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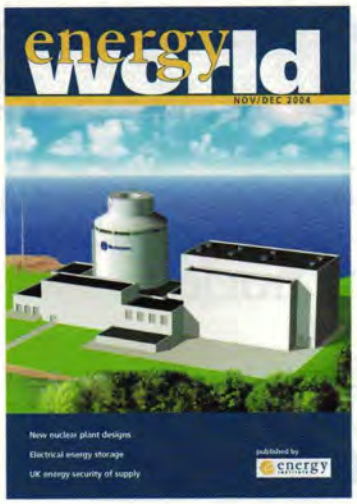
New nuclear? The cover picture shows an artist's impression of the standard AP1000 nuclear power plant design from Westinghouse, which has recently won regulatory approval from the US nuclear authorities. Should there be a new generation of nuclear power plants built around the world, the AP1000 might well win some orders. But see also page 14 for one view on whether the nuclear industry should concentrate on the evolution of current nuclear designs – or move on to a completely new type of reactor.



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Decommissioning the nuclear legacy – a prelude to new build?

Paul Todd, Nuclear and Decommissioning Services, Mitsui Babcock

The UK regulatory and industry environment for decommissioning is in a stage of dramatic transition. The ownership of liability by organisations such as BNFL, now British Nuclear Group, and UKAEA will transfer to the Nuclear Decommissioning Authority (NDA) in April 2005. The NDA will guide the industry in controlling available funds, prioritising programmes and setting integrated UK strategies. The NDA is a very positive move for the decommissioning industry.

A figure of £48 billion was posted in the White Paper (currently stated as £50 billion) for decommissioning liabilities for British Nuclear Group and UKAEA sites, broadly split as £28 billion for Sellafield, £12 billion for Magnox sites, £4 billion for Dounreay and £4 billion for the remaining UKAEA sites. British Energy's decommissioning funds and funds for MoD liabilities are not included in the £48 billion figure and the picture is not yet clear as to how these liabilities will be managed in the context of the NDA.

The published closure dates for the Magnox stations at Dungeness and Sizewell are 2006, with Oldbury and Wylfa in 2008 and 2009 respectively. The British Energy plants are scheduled to begin a closure programme with Dungeness B in 2008, four more stations by 2011 and two more by 2023, leaving only Sizewell B running to 2035. This assumes no life extension of the AGR fleet, which is a business case for British Energy to address. If the above plan runs as scheduled, the installed UK capacity will be reduced by about 8,000 MWe by 2011, about 12% of the current installed UK generating capacity.

UKAEA and British Nuclear Group, as contractors to the NDA, will appoint second and third tier contractors to implement the decommissioning programmes. The second tier contractors are companies, such as Mitsui Babcock, who currently carry out and manage decommissioning projects on their behalf.

Storing nuclear wastes

The current framework for nuclear decommissioning, including the decision to follow the 70 to 80 year 'safestore' route (now under review), has been based on extensive industry consultation. Public objection to the siting of nuclear waste facilities has left the nuclear industry with only Sellafield as a site for receiving high-level and intermediate waste. Other waste must be held on site. It is therefore likely that as many as 20 sites will contain an ILW store as well as a nuclear reactor safestore.

The receiving site for low-level waste, BNFL's Drigg site, has limited capacity, both in radioactive and volume content and will be under further pressure with the expected increase in waste volumes expected if the NDA succeeds in accelerating the decommissioning programme. Further storage sites will be required and failure to address this issue could lead to disparate storage of low-level waste (LLW) at many locations.

Secondary wastes, such as the tools and equipment used in decommissioning must also be taken into account in the costs and techniques to control waste volumes and volume reduction. The key to developing simple reliable technologies for the decommissioning industry is to find those that generate little or no waste and can cope with the wide range of conditions found in UK plant. Keep it simple, do it quickly and at minimum cost are the overall guidelines.

It is encouraging that NDA and the regulators are working together closely in establishing decommissioning strategies for the future and a better understanding of what constitutes 'fit for purpose' decommissioning methodology which will benefit contractors, lead to cost benefits and improved safety.

In the short term, much of the UK decommissioning market will remain decidedly low tech, unlike other EU countries, such as Italy, where decommissioning is carried out soon after station closure using remote technologies. There are necessary UK exceptions but the trend is towards reliable, off-the-shelf equipment away from bespoke single application robotics if at all possible.

The NDA has the opportunity to generate more attractive market conditions. It is hoped that the Authority can work with contractors at all levels and provide criteria by which new and attractive commercial and technological methodologies will become the norm. Industry consultation is already underway. The nuclear legacy will not go away and the current industry trend toward acceleration is very encouraging and an essential part of public acceptance to new nuclear build.

Replacing nuclear with nuclear?

Excepting renewables, there is no new build of any type of power plant, coal, gas or nuclear, in the UK as the market conditions are not conducive to long term investment. As can be seen from the closure plan, if new nuclear build is to come on stream in time to replace nuclear with nuclear we are already behind where we need to be, taking a lead time of 10 or 12 years to bring units on line. We are heading for a conflict with our drive for CO_2 emissions reduction with at least a four or five year gap in non CO_2 generating capacity, our security of supply is at greater risk due to imported energy and a reducing diversity of supply.

The immediate decommissioning business is gradually looking increasingly healthy. The short term focus is to get on with clean up and demonstrate solutions to the legacy. The longer term desire to see new build is dependent on political and economic influences which will become more pressing when energy shortages supersede climate change on the political agenda. ●

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US 'could eliminate oil use in a few decades'

The approaching 'end-of-the-oil-era' for the US, however near or far, does not have to be time of crisis and disaster – far from it, according to a new report from the highly respected Rocky Mountain Institute (RMI). Partly funded by the Pentagon, *Winning the Oil Endgame: Innovation for Profits, Jobs, and Security* is no less than a blueprint for making the US oil-free. It outlines how American industry can restore competitiveness and boost profits by mobilising modern technologies and smart business strategies to displace oil more cheaply than buying it.

Winning the Oil Endgame proves, says the RMI, that at an average cost of $12 per barrel (in 2000 dollars), the US can save half its oil usage through efficiency, then substitute competitive biofuels and saved natural gas for the rest – all this without taxation or new federal regulation.

"Unlike previous proposals to force oil savings through government policy, our proposed transition beyond oil is led by business for profit," said RMI CEO Amory Lovins. "Our recommendations are market-based, innovation-driven without mandates, and designed to support, not distort, business logic. They're self-financing and would cause the federal deficit to go down, not up."

The study shows that, by 2015, the US can save more oil than it gets from the Persian/Arabian Gulf; by 2025, use less oil than in 1970; by 2040, import no oil; and by 2050, use no oil at all. "Because saving and substituting oil costs less than buying it, our study finds net savings of $70 billion a year," Lovins said. "That acts like a giant tax cut for the nation. It simply makes sense and makes money for all."

The RMI study focuses on cars and light trucks. These vehicles account for nearly half of projected 2025 oil use. The report demonstrates that ultralight, ultrastrong materials like carbon-fibre can halve vehicles' weight, increase safety, and boost efficiency to about 85 mpg for a midsize car, or 66 mpg for a midsize SUV.

Winning the Oil Endgame also predicts that, to fight better and save money, the Pentagon – the world's largest oil buyer – will accelerate the market emergence of super-efficient land, sea, and air platforms. A more efficient and effective military can protect American citizens instead of foreign oil, while moving to eliminate oil as a source of conflict. "A fuel-efficient military could save tens of billions of dollars a year," said Lovins, who served on a Pentagon task force studying this issue. "As our nation stops needing oil, think of the possibilities of being able to treat oil-rich countries the same as nations that don't own a drop. Imagine too our moral clarity if other countries no longer assume everything the US does is about oil."

The RMI report says that, by 2015, more efficient vehicles, buildings, and factories will turn oil companies into broad-based energy companies that embrace biofuels as a new product line. The study demonstrates how cellulosic biofuels (wood-based, rather than from starchy or sugary plants like corn) can replace one-fifth of current oil use, more than triple farm income, and create 750,000 agricultural jobs.

Winning the Oil Endgame demonstrates that half of US natural gas can be saved at less than a fifth of its current price. Two-thirds of that figure comes from saving electricity, especially at peak times when it is inefficiently produced from natural gas. This step alone could return natural gas to abundance within a few years, cutting gas and power bills by $55 billion per year.

Recommended policy innovations include:

- revenue-neutral 'feebates' – rebates for buyers of efficient cars, paid for by fees on inefficient ones;
- low-income access to affordable mobility – a new nationwide initiative to buy efficient cars in bulk and lease or sell them to low-income drivers at terms they can afford;
- R&D investment incentives and temporary loan guarantees to help financially weakened US automakers retrain and retool faster; and
- temporary federal loans guarantees to US airlines for buying very efficient new aeroplanes, provided that for every plane thus financed, an inefficient one is scrapped.

For more information, please visit **www.rmi.org**

The 'world's largest grid connected PV power plant' has opened at the site of a former lignite-mine ash deposit near Leipzig, once one of the most polluted areas of Germany. Shell Solar, GEOSOL and WestFonds, have opened the solar park, comprising 33,500 modules, with an output of 5 MW. The power generated, sufficient to meet the electricity demand of about 1,800 households, will be fed into the grid locally.

The project was initiated and developed by GEOSOL, with Shell Solar as the system supplier and the prime construction contractor.

Hans Willemsen, Executive Vice President of Shell Solar, explained: "Shell Solar has strategically been involved in the development of large-scale solar projects in Germany such as this, as we believe that these projects contribute to economies of scale, which result in increasing demand in the market for solar (PV) power."

Russia revives hopes for Kyoto Protocol

The 1997 Kyoto Protocol might yet come into force and become international law, following a September vote by the Russian Cabinet to approve a draft federal law to ratify it. The law now has to be approved by the State Duma, the lower house of the Russian Parliament, in which President Putin's party has a clear majority yet where the draft law could still face some hard opposition.

If approved by the Duma, Russia's ratification will mean the Treaty could come into force three months later. This would be a major diplomatic victory for the EU, leaving US President Bush and the American government out in the cold. The US decided in 2001 to leave the Kyoto process because it feared the economic costs of implementing it would be too high.

Possible Russian ratification is also thought to be good news for the EU's emissions trading scheme (ETS), which is due to begin at the start of 2005.

However, the Kyoto Protocol is only a first step in the global fight against climate change. At the end of this year, the international community is to gather in Buenos Aires for 'COP10' to discuss further policy steps to reduce greenhouse gas emissions in a much more dramatic way after the first Kyoto commitment period (2008–2012). The EU recently started a consultation process to prepare its post-2012 climate change strategy.

US NRC design approval for Westinghouse AP1000

The US Nuclear Regulatory Commission (NRC) has granted final design approval (FDA) to the Westinghouse Electric Company's AP1000 standard nuclear plant design, clearing the way for the company to begin selling the 1100 MWe design internationally.

The AP1000 – now the safest, most economical nuclear plant design currently available with NRC approval, according to Westinghouse – has already received strong interest from potential customers in Asia, Europe and the US.

"The FDA process was both thorough and efficient, coming just 30 months after Westinghouse filed the initial application," said Westinghouse President and CEO Steve Tritch. "Such a short review schedule was achievable because the AP1000 application was basically a power uprate of our highly detailed 600 MWe AP600 standard design, which had received NRC Design Certification in 1999. Most important, the FDA process verifies beyond doubt the advanced safety characteristics of the AP1000 technology."

Marilyn Kray, president of NuStart – the consortium of nine utilities working with the US Department of Energy to test the NRC's process for obtaining a Construction and Operating License (COL) for new plants – said that the FDA is the most recent in a series of positive events that could facilitate new construction in the US. "The AP1000 is one of two technologies NuStart has identified as having high potential for construction in the US," she said.

Copco genests for rural electrification scheme in Angola

Generators being delivered in rural Angola

Atlas Copco has supplied, through its local distributor Blackwood Hodge (Angola) Ltd, seven generating sets for a remote rural electrification scheme in Angola. In addition to supplying the sets, Blackwood Hodge was also responsible for the installation of the necessary infrastructure such as power lines and reserve fuel tanks.

The new sets will provide electricity for remote villages in Angola. Four Atlas Copco QAS generating sets rated at 250 kVA and 300 kVA were initially installed. The remaining QIX units, each rated between 256 kVA and 550 kVA, were installed following the end of the rainy season in villages which can only be accessed via rough bush tracks. The units operate in parallel with a control module which routes the supply according to demand.

A multi-set installation was preferred for this application to ensure that a supply could be maintained when sets are taken out of service for maintenance or a major overhaul in the remote location. As part of the electrification contract with the Provisional Government of Angola, Blackwood Hodge will also maintain the installed systems.

Atlas Copco and its local distributor have also supplied several hundred generating sets to Angolan customers for industrial applications, schools, hotels, banks, embassies and Governmental Institutions.

Vegetable oil from some of the poorest countries in the world, initially India, is to be exported to the UK for refining into biodiesel for use in the transport sector. The UK-based D1 Oils plans to import oil derived from the jatropha tree which can, says the company, grow in some of the least hospitable soils in Africa and Asia, bringing work and foreign currency to those who grow and refine the energy crop, and bringing clean fuel alternatives to both the developed and developing world. The company has secured plantation rights for land in India, Africa and South East Asia.

Once processed, oil from the seeds of the jatropha tree has similar physical and chemical properties and a similar energy content to normal fossil diesel, and can be blended with conventional diesel fuel. Jatropha seeds have an oil yield of up to 40%, says D1, and produce profitable by-products such as glycerine for cosmetics and seed cake for fertilizer and animal feed. Jatropha can be grown almost anywhere, but does especially well in West Africa, Southern Africa and India.

D1 has also developed a modular transportable refinery for producing biodiesel locally from various feedstocks. The refinery produces minimal emissions, uses virtually no water and can be powered in remote locations by its own biodiesel.

US wind energy tax incentive back to end of 2005

The US House and Senate have approved a bill to reinstate the wind energy Production Tax Credit (PTC) – a critical factor in financing new wind power installations in the US – through to the end of 2005. President Bush is now expected to sign it into law. The PTC provides a 1.5 cent/kWh tax credit (adjusted annually for inflation) for electricity generated with wind turbines.

The credit had been the principal cause of a record year for new wind energy schemes in the US in 2003, when nearly 1700 MW of new capacity was installed. 2004 has so far seen a huge drop from this figure, due to the absence of the incentive for nine months.

