The Future is Nuclear

Energy crunch in 2015?

Whilst much of the new energy policy to come out of the Energy Act 2008 is now evident, the effects of these changes on energy investment are not yet apparent, because not all the pieces of the jigsaw are in place. Already, it is clear that the costs of change will be huge and the timescales of change will be long. However, I do not think that we will run out of electricity in the next decade, making the lights going out.

It is clear that the conditions are in place for a squeeze on electricity capacity margins. This will come to a head in 2015. The capacity margin crunch will result from the almost simultaneous shutting down of half of coal stations in response to EU sulphur emissions laws and the closure of the last Magnox and some of the AGR (advanced gas-cooled reactors) nuclear power stations on grounds of age. Neither new renewable generators nor new nuclear will be built in sufficient quantities and time to fill the expected capacity gap.

However, the Government has a range of options to stop the energy gap from occurring. They can:

- Encourage the operator of the AGRs British Energy (owned by EdF) to extend the operating life of the reactors perhaps accepting some operating power limitations – so that the AGRs continue to operate until new capacity is deployed towards the end of the decade:
- Or, seek year-by-year delay from the EU in the legislation-driven coal plant shut-downs:
- Or, allow utilities to build new gas fired conventional generators. Gas fired generators are relatively cheap and quick to construct. There are several projects waiting in the wings ready to be funded if the conditions are right.

The problem with these actions is that they do not take the country in the policy directions set out in the Energy Act. They neither begin to address the issue of climate change nor will they improve UK energy security.

Investing in clean energy

Currently, the key debate in energy is about funding the huge investment required. Ofgem estimates that we need to spend up to £200bn on gas and electricity generation and infrastructure in the next ten years. That investment would take the UK less than half the way along its low-carbon transition path to 80% reduction of carbon emission (and an implied 90% cut in carbon intensity of electricity generation) by 2050.

Finish EPR - Olkiluoto

Investing in clean electricity generation has high capital costs, whether the investment is in wind, nuclear or carbon capture and storage. All these are capital intensive technologies and each has in compensation relatively low operating costs, though CCS operating costs are likely to be higher than the others. For all these generation technologies capital costs per MWe are between four and eight times that of a gas turbine power generator.

In addition to the business risk associated with high capital costs, there is the question of the volume of funding required at a time when access to all types of credit is limited. Current public perceptions of the credit crunch focus on the debt problems of governments. Funds are also short for the private sector, particularly those investments with a long pay-back timescale. The electricity market, in its current form, poses too much risk for such large blocks of investment. Utilities are faced with investing in technologies that pay-back in 20 or more years, but sell electricity in a market where prices are very short term – perhaps priced in periods as short as half an hour. Further market uncertainty is created by the continual modification of subsidy regimes by Government and the frequent alteration of carbon pricing rules by the EU.

Ofgem, the energy regulator, has recognised the energy funding problem and is considering and consulting on a range of complex and radical changes to the electricity market. These include trading for both obligations and capacity, and perhaps the central allocation or the auctioning of new capacity with a specific view technology mix. Until these ideas crystallise and they are considered by the new Government, probably in early 2011, little acceleration in the pace of electricity investment can be expected.

Gen III Reactors
Reactors designed in 1980s incorporating the early learning from large scale nuclear construction & operation – which provide the backbone of the high reliability base load nuclear generation in most developed countries ~200 Gen III reactors built & operating world-wide.

Gen III+ Reactors
Evolutionary developments of Gen III with longer life vessels, longer cycle fuel, improved resistance to major external hazards including earthquake, aircraft accident and terrorist attacks – designed in 20th century and represent the state of the art, starting to be constructed around the world. Designs include those being licensed for the UK:

- AREVA NP – EPR
- Westinghouse AP1000.

Energy R&D

During the next 20 years, the aim for the UK will be to build light water reactors such as the Gen III+ reactors being licensed by the NII: Areva – EPR; Westinghouse - AP1000, which are similar those Gen III reactors operating in large numbers around the world. After a difficult and lengthy period of development, light water reactors are preferred around in many countries because they are a known quantity and they offer high availability and hence predictable revenues and low running cost.

