WESTMINSTER ENERGY FORUM

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THE 3RD AND FINAL WEF NUCLEAR POLICY CONFERENCE IN THE 'HALF LIFE OR STILL LIFE' SERIES

NUCLEAR REGULATION & RISK MANAGEMENT

IMPENDING ISSUES & IMPLICATIONS FOR THE FUTURE OF NUCLEAR POWER IN THE UK

CONFERENCE EXECUTIVE SUMMARY

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Snapshot Summary

- Chris Lambert, WEF Director, outlined progress to date on the WEF agenda, and the next steps for the Forum.

- John Polcyn, Vice President for New Nuclear Generation at Bechtel US, outlined how the US Government has incentivised new build by reducing regulatory risk, particularly through the Energy Policy Act 2005. Key levers have been standard design licences and combined construction and operating licences.

- Preston Chiaro, CEO of Rio Tinto, argued that there have been two cycles in the uranium market already, and that a third is just commencing. Although the demand/supply mechanics of the uranium market suggest growing maturity, he felt it was moot whether or not uranium would ever become less sensitive to one-off socio-political or environmental events.

- Stephen Walls, Head of Technology Services at BNFL, argued that the UK consents/approvals process is complex, risky and expensive. However, he argued that new plants could be onstream within just ten years of a clear and positive Government policy statement on nuclear, if it were backed up by simplified regulation, such as pre-approved site designs.

- Hugo Peek, Global Head of Power and Equities in Corporate Finance at ABN AMRO, argued that whilst demand for nuclear generation is growing, banks will remain reluctant to finance projects unless serious thought is given to mitigating the key risks – economic, regulatory, and public perception.

- Mark Johnston, Greenpeace Europe, argued that the trend of EU regulation is towards greater liberalisation. He stressed that in aiming to create the circumstances for greater competition, the EC is cautious to avoid state aid, and more particularly situations in which Governments bail out firms with respect to liabilities they ought to have foreseen.

- Dr Andy Hall, Deputy Chief Inspector at the National Installations Inspectorate, argued that the current regulatory regime in the UK is both sufficiently robust and sufficiently flexible that it would not need to change to accommodate new nuclear build. He stressed that the onus will remain on licensees to demonstrate that their design and management of plants is safe.

- David Hayes, Strategy and Commercial Director at the Nuclear Decommissioning Agency, outlined the scope and remit of the NDA. He also presented some key issues facing the organisation going forward, including industry restructuring, Government decisions on waste management, an industry-wide pension scheme (IWS), and the restart of THORP.

- Pat Tighe, Vice President for Business Development at AECL, argued that nuclear new builds pose a constellation of risks, which can only be addressed through the appropriate project and financing models – essentially where vendors step up and take on more of the risk. He also outlined some key steps the UK Government could take to facilitate such a transition.

- Professor Roger Kemp, Head of Engineering at Lancaster University, compared nuclear industry restructuring with the rail industry, and drew several important lessons. If new build is to be

commercially viable, his key messages were: plant manufacturers and not operators must be considered the 'design authorities'; and the ALARP system of risk management must be revisited.

- Ciara Ryan, Partner for Energy Markets at Deloitte, outlined the central components of a scenario-driven, integrated, risk-management model for nuclear new build, arguing that such a quantitative model is necessary to reduce public sector liabilities. She also discussed several key issues facing any new build programme: insurance, decommissioning costs, waste management, and a possible IWS.

- Professor Ragnar Lofstedt, The King's Centre for Risk Management at King's College London, highlighted some successes and some failures in the public debate around nuclear. He emphasised the adversarial nature of the debate, and argued that better thought-out communication strategies are necessary for new build to succeed in the UK.

- The conference concluded with a panel discussion in which Russell Marsh, Policy Director of the Green Alliance, Dr Jon Gibbins of Imperial College and the UK Carbon Capture and Storage Consortium, and Carola Hoyos, Energy Correspondent for the *Financial Times*, discussed whether nuclear is really the fuel of the future.

Executive Transcript

The US Energy Bill and the New Build Template

John Polcyn, Vice President, New Nuclear Generation, Bechtel US

The US has 103 nuclear plants, which provide 20% of the nation's electricity. US power generation displaces 680 million metric tonnes of CO2 a year – equivalent to 131 million passenger cars – which is why the co-founder of Greenpeace has concluded that the US needs nuclear power going forward. However, the supply of nuclear plants is now out of sync with demand because many countries have avoided new build until recently – the current queue time for new reactors is five and a half years.

The key drivers of the US new-build agenda include: the US Nuclear Regulatory Authority judges the US industry remarkably safe; the industry has a proven performance – plant capacity has increased to 92% from under 60% in the early 1980s; it is cost-effective and affordable – nuclear is the lowest-cost baseload generation, while tax credits and cost-sharing with Government also make engineering costs very competitive; the Government have linked national security to energy security, judging the US to be too reliant on foreign sources of power – nuclear offers grid stability and greater energy independence; and nuclear generation compares favourably with renewables in respect of CO2 emissions.

In addition, the US nuclear industry has seen great and ongoing consolidation, enabling operators to focus on maximum output at lowest cost. Based on stock performance, US investors now perceive utilities with nuclear assets to be very sound investments. The US began its transition to a deregulated nuclear-generation market in the mid-1990s, and now generation is equally distributed between deregulated and regulated. The regulated market offers fixed but low returns so utilities are increasingly focusing on the deregulated market, particularly since the US is projected to need 50% more energy by 2025.

The US Energy Policy Act 2005 aims to ensure reliable energy transmission by investing in infrastructure and delivering a diversity of fuels/sources. As one element in this it aims to jump-start nuclear new build. The Act means Government now back-stops the pooled private nuclear liability insurance, and offers: loan guarantees for 80% of the project cost, delayed-protection risk assurance, production tax credits, and funds for decommissioning. Government also helps with research and development, including funding two next-generation plant-design tests and a university programme for nuclear engineering. Furthermore, US utilities with nuclear assets must factor lifecycle costs, such as waste managing and decommissioning, into their pricing. Thus, the costs are not borne by the operator.