According to the American Wind Energy Association (AWEA), reinstatement of the PTC, which had expired in December 2003, will facilitate the investment of about $3 billion in wind energy over the next few years. The Association is pressing for reinstatement of the credit to the end of 2006. "We believe wind energy can provide 6% of US electricity by the year 2020, or about as much electricity as hydropower generates today, and this action allows us to go forward toward that goal. AWEA will continue to pursue policies – such as a long-term PTC extension and a renewables portfolio standard (RPS) – that will move the wind industry beyond the boom-and-bust cycles that have resulted from short-term PTC extensions in the past."

Wave power installation; IGCC plant for US

Energetech America LLC has announced plans to build the first wave energy project to provide power to the US mainland. Located more than 1.5 km off the coast of Rhode Island, the proposed 500 kW pilot project will cost about $3.5 million and will use an existing undersea transmission cable to deliver the power to the New England electrical grid.

Called 'GreenWave Rhode Island', the project is expected to begin operating in 2006 for a three-year trial. The Energetech system will use oscillating water column technology, in which the up-and-down movement of waves in an enclosed chamber compresses air and forces the air through a turbine to generate power.

The structure will rise 12 m above the water, with its four legs resting on the ocean floor, and with mooring cables to hold it in place. Energetech, whose parent company is building a similar device for installation at Port Kembla in Australia, plans to begin the permitting process later this year.

Meanwhile, American Electric Power (AEP) says that it will build at least one commercial-scale integrated gasification combined cycle (IGCC) power generation plant as early as 2010. IGCC technology converts coal into a gas and passes it through pollutant-removal equipment before the gas is burned. The process is more efficient than conventional coal combustion and results in fewer emissions of nitrous oxides, sulphur dioxide, mercury, and carbon dioxide.

Oil prices 'to stay high until mid-2005'

The monthly average price for oil is expected to stay above $40 per barrel through to the middle of 2005, according to US Department of Energy's Energy Information Administration (EIA). The EIA's latest: *Short-Term Energy Outlook*, notes that oil prices are remaining high even though the Organisation of Petroleum Exporting Countries (OPEC) is producing oil at its highest levels since it began tracking oil quotas in 1982.

World oil surplus production capacity is near its lowest point of the last 30 years, while petroleum inventories throughout the industrialised world remain below normal.

At the same time, the EIA has revised upward its projected world oil demand growth for 2004 to 3.2% higher than in 2003, with strong demand from China accounting for much of the upward revision. According to the EIA, this combination of factors provides "an extremely limited cushion in the event of unexpected world oil market disruptions."

High gas prices 'caused by oil links and declining supplies'

The main reasons for recent high UK gas prices are high oil prices feeding through to British prices, predominantly via the pipeline link to the rest of Europe; most gas contracts in Europe being linked to oil prices; declining UK gas supplies; and winter gas supplies having fallen more quickly than the market was expecting. These are the findings of an analysis by Energy regulator Ofgem into the causes of recent high wholesale gas prices.

Ofgem launched its review of the gas market following concerns by customers about rising wholesale gas prices in October 2003, and extended the probe in May to look at high gas prices this summer, and for this winter.

Ofgem's Chief Executive, Alistair Buchanan, said: "Record oil prices are costing British customers around £1.4 billion this winter."

But he added that: "Experience from the UK gas market shows that there is little doubt that stronger competition in Europe would have diluted any oil price effect and its significant impact on GB customers' energy bills. The European Commission has been successful recently in establishing a new regulatory framework for competitive European energy markets. Ofgem is now calling on, and will be working with, other national regulators and the Commission to use their powers to make this a reality."

"Declining UK gas supplies also explain a large proportion of recent price increases. While this brings little comfort to business and domestic customers today, we do not expect this to be a permanent influence on British gas prices, as significant new sources of supply, under construction now, will ensure the UK has access to cheaper gas."

Ofgem says that its investigation also uncovered a number of specific issues relating to the supply of gas from other European markets and from the North Sea which may have prevented more gas flowing to the GB market. Increased gas supplies from either source would have lowered prices, says the regulator. Alistair Buchanan added: "We are concerned that, at times of high prices, around 5% of UK gas supplies were physically available but did not reach the market under existing contractual arrangements."

But the gas producers are not happy with this last point. The UK Offshore Operators Association (UKOOA) expressed its deep disappointment at Ofgem's "continuing inability to bring its investigation into rising gas prices to a conclusion."

UKOOA's Chief Executive, Malcolm Webb, said: "Ofgem has clearly stated that the main causes of rising gas prices in the UK are the impact of rising oil prices, declining production from UK gas fields and market sentiment. UKOOA supports these conclusions. However, it would appear that its enquiry will now centre on an allegation that certain gas contracts impeded gas reaching the market during October–November 2003. The contracts concerned (relating to the Sean, Indefatigable and Leman fields) are long-standing and accounted for only about 1% of the total UK gas supply during that period. We must question the materiality of such a small percentage on the overall market over the weeks under investigation."

Webb added that gas producers had, since November 2003, made significant improvements in the quality and quantity of information provided to support Transco's planning and forecasting of future supply.

"The UK has the most liberalised gas market in Europe and, as a result, has enjoyed in recent years unprecedented choice of suppliers and low gas prices," said Webb. "Even today, taking inflation into account, UK gas prices are no higher than they were in 1990, and lower than in the mid 1980s."

A model of the South Hook liquefied natural gas (LNG) facility proposed, for the site of Esso's former oil refinery at Milford Haven, Pembrokeshire, by a joint venture between ExxonMobil and Qatar Petroleum. If built, the facility would process around 16 million tonnes of LNG per year.

The Government says it may exempt new importers of LNG from having to hold a gas transporter licence, as part of moves to help increase competition and benefit the security of UK energy – particularly gas – supplies. The DTI has published a consultation document which asks for views on exempting carriers of gas from an LNG import facility to licensed a pipeline system from holding a licence.

An exemption order for operators of LNG import facilities on the lines proposed would remove a potential barrier to entry to the British gas supply market, says the DTI. In so doing it would facilitate competition in terms of price by increasing diversity of sources, with benefits for security of supply.

Europe approves restructuring aid to British Energy

The UK Government has welcomed a decision by the European Commission to approve its restructuring aid to British Energy plc, subject to certain compensatory measures.

The restructuring aid amounts to a transfer of nearly £4 billion of liabilities to do with nuclear waste from the company to the taxpayer, together new front-end (nuclear fuel supply) and back-end (waste management) contracts with British Nuclear Fuels Ltd (BNFL) which are more favourable to British Energy than previously.

Secretary of State for Trade and Industry Patricia Hewitt said: "The Commission's approval is subject to compensatory measures which are stringent, but workable. The Government's main objectives in assisting British Energy remain safety and security of supply. Contingency plans remain in place to secure those objectives if the restructuring plan fails for any reason and the company decides administration is the only option."

The Commission has approved the restructuring aid to British Energy subject to the following measures:

- the company's nuclear generation business will be ring-fenced from its fossil fuel, supply and trading businesses to ensure the aid to the nuclear business is not used to cross subsidise any other of the company's businesses;
- no nuclear or fossil-fuelled capacity expansion (above British Energy's current capacity) by the company in the European Economic Area for six years, and no hydro-electric capacity expansion in the UK for the same period;
- a restriction on the company selling to its industrial and commercial customers at prices below the prevailing wholesale market price for six years, unless there are exceptional market circumstances as determined by an independent expert.

Environmental organisations reacted to the news with predictable horror; Friends of the Earth calling it a "disgraceful" decision to: "allow the UK Government to pay off £4 billion in debt owed by British Energy plc over the next 100 years using taxpayers' money after the ailing nuclear power company failed to put aside cash to dispose of its nuclear waste. The decision opens the doors to similar cases from EU nuclear operators that have failed to put aside enough money to meet radioactive waste disposal costs."

However, Prospect, the union representing 1,500 senior technical and engineering staff at British Energy, welcomed the announcement as: "a significant step in putting British Energy on a firm financial footing and maintaining the safety and security of supply from the company. We are delighted as the Commission's ruling will help to ensure job security for our members in British Energy and we can now look with optimism towards the future after many months of uncertainty."

Environment MPs pledge to go carbon neutral

In a rare display of cross-party unity, Labour's Minister of State for the Environment, Elliot Morley and Tim Yeo, Conservative Shadow Secretary of State for the Environment and Transport have pledged to run 'carbon neutral' campaigns in the forthcoming general election.

The environmental spokesmen are the first individual MPs to sign up with climate change company, Future Forests, to follow the company's 'CarbonNeutral Measure, Reduce and Offset' pathway. This allows individuals and companies to compensate for their carbon dioxide output through sustainable projects around the world.

Future Forests will help the MPs to calculate their 'carbon footprint' and will then provide suggestions on how they can cut down on all unnecessary carbon emissions. These range from simple methods such as walking rather than taking the car, to more complex processes regarding the finish on printed leaflets. Those emissions which are unavoidable will be 'neutralised' through investment in climate friendly energy and sustainable forestry projects, says Future Forests, which hopes to encourage political candidates from all parties to commit to running CarbonNeutral campaigns.

New power lines to connect Scottish renewable projects?

Scottish Hydro-Electric Transmission Ltd (SHETL) has asked for views on five possible route corridors within which it may develop a new high voltage electricity transmission line. The new line would be necessary to accommodate output from renewable energy schemes which may be developed on the Western Isles.

The five corridors all start at Stornoway on the Isle of Lewis, and take various routes to Fort Augustus or Beauly. The company has also asked for comments on five potential route corridors for the routing of the necessary subsea cables.

Dr Keith MacLean, SHETL's Head of Sustainable Development, said: "While initial studies have suggested that the Stornoway–Ullapool–Garve–Beauly corridor may offer the best option, should it prove necessary to build this link, this preliminary consultation is intended to give local communities and organisations the opportunity to comment on all of the route corridors.

Artist's impression of the two-turbine wind farm at Beatrice

All of the information and comments received will inform the final selection of a corridor and of a preferred route for the electricity transmission line after the new year. The preferred route will then be the subject of a consultation exercise during 2005, before an application is made to Scottish Ministers for consent to build a line.

Meanwhile, Scottish and Southern Energy plc (SSE), and Talisman Energy (UK) Limited have announced plans to build a £24 million deepwater wind farm demonstrator project adjacent to the Talisman-operated Beatrice Field, 25 km off the east coast of Scotland. The project will test technologies for deepwater wind farms distant from the shore, with no visual impact. The project will include the design, construction, installation and operation of two prototype turbines.

The power generated by the turbines will be used at the Beatrice platform. Construction of the turbines could begin later this year, with first electricity generation expected late in 2006. The demonstrator project will receive £3 million in funding from each of the Scottish Executive and the UK DTI and €6 million from the European Commission.

'Wet renewables' could make UK energy self-sufficient

The UK is uniquely placed to become self-sufficient in energy by exploiting deep sea 'wet renewables' – a combination of offshore wind, wave and tidal power generation, according to Benoit Dal Ferro, Distributed Generation specialist with EA Technology.

"The opportunity now exists to build a new British offshore energy industry, on a scale at least as great as the development of oil and gas fields in the North Sea during the 1960s and 1970s," said Dal Ferro. "The difference is that wet renewable technologies will tap into power reserves which are inexhaustible and create virtually zero emissions."

"Britain led the world by creating an entirely new industry to extract fossil fuels from beneath the sea. As that industry dwindles, we now have the chance to apply similar levels of investment and determination to gathering vast amounts of energy from the marine environment itself."

Dal Ferro argues that, ironically, many of the environmental conditions which made life difficult for pioneering oil and gas operators in British waters also make them ideal for wet renewables – high winds, plentiful waves and strong tides. "Maps of the seas around Britain show that we are uniquely suited for large scale wet renewable projects, with many 'hot spots', characterised by powerful movements of water and air," he explained. "It is quite possible to develop an entire infrastructure of wet renewable generation resources offshore, with no visual impact on land and minimal environmental downsides for the marine environment."

Britain's 40 year investment in developing its offshore oil and gas resources should also give the new wet renewables industry a flying start. "Even more importantly, the oil and gas industry has created a vast infrastructure of offshore engineering, logistics, services and expertise, which is in exactly the right place to support the development of wet renewables. Many of the existing technologies will be transferable. The potential benefits to regions which have resigned themselves to losing jobs and investment as oil and gas wind down would clearly be enormous."

"Two challenges focus our attention: the first is to extend what we do now on land into the sea, in terms of power generation, transmission and distribution; the second is to remove the incoming energy transportation bottlenecks such as grid overstress," Dal Ferro said.

One of the most exciting prospects which could emerge from offshore wet renewables is power in the form of hydrogen, produced by electrolysis. The key advantage of hydrogen is that it is transportable in several forms, either in fuel cells or as a gas, which can be used to replace fossil-derived oil and gas. It can also be stored and used to produce electricity on demand. "It may even be possible to transfer hydrogen produced offshore via the existing gas network, revitalizing the existing offshore infrastructure," Dal Ferro said.

- Meanwhile, Humber Wind Ltd (HWL) has appointed ERM as lead environmental consultant for what could be one of the largest wind farms in the UK. HWL, a consortium of Vestas and United Utilities Green Energy, hopes to build an offshore wind farm off the Holderness Coast in the East Riding of Yorkshire, with a capacity of up to 300 MW. The project, named 'Humber Gateway' is being designed for between 60 and 80 turbines depending on the technology selected. HWL intends to submit the planning application for this project to the DTI at the end of 2005. If given the go-ahead, the wind farm could be fully operational by the middle of 2008.

Ultra-low emissions bus runs on diesel electric hybrid power

Low emissions technology company ENECO has launched its 'Epack' product, a unique electronic drive system that draws its power from a battery pack charged by a small diesel engine. The Epack, as fitted to an Optare Solo Bus, has proven to deliver significant emissions savings compared to traditionally powered vehicles, and also benefits operators by reducing fuel consumption.

The Epack, which can be applied to vehicles weighing between 2.5 and 20 tonnes, is aimed primarily at vehicles used in inner city goods, passenger and airport transportation.

In a recent demonstration of the Epack powered Optare Solo Bus, the technology achieved a 33% reduction in fuel consumption, with even greater reductions in emissions. This places the Epack vehicle above the equivalent conventional Euro 3 diesel bus and is well within the low carbon targets planned for buses by The Low Carbon Vehicle Partnership. In day-to-day use, some operators have seen further improvements with even greater fuel consumption reductions. The Epack includes the ability to run electric-only for approximately 6–8 miles before restarting the generator engine.

