What is Nuclear Energy? The Science of Nuclear Power

Nuclear Explained

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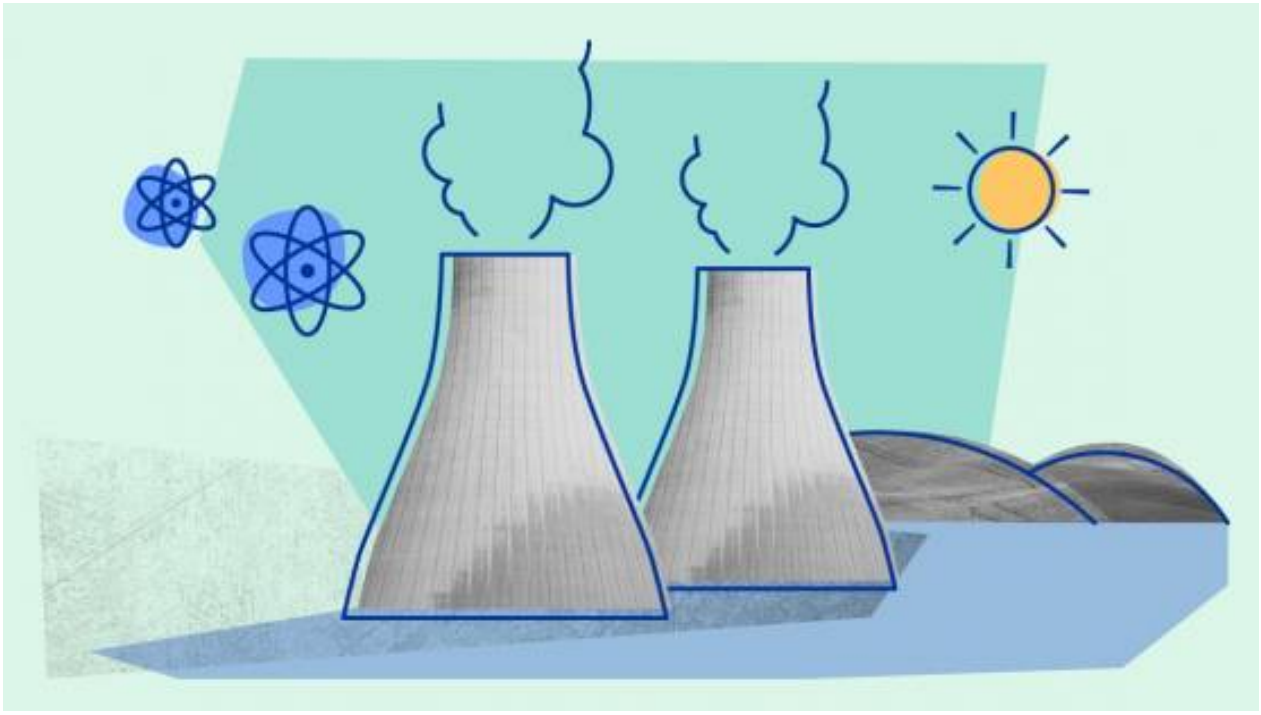


Nuclear energy is a form of energy released from the nucleus, the core of atoms, made up of protons and neutrons. This source of energy can be produced in two ways: fission – when nuclei of atoms split into several parts – or fusion – when nuclei fuse together.