Essential to encouraging new-build has been the new approach to licensing. By creating early site permits, by which site approval is obtained before a utility decides to build, and standard design certifications, the process reduces the risk for utilities and knocks out the early phase of applications – debate will centre only on site-specific elements of the design because other elements are pre-approved. The US Government have created a combined construction and operating licence, which includes all relevant site-specific information and intends to provide greater regulatory certainty for utilities. An independent body will also verify the plant is built to the design requirements. Since this does not offer opportunities for public intervention, it minimises the risk to plant operations.

With the Energy Policy Act 2005 and the forthcoming Nuclear Power 2010 Programme – an industry-Government cost-sharing initiative for new deployment – several utilities are now developing applications for early site permits and combined construction and operating licences. John Polcyn noted that the US nuclear industry has 'stopped apologising': the Nuclear Energy Institute has been active with the media, explaining to the public what nuclear power does for the US, and President Bush intends to talk about nuclear energy in his State of the Union Address. The outcome is the highest-ever public support for nuclear power generally, as well as for new build.

The Uranium Market in a Global New Build Landscape

Preston Chiaro, CEO Energy, Rio Tinto

Rio Tinto is the second largest mining company in the world, the second largest coal and uranium producer, and the second largest iron-ore exporter. Its assets are based in the OECD, but it has global options for growth and exploration. Rio Tinto's two major uranium mines are in Australia and Namibia. Although Rio Tinto has one of the best safety records in the sector, employees are still injured. Interesting, the most common injuries do not stem from mining operations per se, but rather simply from people moving around, either through light vehicles accidents or tripping over etc.

Preston Chiaro presented a map detailing global energy reserves – i.e. the relative amounts of coal, oil, gas and uranium around the world – which showed that uranium reserves are largely concentrated in Australia. Worldwide energy need is projected to rise 70% by 2020, and by three times by the end of the century. Each source of energy, including renewables, has its own attendant environmental, social and economic footprint, and safety issues. Governments must decide for themselves how to weigh these factors. The 170,000,000 tonnes per annum of coal that Rio Tinto produces, and the 9,600 tonnes per annum of uranium oxide (U3O8) that Rio Tinto produces, have almost the same inherent energy content. In other words, a pound of uranium oxide has about 20,000 times as much contained energy as a pound of coal, and Rio Tinto happens to produce about 20,000 times as much (by weight) of coal as uranium

Are there cycles in the uranium market? 1950-1970 can be seen as a first cycle, a period that saw the birth and growth of the nuclear weapons and nuclear power industries. The market faced significant distortions during the period owing to Government demand for weapons-grade material, and then the subsequent huge stockpiles. The price peaked in 1953 at $72/lb of Uranium 308 (U308) at constant dollar rates, and production peaked in 1959 at 130 million lb U308. 1970-2000 represents the second cycle, a period that saw many factors affecting the market – there were nuclear power accidents, and restrictions on nuclear proliferation meant the need for weapons-grade material reduced, creating a secondary source of highly-enriched uranium. The price peaked in 1976 at $100/lb U308, and production peaked in 1981 at 170 million lb U308.

The world now produces 39,000 tonnes of uranium a year, and the estimated demand is 65,000. Albeit with fluctuations, the price is now less than in 1950 and the trend is generally downwards, just as it is with most other such commodities – people become smarter and develop more efficient discovery and production methods.

It is likely the market is at the beginning of a new cycle, particularly given the key factors driving the price going forward: growing demand based on rising reactor capacity in developed countries, developing country demand, and the demand amongst utilities to build inventories; and a lag in the supply of highly-enriched uranium – there was no incentive to explore for new deposits when prices were $10 or less. Thus, it is likely there will be modest growth in demand for nuclear power and uranium, and in response the supply side is likely to significantly increase their exploration spend. The potential price and production peaks for the cycle are hard to judge because the key question remains: will the uranium market finally come of age, or will it continue to be driven by one-off socio-political or environmental events?

Nuclear Regulation and New Build

Stephen Walls, Head of Technology Services, BNFL

A wide range of consents/approvals from a variety of authorities are required in the UK with respect to nuclear new-build. These include: justifying that the benefits outweigh the risks with respect to ionisation processes; planning consent and Section 36/37 approval; the site licence under the Nuclear Installations Act; discharge authorisation under both UK and EU regulation; and the strategic environmental assessment. Attaining requisite approvals can be a protracted and uncertain business, increasing regulatory risk. For example, the Sizewell B enquiry phase lasted six years, of which just 30 days were spent debating local issues. The Hinckley C enquiry that commenced just two years later also took a very long time and covered much of the same ground.

Is there a better way? The French experience of new build was ameliorated for several reasons, not least owing to Government endorsement and the decision in the 1970s to adopt a series of standard designs – i.e. the series is subject to generic review, whilst there is a separate and limited site installations review covering site-specific issues. Moreover, the French regulatory process now obliges a public body to organise widespread public debate. This operates to a tight deadline, but it is intended to ensure the public can raise concerns. Similarly, Finland has achieved timely and robust decision-making in respect of its fifth reactor, which is now under construction. Once again, it was Government that established the need for another reactor before putting the idea out to extensive public debate. The Finnish review was also greatly expedited by lessons from France and Australia, and work commenced very swiftly once a site was selected.

These experiences suggest certain elements are crucial in facilitating new build: public debate and then clear Government policy in favour of new build that establishes need and enjoys widespread support; a clear strategy for regulators that sets out the terms of reference and timetable for each stage; regulators having a view on candidate design 'licensability'; completing regulatory and environmental assessments prior to public enquiry; a clear understanding of regulatory requirements for approvals during construction and commissioning; and a generic design review that looks at all common issues associated with approving a series of stations of the same design.