The development of the Epack was partly funded by The TransportEnergy section of The Energy Saving Trust, together with Bristol City Council and The Greater Manchester Passenger Transport Executive.

Outline orders for a further eleven bus packs are expected to be confirmed shortly. Other Epack designs planned include those for a 7.5 tonne van and tractor units for both a 12 tonne and a 20 tonne urban articulated truck, as well as a 15 tonne single-decker bus.

Reversing the trend away from science and engineering

Power systems company Rolls-Royce has launched an initiative designed to inspire pupils to study science at school. Information packs have been distributed to 35,000 schools and colleges across the UK and the Republic of Ireland, with a call to submit applications to win the Rolls-Royce Science Prize.

The award programme has been developed as a long-term initiative to help arrest the growing skills shortage in science and engineering in the UK. The programme is being supported by Gordon Brown, Chancellor of the Exchequer, Charles Clarke, Secretary of State for Education and Skills, Lord Sainsbury, Parliamentary Under-Secretary of State for Science and Innovation; and over 25 education and science related professional organisations.

There is increasing evidence of a growing skills shortage in science and engineering in the UK, with a recent report to the Treasury showing a decline in applications for university science studies. From 1995 to 2000, university engineering applications fell by 7%. There has also been a huge decrease in the number of pupils studying A-level sciences between 1991 and 2003; a 30% decrease in physics, a 25% decrease in maths and a 19% decrease in pupils studying A-level chemistry.

Explaining the rationale behind the Rolls-Royce Science Prize, Chief Executive Sir John Rose said, "Businesses such as Rolls-Royce operate in intensely competitive, high technology, international markets. We need talented young scientists and engineers to ensure we remain competitive. Recent statistics show a worrying decline in the number of students studying science, engineering and technology subjects. We hope the Rolls-Royce Science Prize will help to reverse this trend and inspire more young people to be interested in science".

The Prize is aimed at teachers of pupils from 3 years to 19 years, and will reward those who create inspiring science teaching proposals that address a specific need in their school or college. The Prize is open to submissions until 25 February 2005.

Meanwhile, the Government is investing over £4 million in a major new facility to help tackle revenue lost to the UK economy because too few women with science qualifications are either entering or returning to science, engineering and technology (SET) sectors.

Launching the new UK Resource Centre for Women in SET, Patricia Hewitt, Secretary for Trade and Industry said: "The nation's science base is the bedrock of our economic performance. We need more people working in science, engineering and technology – that means making sure that professional women in these sectors are able to contribute fully at all stages in their career."

Based in Bradford, the new Centre will work with British business to help maximise the opportunities for professional women in SET.

£16.5 million investment for nine coal mines

Nine UK coal mines have been awarded a total of £16.5 million of Government funding, under the second Coal Investment Aid (CIA) application period, to support planned investment.

Offers have been made to the following mines: Eckington Colliery Partnerships, Derbyshire; Aberpergwm (Energybuild), West Glamorgan; and seven UK Coal Plc mines: Daw Mill, West Midlands; Harworth, South Yorkshire; Kellingley, North Yorkshire; Maltby, South Yorkshire; Rossington, South Yorkshire; Thoresby, Nottinghamshire; and Welbeck, Nottinghamshire.

Energy Minister Mike O'Brien said: "I am delighted to announce this funding allocation, which further reinforces the Government's commitment to safeguard the important role that coal plays in this country's energy needs. Coal Investment Aid will help safeguard the social and economic stability of these local communities for as long as possible and also have positive knock on effects for the regional and national economy."

"Coal supplies around a third of the UK's electricity demand, half of which is generated from UK produced coal. It is therefore crucial that we continue to invest in our mines to ensure that the remaining reserves are fully exploited while they remain economically viable."

The funding announcement brings the total funding commitment to £57.5 million since the CIA scheme was launched in June 2003.

New funding for solar projects

New solar power projects across the UK, including those proposed for Edinburgh Prison and the National Wildlife Centre in Liverpool, are to receive funding under the Government's Major Photovoltaics (PV) Demonstration Programme. Seventeen projects were chosen for funding worth £1.4 million. Schools, community centres and businesses are among those who will benefit from this funding round, which supports medium to large-scale (5–100kWp) solar electric power installations.

Previously, Energy Minister Mike O'Brien announced that schools, houses and commercial buildings will benefit from £8.5 million in new funding to encourage more energy production from solar panels and small-scale renewables.

The two announcements bring the total funding for solar projects under the Major Photovoltaics Programme to £40 million, and will enable a further three funding rounds to take place in 2005/06. This will ensure that help for household applications and medium to large-scale solar electric power installations continues, says the DTI.

O'Brien also announced that communities, not-for-profit organisations and households will benefit from new funding to extend the Clear Skies initiative for a further year, bringing the total finding for that programme up to £12.5 million. Clear Skies grants are available for a variety of renewable technologies where communities can get up to 50% of capital costs, up to a maximum of £100,000, towards capital costs.

Electrical energy storage – challenges and new market opportunities

The last issue of Energy World (October 04) included a news item: 'UK need to invest in energy storage to make clean power work'. Here the originator of that story, John Baker of EA Technology, provides a more considered overview of energy storage technologies in use and under development around the world – and the wide range of applications (including alleviating the effects of intermittent renewable electricity generation) to which they can be put.

Electrical energy storage has been fundamental to the design of uninterruptible power supply (UPS) systems and various off-grid power supplies for many years. However, it is the new challenges posed by the ascendancy of distributed generation and renewables, the associated issues of intermittency, combined with the ever increasing pressures to maintain customer supply standards whilst optimising the utilisation of distribution assets that is now bringing storage far more centre-stage for power network applications. Whilst the UK has led the way with large-scale pumped hydro storage, the current emphasis is very much on smaller-scale packaged systems, which may be far more easily deployed throughout the power systems network. Much of the activities in this latter area currently reside overseas, particularly in North America and Japan. However, there are important lessons to be learnt and still significant opportunities for their development, integration and deployment in the UK.

Storage systems span a considerable spectrum of technologies, ranging from short-term/high power technologies, such as superconducting magnetic energy storage (SMES), through to bulk energy storage technologies, which can include various flow cell, compressed air and pumped-hydro storage options.

The selection of the most appropriate technology for any given application is a function of the application's charge and discharge ratings, the actual energy storage required (eg over seconds, minutes, hours or longer) and its daily operating cycle. Various other considerations also apply, including system acquisition and life costs, footprint, environmental tolerance and overall developmental maturity.

Battery energy storage

Battery energy storage systems (BESS) represent perhaps the most well known form of electrical energy storage, albeit via their storage of chemical energy in the battery reagents and their reversible electrochemical conversion to and from electrical energy.

Lead-acid systems have been established as both larger and smaller-scale packaged systems. The core electrochemistry continues to evolve, particularly in terms of its development for partial-state-of-charge operation, a requirement that is common both to various renewables applications and also hybrid electric vehicles.

Some of the better known lead acid battery storage implementations include:

- the 8.5 MW (power)/8.5 MWh (energy) BEWAG plant in Berlin, constructed in 1986 when West Berlin was effectively an 'electrical island' in East Germany. The system provided a crucial spinning reserve and frequency control functionality; and
- the 3 MW/4.5 MWh Vernon plant at GNB's battery smelting facility in California. The system services a crucial security-of-supply requirement, to safeguard the smelter's environmental control systems in the event of loss of the utility supply, whilst also being used for peak shaving operations.

Alternatives to lead-acid include the nickel-cadmium and sodium-sulphur electrochemistries. The former offers significant advantages over lead-acid in terms of its chronological and cycle life expectancies, its short-term power rating and its low maintenance requirements. Although power utility applications to date have been limited, the technology has achieved significant prominence via its implementation by the Golden Valley Electric Association in Fairbanks, Alaska, as the 'world's largest battery' (pictured).

The system fulfils a critical spinning reserve application in what is essentially an electrical island and provides the Golden Valley utility with sufficient time to start up reserve generators, in the event of individual units dropping off line. The system itself comprises four battery strings, each of 3,440 cells, with a string voltage of 5,200 V. It is rated at 27 MW for 15 minutes, or 40 MW for 7 minutes, up to a maximum transient limitation of 46 MVA, imposed by the power converter. The nickel-cadmium electrochemistry was chosen in view of Golden Valley's requirement for a 20 year life, with the system expected to perform 100 complete and 500 partial discharges during this period. The system was jointly implemented on a turnkey basis by ABB and

The 'world's largest battery': Golden Valley, Alaska, Ni-Cd battery energy storage system

SAFT, at a total project cost of $35 million.

The high temperature sodium-sulphur (NaS) system represents the third principal electrochemistry currently implemented in power systems networks, via the partnership agreement between NGK and the Tokyo Electric Power Company (TEPCO). Although the original developmental drivers for the battery system emanated from electric vehicle applications (including the Silent Power programme in the UK), it is uniquely through NGK's programme in Japan that the technology has been developed for the stationary applications sector.

The NGK system is offered on a modular basis in two basic variants. The PS module is rated at 50 kW/ 60 or 430 kWh capacity, and with the PQ module similarly rated at 50 kW/360 kWh, but with a short term 'pulse power' rating of up to five times its rated power. The system's principal advantages relative to lead-acid include its higher energy density, extended cycle and chronological lives, low O&M costs, short-term high power capability and insensitivity to external ambient temperature.

NGK announced its partnership agreement with TEPCO in October 2001, which has resulted in the latter implementing the system in its own power network, whilst also initiating direct sales to third party customers. In return, NGK has committed to build up production capacity to 65 MW per year, with the potential to increase this to 200 MW/year, in line with market demand. To date, in excess of 80 projects have been implemented, with some 500 MWh of storage capacity.

The largest installation to date, representing the world's highest capacity battery storage project, is the 8 MW/ 57.6 MWh system at a Hitachi plant in Japan. This installation is principally used for load levelling purposes, on a daily operational cycle.

Redox flow cells

Redox flow cells are analogous to batteries in many respects, but with their chemical energy stored in electrolyte solutions, external to the flow cells (or modules) themselves, as shown in Figure 1. The electrolyte solutions are circulated through the flow cells, with electrochemical conversion taking place across an ion exchange membrane which separates the two electrolytes.

Power and energy then become independent variables, with system power rating being determined by the number of flow cells and their surface area, and energy capacity by the volume of the electrolyte solutions. Systems can therefore be designed to suit the requirements of particular applications, with the potential for the provision of medium to longer-term storage capacity via the installation of an increased quantity and/or capacity of electrolyte storage tanks.

Developmental and demonstration activities have centred around three principal electrochemistries to date, namely the polysulphide/bromide system, vanadium and zinc bromine.

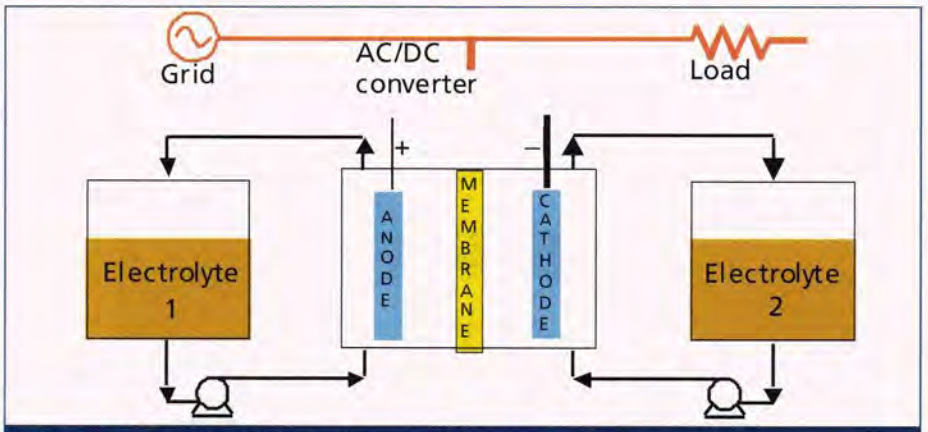

Figure 1: A redox flow cell energy storage system

The polysulphide/bromide system, better known as 'Regenesys' has previously been developed over the past twelve years by RWE Innogy and its predecessor companies (Innogy and National Power). The system has been marketed as a grid-connected utility scale storage system, for power ratings in excess of 5 MWe. Notwithstanding the significant scale-up of and commitment to Regenesys related activities, RWE Innogy announced in December 2003 that it would no longer be funding the technology's development and subsequent commercialisation. It has since announced (September 2004) the sale of an exclusive licence on the intellectual property and related physical assets to VRB Power Systems, for the sum of $1.3 million.

The vanadium redox battery (VRB) employs the V2/V3 and V4/V5 redox couples in sulphuric acid as the negative and positive electrolytes respectively. Vanadium redox batteries are potentially suitable for a wide range of energy storage applications, including power quality, uninterruptible power supplies, peak shaving, increased security of supply and integration with renewable energy systems.

The two principal developers and suppliers of vanadium redox systems are currently VRB Power Systems Inc and Sumitomo, with extensive cross linkages between the two. Further developmental programmes also being pursued by parties such as RE-fuel Technology, Magnam Technologies and the Cellennium Company. Systems installed to date by VRB Power and Sumitomo are summarised in Table 1.

The zinc-bromine battery was first developed by Exxon in the early 1970s and comprises a zinc cathode and a bromine anode separated by a microporous separator. Zinc-bromine batteries are suitable for a range of applications with discharge times ranging from seconds up to several hours. The primary focus of development and demonstration projects to date has been for grid connected utility applications for load levelling and renewable energy system optimisation.

At the present time, the only company that is actively developing and supplying zinc-bromine batteries is ZBB Energy Corporation (ZBB). The company was established in 1982 and over the past 20 years has developed or acquired the intellectual property for the zinc-bromine battery. Its technology is now in the first stages of commercialisation, via the company's F2500 baseline turnkey product, a fully containerised 500 kWh (250 kW x 2 hours) grid-interactive storage system. In addition, it can supply individual 50 kWh modules for renewable energy applications. Key demonstration units installed by ZBB in recent years are summarised in Table 2.

