

# Report on nuclear energy engineering essay

[Engineering](#)



1. 1. Nuclear history

The atom was originally defined by the Greek philosopher Democritus as the smallest indivisible unit of matter, i. e. the smallest part into which an element can be divided without changing its nature. The atom itself is depicted as a number of shells of negatively charged electrons orbiting a nucleus – a cluster of positively charged protons and uncharged neutrons. The history of nuclear energy begins with the discovery of the Uranium, named after the planet Uranus, in 1789 by Martin Klaproth, a German chemist. The countdown starts on November 8, 1895 when Wilhelm Röntgen accidentally discovers X-rays. Roentgen was exploring the path of electrical rays passing from an induction coil through a partially evacuated glass tube. Although the tube was covered in black paper and the room was completely dark, he noticed that a screen covered in fluorescent material was illuminated by the rays. He later realised that a number of objects could be penetrated by these rays, and that the projected image of his own hand showed a contrast between the opaque bones and the translucent flesh. He later used a photographic plate instead of a screen, and an image was captured. Röntgen's findings were quickly confirmed by other laboratories all over the world as his discovery was fairly easy to replicate. The discoveries were followed in 1896 by Henri Becquerel, who found that pitchblende (an ore containing radium and uranium) caused a photographic plate to darken. He went on to demonstrate that this was due to beta radiation (electrons) and alpha particles (helium nuclei) being emitted. Villard found a third type of radiation from pitchblende: gamma rays, which were much the same as X-rays. In 1896, Pierre and Marie Curie, first used the term radiation to describe the effects that they were observing from Uranium. The Curies' also discovered Radium which they used to try to cure

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

cancer, a process that is still used today. The Curies' also attempted to postulate that the element Polonium must exist but they could not prove its existence. The Curies would later die from radiation poisoning after having spent much of their time experimenting with radiation without using appropriate protection. Ernest Rutherford was the one who in 1902 showed that radioactivity as a spontaneous event emitting an alpha or beta particle from the nucleus, created a different element. He went on to develop a fuller understanding of atoms and in 1919 he fired alpha particles from a radium source into nitrogen and found that nuclear rearrangement was occurring, with formation of oxygen. The major nuclear discoveries were still to come. Since, eventually one of the most important concepts for the scientists to understand was how the atom worked. <http://upload.wikimedia.org/wikipedia/commons/1/1e/Atom111.gif>

By 1911 Frederick Soddy discovered that naturally-radioactive elements had a number of different isotopes (radionuclides), with the same chemistry. Also, in 1911 George de Hevesy showed that such radionuclides were invaluable as tracers, because minute amounts could readily be detected with simple instruments. Niels Bohr was another scientist who advanced our understanding of the atom and the way electrons were arranged around its nucleus through to the 1940s. In 1913, Niels Bohr published his model of the atom (Hydrogen Pictured) which is still taught in schools today. In 1932, Bohr's model was further improved. While working under Ernest Rutherford at Cambridge, James Chadwick proved the existence of neutrons, the elementary particle without any electrical charge and a fundamental building block of the atom's nucleus. One of the most important scientific discoveries of the twentieth century, it effectively solved the jigsaw puzzle of the atom, and earned Chadwick the <https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

1935 Nobel Prize for Physics. Finally, in 1935, Enrico Fermi discovered that when a radioactive substance such as Uranium is attacked by neutrons, it produces by-products that are not Uranium and are lighter than the original sample. Fermi continued his experiments, mostly producing heavier elements from his targets, but also, with uranium, some much lighter ones. At the end of 1938, Otto Hahn and Fritz Strassman in Berlin showed that the new lighter elements were barium and others which were about half the mass of uranium, thereby demonstrating that atomic fission had occurred. Lise Meitner and her nephew Otto Frisch, working under Niels Bohr, then explained this phenomenon by suggesting that the neutron was captured by the nucleus, causing severe vibration leading to the nucleus splitting into two not quite equal parts. They calculated the energy release from this fission as about 200 million electron volts. This proved Einstein's theory put forth 33 years earlier that  $E = mc^2$ , so that production of nuclear energy—particles are smashed and their energy is captured. The latter process, the conversion of energy into mass, is demonstrated by the process of particle acceleration, in which low-mass particles zipping through a device collide to form larger particles. This was the first time that all of the components of fission were known. In 1939 Hitler invaded Poland and started World War II. This prompted scientists all over Europe to petition their governments to fund nuclear fission programs, both for energy and for bombs (Mladjenovic, Milorad, 1992).

