Nuclear Power

Why Nuclear isn't an Energy Solution

Sheet E.5

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Governments around the world are reviving nuclear power – and the fact that they're promoting such an unpopular form of energy production should be an indicator of the seriousness of our current situation! Nuclear power does not address the energy depletion problem. The resource constraints mean that nuclear is only a limited, short-term fix, with a long-term toxic legacy.

Nuclear Power in Britain

From the late 1940s, Britain was at the forefront of civil nuclear power research. Britain's first nuclear power reactors, at Calder Hall and Chapelcross, opened in the late 1950s – part of a wider power station building programme that saw the development of the national grid during the 1950s and 1960s. In the 1960s more, larger reactors – the Magnox reactors – were built. Then in the 1970s a much larger design, the Advanced Gas-cooled Reactor (AGR) was built. At the same time Britain was experimenting with fast reactors in the north of Scotland and fusion reactors, and even thorium-fuelled reactors, in England.

Today many of these reactors are approaching the end of their operation lives, and will soon be shut. Britain has poured many billions of pounds into nuclear research, and now we're paying tens of billions of pounds to clean up and make safe the facilities that were built between the 1940s and the 1980s.

Nuclear Electricity

At its peak, in 1998, nuclear power produced just over a quarter of the UK's electricity (see right-side graph below). Today, as the older Magnox nuclear plants have begun to close, this has reduced to less than a fifth. Within five to ten years, as electricity demand is forecast to grow and the AGR reactors close, it will fall to less than 5%. The last nuclear reactor, the Pressurised Water Reactor (PWR) at Sizewell in Suffolk, is due to close by 2035.

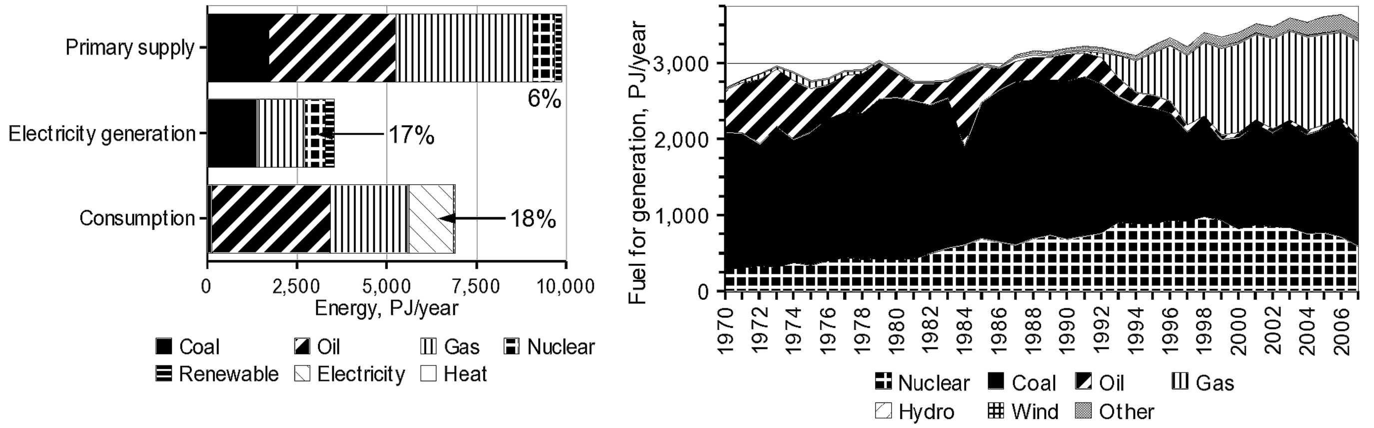
The graphs below show the relevance of nuclear power to the UK energy economy. The top bar graph shows the UK's *primary energy supply* – the total supply of fuels used in the UK in the year 2007. Nuclear power made up about 6% of all the fuel used in 2007. The next bar shows the fuels used for electricity generation in 2007. As shown in the lower graph, electricity generation is only 18% of the energy consumed in the UK. This means that although nuclear is only 6% of primary energy, it made up about 17% of the energy used to produce electricity. However, this doesn't take into account the losses in electricity generation – nuclear plants are only about 35% efficient and so two-thirds of this energy ended up in the sea in the water used to cool the plant.

In terms of our need for energy, oil, and especially gas, are far more significant than nuclear power – and these are the fuels which are going to be difficult to obtain in the near future. For a variety of technical reasons, not least that the energy efficiency of the UK economy overall would fall, it's very difficult to substitute the use of these fuels for nuclear energy. In practice nuclear provides such a small amount of energy that it would be far easier (and cheaper) to reduce consumption rather than expand our nuclear capacity. In fact, if we cut electricity consumption by 1.5% for 10 years, or we converted our large gas- and coal-fired plants into many smaller plants supplying heat and power locally (which would also reduce the carbon emissions per unit of energy) we could just switch off the nuclear power stations.

