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Use It or Lose It

A business case for an alternative way to rejuvenate the UK nuclear industry

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New nuclear power in the UK – what is happening?

In less than ten years, a third of the UK's generating capacity is due to close down, either as a result of EU Directives or simply old age. In particular, our nuclear capacity will drop from providing 18 per cent of our electricity to having just one nuclear plant left at Sizewell by 2023. If the government is to meet legally-enforceable EU carbon targets, then replacing our nuclear power stations is essential; nuclear is the only source of reliable, large-scale, low-carbon electricity. Completing 16GW of new-build nuclear is pivotal to the government's energy policy to meet carbon targets and to keep the lights on. Additionally, the government believes it is revitalising the UK's nuclear industry. This is unlikely to happen within the present policy paradigm.

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Three foreign companies are positioned to take on the task of re-building the UK's nuclear capacity. French state-owned EDF is leading the field, with planning permission granted in March 2013 for two 1630MWe EPRs (European pressurised-water reactors) at Hinkley Point C, in Somerset. The estimated cost has risen to £16bn. After nearly two years of protracted negotiations with the Coalition government, EDF has agreed a 'Strike Price', the new pricing mechanism that will guarantee a price per MW/h for what the French are hoping will be an index-linked 35-year contract. There has been some controversy over the promised £92.50 per MW/h; twice the price of today's wholesale electricity. However, not a penny is due until the new plant starts generating, which, if previous experience of EDF's EPR reactors is any indication, is not likely before 2024 at the earliest. Meanwhile, consumers will have to pay £120 for solar and £155 per MW/h for offshore wind from as early as April 2014.

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EDF's final investment decision rests on the outcome of an ongoing EU investigation to determine whether this 'subsidy' complies with state aid rules. A particular concern for Brussels is the combination of price guarantees and credit protection provided by the UK government, which they find to be potentially inappropriate, disproportionate and in breach of EU law.[1] This will inevitably delay construction of Hinkley C but EDF is not necessarily in a hurry. Half of their UK nuclear plant has recently been extended to 2023, including Hinkley Point B. Further extensions are being considered, subject to strict safety compliance, to maximise return on these assets before their retirement. Meanwhile, most of EDF's 58 operational nuclear plants on French soil are coming to the end of their useful lives and, while some may also secure licence extensions, France will have to decide either to invest in renewables or replace approximately 42 plant over the next 20-25 years. Already heavily indebted, EDF is going to experience considerable difficulties in supplying its own domestic market, hence its perseverance to extract inflated rates and guarantees from the UK consumer. Since Centrica, a 20 per cent equity partner, pulled out of Hinkley C, the project is also dependent on securing 30-40 per cent from other investors. Two Chinese state-owned companies have been encouraged by the Chancellor, George Osborne, with promises of majority shares in future projects and an option to bring Chinese nuclear reactors to the UK.

UK nuclear industry is now entirely vulnerable to the political agendas of other countries.

The second set of new-build development sites are owned by Hitachi, which plans to build up to three 1300MWe Advanced Boiling Water Reactors at Wylfa and Oldbury. Hitachi bought out the formerly German-owned Horizon project when a political decision by Chancellor Angela Merkel to curtail nuclear power in Germany left the partners RWE and EON no financial alternative but to withdraw. Hitachi's decision to invest came at a time when the fallout from the Fukushima disaster left their own domestic market devastated by the Japanese government closing down all of their nuclear plant. However, the financial impact of having to import gas is costing Japan's industrial base dearly. Political pressure has seen a new regime restart a few of the reactors, albeit under more robust standards.

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Transition cone for the steam generator of a Japanese PWR reactor (Sheffield Forgemasters International)

The third UK project, Nu-Gen, a Spanish/French partnership, was recently struggling to progress their Sellafield site due to financial difficulties, partly attributed to the Spanish government's sweeping set of retrospective changes to renewable subsidies and utilities' revenues, adding to Iberdrola's financial difficulties. In early 2014, Toshiba plans to buy out Iberdrola's 50 per cent and 10 per cent of GDF Suez's equity for a total of £102m with the intention of building three of their own Westinghouse AP1000 reactors by 2024.