If these positive elements were in place, a programme of new build could be expected to run as follows. First there would be a period of preparation and policy development before a revised energy policy is issued. Then would come phase one, a pre-licensing and authorisation phase lasting three years, in which a licensable design is selected and by the end of which regulators would have produced licensability statements of site and design. This phase would look at all the design and safety-case information, seek to resolve technical issues, and hopefully achieve a position where regulators can say there are no 'show-stoppers' for a particular design. Next would come phase two, a Section 36 and public enquiry phase lasting two years, by the end of which licences would be issued, planning permission obtained, the investment decision made, and the production contract signed. After phase one, phase two ought to be able to concentrate on site-specific issues. Finally there would be phase three, a construction and commissioning phase lasting five years, by the end of which the first plants would be on stream. If this sort of timely approvals process were in place, new plants could be on stream within approximately 10 years of a supportive Government policy.

Banking and New Build Regulation

Hugo Peek, Global Head of Power and Equities, Corporate Finance, ABN AMRO

Governments globally are reconsidering nuclear as an integral part of the future fuel mix for several reasons, including: energy demand is set to rise dramatically; security of supply, low carbon profile; strong economics compared with fossil fuels; improved technologies; and improved public acceptance – particularly when the focus is on a low-carbon world. Nevertheless, there are several significant hurdles to overcome: the market risks, including high capital costs and uncertainty over financing generally; public acceptance; decommissioning costs; waste storage economics; and the long lead times associated with the permitting processes.

Global plant additions are set to outpace retirements every year to 2019, and although there is no clear European consensus over nuclear, very few nations are wholly set against new build, with many actively considering it and several actually building. Governments in Europe and worldwide are being forced to reconsider their nuclear positions as industry players internationalise and diversify their nuclear operations. Continued consolidation amongst the major energy suppliers is likely as growth prospects and heightened interest amongst investors in the sector drives mergers and acquisitions. This has not been happening with respect to nuclear assets owing to heavy regulation, but is this the next frontier? The interest from private equity firms in nuclear generation is a very significant signal that things are starting to change. Cross-border consolidation between European utilities with nuclear assets in their portfolio is beginning – something that previously could not happen precisely because of this element of their portfolio.

New private financing is likely to focus on new-build and lifetime extension since programmes of enhancement/refurbishment and decommissioning are frequently dealt with by public bodies. The all-in new build costs are reducing over time allowing for profitable construction – new nuclear build now compares favourably with all other sources of generation. Innovative solutions to funding are being developed through project financing and sovereign lending etc. Moreover, private equity is involved in various lifetime extension projects in the US and the Netherlands.

Banks are traditionally cautious in financing nuclear projects compared with corporates because if the firm that owns the assets goes bust, the banks become the owner of those nuclear assets. Moreover, banks are normally the last to accept risks because although they suffer any downside to their investment, they do not normally share in the upside. Banks have to consider the risks to their reputation, as well as the standard economic risks/liabilities in their investments. For nuclear, these include risks associated with: construction, technology, public perception, proliferation, environmental issues, decommissioning, regulation and any residual liabilities.

Banks become involved in project financing when they believe the risks of building and operating the project are adequately spread amongst those best suited to manage those risks – i.e. when there is a liquid market, banks will take on greater risk. With respect to nuclear, the regulatory risks and liabilities are still unproven, which means banks are being asked to be incredibly innovative. Banks need the right public perception, regulation and economics if they are to invest. Facilitating this means achieving: Government-backed financing; a strong and stable regulatory framework; export credit agency backing; liability indemnities; co-financing; and a strong emphasis of the benefits of nuclear to the public.

Post-Closure Liabilities – EU Regulatory Trends

Mark Johnston, Greenpeace Europe

The previous presentation suggests the financial community remains agnostic about nuclear, if not openly sceptical. However, even though there is some interest in financing the front end of new build projects, decommissioning is a bigger problem than private investors yet acknowledge, particularly since it is not only a financial problem, but also a strategic political issue across the EU.

The policy context for nuclear is one of political and legal duality between the EU and the UK, and the regulatory influences run both ways. There is a general presumption against state aid and an emerging EU aim seems to be to create a single internal energy market, hence the two electricity directives – the thinking behind which is avoiding large utilities becoming too dominant. However, there are as yet no legal obligations specifically related to energy, only those that indirectly influence practices, such as environmental protections. The key policy objectives of the EU are economic and environmental, and there are also key external-relations issues associated with fuel and proliferation. All these factors mean there is a much greater focus on energy and much closer scrutiny of the nuclear option. Nevertheless, Brussels moves slowly…

The European Commission (EC) was confident of completing two pieces of work last year, both on decommissioning funds, and both have been delayed. When the EC does publish the second piece, it will set down 'recommendations' for principles governing decommissioning funding, rather than obligations (or directives). The EC's final 'Annual Report Two', a review of issues as part of the new electricity directive, has been delayed by member states unwilling to cooperate, but it is due to be published this year. Moreover, a new in-depth survey and monitoring exercise is now underway.

The European Parliament (EP) has made several key pronouncements on the nuclear issue. In summary, the EP considers it necessary for all member states to ensure nuclear projects have sufficient resources for all aspects, including decommissioning and waste management, to uphold the polluter pays principle and 'avoid any recourse to state aid'. The EP has a broad definition of state aid, one that includes many indirect subsidies. Moreover, the EP has announced that these financial resources must be managed/used with 'maximum transparency', and for 'external auditing to be guaranteed'. The EP also 'questions whether the accounting provisions made so far in a number of member states and the corresponding financial resources are equal to the real needs'.

The Council of Ministers has established a working group to look at these issues in parallel with the EC and EP, one theme of which is decommissioning funding. This group is halfway through its two-year work schedule.

Thus, all these elements come together this year. It is clear there is some support to move towards legislation if the recommendations on decommissioning funds are not picked up by member states and the utilities. Thus, avoiding legislation relies on implementing the recommendations scrupulously from now on.

