The financial crisis and nuclear power

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Introduction

Since the decline following nuclear power's golden era of the mid-70s, there have been frequent predictions of an imminent nuclear revival, but all have so far come to nothing. The latest revival, widely known as the 'Nuclear Renaissance' and dating from 2002-03, is being pursued with greater determination than its predecessors and has much stronger governmental backing than earlier revivals. Because of their status as nuclear pioneers and because of the poor fortunes of nuclear power in these countries in the past 30 years, two markets, the USA and the UK are seen as particularly important indicators of whether this nuclear revival will really re-start ordering in countries that seemed to have turned their back on nuclear power.

But after five years, the absence of any new orders in these 'bellwether' markets and the unresolved issues, for example on finance have led to increasing doubts, even before the extent of the impact on the world economy of the financial crisis is apparent, as to whether the renaissance will again be still-born. While the financial crisis will not be good for most large scale projects, will it be it be particularly damaging for the prospects of a Nuclear Renaissance?

1. Finance

The most obvious place to start is at the heart of the financial crisis itself, the banking system, in particular the ability of electric utilities to borrow the money needed to build nuclear plants. It is clear that one of the legacies of the financial crisis will be that banks will be more risk-averse and will also be more careful in their procedures for assessing risk.

A nuclear power station is the most capital-intensive way to generate electricity and, based on its past record, the most economically risky. So it is clear that unless ways can be found to insulate the banks from this risk, the impact on the prospects for the 'Nuclear Renaissance' will be very severe. There are three main ways that banks can be protected, at least in part, from this risk: by electricity consumers, by government credit guarantees, i.e., tax-payers and by vendors through fixed price contracts.

1.1 Electricity consumers

Deregulation and investment risk

In the past, while electricity was still a regulated monopoly, obtaining cheap finance to build nuclear power plants was made easier by the fact that consumers effectively guaranteed the loans. If costs escalated, performance was worse than expected, alternatives proved cheaper or electricity demand had been over-estimated, the plant owners simply increased electricity prices to recover the additional costs they had incurred. When this assurance broke down, either because competition had been introduced to electricity or, as in the USA in the late 1970s, because regulators were no longer prepared to make consumers pay for the errors of electric utilities, finance for new plants became unobtainable. In the USA, when regulators began to disallow part of the cost of imprudent investments, in other words, utilities were made to pay for the cost of imprudent investments from their profits, ordering ground to a halt and many existing orders were cancelled.

Some have suggested that new nuclear units would be most likely to be built in US states where the electricity industry is still regulated under cost-of-service procedures.

But this still assumes that future regulators will be willing to pass on whatever costs the utility incurs. In some states, it might be reasonable to assume that there will be regulatory continuity and that current support for new nuclear plants will continue. However, in Florida, a state where regulators are seen to be sympathetic to nuclear power, the Public Service Commission gave approval in October 2008 for Progress Energy (planning to build two new nuclear units at its Levy County site) to begin recovering costs for its new planned plants even before they began construction. It was given permission to recover about US$200m in 2009.[1] However, Greg Giordano, chief legislative assistant to Senator Mike Fasano, announced in January 2009 that he planned to introduce a bill that would undo a provision in state law that permits utilities to recover costs associated with new nuclear capacity while it is being planned and built. The planned legislation would require that utilities refund to customers any money they already have collected from customers for early nuclear cost recovery. So even in states with apparently strong regulatory support for new nuclear units, the utility may still not be able to rely on recovering all the costs it incurs.

The risk of failure of utilities building and operating nuclear plants

The poor record of nuclear plants being built to time and cost and the mixed record on reliability has always made nuclear a risky option, but now the risks are falling directly on to the utility building the plant. If, as a result, the utility failed, financiers would not be repaid. This has been proved to be more than a theoretical. In 2002, the privatised British nuclear generating company, British Energy, collapsed because its costs were higher than the wholesale electricity price it had to sell its power at. In this case, the British government chose to rescue the company using tax-payers' money and banks did not lose, but this will not always happen.[2]

The Olkiluoto project in Finland (see Box), the only Generation III+ design on which substantial construction work has been completed, is acknowledged to be 50% over budget and three years late after only three years of construction. The owners, TVO, expect to be covered for the cost escalation by a 'turnkey' construction contract with the Franco-German company, Areva NP, although whether this contract will stick is now far from clear[3]. But most of the costs of late completion - buying the replacement power from a potentially tight Nordic wholesale electricity market - will fall on the owners.

Little new generation has been built since the Nordic market was created in the late 1990s and already, dry winters, which reduce the availability of hydro-power have led to short-term large increases (up to 6-fold) in the wholesale electricity price. So for the period 2009-12, when Olkiluoto should have been producing 12TWh per year, the owners will have to buy that power from the wholesale market, assuming that amount of power is available. The economic studies on which Olkiluoto were based assumed the generation cost would be €24/MWh. If the Nord Pool price was three times that, far from unusual in recent years, the extra cost of purchasing this power from the market, over three years would be in the order €2bn.

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[1] Platts Global Power Report, 2009 'Florida lawmaker to introduce legislation undoing early utility nuclear cost recovery', January 15, 2009, p 30.

[2] Stephen Thomas, Peter Bradford, Antony Froggatt & David Milborrow *The economics of nuclear power*, (Amsterdam, Greenpeace International, 2007).

