nuclear issues

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Now it is official

Recent *Nuclear Issues* have warned of possible electricity shortages within the next ten years before new nuclear plant can be expected to come into operation. Our fears on this have now been confirmed or even exceeded by Ofgem - although the Energy and Climate Change Secretary Ed Miliband, with his head firmly in the sand, can still declare that "The Government is confident that Britain will meet its security of supply needs in the years ahead."

In their report of February 3rd - *Project Discovery: Options for delivering secure and sustainable energy supplies* - Ofgem summarises its concerns - "the decline in our indigenous gas supplies and the need to make demanding cuts in carbon emission levels represent unprecedented challenges, which will grow over the next two decades. Large parts of our ageing energy infrastructure will need replacement and, at the same time, we must make rapid progress towards the substantial decarbonisation of our economy. We estimate that up to £200 billion of investment might be required by 2020 alone, in the face of huge global demand for investment in energy infrastructure; volatile commodities prices; and the ongoing effects of the financial crisis."

An earlier account of their fears was given to the parliamentary Select Committee on Energy and Climate Change on 2nd December 2009. Even if only some of the things that could go wrong do go wrong the probability of extensive power cuts over a period of years now seems inevitable. The consequences would spell disaster for the British economy and social life.

In addition to the plant being closed down under the EU Large Combustion Plant Directive further coal-fired plant closures can be expected under another directive, the Industrial Emission Directive which will limit discharges of nitrogen and sulphur oxides. Power companies have already indicated that the economic case makes it unlikely that they will fit the selective catalytic reduction technology required and will shut the plants down. These coal plant closures can only effectively be replaced by new nuclear and gas fired plants. Yet according to the evidence presented by Ofgem to the select committee there are serious doubts over both the timeliness of new nuclear plant and the future supply of gas.

Nuclear power

On nuclear power Ofgem asserts that we have left it too late. The problems are twofold; the need for and availability of the capital required to build the plants; and the delays in construction which is allowing other countries now ordering nuclear plant to take up most of the limited industrial resources required to build the new plant.

The chief executive of Ofgem Alistair Buchanan told the Committee that unlike five or six years ago, the major power companies now face serious capital constraints. Their balance sheets are full and they have announced substantial capital restrictions. EDF is now considering selling off some network companies in the UK. E.ON has put a freeze on developing three of their coal power stations, Drakelow, High Marnham and Kingsnorth. Iberdrola which owns Scottish Power, has also been capital-constrained this year and has had to go for rights issues and extra debt issuance. Buchanan observed that with a typical nuclear power station costing perhaps £5 to £6 billion huge investments are required and he hinted that these multinational companies can choose where best to place their limited capital.

The prospects for a timely construction of the new nuclear stations are also uncertain. Ofgem pointed out that eighteen months ago Britain was nicely positioned in the leadership of the new nuclear age. Now, Italy has joined the nuclear race, Hungary, Poland, and possibly Germany will also go for new nuclear plant, while China wants to build 24.5 gigawatts of nuclear in short order. But there are also many others as the rest of the world turns to nuclear power. The oil-rich countries of the Middle East are planning new nuclear plants with the lead taken by the United Arab Emirates which has already ordered four new stations. South Korea, India and other Asian countries will also be building new stations. To meet this growing pressure for nuclear build there are very few companies with the skills to do it and the capability to supply key components is very limited.

To the question from the Committee " Where will we be in the queue?" Ofgem responded - "It is not like the halcyon days of six or seven years ago when the companies, if you look at E.ON or RWE, were net cash companies; now their balance sheets are full, so what are they going to do and how does Britain rank in their priorities going forward?" They went on to answer themselves by posing a further question: "markets respond by giving a price, so, if the pricing signal is right, the investment will come to Britain and the issue will be: is the pricing signal correct?" This final question to the Committee remained unanswered, but at times of high demand for scarce resources of capital and equipment the pricing signal will be high and one that will be determined by the electricity companies in the interest of their shareholders, which may not be the same as that of the UK. Already in their *Project Discovery* Ofgem indicated in certain extreme scenarios prices could rise by 60% which in a remarkable understatement would be "particularly uncomfortable for the vulnerable".