Mark Johnston offered two case studies to illustrate why policy is moving so firmly towards making sure the public purse does not have to pick up the ultimate liabilities. British Energy crashed in 2002, and then spent two and half years restructuring. Most of the back-end costs were assumed by the UK. The total public aid package of £3.483 billion received reluctant EC approval in 2004, and is set to extend beyond 2100 – £247 million has been paid thus far. Slovenské Elektrárne was due to be part privatised, with ENEL taking 66% at €840 million. The deal includes four nuclear plants. However, the 'liquidation' fund lacks resources and state aid was proposed to fix this through a supply levy. Sale completion has been delayed owing to a complaint from an NGO, and the EC still awaits notification. ENEL will not commit to any new build because of the back-end cost uncertainties.

Harmonisation of EU laws on post-closure finance is gaining momentum in line with improved market regulation. Therefore, the costs and risks of nuclear will be borne to a much greater extent by undertakings and not states. Ring-fenced provisioning for liabilities will also mean that assumptions are tested more rigorously – in respect of 'disposal', for instance. Thus, EU legislation in this arena is likely.

Would Nuclear Safety Regulation Need to Change to Accommodate New Build?

Dr Andy Hall, Deputy Chief Inspector, National Installations Inspectorate

Health and safety at nuclear plants is regulated under the Health and Safety at Work Act 1974, which amounts to the duty to reduce risk 'as far as is reasonably practicable', and the Nuclear Installations Act 1965, which attaches conditions to nuclear site licences for the safety and handling etc of nuclear matter. Plants are also subject a series of other safety regulations, such as the ionising radiation regulations 1999 etc. The two key authorities in this arena are the Health and Safety Executive (HSE) and the Nuclear Installations Inspectorate (NII). These bodies regulate the entire range of nuclear activities – i.e. the Atomic Weapons Establishment, fuel fabrication facilities, power reactors, reprocessing plants, dockyards for nuclear submarines etc. The arrangements licensees have vary according to the type of facility, but all

licenses granted are lifetime licences – i.e. there are not separate licences for building versus decommissioning. Moreover, these licences cannot pass between companies unless specifically agreed by the regulators.

Special features of the UK nuclear regulatory system include: it is non-prescriptive – operators are not told how to achieve safety, but rather given safety goals. Moreover, the nuclear site licensee bears absolute responsibility for harm resulting from work activities on the site and has to: be an 'intelligent customer' for any work placed with contractors; comply with a set of standard licence conditions; and manage nuclear safety and demonstrate this to NII. In demonstrating safety, a licensee's procedures must grade their proposals for new plants or changes to existing plants/organisation on the basis of their potential safety significance. NII agreement must then be gained before the most safety-significant changes may be implemented. Making licensees set out the reasons they believe they are safe means they have to have large technical departments, cutting the costs to the regulator. NII approval is based on realtime technical assessment of the licensees' safety cases in that the regulatory regime sits in place all throughout the process – there will be issues about which companies must approach the regulator throughout the lifetime of projects.

The benefits of such a system include: the goal-setting philosophy does not constrain proposals; the range of plant regulated shows the flexibility in the system; and the onus on the licensee to set out their own standards, design and operating regime, and to demonstrate that this is safe, significantly reduces the cost of regulation.

The technology has matured over the past two decades since the Three-Mile Island incident at Sizewell B. Moreover, there have been several key shifts in the regulatory and economic environment since that time that have improved safety and made nuclear more attractive. These include: the development of 'international' reactor designs; international safety requirements/guidance; the Nuclear Safety Convention; NII policy revisions; energy generators are no longer the monolithic entities they once were; companies are encouraged to seek regulators' views on design/technology to promote future sales; and there is better joined-up working between health, safety, environmental and security regulators.

Nevertheless, a number of key questions remain for the future of nuclear regulation: how best to manage regulatory and commercial risks; whether foreign regulatory assessments could inform the judgement of domestic regulators, and if so how this might happen; and whether the HSE could respond to a request for view from a company other than a prospective licensee.

The current regulatory system does not need to change to accommodate new build; there is new nuclear build underway already, albeit not nuclear reactors. However, the regulatory strategy may need further development to respond to any issues thrown up. Companies must recognise that both regulators and the licensee might require design changes, rather than simply being able to implement those used abroad. Whatever happens, the licensee will still need to demonstrate they have reduced risk as far as is reasonably practicable.

The Nuclear Decommissioning Agency – Strategic Perspectives

David Hayes, Strategy and Commercial Director, NDA

The NDA was established by the Energy Act in April 2005. It covers 20 nuclear sites – both BNG and UKAEA – with £56 billion of liabilities. It has an annual budget of £2.3 billion, and an annual income of £1.2 billion through management and operations contracts fixed at a cost-plus-one basis. One of the NDA's key Public Service Agreement targets is to reduce liabilities by 10% by 2010.

The NDA has now submitted a draft strategy to Government, which must be approved or otherwise by August 2006. The key tenets of this strategy are: robust, costed and funded plans; real progress in reducing high-hazards; competitions to manage sites; a better approach to waste management, particularly low-level waste for which the only disposal site is due to run out of capacity soon; to accelerate Magnox decommissioning; and to create defined end states and timescales, reducing clean-up time, which currently takes 125 years. Moreover, there is a soft agenda of promoting skills, developing best practice, and encouraging socio-economic development in neighbouring communities, especially since plants will previously have been the major employer in the area.

The key issues for the NDA in coming years include: industry restructuring – e.g. the sale of BNG, and developments for Westinghouse and UKAEA; Government decisions on waste management; establishing an IWS in preparation for competition; the restart of THORP; and approval for the strategy and competition schedule. The NDA now has a better idea of the cost, scope and schedule of what needs to be done, and it is beginning to make its mark on the skills agenda. Moreover, there is now greater recognition amongst industry of the Agency's role.