[3] Nucleonics Week 'Target date for operating Olkiluoto-3 again delayed, this time until 2012' October 23, 2008

However, these costs are not just extra costs that will either have to come out of profits or be passed on to consumers. TVO is owned by its customers, energy intensive industries such as paper and chemicals industries for which electricity purchase is likely to be one, if not the largest of their input costs. So passing these extra costs on to consumers has serious repercussions for the viability of these companies. While the owners of TVO would not want to cause TVO's failure, their first priority must be to ensure that the cost of the power they buy is not so high as to make their products uncompetitive. It is not hard to imagine a utility with less financial and contractual back-up than TVO collapsing under the strain of the cost and time overruns suffered at Olkiluoto. If cost escalation at the site continues, perhaps even TVO will collapse, with long-lived impact on the financing of nuclear projects.

The turnkey contract is now in dispute and seems likely to be settled acrimoniously. In December 2008, Areva announced it had initiated a second arbitration against TVO to recover €1bn in compensation for the delays, which it attributes to failings on the part of TVO, in particular slowness in processing technical documentation.[4] TVO countered in January 2009 by demanding €2.4bn in compensation from Areva NP for delays in the project.[5] These cases are likely to take several years to settle and will hang over both TVO and Areva NP until they are settled.

1.2 Government guarantees

Even before the financial crisis, the risk premium involved in nuclear projects discussed above was a severe barrier to new orders. At the top of the utilities' and vendors' wish lists for government support were credit guarantees. These shift the risk of utility failure from the vendor to tax-payers. One of the factors that made the Olkiluoto order financeable was export credit guarantees from the French and Swedish government. This made loans at only 2.6% interest rate possible. At the time, these export credit guarantees, usually utilised for exports to economically unstable developing countries, were surprising and looked extensive but in comparison with what US utilities are asking for, they now seem small, with inadequate coverage.

The US program

In February 2002, the Bush announced a program aimed at re-starting nuclear ordering in the USA. The rationale was that the new nuclear designs, so-called Generation III+, would be economically competitive but that initial financial and regulatory hurdles would prevent them being ordered. The policy to overcome these barriers was therefore to streamline regulatory processes, ensure regulatory approval for a number of new designs and provide subsidies for units at up to three sites (perhaps up to six units). The objective was:[6]

> 'to complete the first-of-a-kind Generation III+ reactor technology development and to demonstrate the untested Federal regulatory and licensing processes for the siting, construction, and operation of new nuclear plants.'

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[4] Nucleonics Week, 2008 'Olkiluoto costs weigh on Areva 2008 profits; TVO rejects blame' December 25, 2008, p 9

[5] Taloussanomat, 2009 'Finland/France: TVO demanding compensation from Areva' January 29, 2009.

[6] United States Department of Energy *A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010* (Washington, USDOE, 2001)

The program was unrealistically optimistic on time-scales and was based on an assumption that a new nuclear unit could be on-line by 2010. Loan guarantees were offered so that utilities could borrow at government Treasury bond rates. When the program was launched, the estimated construction cost of a nuclear unit was about US$2bn and to provide guarantees to cover 80% of the debt, if debt made up half the finance cost, would have required guarantees worth about US$3bn. The number of units expected to be built under the program, their cost and the coverage of loan guarantees escalated rapidly. In 2003, the Congressional Research Service estimated that the taxpayer liability for loan guarantees covering up to 50 percent of the cost of building six to eight new reactors would be US$14-16 billion.[7] The Congressional Budget Office concluded that the risk of loan default by industry would be 'well above 50 percent.'[8]

The Department of Energy estimates that loan guarantees could reduce total generation cost by about 40%:[9]

> A new merchant nuclear power plant with 100% loan guarantee and 80/20 debt to equity ratio could realize up to a 39% savings in the levelized cost of electricity when compared to conventional financing with a 50-50 debt to equity ratio

There are restrictions on the type and number of plants that would be eligible for loan guarantees. The Congressional Budget Office stated:[10]

> The Department of Energy has indicated that it will deny a utility's application for a loan guarantee if the project is not deemed to be both innovative (essentially, in the case of nuclear technology, a plant design that has not been built in the United States) and commercially viable, and that no more than three plants based on each advanced reactor design can be considered innovative.

If three units of each of the five designs of plant under consideration were built, 15 units would be eligible for loan guarantees. But while utilities have been keen to stand in line for these handouts, with 30-40 plants now at various stages of planning, it seems increasingly likely that only plants with loan guarantees will be ordered. For fiscal year 2008/09, Congress made US$42.5bn available in Federal loan guarantees for 'innovative' generation sources, of which US$18.5bn would be for new nuclear plants.[11] If the new US government really wants to get a significant proportion of the 30-40 reactors proposed built, the $18.5bn will not go far. Utilities have already filed applications for about US$122bn worth of loan guarantees for 21 new nuclear power plants.

If we assume that a new plant will cost no more than US$7-9bn and industry gets its wish that 80% of this cost is covered by Federal loan guarantees, guarantees worth about US$100bn would be needed to build just the 15 'innovative' units. To build 35 units, guarantees of US$230bn would be needed. By October 2008, 17 power

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[7] Congressional Research Service, *Potential Cost of Nuclear Power Plant Subsidies in S.14*, May 7, 2003. Requested by Senator Ron Wyden.
[8] Congressional Budget Office *Cost estimate of S.14, Energy Policy Act of 2003*, (Washington, Congressional Budget Office) http://www.cbo.gov/doc.cfm?index=4206 .
[9] Prepared remarks of Deputy Energy Secretary Dennis Spurgeon at the second annual 'Nuclear Fuel cycle monitor global nuclear renaissance summit' Alexandria, Virginia, July 23, 2008.
[10] Congressional Budget Office (2008) 'Nuclear Power's Role in Generating Electricity' p 33. http://www.cbo.gov/ftpdocs/91xx/doc9133/05-02-Nuclear.pdf
[11] Platt's Global Power Report 'Nuclear Energy Institute president says Congress needs to boost loan guarantees' October 16, 2008.

companies had already applied for $122bn in federal loan guarantees.[12] If, as argued by Standard & Poors,[13] skills and component bottle-necks mean that only 'a few' units can be supplied per year to the US market the need for this very large number of guarantees may not arise.