The priority for the UK must be to build sufficient new nuclear power stations to provide the base load supply of low-carbon energy, complementing a substantial renewable sector. We should be aware that strong growth in demand for electricity is inevitable, because of a strategic switch of fuel source from coal and gas, to clean sources of electricity – wind, nuclear and CCS (carbon capture and storage). Therefore, it is quite likely that the demand for clean power could be two or three times the level implicit in the current plans of the utilities.

The strategic change in energy demand means that we should start again to fund energy R&D, including nuclear.

As someone who has spent much of his career designing, building and supporting nuclear reactors, the idea that any of the GIF (Generation IV International Forum) reactors could be built to generate power on a commercial basis by 2020 is over-optimistic. Rather than 2020, it would be hard to argue that any date prior to 2030 would be realistic for a large commercial Gen IV reactor.

Russian Fast Reactor - BN350

The leading Gen IV reactors are fast neutron systems. Though there is substantial experience of sodium cooled fast reactors based on the demonstration plants in the UK, France, Russia and Japan, technical difficulties remain and no new prototype fast reactor is planned in Europe.

The US has stood aside from fast reactors because of their association with reprocessing and hence in their view, with nuclear proliferation. In Europe, the most recent studies have been of a gas-cooled fast reactor and now the EU is funding an R&D programme with a small lead-cooled fast reactor in Belgium called MYRRHA and perhaps a small gas cooled fast reactor – ALLEGRO.

Though the Gen IV reactor programme includes most types of future reactor technology, the journey to the construction of these designs will be long and may take a more circuitous route.

A further barrier is that the current UK civil nuclear R&D budget can be counted (in millions of pounds) on the fingers of just two hands.

Gen IV Reactors

Completely new type of reactor systems concepts based on international collaboration with specific characteristics aimed at replacing or going beyond the capabilities of Gen III in 20 or more years time. Systems selected for further study:

- **Gas-Cooled Fast Reactor (GFR)** - features a fast-neutron-spectrum, helium-cooled reactor and closed fuel cycle;
- **Very-High-Temperature Reactor (VHTR**) - a graphite-moderated, helium-cooled reactor with a once-through uranium fuel cycle, providing high thermal efficiency & the potential for process heat applications, including the direct generation of hydrogen;
- **Supercritical-Water-Cooled Reactor (SCWR)** - a high-temperature, high-pressure water-cooled reactor that operates above the thermodynamic critical point of water;
- **Sodium-Cooled Fast Reactor (SFR)** - features a fast-spectrum, sodium-cooled reactor and closed fuel cycle for efficient management of actinides and conversion of fertile uranium;
- **Lead-Cooled Fast Reactor (LFR)** - features a fast-spectrum lead of lead/bismuth eutectic liquid-metal-cooled reactor with a closed fuel cycle for efficient conversion of fertile uranium and effective management of actinides;
- **Molten Salt Reactor (MSR)** - produces fission power in a circulating molten salt fuel mixture with an epithermal-spectrum reactor and a full actinide recycle fuel cycle.

In the near term, nuclear R&D investment is more likely to be worthwhile in developing light water reactors than in Gen IV reactors. Such systems are worth studying for the longer term and the specific advantages of these novel systems. Because of the scale of investment required for each Gen IV system is so large these developments will be progressed through international collaborative programmes.

If the nuclear generating renaissance happening now in the UK, as seems likely follows widely in other countries, pressure on the finite supplies of uranium may rise. One immediate priority for R&D investment should be developing and deploying advanced nuclear fuels, based on breeding new fissile material from either uranium and thorium, and which can be employed to extend the operation of existing types of light water reactors.

More broadly, I believe that there are three priorities for UK energy strategy:

- Seeking an electricity market that values and supports investment in high capital but low carbon technologies, of whatever type:
- Using the UK's position of both developing its rich off-shore renewable resources and its the lead in a world-wide renaissance of nuclear power, to build a competitive manufacturing capacity both for our own programme and for export.
- Restarting investment in civil nuclear R&D because of its potential both to deliver low-carbon energy, and to create wealth and jobs for the UK in the long term.

Tony Roulstone **2 June 2010**

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Published in **IET Members News** in June 2010 - on energy supply, IET member **Tony Roulstone** argues that the Energy Act of 2008 together with the related Climate Change Act represent a sea change for energy strategy.