Customer	Basic specification	Application	Start date
Eskom	250 kW x 2 hours	Demonstration unit at Univ. of Stellenbosch	Sep 2001
Pacificorp	250 kW x 8 hours	Peak power capacity and end of line voltage support	Mar 2004
Hydro Tasmania	200 kW x 4 hours	Three way hybrid with wind turbines and diesel generator	Nov 2003
Institute of Applied Energy	AC 170 kW x 6 hours	Stabilisation of wind turbine output	Mar 2001
Tottori Sanyo Electric	AC 3 MW x 1.5 seconds AC 1.5 MW x 1 hour	UPS Peak shaving	Apr 2001
Obayashi Corporation	DC 30 kW x 8 hours	Hybrid with PV cells	Apr 2001
Kwansei Gakuin Univ.	AC 500 kW x10 hours	Peak shaving	Nov 200l
Centro Elettrotecnico Sperimentale Italiano	AC 42 kW x 2 hours	Peak shaving	Nov 2001

Table 1. Energy storage systems supplied by VRB Power and Sumitomo

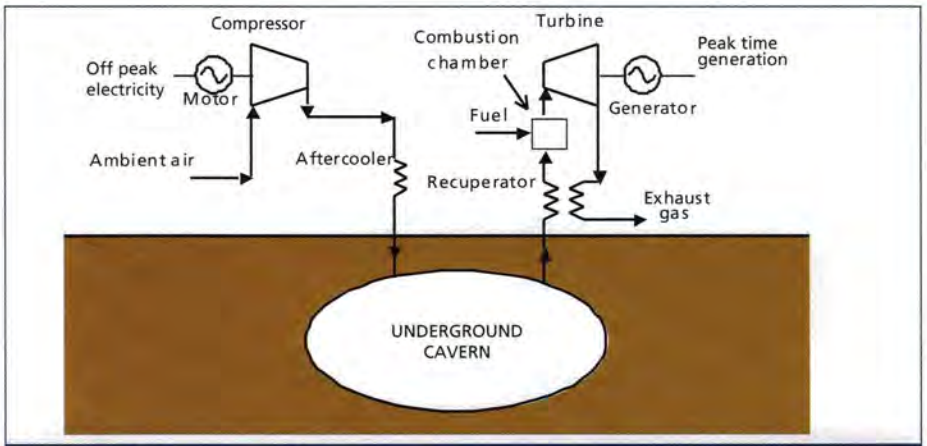

Figure 2: Compressed air energy storage system

Longer-term storage – compressed air

Compressed air energy storage (CAES) complements pumped hydro as a larger-scale (100 MW class), medium/longer-term (hours) storage option. Input power, storage capacity and output power are independent variables, which provides for a great degree of design flexibility. A diagrammatic representation of a CAES plant is shown in Figure 2.

Only two CAES plant have been constructed and commissioned to date, namely the 290 MW Huntdorf plant in Germany (1978) and the 110 MW McIntosh plant in Alabama (1991). Operating experience on both plant is extremely favourable, with the former having completed some 7,000 starts to date, with 90% availability and 99% start reliability.

Such large scale implementations rely on the availability of favourable geological conditions for their underground storage reservoirs. More recently, attention has focussed on the possibility of small scale CAES, utilising fabricated pressure vessel/piping storage and able to provide some 3 to 5 hours storage capacity, at ratings of 5 to 10 MW. Such small scale CAES systems are of particular interest in the US, in the context of buffering wind resources in several states.

Shorter-term storage – flywheels

Flywheel storage, more correctly referred to as kinetic energy storage, provides a high power rating storage medium, typically sized to discharge over some 10 to 100 seconds. Conventional steel rotor systems have been in place for many years and are often installed in combination with standby diesel generators, to provide extremely secure power supplies to such applications as primary broadcasting stations, financial processing centres and air traffic control hubs. The leading commercial suppliers include Piller, Active Power and Satcon.

Much of the current research and developmental effort in relation to kinetic energy storage is directed towards high speed machines, running at tens of thousands of RPM and utilising state-of-the art composite materials technology. The high directional strength properties of such composites, in combination with their relatively low densities allows the designer considerable freedom in optimising the overall flywheel configuration and hence its specific energy and specific power. Units have already been supplied on a commercial basis by Urenco Power Technologies (UPT) and with further systems being developed by AFS-Trinity, Beacon Power, Piller and others.

UPT, in particular, has implemented various systems providing railway trackside voltage support and has also demonstrated the application of a device providing a short-term power smoothing capability in relation to wind turbine output. However, the company's future is now far from certain, following the decision by its Urenco parent, in May 2004, to cease funding the development of the technology.

Customer	Basic specification	Application	Installation date
Detroit Edison	400 kWh	Peak shaving and voltage imbalance	June 2001
United Energy, Melbourne	200 kWh	Demonstration unit for network storage	November 2001
Australian Inland Energy	500 kWh	Hybrid with photovoltaic cells	June 2002
PowerLight Corporation	2 x 50 kWh	Hybrid with photovoltaic cells	November 2003
Pacific Gas and Electric Company	2 MWh	Peak power capacity (substation upgrade deferral)	2005

Table 2: Zinc-bromine energy storage systems supplied by ZBB Energy

Application	Annualised benefit (£ per kW per year)
Arbitrage	25–60
Load levelling	150–200
Spinning reserve	50–120
Frequency regulation	50–130
Voltage support	20–50
Renewables integration	20–60
Power quality	50–500

Table 3: Illustrative value/revenue flows

Market applications

The power utilities sector is presently in a time of unprecedented change, with a shift away from large central generating resource in favour of smaller-scale, distributed resources. The implications of such a shift on power distribution networks are potentially massive, for the UK akin to 're-wiring Britain'. The electricity regulator, OFGEM, is therefore keen to promote innovative design solutions via such initiatives as the IFI (Innovation Funding Incentive) and RPZs (Registered Power Zones), which provide an opportunity to introduce such new technologies as storage.

The overall financial viability of any storage system is a function of its ability to extract value (revenue) from one or more value/revenue streams. A multi-faceted storage system will be able to extract value from multiple revenue streams and thereby enhance its overall financial viability. Value and revenue flows may be extracted from such functionalities as arbitrage and load levelling ('traditional' storage applications), spinning reserve, frequency regulation, network stability, voltage support, renewables integration, quality of supply, power quality and asset deferral. Such value/revenue flows are usually expressed in terms of £ per kW per annum; Table 3 summarises some illustrative values.

A summation of the total revenue flows may then be used to calculate a break-even capital cost for the storage system, based on its capital and O&M costs, and an assumed amortisation period and capital charge (discount rate). Provided the system is able to come in at under this break-even cost level, it is likely to be worthy of a more detailed feasibility study.

This article has demonstrated the considerable number of developments in hand in relation to energy storage technologies. The various systems available are able to span a full range of applications, from high power/short duration requirements to longer-term multiple-hour systems. The complementary developments in the wider power utilities sector present a whole range of new issues and challenges, including very specific opportunities for storage. The immediate challenge for storage systems is to demonstrate their technical and commercial viability, in early demonstration schemes. ●

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Controlling business risk through self-billing

As prices rise, it is even more important that large energy consumers have timely and accurate energy bills. Here, Sam Shields, commercial and industrial business development manager at Siemens Energy Services, proposes a rigorous self-billing process that would be in both the consumers' and energy suppliers' best interests.

Large energy users understand the importance of accurate bills. They need a reliable, robust process that delivers complete visibility of their energy spend. However, the delivery of accurate billing is not straightforward. Energy suppliers openly admit that improving the accuracy of billing is high on their agenda. In practice, this is not an easy task to achieve. Today's suppliers have inherited complex and disparate billing systems as a result of the many utility company mergers and acquisitions in the past ten years and integrating these is a difficult task. At the same time, large energy users are now playing a significant role in shaping the market.

Alongside the complexities prevalent is the demand for reliable, accurate quality data to construct bills. Users know that inaccurate information about their energy use results in poor projections and insufficient visibility of their energy expenditure. This inhibits potential cost savings and opportunities for benchmarking – a significant business risk.

The new self-billing solutions recently developed by Siemens Energy Services provide the user with the visibility required to enable effective data validation, bill settlement and the ability to scrutinise the financial impact of their energy usage. Consumers can determine the level of detail and manner in which their data should be presented and then receive an e-bill in an easy-to-read format. This then becomes a fundamental part of a transparent, customer-driven payment process.

Two-stage concept

There are two basic stages to the concept of self-bill. The first is widespread within the market currently as a simple form of self-billing. It utilises energy data remotely polled from the meter prior to any regulatory validation processes having been undertaken. The disadvantage with this approach is that it is software and resource-intensive with minimal benefits.

The second stage of self-billing is a new concept for the UK energy market to be introduced by Siemens Energy Services. It is based on the use of validated Settlements data collected, validated and aggregated by an independent service provider. Distribution network operators' on-costs and contract tariffs are independently collated, factored and continuously updated to produce a virtual e-bill in an easy to read, on-line format – and this is achieved with minimum data manipulation.

Successful pilot scheme

Siemens Energy Services conducted a successful pilot project to explore the benefits of the self-bill solution. The pilot identified quantifiable, billing discrepancies, which assisted the supplier in improving its billing system and logic. In turn, significant cost savings were highlighted to the customer. The longer-term benefit to the customer would be improved visibility of its energy spend. The final stage to the process will be the customer settling payment to the supplier on the self-bill results – total customer-driven-payment.

This pilot was successful because the objectives of the self-bill concept were achieved and it was supported by the supplier through its validation process. All parties embraced the concept and processes. Suppliers will have legitimate concerns about self-billing, not least because their billing methodologies will be scrutinised by their own customers or agents. However, as the trial identified, positive results can be achieved in the delivery of a solution aimed at minimising customer risk through self-bill.

Customers and supplier benefits

The benefits to energy users are clear. The self-bill concept allows them to check their supplier's bills for the first time in a robust, reliable format. It is particularly valuable for large energy consumers, who need to compare energy use between sites and set targets. In addition, comparable solutions are available for businesses without half-hourly metering facilities to have a reliable, cost effective, remotely read metering installation that incorporates the full benefits of self-billing.

Suppliers will benefit from fewer queries, which take up management time, and also improved cash- flow. Another benefit comes when contracts are renegotiated. If energy usage and payment are accurate, then customers can better predict their future demand. Suppliers are risk averse and are often happier to negotiate on price if users can provide these more accurate predictions.

Suppliers' current experience is that today's partial form of self-bill (the validation of raw metered data) is time-consuming and is not fit for purpose. The lengthy process of comparing, debating and disputing the billing data with customers is resource-intensive and delays payment. The answer? Self-billing using Settlements data reconciled by an independent service provider. This turns the complexity of large volumes of data into a simple, clear virtual bill, which will meet the demands of any cost-efficient business.

The ultimate benefit of self-bill, however, will lie in the strengthening of the supplier/customer relationship. Suppliers who embrace the objectives of the concept are those who are listening to their customers' needs and responding to them. ●

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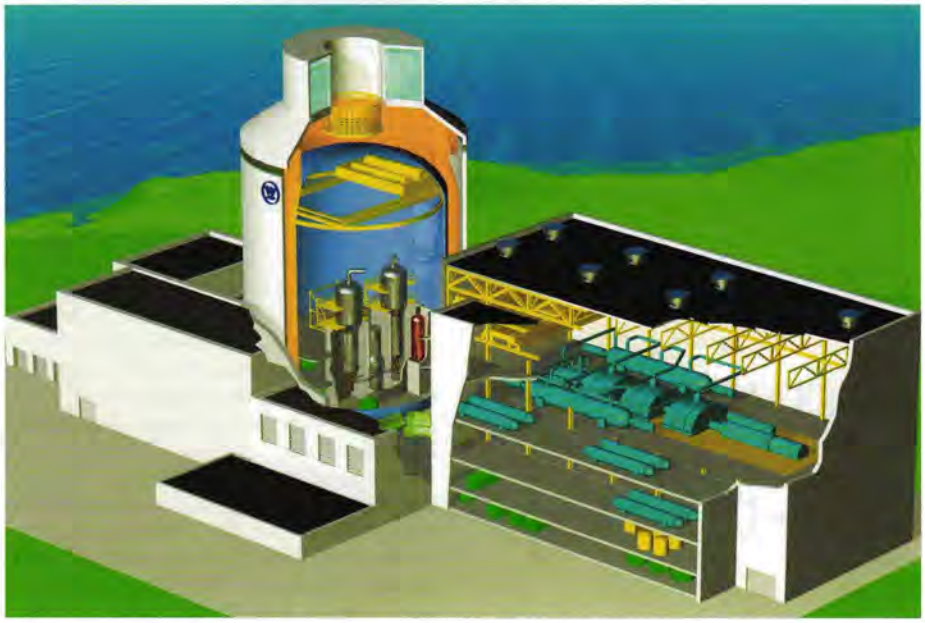
The future of fission power – evolution or revolution?



Cutaway diagram of the Westinghouse AP1000 plant design

Will we need another generation of nuclear power plants to deliver energy security and limit climate change to manageable proportions – or can the combination of increased energy efficiency, renewables and, perhaps, hydrogen be brought on-board fast enough to make this move unnecessary? This seems to be about the most important energy question currently being debated around the world. And, if there is merit in a new nuclear generation, what sort of technology might it use?

The following article is a heavily-edited version of a technical paper published earlier this year by the Institute of Physics (IOP) to answer the second question on technology. The paper was itself commissioned by IOP and is the work of IOP Fellow Richard Mayson, and Members Andrew Worrall and Kevin Hesketh, each of British Nuclear Fuels plc (BNFL). The authors suggest that both evolutionary and revolutionary approaches to new reactor design are necessary.

There are about 440 operational nuclear power plants in the world at present, with a total installed electrical capacity of almost 360 GW. During the course of the year, they will generate more than 2500 TWh of electrical energy, avoiding the production of more than 1 billion tonnes of carbon dioxide from fossil fuels. Moreover, nuclear power makes a significant contribution to security of supply and governments are becoming increasingly concerned about this aspect in the light of Californian experiences, in addition to recent volatility in oil and gas prices and growing dependence on imported energy.

The output of the world's nuclear plants has improved gradually with time such that the world average energy availability factor in 2002 was nearly 84%. The corresponding figure for 1992 was 74%, so that through improved plant performance, annual output has been boosted by more than 12% or 300 TWh. However, many of these plants are already quite old and will be decommissioned by the end of 2020. If they are to be replaced by new nuclear plants, the replacement plants will need to meet new standards of safety, reliability, efficiency, cost and sustainability.

