

## Nuclear costs and financing

### Introduction

Over the last two decades there has been a steep decline in orders for new nuclear reactors throughout the world. Although the Chernobyl accident is one reason for this, poor economics is a major driving force behind the move away from nuclear power.

Fourteen of the UK's nineteen operating reactors are Advanced Gas-cooled Reactors (AGRs). The AGR programme was, according to Sir Arthur Hawkins, Chairman of the Central Electricity Generating Board (CEGB), in 1973, "*a disaster we must not repeat*".<sup>1</sup> None of the stations were completed on time and there were huge cost overruns. Dungeness B was the first AGR plant to be ordered in 1965. At the time it was expected to be operational by 1970-1, but it did not produce commercial energy until 1989.

According to the New Economics Foundation, Dungeness B exceeded its budget by 400%, and its construction period was almost as long as its economic life.<sup>2</sup> Problems persisted throughout the AGR building programme. For example Heysham A was 13 years late, and cost almost double its original budget. Even the final pair, Torness and Heysham B, were over a year late. Delays caused budget overruns, and when completed the majority failed to perform to their designed output, further reducing income.<sup>3</sup>

But these cost overruns and construction delays are not a uniquely British problem. Country after country has seen nuclear construction programmes go considerably over-budget. In the United States, an assessment of 75 of the country's reactors showed predicted costs to have been \$45 billion (€34bn) but the actual costs were \$145 billion (€110bn).

In India, the country with the most recent and current construction experience, completion costs of the last 10 reactors have averaged at least 300% over budget. The average construction time for nuclear plants has increased from 66 months for completions in the mid 1970s, to 116 months (nearly 10 years) for completions between 1995 and 2000. The longer construction times are symptomatic of a range of problems including managing the construction of increasingly complex reactor designs.<sup>4</sup>

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<sup>1</sup> Sir Arthur Hawkins giving evidence to the House of Commons Select Committee on Science and Technology on 19<sup>th</sup> December 1973.

<sup>2</sup> Andrew Simms, Petra Kjell and David Woodward, "Mirage and Oasis: Energy choices in an age of global warming", New Economics Foundation, 2005, p34.  
[http://www.neweconomics.org/gen/z\\_sys\\_PublicationDetail.aspx?PID=209](http://www.neweconomics.org/gen/z_sys_PublicationDetail.aspx?PID=209)

<sup>3</sup> Olaf Bayer and Chris Grimshaw, Broken Promises: Why the nuclear industry won't deliver, Corporate Watch, July 2007 <http://www.corporatewatch.org.uk/?lid=2968>

<sup>4</sup> The Economics of Nuclear Power, by P. Bradford, A. Froggatt, D. Milborrow and S. Thomas Greenpeace International, May 2007

[http://www.greenpeace.org.uk/files/pdfs/nuclear/nuclear\\_economics\\_report.pdf](http://www.greenpeace.org.uk/files/pdfs/nuclear/nuclear_economics_report.pdf)

### Buy one get seven free

When the Thatcher Government began the process of privatising the electricity industry, investment analysts in the City of London refused to go along with it if nuclear power was included. They were unwilling to take the risk because of the industry's track record and open-ended liabilities.

In November 1989 the then Secretary of State for Energy, John Wakeham, was forced to withdraw the UK's existing nuclear stations from the Government's privatisation plans. He also announced a moratorium on the construction of new nuclear power stations beyond Sizewell B, the UK's first Pressurised Water Reactor (PWR), under construction at the time, until 1994, at which point the government "*would review the prospects for nuclear power as the Sizewell B project nears completion*".<sup>5</sup>

The nuclear stations were assigned to two new companies - Nuclear Electric and Scottish Nuclear – which remained in Government ownership. But these companies proved unable to compete in the new electricity market, even though, for all but the newest, the original capital costs were already written off, and nuclear fuel costs are always claimed to be low. Electricity users were compelled to pay a ten percent surcharge, known as the non-fossil fuel obligation, to contribute a subsidy of more than £3 billion a year to the industry.<sup>6</sup>

The Government's nuclear review, published in May 1995, concluded: "*there is at present no evidence to support the view that new nuclear build is needed in the near future on emission abatement grounds*"... nor is "*there any case for the intervention in the market in support of additional nuclear capacity on diversity grounds*".

This effectively finally killed off plans to build further PWRs including one at Hinkley in Somerset, a second at Sizewell and one at Wylfa on Anglesey in North Wales.<sup>7</sup> The Government also decided that while the old Magnox reactors were to remain in public ownership, the newer AGR stations and the Sizewell B PWR would be sold off. So, in 1996, the Government sold eight nuclear stations for around the price it cost to build one – buy one get seven free - now bundled together as a company known as British Energy.<sup>8</sup>

British Energy no longer had the benefit of the non-fossil fuel obligation, but despite getting its reactors at a bargain basement price, only six years after it was privatized, in September 2002, the company was forced to go cap in hand to the Trade and Industry Minister in order to keep its reactors open. The Government loaned the company £650 million to stop it going bankrupt. In 2004 the European Commission approved a state aid package which allowed the Government to pay £4-5bn towards British Energy's decommissioning costs and waste liabilities, even though the

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<sup>5</sup> Hansard, Cols 1175-6, November 9, 1989.

<sup>6</sup> Walt Patterson, Nuclear Amnesia, The World Today, April 2006, <http://www.waltpatterson.org/nucamnesia.pdf>

The arrangement in Scotland was slightly different, rather than the Non-Fossil Fuel Obligation, a premium was paid to Scottish Nuclear through the Nuclear Energy Agreement.

<sup>7</sup> "The prospects for nuclear power in the UK: conclusions of the government's nuclear review" Cm2860, HMSO, May 1995.