In January 2009, the Senate Appropriations Committee proposed that an additional US$50bn be made available for innovative generation technologies.[14] This was part of the Senate's version of the government's US$884bn programme to stimulate the economy in the wake of the financial crisis. At the beginning of February 2009, the House and the Senate had yet to debate this proposal.

Other loan guarantee agencies

There has also been speculation that the French and Japanese governments would offer loan guarantees for plants supplied by their national companies.[15] Areva NP is controlled by French interests, indeed, it is majority owned by the French state[16] and the French government has already proved itself willing to offer loan guarantees through Coface, for example to China, Finland and South Africa.[17]

The Japanese government is much less experienced with supporting Japanese vendors. Despite the extensive nuclear programme in Japan as well as large exports of nuclear components, this is the first time Japanese vendors have tried to win foreign orders as a main contractor. Nevertheless, Japanese vendors are involved in four out of five of the designs being considered in the USA – the Franco-German EPR is the fifth. Mitsubishi has its own design, USAPWR. Hitachi is collaborating with GE to offer the ESBWR and, perhaps, the ABWR. Westinghouse, which is offering the AP-1000, although largely based in the USA, is now owned by Toshiba, which is also offering the ABWR. Standard & Poors believes the Japanese government will provide finance for orders from Japanese vendors through the Japan Bank for International Cooperation.

Japan set up the Japan Finance Corp on October 1, 2008 to provide investment credits for nuclear projects in developed countries.[18] These guarantees would complement the US guarantees and might reduce the scale of US loan guarantees needed.

Political issues

There are problems with the OECD's agreement on export credits, the Arrangement on Guidelines for Officially Supported Export Credits (established 1978). The Arrangement is a gentlemen's agreement, not an official OECD document. It provides special treatment for certain sectors, notably nuclear power plant equipment, materials and services. The Arrangement allows a 15-year payback period for nuclear export credits — three more than for conventional power plants and five more than for other

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[12] http://www.lgprogram.energy.gov/press/100208.pdf
[13] Standard & Poors (2008) 'Construction Costs To Soar For New U.S. Nuclear Power Plants'.
[14] Washington Post, 2009 'Energy Provision May Test Priorities' February 3, 2009, p D01.
[15] Nucleonics Week 'US working with allies to change global rules for nuclear financing' October 23, 2008.
[16] Areva NP is 66% owned by Areva with the remaining 34% held by Siemens. In January 2009, Siemens announced its intention to sell its stake to Areva. The Economist, 2008. 'Power struggle; Nuclear energy' December 6, 2008 (US Edition).
[17] Nucleonics Week, 2008, 'French export credit agency to insure loans for Cgnpc, Eskom' August 21, 2008.
[18] Nucleonics Weeks, 2008. 'Japan clears way for loan guarantees in US', September 25, 2008

types of equipment but this is not seen as long enough for nuclear plants.[19] The Participants to the Arrangement were due to meet in Paris in November 2008, but by end January 2009, there had been no reports on whether the meeting took place and, if it did, what the outcome was.

Providing guarantees for one order, like Olkiluoto, which was seen as opening up the market for French exports might be acceptable to French and Japanese taxpayers. However, if such guarantees are a condition for all orders to be placed, taxpayers will see this as a blank cheque. If the Olkiluoto order does lead to a default or the Congressional Budget Office's estimate that the risk of loan default by industry would be 'well above 50 percent, loan guarantees will be seen as a highly risky option.

Options on loan guarantees

For US orders, if worldwide public opinion remains that failures of the US banking system were at the root of the financial crisis, the idea of foreign banks supporting US financial institutions through loan guarantees to again make risky investments will be even more unpopular.

This is an issue that the new Obama administration will need to look at urgently. The US government seems to have three choices:

- Abandon the programme;
- Build 3-4 'totemic' plants within the US$18.5bn budget; or
- Cave in to the nuclear industry's demands for blank cheque support.

The first option is more feasible for a new administration at the start of its term and would be the logical choice if it was judged that orders without loan guarantees would not be feasible. It would face huge opposition from those who stood to gain from nuclear orders. The second option would be a politically less contentious way of avoiding the opposition that abandoning the programme would lead to, but would put US$18.5bn of public money at risk. If the Senate Appropriations Committee's recommendation that up to a further US$50bn was made available for nuclear loan guarantees, this would suggest the third option was being followed. While the total on offer would fall short of the US$122bn applied for, in practice, it might satisfy demand. If some projects dropped out or regulatory approval for a design was not completed or fewer than 3 units of each design were submitted, about US$70bn might be sufficient to get 10 or more units built.

For other countries, especially the UK, the government has still not faced up to the prospect that loan guarantees will be necessary if orders are to be placed. The utilities have not acknowledged that loan guarantees would be needed but, they are several years away from ordering and it is probably tactically astute for them to play along with the government's policy that guarantees were not required and when ordering was actually required and the government was too far committed to nuclear to easily turn back, to then ask for subsidies.