Mitigation of Project Risk in New Build

Pat Tighe, Vice President, Business Development, AECL

The number of reactors in service has dwindled over the last decade. Many people with knowledge in the nuclear industry have retired, and this trend continues, causing inevitable concerns over supply. The top four suppliers worldwide are AECL, AREVA, General Electric and Westinghouse. Even though the last ten years have seen several new builds, the number of suppliers has also dwindled, restricting the requisite expertise to ever fewer companies. Meanwhile, demand for increased generation is growing across the world and because supply is limited, nuclear generation is being considered seriously by all nations. It is conservative to expect that 157 GW of new nuclear plants will be constructed by 2030. Thus, it is crucial for nuclear to address its issues.

There are several key issues facing new builds. The industry must recognise that it comes with a tarnished image, and there is a lot of work to do to address the perception nuclear is heavily subsidised and uneconomic. The industry has always been linked to Government because of its 'special features', but that need not be the case going forward. The industry is seeking new orders on a commercial basis with limited Government support, and some jurisdictions are working on solving this problem – the US Energy

Act for example. Nevertheless, financing remains the key issue for new build and this comes down to a clear identification and management of risk. The vendor cannot look backwards in this respect; the industry needs innovative approaches to risk.

Nuclear new build comes with a constellation of risks, including: nuclear risks – political, regulatory, decommissioning and waste disposal etc; commercial risks – market price and demand, and operations; project cost risks – completion, schedule, 'soft' costs; and financing risks – lenders and equity holders (who focus on all risks, including country risks, decommissioning etc). Addressing these risks effectively means finding an appropriate blend of risk in the project model and the financing model. The key message is that vendors must be willing to step up and take more risk than they have in the past.

Historically the situation has been simple for vendors in that owners take all the risk. In the future, AECL expect to see vendors taking an ownership stake in plants as part of a consortium, which will take most of the risk. Nevertheless, there will still be a need for Government prior to and during the life of the project in that there must be a sufficiently clear regulatory environment. It is also important to create some stability on the market side to attract investors, but it is a moot point how to bring this about. The key elements of success for vendors and turnkey-suppliers will then be: local expertise and resources, defined scope and division of responsibilities, effective turnovers from design to construction to commissioning, and advanced project management tools.

There are several key issues to think about in applying all this to the UK. Although the UK energy market is fully liberalised, it is not necessarily structured in such a way that makes large capital projects attractive. Carbon emission trading needs to be extended to nuclear as an incentive mechanism. Financing models for new build should reflect new financial and commercial risks as the level of proponent/vendor risk sharing increases. The Government must backstop with respect to key nuclear issues, in particular decommissioning and waste disposal. Finally, some thought should be given to market price stability and how to support it.

Regulating Safety in a Disaggregated Private Sector – A Challenge for New Build

Professor Roger Kemp, Head of Engineering, Lancaster University

Professor Kemp composed his comments on safety requirements and the new nuclear industry structure around a comparison with the rail industry, which went through a similar restructuring. Privatising the rail industry did not compromise safety – fatal accidents have been falling since the 1960s. However, it did increase the regulatory burden on the industry by an order of magnitude, greatly increasing cost and driving away some foreign investors. A similar experience is likely for nuclear. Structural change in the two industries is also similar: past experience was of a single, monolithic state operator owning all designs, but the future for nuclear will see several operators buying 'proven' designs from overseas – i.e. rather as train operating companies (TOCs) do. Moreover, other elements of the previous monolithic organisation will move out to specialist firms – nuclear plant operators will be just one element of the industry.

Another way of looking at this is in thinking of which elements of the design will be expected to be controlled by plant operators versus other elements of the industry. For example, British Rail was responsible for the vast bulk of design under the old rail system, including the business, functional and system specifications as well as the specifications for detailed requirements. After privatisation, TOCs were only responsible for the business specification and some elements of the functional specification; the rest was handled by other companies.

A design authority (DA) for a system is the body that understands both the technical and operational requirements, and the design of the system – i.e. the 'know why'; not just the 'know how'. It has the authority, competence and responsibility for confirming that the system meets its technical requirements and is safe for use. It retains the design information such that if an accident occurs many years after the system is in service, it can recall the original designs. Moreover, it is responsible for establishing and maintaining the configuration of the design throughout its life, and thus may be called on to assess the technical, operational and safety implications and suitability of modifications.

There are two models for a DA: the 'construction, design and management model' (CDM), where the contractor produces a safety file with all relevant calculations, and the owner retains this file and assumes responsibility for monitoring etc; and the 'original equipment manufacturer model' (OEM), where the manufacturer retains the design information and monitors safety performance etc. The CDM model failed in the rail industry because when several different operators bought similar trains, they had to go through separate and complete regulatory reviews each time. Contrast this with the aircraft model, by which Boeing guarantee the safety of their product. If several different operators are planning to use the same design of reactor, which model is more appropriate for the nuclear industry? One issue to consider here is that it is easier to retain straightforward information at a single source, rather than diverse information at disparate sources.

UK risk management policy operates on a goal-setting philosophy – i.e. it is not prescriptive. Control of risks remains the responsibility of those who create them, rather than the legislator. The aim is that legislation can withstand rapid technological advancement and societal change. The UK has also always taken the view that someone who operates something is responsible for maintaining it. When the railway was privatised, Railtrack assumed responsibility for the safety of the network, whilst TOCs were assumed to be an 'intelligent customer' for the trains. This did not work because the manufacturer was the only authority that truly understood the product.

Power stations are more difficult than trains for several reasons: they are much more complicated; safety incidents have potential for far greater impact; power stations are less self-contained; there is less recent UK experience of building and regulating them; and there are factions of the population strongly opposed to new nuclear build, which one can expect the regulator to take greater notice of.

The philosophy behind managing risk stems from the health and safety concept of ensuring risk is 'as low as is reasonably practicable' (ALARP) – i.e. it is a flexible model. However, it is clear that the public are either unaware of or unwilling to accept this philosophy – think of public reaction to the BSE crisis or various rail incidents. Moreover, although the flexibility ALARP affords can be very useful, it can lead to anomalies. If one breaks down projects into their elements rather than dealing with them in their entirety, or if projects require modifications, the interpretation and reinterpretation of ALARP with respect to the various project elements can lead to cost overruns and overly-restrictive regulatory intervention. The value of the French

system, for instance, is that there is a clear baseline, which is not open for interpretation. PA Consulting has argued that ALARP places a huge burden on the industry by forcing them to chase perfection. Indeed, PA continue, whilst ALARP is useful for improving safety performance that is close to the intolerable level, a baseline system is more appropriate for risk that is at least in the middle of the tolerable range, such as for the rail industry.