<sup>8</sup> Friends of the Earth Scotland Press Release, 15<sup>th</sup> May 2002 <http://www.foe-scotland.org.uk/www.foe-scotland.org.uk/press/pr20020509.html>

company was supposed to have established a segregated fund to pay for this when it was privatised.<sup>9</sup>

### **Economics unattractive**

The Blair Government's first Energy White Paper in February 2003<sup>10</sup> concluded that "...the current economics of nuclear power make it an unattractive option for new generating capacity".<sup>11</sup> The Department of Trade and Industry (DTI) Minister at the time, Patricia Hewitt, said: "*It would have been foolish to announce ...a new generation of nuclear power stations, because that would have guaranteed we would not make the necessary investments in energy efficiency and renewables*".<sup>12</sup>

### **180° u-turn**

Now, just over five years later, Hewitt's replacement, Secretary of State for Business John Hutton, wants the UK's reliance on nuclear power to increase "significantly" over the next two decades. He says he expects a new generation of reactors to supply much more of the country's electricity than the current 19% - perhaps 30% or more.<sup>13</sup>

The Prime Minister, Gordon Brown, has called for 1,000 new nuclear power stations to be built around the world to meet global energy needs with 30 reactors opening every year for the next 30 to 40 years.<sup>14</sup>

Why has there been a 180° u-turn in such a short time? It was clear back in 2003 that Blair disagreed with the results of the 2003 energy review, as did the nuclear establishment which included civil servants, particularly in the DTI. There were warnings even then that DTI officials would deliberately go slowly on renewables to keep nuclear alive – this is indeed what seems to have happened. Blair began talking about re-visiting the issue as early as 2005.

Nearly all the Ministers who pushed renewables and energy efficiency in 2003 had been moved by then. In November 2005 Blair announced a second energy review. The Review's conclusions, published in July 2006, backed new reactors.<sup>15</sup>

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<sup>9</sup> Greenpeace slams Commission decision on state aid for British Energy, Greenpeace UK Press Release, September 22, 2004.

<http://www.greenpeace.org.uk/media/press-releases/greenpeace-slams-commission-decision-on-state-aid-for-british-energy>

<sup>10</sup> Energy White Paper: Our Energy Future – creating a low carbon economy, DTI, February 2003.

<http://www.berr.gov.uk/files/file10719.pdf>

<sup>11</sup> para 4.68

<sup>12</sup> Hansard 24<sup>th</sup> Feb 2003, Column 32.

<http://www.publications.parliament.uk/pa/cm200203/cmhansrd/vo030224/debtext/30224-07.htm>

<sup>13</sup> FT 6th March 2008 <http://www.ft.com/cms/s/0/209d689c-eafb-11dc-a5f4-0000779fd2ac.html>

Times 3rd March 2008

[http://business.timesonline.co.uk/tol/business/industry\\_sectors/utilities/article3471797.ece](http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article3471797.ece)

Guardian 26th March 2008 <http://www.guardian.co.uk/environment/2008/mar/26/nuclearpower.energy>

<sup>14</sup> Scotsman 13<sup>th</sup> June 2008 <http://news.scotsman.com/latestnews/Brown-World-needs-1000-more.4182560.jp>

<sup>15</sup> The Energy Challenge, DTI, July 2006

<http://www.berr.gov.uk/files/file31890.pdf>

## Lobbying strategy begins

The nuclear lobbying offensive began almost before the ink was dry on the 2003 White Paper. Jonathan Leake detailed in the *New Statesman* how, in the year or so before the May 2005 General Election, the nuclear industry slowly but surely put together a lobbying strategy targeting politicians, the media and the captains of industry.<sup>16</sup> One of the first things the nuclear lobby had to counter was the fact that nuclear power is far too expensive.

The February 2002 Performance and Innovation Unit Report,<sup>17</sup> by a group of energy experts, which fed into the 2003 Energy White Paper, expressed scepticism about the optimistic projections put forward by the nuclear industry. The industry said it expected to be able to deliver power at between 2.5p/kWh to 3p/kWh. But such a result would depend on several factors: achieving construction costs below the bottom end of the International Energy Agency's estimates; achieving very high operating availability; being able to build a series of 10 identical reactors; and quicker construction-to-commissioning times than have been achieved in the past. PIU concluded that nuclear costs were more likely to be in the range 3-4p/kWh.<sup>18</sup>

Five year later, in September 2007, Paul Joskow, Director of the Center for Energy and Environmental Policy Research at Massachusetts Institute of Technology in Cambridge, was still making the same point: "*The nuclear industry has put forward very optimistic construction cost estimates, but there is no experience that comes even close to backing them up*".<sup>19</sup> So, where the industry hasn't been able to demonstrate its case by experience, it has used 'spin' to convince politicians and the public.

## Information out of date and wrong

In March 2004, the Royal Academy of Engineering (RAE), estimated the cost of electricity from new nuclear plant at 2.3p/kWh, compared with up to 5.4p/kWh for onshore wind.<sup>20</sup> Dr Catherine Mitchell of Warwick Business School, who had been a member of the PIU's Energy Review Team, speaking at the Friends of the Earth 'Meeting Scotland's Energy Needs Conference' in Edinburgh on 21 May 2004 complained that:

*"The PIU examined the cost of nuclear power, both current and future, in great depth. It concluded that the figures put forward by the nuclear industry are extremely optimistic and PIU's own figures were much higher. Now, bodies such as RAE are giving the cost of nuclear power as those put forward by the nuclear industry without including other evidence based analyses, such as the PIU. It is extremely depressing*

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<sup>16</sup> The nuclear charm offensive, by Jonathan Leake, *New Statesman*, 23<sup>rd</sup> May 2005  
<http://www.newstatesman.com/200505230004>

<sup>17</sup> The Energy Review, Performance and Innovation Unit, February 2002.  
[http://www.cabinetoffice.gov.uk/strategy/work\\_areas/~media/assets/www.cabinetoffice.gov.uk/strategy/theenergyreview%20pdf.ashx](http://www.cabinetoffice.gov.uk/strategy/work_areas/~media/assets/www.cabinetoffice.gov.uk/strategy/theenergyreview%20pdf.ashx)

<sup>18</sup> See para 44-47 pp195-6

<sup>19</sup> Bloomberg 5th Sept 2007  
<http://www.bloomberg.com/apps/news?pid=20601109&sid=aFh1ySj.IYQc&refer=news>

<sup>20</sup> 'The Cost of Generating Electricity', Royal Academy of Engineering (March 2004)  
[http://www.raeng.org.uk/news/publications/list/reports/Cost\\_of\\_Generating\\_Electricity.pdf](http://www.raeng.org.uk/news/publications/list/reports/Cost_of_Generating_Electricity.pdf)

*that after 2 years of evidence based analysis by the Government, energy institutions continue to provide out of date and probably wrong information”.*

RAE’s figures were basically the same as the numbers submitted by the industry to the PIU Energy Review. Nuclear Economist Gordon MacKerron who had also been a member of the Energy Review team said these figures overlap with the cost of generating electricity from Combined-cycle Gas Turbines (CCGTs) and are, therefore potentially competitive without any Government support mechanism. But nobody within the investment community was anywhere near regarding nuclear power as a close competitor with CCGTs.<sup>21</sup>

### **Uncertainties remain**

In November 2005, Mackerron and others were commissioned by the Sustainable Development Commission (SDC) to produce a report on the economics of nuclear power. This was published in March 2006 as one of a series of papers which SDC submitted to the 2006 Energy Review.<sup>22</sup> The authors said the uncertainties surrounding nuclear costs had not materially reduced since the 2003 Energy White Paper. Neither of the two main potentially competing reactor designs have yet been built anywhere in the world. The UK’s history of building nuclear projects to time and cost has been poor, and while there are solid grounds for expecting that future construction would be less costly, ‘appraisal optimism’ remains a real risk.