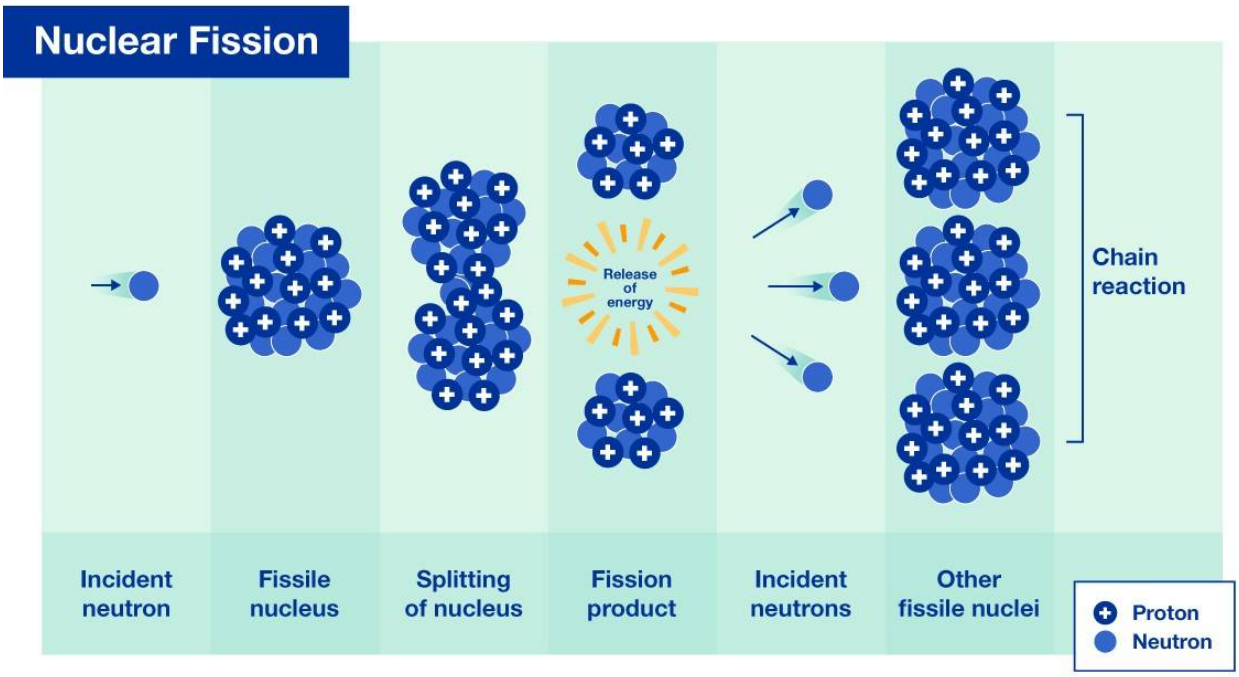
The nuclear energy harnessed around the world today to produce electricity is through nuclear fission, while technology to generate electricity from fusion is at the R&D phase. This article will explore nuclear fission. To learn more about nuclear fusion, click here.

What is nuclear fission?

Nuclear fission is a reaction where the nucleus of an atom splits into two or more smaller nuclei, while releasing energy.

For instance, when hit by a neutron, the nucleus of an atom of uranium-235 splits into two smaller nuclei, for example a barium nucleus and a krypton nucleus and two or three neutrons. These extra neutrons will hit other surrounding uranium-235 atoms, which will also split and generate additional neutrons in a multiplying effect, thus generating a chain reaction in a fraction of a second.

Each time the reaction occurs, there is a release of energy in the form of heat and radiation. The heat can be converted into electricity in a nuclear power plant, similarly to how heat from fossil fuels such as coal, gas and oil is used to generate electricity.

