Nuclear Energy post Fukushima

Malcolm Grimston considers the hidden lessons

Surely we have been here before? In 1979 the world was in a recession caused by high oil prices; nuclear investment, though costs had stabilised since the early 1970s, was looking more expensive than had been expected a decade earlier; a sophisticated anti-nuclear movement had developed, and had for example been instrumental in ensuring that the Zwentendorf plant in Austria was refused an operating licence although it had been completed. Then came the accident at Three Mile Island in Pennsylvania, followed in 1986 by Chernobyl (Ukraine). Costs of nuclear investment shot through the roof as plants had to be redesigned (in many cases after construction had already begun), public and political sentiment changed decisively, leading to an Italian referendum to shut down their nuclear plants immediately (or at least by 1990), a phase-out policy in Germany, a whole range of other countries such as Switzerland placing moratoria on new build or barriers to entering the nuclear club. Liberalisation of power markets created further challenges for heavily capital-intensive sources of power like nuclear.

So why should it be different this time? Well, it might not be, of course. But there are key differences, both in the external environment and in the realms of nuclear technology and public perceptions.

Key Differences in the Environments of 1979 and 2011

Striking as the similarities may seem, there are key differences between the situation post-TMI and Chernobyl and the position post-Fukushima which suggest that the response may not be as damaging for nuclear construction.

First, TMI and Chernobyl happened at times of over overcapacity in electricity supply systems of many countries, caused by over-ordering in the early 1970s and the subsequent effect of the global recession. By contrast, the early years of this decade are a time of impending capacity shortages, not least in the UK, as the first cycle of liberalisation (which largely involves sweating existing assets rather than new investment) comes to an end. In developing countries, notably in the Asia-Pacific region, electricity demand is burgeoning (Figure 1).

So there is a need to invest in large amounts of new generating capacity of some description. The more of the new plant that is fossil fuel-fired, the more the world is locked into greenhouse gas emissions for some decades, depending on the lifetime of the plant in question. For baseload power, given the current state of technology, the intermittency of many renewables is a significant barrier, while carbon capture and storage has not been demonstrated on a very large scale (the first UK pilot, at Longannet, unlikely to be operational before 2015). In effect then, the choice for new baseload capacity is nuclear, coal or gas. The geopolitics of gas, for example the interruption of Russian supplies to Ukraine in 2005, and the carbon emissions associated with LNG look more challenging than they did in the 1990s, though the prospects for shale gas may change these perceptions considerably.

Secondly, TMI occurred at a time when many plants were already under construction. Backfitting design changes is a more expensive business in such circumstances, because of both inherently higher costs and the effects of keeping committed capital tied up without an income stream for several years (or indeed for ever in the case of Shoreham in New York State, which was never granted an operating licence as an acceptable evacuation plan could not be agreed with local regulators). If a major nuclear renaissance is under way today it is still in its infancy, with only 65 plants under construction globally at the end of 2010; any necessary post-Fukushima redesign should be relatively cheap.

Third, of course, is the growing influence of climate change on the debate, if not as yet on policy in any serious way. Despite decades of calls for greater energy efficiency and more renewables, the goal record on carbon dioxide emissions since the Kyoto base year of 1990 has been woeful, 2010 seeing the greatest increase on record.

Learning from Mistakes

There are important differences concerning the technology as well.

Most notably, both Three Mile Island and Chernobyl occurred because of

Figure 1: China Electricity Demand (TWh)