### **The future of nuclear power**

British Energy’s Hunterston B Station Director, Mark Gorry, says it is a popular misconception that nuclear power is expensive. He uses the Government’s May 2007 consultation document, ‘The Future of Nuclear Power’ as evidence. He says that nuclear power, even with the inclusion of waste management and decommissioning costs, is considerably less expensive than wind power, and is comparable in cost to fossil fuels once the cost of carbon emissions are included, and that was before the huge rise in the costs of fossil fuels this year.<sup>23</sup>

The Future of Nuclear Power examined a number of scenarios and estimated that nuclear power would cost between £31/MWh and £44/MWh (3.1p/kWh-4.4p/kWh). The document stresses the uncertainties involved in estimating the costs of nuclear electricity, and that it mainly relied on industry estimates.<sup>24</sup> It concludes: “*Based on this conservative analysis of the economics of nuclear power, the Government believes that nuclear power stations would yield economic benefits to the UK...*”<sup>25</sup>

<sup>21</sup> MacKerron, Gordon (September 2004) ‘Nuclear Power and the Characteristics of Ordinarity – the Case of UK Energy Policy’ NERA Economic Consulting.

<sup>22</sup> Economics of Nuclear Power, A report to the Sustainable Development Commission, by Gordon Mackerron et al, University of Sussex and NERA Economic Consulting, November 2005. <http://www.sd-commission.org.uk/publications/downloads/Nuclear-paper4-Economics.pdf>

<sup>23</sup> Largs & Millport News 23rd July 2008 <http://www.largsandmillportnews.com/articles/3/26539>

<sup>24</sup> The Future of Nuclear Power: The Role of Nuclear Power in a Low Carbon Economy, BERR. May 2007. <http://www.berr.gov.uk/files/file39197.pdf> See para 4.19 & 4.22

<sup>25</sup> p4.45

In response, MacKerron, and his colleague at Sussex University Energy Group, complain this is not robust conclusion: “...it does not properly acknowledge the uncertainty that inevitably attaches to the introduction into the UK of technology that is both novel and politically contentious”.<sup>26</sup> The simple answer to the question ‘what are the economics of nuclear power’, the group concludes, is: we don’t know.

### **Finland’s flawed nuclear renaissance**

The two reactor designs most likely to be built in the UK are the Siemens-Areva European Pressurised Water Reactor (EPR)<sup>27</sup> and the Toshiba-Westinghouse AP1000 design.<sup>28</sup> The latter design has not yet even begun construction anywhere in the world. The first European Pressurised Water Reactor (or EPR) started construction in 2005 in Finland, but is already three years late and about 50% over budget. It was originally budgeted at €3bn, but is now expected to cost at least €4.5bn.<sup>29</sup>

French nuclear group Areva and German engineering company Siemens are building the 1,600 megawatt EPR at Olkiluoto 3 on Finland's west coast, under a fixed price contract. It was the first new nuclear reactor to be constructed in Western Europe for more than a decade. Its start-up was originally scheduled for 2009 but this has now been postponed until 2012. Siemens says it expects a “not insignificant” financial impact from the delays, amounting to between €700m and €1.5bn.<sup>30</sup> Flawed welds for the reactor's steel liner, unusable water-coolant pipes and suspect concrete in the foundations have all been blamed.<sup>31</sup> Nine months into construction, Europe’s second EPR being built at Flamanville in France was already nine months behind schedule.<sup>32</sup>

One nagging issue for reactor builders is that contractors are inexperienced. They will be getting asked to work for an industry that has been dormant in most of Europe and the U.S. for 20 years. Mackerron et al. conclude that the novelty of the designs offered by reactors vendors represents a high level of technologically-derived risk to capital cost estimates.<sup>33</sup> None of the designs has yet won UK safety approval, a process that could lead to higher costs. The cost of constructing reactors is heavily dependent on the number built. Building eight to 10 reactors would reduce unit costs but involve huge inflexibility, while a single unit would have low market impact but involve much higher unit costs.

<sup>26</sup> Sussex Energy Group response to the Future of Nuclear Power Consultation, October 2007.

[http://www.sussex.ac.uk/sussexenergygroup/documents/seg\\_spru\\_nuclear\\_response.pdf](http://www.sussex.ac.uk/sussexenergygroup/documents/seg_spru_nuclear_response.pdf)

<sup>27</sup> <http://www.epr-reactor.co.uk/scripts/ssmod/publigen/content/templates/show.asp?P=57&L=EN>

<sup>28</sup> <https://www.ukap1000application.com/AP1000Documentation.aspx>

<sup>29</sup> Guardian 18<sup>th</sup> Oct 2008 <http://www.guardian.co.uk/environment/2008/oct/18/nuclearpower>

<sup>30</sup> Reuters 31<sup>st</sup> March 2008

<http://uk.reuters.com/article/oilRpt/idUKL3132855120080331>

Forbes 28<sup>th</sup> Sept 2007 <http://www.forbes.com/markets/feeds/afx/2007/09/28/afx4165822.html>

<sup>31</sup> Bloomberg 5<sup>th</sup> Sept 2007

<http://www.bloomberg.com/apps/news?pid=20601109&sid=aFh1ySJIYQc&refer=news>

<sup>32</sup> Greenpeace International 27<sup>th</sup> August 2008

<http://www.greenpeace.org/international/press/releases/greenpeace-reaction-to-france>

<sup>33</sup> Sussex Energy Group response to the Future of Nuclear Power Consultation, October 2007.

