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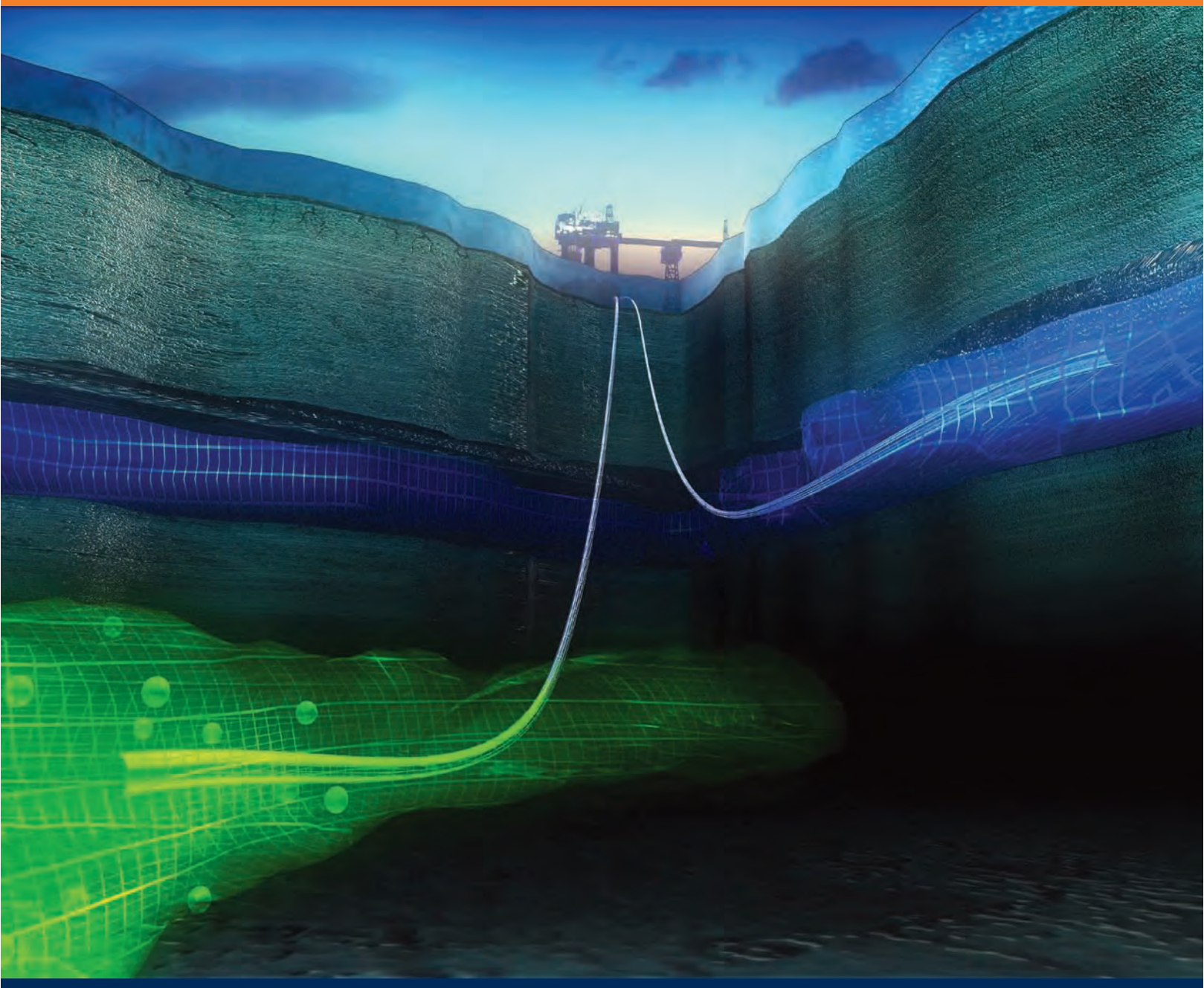

Carbon capture and storage in the UK and Europe

Underground coal gasification – suitable for Scotland?

Biomass – carbon sink or carbon sinner?

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Carbon capture and storage (CCS) at Statoil's Sleipner project in the North Sea. CCS is coming further into focus as a necessary means to continue the use of fossil fuels, particularly coal. This issue takes a hard look at the prospects for CCS from both UK and European perspectives – see features on pages 10 and 12. Major UK Government announcements on coal and CCS are also reported on the news pages.

Much discussion of CCS looks to the future, but certain processes needed for CCS already exist. It is easy to transport carbon dioxide in pipelines and, since 1996, StatoilHydro has captured one million tonnes of carbon dioxide per year from natural gas production processes in the Sleipner field, and stored this in an aquifer more than 800 metres below the seabed (see cover illustration). The key is joining the technology together at scale, enabling emissions to be captured from large power plants and buried safely away.

This issue also looks at underground coal gasification, how to get sensible carbon reductions when using biomass, and ponders the future of the UK electricity grid.