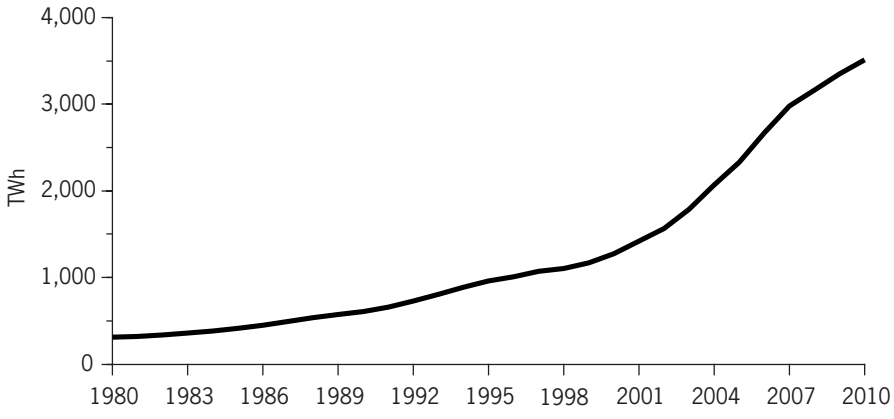
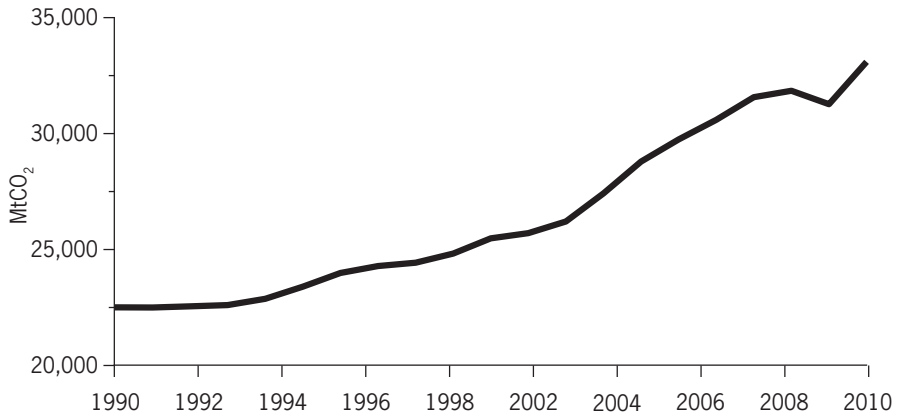


Figure 2: Global Carbon Dioxide Emissions from Oil, Coal and Gas, $MtCO_2$



problems with the plant, not because of outside challenges. Both occurred in reactors that were only a year or two old. In the case of TMI, it was a Pressurised Water Reactor, the dominant nuclear technology then and indeed now. As a result, TMI in particular was enormously relevant to the nuclear plants under construction or planned at the time. (Chernobyl was a design – RBMK – unique to the former Soviet Union which had been rejected in a several countries, including the UK, owing to safety concerns around the possibility that it could 'runaway with itself', which is what happened in 1986.) Fukushima, by contrast happened in technology that had been developed in the 1960s at the very start of the large-scale deployment of nuclear power (the first ever commercial-scale reactor only opened in 1956, at Calder Hall in the UK). One of the most remarkable features of the accident in Japan was how all 14 reactors in the earthquake/tsunami zone withstood the earthquake and the 10 newest ones (plus Fukushima unit 4, which has been defuelled) were in cold shutdown within a week of the tsunami.

Nonetheless, one result of the lessons learned from Three Mile Island involved a reappraisal of the level of dependence on engineered safety systems. The 'multiple redundancy' principle, whereby several back-up systems are provided to ensure availability of a safety function, has been generally very effective in ensuring plant safety in a range of anomalous operating conditions. But, the plant can still be severely compromised under certain conditions. First, albeit highly unlikely, is the independent and coincidental failure of all back-up systems. Secondly, much more difficult to assess, is the possibility that the safety systems might interact with each other in an unpredictable way. Third, as was seen at Fukushima, a severe external stress which caused simultaneous failure of all back-up systems, in that case generators to keep the cooling water pumps operating and remove waste heat from the reactor cores after they had tripped, could leave the plant in severe trouble.

Probabilistic Risk Assessment, leading to statements like 'major core degradation every 10 million reactor years', has proved reasonably accurate in other industries with regard to the first of these three risks. But there have been five major core degradations (TMI, Chernobyl and Fukushima Daiichi units 1–3) in 12,000 reactor years, suggesting that the calculations are seriously deficient when it comes to the real world.