[http://www.sussex.ac.uk/sussexenergygroup/documents/seg\\_spru\\_nuclear\\_response.pdf](http://www.sussex.ac.uk/sussexenergygroup/documents/seg_spru_nuclear_response.pdf)

## Reactors in India, China, Taiwan – late

Finland's experience suggests that the “nuclear renaissance” may be short-lived. And problems are not confined to Europe. Country after country has seen nuclear construction programmes go considerably over budget - for example, completion costs for the last ten Indian reactors have been 300% over budget.<sup>34</sup> China's Tianwan project began commercial operation in June 2007, more than two years later than planned.

The Chinese regulator halted construction for almost a year on the first of two Russian-designed reactors while it examined welds in the steel liner for the reactor core. In Taiwan, the Lungmen reactor project is five years behind schedule. Difficulties include welds that failed inspections in 2002 and had to be redone. The rising cost of steel, concrete and other commodities has gutted subcontractors' profits, causing them to stop work to renegotiate fixed-price contracts.<sup>35</sup>

The World Energy Council says construction times for new reactors have risen from 66 months in the mid-1970s to 116 months - nearly ten years - for completions between 1995 and 2000. The unproven designs being proposed for the UK are likely to lead to more potential delays.<sup>36</sup>

## Will investors invest?

The Government continues to insist it will not subsidise new reactors. If the private sector does not provide the huge investments needed, the country will have to do without. Potential investors complain there is still too much risk to commit to such long-term projects.<sup>37</sup> Poyry Energy Consulting (previously Ilex) said the policies outlined in the May 2007 Energy White Paper<sup>38</sup> could spell the end of nuclear power, because there was little in the way of positive action for delivering new reactors.<sup>39</sup>

Poyry suggests setting a high and long-term price for carbon dioxide emissions to help the economic case for new reactors.<sup>40</sup> An Oxford University task force complained the government has no coherent strategy. The hotchpotch of measures is unlikely to deliver the government's vision on climate change, energy security and poverty.<sup>41</sup>

<sup>34</sup> The Economics of Nuclear Power, by P. Bradford, A. Froggatt, D. Milborrow and S. Thomas, Greenpeace, May 2007.

[http://www.greenpeace.org.uk/files/pdfs/nuclear/nuclear\\_economics\\_report.pdf](http://www.greenpeace.org.uk/files/pdfs/nuclear/nuclear_economics_report.pdf)  
Guardian 3rd May 2007 <http://business.guardian.co.uk/story/0,,2070918,00.html>

<sup>35</sup> Bloomberg 5th Sept 2007

<http://www.bloomberg.com/apps/news?pid=20601109&sid=aFhlySJ.IYQc&refer=news>

<sup>36</sup> The Economics of Nuclear Power, by P. Bradford, A. Froggatt, D. Milborrow and S. Thomas, Greenpeace, May 2007.

[http://www.greenpeace.org.uk/files/pdfs/nuclear/nuclear\\_economics\\_report.pdf](http://www.greenpeace.org.uk/files/pdfs/nuclear/nuclear_economics_report.pdf)  
Guardian 3rd May 2007 <http://business.guardian.co.uk/story/0,,2070918,00.html>

<sup>37</sup> Reuters 21st June 2007 <http://uk.reuters.com/article/topNews/idUKL2179895320070621?rpc=401>

<sup>38</sup> Meeting the Energy Challenge, A White Paper on Energy, DTI, May 2007

<http://www.berr.gov.uk/files/file39387.pdf>

<sup>39</sup> Poyry Energy Consulting Press Release 11th June 2007.

[http://www.illexenergy.com/pages/White\\_Paper\\_PR\\_11\\_06\\_2007\\_v1\\_0.pdf](http://www.illexenergy.com/pages/White_Paper_PR_11_06_2007_v1_0.pdf)

<sup>40</sup> Reuters 11th June 2007

<http://uk.reuters.com/article/domesticNews/idUKL1113886120070611?rpc=401>

<sup>41</sup> Guardian 4th June 2007, <http://business.guardian.co.uk/story/0,,2094616,00.html>

The UK Energy Research Centre warned that investment in nuclear and renewables may not be forthcoming because the Government doesn't understand the needs of investors. The academics argue that the Government's objectives rely on the private sector investing tens of billions of pounds. Robert Gross of Imperial College says the Government has somehow to persuade the private sector to invest in nuclear reactors and renewables when what it wants to do is invest in new gas-fired stations. Investors remain sceptical about the appeal of new reactors.<sup>42</sup>

In January 2008, Gordon MacKerron said the Government had done nothing to make nuclear power more attractive. It has opened up the danger of the country being left with no new reactors, and no green alternatives.<sup>43</sup> And Dieter Helm, Professor of Energy Policy at New College, Oxford appears to agree. He says the Government's nuclear energy policy is fundamentally flawed because it relies on the "fiction" that a new generation of reactors can be built without state support. No country has developed nuclear power in a liberalised market. He believes the Government will be forced to rig the market if it wants to ensure that new reactors are built.<sup>44</sup>

### **What every investor wants**

Richard Noble of investment bank Lehman Brothers addressed various nuclear conferences over the summer of 2007, saying that as long as the "key uncertainties" are addressed, the financing for new reactors will follow.<sup>45</sup> Catastrophic insurance exposure was one uncertainty which he said needed to be resolved – what happens if a nuclear operator is unable to obtain the required insurance cover for a nuclear accident? No insurance giant is going to be prepared to insure against a Chernobyl-scale accident, so the taxpayer has to take much more of the risk than in other forms of power generation.

In the UK, claims relating to third party damage arising from a nuclear accident are regulated by the Nuclear Installations Act 1965. Under this Act liability is channeled exclusively to the operator, but the third party liability of UK nuclear operators is currently capped at £140m, with this cover being provided by insurance from the commercial market. Once this cap has been reached the Act provides that public funds can be made available to meet claims for compensation.<sup>46</sup>

Under the Paris/Brussels convention<sup>47</sup> third party liability is due to be raised to £500m. The scope of liability is also due to be extended to include environmental damage. These proposals will be consulted on soon. These plans are due to come into force in spring 2009. The economic cost of the Chernobyl accident can only be

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Oxford University Press Release 4<sup>th</sup> June 2007 <http://www.admin.ox.ac.uk/po/070604.shtml>

<sup>42</sup> "Investing in Electricity Generation: the role of costs, incentives and risks". UKERC, June 2007. <http://www.ukerc.ac.uk/content/view/410/014>

<sup>43</sup> Independent on Sunday 13th Jan 2008 <http://www.independent.co.uk/opinion/commentators/gordon-mackerron-this-way-is-more-likely-to-leave-us-in-the-dark-770005.html>

<sup>44</sup> Times 28<sup>th</sup> January 2008 [http://business.timesonline.co.uk/tol/business/industry\\_sectors/utilities/article3261571.ece](http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article3261571.ece)

<sup>45</sup> From end to beginning, Nuclear Engineering International, August 2007.