Although the market for new nuclear plants has been stagnant in western Europe and the USA for more than 20 years, reactor vendors have been developing so-called evolutionary designs, which attempt to capitalise on existing technological knowledge and introduce system simplifications that improve safety performance while, at the same time, reducing construction and operating costs. Engineering cost analyses for these plants indicate that they can be economically competitive compared with combined cycle gas turbine (CCGT) plants, provided that the conditions for investment are right.

Evolutionary designs offer very high levels of performance that build on past knowledge and experience. They provide reliable, economic, safe forms of generation based on well established technology. This gives confidence to invest in their deployment in very competitive electricity generation markets.

Revolutionary designs plan to go even further and offer even higher levels of performance, competitiveness, reliability, safety and sustainability. Although still at the research and development stage they abandon the constraints imposed by current reactor technology and aim to demonstrate significant further performance improvements over the evolutionary designs. Progress on revolutionary designs has recently been buoyed by the Generation IV (Gen IV) Initiative, led by the USA. This has identified six revolutionary reactor and fuel cycle systems that will be the focus of an international research collaboration. It is hoped that one or more of these systems will form the core of a new generation of reactors that will allow fission power to contribute to sustainable development well into the 21st century.

The Gen IV designers envisage a future in which nuclear reactors contribute alongside fossil and renewable energy sources as part of an integrated approach to energy production, which may include transport through the production of hydrogen. Nuclear power needs to overcome the current stigma which often prevents politicians from recognising its positive contribution to reducing carbon dioxide emissions. The development of the evolutionary and revolutionary designs is hopefully the first step towards this goal.

Evolution

The current fleet of pressurised water reactors (PWR), boiling water reactors (BWR) and CANDU heavy water moderated reactors (HWR) all originated in the 1950s. With many thousands of reactor

years' operation behind them, they have proven themselves to be reliable and safe. They are designed to stop automatically the nuclear fissions in the event of abnormal conditions occurring.

The single most important safety requirement is being able to guarantee the reliable removal of the nuclear decay heat, which remains after the reactor has been shutdown. PWRs, BWRs and CANDUs all have compact, primary heat transfer pressure circuits with relatively low thermal inertia. This means that the transient response of the coupled reactor/heat transfer system can be quite rapid, which puts stringent demands on the control and protection circuitry and the associated safety systems. Historically, therefore the design approach has been to build in multiple redundancies of sensors, valves, pumps, accumulators, back up power supplies etc. The need to install and maintain multiple systems to nuclear grade standards adds to the construction and maintenance costs and represents an economic penalty.

Moreover, safety requirements have become more stringent over the years, leading to ever more complicated systems. This has meant that, unlike most other items that one would purchase (for example a video recorder), the cost of a given reactor has not reduced with time. In addition to the cost implications, adding layers of complexity can sometimes be counter-productive as there may be a possibility of more complex fault sequences developing. A paradigm change is required and evolutionary light water reactor (LWR) and HWR designs are now at stages of development that make more use of passive safety systems to avoid some layers of complexity.

An example is the Westinghouse Advanced Passive 1000 (AP1000). This is a simplified PWR with passive safety systems. Passive systems use only natural forces, such as gravity, natural circulation, and compressed gas – simple physical principles we rely on every day. There are no pumps, fans, diesels, chillers, or other rotating machinery required for the safety systems. This eliminates the need for safety-related AC power sources. A few simple valves align the passive safety systems when they are automatically actuated. In most cases, these valves are 'fail safe'; they require power to stay in their normal, closed position. A loss of power causes them to open into their safety alignment. In all cases, they are actuated using stored energy from springs, compressed gas or batteries.

AP1000 is based on the well proven 3-loop Westinghouse PWR, many of which are currently in operation. The intent is to benefit as far as possible from the extensive design and operational experience that has been built up, while using passive safety wherever feasible. This approach enables AP1000 to dispense with 50% of the valves, 36% of the pumps and more than 80% of the pipework and cables compared with a comparable, previous generation plant. Moreover, the volume of seismically qualified buildings is reduced by 56%. This results in a smaller footprint for AP1000, in addition to improved safety characteristics.

All this translates directly into significant savings on the cost of construction. Estimates of the cost of building and operating an AP1000 in the UK, after accounting for UK specific cost factors, puts the overall generating cost between £24/MWh for the first plant to be built and £20/MWh for subsequent plants of a series. This is competitive with electricity produced by CCGT plants.

Advanced light water plants are all ready being constructed around the whole in Japan, Korea and Finland. More evolutionary designs such as AP1000 and EPR have already received design approval in their native countries and as such will soon be ready to deploy worldwide.

Research on light water designs is still continuing, nuclear technology is by no means mature. The evolutionary approach is being taken a stage further with the International Reactor Innovative and Secure (IRIS) integral PWR; IRIS and other similar designs that are under development integrate all the primary and secondary pressure circuit equipment inside a single pressure vessel. This approach eliminates many potential fault scenarios resulting from the breakage of interconnecting pipework and can potentially reduce the probability of core accidents by a factor of 10 or more.

Recent developments point to the convergence of HWR and LWR technology. A new variant of CANDU called Advanced CANDU Reactor (ACR) is being developed. In a significant departure from other CANDU plants, ACR dispenses with heavy water as the coolant, replacing it with light water. Heavy water is still used as the moderator, but the presence of light water necessitates the use of slightly enriched uranium fuel to compensate for increased neutron absorption, as in LWRs. The combination of light water coolant and heavy water moderator allows the size of the reactor to be more compact, reducing construction costs, while at the same time reducing operating costs.

These new designs carry on the historic trend that new reactors have to meet ever more demanding safety requirements. A striking example is the new emphasis, post September 11th, on the potential of aircraft impacts on reactors. A recent US study sponsored by the Electric Power Research Institute (EPRI) determined that current reactor structures are robust and protect the fuel from impacts by large commercial aircraft.

The evolutionary approach has resulted in new reactors that offer very high levels of confidence in performance, safety and economics. Such criteria are necessary requirements for any new generation plant operating in commercial electricity markets. The challenge of improving nuclear plant design even further will be difficult given the success of current designs and those currently being licensed. This challenge is not insurmountable and research and development programmes are currently underway worldwide on more revolutionary concepts.

Revolution

Although revolutionary designs are not yet ready to be deployed, there is significant interest in advanced concepts such as High Temperature Gas Reactors (HTRs) and Fast Reactors.

Prototype HTR designs are well advanced for the Pebble Bed Modular Reactor (PBMR) and progress is also being made on the Gas Turbine - Modular Helium Reactor (GT-MHR). HTRs are distinguished by having all-ceramic cores. The absence of metal components in the active core allows extremely high operating temperatures, which gives high thermal efficiency. Moreover, the refractory nature of the fuel makes passive safety possible; the highest temperature in the core following the most onerous fault sequence (which assumes no active decay heat removal) is lower than the degradation temperature of the ceramic fuel.

The fuel for both PBMR and GT-MHR is based on coated particle technology. This involves 1 mm diameter spheres at the centre of which is a kernel containing the fuel material (uranium or uranium/plutonium dioxide). The kernel is encapsulated by lay-

Fossilised gravity

Nuclear reactors need to be competitive with other energy sources and the nuclear industry advocates a future electricity supply with a balance of diverse electricity sources. It is instructive to ask what is the ultimate source of energy in fossil fuels and renewables? It is, of course, solar energy, which formed the fossil fuel, while solar energy ultimately drives all forms of renewable energy. Since solar energy is ultimately derived from nuclear fusion in the sun's core, it is ironic that while controlled nuclear fusion is taking time to develop, most current and historic energy production is derived from it.

But what about fission energy? The heavy nuclei that we use in nuclear reactors were created in r-process neutron captures in supernova explosions. The physical process that drives the collapse of the supernova core is gravity. So fission power can ultimately be traced to gravity; fissile nuclides are effectively fossilised stores of gravitational potential energy from massive stars that long ago ended their lives with an explosion.

ers of pyrolytic carbon and silicon carbide that retain gaseous fission products so that each microsphere is effectively a sealed vessel. In the PBMR, the fuel microspheres are incorporated in a graphite matrix in the form of 6 cm diameter spheres that form the pebble bed core. In GT-MHR, the graphite matrix is formed into hexagonal fuel blocks that are stacked in a more conventional core arrangement.

HTRs are not a new concept; they were extensively developed between the 1960s and 1980s and they use helium as the coolant. They fell out of favour in the 1980s because they were felt to be uneconomic compared with LWRs. There is now a different perspective because the secondary steam loop used to drive a steam turbine is now replaced by a direct gas turbine operating on the so-called Brayton cycle. As well as driving the generator, the helium gas drives high and low pressure compressors, which restore the gas pressure in a continuous cycle. Direct gas turbine cycles allow a higher thermal efficiency and are simpler and cheaper to build and operate than the previous design.

PBMR and GT-MHR represent the first of a class of revolutionary systems that, if the prototypes are a success, could eventually displace LWRs. However, both LWRs and HTRs (at least as embodied by PBMR and GT-MHR) fall short of meeting the requirements for the new Gen IV systems.

Inspired by the US, the Gen IV Initiative is an international collaboration that is looking to the longer term future of fission power. The goals of Gen IV are to develop sustainable new reactor and fuel cycle systems with improved economics, safety, reliability, and proliferation resistance with a view to be ready for commercial deployment by 2030.

Sustainability is perhaps the key driver for Gen IV systems that current nuclear reactors are unable to satisfy fully. One aspect of sustainability is to be able to extract the maximum electrical energy output from each kilogram of uranium ore mined. Most of today's reactors operate a once-through fuel cycle, where spent fuel is stored at the reactor pending its eventual conditioning and geological disposal. Only about 1% of the energy potential of the uranium can be tapped in a once-through cycle, which makes it a relatively inefficient way to use the limited uranium resource. Fuel for some of today's reactors is reprocessed and the plutonium is recycled. Although this moves some way towards the sustainability goal, the practicalities of recycling in current reactors limits the number of times the plutonium can be recycled before its isotopic composition degrades such that it is no longer usable.

Efficient recycling of material is easier to achieve in a fast spectrum reactor, which is one of the reasons why four of the six Gen IV systems identified in the Gen IV Roadmap are fast reactors. These are the Gas Cooled Fast Reactor (GFR), Lead Cooled Fast Reactor (LFR), Sodium Cooled Fast Reactor (SFR) and the fast neutron spectrum Supercritical Water Cooled Reactor (SCWR). All these systems would use advanced reprocessing technology to establish a breeding cycle; after the initial load of fuel, they generate just sufficient plutonium from fertile uranium-238 to be self-sustaining in the fuel. Advanced reprocessing technology is intended to enhance proliferation resistance by maintaining the fuel in a form that is 'too hot to handle' by utilising self-protecting barriers such as irradiation fields.

The LFR and SFR systems can all claim to have some basis in reactors that have already been built and operated. The fast neutron spectrum SCWR and a thermal spectrum variant also being pursued in the Gen IV Roadmap introduce a new aspect of technology. Supercritical fluids have many industrial applications, but these are the first reactors to exploit their unusual properties. Near the critical point, many of the thermodynamic properties of a fluid, such as its heat capacity and heat transfer coefficients, are strongly enhanced compared with the normal phases. Although these enhancements have some benefits in the system design, the most useful feature of supercritical water is that there is no longer any distinction between liquid and gas. The supercritical water can therefore be used both as coolant in the core and as the working medium for a turbine.

Unlike conventional LWRs, where an upper limit of around 300°C on water temperature limits the thermal efficiency to around 33%, an SCWR can operate at much higher temperatures and achieve 44% thermal efficiency. For a given electrical output, a smaller system size will suffice, cutting construction costs. There is also a proportional reduction in the uranium and fuel requirements, even with a once-through cycle. Fissile inventories and waste arisings are also reduced. Thus, the high thermal efficiency on its own allows significant progress towards the Gen IV drivers.

Gen IV is also pursuing the Very High Temperature Reactor (VHTR), which is intended to advance PBMR and GT-MHR technology to meet the Gen IV objectives. At the gas outlet temperatures envisaged (more than 900°C), very high thermal efficiencies are achievable and there is also the option to use the gases to provide process heat for hydrogen generation. VHTR could also be considered as a GFR precursor.

The Gen IV Roadmap identifies the technology gaps for each of the systems being taken forward. All the systems have significant technology gaps, as might be expected for technologies which are revolutionary departures from existing technology. Many of the gaps are common to more than one system, such as fuel technology, engineering systems development, fuel cycle technologies and materials technology. Development and testing programmes for reactors typically extend over very long timescales and are expensive to implement, which is one of the main reasons why such an ambitious project can only realistically be carried out via an international collaboration. It is hoped that Gen IV will generate the technological knowledge that is needed to bridge the gaps and allow one or more systems to be developed to commercial readiness within 20 years.

Next step

There are those who object to nuclear fission power on the grounds that it is unleashing an unnatural force.

Given the environmental threats which face the earth, we owe it to ourselves not to forgo a technology that has a proven ability to deliver energy reliably and safely with no greenhouse gas emissions. In the UK, there is already an urgent need to start planning for new nuclear build to replace the existing plants as they are decommissioned, if we wish to avoid adding to the UK's emissions of greenhouse gases. However, at the moment the social and political climate is not conducive for new build. Key areas that need to be addressed include:

- the exploration of mechanisms for encouraging private investment;
- the need to streamline the licensing and consent process; and
- improved understanding by the public of the benefits and risks of nuclear power.

Scientists and engineers have a significant role in the future developments of new reactor systems; in addition to providing the science and technology, it will be important for them to work towards improved public education to allow informed debate on this crucially important issue.

In conclusion, the answer to the question posed by the title of this paper is that we need both evolutionary and revolutionary reactor designs. The evolutionary designs offer extremely high levels of performance, reliability, safety and economics that are demanded in any commercial electricity market today. These designs are either ready to be deployed or are in the final stages of licensing. They will plug the gap left by the retirement of current nuclear plants and will avoid sizeable increases in carbon dioxide emissions in the not too distant future. The construction of evolutionary designs would also keep alive the knowledge and expertise that has been built up and hence assist in keeping the nuclear option open now and in the future.