Any bidder faces some key regulatory risks associated with using ALARP: the amount of work involved in proving risks are ALARP for every sub-system; finding statistics to satisfy regulators with respect to highly improbable events; demonstrating risks are ALARP for societal concerns where there is no quantifiable risk; and whether societal concern allows the regulator to impose arbitrary regulations against scientifically implausible risks (and the costs associated with that).

All this poses some key regulatory challenges going forward. If there are to be several power stations of basically the same design, run by different operators, is it appropriate for each operator to be treated as the DA for that station? If not, how is an overseas constructor brought into the safety process? How does a contractor demonstrate ALARP in a complicated project where there may be thousands of ways of reducing risk? How do we bring into an ALARP regime designs that have been produced under other safety regimes? Is an ALARP regime suitable for dealing with societal concern? Thus, the issue is this: how do we construct a safety regulatory system that allows new power stations to be built by the private sector without huge financial provisions for regulatory risk?

Integrated Risk Management Models – Reducing Public Sector Liabilities

Ciara Ryan, Partner, Energy Markets, Deloitte

Real and effective joined-up policy will require some complex analysis to make explicit the costs, explicit and hidden, for UK plc of any power generation mix. 2006 represents a key crossroads for UK energy policy; no longer can the market alone be relied upon to deliver policy objectives. The challenge for Government policy is twofold: to provide appropriate signals/levers to the market to best meet its objectives; and to establish monitoring frameworks that allow Government to manage the exposures associated with each and every technology option in the generation portfolio. Three elements are key to developing solutions (market signals/levers) to this complex challenge: scenario design; risk quantification of the 'portfolio' effect of those risks to UK plc; and stakeholder assessment. Thereafter a suite of tools are available to Government to shape energy policy outcomes and manage risk. Although a number of nuclear risks are particularly complex, solutions exist whereby Government could proactively minimise Exchequer exposure on these issues.

Joined-up energy policy requires an assessment of the market levers that will deliver; and a joined-up approach to managing the consequent exposures for UK plc. There are three key elements of decision-making. First, taking into account both transparent (such as decommissioning/waste) and less transparent (such as industry-displacement/price-volatility) costs/benefits to the UK of different forms of generation. Second, a scenario-driven understanding of the correlation of costs and risks between and among technologies that is able to provide for analysis and resolution of concerns. Third, identifying the

right market frameworks, reinforced by long-term policy measures, which provide investors, businesses and consumers with the right incentives to invest in a particular technology.

Some of the hidden costs for UK plc to consider are potentially huge, for example think of those associated with security of supply, decommissioning, building of a nuclear repository, over-sizing UK storage and interconnection, and oil and gas volatility. Moreover, there are indirect costs, such as the damage to other UK industries if UK energy prices rise to high.

Exploring the risks and costs to Government of energy policy in a joined-up manner means focusing on four elements: developing illustrative scenarios; for which risk mapping is then carried out; and risk/outcomes quantified for UK plc; and then a set of possible instruments developed enabling Government to either mitigate those risks, or design them out. Risk-sharing models would be one instrument available to Government, by which risks are placed with those best able to manage them. For example, the public sector may take total responsibility for regulatory risk, but only partial responsibility for risks like decommissioning costs, or market risks like CO2 prices.

Several key issues must be addressed whatever happens. First, there is the issue of who bears responsibility for insuring nuclear plants. The core problem is that the principle objective of various international conventions is to channel the economic effects of injury or damage caused to the public to the nuclear operator on a strict basis, and operators require financial security or insurance in support of this obligation. However, where even part of this liability risk is uninsurable, there is a need for Government intervention or risk taking that has financial and political implications. Potential solutions include: finding alternative sources of insurance capacity; a high degree of mutualisation of risk by operators, as in the US; and facilitating industry in funding its own risk. Further, the Government could help by: attaining agreement on implementable current limits within the market, and enacting legislation; and reviewing over time the scope for further proactive mutualisation of liability risk within Europe or the use of commercial charging for risk assumed by Government as insurer of last resort.

Second, there is the issue of who is going to fund the future costs of decommissioning. The core problem is identifying who bears responsibility for funding future decommissioning/dismantling activities resulting from a new nuclear programme. The 'polluter pays' principle implies that the responsibility should rest with the owner(s) of the plant. If the plant operator is unable to perform its required duties, the responsibility may fall on the regulator (Canada), or to the state (Finland), or a governing body that will accept long-term responsibility (Spain, Belgium and the UK). EU OECD countries are also bound by the terms dictated in the Euratom Treaty, which establishes uniform safety standards to protect workers and the general public. Potential solutions include: in many OECD countries it is a legal or contractual requirement that nuclear operators create and maintain mechanisms for decommissioning; in other countries the relevant Government agency has devised specific formulas, fees or taxes; and the US industry is currently exploring options for insuring on a mutual basis the risk of shortfall in decommissioning. On existing decommissioning, NDA performance as professional manager needs to be proven in order to achieve public and political acceptance. Moreover, for new build, the funding is relatively small at approximately 1% of revenue. Thus, Government could, for instance, mandate 2% per annum funding to mitigate risk where the upside was shared. Government may also wish to explore possible insurance options for sections of under-funded exposure.