1.3 Vendors and turnkey contracts

The financial assurance a turnkey contract seemed to give was an important element in Areva NP winning the Olkiluoto contract and also the French and Swedish

[19] Nucleonics Week 'US working with allies to change global rules for nuclear financing' October 23, 2008

governments offering loan guarantees. However, it was surprising that Areva NP was so desperate for the order that it was prepared to take the massive financial risk a turnkey contract involves. There have been few (if any) genuine 'whole plant' (as opposed to individual component) turnkey contracts since the notorious 12 turnkey orders that launched commercial ordering in the USA in 1964-66[20]. These lost the vendors massive amounts of money although they did achieve one of their aims, which was to convince utilities that nuclear was little more challenging than, say, a coal-fired plant and could be ordered with confidence as a proven technology. Turnkey orders for nuclear plants are much more risky compared to other power plants because so much of the work in nuclear construction is on-site engineering and construction, a process that is notoriously difficult to control. It is also not easy for the vendor to control the quality of work for the large number of contractors involved.

Standard & Poors were clear in a recent report that turnkey contracts would not be on offer.[21] 'We expect no EPC [engineering, procurement and construction] contracts to be fully wrapped through a fixed-price, date certain mechanism.'

2. Keynesian stimulation

With governments desperately looking for measures that will prevent their economies slipping too deeply into recession, there is bound to be some pressure for Keynesian measures to stimulate the economy through government or government-inspired investment in infrastructure. In addition, with job losses running at a very high level, new projects that can be presented as 'creating new jobs' will have great popular appeal.

Building nuclear power plants might seem a good way to stimulate the economy and already the Senate Appropriations Committee has tried to take advantage of the US government's stimulation package to increase support for nuclear power (see above). To some extent, any major infrastructure project will stimulate the economy because it will employ labour and use materials that would otherwise not have been required. However, that does not avoid the need for governments to choose projects that have long-term value to the economy so choices still have to be made. The other relevant issue is how quickly can the chosen project have an impact and this is the major weakness for nuclear projects. Even in the countries where the process of re-starting nuclear ordering is most advanced, notably USA and UK, no orders can be realistically placed for 4-5 years.

However, proposals to build component factories will be attractive to the communities they are sited in. Areva has been aggressive in its efforts to gain political advantage in the USA by proposing to site a component manufacturing facility in Newport News[22] and a uranium enrichment plant in Idaho.[23] Indeed, it has applied for Federal loan guarantees to build the enrichment plant, which is expected to cost US$2bn and is planned to employ 250 full-time workers at the operational site and 1,000 during

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[20] Bupp, I C.& Derian, J-C. Light Water: How the Nuclear Dream Dissolved. NY. Basic Books, 1978.
[21] Standard & Poors (2008) 'Construction Costs To Soar For New U.S. Nuclear Power Plants'
[22] Nucleonics Week, 2008. 'Heavy component manufacturing for new reactors to return to US' October 30, 2009, p 5
[23] Idaho Business Review, 2008. 'Areva applies for federal loan guarantee for Eagle Rock facility' December 3 2008

construction. The component factory at Newport News is forecast to cost US$363m and create about 500 skilled jobs.

If an immediate stimulus is needed in the energy sector, energy efficiency measures, which have a short lead-time, which employ a large number of workers with varying skills and which have a huge long-term welfare benefit would seem likely to be far more effective. It is therefore particularly surprising that the British government is cutting funding for its 'flagship' energy efficiency programme, Warmfront.[24]

3. Nuclear construction costs

3.1 Cost estimates

One of the most bewildering aspects of the nuclear debate in the past few years has been the escalation in forecast nuclear costs, even before any new plants have been built. The figure of US$1000/kW (so that a 1000MW plant would cost $1bn) was toted by the nuclear industry in the late 1990s as an achievable cost for the new Generation III+ nuclear plants then being designed. This figure was seen by many outside the industry as a target rather than a realistic forecast. So when the first order for a Generation III+ plant was placed for Olkiluoto in 2004, the size of the contracted cost, €3bn or US$3000/kW – three times the figure the nuclear industry had forecast – was not a surprise to experienced industry watchers. Indeed, it was seen as a 'loss-leader', although given that the vendors would have to pay for any cost overruns, there was an expectation that it was at least of the right order of magnitude.

It is now clear that construction at the site is going very badly and the project is 50% over budget and 3 years late. Further cost increases are expected. Even companies as big as Areva NP's owners (Areva and Siemens) cannot easily take losses on this scale without expecting serious repercussions from their shareholders.

How far the cost overrun is the result of the problems at the site and how far it is because the price was an underestimate will be difficult to establish. Areva NP, in its attempt to pass these costs on to TVO, will have a strong incentive to argue it is due to specific site problems, while TVO will argue poor management by Areva NP.

However, estimated prices continued to escalate rapidly even after the Olkiluoto price was announced. By 2008, the estimated construction cost from a range of sources for a Generation III+ unit seemed to be settling at around US$4000-6000/kW, double the Olkiluoto price and often double the estimates made by the same utilities a year or two previously. These cost estimates are not extrapolations by anti-nuclear activists, they are from credible organisations with no apparent motive for over-estimating costs such as experienced nuclear utilities and financial institutions like Standards & Poors. The figures need to be treated with some care partly because the projects are still at an early stage of development and partly because it is not always clear what is included in the estimates. In particular, some estimates may include finance costs, while others, e.g., Duke Power, Progress and Florida Power & Light, are 'overnight costs'.