Nuclear technology is by no means mature; levels of performance, safety and sustainability can be taken still further through research and development of more revolutionary designs as envisaged in the Generation IV programme. ●

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Securing energy for Britain – 2010 and beyond

The final sentence of this issue's 'Viewpoint' article, from Paul Todd of Mitsui Babcock's nuclear section, suggests that the case for building new nuclear power stations in Britain will strengthen "when energy shortages supersede climate change on the political agenda". But energy shortages – or the inverse, energy security – is already on the agenda and was the subject of a major one day conference organised by the Energy Institute and held in London in September. Most of the talk, though, was about gas. Steve Hodgson was there.

The most striking presentation was from Michael Smith, Head of Energy Analysis at BP's Economics Unit, who was in no doubt that the UK has already entered a period of very rapid change from a net energy exporter to a country that is now "managing decline" and will become a net energy importer again, probably this year.

UK oil production peaked in 1999 and gas in 2000, but this only half of the story, said Smith, with coal and nuclear production falling rapidly as well. He quoted DTI data that states the UK has already pulled 60% of its oil reserves out of the ground, and 55% of its gas. At 2003 production levels, oil would last just five-and-a-half more years; gas six. Gas within the UK-Continent Interconnector pipeline, built to export UK gas to Europe, now frequently flows from Zeebrugge to Bacton, said Smith.

And Britain's decline is steeper than most people think – 2004 oil production is some 30% down from its 1999 peak and gas 10% down from 2000. The challenge now, said Smith, is to maintain the competitiveness of the remaining supplies, and to attract investment in new exploration to ensure that remaining reserves are all found and exploited. Smith worked in another declining region, Alaska in the 1980s, where it had been very difficult to attract that exploration investment.

Two tight winters

Smith was the first of several speakers to talk about a "very tight gas supply situation for the next two winters", after which new import arrangements will result in potential oversupplies again for the following few years. Prices could fall again at this point.

Neil Hirst, Head of the Energy Markets Unit at the DTI had made similar "two tight winters" point earlier, adding that new gas importing infrastructure (mainly to facilitate new imports from Norway) would allow supplies to catch up with demand again – at least until 2012 or so, when the supply and demand graphs cross again.

Hirst added that depending on gas imports was not necessarily a problem for Britain – all the G7 countries except Canada and the UK are energy importers – but that new sources of gas and new and upgraded importation infrastructure would both be vital. Plenty of new import options exist, added Hirst:

- More import connections to Norway;
- new LNG terminals to import gas from worldwide sources;
- more interconnection with EU gas grid;
- pipeline upgrades to increase import capacity of the Interconnector; and
- new gas storage capacity and/or access to EU storage.

And gas markets can deliver the required investment, added Hirst, with major companies already committing more than £10 billion for new gas importation projects.

Ken McKellar of Deloitte Petroleum Services gave details of some of the projects at various stages of development. Taking these in likely order of completion, McKellar started with the proposed Langeled to Bacton pipeline to bring new Norwegian supplies to the UK, followed by reversal of the Interconnector to allow new supplies to arrive from Russia via Germany and Belgium, and the upgrading of Zeebrugge's LNG terminal. Completion of these projects would delay the UK 'gas gap' until 2012 or so, said McKellar. New LNG terminals proposed for Britain itself, at the Isle of Grain and Milford Haven, would extend this to 2015.

Longer-term projects are further LNG supplies to Milford Haven and new pipelines to the UK from the Netherlands and, via Germany, from Russia.

Diversity of suppliers

BG Group's Bill Adamson confirmed the two tight winters scenario and that the winter of 2006/07 would see the UK back into an oversupply situation. But the existence of a "diversity of suppliers" for the next two winters will prevent any damage to the UK's security of supply. One of those suppliers will be the BG Group, which "aims to be a very major investor in the UKCS over the next two years".

Adamson also confirmed BG Group's intention to bring the Dragon LNG terminal at Milford haven online by 2007 to the tune of 6 billion cubic metres (bcm) per year. The project had been helped along by winning exemption (by the EC) from having to allow third party access to the terminal.

So it all looks fine for gas, once we have seen out the next two 'tight' winters, it seems. What about keeping the lights on?

The Managing Director of Corporate Strategy at Ofgem, Boaz Moselle, is convinced that the markets will deliver required new gas importation and electricity generating capacity. For gas, the market is responding because it sees demand, a competitive market and a stable regulatory regime. Meanwhile, the power market has already responded to growing demand by taking several stations out of mothballs since the autumn of 2003, and longer-term prospects are good too.

Quite what the fuel make up for new generation plant will be is uncertain, to say the least. But the DTI's Neil Hirst pointed out that recent rows over new wind power was evidence that renewables are starting to measure up to the ambitious targets set for them. Success brings its own problems. The DTI currently expected the electricity system could accept wind generation up to a little more than 10% of the total without any dedicated back-up generating capacity, and that, going beyond 10% could stimulate the building of single-cycle gas plant as a dedicated back-up. ●

Meet the energy gap by making use of 'waste' heat from power stations

It does seem ridiculous, given falling supplies of UK-sourced coal, oil and gas, to watch large electricity generating stations continue to discard half or two thirds of their fuel input energy to the environment as 'waste' heat. Indeed, the heat lost at power stations (and, to a lesser extent in electricity transmission lines) could go a long way towards meeting the heating needs of all UK buildings. Against this background, John Amos, electrical engineer and energy specialist with Hoare Lea, argues that government objectives to reduce emissions of carbon dioxide will never be met without a campaign to harness discarded heat. And that points to a massive increase in the use of combined heat and power (CHP) and district heating.

With dwindling UK Continental Shelf oil and gas supplies, the Government's 2003 Energy White Paper set out to limit dependence on fuel imports mainly through various end-use energy efficiency measures. It is suggested that energy efficiency measures in buildings will make a substantial contribution to meeting the UK's commitment to reduce carbon dioxide emissions by 60% by 2050. This is a formidable commitment using the proposed economy measures alone. However, the White Paper does not take account of the significant reduction in UK energy consumption and carbon emissions which would result from our using waste heat from power stations and other sources to heat buildings via large scale district heating schemes, as in much of Europe.

There are, of course, other unused UK energy resources which are not described here. For example, the International Energy Agency estimates that UK use of renewable energy is about the lowest among all OECD countries.

UK power supplies

Following the oil supply interruptions and price fluctuations of the 1970s, many European countries adopted energy policies and technologies to reduce their dependence on imported oil supplies. However, the UK had substantial coal deposits and seemingly ample offshore oil and gas deposits. With the prospect of increasing nuclear power resources in addition, there seemed no need for the UK to consider the sort of measures adopted in Europe.

However, since the 1970s, UK energy supply has gradually become more precarious. UK energy use has continued to increase and UK offshore oil and gas supplies are shrinking and not expected to last many more years. The UK coal industry is much reduced and electricity generating margins are a cause for concern. We have been selling a proportion of our extracted oil and gas supplies to other countries, and have become perhaps over dependent on the resulting tax revenues and beneficial effects on our balance of trade.

We are not only now faced with shrinking UK oil and gas reserves, with energy consumption expected to continue increase at least until 2020, but also with growing pressure to reduce UK carbon emissions. The Government has consulted widely as to what should be done, and in 2003 published its Energy White Paper on how to deal with the pressures now facing us.

The Energy White Paper proposed measures aimed at reducing our carbon emissions by 60% by 2050. The DTI's estimate of UK carbon emissions in 2001 was 154 million tonnes of carbon (MtC). The White Paper suggests that current policies may reduce this figure to 135 MtC by 2020 and aims for a further 15–25 MtC reduction by 2020 resulting from the further measures.

For their estimated cuts in carbon emissions up to 2010, the Government is looking mainly to various measures to improve the energy efficiency of households, businesses and the public sector, with contributions from the UK's voluntary carbon emissions trading scheme.

Carbon emissions from UK electricity production are at present about a quarter of UK total carbon emissions. With the progressive closure of existing nuclear power stations, it is planned to control any resulting increase in carbon emissions by further reducing coal-fired electricity production and by increasing gas-fired electricity production, with electricity from renewable sources making some contribution by 2020.

UK nuclear power has not been developed to the extent envisaged in a 1976 report from the Royal Commission on Environmental Pollution. The 2003 White Paper explains that the current economics of nuclear power make it an unattractive option for new carbon-free generating capacity, and there are important issues of nuclear waste to be resolved. However much care is taken, the dangers from nuclear power are formidable, but no attempt is made to describe them here.

With UK offshore oil and gas supplies shrinking, it is planned to use gas imports from Norway, Russia and North Africa to fuel the increase in gas-fired electricity supplies envisaged, doubling the present gas consumption for electricity production.

The proposed building energy efficiency improvements proposed are not enough by themselves to achieve the carbon emission reductions aimed for. UK energy supply security seems likely to become increasingly precarious unless the Energy White Paper proposals can be considerably enhanced.

UK energy consumption and carbon emissions

Table 1 is compiled from the DTI's 2002 report: *Energy – its impact on the environment and society,* from the *2002 Digest of UK Energy Statistics* and from *EP 68: Energy Predictions for the UK*. Energy consumption figures include electricity consumption by end users and power station fuel consumption. Carbon emissions from electricity production are here ascribed to power stations, not to electricity end users.

It will be seen that 2001 losses from power stations exceeded the estimated fuel consumption for building heating purposes. Technically unnecessary losses through inefficiency of existing building energy systems have not been estimated, and are likely to be much more than is generally realised.

Amended versions of the Government papers referred to will no doubt be issued to take account of the White Paper carbon emission projections and proposed energy efficiency improvements.

UK power stations, including nuclear power stations, waste a substantial proportion of the energy they consume in generation losses and are, at present, the largest UK source of carbon emissions. UK power station fuel consumption in 2001 was 82 mtoe, from which the equivalent

of only 28.7 mtoe was delivered to final users as electricity. Much of the 53 mtoe difference was recoverable waste heat.

There are also UK industrial and other waste heat sources of which no use can be made at present and the waste heat has to be rejected into the environment. At the same time as having large amounts of waste heat rejected into the environment, UK final energy consumption was 171 mtoe, much of it used for building heating purposes.

The UK needs CHP and district heating on a European scale

UK dwellings and other buildings consume about 70 mtoe/annum of electricity and fossil fuels with all the associated carbon emissions and efficiency losses, and at the same time UK power stations have perhaps 50 mtoe/annum recoverable heat losses. The UK now needs, with some urgency, to control its fossil fuel consumption. Using power station waste heat to heat buildings instead of using individual boilers could make a significant contribution to meeting the White Paper's objectives.

In Europe, many dwellings and other buildings are connected to extensive district heating schemes, and use nearby CHP/DH power stations to serve them with both heating and electricity. For example, about 60% of Danish homes are connected to district heating schemes and thus avoid considerable fuel consumption and carbon emissions. DH systems can also make use of industrial waste heat, and heat from renewable sources.

District heating is not unknown in the UK. Several new municipal DH schemes were installed in the 1960s to serve the local authority housing schemes. However, many of the schemes were poorly engineered and suffered premature underground mains failures. Most schemes used commercial fuels whose cost rose steeply with time. Many of the initial schemes were not expanded and adapted to changing conditions, and many have been abandoned.

Recently, a few new UK DH schemes have been installed, for example in Southampton and Woking. With the Government's Community Energy programme, grants are available for new and refurbished DH schemes, but development and expansion on a European scale is unlikely.

Government, policy, planning and research support for CHP/DH has not been available in the UK to the same extent as in countries such as Denmark. Even there, it has taken many years for CHP/DH schemes to reach their present stage of development. It is unlikely that the UK will catch up with Europe within any reasonable timescale if we have to rely on present Government policy and support arrangements alone.

Best practice CHP/DH system planning and design

Danish CHP/DH is a well developed example of European best practice. Typical features in outline are as follows.

The first stage is to plan the scheme development, to decide where the initial heat network pipes are to be laid and the heat stations needed to serve them. Hot water is the preferred heating medium with typical winter flow and return temperatures of 90° and 50°C. Primary distribution is in steel pipes with plastic foam insulation and tough plastic sheathing. Cities and small towns may have several local piping networks, each with a heat station with fossil fuelled boilers. Heat from refuse incineration may also be used.

Various methods are used for absorbing pipe expansion and contraction. Secondary distribution may be in all plastic insulated pipe systems. Variable speed pumping is used with controls to maintain reasonably constant differential pressures throughout the network. Maintaining a wide flow and return temperature difference reduces water flows and the distribution pipe sizes needed. Modern pipe systems with well controlled water treatment have relatively long lives before needing to be replaced.

The building heating systems needed are simpler than typical UK practice. Small packaged heat terminals take hot water from the incoming heat mains and distribute the heat within a building by indirect connection through plate heat exchangers. Controls provide variable flow, constant 80° to 40°C temperature difference. The thermostatic controls for heat emitters have flow limiters to ensure that return temperatures are maintained at the designed value. Modern heat meters transmit heat usage to the heat station together with water return temperature.

When local heat networks are extensive enough, and the heat load has grown sufficiently, the local heat stations may be linked together and joined to a local CHP/DH power plant. Such plants use various technologies, depending on the available fuel supplies. Gas-fired combined cycle gas turbine plants such as that at Viborg are relatively simple, with overall efficiencies approaching 90%, and with twice the energy for sale as similar electricity-only power plants. Other CHP/DH power stations could use other fossil fuels, refuse or such renewable fuels as straw and forestry waste.

UK barriers to be overcome

The UK could and should set out to adopt CHP/DH on a sufficient scale to contribute substantially to meeting the White Paper's objectives. However there are significant barriers to be overcome before the UK could adopt such a policy.

First, we need enough professional engineers, technicians, university and government departments who know how much energy is being wasted by UK power stations and buildings, and understand the reasons for it, as few seem to do sufficiently well at present.

Second, we need to adapt European CHP/DH best practice to UK conditions. Current UK practice in building heating system design is unfortunately very different in principle from European CHP/DH best practice. Even experienced engineers need some time to get their minds round the changes needed. All the technology and planning expertise needed is available in well developed form in Europe. We could learn if we had a mind to.

Third, UK supply side energy supplies are in the hands of international commercial companies. In planning any reductions in energy use, commercial imperatives and current international agreements would have to be taken into account. Further, the introduction and expansion of CHP/DH would require progressive detailed legislation to establish the necessary organisations with powers to carry it out, as it has for example in Denmark since the 1970s. The present UK community energy schemes are hardly big enough to worry the big players.

Fourth, the UK Treasury depends on the fuel extraction tax revenues and on the contribution to our balance of trade from selling our extracted oil and gas supplies to other countries. These and probably other economic considerations have to be taken into account by the UK Government.