A more optimistic account is given by the Government Office for Nuclear Development (OND) which foresees a first nuclear station beginning to supply power in the spring

of 2018. This is on the assumption that the first licensing and construction consents are given by mid 2011 with first concrete pouring on site by early 2013. These dates are supported by a report in *World Nuclear News* that EDF Energy are to submit a planning application for two units at Hinkley Point C early in August this year to the new Independent Planning Commission and expect approval by mid 2011. In anticipation EDF are to begin site preparation before the end of this year with construction starting early in 2012 - this is in accord with the timechart set out by the OND. The first plant could start operation in 2017, the second about 18 months later. EDF then plans to submit a further application in 2011 for a station at Sizewell. Horizon Nuclear Power - the name of the partnership between RWE and E.ON - also plans new stations at Wylfa and Oldbury.

This programme however is critically dependent on the implementation of the supply chain with the placing of contracts for key components. This is entirely in the hands of the power companies, and is a matter on which Ofgem expressed concern.

Gas

The uncertainties over the availability and price of future gas supplies are also a cause for alarm. Gas is required mainly for domestic and industrial heating as well as for power generation. According to Ofgem the main import to Europe and hence on to the UK will be by pipeline from Russia and Turkmenistan, and also as Liquefied Natural Gas.

The supply of gas from Russia depends on the timely replacement of its current gas output with the development in the next ten years of three super-giant gasfields in western Siberia to make up the loss of about 200 bcm of present output of around 600 bcm. The original date for this of 2013 has now been delayed to 2015, or even as Ofgem suggested 2016. It will also depend on the construction of new pipelines. North Stream (due for completion in 2011) would go under the Baltic direct to Germany; South Stream to the Balkans. According to Ofgem, of the 200 bcm that in 2020 are expected to come from Russia to Europe (60% of European consumption) 50 bcm should come from Turkmenistan. But given the expected output of gas in Turkmenistan in 2020 and the supply commitments it has already made to China and Iran the amount of gas available to come to Europe through the Nabucco pipeline may be no more than 6 bcm.

There are also serious uncertainties about the Nabucco pipeline itself, which is planned to go from Turkmenistan across the Caspian, through Turkey and then up into the Balkans. This route is fraught with political difficulties. Will Turkey demand 15% of the throughput? There could also be problems with other transit countries such as Azerbaijan. Vitally it will have to pass the Caspian where Iran and Russia, citing a 1920s pact between them, say that the Caspian is theirs and no other country's. As Ofgem graphically put it "Here we were ten years ago a self-sufficient island, with gas coming from the North Sea, and now we are having to start to worry about the relationship between Turkey, Azerbaijan, Armenia and Russia and a pact from the 1920s on the Caspian. Really, to me, this is just a perfect illustration of how the energy outlook for us has gone from this very protected market status to this incredible interface, both geopolitical and economic."

The UK only obtains Russian gas indirectly through the pipeline connections with Europe and is then dependent on the conditions operating in the European gas market where they play by different rules. Ofgem complained, somewhat petulantly, over the iniquity of long-term contracts which most European countries (wisely) use to ensure security of supply whereas the UK believes in the working of the market. As Ofgem put it "gas follows the cash, which is what it should do." But in the event of severe supply shortages arising it seems that almost all supplies into mainland Europe will be tied up under long-term contracts leaving little to come to the UK under spot market trading at peak prices.

Ofgem did not mention the Langeled pipeline connection with Norway with a capacity of 20 bcm/year. But Norway also delivers gas to Germany, Belgium and France. Langeled recently suffered a disruption in supply which in January left the UK short of gas.