## **1. 2. History of other nuclear applications**

[http://farm5.static.flickr.com/4023/4446222744\\_80ff98dda2\\_z.jpg](http://farm5.static.flickr.com/4023/4446222744_80ff98dda2_z.jpg)It would be logical to assume that the discovery of fission preceded the invention of

the atomic bomb. It would be normal also to expect that no single individual could really claim to be "the inventor", since the possibility sprang naturally from a physical process, and required the efforts of many thousands to bring it into existence. Many descriptions of the origin of atomic bombs can be found that logically and normally say exactly these things. However in case with nuclear weapons it is not the case. The world knows the name of the founder and instigator of the atomic bomb and it is - Leo Szilard. On September 12, 1932, within seven months of the discovery of the neutron, and more than six years before the discovery of fission, Leo Szilard conceived of the possibility of a controlled release of atomic power through a multiplying neutron chain reaction, and also realized that if such a reaction could be found, then a bomb could be built using it. On July 4, 1934 Leo Szilard filed a patent application for the atomic bomb. In his application, Szilard described not only the basic concept of using neutron induced chain reactions to create explosions, but also the key concept of the critical mass. The patent was awarded to him - making Leo Szilard the legally recognized inventor of the atomic bomb. One of the noble theories is that Szilard did not patent this prescient and tremendously important idea for personal gain. His motive was to protect the idea to prevent its harmful use, for he immediately attempted to turn the idea over to the British government for free so that it could be classified and protected under British secrecy laws. On October 8, 1935 the British War Office rejected Szilard's offer, but a few months later in February 1936 he succeeded in getting the British Admiralty to accept the gift. Szilard's actions in attempting to restrict the availability of the atomic bomb, are also the earliest case of nuclear arms control. Later, when the possibility of a German atomic bomb had been shown to be nonexistent,

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

Szilard campaigned vigorously against the use of the bomb, and went on to help found The Bulletin of Atomic Scientists and The Council for a Livable World. He had eventually fled from Europe. In October 1939, just after the outbreak of World War II in Europe, the President of the United States Franklin D. Roosevelt received a letter from Leo Szilard and Albert Einstein, calling to his attention the prospect that a bomb of unprecedented power could be made by tapping the forces of nuclear fission. The two scientists, who had fled from Europe in order to escape Nazism, feared that Hitler-Germany was already working on the problem. Should the Germans be the first to develop the envisaged "atomic bomb," Hitler would have a weapon at his disposal that would make it possible for him to destroy his enemies and rule the world. To avoid the unforeseen and impossible in its impact to be measured, consequences, Einstein and Szilard urged the government of the United States to join the race for the atomic bomb. Roosevelt agreed, and for the next four and half years a vast, utterly secret effort was launched in cooperation with the United Kingdom.

## **" Manhattan Project"**

Code-named "The Manhattan Project," the effort eventually employed more than 200,000 workers and several thousand scientists and engineers, many of European background. Despite its official founding in August, the Manhattan Project really began on September 17, 1942 when Col. Leslie Richard Groves was notified at 10:30 a. m. by Gen. Brehon Somervell that his assignment overseas had been cancelled. Groves, an experienced manager who had just overseen the colossal construction of the Pentagon, seized immediate and decisive control. In just two days he resolved issues

that had dragged on for months under Compton. On September 18 Groves ordered the purchase of 1250 tons of high quality Belgian Congo uranium ore stored on Staten Island, and the next day purchased 52000 acres of land to be the future site of Oak Ridge. Groves was promoted to Brigadier General on September 23. By September 26 Groves had secured access to the highest emergency procurement priority then in existence (AAA). The era of weak, indecisive leadership was over. Groves' pushy, even overbearing, demeanor won him few friends among the scientists on the Manhattan Project (in particular a special enmity developed between Groves and Szilard.) During the fall, while Fermi built CP-1 in Chicago, Groves took the fissile material programs out of the hands of the scientists and placed them under the management of industrial corporations like DuPont and the Kellogg Corporation. He ordered construction begun immediately on the fissile material production plants, even though designs and plans had not yet been drawn up, realizing that the same basic site preparation work would be required no matter what. On October 15, 1942 Groves asks Dr. J. Robert Oppenheimer to head Project Y, the new planned central laboratory for weapon physics research and design. The site for which he selected on November 16 at Los Alamos, New Mexico. On Monday morning July 16, 1945, the world was changed forever when the first atomic bomb was tested in an isolated area of the New Mexico desert. Its power astonished even those who had constructed it. Robert Oppenheimer, the physicist who had directed the scientific work on the bomb, witnessing the spectacular explosion, remembered a line from the Vedic religious text Bhagavad-Gita: " I am become death, the shatterer of worlds." And so conducted in the final month of World War II by the top-secret Manhattan Engineer District, this test was

