependent on assumptions about construction timescales and capital financing for nuclear plants. Cost estimates take into account plant decommissioning and nuclear waste storage or recycling costs in the United States due to the Price Anderson Act. With the prospect that all spent nuclear fuel/"nuclear waste" could potentially be recycled by using future reactors, generation IV reactors, that are being designed to completely close the nuclear fuel cycle.

On the other hand, construction, or capital cost aside, measures to mitigate global warming such as a carbon tax or carbon emissions trading, increasingly favor the economics of nuclear power. Further efficiencies are hoped to be achieved through more advanced reactor designs, Generation III reactors promise to be at least 17% more fuel efficient, and have lower capital costs, while futuristic Generation IV reactors promise 10000-30000% greater fuel efficiency and the elimination of nuclear waste.

In Eastern Europe, a number of long-established projects are struggling to find finance, notably Belene in Bulgaria and the additional reactors at Cernavoda in Romania, and some potential backers have pulled out. Where cheap gas is available and its future supply relatively secure, this also poses a major problem for nuclear projects.

Analysis of the economics of nuclear power must take into account who bears the risks of future uncertainties. To date all operating nuclear power plants were developed by state-owned or regulated utility monopolies where many of the risks associated with construction costs, operating performance, fuel price, and other factors were borne by consumers rather than suppliers. Many countries have now liberalized the electricity market where these risks, and the risk of cheaper competitors emerging before capital costs are recovered, are borne by plant suppliers and operators rather than consumers, which leads to a significantly different evaluation of the economics of new nuclear power plants.

Following the 2011 Fukushima I nuclear accidents, costs are likely to go up for currently operating and new nuclear power plants, due to increased requirements for on-site spent fuel management and elevated design basis threats.[15] However many designs, such as the currently under construction AP1000, use passive nuclear safety cooling systems, unlike those of Fukushima I which required active cooling systems, this largely eliminates the necessity to spend more on redundant back up safety equipment.

**Safety and accidents**

In his book, Normal accidents, Charles Perrow says that multiple and unexpected failures are built into society's complex and tightly-coupled nuclear reactor systems. Such accidents are unavoidable and cannot be designed around. An interdisciplinary team from MIT has estimated that given the expected growth of nuclear power from 2005 – 2055, at least four serious nuclear accidents would be expected in that period. However, the MIT study does not take into account improvements in safety since 1970. To date, there have been five serious accidents (core damage) in the world since 1970 (one at Three Mile Island in 1979; one at Chernobyl in 1986; and three at Fukushima-Daiichi in 2011), corresponding to the beginning of the operation of generation II reactors. This leads to on average one serious accident happening every eight years worldwide.

Plant location

In many countries, plants are often located on the coast, in order to provide a ready source of cooling water for the essential service water system. As a consequence the design needs to take the risk of flooding and tsunamis into account. The World Energy Council (WEC) argues disaster risks are changing and increasing the likelihood of disasters such as earthquakes, cyclones, hurricanes, typhoons, ﬂooding. High temperatures, low precipitation levels and severe droughts may lead to fresh water shortages. Failure to calculate the risk of flooding correctly lead to a Level 2 event on the International Nuclear Event Scale during the 1999 Blayais Nuclear Power Plant flood, while flooding caused by the 2011 Tōhoku earthquake and tsunami lead to the Fukushima I nuclear accidents.

The design of plants located in seismically active zones also requires the risk of earthquakes and tsunamis to be taken into account. Japan, India, China and the USA are among the countries to have plants in earthquake-prone regions. Damage caused to Japan's Kashiwazaki-Kariwa Nuclear Power Plant during the 2007 Chūetsu offshore earthquake underlined concerns expressed by experts in Japan prior to the Fukushima accidents, who have warned of a genpatsu-shinsai (domino-effect nuclear power plant earthquake disaster).

Nuclear safety systems

The three primary objectives of nuclear safety systems as defined by the Nuclear Regulatory Commission are to shut down the reactor, maintain it in a shutdown condition, and prevent the release of radioactive material during events and accidents. These objectives are accomplished using a variety of equipment, which is part of different systems, of which each performs specific functions.

**Controversy**

The nuclear power debate is about the controversy which has surrounded the deployment and use of nuclear fission reactors to generate electricity from nuclear fuel for civilian purposes. The debate about nuclear power peaked during the 1970s and 1980s, when it "reached an intensity unprecedented in the history of technology controversies", in some countries.

Proponents argue that nuclear power is a sustainable energy source which reduces carbon emissions and can increase energy security if its use supplants a dependence on imported fuels. Proponents advance the notion that nuclear power produces virtually no air pollution, in contrast to the chief viable alternative of fossil fuel. Proponents also believe that nuclear power is the only viable course to achieve energy independence for most Western countries. They emphasize that the risks of storing waste are small and can be further reduced by using the latest technology in newer reactors, and the operational safety record in the Western world is excellent when compared to the other major kinds of power plants.