These problems would increase dependence on LNG. But LNG is expensive. The recent exploitation in America of gas from shale has also dramatically changed the US gas market from a need to import up to 30% of gas demand as LNG to near self-sufficiency. It is also possible that shale gas may be found in Europe. But there are doubts over the life of the shale gas which may be exhausted in a matter of less than ten years. If there is a short-term glut Ofgem foresees a problem if we fail to build now the expensive LNG terminal facilities that could be required in ten years time. There are also reports that China and India expect large increases in their imports of LNG. A pipeline ties supplier and recipient together. An LNG cargo can go to the highest bidder.

Another problem is the lack of gas storage in the UK. But an example from Holland shows that the construction of a large storage facility can take up to seven years. It is also the case that such storage can be seen as a national responsibility to create a strategic reserve.

What next?

In its final *Project Discovery* report of 3rd Feb *"Options for delivering secure and sustainable energy supplies"* Ofgem summarises the problems which it had previously put to the Energy and Climate Change Committee and makes its recommendations.

A key issue is the uncertainty over gas supplies and the growing dependence on imports. With the progressive closure of coal stations under the EU directives and a decline in nuclear output from the ageing AGR stations we will become critically dependent on gas for up to three quarters of electricity output. Wind power only adds to the problem in so far as gas-fired stations will be required to cover for the intermittency of wind. There is then the risk that the electricity generating companies may be reluctant to invest in new plant with concerns that these plants could become 'stranded assets' when the new nuclear plants eventually come into operation. As Ofgem puts it "the system would experience a reduced level of security of supply in the 2016-2020 period before new CCS/nuclear

plant comes on stream. This period could be extended if the large capital investment required for new nuclear plant and/or investment in CCS are also seen as too risky." This could lead to some short term interventions to boost security of supply such as expensive contingency contracts with generating units that might otherwise be closing; investment in short lead-time peaking plant (such as Open Cycle Gas Turbines (OCGTs)); or avoidable demand reduction.

There are however two alternatives which Ofgem fails to consider. The first is to obtain a limited exemption from the EU plant closures and keep some coal-fired plant in operation until the new nuclear plants come on line around 2020. There are reports that this possibility is now being urged by some of the UK electricity companies. The second is to import electricity from other European countries. In addition to the cable connection with France, the BritNed cable with a 1000 MWe capacity is now under construction and should be in operation by the beginning of 2011 - at a reported cost of €600 million. A connection to Norway has also been considered in the past but for some reason has not been carried to fruition. A link to Sweden should also be explored. A connection to Iceland via the Shetlands is perhaps more remote possibility.

A general concern is that the present energy market conditions are not adequate. In particular it has failed to bring forward the 'lumpy' high capital cost projects including nuclear plant and wind, preferring to invest in lower cost gas-fired plant. To deal with this problem Ofgem puts forward five policy packages ranging from a minimal Targeted Reforms to the more draconian Central Energy Buyer. But even this last proposal depends on making the right key decisions. While a central buyer (nationalisation?) could accelerate the construction of new nuclear plants there is the probability that it would put greater emphasis on meeting the (unworkable) 30% target for renewables by 2020 and the (illusory) carbon capture and sequestration development, both favoured by the present DECC

Ofgem also, by criticising the uncertainty of carbon pricing under the EU ETS scheme, which it says makes investment decisions more difficult and is likely to delay or deter investment in low carbon technology, seems to make the case for a fixed carbon tax. This would be a sensible step.

The depressing conclusion must be that uncertainties will remain over the future UK energy supply and in particular over the security of electricity from 2015 to after 2020 when the new nuclear stations could begin to make a substantial contribution. Ever- higher energy and electricity prices are inevitable. The complacency of the Department of Energy and Climate Change faced with this threat to society and the economy is difficult to understand.