Table Recent estimates of nuclear construction costs

Organisation	Plant	Estimate ($/kW)	Date

[24] The Observer 'Extra fuel poverty funding 'will last a single winter'' November 9, 2008

Duke Power[25]	Lee (AP-1000)	4700	November 2008
Progress Energy/Harris[26]	Harris (AP-1000)	4000	October 2008
Standard & Poors[27]	n/a	3000-5000	October 2008
E.ON[28]	n/a	6000	May 2008
Florida Power & Light[29]	Turkey Point	5400-7900	February 2008

A variety of explanations can be suggested for this escalation[30]. These include:

- Rapidly rising commodity prices driven by China's demands for them which makes all power plants more expensive, but affects nuclear plants particularly severely because of their physical size;
- Lack of production facilities, which is means that utilities hoping to build nuclear plants are taking options on components like pressure vessels;
- Shortages of the necessary nuclear skills as the nuclear work-force ages and is not replaced by younger specialists;
- Weakness of the US dollar; and
- Greater conservatism in cost estimation by utilities

All of these deserve consideration in the light of how the financial crisis will impact on them.

Commodity prices

As the recession triggered by the financial crisis begins to bite hard, commodity prices (including fossil fuels) are falling steeply in the short-term and this might at least help check the growth in estimates for nuclear construction costs because the materials used will be cheaper. However, it will also tend to reduce the price of other types of power plant, albeit to a lesser extent because other types of power plants use less metal and concrete than nuclear plants. Falling fossil fuel prices will also reduce the running costs and improve the competitiveness of fossil-fuel plants.

In the longer term, whether lower prices can be maintained will depend on resource and capacity issues. If the price of commodities rose because of resource issues, e.g., the marginal reserves that were being exploited had much higher costs than the main resource base, prices will tend to remain high. Advocates of the 'peak oil' theory would probably argue this was the case for oil.[31] If the high prices are simply the result of a short-term supply-demand imbalance, as new capacity is built, prices will drop back sharply. This may be the case for steel and concrete, where there does not appear to be any basic resource problem. However, the depth and speed of the recession may lead to losses of capacity for these resources. For example, steel prices

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[25] The Business Journal of the Greater Triad Area 'Duke doubles cost estimate for nuclear plant' November 4, 2008

[26] The News & Observer (Raleigh, North Carolina) 'Reactors likely to cost $9 billion; Progress Energy doubles estimate

[27] Standard & Poors (2008) 'Construction Costs To Soar For New U.S. Nuclear Power Plants'

[28] The Times 'Reactors will cost twice estimate, says chief' May 5, 2008

[29] Nucleonics Week 'FPL says cost of new reactors at Turkey Point could top $24 billion' February 21, 2008

[30] For more discussion on these factors, see Standard & Poors (2008) 'Construction Costs To Soar For New U.S. Nuclear Power Plants'

[31] 'Peak Oil' advocates claim we are near the maximum oil production level that can e achieved and that, as reserves become further depleted, and supply cannot fulfil existing demand, prices will rise rapidly.

halved in 2008 and demand had fallen 60 per cent leading to Corus, the Indian owned steel company to sack 10% of its UK workforce.[32] If these job losses are also accompanied by capacity losses, the economic recovery could quickly lead to shortages of steel capacity and high prices again.

Note that some of the escalation in commodity prices may also be due to the decline from the end of 2005 to mid-2008 of about a third in the value of the US dollar. Much of this decline had been recovered by November 2008 (see below).

Component bottle-necks and skills shortages

Standard & Poors[33] places great emphasis on the issue of shortage of component manufacturing facilities. It identifies in particular pressure vessels, circulating water pumps and turbine forgings as particularly problematic. There is only one supplier, Japan Steel Works (JSW), which manufactures ultra heavy forgings for pressure vessels. While a large demand for these products would undoubtedly lead to an increase in capacity, the certification requirements for nuclear components will make this a slower process than it would be for less demanding technologies and companies will be reluctant to commit the investment needed to build such production facilities until they see solid evidence of long-term demand. Areva has announced it will build a new plant in Virginia to fabricate large components including pressure vessels and this is forecast to come on line in 2011[34] but it will use forgings purchased from JSW. Standard & Poors forecasts that component supply capacity will limit USA to a 'few' orders per year and that further orders will rely on capacity expansion will.

Standard & Poors also notes skills shortages as major constraint and, again, such skills shortages cannot quickly or easily be overcome. It expects the USA to have to rely on expertise from foreign countries, especially France and Japan initially.

Currency instability

Currencies values have been particularly volatile in the past two years with the dollar hitting historic lows against European currencies. From November 2005 to July 2008, the value of the dollar against the Euro fell from €1=$1.17 to €1=$1.57. Yet by November 2008, the dollar had recovered much of this ground to €1=$1.27. It seems likely that at least some of the cost escalation was related to the decline of the US dollar making some inputs more expensive in dollar terms but not necessarily in Euro terms. For the future, this currency instability represents a particular risk to vendors and utilities. For example, a Japanese or French company selling plants or components for which the contract is denominated in dollars while their costs were incurred in Yen or Euro would lose substantial amounts of money if the value of the dollar was to fall back sharply again.