Third, there is the issue of waste management. The core issue is to define a strategy for radioactive waste disposal – i.e. in the first instance deciding on the appropriate technology to handle waste. The most favoured method for high-level waste is burial of vitrified wastes, or of spent fuel assemblies, without reprocessing in dry, stable geological formations some hundreds of metres deep. The scientific and technical community is generally convinced as to the soundness of this approach. Because surface storage for 30-50 years is first required so that heat and radioactivity can dissipate to levels that facilitate handling and storage, to date there has been no practical need for final high-level waste repositories. Given that some radioactive waste has half lives of tens of thousands of years, arrangements relating to who bears the responsibility for the management of waste during this period present some challenges. Moreover, the funding of waste disposal activities also needs to be considered, either with or in parallel to the funding and management arrangements for decommissioning and dismantling activities. Potential solutions include: construction of the Olkiluoto Underground Rock Characterisation Facility in Finland; the selection process for deep geological repositories is now underway in several countries; a short-term solution adopted by many countries has been to build interim facilities; and US operators have begun using the short-term, but realistic solution of concrete and steel casks. Affirmative action is required by the UK Committee on Radioactive Waste Management regarding the appropriate strategy for the UK.

Fourth, there is the issue of creating an IWS. The core issue is ensuring that a pension mechanism is available to provide an environment for the retention of skills to safely decommission the UK's nuclear facilities. The target is for IWS to be established by June 2006. The current consultation paper was issued by NDA in December 2005. The proposal is that it would be available to SLC employees unable to remain in their existing schemes, and may include contractors subject to discussion. Benefit packages are proposed to mirror existing arrangements, and it would be open to new entrants, but the details of that remain under discussion. The trustees and the NDA shall agree the contribution rate, but under-funding risk would ultimately rest with the NDA. For the initial round of SLC decommissioning contracts, pension contributions are an effective pass-through to the NDA, including deficit risk. Thereafter no radical change in this approach is expected. The scheme assets would be held by a trust separate to employers, the NDA or Government, and the NDA would act as 'lead company' for the scheme. Otherwise, the scheme would be subject to normal industry pension regulation, and could be seen as a form of benchmark for the decommissioning sector.

In summary, nuclear new build success requires: addressing waste management; success of NDA operations – driving public support in the professionalism of the private sector in dealing with decommissioning risk; identifying solutions for funding decommissioning and mitigating risk for new build; creating an industry-wide pension scheme to retain sufficient skills to manage decommissioning; addressing insurance – mutualisation models may be viable on a European basis; and delivering the clear and prompt signals regarding nuclear planning/licensing crucial to enable private sector participation.

The Public Debate over New Build in the OECD – New Features and Implications for the UK

Professor Ragnar Lofstedt, The King's Centre for Risk Management, King's College London

Drivers of nuclear power in the OECD include: security of supply – high dependence on Russian natural gas; Finland and Slovakia, where a favourable view of nuclear is probably driven by a lack of trust in Russia; climate change remains important, yet the 'easy' renewables have already been explored and the clean-coal option is not readily available; positive developments in the Nordic countries and France, helped by the sort of large state machinery that exists throughout Europe; and security of long-term contracts – nuclear is more predictable. Some success stories include: Finland's fifth reactor and the interest private investors are showing in this; Sweden's low-level radiation waste storage; Finland and Sweden's high-level radiation waste storage; and Swedish regulators' handling of past incidents.

Nevertheless, there have been some errors in thinking. There have been unrealistic expectations of renewables and energy conservation. For example, in the late 1980s there was a suggestion that Sweden could get rid of two nuclear reactors simply by reducing its level of energy consumption, primarily domestic. Unsurprisingly, the vast majority of the public were resistant to this. Another suggestion in Sweden was that nuclear generation could be replaced by large-head hydro, yet the reality is that this type of generation has already run out of capacity in Sweden – there is no space to build more. A suggestion in Austria was that they could fulfil all their energy needs from renewable sources, yet they are already importing, and thus driving demand for high-carbon production elsewhere. Another example is the idea of changing to Swedish building standards in the UK to reduce heating costs. It is obvious that this could not happen even over many decades.

There is an adversarial debate on both sides of the nuclear spectrum. Austrian policymakers and NGOs ended up poisoning the country's relationship with Slovakia and the Czech Republic by blocking their borders with them. Swedish NGOs blocked a shipment of nuclear waste by boat, even though this is a far safer and more efficient means of transport. The US Government forced the state of Nevada to take on the country's entire nuclear waste – a very stupid move. The problem is that certain members of the nuclear industry believe the public are ignorant and stupid. In fact the public are responding rationally to the information they have. The industry state that nuclear is completely safe, highly cost-effective and that the waste issue is solved. NGOs state that nuclear is dangerous, a complete waste of money, and that waste is a major problem.

In this context, the BBC is now putting in place guidelines to ensure correspondents report science and risk properly. Nevertheless, there is a lack of well thought-out communication strategies. There is too little transparency on all sides, along with cover-ups, fabrications and simply works of fiction. Examples include: the Temelin nuclear reactor has been called 'inherently unsafe', yet it is very safe compared with other Eastern European reactors; the Government claim nuclear power can save the world from climate change, but nuclear is not carbon neutral; there has been a supposed phase-out of nuclear-generated electricity in Sweden replaced by renewables and energy conservation, yet the country is actually importing electricity from Poland, where power is generated with far greater emissions than the more efficient Swedish nuclear plants.

The adversarial debate in the UK remains potent. Thus, one key lesson for the UK is that there must be a properly conducted debate in respect of renewables and energy conservation compared with nuclear power. The advantages of offshore wind are still not clear, and the real numbers for the benefits of energy conservation are hard to pin down. The real debate is between nuclear power versus clean-coal technology. Another lesson is the importance of trust. In the UK, regulators and industry are not well trusted. Thus, to build new nuclear power plants in the UK, these individuals need to work with trusted actors. If they fail to do so, nuclear will not be an option, particularly since public perception of the industry would surely fall further if a targeted NGO campaign commenced now. The waste problem must also be properly addressed; Finnish success was partially due solving the waste issue. Finally, communication processes need to be far more transparent and proactive, unlike the UK nuclear review.