Waste back to Japan

A first shipment of radioactive waste back to Japan received a little publicity on the BBC in January. This is part of the contracts with the then British Nuclear Fuels plc (BNFL) to reprocess Japanese used nuclear fuel and extract fission product waste and plutonium and unused uranium. It is similar to contracts that the Japanese have with the French but in their case the waste and plutonium enriched recycle fuel have been being shipped back for many years.

What the BBC film failed to note was that they were only showing the fission product waste being sent back. This is very radioactive and needs to be handled with great care but it decays relatively quickly and in one or two hundred years it is no more radioactive then the uranium that was dug out of the ground in the first place.

The film showed the store adjoining a vitrification plant where the waste is solidified and incorporated in glass blocks in stainless steel containers about the size of milk churns. These are stored in a modest sized building which is approximately a 30 metre cube. This, as the film said, contains about 95% of the UK's nuclear waste. It did not mention that this represents more than sixty years of military and civil nuclear development. The glass blocks will certainly be perfectly safe for a couple of hundred years and there is no real rush to bury them underground.

It is the products of plutonium, and to a lesser extent unused uranium-238, that cause some people more concern, though even today they are only about eight times as radioactive than the uranium. These valuable products are going to be recycled by the Japanese and should also be recycled in the UK if only we get on with it. If the plutonium is put back in a reactor it is completely safe from any terrorist and it finishes up in used fuel which only occupies one eighth of the space of the fuel that was reprocessed. Much larger reductions of the quantities of uranium-238 and plutonium can be achieved if we re-invent the fast reactor which operated so smoothly at Dounreay for many years.

BNFL, unfortunately, blotted their copy book with the Japanese in their quality control while trying to make plutonium into recycle fuel and the only batch they have made was returned. The French, on the other hand, have shipped recycle fuel back to Japan as well as radioactive waste. Now, of course, the Japanese can make their own plutonium fuel. The BBC did not deal with the question of plutonium perhaps because of the embarrassment of the British but it really is time for us to start doing something with it because we have nearly 100 tonnes in its most dangerous separated form.

Using all the uranium

Only 0.7% of the uranium that is dug out of the ground is the isotope with an atomic weight of 235. The majority is U-238. For the present generation of light water cooled reactor one enriches the U-235 up to 5%. This uranium undergoes fission easily with bombardment with neutrons at thermal energy. But the U-238 also contributes to energy production. Some of it is converted to plutonium which also undergoes fission easily by thermal neutrons. It is not often realized that this becomes an increasingly important contribution to the energy as it builds up in a reactor. Typically as much as 25% of the total energy produced in a light water reactor comes from the fission of the plutonium before the build up of fission product makes it desirable to put new fuel in.

It is possible reprocess used fuel and extract enough plutonium to "enrich" new fuel. It takes the plutonium produced in about eight used fuel elements to make one new fuel element containing a mixture of uranium and plutonium (mixed oxide or MOX fuel). In this way we get about 25% more energy from the uranium that we dug out of the

ground. Ten or more years ago the cost of reprocessing and manufacture of MOX fuel was not particularly attractive compared with simply enriching some more uranium. But all that has now changed and the economics of using MOX fuel is now looking quite good. This is what the French have found and they are making good money doing it in many of their reactors. The Japanese are also starting to use MOX but the rest of the world is dithering.

Opponents of the peaceful use of nuclear energy have invented an emotive phrase: the "plutonium economy". They argue that there is a proliferation risk associated with the commercial use of plutonium. This is absolute rubbish. It is much better to recycle plutonium back in a reactor where intense radiation makes it effectively inaccessible and where it can be productively destroyed by fission. The alternatives are to simply store the material or try to dispose of it by some means other than fission.

Much more of the uranium-238 can be productively utilized by putting it into a fast reactor. The technology of doing this has been demonstrated around the world but only Russia is at present using it in a small way. There are various developments of so called "new generation" reactors which can also burn up uranium-238 but they are going to take years and lots of money to develop. So why not use the perfectly acceptable fast reactor in the meantime.