Utility conservatism

A fifth factor, greater awareness amongst utilities that if the estimates they make are not accurate, there will be serious financial consequences for them is difficult to quantify. Experience with Olkiluoto and awareness that regulators and the public are

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[32] The Times, 2009, 'Give us the subsidies our European rivals are getting, angry steelmen tell Brown' January 26, 2009, p 16-17.
[33] Standard & Poors (2008) 'Construction Costs To Soar For New U.S. Nuclear Power Plants'
[34] Associated Press 'Areva plans US nuclear parts plant' October 23, 2008

likely to be much less indulgent to cost-overruns than they were in the past will be a strong incentive for utilities to build in ample contingencies.

Given that the current costs estimates are based on minimal actual construction experience and such estimates have, in the past, seriously actual costs, the figure of $6000/kW may yet turn out to be an under-estimate.

3.2 Turnkey contracts

As discussed above, fixed price turnkey contracts for the overall plant have a poor history for vendors and this means that for the future, they will remain rare exceptions. Standard & Poors were clear in a recent report that turnkey contracts would not be on offer.[35] 'We expect no EPC [engineering, procurement and construction] contracts to be fully wrapped through a fixed-price, date certain mechanism.'

4. Competitiveness and demand

Nuclear power is just one of many possible ways of meeting electricity demand and if it is not competitive or demand does not justify it, in the long-term plants will not be built. Going back thirty years, large numbers of US orders were cancelled when it became clear either that demand did not warrant them or that the cost of meeting demand with nuclear plants would have been prohibitive.

4.1 Competitiveness

Even though estimated costs have escalated rapidly in the past 3 years, this seems to have had little impact on the enthusiasm of governments for nuclear power. One explanation for this was the rapid fossil fuel prices and insecurity in their markets. As in 1975, after the first oil crisis, the notion that fossil fuels could ever be cheap again seemed unimaginable. But now, as then, while fossil fuel markets are far from perfect, they do respond and by winter 2008/09, this response was already apparent and oil prices were only at less than a third of the level only 6 months previously. Sharp falls in electricity demand were also becoming apparent. For example, in the UK, electricity demand in the 3 months to end November was 2.1% lower than the equivalent period a year before.

High oil prices led in the short-term to recession and the financial crisis is likely to deepen this recession. This will reduce energy demand in the short-term because of the reduction in economic activity. In the longer term, there will be a more significant demand and supply side response. This is clearly illustrated by the marketing of new cars, which for the first time in 30 years are being sold on their fuel consumption. On the supply side, higher oil and gas recovery rates may be justified, exploration efforts redoubled and previously uncommercial reserves, especially for gas, will become economic if oil and gas prices do recover somewhat.

The competitiveness of renewables will be improved, but it might be energy efficiency that is the real winner. 'Fuel poverty', in the UK government' definition, a household spending more than 10 per cent of disposable income on energy, has become a major issue with the forecast that by the end of 2008, a quarter or more of British households will be fuel poor. Building nuclear plants might help keep the lights on in the long-term, but even its most committed advocates cannot claim it will

[35] Standard & Poors (2008) 'Construction Costs To Soar For New U.S. Nuclear Power Plants'

reduce the price of power. Spending money on energy efficiency to reduce demand will not only keep the lights on and replace fossil fuels, it will also permanently lift households out of fuel poverty with huge health and welfare benefits as well as reducing strain on the social security system. Few policies pay off in so handsomely in so many ways. This message does not seem to have got through to the UK government, which had already cut spending on its flagship 'Warmfront' energy efficiency programme. It did find extra money for 2008/09 but funding will fall back to below 2007/08 levels after that.

4.2 Capacity need

In the past when the economic case for nuclear power is not so strong, nuclear programmes have been justified by the nuclear industry on the basis of capacity need. Without a nuclear power programme, they argue, the lights will go off, a prediction usually based on a projection of high electricity demand growth. High energy prices and the financial crisis are likely to cause a recession and a strong demand side response on energy efficiency so electricity demands will be much lower than earlier forecasts.

5. Nuclear power markets other than USA and UK

While most eyes are on the US and UK nuclear programmes, other countries' programmes are also being affected, especially South Africa and Italy.

5.1 South Africa

South Africa has, for the past decade, been trying to commercialise Pebble Bed Modular Reactor technology, but progress has been slow and the publicly-owned South African utility, Eskom prioritised orders for 'conventional' nuclear plants, either the Areva NP EPR or the Westinghouse AP-1000. It has a budget of R343bn (US$34bn) to build 16GW of new coal and nuclear plant by 2017. In the longer term, it plans to build 20GW of nuclear plant by 2025. But at $6000/kW, its budget would provide less than 6GW of new nuclear capacity. Eskom's credit rating is falling: in August 2008, Moody's reduced their rating to Baa2. It is also deeply unpopular because of numerous black-outs in the past two years so its priority must be to deal with power shortages and strengthen the grid so these black-outs are a thing of the past. New nuclear plants which, realistically, will not be on line before 2020 will do nothing to achieve this. So South Africa's ability to proceed with any nuclear programme looked questionable.[36] Finally in November 2008, Eskom admitted defeat and scrapped its tender because the scale of investment was too high. This was despite the willingness of Coface to offer export credit guarantees[37] and despite Areva's claims that it could have arranged 85% of the finance.[38] While Eskom is still maintaining its desire to order nuclear plants, it seems unlikely it will re-issue the tender soon. If the problems had been short-term and easily soluble, it would surely have asked for a delay with the vendors rather than withdrawing it totally.