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

code named Trinity. The Trinity test took place on the Alamogordo Bombing and Gunnery Range, about 230 miles south of the Manhattan Project's headquarters at Los Alamos, New Mexico. Today this 3, 200 square mile range, partly located in the desolate Jornada del Muerto Valley, is named the White Sands Missile Range and is actively used for non-nuclear weapons testing. By the time of the Alamogordo test, Germany had already surrendered. This meant that the potential threat of a Nazi atomic bomb no longer existed. But the war in the Pacific was still raging, and the President of the United States Harry S. Truman decided to use the atomic bomb in order to force the Japanese leadership to surrender as quickly as possible. Thus, on August 6 an atomic bomb with an explosive yield equivalent to 12.5 kilotons of the explosives TNT (trinitrotoluene) was dropped on the Japanese city of Hiroshima, instantly killing some 70, 000 of its inhabitants, with another 70, 000 deaths registered by the end of 1945. Meanwhile, on August 9, a second bomb was used against the city of Nagasaki. This explosion had a higher yield (equivalent to 22 kilotons of TNT) but caused fewer instant deaths. However, many of the survivors suffered from heavy burns, radiation sickness, etc., and the death toll continued to rise. By the end of the year more than 70, 000 of Nagasaki's citizens had lost their lives. Five years later, as many as 340, 000 people, or 54 percent of the original population, had died from the two explosions. Setting the downsides of the atomic bomb invention aside, an integral and inevitable step in the development of the nuclear bomb was the establishment of a stable nuclear reaction. This was realized for the first time on December 2, 1942 when Enrico Fermi, continuing his research described above, established the first self-sustaining nuclear reactor on a squash court underneath the stadium at <https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>



Chicago University. Fermi and his partner, Leo Szilard were working under the assumption that if enough uranium and graphite were placed together in a cube, then a fission reaction would happen automatically and be self-sustaining. This is what prompted them to build Chicago Pile-1, the world's first nuclear reactor, with an addition of Cadmium control rods to slow down the reaction and make sure it would not get out of hand. The first self-sustaining nuclear chain reaction was initiated in CP-1 on 2 December 1942. At 3: 25 PM, the reactor reached critical mass and began to produce energy.

### **1. 3. Developing the nuclear power as energy source.**

Once World War II was over, the world was free to use what Fermi had learned to pursue nuclear power as an energy source. The earliest large nuclear reactors built in the USA, Britain, USSR and China were all designed to make weapons-grade plutonium for atomic bombs. These atomic piles comprised simply of piles of graphite blocks into which uranium reactor fuel was loaded for transformation into plutonium. The USA was a pioneer of nuclear power development. The first experimental nuclear reactor to 'go critical' without an external source of neutrons was constructed in Chicago in the late 1942 – but the Americans withdrew behind a veil of military secrecy in 1946, and the international effort was succeeded by national programmes. The US government supported nuclear power as an energy source and created a special type of reactor called a breeder reactor. Experimental Breeder Reactor I, was completed December 20, 1951 in Idaho. EBR-I produced the first electricity from nuclear energy, but in very small amounts. The first commercial nuclear power plant in the US was built in Shippingport, Pennsylvania in 1957. Once Shippingport was up and running, utility

companies all over the US started to build nuclear power plants to sell energy to their customers; the first of such plants was the one constructed in Dresden, Illinois which was constructed entirely without any government funds. Westinghouse Electric Corporation (Westinghouse Electric and Manufacturing Company changed its name to Westinghouse Electric Corporation in 1942) designed the first fully commercial pressurised water reactor (PWR) of 250 MWe capacity, Yankee Rowe, which started up in 1960 and operated to 1992. Meanwhile the boiling water reactor (BWR) was developed by the Argonne National Laboratory, and the first commercial plant, Dresden 1 (250 MWe) designed by General Electric, was started up in 1960. A prototype BWR, Vallecitos, ran from 1957 to 1963. By the end of the 1960s, orders were being placed for PWR and BWR reactor units of more than 1000 MWe capacity, and a major construction program got under way. These remain practically the only types built commercially in the USA. Nuclear developments in USA suffered a major setback after the 1979 Three Mile Island accident, though that actually validated the very conservative design principles of Western reactors, and no-one was injured or exposed to harmful radiation. Many orders and projects were cancelled or suspended, and the nuclear construction industry went into the doldrums for two decades. Nevertheless, by 1990 over 100 commercial power reactors had been commissioned. Most of these were built by regulated utilities, often state-based, which meant that they put the capital cost (whatever it turned out to be after, for example, delays) into their rate base and amortised it against power sales. Their consumers bore the risk and paid the capital cost. (With electricity deregulation in some states, the shareholders bear any risk of capital overruns and power is sold into competitive markets.) In the US in <https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