Nuclear Processes

There's nothing "special" about nuclear power stations. The heat that is usually provided by coal or gas – which boils the water to turn the turbines to make the electricity in the generators – is instead provided by nuclear reactions.

Nuclear Power in the UK Energy Economy



The problem with talking about the future of nuclear power is that you first have to be clear about what kind of process you are discussing: Globally, most of the 400+ nuclear power plants are *thermal reactors* – these use slow neutrons to split, or *fission*, atoms of uranium-235; The alternative process is *fast-fission*, or *fast reactors* – these are more complex since they use fast neutrons to turn uranium-238 into plutonium-239, which can then (after reprocessing of the “bred” material to make new reactor fuel) be split in the same way as uranium-235; The “grail” of the nuclear industry is *nuclear fusion* – this uses processes similar to those in the Sun to stick isotopes of hydrogen together, making helium and an excess of heat. Theoretically there are variations on the fission process, using other materials such as thorium, which all have their good and bad points but they are too complex to go into at length here.

The problem with the thermal fission process is that, by a quirk of nature, only 1 in 140 uranium atoms (the uranium-235) is usable. The other 139 atoms (the uranium-238) are not directly usable in thermal reactors. This means that, using the current thermal technology, only 1% of the world's uranium reserves are available to make energy. The rest ends up as depleted uranium – almost pure uranium-238 that's good for little else but making counterbalance weights for aircraft, ships keels, and armour-piercing armaments (it's cheaper than lead!).

In order to use the rest of the uranium resource we'd have to perfect fast reactors. The problems here are two-fold: Unlike thermal reactors, fast reactors don't contain a lot of water or graphite and so the core has a far higher 'energy density'. In abnormal circumstances they can overheat very quickly and so their operation, and removing heat from the core to prevent a meltdown, is more challenging than in the other reactors in use today. The other, and more significant, problem is the effect of fast neutrons on the fabric of the reactor itself. If you put high tensile steel in a dense flux of fast neutrons they act like sub-atomic bullets, damaging the structure of the steel at the atomic level. In a few years the steel become brittle, loses its strength, and after five to ten years it must be replaced.

Fusion has similar problems. We now understand the basics of the fusion reaction, and the JET reactor in Oxfordshire has achieved fusion. The problem we have is building a reactor vessel that can withstand the effects of neutron bombardment. One of the main functions of the new *International Thermonuclear Experimental Reactor* (ITER), being built in France, is to test materials to try and find something which does not fall apart under neutron bombardment. However, as stated by the director of the JET project in 2005, there is no certainty that the problems of building a fusion reactor vessel can be overcome, and certainly not within the next 40 to 50 years.

The Major Problem with Nuclear Power

We'll take the problem of accidents and waste disposal as read – *there's plenty of information out there already on these issues*. Instead let's concentrate on one specific aspect of nuclear power that's seldom discussed in public – *fuel resources*.

In his book, *The Revenge of Gaia*, James Lovelock says that nuclear power is the best carbon-free source of energy – primarily because in the UK rocks such as granite contain uranium. However, given the work that needs to be undertaken to extract enough usable uranium, it would take more energy to get the uranium to make nuclear fuel than the fuel would produce in the reactor. For this reason, although theoretically there are about 4 billion tonnes of accessible uranium, only 4 to 6 million tonnes is in a form that would produce an energy surplus if it were used.

At the moment the world uses around 65,000 tonnes of uranium each year. With global reserves of 4 million tonnes, that's about 62 years of fuel (assuming we could use it at a constant rate) – but in reality uranium production is likely to peak in one to three decades time. To make a realistic contribution to reducing carbon emissions we'd have to increase the current scale of nuclear energy globally from about 6% to between 30% and 40% of global energy supply. Increasing demand by a factor of five or six times reduces the lifetime of the resource five or six times, so we'd have just 12 years of uranium remaining (i.e., it's not going to happen!). Of course reactors could be made more efficient – high temperature reactors could increase efficiency and get another 50% from the reserves. But without fast reactors, thermal reactors will not be able to last longer than 30 to 60 years.

Those in the nuclear industry who talk of there being hundreds or even thousands of years of energy from nuclear power are being disingenuous: Their claims would be true if we could perfect fast reactors, but there is no guarantee of this, and so we can only assess the uranium reserve in terms of its use in thermal reactors. For this reason we can only talk of a few decades of energy, not a few centuries.

The Wrong Solution to the Wrong Problem

Nuclear power is a limited energy option because the research required to perfect the new materials and systems required to utilise the uranium resource more efficiently is itself highly resource intensive. Ultimately nuclear power is dependent upon the supply of conventional energy sources and the materials produced using oil and gas. As these other energy sources are going to peak soon the shortages would limit/curtail further nuclear research.

In our homes, nearly 90% of the energy we need is heat, not electricity (although that's might be how we may obtain that heat). Meeting most of our energy needs from nuclear power is not efficient or practical, and it would just accelerate the depletion of uranium. Also, nuclear only works in large-scale, centralised plants. For this reason it's the wrong solution as we need smaller, local and efficient facilities that provide both heat and power.