Thus the UK nuclear industry is now entirely vulnerable to the political agendas of other countries. Only government-owned utilities have the capacity to fund these massive projects which will each take about ten years to build. Significantly, these global utilities already have their own established supply chains. When Secretary of State for Energy Ed Davey announced the EDF deal on 21 October 2013, he claimed that UK businesses would reap 57 per cent of the £16bn project. This was swiftly denied the next day by EDF's Chairman, Henri Proglio. Ken Owen, Commercial Director for EDF at Hinkley, was unequivocal in stating 'most of the available contracts could be beyond UK suppliers which are struggling to meet the complex safety and quality standards of the nuclear industry'. To dismiss the UK nuclear industry on such grounds is disingenuous. He is perhaps unaware that the UK nuclear industry has a total commercial turnover estimated at approximately £4 billion.[2] Our safety record is second to none. Numerous UK businesses have been supplying the international nuclear market for decades across the whole lifecycle of nuclear from fuel enrichment, design, civil engineering, construction, systems, security, operation and maintenance, decommissioning and waste management. Millions of pounds have been allocated by the Technology Strategy Board for nuclear innovation and the National Nuclear Laboratory is leading an exciting new era of R&D.

Nuclear is a global industry. For technical development, continually improving safety standards and strategies to reduce costs, international collaboration on nuclear power is essential. Nonetheless, it makes economic sense to capitalise on our sixty years of nuclear expertise and experience for our own domestic market. If Hinkley C is the first of several new reactor sites to be developed over the next decade, then it is vital that the UK's supply chain can fully participate from the outset of the UK's nuclear new-build programme. Yet, with EDF planning to use their own supply chain, UK input of any significant value could be in doubt.[3] The 40 per cent equity to be held by two Communist state-owned corporations adds another complexity. The Chinese have great ambitions to use the gold standard credentials of the UK nuclear industry to launch their 'go global' export policy, a policy being pursued at a high level politically utilising China's economic influence.[4] China has become largely self-sufficient in reactor design and construction, as well as other aspects of the fuel cycle, but is making full use of western technology while adapting and improving it and retaining the IP. In return for their investment at Hinkley C, Peter Atherton of city firm Liberium Capital has calculated that the French and Chinese state-owned firms will earn 'between £65bn and £80bn in dividends from British consumers over the project's lifetime'.[5]

At time of writing, not one EPR anywhere is actually built and generating electricity. They are capital-intensive, high-risk projects in today's economic climate. There is an alternative: SMRs or small modular reactors.

Where opportunities for the UK supply chain exist, there may be long time-lapses between the three disparate projects. Such uncertainty is not conducive to investment in the human and physical resources essential to sustain a robust supply chain. Without an additional, more accessible market, the UK's supply chain may not be able to participate fully in the nuclear renaissance and risks being left behind; a scenario that the government, which has woken up to the value of an advanced manufacturing sector, is surely keen to avoid.

A UK-based alternative solution

Building reactors in excess of 1600MW, such as EDF's EPRs, is proving eye-wateringly expensive. The Flamanville plant is four years behind schedule with costs soaring to €8bn. Olkiluoto 3 in Finland is five years late and over double the original budget. At time of writing, not one EPR anywhere is actually built and generating electricity. The feasibility of such capital-intensive, high-risk projects in today's economic climate has to be questioned.

There is an alternative: SMRs or small modular reactors. SMRs are defined by the IAEA as reactors less than 300MW,[6] although in practice a range of reactors around 45MWe to 225MWe are being designed by several countries that are keen to have access to secure, baseload, low carbon energy without the prohibitive upfront capital costs and uncertain timescales that plague the larger nuclear plant. Most SMRs come under one of four categories: light water reactors (LWR), fast reactors, high-temperature gas-cooled reactors and molten-salt reactors. Focus is on advancing the LWR designs; moderated and cooled by ordinary water they have the lowest technological risk, particularly due to their similarities to conventional operating plant today. They mostly use fuel enriched to less than five per cent uranium-235 with an average four-year refuelling cycle, and of all SMRs probably face the least regulatory hurdles.[7] These SMRs offer considerable advantages:

- *Financing:* The onerous upfront capital costs of building large nuclear plants are exacerbated by long lead-in times to completion and achieving revenue. Smaller units are built more rapidly, typically in three rather than eight to ten years. Where units are built in a modular programme, either as part of a predetermined set configuration or on an as-required basis, each completed unit generates positive cash flow for subsequent construction.

- *Manufactured off-site:* SMRs can be fabricated, fuelled and sealed in the factory then delivered by road, rail or ship to the site ready for full operational status, thus the construction costs and risks associated with larger reactors are considerably reduced.

- *Non-proliferation:* Many of the designs being considered operate on fuel with a <5 per cent enrichment, satisfying international concerns over proliferation.