Panel Comments

Russell Marsh, Policy Director, Green Alliance

Nuclear is not the answer. Public support is questionable, and it is not even clear that the UK Energy Review will be considering nuclear as a serious option. Although nuclear represents 20% of UK electricity, it represents just 4% of total energy use. There are many other factors in bringing down carbon emissions – transport emissions are a major factor, for instance. Moreover, even in a best-case scenario for new build, nuclear plants would not be on stream quickly enough to affect our 2020 carbon-reduction target. For the same reason, nuclear will not benefit security of supply in the short term. Nor is nuclear is a worthy comparator with gas in this respect: nuclear only deals with electricity generation, whilst a great deal of gas is used for things like domestic heating etc. Thus, dealing with environmental and security issues will require other technologies. The Green Alliance believe it preferable to get the policy mix right now, to invest appropriately in getting other technologies on stream such that the Government revisit the issue in 2020, nuclear is unnecessary.

Dr Jon Gibbins, Imperial College, and the UK Carbon Capture and Storage Consortium

BP has projected that the first carbon-capture and storage plants shall come online by 2009/10. Another scheme is using a gasifier, whilst others are looking at converting existing plants to supercritical, adding carbon capture when economically justified. All these options could come online much sooner than nuclear. However, there is an issue of baseload: although such plants can beat nuclear to the baseload, nuclear will always take priority once it exists, so if the Government start a programme of new nuclear build, this will severely affect the project economics of carbon-capture projects. It is not reasonable to argue that it is a case of carbon-capture 'versus' nuclear, yet there is something of an 'either/or' decision to be made. The purpose of paying over the odds for any low-carbon option is mitigating climate change (even though there might be security of supply benefits too). However, when the Government chooses whether to incentivise carbon capture or nuclear, it ought to consider the economic implications. China would be very interested in new carbon capture technology, but not in nuclear new build since they already have a large programme of nuclear build. Moreover, on the best current information, there is very

little difference in cost between nuclear and carbon capture options; carbon capture is half a pence more expensive, or 5% of total energy expenditure.

Carola Hoyos, Energy Correspondent, Financial Times

The current high oil price reflects the shrinking of the OPEC spare-supply cushion – if Iran stops pumping oil, Saudi Arabia could not increase production significantly enough to cover the shortfall. This is the fundamental reason why the high price is the new paradigm. However, the rapid increase in price has not led to recession as it did in the 1970s because it is a demand-side shock.

Governments have increasingly less control of their energy destiny as they are increasingly dependent on what Middle Eastern (or Russian, Latin American etc) administrations choose to do. This is why nuclear has a role in security of supply. However, there is a relatively short window in which for proponents of nuclear to achieve their ends. For example, the world is not running out of oil, only easily-accessible oil. Moreover, the world is not running out of gas, of which there are plenty of easily-accessible deposits around the world. LNG is likely to be the fuel of the future, a major competitor with nuclear, and the evidence for this is provided by the five major oil companies, all of whom are beginning to shift to gas. Coal will also be a massive energy driver, particularly for India and China where there are massive reserves. Thus, although the nuclear debate is very timely, it is a moot point whether other technologies/fuels will close the debate before nuclear can take advantage.

The oil price is clearly starting to decouple from the gas price, which will add to uncertainty going forward. However, this will take time, and geopolitics will continue to play a role in pricing. Moreover, the price-deciding unit of gas will eventually become the LNG cargo rather than the pipeline gas. It is worth noting that LNG is a more fungible asset than pipeline gas, which means it is more politically fraught. Although LNG-producing countries are generally considered subject to less political risk, this issue is another reason that politics will remain a fixture of pricing.

Plenary Discussion

- Nuclear is not carbon neutral, which could be a key factor in the public debate since recent polls suggest that the public are willing to accept new build if and only if it helps meet the UK's carbon obligations. Preston Chiaro stated that in fuel lifecycle terms, nuclear power stations produce 40kg of CO2 MW/hr, whilst a modern pulverised-coal-fired plant produces 780kg MW/hr.

- Mark Johnston confirmed that Greenpeace remain opposed to nuclear new build. He argued that there are a range of better options, starting with demand management and moving through to various renewable technologies. Moreover, he suggested that in the medium term this could be hedged against natural gas as the least dirty, most efficient fossil fuel. He argued that there is a fundamental difference between continuing to use existing assets safely and investing in new assets when there are better options available, economically and environmentally etc.

- Andy Hall acknowledged that a new build programme would stretch HSE resources, particularly expertise, but he noted that the senior team have recognised the problem and have plans in place to address capacity should the need arise.

- Mark Johnston reported that the EC are taking a detailed approach to identifying nuclear liabilities, one that correctly distinguishes weapons programmes, civil electricity generation and research and development activities.

- If the UK Government were to find some support mechanism for new build, it would need to be approved in Brussels. Mark Johnston reported that because the UK has made two applications for state aid to Brussels so recently, the EC's patience is 'wearing thin'.

- With only 15,000 qualified people in the UK nuclear industry, the vast majority of whom engaged in operational roles, the industry is rapidly running out of expertise. Pat Tighe noted that most major nuclear players have programmes in place to recruit, retain and transfer knowledge, but he acknowledged that whether these are sufficient or not is a moot point. He argued that an even bigger concern may be expertise in the equipment-supply arena, where capacity is not enough to satisfy demand at the moment.

- Nuclear plants suffer from delays in restarting, which is an additional associated risk, particularly in countries with colder climates, such as the UK. Ciara Ryan argued that there has yet to be sufficient quantification of all risks involved in nuclear, but she noted that the same can be said of renewables.

- Hydrogen may be used as a transport fuel in the future, and it could be produced by electrolysis in nuclear power stations. However, Russell Marsh argued that although powering transport with hydrogen in nuclear plants solves the emissions problem, the Green Alliance believes it creates new problems – all of those associated with nuclear per se. Moreover, hydrogen is not the only answer to the transport issue; the industry should consider all options. Dr Jon Gibbins noted that a recent DTI report indicated that the lowest-cost method of producing carbon is the conventional, low-risk chemical approach, which is being used by BP now.

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