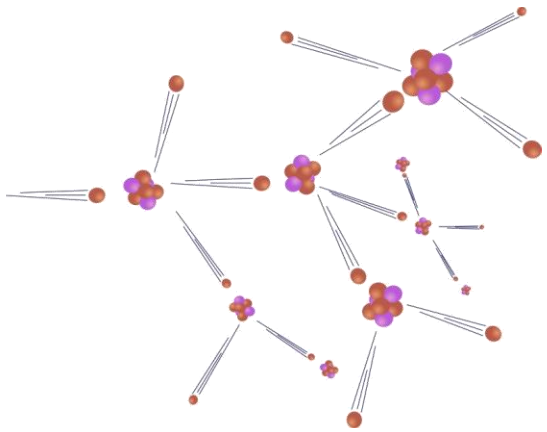
NUCLEAR POWER

- 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.
- In the 1950s attention turned to the peaceful use of nuclear fission, controlling it for power generation.

- **Nuclear power** is the use of nuclear reactions that release nuclear energy to generate heat, which most frequently is then used in steam turbines to produce electricity in a nuclear power plant.
- Nuclear power can be obtained from nuclear fission, and nuclear fusion. The possibility of generating electricity from nuclear fusion is still at a research phase with no commercial applications, nuclear fission used for this purpose generally.

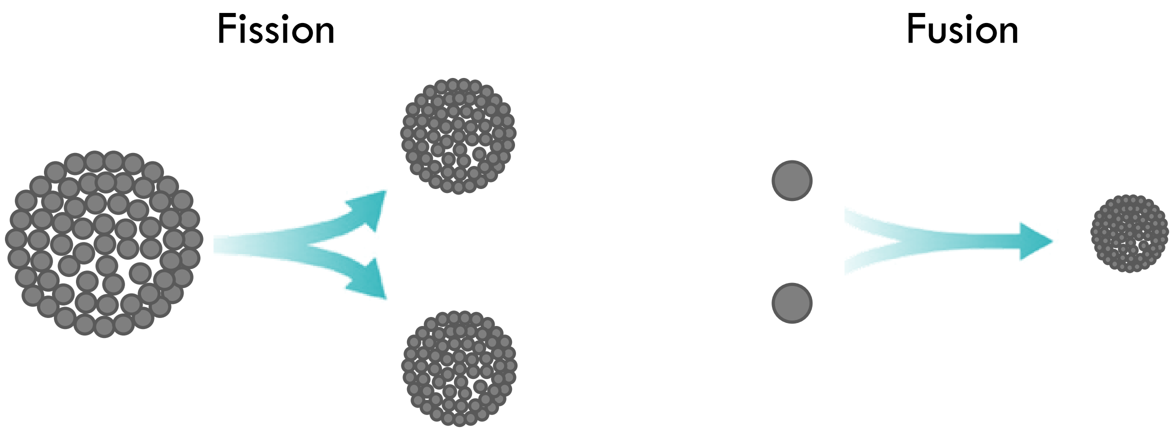


- Nuclear power is one of the leading low carbon power generation methods of producing electricity. In terms of total life-cycle greenhouse gas emissions per unit of energy generated, nuclear power has emission values comparable or lower than renewable energy.

- From the beginning of its commercialization in the 1970s, nuclear power prevented about 1.84 million air pollution-related deaths and the emission of about 64 billion tonnes of carbon dioxide equivalent that would have otherwise resulted from the burning of fossil fuels in thermal power stations.

NUCLEAR POWER GENERATION

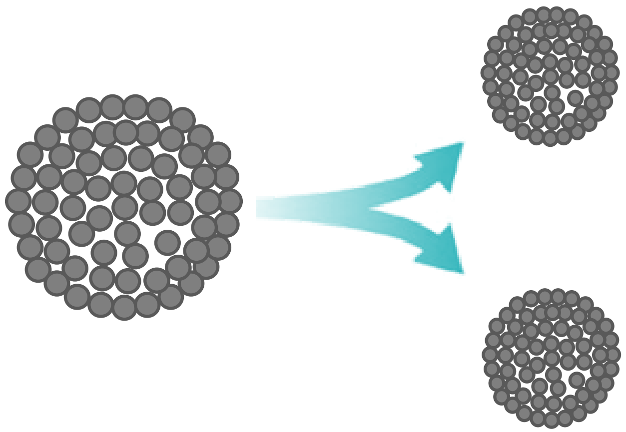
Nuclear energy is fundamentally produced in two different ways:



In the process of nuclear fission large radioisotopes, such as uranium-235 and plutonium-239 are split to release energy, while in nuclear fusion small nuclei are combined to release energy.