the 1960s, the number of atomic energy plants increased dramatically. One reason nuclear power took off was because of the growing environmental movement. As energy needs increased, the number of fossil fuel plants increased, which in turn increased environmental pollution. Nuclear power was seen as a solution to this because it released no smoke and did not greatly affect air quality. Nuclear plant builders were also creating an environment that was safe for nuclear technology. The companies who built the nuclear plants were competing against each other to become head of nuclear plant construction. They competed so hard that they would sign contracts where they would lose thousands of dollars just to secure a deal. This allowed the utilities to purchase nuclear plants relatively inexpensively. Operationally, from the 1970s the US nuclear industry dramatically improved its safety and operational performance, and by the turn of the century it was among world leaders, with average net capacity factor over 90% and all safety indicators exceeding targets. In 1973, there was an oil embargo against the US by Arab nations. For the first time, the cheap, available oil and coal that Americans had come to rely on was not as available as it used to be. The oil crisis prompted President Nixon, to announce Project Independence. The goal of Project Independence was to make the US energy independent and increased incentives for nuclear power plants. However, this fervor was short lived. In 1974, the oil embargo ended and the majority of companies that had once ordered nuclear plants decreased. With cheap and abundant oil making a rebound along with the increased cost of construction and the safety regulations in nuclear plants, many plants were cancelled and several already under construction were converted to coal fired plants. With the advent of Three Mile Island's partial meltdown in 1979,

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

energy companies of the day did not order a single new nuclear power plant. In 1991, at the peak of nuclear power generation, there were 111 nuclear power plants operating in the US, accounting for 22% of the energy need. Nuclear Power in the Soviet Union

Going back to the nuclear power infancy stage, the Soviet Union was not far behind the US at that period of time. In June of 1954 the USSR completed the world's first nuclear powered electricity generator in Obninsk, Soviet Union. The USSR's plans to develop nuclear power could not rely upon only one type of nuclear power plant. This would not have ensured the necessary reliability and stability. But at the same time, to develop any type of nuclear power reactor up to a commercial scale requires time, and huge material and financial resources. To select the types of reactor which would be most appropriate and economic for the Soviet Union, the State Committee for the Utilization of Atomic Energy set up a research and development programme on different types of nuclear power reactors: pressurized water and boiling-water (vessel type) reactors, channel type boiling-water reactors, organic-moderated and cooled reactors, etc. The USSR paid special attention to the development of fast breeder reactors because, from the very beginning, it seemed evident that a large-scale long-term nuclear power programme could not be realized without fast breeder reactors. The first experimental reactor, with plutonium fuel, went into operation in 1955. The capacities of experimental reactors which then followed have been successively increased. In 1969, a 12 MWe test prototype fast reactor with sodium coolant, BOR-60, went into operation in Dimitrovograd. In the process of development, construction, and operation of different prototype units, it became clear which types of nuclear power plants were optimal for the specific conditions of the USSR. In the second

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

half of the 1960s, on the basis of the accumulated experience, it was decided to base further development of nuclear power on two thermal reactor types: the WWER pressurized-water reactor; and the RBMK, channel-type uranium-graphite boiling-water reactor. While nuclear reactors were being installed all over the world for commercial purposes, the US was adapting the nuclear reactor for military purposes, most notably, nuclear powered submarines. Nuclear powered submarines are submarines that use a nuclear reactor for propulsion, rather than a diesel engine. The benefit of using a nuclear reactor in this way is that the submarine almost never has to refuel, can maintain high speeds for longer periods of time, and only needs to surface when running low on provisions. The first nuclear vessel was built in 1954-1955 and was named the USS Nautilus. <http://upload.wikimedia.org/wikipedia/commons/d/d9/SS-571-Nautilus-trials.gif> Westinghouse Electric Corporation ranked 21st among United States corporations in the value of World War II production contracts builds the S2W reactor, a naval reactor used by the United States Navy to provide electricity generation and propulsion on warships, in 1954 for the USS Nautilus, the world's first nuclear-powered submarine. Further on Westinghouse builds the A2W (A stands for aircraft carrier platform) reactor in 1960 for the USS Enterprise, the world's first nuclear-powered aircraft carrier. Having the sky as its limit in 1972 Westinghouse and Newport News Shipbuilding and Drydock jointly formed Offshore Power Systems to build floating nuclear power plants for Public Service Electric and Gas Company. [http://upload.wikimedia.org/wikipedia/commons/a/aa/Cofrentes\\_nuclear\\_power\\_plant\\_cooling\\_towers\\_1.jpg](http://upload.wikimedia.org/wikipedia/commons/a/aa/Cofrentes_nuclear_power_plant_cooling_towers_1.jpg) [http://www.instituteforenergyresearch.org/energycharts/nuclear/nuclear\\_shutdowns.jpg](http://www.instituteforenergyresearch.org/energycharts/nuclear/nuclear_shutdowns.jpg) UK nuclear path British <https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