- *Safety:* SMRs are smaller, intrinsically safe, with simpler components. Many are small enough to be installed underground for added safety.

Significantly, passive mechanisms to initiate remote shut-down procedures, potentially without either AC or DC input, have been incorporated.

- *Refuelling and decommissioning:* Depending on design, an SMR would only need refuelling every two to seven years. Decommissioning can also proceed on a modular timetable, easing the financial burden.

- *Markets:* For the domestic market: a set of SMRs would be highly beneficial to the National Grid in balancing supply against intermittent renewables. Other applications include process steam/ power for industry and district CHP. For export markets SMRs are ideal for countries without the robust infrastructure required for large reactors. SMRs' capacity to provide remote, distributed power allows for onshore military use, or at oil and gas facilities.

- *Replace fossil fuel:* SMRs could be a low-carbon replacement for retiring coal plant, to take up a proportion of the 38-40 per cent of base load electricity currently provided by coal, which renewables will be unable to achieve.

- *UK supply chain:* Few countries have the capacity to produce the huge steel forgings required by large reactors, a market dominated by Japan with contributions from Russia, China and France. However, the UK could supply the necessary forgings for SMRs and already has the capacity to supply around 70 per cent of other nuclear components;[8] this opportunity increases with SMRs. A unique opportunity exists to secure demand for the UK's advanced manufacturing skills.

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Forging for nuclear reactor pressure vessels (Sheffield Forgemasters International)

Costs

Capital costs estimates for SMRs are in early stage development with little information yet in the public domain. As more data becomes available a number of issues should be taken into account when analysing costs for SMRs. Nuclear power plants are capital intensive, so the cost of capital is crucial. China's nuclear corporations are building 40 per cent of the world's new nuclear plant owing to their access to state-subsidised finance capital. Conventional nuclear plants gain from economies of scale; to what extent can the loss of economies of scale be offset against the economies of mass production of modular reactors? Additionally, although based on known technology, a commercially operating SMR has yet to be built. What are the cost implications of a FOAK (first of a kind), undetermined learning rates and ongoing NOAK (nth of a kind, in other words subsequent modules built with 'lessons learnt' and design costs incorporated)?

In 2011 a study team at the University of Chicago determined estimates based on a hypothetical SMR plant of six 100MWe modules.[9] The overnight capital cost for the first custom-built plant is considerably higher than NOAK SMRs, which would benefit from the learning process and dedicated manufacturing processes. A range between $7,000 and $11,500/kW is estimated for the FOAK units, dropping to $4,700/kW for NOAKs. This converts to £2.8m/MW and compares with the US Department of Energy's estimate of just over £3m/MW.[10] Babcock & Wilcox indicated that the overnight costs for their 'mPower' technology is in the region of £3.2m/MW.[11]

In analysing costs, it is important to make comparison with other similar-sized low-carbon technologies. Initial calculations suggest that CAPEX costs are comparable with offshore wind. Significantly, the load factor for offshore wind is around 30 per cent and the equipment would need replacing after 20 years, compared with 92 per cent for a nuclear plant with a life expectancy of 60 years.

Competition & Challenges

The United States has already seen the potential for SMRs to generate cost-effective low-carbon energy while boosting US manufacturing capabilities and creating and sustaining jobs. A comprehensive programme supporting SMRs through to commercialisation is being implemented by the US Department of Energy. In January 2012 the DOE announced a competition to incentivise the first commercial SMR, offering $452m over five years on a 50 per cent match-funding basis for successful projects. In April 2013 the first $79m was awarded to Babcock & Wilcox for their mPower 180MWe design as part of a $226m deal over a five-year programme. The US Government provided the site at Clinch River free of charge. A second round of closely fought funding was won by Nu-Scale, a 45MW reactor, potentially to be built in sets of

The Babcock & Wilcox mPower twin 180 MWe reactors, installed underground

Developer/Product	Development Cost	Time to Market	Cost as per cent of Market Cap (Sep 2011)	Cost as per cent of Annual Revenues (2010)
Boeing – 787 Dreamliner	$15bn	7 years	31%	23%
EADS – A380	$24bn	7 years	80%	29%
Merck – New Pharmaceutical	£0.5bn	7.5 years	0.5%	1.00%
Pfizer – New Pharmaceutical	$0.5bn	7.5 years	0.33%	0.7%
Illustrative SMR Vendor (100MW)	$1bn	10 years	30%	37%