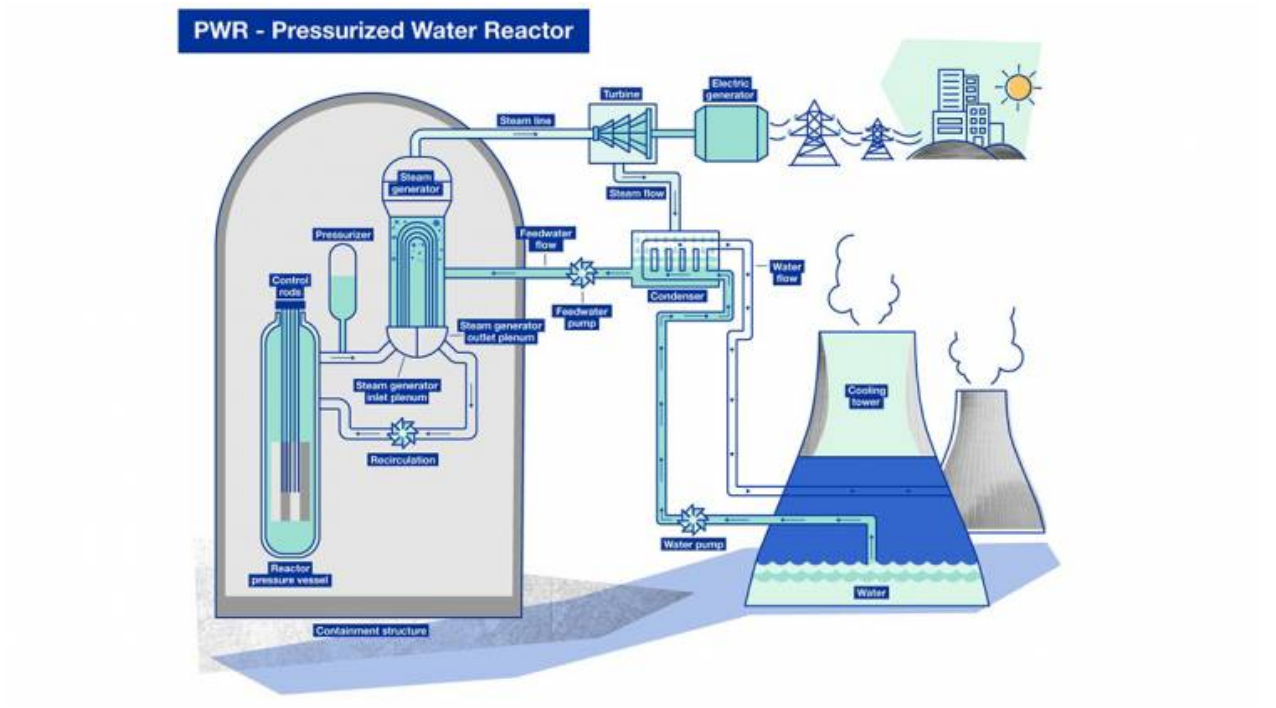


Nuclear fission (Graphic: A. Vargas/IAEA)

How does a nuclear power plant work?

Inside nuclear power plants, nuclear reactors and their equipment contain and control the chain reactions, most commonly fuelled by uranium-235, to produce heat through fission. The heat warms the reactor's cooling agent, typically water, to produce steam. The steam is then channelled to spin turbines, activating an electric generator to create low-carbon electricity.

Find more details about the different types of nuclear power reactors on this page.



Pressurized water reactors are the most used in the world. (Graphic: A. Vargas/IAEA)

Watch Video At: https://youtu.be/4j_wptct7kA

Mining, enrichment and disposal of uranium

Uranium is a metal that can be found in rocks all over the world. Uranium has several naturally occurring isotopes, which are forms of an element differing in mass and physical properties but with the same chemical properties. Uranium has two primordial isotopes: uranium-238 and uranium-235. Uranium-238 makes up the majority of the uranium in the world but cannot produce a fission chain reaction, while uranium-235 can be used to produce energy by fission but constitutes less than 1 per cent of the world's uranium.

To make natural uranium more likely to undergo fission, it is necessary to increase the amount of uranium-235 in a given sample through a process called uranium enrichment. Once the uranium is enriched, it can be used effectively as nuclear fuel in power plants for three to five years, after which it is still radioactive and has to be disposed of following stringent guidelines to protect people and the environment. Used fuel, also referred to as spent fuel, can also be recycled into other types of fuel for use as new fuel in special nuclear power plants.

What is the Nuclear Fuel Cycle?

The nuclear fuel cycle is an industrial process involving various steps to produce electricity from uranium in nuclear power reactors. The cycle starts with the mining of uranium and ends with the disposal of nuclear waste.

Nuclear waste

The operation of nuclear power plants produces waste with varying levels of radioactivity. These are managed differently depending on their level of radioactivity and purpose. See the animation below to learn more about this topic.

Radioactive Waste Management

Radioactive waste makes up a small portion of all waste. It is the by-product of millions of medical procedures each year, industrial and agricultural applications that use radiation and nuclear reactors that generate around 11 % of global electricity. This animation explains how radioactive waste is managed to protect people and the environment from radiation now and in the future.

The next generation of nuclear power plants, also called innovative advanced reactors, will generate much less nuclear waste than today's reactors. It is expected that they could be under construction by 2030.

Nuclear power and climate change

Nuclear power is a low-carbon source of energy, because unlike coal, oil or gas power plants, nuclear power plants practically do not produce CO_2 during their operation. Nuclear reactors generate close to one-third of the world's carbon free electricity and are crucial in meeting climate change goals.

To find out more about nuclear power and the clean energy transition, read this edition of the IAEA Bulletin.

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