scientists were preeminent in the development of nuclear energy through to the early 1940s. This work was picked up again after the Second World War and while the USA was initially focused on reactors for marine propulsion, the world's first commercial-scale nuclear power reactor started up in the UK in 1956. A fleet of 26 Magnox power reactors was built, followed later by 14 advanced gas-cooled reactors (AGRs), and finally a single PWR at Sizewell B. Plans for a new era of nuclear power are now in place and described in the main information page on Nuclear Power in the United Kingdom. Following the Second World War, nuclear research in the UK was mainly focused on defence-related applications. The country's first nuclear reactors were built at the Atomic Energy Research Establishment (AERE) at Harwell in Oxfordshire, which was formed at the beginning of 1946 under the UK's Ministry of Supply. The first reactor at AERE – the 3 kWth air-cooled graphite-moderated GLEEP (Graphite Low Energy Experimental Pile) – commenced operation in August 1947. This was followed by the commissioning in 1948 of the first large reactor outside the USA, the 6 MWth British Experimental Pile 'O' (BEPO). The reactor demonstrated the viability of commercial power reactors and was a forerunner of the Windscale Piles<sup>1</sup>. During 1947, the site of the former Sellafield ordnance factory – renamed Windscale – was announced as a new atomic energy site, and construction activities on the two Windscale Piles commenced. Fuel for the Piles was produced at the Springfields nuclear fuel manufacturing facility in Preston, established by the Ministry of Supply in 1946. Piles No 1 and 2 were completed in 1950 and 1951, respectively. In 1953, following the government announcement that the country would begin a civil nuclear power program, the Ministry of Supply commenced construction on the first nuclear power reactors at <https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

Calder Hall on the Windscale site. The next year, the Atomic Energy Authority Act 1954 created the United Kingdom Atomic Energy Authority (UKAEA), which took on the responsibility for the UK's nuclear energy program. The UK's civil program was also to include the construction of an experimental fast breeder reactor (FBR) and in March 1954, a former wartime airfield at Dounreay in Caithness, on the north coast of Scotland, was chosen for this purpose. The UKAEA commenced work on the Dounreay Fast Reactor (DFR) the following year (see section below on UKAEA). One of the greatest achievement's of these early years of the UKAEA was marked in October 1956 with opening by Queen Elizabeth II of the world's first commercial nuclear power station at Calder Hall. The reactor was the first of eight small prototype Magnox units to be built at Calder Hall and Chapelcross (in southwest Scotland). Early in 1955, construction on the 60 MWth Dounreay Fast Reactor (DFR) commenced. The production of plutonium for military purposes was the main driving force behind FBR development. As was the case with the Magnox reactors that were under construction at Calder Hall at that time, power generation of the Dounreay Fast Reactor was a secondary consideration. The reactor achieved criticality in November 1959 and in October 1962 became the world's first fast reactor to supply electricity to the grid. The maximum electrical power it achieved was 14. 5 MW in 1963. It was cooled by liquid NaK (sodium-potassium 70: 30 alloy) and shut down in 1977. In 1958, the 25 MWth Dounreay Materials Test Reactor (DMTR) became the first operational reactor in Scotland. DMTR used enriched uranium fuel with aluminium cladding and was heavy water cooled. The reactor was shut down in 1969. With DFR in operation, a second fast reactor at Dounreay was ordered in 1966. Construction on the Prototype Fast

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

Reactor (PFR) commenced in 1968 and it began supplying electricity to the grid in 1975. The 660 MWth (250 MWe) reactor used plutonium metal fuel and was cooled with liquid sodium. Despite the success of the fast reactor program, PFR was shut down in 1994 following the government's decision to withdraw its support for the program. Certain fuel cycle operations continued at Dounreay for a few years, but these ceased in 1998, since when the site has had no operational nuclear facilities. A number of major plants were built at Sellafield. Following the decision to reprocess used oxide fuel from the UK's AGR fleet, as well as from foreign nuclear reactors, the go-ahead for construction of the Thermal Oxide Reprocessing Plant (Thorp) was given in 1978. (Used Magnox fuel has been reprocessed at the B205 Magnox reprocessing plant since 1964dd.) With a design capacity of 1200 t/yr, Thorp commenced operation in 1994 (see also information page on Processing of Used Nuclear Fuel). A leak at Thorp in April 2005 put its continued operation into question, but permission to restart was given at the beginning of 2007.