Nuclear Fission

When an atom undergoes fission, it releases a large amount of energy which is transformed into heat. In a nuclear reactor, this heat is recovered to generate electricity.



- Nuclear power generation plants use radioactive uranium-235 as the fission fuel. It is different from other radioactive decay as it can be controlled via a chain reaction so that only that much energy is produced which can be harnessed for electrical power generation.

$$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \longrightarrow ^{92}_{36}\mathrm{Kr} + ^{141}_{56}\mathrm{Ba} + 3^{1}_{0}\mathrm{n}$$

- In addition to the huge amount of energy released by nuclear fission reactions, another important result of such reactions is that more neutrons are produced than the number of neutrons used to bombard. The produced neutrons may also strike other ^{235}U isotopes and causes new fissions. The new nuclear fission reactions also produce neutrons with huge amounts of energy, and so on. This continuous process is said to be the *atomic bomb*, and is the basic principle of nuclear reactors.

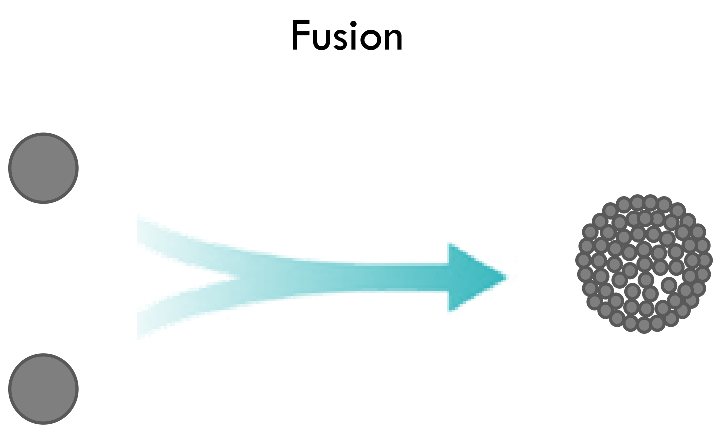
- This chain reaction was firstly achieved by Enrico Fermi on September 2, 1942 in Chicago.

- The first test of the atomic bomb was carried out on July 16, 1945 in the New Mexico desert.

- After this successful test, the first atomic bomb was dropped on Hiroshima during World War II, on August 6, 1945. The second atomic bomb was dropped three days later on Nagasaki, leading to the end of the World War II.

Nuclear Fusion

In order to obtain nuclear energy two lighter nuclei can be fused together to form heavier nuclei. The energy produced by sun and stars is an example of fusion reaction.



- The amount of energy released in fusion reactions is greater than the amount of energy released in fission reactions. However, a huge amount of activation energy (such as an atomic bomb explosion) is needed to initiate nuclear fusion reactions.
- The simplest nuclear fusion reaction is the combination of the isotopes of hydrogen (deuterium and tritium) to form the heavier nucleus of helium.

$$^{2}_{1}H + ^{3}_{1}H \longrightarrow ^{4}_{2}He + ^{1}_{0}n + \text{energy}$$

$$^{2}_{1}H + ^{2}_{1}H \longrightarrow ^{4}_{2}He + \text{energy}$$

- The nuclei of deuterium and tritium have to get very close to each other to initiate nuclear fusion reactions. Since atomic nuclei repel each other, the nuclei must have very high energy to overcome the repellent forces between them.
- This process is possible at temperatures above 100 million degrees centigrade. At this temperature, atoms are separated into their components (nuclei and electrons) and a plasma state is attained. Hence, substances are in the form of positively charged nuclei floating electron clouds.
- The energy sources of the sun and stars are samples of fusion reactions.

- The most important advantage of fusion reactions with respect to fission reactions is the abundance of hydrogen and its isotopes in nature.
- Nuclear fusion is the basis of the hydrogen bomb. An atomic bomb was first exploded to initiate the reactions in the hydrogen bomb.
- The effects of the atomic bomb, high temperature and pressure, started the nuclear fusion reaction. In other words, the igniter of hydrogen bomb is an atomic bomb.
- The power of a hydrogen bomb is about 1000 times greater than that of an atomic bomb.