Actual and estimated

Some confusion was caused by last month's figures is our item on *what did not happen at Chernobyl.* This is because official bodies insist on presenting estimates of deaths. These are usually based on linear extrapolations from the experiences of Japanese bomb survivors some sixty years ago. The point that we were making is that actual observations around Chernobyl have not shown anything and in some cases the death rates of leukaemia and solid cancers have been less than expected in the general public. There are lots of possible explanations for this but we think that somebody should at least be looking at the possibility of a radiation threshold or even a hormesis effect (a little radiation is good for you).

When you produce an extrapolation down to low levels the statisticians place an error band on the points of their plot. These still include the possibility of a linear extrapolation down to zero but within the same error band it is possible to plot a curve with a threshold at around 300 mSv. We have asked the author of one study why the linear option was chosen and she said because that it is what we believe. But she had not looked at the possibility of a slightly better fit to the actual points plotted of a threshold curve. It is argued that the linear plot gives a conservative estimation of the effects of low level radiation but we are having to pay a lot of money to meet those standards. Now that we have so many figures from Chernobyl we should be able to do a little bit better.

Iodine

There remains the question of thyroid cancers among people who drank milk produced in the region around Chernobyl. These have appeared in the localities most severely contaminated after the accident and seem definitely to have been caused by the fallout.

Iodine-131, which is a product of the fission of uranium, is concentrated by cattle grazing an area of land and then further concentrated in the thyroid gland of the consumer of milk. One may recall after the fire in a plutonium production reactor at Windscale in 1957 we saw pictures of milk being poured down the drain. It is a short term problem because the iodine-131 has a half life of only eight days and decays to insignificant levels in a month or two. An alternative to throwing milk away would be to turn it into butter or cheese and introduce time for the iodine to decay before the products are consumed. An additional action is the distribution of potassium iodide tablets which saturate the thyroid gland with non active iodine but this must be done quickly after an accident. In the town of Pripyat close to the Chernobyl plant potassium iodide was distributed but in the wider region they never really got round to it.

Unfortunately the response at the time of Chernobyl was lamentable. Professor Leonid Ilyin, the eminent radiobiologist and chief of the Russian Academy of Medical Science, who was at Chernobyl in the days after the explosion when the graphite core was still burning, describes later in a book the dreadful bureaucracy of official bodies. He even wrote a special letter to President Gorbochev to try to expedite the control of milk distribution. But it was only on May 27, 1986, that effective restrictions on milk distribution in the area were finally introduced. This was a month after the reactor exploded and was not far short of the time that they should have been considering the lifting of any restrictions on milk as the iodine decayed to low levels. The text in Ilyin's chapter on this subject has several inserts of (?!!) as the author questions the lack of action from this or that official commission.

So it is not exactly surprising that thyroid cancers started to appear. It is reported that about 4000 cases of thyroid cancer, mainly in children, have resulted from Chernobyl contamination. It is also said that at least nine children have died from thyroid cancer (though not specified whether due to Chernobyl or not). However the survival rate has been almost 99%. There was some questioning of incidence of the cancers appearing in the first two years after the event. Experience from Japanese bomb survivors suggested that it would be five to ten years before the thyroid cancers developed. This has cast some doubt on the naturally occurring levels. They that had not been well recorded in the area before and there is some indication that it was more widespread than had been expected. Nobody, however, seems unduly concerned about these questions. The cancers, while distressing, are easily treatable so why worry? !!

Correction

We are sorry that a 'not' found its way into last paragraph of last month's article on *What happened at Chernobyl*. It completely reversed what we were saying. It should have read: "The situation would have been made worse by a considerable build up of xenon ..."

The build up of xenon in the core of any reactor when it is shut down or operated at reduced power is a familiar problem for all reactor physicists. Xenon absorbs neutrons and therefore is said to poison the nuclear fission reaction. The xenon should be allowed to decay before the reactor is restarted.