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THE FUTURE OF POWER ENGINEERING

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Electricity generation is presumably the most important product of commercial energy. Presently electricity is a common input in almost all fields of human life and activities. That is why access to energy in general and electricity in particular, is important for growth and for improving people's standards of living. In addition to generation of electricity, primary fuels are also used directly in other important economic activities such as transport, agriculture, heating and other household and domestic uses. In some of these activities, in transport for instance, the use of primary fuels dominates that of secondary fuels such as electricity.

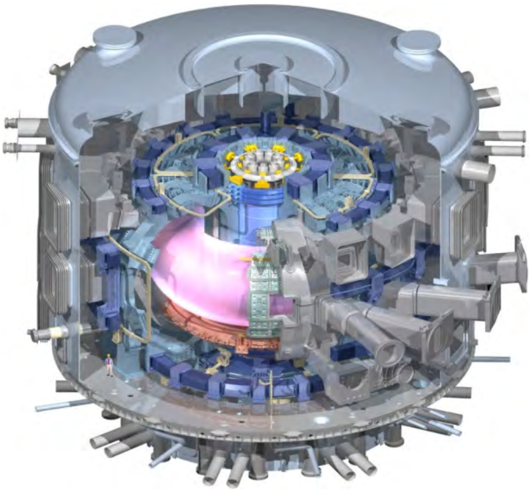
In today's world, there exist five main conventional sources of producing electricity commercially. Listed in a descending order according to their world shares in 1997, these are coal, hydropower, nuclear power, gas and oil.

Fusion power is another fast growing energy source that will take place in power engineering in future. Fusion power is the power generated by nuclear fusion processes. In fusion reactions, two light atomic nuclei fuse to form a heavier nucleus (in contrast with fission power). In doing so they release a comparatively large amount of energy arising from the binding energy due to the strong nuclear force which is manifested as an increase in temperature of the reactants. Fusion power is a primary area of research in plasma physics.

Nuclear fusion is one of the most promising options for generating large amounts of carbon-free energy in the future.

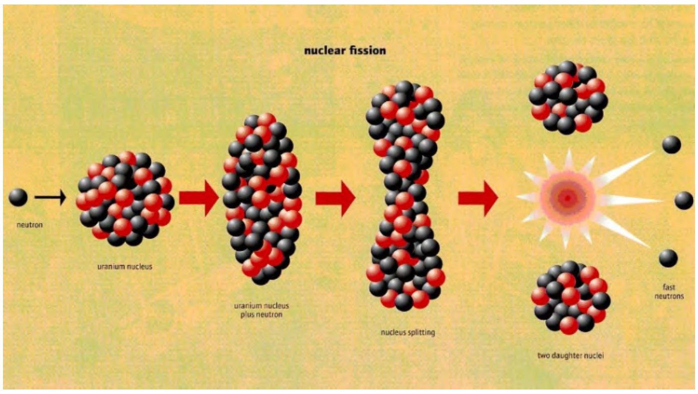
To achieve high enough fusion reaction rates to make fusion useful as an energy source, the fuel (two types of hydrogen – *deuterium* and *tritium*) must be heated to temperatures over 100 million degrees Celsius. At these temperatures the fuel becomes a *plasma*.

Magnetic confinement is the approach that Culham and many other laboratories are researching to provide energy from fusion. Plasma of light atomic nuclei is heated and confined in a circular bottle known as a *tokamak*, where it is controlled with strong magnetic fields.



Picture 1 – Tokamak

In a magnetic fusion device, the maximum fusion power is achieved using deuterium and tritium. These fuse to produce helium and high-speed neutrons, releasing 17.6MeV (megaelectron volts) of energy per reaction. This is approximately 10,000,000 times more energy than is released in a typical chemical reaction. A commercial fusion power station will use the energy carried by the neutrons to generate electricity. To get energy from fusion, gas from a combination of types of hydrogen – deuterium and tritium – is heated to very high temperatures (100 million degrees Celsius). One way to achieve these conditions is a method called ‘magnetic confinement' – controlling the hot gas (known as a plasma) with strong magnets. The most promising device for this is the ‘tokamak', a Russian word for a ring-shaped magnetic chamber.



Picture 2 – Nuclear fusion process

The world needs new, cleaner ways to supply our increasing energy demand, as concerns grow over climate change and declining supplies of fossil fuels. Power stations using fusion would have a number of advantages:

No carbon emissions. The only by-products of fusion reactions are small amounts of helium, which is an inert gas that will not add to atmospheric pollution.