<http://www.neimagazine.com/story.asp?sectionCode=76&storyCode=2046213>

<sup>46</sup> Ministerial Statement, 27<sup>th</sup> Feb 2008, <http://www.berr.gov.uk/files/file45074.pdf>

<sup>47</sup> <http://www.berr.gov.uk/energy/sources/nuclear/safety-security/liability/page18577.html>



estimated, but runs into hundreds of billions of dollars. Belarus, for example, has estimated the losses over 30 years at US \$235 billion.<sup>48</sup>

### **NDA limited liability guarantees at Drigg and Sellafield?**

Most European governments have signed up to the Paris and Brussels conventions on nuclear energy. But the United States and Japan are not signatories. Even among European signatories, governments have set different caps on liability for nuclear accidents. Because every country has different laws setting out liability in the event of a nuclear accident, the UK Government has been forced to waive rules that require companies to pay the first £140m of clean-up costs for contractors at Sellafield and the low-level waste repository near Drigg in Cumbria.

This means that taxpayers are being forced to indemnify the consortium chosen as the preferred bidder for the £7.5bn contract to operate and decommission Sellafield. The Nuclear Management Partners, which won the competition, includes Areva, Washington Group, and Amec.<sup>49</sup> The Nuclear Decommissioning Authority indemnifies operators against 'claims arising as a result of property damage, damage to human health', 'cost of measures of reinstatement of significantly impaired environment' and 'the cost of preventative measures'. Under the arrangements, the NDA will also compensate operators for the resulting loss of income after an accident, even if it was their fault.

A similar liability issue held up the NDA finalising the contract for the Low-Level Waste Repository near Drigg with UK Nuclear Waste Management, also led by Washington Group. The issue was eventually resolved by the Government taking the risk.<sup>50</sup> This could be a foretaste of what will happen if overseas companies propose building new reactors in the UK.

### **Full share of waste costs?**

The industry also needs certainty on how waste management and decommissioning costs (so-called back-end costs) will be funded. Richard Noble says that despite the fact that back-end costs will be incurred far into the future, thus reducing their apparent value today, they “*are potentially very significant numbers and there are still considerable uncertainties about them.*”

The Future of Nuclear Power consultation document said that developers of new reactors would have to meet their full share of waste management costs, and there would be no subsidies.<sup>51</sup> Energy Minister Malcolm Wicks explained that this:

*"...reflects the fact that the storage facilities and deep repository will be primarily for waste that already exists: this will be for the public sector to fund. But we need to decide what contribution owners of new nuclear plant should make to the total costs.*

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<sup>48</sup> See <http://www.greenfacts.org/en/chernobyl/1-3/5-social-economic-impacts.htm>

<sup>49</sup> Observer 6<sup>th</sup> July 2008

<http://www.guardian.co.uk/business/2008/jul/06/1>

<sup>50</sup> Whitehaven News 23<sup>rd</sup> July 2008

<http://www.whitehaven-news.co.uk/news/business/1.208390>

<sup>51</sup> para 8.4 and 8.44

*Our principle is that they should meet their 'full share' of these costs, but we need to do more detailed work on how this should be calculated".*<sup>52</sup>

He re-iterated to *The Financial Times* that the private sector would foot the *entire* bill for the decommissioning and waste disposal costs of any new reactors.<sup>53</sup>

The Energy Bill 2008 contains clauses to ensure adequate funding provision is made by reactor developers for the full cost of decommissioning and their full share of waste management costs. It also establishes a new independent advisory body, the Nuclear Liabilities Financing Assurance Board (NLFAB) to provide advice to the Government on all aspects of the financial arrangements operators plan to put in place.<sup>54</sup>

A draft framework on how decommissioning and waste costs would be paid for was published for consultation in February 2008,<sup>55</sup> and the Government responded to the consultation in September 2008.<sup>56</sup> Companies must produce a detailed funded decommissioning programme before new reactors are approved. This will include a commitment to pay into a secure and independently managed fund to cover all the costs of decommissioning, clean up and disposing of the waste. The Nuclear Liabilities Financing Assurance Board will monitor these funds.<sup>57</sup>

Dieter Helm, Professor of Energy Policy at New College, Oxford, says the system proposed effectively means utilities will pay for the state to absorb the risks of handling nuclear waste in exchange for payments into a fund. "It's a fixed-price contract for the Government to take the waste. The Government absorbs the final-end risk," he says.<sup>58</sup>

Shetland Island Council launched a scathing attack on the proposals arguing that any funding risks should be borne by the operator, not the public.<sup>59</sup> *The Spectator* said there is every risk that the public will end up footing the bill. The Government has left open the possibility of subsidizing reactors, despite its disclaimers. It says in 'extreme circumstances' it is prepared to help meet the massive decommissioning and waste disposal costs — knowing full well that such extreme circumstances almost always attend decommissioning and waste disposal.<sup>60</sup>

<sup>52</sup> Hansard, 21 June 2008, Column 2064W

<sup>53</sup> FT 20th August 2007 <http://www.ft.com/cms/s/0/fb8e6cb0-4e86-11dc-85e7-0000779fd2ac.html>

<sup>54</sup> Modern Power Systems 17<sup>th</sup> January 2008

<http://www.modernpowersystems.com/story.asp?sectioncode=131&storyCode=2048395>

<sup>55</sup> Consultation on Funded Decommissioning Programme Guidance for New Nuclear Power Station, BERR, February 2008 <http://www.berr.gov.uk/files/file44486.pdf>  
Telegraph 22<sup>nd</sup> February 2008

<http://www.telegraph.co.uk/earth/main.jhtml?xml=/earth/2008/02/22/eanuc122.xml>

<sup>56</sup> The Government Response to the Consultation on Funded Decommissioning Programme Guidance for New Nuclear Power Stations, BERR September 2008. <http://www.berr.gov.uk/files/file47629.pdf>