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[36] Business Day, 2008 'South Africa; Funding Costs 'Will Rise for Eskom'' September 3, 2008
[37] Nucleonics Week, 2008, 'French export credit agency to insure loans for Cgnpc, Eskom' August 21, 2008.
[38] The Star, 2009 'Nuclear bid had funding – Areva' January 30, 2009.

Engineering News reported that the issue was the credit rating of Eskom[39]:

> 'In fact, ratings agency Standard & Poor's said on Thursday that South Africa's National Treasury needed to extend "unconditional, timely guarantees" across all Eskom's debt stock if it hoped to sustain the utility's current BBB+ investment-grade credit rating. The National Treasury was still to announce the details of the package.'

This clearly illustrates the point that credit guarantees are not sufficient in themselves to solve the finance issues. Credit guarantees protect the vendor from default by the utility and allow lower rates of interest but they do not protect the utility from bankruptcy nor do they protect its credit rating.

In February 2009, the other element of South Africa's nuclear policy, the PBMR also appeared on the verge of collapse. It was reported that PBMR Co had no funds beyond 2010 and that as a result it was suspending manufacturing work on components for a demonstration unit and was seeking a new customer.

5.2 *Italy*

Prime Minister Berlusconi has been vocal in his support for nuclear power and is trying to overturn the 1987 referendum verdict that required the phase-out of nuclear plants in Italy.[40] However, the practical difficulties of re-launching the programme, such as re-building skills and capabilities, were always underestimated and the financial crisis may make finance, even for a utility of the size of ENEL, difficult, especially given the financial strain on ENEL of its purchase last year, for over €40bn, of the Spanish utility, Endesa.

6. Decommissioning funds

While the financial crisis could have an immediate impact on the prospects for new nuclear orders because of its impact on finance, construction, demand and competitiveness, it could also have a long-term impact on funding for decommissioning.

Under the polluter pays principle, the responsibilities for decommissioning should be clear. Those that consume the electricity should be responsible for paying for the clean-up of the site. The consensus now emerging is that this is best ensured by setting up 'segregated funds' that are only invested in low risk investments. In practice, funds have not always been segregated and decommissioning cost estimates have proved a huge under-estimate so funds have been lost or are inadequate. While for long-term investments, the return will fluctuate over time, the financial crisis may well lead to large shortfalls in these funds which will not be repaired simply by the next economic upswing. Only a few examples have surfaced so far but if these prove to be the tip of an ice-berg, more extensive ways of ensuring adequate funds are available when needed.

The Vermont Yankee plant's decommissioning fund was reported to have lost 10% of its value in a matter of weeks.[41] This plant is licensed until 2012 but the license may be extended for another 20 years in which case, there will be time to make up the

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[39] Engineering News, 2008 'Eskom terminates Nuclear 1 procurement process, but SA still committed to nuclear' December 5, 2008.
[40] Reuters 'Financial crisis may slow down Italy nuclear relaunch' October 17, 2008
[41] Brattleboro Reformer 'Entergy balks at document requests' November 1, 2008

shortfall. Decommissioning of the Zion plant (already closed) has had to be delayed because its fund had also lost 10% of its value[42]. TVA reported December 2008 that it had lost more than $3 billion in investment income last year. How far these losses were due to its employee retirement program and how far to its nuclear decommissioning fund is not clear.[43] Ontario Power Generation's decommissioning fund for which the value was, as of September 30 2008, C$4.624 billion had lost C$448 million since the beginning of the year.[44]

On average, US decommissioning trusts are 60% equity and 40% debt (bonds). Given the indices like the S&P 500 have lost more than a third of their value in 2008, it is not difficult to see how losses could be as high as 20%. If plants are reaching the end of their life with inadequate funds for decommissioning there may well be a need for further assurance mechanisms. For example, it could be required that utilities take out financial instruments (insurance policies) so that if there is a shortfall, it will be covered by the insurers.

7. Conclusions

The 'Nuclear Renaissance' has much greater government backing than previous prospective nuclear revivals. This is both a strength and a weakness. The strength is that governments are facilitating enabling elements such as safety regulatory approval and, in some cases, offering guarantees and subsidies. Its weakness is that the programmes are vulnerable to political changes and if new governments are less sympathetic to nuclear power, the programmes could collapse.

Even before the scale of the impact of the financial crisis began to be appreciated the cracks in the Nuclear Renaissance were becoming clear. The designs were unproven; costs were escalating sharply; obtaining finance was problematic; and skills shortages and component supply bottle-necks. The financial crisis has done nothing to lessen these concerns.

There are likely to be many unexpected developments before 'business-as-usual' for the world economy resumes but two changes are clear:

- Banks' scrutiny of projects they lend money to will be far more rigorous in the future so that the mistakes that led to the financial crisis can never be repeated;
- Public appreciation of risk will be sharpened and where risk is being passed to taxpayers (or electricity consumers), government will need a strong case for such support to be agreed.