CHP/DH is nevertheless almost the only way of making use of the immense quantities of waste heat available in the UK at present which is dissipated into the environment and wasted. With UK fuel supplies dwindling and the need to control carbon emissions, it is time for CHP/DH on a European scale to be adopted as an important new component of UK energy policy. We would be foolish to wait until the lights go out before we decide what to do. ●

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The views expressed here are entirely his own, and do not necessarily reflect those of any company or organisation.

Source	Carbon emissions 2001 (MtC)	Projected carbon emissions 2020 (MtC)	Energy Consumption in 2001 (mn tonnes of oil equivalent, mtoe)
Power stations	43.7	37.1	82.1 (includes 50 mtoe losses)
Industry	37.2	38.8	35.1
Transport	33.5	47.2	54.9
Domestic	23.9	24.3	48.6 (includes 30 for heating)
Commerce & services	8.5	9.9	22.1 (includes 11 for heating)
Other	11.1		10.9
Totals	154.5	157.3	253.7

Table 1. UK energy consumption and carbon emissions

The route map to a clean energy future with coal

The world's most carbon-intensive fossil fuel – coal – will continue to have a very major role in energy economies around the world for several decades to come, but that doesn't mean that coal cannot contribute to moves towards global sustainable development. This article, from the World Coal Institute (WCI) charts the very considerable technological progress required to help coal move towards a 'zero emissions' scenario, but suggests that moves in this direction are well underway. The article is a summary of the WCI's latest report: Clean Coal – Building a Future through Technology.

Coal plays a major part in the world's energy system, currently supplying over 38% of the world's electricity. Coal-fired electricity drives the economies of the two most populous and fastest growing countries in the world today – China and India – as well as a number of key industrial economies such as the USA and Germany. Coal consumption is expected to grow by about 1.4% per year over the next thirty years.

Within this context, the coal industry recognises that it must be able to meet the environmental challenges before it. In particular, coal and other carbon-intensive energy sources must significantly reduce their potential greenhouse impacts if they are to claim a continuing and sustainable role in the energy mix.

The key to achieving this goal is through the further deployment of currently available technologies, and the development of new advanced clean coal technologies. A technological pathway can be set out, demonstrating how the major advances already achieved can be built upon to ensure that coal has a central role in a sustainable energy future.

Coal's technology pathway

Coal's technical response to the environmental challenge is ongoing and multi-faceted. One representation of the coal-fired route to carbon reductions is shown in Figure 1. There are three core elements:

- eliminating emissions of pollutants such as particulate matter, oxides of sulphur and nitrogen – the technologies are readily available and have been applied in many parts of the world;
- increasing thermal efficiency to reduce carbon dioxide and other emissions – major gains have already been achieved and further potential can be realised; and
- eliminating carbon dioxide emissions – the development of 'zero emission technologies' has commenced and is accelerating rapidly.

Coal also has the potential to be used as an essential source of hydrogen for completely clean future energy systems – for both stationary and transport applications.

Many of the steps along the technology 'road' have been taken already in many countries around the world. Some countries are at the beginning but are moving forward along the pathway.

Enhanced take up of existing options

A range of options already exists to improve the environmental performance of conventional coal-fired power stations.

Coal cleaning by washing and beneficiation continues to play an important role in reducing emissions from coal-fired power stations. It can reduce the ash content of coal by over 50%, reduce sulphur dioxide (SO_2) emissions and improve thermal efficiencies (leading to lower carbon dioxide emissions). Coal preparation is standard in many countries, but it could be usefully extended in developing countries as a low-cost way to improve the environmental performance of coal use. Only around 11% of thermal coal in China, for example, is currently washed. If a greater proportion of this coal were cleaned, there is the potential for thermal efficiency improvements of at least 2–3% and possibly up to 4–5%.

Particulate emissions can be reduced by methods such as electrostatic precipitators, fabric filters (also known as baghouses), wet particulate scrubbers and hot gas filtration systems. Both electrostatic precipitators and fabric filters can remove over 99% of particulate emissions.

Global concerns over the effects of acid rain have led to the widespread development and utilisation of technologies to reduce, and in some cases eliminate, emissions of oxides of sulphur (SOx). Flue gas desulphurisation (FGD) technology, for example, employs a sorbent, usually lime or limestone, to remove sulphur dioxide from the flue gas. FGD systems are currently installed in 27 countries and have led to enormous reductions in emissions. Wet scrubbers, the most widely used FGD technology, can achieve removal efficiencies as high as 99%. The cost of FGD units has also reduced significantly, now costing one-third of what they did in the 1970s.

Oxides of nitrogen (NOx) reduction technologies include the use of low NOx burners, selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR). Low NOx burners and burner optimisation techniques are used to minimise the formation of NOx during combustion.

Techniques such as SCR and SNCR lower NOx emissions by treating the NOx post-combustion in the flue gas. SCR technology achieves 80–90% NOx reduction and has been used commercially in Japan since 1980 and in Germany since 1986.

Deployment of advanced technologies

Fluidised bed combustion

Fluidised bed combustion (FBC), in its various forms, can reduce emissions of SOx and NOx by 90% or more. In fluidised bed combustion systems, coal is burnt in a bed of heated particles suspended in flowing air. FBC systems are popular because of the technology's fuel flexibility; almost any combustible material can be burnt. In the USA, for example, FBC systems are increasingly utilised to burn abandoned piles of coal waste, turning what could otherwise be an environmental problem into a useful source of power.

Supercritical and ultrasupercritical power plant technology

Supercritical pulverised coal-fired power plant operate at higher steam temperatures and pressures than conventional subcritical PCC plant, and offer higher efficiencies – up to 45% – and hence lower emissions, including emissions of carbon dioxide, for a given power output. Even higher efficiencies – up to 50% – can be expected in ultrasupercritical (USC) power plant, operating at very high temperatures and pressure.

More than 400 supercritical plant are in operation worldwide, including a number in developing countries. The 2 x 600MW supercritical Shanghai Shidongkou coal-fired power plant in China, for example, was put into operation in the early 1990s and China is now installing supercritical plant as standard for new plant. There are currently nine supercritical plant in operation in China, with 16 under construction and a further eight planned, altogether totalling over 21 GW of coal-fired capacity.

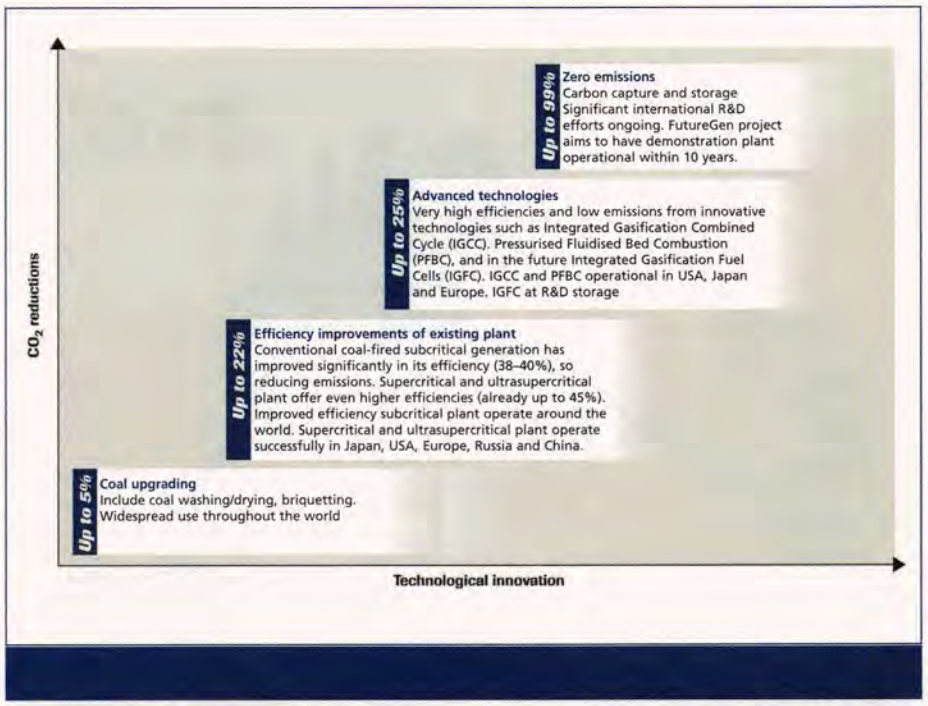
Integrated gasification combined cycle

In integrated gasification combined cycle (IGCC) systems, coal is not combusted directly, but reacted with oxygen and steam to produce a 'syngas' composed mainly of hydrogen and carbon monoxide. The syngas is cleaned of impurities and then burned in a gas turbine to generate electricity and to produce steam for a steam power cycle.

IGCC technology offers high efficiency levels, percentages typically in the mid-40s – although plant designs offering close to 50% efficiencies are available – and as much as 95–99% of NOx and SOx emissions are removed. The further development and support of IGCC offers the prospect of net efficiencies of 56% in the future. There are around 160 IGCC plants worldwide.

The appeal of IGCC technology also extends beyond the potential for increased efficiencies and further reductions in pollutants. IGCC technology may also be the chosen pathway for the ultra low emissions system of the future, using carbon capture and storage, and as part of a future hydrogen economy. In IGCC, the syngas can be 'shifted' to produce carbon dioxide and hydrogen, which can then be separated so that the hydrogen is available as a clean fuel product for use in power generation via gas turbines and fuel cells. The carbon dioxide is then available in a concentrated form for capture and storage.

At present, IGCC applications for power generation are considered by some to be less reliable than other clean coal technology options, such as supercritical PCC and CFBC. Further development in this area will be necessary if the technology is to become the chosen pathway.



Exploiting synergies with renewables

Renewable energy technologies are increasing their share of the world's energy mix. However, there are a number of significant practical and economic barriers that limit their rate of penetration. The International Energy Agency estimates that new renewable technologies will still account for less than 5% of world electricity supply by 2030.

Renewable energy forms tend by their nature to be intermittent or unpredictable and to be 'site dependent' – ie only available at particular suitable sites. Wind energy, for instance, depends on whether and how strongly the wind is blowing and even the best sites do not normally operate for more than about one third of the time. Hydroelectric power similarly depends on the right sort of geographic conditions and on rainfall; a dry year may see shortages. Many forms of biomass are seasonal or difficult to transport.

Coal can be used to help overcome these difficulties, and hence support the use of renewables. Coal is widely available, easy to store and transport, and its reliability in generation can balance the uncertainties introduced into the power grid by intermittent renewable energy. There are also operational synergies between coal and renewables that can significantly increase the efficiency of the renewable technologies and may be the most cost-effective way of increasing their use.

In particular, the economics and efficiency of biomass renewable fuels can be improved by co-firing with coal. Existing conventional coal-fired power stations can generally use between 10% and 20% biomass without modification, making it possible to reduce greenhouse emissions and use renewable resources, which would otherwise often go to waste.

Other renewable energies offer similar synergies with coal – for instance, linking steam from solar thermal technology with the steam cycle of coal-fired power plant can be an effective way of converting solar energy into electricity, at lower cost and with higher efficiencies than alternative routes, such as photovoltaics.

On a wider scale, coal-fired plant can complement wind or hydro generation providing the back-up needed when the renewable sources are not available.

Development and commercialisation of next-generation technologies

In the longer term, technologies for carbon capture and storage (CCS) have the potential not only to be an economic and environmentally acceptable route to a low carbon future but also to enable coal to form the basis of a future hydrogen economy.

These technologies enable emissions of carbon dioxide to be 'captured' and 'stored'; that is stripped out of the exhaust stream from coal combustion or gasification and disposed of in such a way that they do not enter the atmosphere. Carbon storage is not currently commercial but the required technologies are already proven and have been used in commercial applications in other contexts.

Storing and using carbon dioxide

A number of options for the storage of carbon dioxide are being researched – Figure 2 illustrates some of these.

Geological storage – injection of carbon dioxide into the earth's subsurface offers potential for the permanent storage of very large quantities of carbon dioxide and is the most comprehensively studied storage option. The carbon dioxide is compressed to a dense state, before being

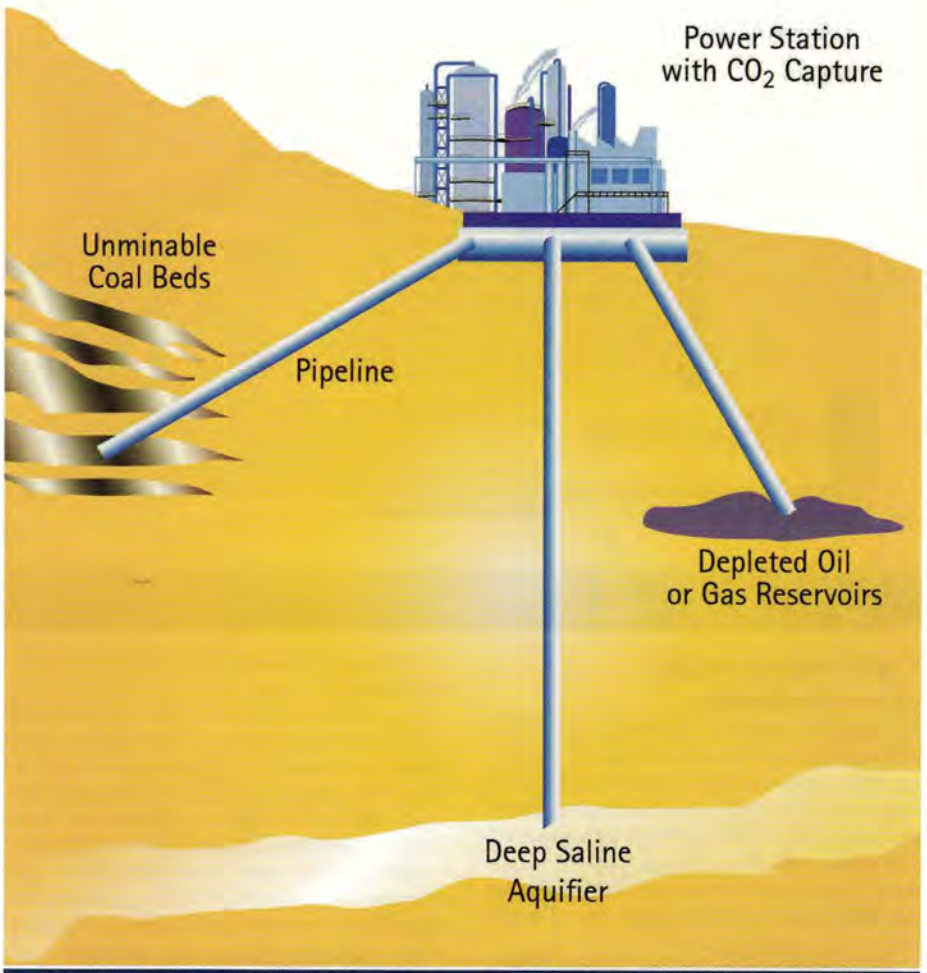


Figure 2. Options for storing carbon dioxide from coal-fired power stations

piped deep underground into natural geological 'reservoirs'. Provided the reservoir site is carefully chosen, the carbon dioxide will remain stored (trapped in the bedrock or dissolved in solution) for very long periods of time and can be monitored. Carbon dioxide is already widely used in the oil industry to increase oil production – the carbon dioxide helps pump oil out of the underground strata, so increasing the level of recovery from the field while remaining stored in the geologic reservoir.