Abundant fuels. Deuterium can be extracted from water and tritium is produced from lithium, which is found in the earth's crust. Fuel supplies will therefore last for millions of years.

Energy efficiency. One kilogram of fusion fuel can provide the same amount of energy as 10 million kilograms of fossil fuel.

No long-lived radioactive waste. Only plant components become radioactive and these will be safe to recycle or dispose of conventionally within 100 years.

Safety. The small amounts of fuel used in fusion devices (about the weight of a postage stamp at any one time) means that a large-scale nuclear accident is not possible.

Reliable power. Fusion power plants should provide a baseload supply of large amounts of electricity, at costs that are estimated to be broadly similar to other energy sources. Nowadays there is a prototype of a power plant using nuclear fusion power called ITER. This plant is being in the process of building and is based in France. ITER (originally an acronym of International Thermonuclear Experimental Reactor and Latin for "the way" or "the road") is an international nuclear fusion research and engineering project, which is currently building the world's largest experimental tokamak nuclear fusion reactor adjacent to the Cadarache facility in the south of France. The ITER project aims to make the long-awaited transition from experimental studies of plasma physics to full-scale electricity-producing fusion power plants.

The project is funded and run by seven member entities – the European Union, India, Japan, People's Republic of China, Russia, South Korea and the United States. The EU, as host party for the ITER complex, is contributing 45 percent of the cost, with the other six parties contributing 9 percent each. The ITER fusion reactor itself has been designed to produce 500 megawatts of output power. The machine is expected to demonstrate the principle of producing more energy from the fusion process than is used to initiate it, something that has not yet been achieved in any fusion reactor. Construction of the ITER facility began in 2007, but the project has run into many delays and budget overruns. The facility is now expected to finish its construction phase in 2019. It will start commissioning the reactor that same year and initiate plasma experiments in 2020, but isn't expected to begin full deuterium-tritium fusion until 2027. When ITER becomes operational, it will become the largest magnetic confinement plasma physics experiment in use, surpassing the Joint European Torus. The first commercial demonstration fusion power plant, named DEMO, is proposed to follow on from the ITER project.

New, environmentally sustainable forms of electricity will be required to meet the aspirations of a growing world population. By 2050, an expected rise in global population from six billion to nine billion and better living standards could lead to a two to threefold increase in energy consumption. No single technology will fulfil this demand. Each has strengths and weaknesses, and a mix of power sources will be needed to meet the challenges of energy security, sustainable development and environmental protection. Future energy supply options may comprise fossil fuels, nuclear fission, fusion, and renewables. At present, 80% of the developed world's energy comes from fossil fuels. Environmental problems – the greenhouse effect and the effects of acidic pollution – and diminishing fuel supplies mean that reliance on coal, gas and oil will have to be severely constrained. Nuclear fission will continue to make a major contribution to electricity. Fusion and alternative sources of energy offer a secure, long-term source of supply, with important advantages. These include: no production of greenhouse gases from the fusion process; no long-lived radioactive waste (all waste will be recyclable within 100 years); inherent safety features; and almost unlimited fuel supplies. On current estimates, the cost of fusion-generated electricity is predicted to be broadly comparable to that obtained from fission, renewables and fossil fuels. Fusion and alternative energy, therefore, could have a key role to play in the energy market of the future, with the potential to produce at least 70% of the world's electricity by 2100.

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PRACTICAL USE OF PIEZOELECTRIC EFFECT

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The piezoelectric effect converts mechanical strain into electric current or voltage. This strain can come from many different sources. Human motion, low-frequency seismic vibrations, and acoustic noise are everyday examples. Except in rare instances the piezoelectric effect operates in AC requiring time-varying inputs at mechanical resonance to be efficient.

The piezoelectric effect occurs in certain compounds when pressure is applied to them. The mechanisms behind how it works are still not fully understood, but this hasn’t stopped scientists from starting to explore ways to use it in our everyday lives. Although we don’t understand the entire process, this is what we do know. When particular arrangements of molecules are pressed together, the proximity of one atom to another changes enough that there is a change in the configuration of the valance electrons. When the pressure is released, the electrons return to their previous places. When piezoelectric compounds are fitted with an auxiliary circuit, these electrons can be captured and used to create a micro circuit.

Piezoelectricity from Dancing

One of the most intriguing applications of piezoelectric technology is championed by the company Sustainable Dance Club, whose Rotterdam nightclub Watt generates part of its power from the dance moves of its patrons. The dance floor is suspended on a series of springs and piezoelectric crystals, and as dancers move, the crystals compress, generating electricity.