Nuclear Power

Why Nuclear isn't an Energy Solution

Sheet 5

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Governments around the world are reviving nuclear power – and the fact that they consider such an unpopular form of energy production to be viable should be an indicator of the seriousness of our current situation! But nuclear power does not address the energy depletion problem. The resource constraints mean that nuclear is only a short-term fix, with a long-term 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 are doing so again to pay 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 figure 1). Today, as the older Magnox nuclear plants have begun to close, this has reduced to around one 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 American designed *Pressurised Water Reactor* (PWR) at Sizewell in Suffolk, is due to close by 2035.

Only 17% of the energy consumed in the UK is consumed in the form of electricity, and nuclear-generated electricity represents 21% of electricity supply. So in terms of total energy consumption, nuclear power is only (17% x 21% =) 3.6% of the energy consumed in the UK. 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.

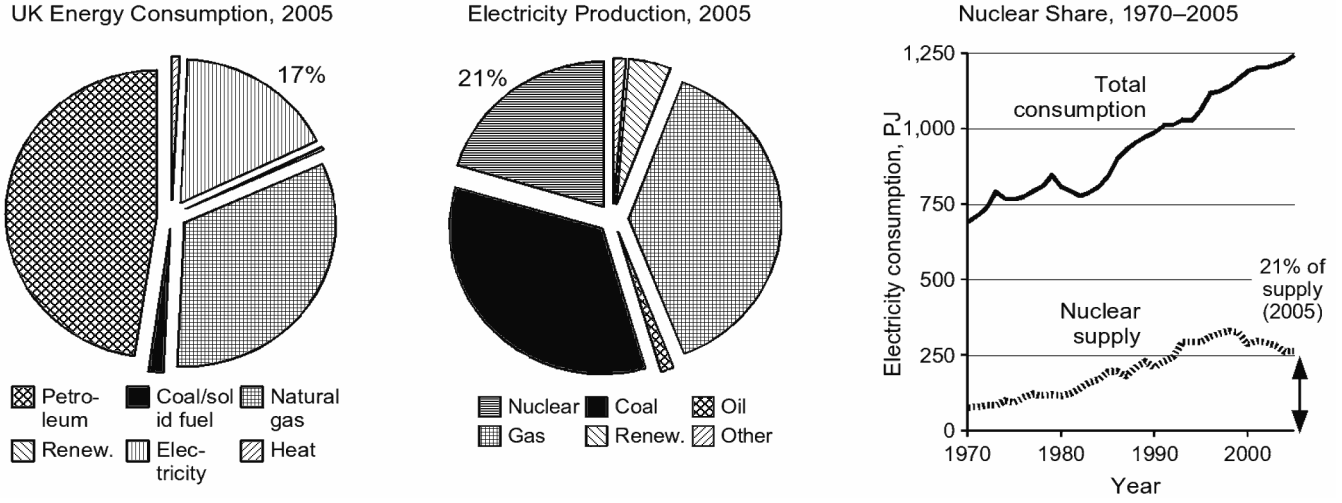
Nuclear Processes

There's nothing “special” about nuclear power stations. The source of heat that is usually provided by coal or gas, which boils the water to turn the turbines to make the electricity in generators, is instead provided by nuclear reactions. Also, like most coal-fired power stations, about two-thirds of the energy produced by the nuclear reactor is just thrown away into the environment as waste heat (mostly into the sea, as our nuclear plants use the sea for cooling).

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 other significant 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.

Fig. 1. Electricity and Nuclear Power in the UK, 2005 (source: *Digest of UK Energy Statistics*, 2006)



- The “grail” of the nuclear industry is *fusion* – this uses processes similar to those in the Sun to stick isotopes of hydrogen together, making inert 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) is 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.

In order to use the rest of the uranium resource we'd have to perfect *fast reactors*. The problems here are two-fold: Firstly, because these reactors don't contain a lot of water or graphite, the core has a far higher energy density – so in abnormal circumstances it can overheat very quickly making controlling them, and removing the heat from the core, far more of a challenge. 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 the neutrons act like little 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 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. The results of this work would also be welcomed by the fast fission scientists who are seeking the same type of material for their reactors. However, as has been made clear by the director of the JET project, there is no certainty that the problems of building a fusion reactor vessel can be overcome, and probably 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 was 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 it would produce in the reactor. For this reason, although theoretically there are about 4 billion tonnes of accessible uranium, only four to six 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). However, to make a realistic contribution to reducing carbon emissions we'd have to increase the current scale of nuclear energy globally – from about 6% of global energy supply 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!

Of course reactors could be made more efficient – e.g. high temperature reactors could increase operational efficiency and get another 50% from the reserves. But without fast reactors, thermal reactors (which can only use 1% of the total uranium resource) will not be able to last longer than 30 to 60 years.

The Wrong Solution to the Wrong Problem

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. However, 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. A year or so ago the then energy minister, Malcolm Wicks, talked about Britain's stock of uranium being an “indigenous resource” – we do have a lot of uranium, but it's nearly all depleted uranium, and so is completely useless in our thermal reactors.

Nuclear power is as limited an energy option as oil or natural gas – because uranium is a finite and depleting resource. We cannot have any guarantee that either fusion or fast reactors will be perfected over the next 40 or 50 years. The research required to perfect the new materials required is highly resource intensive, and is dependent upon the energy and materials produced by oil and gas – which are themselves running out (Peak Energy could curtail nuclear research).

Consequently we have to look at the energy we need, and what nuclear can provide. Nuclear provides electricity, and theoretically it could provide hydrogen, but both of these are *energy carriers* – there are practical thermodynamic and efficiency barriers to their use. In our homes, nearly 90% of the energy we need is heat, not electricity (although that's how we may obtain that heat). Consequently meeting most of our energy needs from nuclear power is not practical, and it would just accelerate the depletion of uranium. Eventually, perhaps within a decade or two of any global initiative to “go nuclear”, uranium production would itself peak, and ultimately we would face the same problems then as we have with oil and gas today.

This briefing was produced for the “UK Peak Energy Tour”, 2007 – see http://www.fraw.org.uk/ebo/ for information.