Opponents say that nuclear power poses many threats to people and the environment. These threats include health risks and environmental damage from uranium mining, processing and transport, the risk of nuclear weapons proliferation or sabotage, and the unsolved problem of radioactive nuclear waste. The environment issue is also regarding discharge of hot water into the sea. The hot water modifies the environmental conditions for the marine flora fauna. They also contend that reactors themselves are enormously complex machines where many things can and do go wrong, and there have been many serious nuclear accidents. Critics do not believe that these risks can be reduced through new technology. They argue that when all the energy-intensive stages of the nuclear fuel chain are considered, from uranium mining to nuclear decommissioning, nuclear power is not a low-carbon electricity source.

**Reprocessing**

Nuclear reprocessing technology was developed to chemically separate and recover fissionable plutonium from irradiated nuclear fuel. Reprocessing serves multiple purposes, whose relative importance has changed over time. Originally reprocessing was used solely to extract plutonium for producing nuclear weapons. With the commercialization of nuclear power, the reprocessed plutonium was recycled back into MOX nuclear fuel for thermal reactors. The reprocessed uranium, which constitutes the bulk of the spent fuel material, can in principle also be re-used as fuel, but that is only economic when uranium prices are high or disposal is expensive. Finally, the breeder reactor can employ not only the recycled plutonium and uranium in spent fuel, but all the actinides, closing the nuclear fuel cycle and potentially multiplying the energy extracted from natural uranium by more than 60 times.

Nuclear reprocessing reduces the volume of high-level waste, but by itself does not reduce radioactivity or heat generation and therefore does not eliminate the need for a geological waste repository. Reprocessing has been politically controversial because of the potential to contribute to nuclear proliferation, the potential vulnerability to nuclear terrorism, the political challenges of repository siting, and because of its high cost compared to the once-through fuel cycle.

**What are Nuclear Power Plants?**

In this introduction of a nuclear power plant, you should know that a nuclear power plant can be defined as a thermal power station in which a nuclear reactor is used as the main heat source. After that, the heat produced by nuclear reactors is used for generating steam. This steam moves the steam turbines that are connected to generators. And these generators produce the needed electricity.

As of 2018, the International Atomic Energy Agency has reported that there are 450 nuclear power plants working all across the globe. Nuclear power plants are also considered as baseload stations. This is mainly because the fuel is a very small part of the cost of production and they cannot be quickly or easily dispatched.

The operation, maintenance, and fuel costs of nuclear power plants are rather low. This means that these plants are suitable for base-load power suppliers. However, at this time, the cost of proper long-term radioactive [waste](https://www.vedantu.com/chemistry/waste) storage is not certain. This should be included in the principle of the nuclear power plant.

**The Structure of a Nuclear Power Plant**

The structure of a nuclear power plant definition can be a bit complicated. But in this section, students will be walked through all of it step by step. The first thing one needs to know about the structure of a nuclear power plant is that the conversion to electrical energy takes place in an indirect manner.

The fission in the nuclear reactor is also responsible for heating the reactor coolant. The coolant can be water, [gas](https://www.vedantu.com/chemistry/gas), or even a liquid metal. The selection of coolant depends on the type of reactor that is used. After that, the reactor coolant goes to the steam generator. The water starts to heat for the production of steam.

The pressurized steam is usually fed to a steam turbine that is formed by multiple stages. Once the steam turbine expands and partially condenses the steam, the vapour that is remaining will also condense in the condenser.

It should be noted that the condenser is a heat exchanger that is connected to the secondary side, like a cooling tower or a river. After that, the water is pumped back into the steam generator. From there, the cycle can begin again. The cycle of water and steam also corresponds to the Rankine cycle. This is somewhat similar to the thermal power plant structure.

In the entire structure, the nuclear reactor is located at the centre of the nuclear station. At the core of it, the reactor produces heat through the process of nuclear fission. Because of this heat, a coolant is heated while being pumped through the reactor. This removes the energy from the reactor.

The heat from the nuclear fission gets utilized to raise steam, it runs the turbines, and that turns the power of the electrical generators. The nuclear reactions or the chain reaction inside the nuclear reactor are powered by [uranium](https://www.vedantu.com/chemistry/uranium). Different isotopes can also be used but those isotopes can have different behaviours.

The reactor core also has a protective shield around it. This is because radioactivity is creased by nuclear fission. The job of the containment is to absorb the radiation and prevent any radioactive material from being released directly into the environment.

There are also several reactors that come equipped with a dome of concrete. This concrete helps in protecting the reactor against any external impacts and internal casualties. Students should remember that the steam turbine, which is present with the engine house, is present in a separate structure from the main reactor building. This alignment is done to prevent the debris from any destruction of a turbine in operation from flying towards the reactor. This is also roughly the same structure of the 1st nuclear power plant in India or the largest nuclear power plant in India.

**Fun Facts About Nuclear Power Plants**

Did you know that nuclear stations are mainly used for the baseload? This is because of several economic factors. The cost of operation for fuel for a nuclear station is smaller when compared to the cost of operation of fuel for [coal](https://www.vedantu.com/chemistry/coal) or gas power plants. Further, most of the cost of a nuclear power plant information is mainly capital cost, this means that there is almost no cost saving by running the plant at less than full capacity.

Students might also find it interesting to note that nuclear power plants are frequently used in load-following mode. This is done on a large scale in France even though it is usually accepted that this is not an ideal economic situation for any nuclear station. This is a very important point when it comes to nuclear power plant working.