Saline aquifers – storing large amounts of carbon dioxide in deep saline water-saturated reservoir rocks also offers great potential. A major project is already being conducted at the Sleipner field in the North Sea, where about 1 million tonnes a year of carbon dioxide are being injected at a depth of about 800–1000 m below the sea floor.

Another option for permanent carbon dioxide storage is mineral carbonation – a process whereby carbon dioxide is reacted with naturally occurring substances to create a product chemically equivalent to naturally occurring carbonate minerals.

Enhanced coalbed methane is a potential opportunity for storing carbon dioxide in unmineable coal seams and obtaining improved production of coalbed methane as a valuable by-product.

The capture and storage of carbon dioxide presents one of the most promising options for large-scale reductions in carbon dioxide emissions from energy use – and its economics are likely to be broadly comparable with those of other options, such as renewables.

Hydrogen from coal

In the longer term, one option is the move towards hydrogen-based energy systems, in which hydrogen is used to produce electricity from gas turbines and, ultimately, fuel cells.

A key uncertainty surrounding the widespread uptake of fuel cells relates to the availability of hydrogen, which does not naturally occur in usable quantities. Coal, with the biggest and most widespread reserves of any fossil fuel, is a prime candidate to provide hydrogen (via coal gasification) in the quantities needed and over the timeframe required.

Several countries are starting to implement hydrogen programmes and many of them are considering coal as an option for the production of hydrogen. The European Commission's proposed Hypogen project – a €1.3 billion project to generate hydrogen and electricity produced from fossil energy sources including coal – is one such programme. Similarly, the US DOE FutureGen programme has declared a 10-year timescale to demonstrate hydrogen from coal gasification technology.

Jaan's Eagle project is aiming to demonstrate a hybrid system of coal gasification with fuel cells (IGFC), with the ultimate goal of reaching efficiencies of 60%.

Realising the Vision

Continued improvements in the performance of coal-fired power generation have been made possible by past research and development work undertaken in many countries and involving many organisations, in both government and industry. Such work continues, with the aim of leading us further down the road to lower emissions, towards the vision of an ultra low emissions future.

Some current research programmes looking into future clean coal technologies include the AD 700 Power Project (Europe), Canadian Clean Power Coalition, CANMET Energy Technology Centre (Canada), EAGLE Project (Japan), FutureGen (USA) and COAL21 (Australia)

The Carbon Sequestration Leadership Forum (CSLF) is an international initiative focusing on the development of carbon capture and storage technologies through collaboration. Some 15 countries, plus the European Commission, are involved in the Forum to "facilitate the development of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term safe storage; to make these technologies broadly available internationally; and to identify and address wider issues relating to carbon capture and storage."

Conclusion

Significant reductions in carbon dioxide emissions from coal-fired power stations have already been achieved through increasing efficiency. However, the road to sustainable coal consumption involves going further and achieving major reductions through the development and application of zero emissions technology. Zero emissions will not be achieved overnight, but a realistic pathway can be identified leading to substantial and sustained emissions reductions.

With a favourable policy environment to facilitate the continued deployment of existing clean coal technologies and the development of the next generation of technologies, the vision of an ultra low emissions energy production system for the 21st century can be realised. The coal industry is committed to working with others to achieve this goal. ●

For a copy of the report, or for information about the World Coal Institute please visit the WCI website at: **www.wci-coal.com**

Events

This page lists some of the energy events being held around the UK and the world that are most relevant to readers of *Energy World*, including major events organized by the Energy Institute. A list of events organized by EI branches can be found in *Energy Network*, distributed with *Energy World*. To submit details of your event for inclusion here, please send brief details to eworld@energyinst.org.uk

NOVEMBER 2004

2 November
Energy solutions in action
Seminar and exhibition for energy managers, Birmingham, free
Details: ESTA
t: +44 (0) 7041 492049
www.esta.org.uk

8 November
Engineering challenges at the dawn of wave and tidal energy
Conference, London
Details: Tina Churcher, IMechE
t: 0207 973 1258
e: t_churcher@imeche.org.uk

9–10 November
Fitting Europe's gas supply into an international context
Conference, Barcelona
Details: EAGC
t: 01895 454545
e: info@theeagc.com

10 November
Oil depletion – no problem, concern or crisis?
EI conference, London
Details: EI Events Team
t: 0207 467 7100
e: events@energyinst.org.uk

16–17 November
EIConnect supply chain event
Conference, London
Details: Energy Industries Council
t: +44 (0)20 7221 2043
www.the-eic.com

17–20 November
Renewable energies and co-operation exchange
Conference, Vienna
Details: Congress Office
t: +43 50550 6484
www.bit.or.at/energy

18 November
CHP: putting the heat on
CHPA conference, London
Details: CHP Association
t: 0207 828 4077
www.chpa.co.uk

22 November
EI Awards Dinner
London
Details: EI Events Team
t: 0207 467 7100
e: events@energyinst.org.uk

22-23 November
Emissions trading
Conference, London
Details: Euromoney Energy Events
t: 0207 779 8103
www.euromoneyenergy.com

22-25 November
European wind energy
EWEA conference, London
Details: European Wind Energy Association
t: +32 2546 1980
e: info@ewea.org

DECEMBER 2004

1–2 December
Power and desalination projects
Workshop, Brighton
Details: Power ink
e: workshops@power-ink.com

2 December
Could the lights go out?
NIA/BNES conference, London
Details: Nuclear Industry Association
t: 0208 542 7622

9 December
Preparing for new volatilities in European electricity markets
Seminar, London
Details: Power ink
e: workshops@power-ink.com

9 December
Biogas – how to sustain output
Conference, London
Details: Renewable Power Association
t: +44 (0)20 7747 1841
www, r-p-a.org.uk

HEATING DEGREE DAYS

to 15.5°C base temperature

	Region	July 2004	Aug 2004	Sept 2004
1	Thames Valley	21	9	33
2	South East England	34	16	49
3	South Coast	27	14	33
4	South West England	33	14	33
5	Severn Valley	30	15	41
6	Midlands	38	17	50
7	West Pennines	44	19	52
8	North West England	48	24	67
9	Borders	62	33	76
10	North East England	53	28	76
11	East Pennines	39	18	51
12	East Anglia	42	19	56
13	West Scotland	62	36	87
14	East Scotland	73	38	85
15	North East Scotland	74	42	90
16	Wales	49	24	47
17	Northern Ireland	59	35	68
18	North West Scotland	78	51	104

For earlier data see **http://vesma.com/ddd/history.htm**

To all readers,

We would really like to hear your views on *Energy World, Energy Network* and *Petroleum Review*.

We have prepared a quick questionnaire inserted with this magazine, and would really appreciate your time in answering the questions and faxing or posting it back to the Energy Institute. All completed entries will be entered into a competition to receive one of 5 Blue Voucher Red Letter Experience Days. For more information please visit www.redletterdays.co.uk

Please send your completed questionnaire to:
***Energy World* Questionnaire, Energy Institute, 61 New Cavendish Street, London W1G 7AR**
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Thank you

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For more information, please visit our website at www.energy2000.co.uk or email your CV to analysis@energy2000.co.uk.

Closing date: 19th November 2004.

IFEG **INFORMATION FOR ENERGY GROUP**

Copyright – One Year On

Tuesday 16 November 2004
14.00-1700 with free buffet lunch
held at the Energy Institute, W1G 7AR

Attendance FREE for IFEG members; £10 for ASLIB Members
£25 to non-members of IFEG or ASLIB or £20 to join IFEG

Just a year ago the new Copyright Act came into force. *Graham Coult*, editor of *Managing Information*, will chair this seminar on:

- the Copyright Licensing Agency's plans for licences in the future by Des Brennan;
- how the British Library is coping with the new regulations by Andrew Braid;
- advice on staying legal by Paul Pedley; and
- open discussion forum for delegates

The seminar will be sponsored by

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www.managers.org.uk/checkpointdemo

and the refreshment break will be sponsored by

LG Lawrence Graham

www.lawgram.com

Attendance is FREE for IFEG members
(only £20 to join IFEG). £10 for ASLIB members.
£25 for non-members of either organisation.

For more information contact Deborah Wilson on
t: 020 7467 7115 or
e: **ifeg@energyinst.org.uk**
or visit the website: **www.energyinst.org.uk**

All details are correct at time of going to press, but IFEG reserves the right to make alterations if necessary

EI Oil and Gas Training 2004

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Introduction to Lubricants

4–5 November 2004, London,

EI member: £1,000 (£1,175 inc VAT) Non-member: £1,200 (£1,410 inc VAT)

This **two-day** course is designed to provide an overview of the lubricants business for those personnel needing a working knowledge of it, but in a limited amount of technical detail. The broad scope of the course will allow those new to the industry, or those with some experience of it, to draw immediate benefits from their increased knowledge to the advantage of themselves and their organisations. The environmental aspects of lubricants will be explored during the programme, together with their impact on the business itself.

Who should attend?

The course is pitched to appeal to Lubricant Buyers, Analysts, Planners, New Personnel to the Oil Industry, Lubricant Sales Personnel, Fleet Operators, Oil Company Sales and Marketing Personnel, Environmental Issues Personnel, Oil Company Strategy and Planning Staff, Additive Manufacturers and Suppliers.

LNG – Liquefied Natural Gas Industry

17–19 November 2004, London

EI member: £1,400 (£1,645 inc VAT) Non-member: £1,600 (£1,880 inc VAT)

This **three-day** course covers technical and commercial perspectives of all segments of the LNG gas supply chain from gas field development, liquefaction processes, shipping, re-gasification, storage, supply into a gas distribution network, embedded opportunities for LNG within existing gas markets, supply and construction contracts, project finance and economic valuation. This differs from other LNG courses in providing an integrated insight to the technologies, the markets, the economics and the finance of the industry.

Who should attend?

Those working in the LNG industry in production, liquefaction, transportation and receiving, including those reliant upon LNG supply or the financing of LNG projects; analysts, planners and commercial staff; personnel operating in the gas, electricity and related energy industries and markets, regulators, advisors and policy makers, bankers, financiers, legal advisors and risk managers.

Price Risk Management in the Oil Industry

29 November–3 December 2004, Cambridge

£2,800 (£3,290 inc VAT)

During this **five-day** course, delegates become part of Invincible's fictional trading team, identifying and then managing the exposure to price risk. They trade the full range of derivative markets, including the live futures markets which are received on-line through Telerate and Reuters. Options are traded using a simulation programme. Delegates compare the performance of different instruments over time and in changing market conditions and learn how to choose the appropriate instrument to match their objectives.

The course explains the workings of futures, forwards, swaps and options markets and how they can be used for hedging and price management purposes. The costs and relative benefits of the instruments and the implementation of risk management strategies are explored as well as technical analysis and the principles of management control.

Exercises are performed in syndicates, with comprehensive debriefs to study the consequences of the decisions made. The course expects a high degree of participation from delegates.

2005 EI Oil and Gas Training Courses' Calendar now available

Forthcoming 2005 training courses

NEW COURSE

European and UK Gas Supply and Demand
8 February
27 September

Oil and Gas Industry Fundamentals
9–11 February
15–17 June
28–30 September
28–30 November

Investment Profitability Studies in the Petroleum Industry
21–25 February

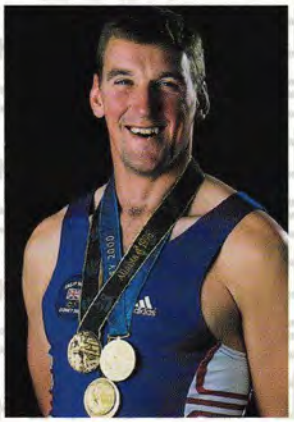
For more information please contact Nick Wilkinson

t: +44 (0)20 7467 7151 f: +44 (0)20 7255 1472 e: nwilkinson@energyinst.org.uk

ei awards 2004

22 NOVEMBER 2004, THE SAVOY, LONDON, UK

Guest Speaker and Presenter
Matthew Pinsent, CBE



In the final of the men's Coxless Four at the Millennium Olympic Games in Sydney, Matthew Pinsent CBE, (right) won his third Olympic Gold Medal. 'THE RACE' in which he did it has been voted 'Britain's Greatest Sporting Moment' and the crew have secured themselves a very special place in the heart of the nation.

In 1992, at the age of only 21, Matthew had his first taste of Olympic success, when in a Coxless Pair with partner Sir Steve Redgrave, he won the Gold Medal at the Barcelona Olympics.

At the Olympics in Atlanta in 1996 the Pinsent/Redgrave duo won another Gold Medal and throughout the nineties their outstanding combination also brought them Seven World Championship Gold's.

Their unbroken run of successes continued through to Sydney 2000 when Pinsent, again with Redgrave (now in a Coxless Four with James Cracknell and Tim Foster) again triumphed earning Pinsent his third Olympic Gold Medal in the final of the Coxless Four.

Since Sydney, Matthew has formed a Coxless Pair partnership with James Cracknell MBE. Undefeated throughout 2001, they went on to complete a unique feat in the history of rowing, by winning the Coxless Pair at the World Championships in Lucerne, a mere two hours after winning the Coxed Pairs. In the 2002 World Championships in Seville they defended their Coxless Pairs title, breaking the world record by 4 seconds in the process.

Matthew was awarded the MBE in the 1993 New Year's Honours List and the CBE in the New Years Honours list 2000.

Last chance to book your table

For information about table bookings, please contact:

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