<sup>57</sup> FT 22<sup>nd</sup> February 2008 <http://www.ft.com/cms/s/0/70bd3824-e0d4-11dc-b0d7-0000779fd2ac.html>

<sup>58</sup> Times 28<sup>th</sup> January 2008

[http://business.timesonline.co.uk/tol/business/industry\\_sectors/utilities/article3261571.ece](http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article3261571.ece)

<sup>59</sup> <http://www.shetland.gov.uk/news-advice/documents/NuclearWaste-Background1.doc>

<sup>60</sup> Spectator 12<sup>th</sup> March 2008

[http://www.spectator.co.uk/the-magazine/features/553546/part\\_3/go-nuclear-but-keep-your-hand-on-your-wallet.thtml](http://www.spectator.co.uk/the-magazine/features/553546/part_3/go-nuclear-but-keep-your-hand-on-your-wallet.thtml)

### What is a 'fair share'?

BERR officials indicate the 'fair share' for waste 'disposal' will be calculated as the proportion of space nuclear operators' radioactive waste takes up in any repository. But this overlooks the hundreds of millions spent on research and development for a repository, representing a huge hidden subsidy. Nuclear Economist Ian Jackson says that foreign utility companies with reprocessing contracts with Sellafield appear to be paying a levelised unit disposal cost of some £201,000/m<sup>3</sup> for intermediate-level waste. Commercially speaking it would be hard to justify charging British utilities a lower price for geological disposal and would risk accusations of illegal state aid, in contravention of European competition law.

Assuming ten new reactors are built and that British utilities pay the same, the price of waste disposal for a new build programme would be around £8.2 billion. The problem is that this fully commercial price would make disposal far too expensive, killing the prospects of any new reactors. The £820 million per reactor is equivalent to 41% of each reactor's expected £2 billion capital cost. Business models for nuclear generation assume costs of only 5% for waste management and decommissioning.<sup>61</sup>

Jackson says nuclear utilities probably need fixed waste disposal 'prices' for repository disposal capped somewhere in the range from £12,200 to £24,400/m<sup>3</sup>, but the NDA's true marginal 'cost' is nearer to £67,000/m<sup>3</sup>, and the commercial 'value' of the repository asset could approach £201,000/m<sup>3</sup> if operated as a fully private sector venture. In other words, new reactors will not be built unless the government fixes the market.<sup>62</sup>

### Bankruptcy?

And what happens if an operating company is unable to meet its commitments to the nuclear decommissioning fund? The Government has taken liabilities off the nuclear private sector before - British Energy passed on its £5.3bn liabilities bill to the taxpayer - and the Energy Act 2004 contains powers which allow the Secretary of State to direct the NDA to take over financing of nuclear waste liabilities for private nuclear companies in the future should they be unable to meet their obligations.<sup>63</sup>

Gordon Mackerron, former chair of the Committee on Radioactive Waste Management, says this system proposed by BERR for funding decommissioning and waste management amounts to a hidden subsidy for new reactors. He attacks as "frankly not credible" Government assurances that new reactors would meet the full cost of waste management. His concern centres on proposals to offer operators of nuclear reactors a fixed unit price for waste disposal. And Ministers have agreed to

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<sup>61</sup> Buried Costs, by Ian Jackson, Nuclear Engineering International, 27<sup>th</sup> March 2008.

<http://www.neimagazine.com/story.asp?storyCode=2049209>

<sup>62</sup> Greenpeace 27<sup>th</sup> March 2008 <http://www.greenpeace.org.uk/media/press-releases/taxpayers-facing-nuclear-missile>

<sup>63</sup> Guardian website 21st August 2007

[http://commentisfree.guardian.co.uk/john\\_sauven/2007/08/waste\\_not\\_want\\_not.html](http://commentisfree.guardian.co.uk/john_sauven/2007/08/waste_not_want_not.html)

cap the liability of operators for decommissioning and clean up. Mackerron says we can only have a hazy idea at this stage what a waste repository will cost.<sup>64</sup>

Stephen Thomas of Greenwich University agrees the Government is failing to adhere to its pledge not to subsidise the industry. Companies building reactors will be given a guaranteed fixed price for disposal of waste when they start construction. Claims by Government adviser Tim Stone that this fixed price was “absolutely not a subsidy” are not credible. And from past experience of the accuracy of nuclear cost estimates, it is one that could prove costly to taxpayers more than 100 years into the future when this waste is actually being disposed of.<sup>65</sup>

Thomas believes that with the first UK reactor order still five years away, if companies insist in five years time they will not proceed with construction unless further subsidies are offered, the Government might prefer to capitulate rather than abandon its nuclear ambitions.

Subsidies and guarantees might include: a guarantee from either the vendor or the government of a fixed price for construction, so if the costs do overrun, they do not pay; loan guarantees so that if the companies go bankrupt the banks lending the money are still repaid; and some guarantee on the price paid for the power produced so that if the electricity wholesale price collapses, as it did in 2002, the company is protected.

## Carbon pricing

A company planning to spend £1bn or more on a nuclear plant needs some assurance about the minimum electricity price achievable 12 to 25 years into the future. In a UK-style liberalised market, this is impossible. But if there were guarantees about the long-term price of carbon this might help. At the moment the uncertainty about future carbon pricing is a key block to investors' confidence, so the volatility of the price of carbon needs to be reduced. This could be done by replacing the EU Emissions Trading Scheme (ETS) with a carbon tax, or the ETS could be balanced by government acting as a buyer of last resort under a ‘cap and collar’ system to keep the carbon price within an agreed range.<sup>66</sup>

British Energy (BE) claimed in its response to the Future of Nuclear Power consultation that new reactors don't need to be subsidized provided standard international designs are adopted and fossil fuel alternatives "*carry the cost of the carbon emissions associated with their use*".<sup>67</sup> Similarly EDF say new reactors cannot

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<sup>64</sup> FT 11<sup>th</sup> June 2008 [http://www.ft.com/cms/s/0/4c7e0c5c-370c-11dd-bc1c-0000779fd2ac.html%3Fclick\\_check%3D1](http://www.ft.com/cms/s/0/4c7e0c5c-370c-11dd-bc1c-0000779fd2ac.html%3Fclick_check%3D1)

Gordon Mackerron's Response to 'Consultation on Funded Decommissioning Programme Guidance for New Nuclear Power Stations', May 2008

[http://www.sussex.ac.uk/sussexenergygroup/documents/decom\\_funding\\_consultation\\_gm.pdf](http://www.sussex.ac.uk/sussexenergygroup/documents/decom_funding_consultation_gm.pdf)