The response was to develop passive approaches to safety in an emergency situation. The Westinghouse AP1000, for example, has a large reservoir of water situated at the top of the primary containment, connected to the containment by pipework and pressure valves. Should all power be lost to cooling circuits, pressure will build up in the containment, causing the valves to blow and water to fall under gravity into the containment. No power is required, giving an estimated 72 hours to get emergency water or power to the core. Fukushima may give a further push towards such 'Generation III+' approaches to safety, notably in China, the only major market where plants of Generation II technology (albeit a very modern version, the CPR, with many advanced safety features) are being built

The Response to a Major Accident

The immediate and longer-term local response to a nuclear accident is perhaps a field in which the lessons from TMI and Chernobyl have not been learned so effectively.

There was practically no release of radioactivity at Three Mile Island. At Chernobyl there was a huge release, coupled with mistakes made by the authorities which led to a fatal delay in distributing iodine tablets to the most affected populations. As a result there were some 6000 cases of thyroid cancer (and perhaps 15 fatalities). Apart from this, the credible (peer-reviewed) literature suggests that it is extremely difficult to find radiological health detriments among anyone not on site during the accident or in the clean-up operation, though there is widespread stress-related illness. (Similarly, the *Report of the President's Commission on the Accident at Three Mile Island* stated, 'We conclude that the most serious health effect of the accident was severe mental stress, which was short lived.') However, the health records of residents in the Chernobyl area before the accident were poor to non-existent, inevitably reducing confidence in the findings. On average, lifetimes of those in the regions affected by fallout may be reduced by a few minutes but this will not be detectable against natural variations in mortality. But even if some of the apparently more fanciful claims are closer to the truth, the health effects pale compared to those of other forms of environmental pollution, let alone climate change.

Fukushima will give much better data and hence allow more comprehensive analysis. It may also offer an opportunity to put the risks into perspective.

Though it is too early to be sure, it is likely that the risk of living in a city like Tokyo, with its air pollution, is higher than that of living in at least the southern reaches of the evacuation zone. (The World Health Organisation estimates some 2.5 million early deaths per year because of airborne pollution in cities.) If so, it would ironically be a stronger argument purely on health grounds to move the citizens of Tokyo into the evacuation zone than vice versa.

"In effect then, the choice for new baseload capacity is nuclear, coal or gas"

This leads to some interesting speculation about the financial costs of the accident. Does it make sense to introduce evacuation measures with very heavy financial costs and no net health benefits, and if so to whom should those costs accrue? As Richard Wilson points out in the *Bulletin of Atomic Scientists*, 6 July 2011 (generally regarded as sceptical in nuclear matters), before 1980 the US Nuclear Regulatory Commission asked for an 'Emergency Planning Zone' with a 10-mile diameter around each nuclear power plant, but after the Three Mile Island accident these areas became 'evacuation zones' without much discussion. There should be an important distinction drawn between compulsory evacuation and voluntary evacuation. Faced with a nuclear accident, some people will want to leave voluntarily, and government can play a valuable facilitating role for example in creating one-way streets and banning parking on exit routes. But compulsory evacuation is much more difficult to justify, as is ongoing prevention of people from returning to their homes if they so choose to do. 'The high-speed train from Tokyo to northern Japan was discontinued for three months to avoid exposing passengers to minuscule doses of radiation. Those who travelled by air instead got a similar dose from the increased cosmic radiation at higher altitudes!'

Wilson goes on to argue that the proposed contamination levels above which citizens would be prevented indefinitely from returning to the area, at 10–20 mSv per year, would be irrationally low and entirely counterproductive, citing World Health Organisation figures reporting a 5 percent increase in cancer rates for anyone dislocated for any reason. '[The whole furore] contrasts with more than 15,000 dead bodies and nearly 8,000 people still missing after the earthquake and tsunami.'