Canada's developmentsCanadian reactor development headed down a quite different track, using natural uranium fuel and heavy water as a moderator and coolant. The nuclear industry (as distinct from the uranium industry) in Canada dates back to 1942 when a joint British-Canadian laboratory, the Montreal Laboratory, was set up in Montreal, Quebec, under the administration of the National Research Council of Canada, to develop a design for a heavy-water nuclear reactor. This reactor was called National Research Experimental and would be the most powerful research reactor in the world when completed. In the meantime, in 1944, approval was given to proceed with the construction of the smaller ZEEP (Zero Energy Experimental Pile) test reactor at Chalk River, Ontario and on September 5,

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>



1945 at 3: 45 p. m., the 10 Watt ZEEP successfully achieved the first self-sustained nuclear reaction outside the United States.[2]In 1946, the Montreal Laboratory was closed, and the work continued at the Chalk River Nuclear Laboratories. Building partly on the experimental data obtained from ZEEP, the National Research Experimental (NRX)—a natural uranium, heavy water moderated research reactor—started up on July 22, 1947. It operated for 43 years, producing radioisotopes, undertaking fuels and materials development work for CANDU reactors, and providing neutrons for physics experiments. It was eventually joined in 1957 by the larger 200 megawatt (MW) National Research Universal (NRU) reactor. In 1952, the Canadian government formed AECL, a Crown corporation with the mandate to develop peaceful uses of nuclear energy. A partnership was formed between AECL, Ontario Hydro and Canadian General Electric to build Canada's first nuclear power plant, called NPD for Nuclear Power Demonstration. The 20 MWe NPD started operation in 1962 and successfully demonstrated the unique concepts of on-power refuelling using natural uranium fuel, and heavy water moderator and coolant. These features formed the basis of a fleet of CANDU power reactors (CANDU is an acronym for Canada Deuterium Uranium) built and operated in Canada and elsewhere. In the late 1960s (1967–1970), Canada also developed an experimental miniature nuclear reactor named SLOWPOKE (acronym for Safe Low-Power Kritical Experiment). The first prototype was built at Chalk River and many SLOWPOKEs were subsequently built, mainly for research. Many SLOWPOKEs are still in use in Canada; there is one running at École Polytechnique de Montréal, for instance.

FranceFrance started out with a gas-graphite design similar to Magnox and the first reactor started up in 1956. Commercial models operated from 1959.

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

It then settled on three successive generations of standardised PWRs, which was a very cost-effective strategy. The history of nuclear power thus starts with science in Europe, blossoms in UK and USA with the latter's technological might, languishes for a few decades, then has a new growth spurt in east Asia.

#### 1. 4. How it actually works: fission and nuclear reaction

Nuclear technology uses the energy released by splitting the atoms of certain elements. It was first developed in the 1940s, and during the Second World War research initially focused on producing bombs by splitting the atoms of particular isotopes of either uranium or plutonium. The process of nuclear fission ('splitting the atom' or, more precisely, 'splitting the atomic nucleus') releases immense amounts of energy. Under controlled conditions within a nuclear reactor, this process can release one million times more energy per atom than any chemical reaction, including combustion. Furthermore, this occurs without many of the pollutants associated with combustion, e. g. oxides of nitrogen, sulphur and carbon. So it is hardly surprising that over the past 60 years considerable efforts have been made to harness this theoretically efficient use of the Earth's energy resources. The atom itself is depicted as a number of shells of negatively charged electrons orbiting a nucleus – a cluster of positively charged protons and uncharged neutrons. Although the protons repel one another due to their similar electrical charge, the more powerful but short-distance 'strong nuclear force' which acts between all neutrons and protons holds the nucleus together (Figure 1. 1). Together with its 92 protons, the nucleus of the heaviest naturally occurring element, uranium (symbol U), contains 146 neutrons. The atomic weight of each element is the sum of its number of protons and neutrons, since the orbiting electrons have negligible mass: in

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

the case of uranium, this is  $92\ 146$ , i. e. 238. Uranium with this atomic weight is known as uranium-238, or  $^{238}\text{U}$ . The stability of the nucleus is governed by the balance of attractive and repulsive forces between the protons and neutrons, but the neutron to proton (N: P) ratio can vary only within certain limits. Since it is so massive, with a large number of protons and neutrons clumped together, the uranium nucleus is particularly sensitive to changes in the balance of these attractive and repulsive forces. Unstable nuclei tend to emit particles or energy (radioactive decay), or more drastically, to break apart (nuclear fission) in an attempt to restore the balance of neutrons to protons. Radioactive decay may take the following forms: • Alpha • Beta • Gamma All three kinds of radioactive decay may cause biological damage and require precautions to be taken with naturally occurring radioactive substances such as uranium and its compounds, as well as with any radioactive by-products of unstable nuclei. High doses of 'nuclear radiation' can kill a living cell, but much lower levels can damage genetic material and affect cell division (possibly leading to cancers). More severe transformation of unstable nuclei may take place by the process of nuclear fission, whereby the nucleus divides into two substantial parts. The fission products tend to be unstable also, with an excess of neutrons over protons, and so they are usually  $\beta$ - and  $\gamma$ -emitters. Following the fission of a single nucleus of the unstable isotope uranium-235, two to three (on average about 2.5) stray neutrons are released, which may be 'captured' by other nuclei of  $^{235}\text{U}$ . These, in turn, immediately become highly unstable, resulting in further induced fissions, with the accompanying release of further neutrons and energy as heat. Thus an initial spontaneous nuclear fission may result in 2 further induced fissions, then 4, 8, 16, 32, etc.,