<sup>65</sup> Guardian 12<sup>th</sup> June 2008

<http://www.guardian.co.uk/commentisfree/2008/jun/12/nuclearpower.nuclear>

<sup>66</sup> Nuclear Engineering International 24th July 2007

<http://www.neimagazine.com/story.asp?sectioncode=76&storyCode=2046213>

<sup>67</sup> British Energy Press Release 20<sup>th</sup> September 2007 <http://www.british-energy.com/article.php?article=201>

be built in the UK without a mechanism to guarantee the long-term price of carbon. It says the Government has until around 2009 – when new construction decisions are expected – to develop a mechanism "supplemental" to the EU's Emission Trading Scheme. EDF wants the government to guarantee a floor price for carbon, which would mean a Government pay-out if the market price for carbon sinks below the agreed floor price.<sup>68</sup>

The industry had hoped for progress on carbon pricing during the nuclear consultation process, but none was forthcoming.<sup>69</sup> Overall then, the financial risks of private nuclear investment were not reduced by anything in the January 2008 White Paper on Nuclear Power.<sup>70</sup> Mackerron warns there is a real risk we may get the worst of both worlds, where nuclear investment stalls under a risky investment climate while markets hold back from other investment in the expectation that nuclear is just around the corner. Then we really might have a capacity gap and an even bigger risk of the lights going out.<sup>71</sup>

### **Opportunity costs**

Of course a high carbon price, or high prices for fossil fuels, will also make renewable energy and energy efficiency more attractive. As Amory Lovins, co-founder, chairman and chief scientist of Rocky Mountain Institute in Colorado points out, if you buy more nuclear plants, you're going to get about two to ten times less climate solution per dollar, and you'll get it about twenty to forty times slower, than if you buy instead the cheaper, faster stuff – energy efficiency, micropower, and renewables.

So investing in new reactors would actually be damaging efforts to tackle climate change because you are getting less 'solution' for every pound spent. Lovins calls the so-called nuclear revival "a very carefully fabricated illusion". And the reason it isn't happening is there are no buyers. Wall Street is not putting a penny of private capital into the industry.<sup>72</sup>

### **United States**

While the UK Government may be keen to stress that it is leaving the development of new reactors to the free market, there are no such qualms in America. Following months of lobbying from both sides on the nuclear power issue, the U.S. Congress voted in mid-December 2007 to give the nuclear industry about half of what it wanted and approved \$18.5 billion in loan guarantees for new reactor construction and \$2 billion for a proposed uranium enrichment plant in Ohio. But Wall Street is projecting

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<sup>68</sup> Nucleonics Week, Volume 48, No. 44 1<sup>st</sup> November 2007.

<sup>69</sup> Gordon Mackerron: This way is more likely to leave us in the dark, Independent on Sunday, 13<sup>th</sup> January 2008.

<http://www.independent.co.uk/opinion/commentators/gordon-mackerron-this-way-is-more-likely-to-leave-us-in-the-dark-770005.html>

<sup>70</sup> Meeting the Energy Challenge: A White Paper on Nuclear Power, BERR, January 2008.

<http://www.berr.gov.uk/files/file43006.pdf>

<sup>71</sup> The Economics of Nuclear Power: Has Government Got it Right? By Gordon MacKerron, Sussex Energy Group, Dec 2007

[http://www.sussex.ac.uk/sussexenergygroup/documents/economics\\_brief\\_webonly.pdf](http://www.sussex.ac.uk/sussexenergygroup/documents/economics_brief_webonly.pdf)

<sup>72</sup> Amory Lovins: Expanding Nuclear Power makes Climate Change worse, Democracy Now 16<sup>th</sup> July 2008 [http://i3.democracynow.org/2008/7/16/amory\\_lovins\\_expanding\\_nuclear\\_power\\_makes](http://i3.democracynow.org/2008/7/16/amory_lovins_expanding_nuclear_power_makes)

costs of \$5 billion to \$9 billion or more per reactor, so the money won't last long, if it's spent at all. In fact, it would only cover four to perhaps six, at most, new reactors.<sup>73</sup>

Wall Street has signalled it is unwilling to underwrite nuclear projects that are not covered by government loan guarantees. Last year, six major investment banks, including Goldman Sachs and Morgan Stanley, told the U.S. Department of Energy they believed the technology risks, combined with high capital costs and long construction schedules, "*will make lenders unwilling at present to extend long-term credit*".<sup>74</sup>

*"If you were a utility CEO and looked at your world today, you would just do gas and wind,"* says Jeffrey Immelt, chairman and chief executive of General Electric. *"You would say [they are] easier to site, digestible today [and] I don't have to bet my company on any of this stuff. You would never do nuclear. The economics are overwhelming."* Mr Immelt told the *Financial Times* that large-scale nuclear construction would go ahead only if a high enough cost was placed on carbon-dioxide emissions. Only five to 10 US nuclear power projects are likely to go ahead without a carbon-pricing framework.<sup>75</sup>

### **Nuclear economics**

The nuclear industry continues to claim that a combination of learning from past mistakes and new, more cost-effective designs will, unlike earlier reactor programmes, allow the promise of cheap power to be fulfilled.<sup>76</sup>

As a general rule-of-thumb about two thirds of nuclear generation cost is accounted for by fixed costs, that is, costs that will be incurred whether or not the plant is operated, and the rest by running costs. There are three main elements to the fixed cost per kilowatt hour: the construction cost; the cost of capital, which determines how much it costs to borrow the money to build the plant; and the plant's reliability, which determines how much saleable output there is over which to spread the fixed costs.