The implications for nuclear power of these changes are severe and it is clear that governments and utilities will no longer be able so easily to pass the risk of nuclear programmes on to taxpayers and electricity consumers. Nuclear power has demonstrated extraordinary resilience in the past two decades, still remaining on the policy agenda despite its failings. So it would be unrealistic to assume that in a decade, powerful interests would not still be lobbying for more nuclear orders. But the current conditions may be the best and perhaps the last chance for the nuclear

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[42] Chicago Tribune 'Economy delays dismantling of Zion nuclear plant' October 17, 2008.
[43] Chattanooga Times and Free Press, 2009 'Ratepayers feel chill from higher power rates' January 22, 2009
[44] Toronto Star, 2008. 'Markets zap OPG's investments; Loss of $190 million in third quarter could be merely the tip of an iceberg, analyst warns' November 22, 2008.

industry. The external factors, such as fossil fuel prices, the need to act on climate change and the geopolitical situation are as favourable as they are likely to get. So if nuclear cannot take advantage of these, will it get another chance? But the nuclear workforce is ageing and not being replaced and if a whole generation of new designs, which in a decade will be looking a little dated, has remained largely on paper, will there really be the appetite amongst private companies to spend the money necessary to bring another generation of designs to the market? Olkiluoto will continue to be the marker for the industry. At best, if there are no more delays and cost overruns, it will be a warning to potential investors, but if things keep going wrong and TVO fails financially the ability to finance any nuclear project will be put in doubt.

It is one thing for taxpayers to be forced to find this sort of sum to save the global banking system, it is a very different thing to volunteer this level of taxpayers' money simply to get nuclear power plants built when there are non-nuclear alternatives that would not need this level of support. The public opposition to the US government's $700bn bail-out of the banking sector demonstrated that the public is not prepared to risk its money on what appear to be ill thought-out policies.

BOX Finland's Olkiluoto plant

The Olkiluoto construction project in Finland has become an example of all that can go wrong in economic terms with nuclear new build. It demonstrates the problems of construction delays, cost overruns and hidden subsidies. A construction licence for Olkiluoto was issued in February 2005 and construction started that summer. As it was the first reactor ordered in a liberalised electricity market, it was seen as proof that nuclear power orders were feasible in liberalised electricity markets and as a demonstration of the improvements offered by the new designs. To reduce the risk to the buyer, Areva NP offered the plant under 'turnkey' terms, which means that the price paid by the utility (TVO) is fixed before construction starts, regardless of what actually happens to costs. The contract allows for fines on the contractors if the plant is late. The schedule allowed 48 months from pouring of first concrete to first criticality.

Finance

The European Renewable Energies Federation (EREF) and Greenpeace France made complaints to the European Commission in December 2004 that the financial arrangements contravened European State aid regulations. The Bayerische Landesbank (owned by the German state of Bavaria) led the syndicate that provided a loan of €1.95bn, about 60% of the total cost, at an interest rate of 2.6%. France's Coface provided a €610m export credit guarantee covering Areva NP's supplies, and the Swedish Export Agency SEK provided €110m. In October 2006, the European Commission finally announced it would investigate the role of Coface. Subsequently, in what was seen as an eccentric judgement, it found that the guarantees did not represent unfair state aid. Regardless of this, it is clear that the arrangements for Olkiluoto are based on substantial state aid that will not be available to many plants. The interest rate on the loan is far below the levels that would be expected to apply for such an economically risky investment.

Construction problems

In August 2005, the first concrete was poured. In September 2005 problems with the strength and porosity of the concrete delayed work. In February 2006, work was reported to be at least 6 months behind schedule, partly due to the concrete problems and partly to problems with qualifying pressure vessel welds and delays in detailed engineering design. In July 2006, TVO admitted the project was delayed by about a year and the Finnish regulator, STUK, published a report which uncovered quality control problems. In September 2006, the impact of the problems on Areva started to emerge. In its results for the first six months of 2006, Areva attributed a €300m fall in first-half 2006 operating income of its nuclear operations to a provision to cover past and anticipated costs at Olkiluoto. The scale of penalties for late completion was also made public. The contractual penalty for Areva is 0.2% of the total contract value per week of delay (past May 1, 2009) for the first 26 weeks, and 0.1% per week beyond that. The contract limits the penalty to 10%, about €300m. In December 2006, after only 16 months of construction, Areva announced the reactor was already 18 months behind schedule, which seems to assure that the full penalty will be due. In late 2007, the cost overrun was reported to have increased to €1.5bn and in October 2008, the estimated delay was increased to three years.

Relations between Areva NP and TVO are near breaking point with Areva NP now appearing to want to renege on the turnkey contract, claiming that TVO had not fulfilled its part of the deal. The turnkey contract is now in dispute and seems likely to be settled acrimoniously. In December 2008, Areva announced it had initiated a second arbitration against TVO to recover €1bn in compensation for the delays, which it attributes to failings on the part of TVO, in particular slowness in processing technical documentation.[1] TVO countered in January 2009 by demanding €2.4bn in compensation from Areva NP for delays in the project.[1] These cases are likely to take several years to settle and will hang over both TVO and Areva NP until they are settled.

Implications

The scale and immediacy of the problems at Olkiluoto has taken even sceptics by surprise. It remains to be seen how far these problems can be recovered, what the delays will be and how far these problems will be reflected in higher costs (whether borne by Areva or TVO). However, a number of lessons do emerge:

- The contract value of €2000/kW, which was never – due to the turnkey nature of the contract – a cost estimate, now appears likely to be a significant underestimate.
- Turnkey contracts may well be required by competitive tenders in liberalized electricity markets. Or regulators may impose caps on recoverable nuclear construction costs, which would have the same effect. The willingness of vendors to bear the risk of cost over-runs in the light of the Olkiluoto experience is open to serious question.
- The skills needed to successfully build a nuclear plant are considerable. Lack of recent experience of nuclear construction projects may mean this requirement is even more difficult to meet.
- There are serious challenges to both safety and economic regulatory bodies. The Finnish safety regulator had not assessed a new reactor order for more than 30 years and had no experience of dealing with a 'first-of-a-kind' design.