Source: Adapted from Rosner & Goldberg – see ref 12

12 units, sponsored by the Fluor Corporation, beating Westinghouse and Holtec. These awards support the expensive process of engineering, design certification and licensing. Significant work is simultaneously being undertaken and funded by the US nuclear agencies to work with industry to resolve some of the SMR licensing issues.[12]

The US acknowledges that not having built nuclear plant for some time, there has been 'erosion of US nuclear manufacturing capacity and the need for strong government assistance, such as manufacturing tax credits and loan guarantees, specifically for manufacturers'.[13] Market coordination can only be achieved by 'subsidising mutually-supporting investments'.[14] The important role of government support for this enabling technology is relative to the relationship of development cost to company size.[15] Comparisons can be drawn between the extensive development and schedule costs and exacting regulatory approval processes of a new nuclear reactor design and new commercial aircraft and new pharmaceuticals. As Rosner and Goldberg explain: 'unlike SMR developers, the commercial aircraft and pharmaceutical industries are concentrated in a few large players with large balance sheets that can facilitate private funding for the design and licensing efforts'. Rosner and Goldberg's table below shows that the total development cost of the Boeing 787 was about $15bn, comprising 31 per cent of Boeing's market capitalisation (as at 30 September 2011) and about 23 per cent of 2010 revenues. The development costs for a new pharmaceutical are about half the estimated development costs of a new SMR technology and represent a small fraction of the financial resources of a large pharmaceutical company. Time to market for SMRs is one-third longer than that of either new commercial aircraft or pharmaceuticals, representing a much longer period before the initiation of revenue generation.

A comprehensive programme supporting SMRs through to commercialisation is being implemented by the US Department of Energy.

In trying to rejuvenate a domestic nuclear industry, the UK is in a similar situation to the US. The rewards are high in terms of a full panoply of jobs across design, manufacturing, construction, services and R&D activities, coupled with economic growth, but it is recognised

A CGI of a typical site setting proposed by Babcock & Wilcox for their mPower SMR power stations

that the market alone will not open up this opportunity due to unsustainably cheap shale gas and international government-owned corporations with access to cheap finance capital.

Old industry, new models

With the current policy paradigm steering the UK towards being a host nation for nuclear, an analogy may be drawn with the UK's automotive industry. The UK lacks a high-volume home-grown car manufacturer. However, the past few decades have seen impressive growth funded by foreign investment. Nissan's Sunderland-based car factory is the highest producing outlet in Europe. In 2012, overall UK production was a record 1.58m cars; 1.2m of them were exported. However, the UK is a net importer with a trade deficit of approximately £10bn.[16] But the biggest crisis facing the industry is, according to the former President of General Motors Europe, the lack of a domestic supply chain.[17] Only one third of parts are sourced in the UK. Nick Reilly explains that the situation adds to shipping costs and creates currency risks, affecting competitiveness and putting the long-term future of the industry in danger. The government and automotive sector acknowledge that this is a lost £3bn opportunity and have been working together to address this. However, the biggest game changer is that by 2040 almost none of Europe's new cars will be powered solely by a traditional petrol or diesel engine. The new joint strategy[18] outlines the necessity to expand the supply chain and recognises that this is a once-in-a-lifetime technology change that offers the UK an opportunity to gain a foothold in R&D, breaking into the new electric/hybrid car market, creating tomorrow's vehicles, increasing its market share and creating new supply chain companies. Without a high-level supply chain, the industry risks slipping into low-level assembly, which is unlikely to be a long-term cost-effective activity for car manufacturers, and thus leaving the industry vulnerable to relocation to countries with cheaper labour and lower energy costs.

The rewards are a full panoply of jobs across design, manufacturing, construction, services and R&D activities, coupled with economic growth

Conclusion

With so much generating power retiring in the next decade, and carbon targets to meet, there is a sense of urgency to replace it. However, outsourcing nuclear power projects that the UK will be committed to for the next 60 years must be handled carefully if our indigenous industry is not to be diminished. Short-term myopia on complying with carbon targets could obscure the vision to sustain the long-term economic well-being of a key industry. International investment is welcome, if in collaboration with UK businesses. The government has two options; let the UK become merely a host nation whence other nations can springboard their global nuclear ambitions and lose our own nuclear capability; or choose to let the start of a new-build programme of nuclear power reignite the UK's nuclear supply chain, expand our fuel cycle facilities and showcase our world-class R&D capability. Supporting a programme to bring smaller, affordable, secure, small modular reactors to UK-based commercialisation could do just that.

Notes

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