The construction cost is sometimes known as the "overnight cost" i.e. the cost that would be incurred if the plant could be built overnight. In 2003, the Massachusetts Institute of Technology estimated the overnight cost of a new reactor to be \$2,000 per kilowatt (kw).<sup>77</sup> In 2004 the University of Chicago estimated it at \$1,500/kW. More recent estimates and actual experience suggests costs are much higher. Duke Energy, which wants to build reactors in the US, estimates \$2,500 - \$2,600/kW. The Keystone Center's joint fact-finding committee, which included nuclear industry personnel as

<sup>73</sup> Nuclear Monitor 665, 17<sup>th</sup> January 2008. <http://www.nirs.org/mononline/nm665.pdf>

<sup>74</sup> Globe and Mail 13<sup>th</sup> Feb 2008

<http://www.theglobeandmail.com/servlet/story/RTGAM.20080213.wrcandu0213/BNSStory/energy/home>

<sup>75</sup> FT 19th Nov 2007 <http://www.ft.com/cms/s/0/0338c4e2-9621-11dc-b7ec-0000779fd2ac.html>

<sup>76</sup> The Economics of Nuclear Power, by P. Bradford, A. Froggatt, D. Milborrow and S. Thomas Greenpeace International, May 2007

[http://www.greenpeace.org.uk/files/pdfs/nuclear/nuclear\\_economics\\_report.pdf](http://www.greenpeace.org.uk/files/pdfs/nuclear/nuclear_economics_report.pdf)

<sup>77</sup> Science for Democratic Action, Volume 15, Number 2, January 2008.

<http://www.ieer.org/sdfiles/15-2.pdf>

well as those more sceptical, made an estimate which included interest during construction. This was \$3,600 to \$4,000/kW. The cost of the Finnish reactor currently amounts to around \$4,000/kW. The following table illustrates this:

	Overnight Capital Cost	Capital cost contribution to elec cost	Interest During Construction	Fuel Cost and operating and maintenance	Spent Fuel Disposal	Total
MIT 2003	\$2,000/kW					
Chicago 2004	\$1,500/kW					
Duke 2007	\$2,500 - \$2,600/kW	4c/kWh	1-2c/kWh	1.5-2c/kWh	0.1c/kWh	7-8c/kWh
Keystone 2007	\$3,600 - \$4,000	4.6c – 6.2c/kWh	included			8.3c – 11.1/kWh
Moody's 2007	\$5,000 - \$6,000	9c/kWh	included			14c/kWh
Progress Energy Florida	\$7,727		included	included		
Standard & Poor's 2008	\$5000 - \$8,000/kW		Included.			

The Wall Street firm Moody's also estimated, in October 2007, capital cost including interest during construction, at \$5,000 to \$6,000/kW. Using the same numbers for operating costs as the Keystone Center, this would bring the total cost of electricity to 14c/kWh.

The estimate for two 1,100MW reactors in Florida has tripled to \$17billion.<sup>78</sup> The cost of building new reactors has more than doubled since 2000, according to Cambridge Energy Research Associates (Massachusetts) with a majority of the increase occurring since 2005.<sup>79</sup>

Construction costs for new reactors in the US will soar, according to Standard & Poor's Ratings Services. Construction risk issues that are "more acute" for new nuclear units than for other types of power projects include "cost inflation in input materials and labour, especially nuclear-related labour; supply chain bottlenecks; and a limited construction track record. S&P said it expects "project contingencies to be high to accommodate uncertainty in pricing." Capital costs, after including interest during construction could vary between \$5,000 per kW and \$8,000 per kW.<sup>80</sup>

<sup>78</sup> St Petersburg Times (Florida) 11th March 2008

[http://www.sptimes.com/2008/03/11/news\\_pf/State/Nuke\\_plant\\_price\\_trip.shtml](http://www.sptimes.com/2008/03/11/news_pf/State/Nuke_plant_price_trip.shtml)

<sup>79</sup> <http://www.cera.com/asp/cda/public1/news/pressReleases/pressReleaseDetails.aspx?CID=9505>

<sup>80</sup> Construction Costs To Soar For New U.S. Nuclear Power Plants, Standard & Pooors, 15<sup>th</sup> Oct 2008

Arjun Makhijani of the Institute for Energy and Environment Research in Maryland, says electricity costs from new reactors planned in the US are estimated at 10 to 17 cents per kilowatt-hour. This compares with 8 to 12 cents for wind. And new large solar plants in California are expected to yield electricity prices about the same. Rapid new developments in solar and wind energy and energy storage technologies indicate that new nuclear power plants are likely to be economically obsolete even before the first new ones come online in the United States.<sup>81</sup>

Back in Britain, the Government has vastly underestimated the cost of building new reactors, according to Wulf Bernotat, chairman and chief executive of Eon. He says the cost per plant could be as high as £4.8 billion - nearly double the Government's latest £2.8 billion estimate. His figures indicate that the cost of replacing Britain's ten nuclear power stations could reach £48 billion, excluding the cost of decommissioning ageing reactors or dealing with nuclear waste.<sup>82</sup>

### **Learning from past mistakes**

Former *Guardian* Environment Correspondent, Paul Brown, in a report called 'Voodoo Economics and the Doomed Nuclear Renaissance', says "*the Government is trying to dupe the public into believing [the huge cost overruns] won't happen next time, although all the evidence is to the contrary ... the scale of the technical failures and financial disasters facing the current nuclear industry [is shocking] the costs of which will all fall on the taxpayer*". The report concludes it won't be possible to build a new generation of nuclear power stations without pledging large sums of taxpayers money and extending unlimited guarantees to underwrite the debts of the existing and future nuclear industry.<sup>83</sup>

The New Economics Foundation accuses the Government of "fixing the market". Hidden subsidies not mentioned above could include the cost of adapting transmission lines from any new plants which are expected to be considerably larger than existing plants; and security and transporting waste fuel which could run into millions of pounds a year would also come from the public purse.<sup>84</sup>

The Government appears to be making every effort to give the industry the reassurances it wants on waste and liability. Whether this will be enough to convince investors to invest without a long-term guaranteed price for carbon remains to be seen. Either way it seems clear the Government will, as many expected, renege on its commitment not to subsidise new reactors.

### **Pete Roche**

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<sup>81</sup> Nature 2<sup>nd</sup> Oct 2008 <http://www.nature.com/climate/2008/0810/full/climate.2008.103.html>

<sup>82</sup> Times 5<sup>th</sup> May 2008

[http://business.timesonline.co.uk/tol/business/industry\\_sectors/utilities/article3872870.ece](http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article3872870.ece)

<sup>83</sup> Voodoo Economics and the Doomed Nuclear Renaissance by Paul Brown, FoE May 2008

[http://www.foe.co.uk/shop/index.php?main\\_page=product\\_book\\_info&cPath=1\\_2&products\\_id=342](http://www.foe.co.uk/shop/index.php?main_page=product_book_info&cPath=1_2&products_id=342)

<sup>84</sup> Guardian 11<sup>th</sup> Jan 2008

<http://www.guardian.co.uk/environment/2008/jan/11/nuclearpower.energy1>