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

resulting in a chain reaction. After 80 or so generations, the chain reaction produces a catastrophic release of energy – a nuclear explosion. The principle of the atom bomb was therefore how to set off a chain reaction to order (and not before!) – a function of the concentration of neutrons being produced, the proportion that result in induced fissions and their rate of loss from the outer surface of the mass of fissile material. In a nuclear weapon, this may be achieved by rapidly bringing together two smaller blocks of fissile material into a larger critical mass, within which the chain reaction will be sustained. However, civilian applications of nuclear energy require a more controlled chain reaction, maintained as a source of heat – without the possibility of an explosion. (Nuclear Or Not? Does Nuclear Power Have a Place in a Sustainable Energy Future? D. Elliott. Nuclear Energy: An Introductory Primer. Jonathan Scurlock).

## **II. Nuclear energy: benefit versus hazard**

2. 1 Outlook at the world energy supply and consumption. Global energy map  
2. 2. Nuclear power versus sustainable energy resources: cost/benefit approach  
In favour: Are climatologists mostly in favor of nuclear?

### **James Hansen - climatologist**

Book " Storms of my grandchildren". " Coal plants are factories of death." 5  
out of six live in developing world, move to the cities. Developing world – 5. 7  
mln. And one of the things we want most is – electricity and is still most  
desired by poor people in the world. Baseload electricity – on all the time in  
the cities. Three major sources for electricity – coal and gas, hydroelectric  
and nuclear. Renewables are inconstant. So nuclear shall win. Environmental  
standpoint – what happens to the waste from coal and nuclear. All electricity  
<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

from nuclear – the waste will fit in coke can, 1 day of electricity consumption from coal – much more waste. Nuclear – 1GW a year = 20 tonnes= 2 casks. Comparable to renewables in terms of harm to environment. Coal waste – 1 GW a year = 8, 000, 000 tons of CO<sub>2</sub>. Renewables: Wind as a solar is a relatively dilute source of energy. Takes a very large footprint on the land to get 1GW – 200000 sq miles of wind farms. 5-10 times of materials you would use on nuclear. Denmark and Germany run out of sites, lines overloaded. Solar – 80 solar farms, 1000 sq miles of a desert. On a landscape. Adding it all up 13 clean terrawatts of energy from wind solar and biofuels – area size of USA. "Renewistan" David MacKay, Cambridge physicist, his book Sustainable Energy – "I am not pronuclear, but pro-arithmetic". 10% of American energy Recycling/decommissioned warheads (Russian weapon). New generation of reactors – very small – 10-120 Megawatts, put underground, very safe. Mexico, Oregon (Newscale). Against: Professor Mark Jacobson from Stanford. Nuclear emits more CO<sub>2</sub> than any other source and nuclear weapons proliferation. Nuclear weapon proliferation. For the past decade there has been worldwide concern over Iran's nuclear program. In November 2011, the International Atomic Energy Agency released a report saying it has "serious concerns" and "credible" information that Iran may be developing nuclear weapons. Iran maintains that it is enriching uranium for civilian energy purposes only, but the IAEA says Iran has not been cooperating enough for the agency to verify whether the intent is solely for peaceful means. As a result, the U. N. Security Council and a number of Western nations have placed economic and arms-related sanctions on Iran. There have been several meetings in the past year between Iran and the "P5+1" group, which consists of representatives from Germany and the five

<https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

permanent members of the U. N. Security Council: China, France, Russia, the United Kingdom and the United States. But there is yet to be a diplomatic breakthrough. Iran has been developing ballistic missiles since the 1980s, and it has the largest number of deployed missiles in the Middle East, according to a December 2012 report by the U. S. Congressional Research Service. But experts say these missiles aren't nuclear-ready; even if Iran acquires a nuclear warhead, it would have to spend significant time and research on making it a deliverable weapon.

2. 3. NGOs involved in nuclear power development, monitoring and regulation.

International Atomic Energy Agency  
The IAEA is the world's center of cooperation in the nuclear field. It was set up as the world's "Atoms for Peace" organization in 1957 within the United Nations family. The Agency works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. <http://www.iaea.org/>

The World Nuclear Association is the international organization that promotes nuclear energy and supports the many companies that comprise the global nuclear industry. Since its inception in 2001 on the foundations of the Uranium Institute, WNA has grown in pace with the widening prospects for the worldwide use of nuclear power. <http://www.world-nuclear.org/>

The Nuclear Energy Agency (NEA) is a specialised agency within the Organisation for Economic Co-operation and Development (OECD), an intergovernmental organisation of industrialised countries based in Paris, France. In order to achieve this, the NEA works as a forum for sharing information and experience and promoting international co-operation; a centre of excellence which helps member countries to pool and maintain their technical expertise and a vehicle for facilitating policy analyses and developing consensus based on its technical work. The NEA's <https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>

current membership consists of 31 countries in Europe, North America and the Asia-Pacific region. <http://www.oecd-nea.org/2>. 3. Countries example