The Changing Debate

Another striking feature of the Fukushima accident has been the wide range of public and political responses in different countries. A major Gallup poll held when the accident was at its height (involving 34,000 respondents from late March to April 11) showed a majority of those polled still supported nuclear new build, although the net positive figure had fallen from +27 percentage points to +6. However, even leaving out Japan itself, there was a huge difference between the major antinuclear swing in countries like Germany and Italy and the relatively phlegmatic response in South Korea, China (which remained heavily pro-nuclear) and the USA. In the UK a *Times* poll in early July showed support for replacement build falling from 52 to 47 percent in the UK (opposition growing from 24 to 28 percent), representing support at similar levels to what it had been in 2007. The calm and measured response from the UK coalition government contrasted with the sheer political panic displayed for example in Germany. That an event of this nature should have so little effect on public perceptions suggests that the British public, at least, has quite a sophisticated, considered and even settled view on nuclear power, though of course the longer-term trends will need to be monitored to check this hypothesis.

The media coverage in the UK was interesting. In the past the opportunity would perhaps have been grasped to seek out the most extreme views (pro or anti nuclear power), no matter how little credibility they might command among serious scientific commentators, in order to maximise the theatre and the controversy. This time the 'pantomime dames' from either side of the debate hardly made an appearance. A range of mainstream views (including those of credible nuclear sceptics and supporters of course, plus the growing ranks of committed environmentalists who now support nuclear power) was sought and the coverage was responsible and sober. In particular, those whose extreme views have added shamefully to fears of radiation and thence to stress and mental health problems seem to have been found out and bypassed.

Three phases can be identified in the historical relationship between the nuclear industry (insofar as the term makes any sense in these days of large companies with cross-national and cross-technology portfolios) and the public. During the first wave of nuclear investment, industry in general, and nuclear proponents in particular, were largely trusted and respected by public and politicians alike (just as people broadly trusted their governments). The nuclear industry was given pretty much free rein, including enormous state investment and a large say in setting public policy as well as executing it. The industry became rather arrogant, secretive and perhaps even deliberately dishonest, although in the author's experience (from the late 1980s onward) there were many people of the highest personal integrity at the top of the industry.

Then people started to notice that industrialists, and scientists working for them, sometimes told untruths, more often were wrong, more often still were secretive and most of all were prone to exaggeration and wishful thinking. A growing Green movement in particular captured a growing sense of public disillusionment, and public sentiment moved close to rejecting the very idea that science and technology have a unique contribution to make to human wellbeing. It took (the) industry quite a time to realise this was happening.

The beleaguered nuclear industry has slowly and imperfectly begun to mend

its ways and become more open, honest and humble, though its previous attitude has understandably made this difficult for some people to believe (and in some countries, notably Japan, it is not clear whether the process has really started at all). At the same time the Greens, as free from serious challenge as the nuclear industry had been in its early days, similarly started to treat people of opposing views with contempt and sometimes personal abuse and to believe in their own supposed (and fictional) moral superiority and infallibility. Bit by bit people started to realise that Greens too are sometimes untruthful, more often wrong, frequently secretive and have a pronounced tendency to wishful thinking and exaggeration. Greens talking passionately about the need for renewables while pocketing large subsidies for manufacturing solar panels can no longer expect an easy ride.

The public (and the media) may now be moving into a healthy Marxist synthesis of challenge and scepticism towards industry and Greens alike. Science and technology are increasingly recognised as having a unique contribution to make to decision-making and public happiness, but not to be trusted to set their own technocratic agenda to the exclusion of democratic and ethical values. There is no longer a need for the untrustworthy wing of the Greens, but every need for robust and credible challenge to all viewpoints, something which the broadcast media seem to have sensed and to be acting upon.

If so, the prospect for good science-based policy to get us out of the two-pronged resource and climate crisis may be brighter than perhaps seemed to be the case before Fukushima. Whether that is enough to get us through is a different question, but to be able to have the debate unhampered by the theological and inflexible extremes from either side of the nuclear debate must be a good start.