### **III. Future outlook: potential and perspectives of nuclear energy**

3. 1. Current trendsIn the new century several factors have combined to revive the prospects for nuclear power. First is realisation of the scale of projected increased electricity demand worldwide, but particularly in rapidly-developing countries. Secondly is awareness of the importance of energy security, and thirdly is the need to limit carbon emissions due to concern about global warming. These factors coincide with the availability of a new generation of nuclear power reactors, and in 2004 the first of the late third-generation units was ordered for Finland - a 1600 MWe European PWR (EPR). A similar unit is planned for France as the first of a full fleet replacement there. In the USA the 2005 Energy Policy Act provided incentives for establishing new-generation power reactors there. But plans in Europe and North America are overshadowed by those in China, India, Japan and South Korea. China alone plans a sixfold increase in nuclear power capacity by 2020, and has more than one hundred further large units proposed and backed by credible political determination and popular support. A large portion of these are the latest western design, expedited by modular construction. Countries that are newcomers to nuclear energy face challenges in developing the necessaryinfrastructures and acquiring the necessary prerequisite skills to meet project milestones. Additionally, more than 20 Member States have initiated plans for new research reactor projects. The Agency has identified capacity building as a primary issue

which Member States have to resolve, since it has found significant weaknesses in some Member States areas, such as: legislative, regulatory, technical, educational and safety infrastructures. Strong and early governmental support is required to facilitate the establishment of these infrastructures. In order to assist in this process, the Agency provides various safety standards and guidance documents — in particular, Milestones in the Development of a National Infrastructure for Nuclear Power (IAEA Nuclear Energy Series No. NG-G-3, Vienna, 2007) and Establishing the Safety Infrastructure for a Nuclear Power Programme (IAEA Safety Standards Series No. SSG-16, Vienna, published in 2012). An additional challenge for newcomer countries will be to apply the lessons learned from the Fukushima accident, when developing their nuclear infrastructures. (IAEA Energy safety report 2012)

### 3. 2. Countries' plans and developments

#### Current status and plans

The United States has conducted more nuclear tests than the rest of the world combined and is the only country to have used a nuclear weapon in combat. The United States is also the only nuclear power with weapons deployed in other countries: Through NATO's nuclear sharing program, there are U. S. bombs in Belgium, Germany, Italy, the Netherlands and Turkey. Through various treaties, the United States and its former Cold War adversary, Russia, have been working together to reduce their vast nuclear arsenals, which are easily the two largest in the world. Both countries have the capability to launch nuclear weapons via land, air and sea. As of December 2012, the United States was estimated to have about 2, 150 operational warheads -- weapons that are deployed or could be deployed at short notice. An additional 2, 500 warheads are believed to be in reserve, and 3, 000 more are retired and awaiting dismantlement, according to the <https://assignbuster.com/report-on-nuclear-energy-engineering-essay/>



Federation of American Scientists. 3. 2. Forecast and

expectations([https://sites.google.com/a/ncsu.](https://sites.google.com/a/ncsu.edu/nuclear-energy/history#TOC-Future)

[edu/nuclear-energy/history#TOC-Future](https://sites.google.com/a/ncsu.edu/nuclear-energy/history#TOC-Future))With globally increasing demand for electricity, decreasing supplies of fossil fuels, and global warming due to carbon emissions, nuclear power is quickly becoming the energy source of choice for many countries. For more information on this, and to see nuclear energy's impact around the world, please see the Foreign Politics page. Also in the future for nuclear energy is the potential for nuclear fusion. Current nuclear reactors use fission, using fusion, reactors will be able to create more energy and produce only a fraction of the waste. Fusion is still a long way off however, and research into the workings of the technology has been going on since the 1950s with very little headway. Scientists are hopeful that, within the next 30 to 50 years, we will have controlled nuclear fusion.

### **Main sources:**

Atomic Rise and Fall, the Australian Atomic Energy Commission 1953-1987, by Clarence Hardy, Glen Haven (PO Box 85, Peakhurst, NSW 2210), 1999.

Chapter 1 provides the major source for 1939-45. Radiation in Perspective, OECD NEA, 1997. Nuclear Fear, by Spencer Weart, Harvard UP, 1988. Judith Perera (Russian material). 2. Bailey, C. C. The Aftermath of Chernobyl:

History's Worst Nuclear Power Reactor Accident. Dubuque, Iowa:

Kendall/Hunt, 1989. Print. 3. Mladjenovic, Milorad. The History of Early Nuclear Physics. Singapore: JBW Printers & Binders, 1992. Print.