Illustration source: Aligator film/BUG/StatoilHydro

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Restoring the UK's international leadership on climate change

Carbon capture and storage will not deliver a silver bullet but it is an essential weapon in the battle against global climate change. As well as using energy much more efficiently, humanity will need every available sustainable source of low greenhouse gas emission energy at its disposal to avoid very dangerous and potentially catastrophic climate change. This includes renewable energy, nuclear power and fossil fuels with carbon capture and storage.

The challenge is huge. Carbon dioxide emissions from coal combustion are projected to rise by about 60% by 2030 to 18.6bn tonnes worldwide, two thirds of this for power generation, according to the International Energy Agency. This is simply unsustainable set against the need to cut global greenhouse gas emissions by at least half by the middle of this century, carbon dioxide being the main culprit.

Yet it is hard to believe that major developing countries, including China and India, will not continue to exploit their coal reserves for social and economic development, or even rich countries like the United States. China alone accounts for two thirds of the projected growth in demand for coal to 2030 and India a further 19%. The US, Russia and China together account for around 60% of global coal reserves.

In Britain too, fossil fuels look set to play a major continuing role in power generation. The UK faces a massive challenge to deliver 15% of its energy from renewable sources by 2020, which requires increasing renewable electricity supplied from about 7% now to around a third of the total. Even if existing nuclear power stations are replaced, then there will still be a big gap that will be filled with coal and gas.

Over time, the importance of electricity in Britain's energy system is also likely to increase as the surface transport system is weaned off oil and becomes electricity-based. There is a clear evolutionary path for cars, for example, from petrol and diesel, through hybrid to plug-in hybrid then fully electric engines, battery powered.

The Committee on Climate Change advises the Government on legally binding greenhouse gas emissions targets and carbon budgets under the Climate Change Act. It suggests that, if the UK is to get on a path to reducing its overall greenhouse gas emissions by at least 80% from the 1990 level by 2050, then UK electricity generation will need to be almost fully 'decarbonised' by 2030. It recommends that new coal fired power stations should only be permitted on the clear expectation that they will have full scale carbon capture and storage operational no later than the early 2020s. The Government has accepted the advice of the committee that an 80% cut is the UK's fair contribution to the international effort.

So without carbon capture and storage, it seems likely that humanity is doomed to live with dangerous climate change. The World Health Organisation estimates that already 150,000 deaths are caused by climate change each year, mainly due to extreme weather events. Further climate change is in store due to the inertia in the global climate and energy systems and the death toll will rise.

There is a lot of focus on the iconic issue of melting polar ice caps, and the resulting rise in sea levels is undoubtedly a serious issue, a life threatening one for low lying countries and some small island nations and an expensive problem even for rich countries to deal with. Even more serious are the likely effects of climate change in reducing global food production and freshwater availability for billions of people. Major ecosystems on which human welfare depends are also under serious threat, including rainforests and coral reefs that hold much of the world's biodiversity and store huge amounts of carbon.

Rapid deployment of CCS

But there is still time to avert the worst effects if we act now and decisively to cut emissions, including the rapid development and deployment of carbon capture and storage. Hence Ed Miliband's announcement that that there will be no new coal-fired power stations in the UK without carbon capture and storage, and up to four large-scale UK demonstration projects is a big step forward both domestically and internationally.

A number of features of the package he announced are particularly welcome: the commitment to demonstrate both pre- and post combustion technologies; a secure source of funding for the demonstration projects through a levy on electricity companies; and a commitment to require carbon capture and storage to be fitted across the whole power station within five years of the technology being judged as technically and commercially proven.

The Environment Agency welcomes the prospect of playing an important role in making an independent judgement of when that standard is met. It is something we are equipped for through the Best Available Technique (BAT) route under the Environmental Permitting Regulations.

There is still, of course, much to be worked out. The role of emissions performance standards for power plant needs to be worked out and EU environmental law needs to be clarified and may need amending. The provision in the Integrated Pollution Prevention Control Directive that currently prevents setting limits on carbon dioxide emissions on installations in the EU Emissions Trading System may be an obstacle to enforcing carbon capture and storage as BAT.

Contingency plans for circumstances in which it takes longer than hoped to prove the technology are needed. There is also a question of whether the carbon price will be sufficient to deliver carbon capture and storage once it has been proved, or whether ongoing subsidy will be required – for example through an obligation similar to that for renewable electricity.

None of this should detract from the importance of the announcement. Ed Miliband has passed an important test of strength as Secretary of State for Climate Change and Energy. By doing so, he has restored the Government's credibility and the UK's international leadership on climate change. ●

Tony Grayling is Head of Climate Change and Sustainable Development at the Environment Agency, **www.environment-agency.gov.uk**

China could take lead in clean coal, says IEA

China has the opportunity to take the lead in developing cleaner coal technologies, according to a new report, *Cleaner coal in China*, published by the International Energy Agency (IEA). Speaking at the launch of the report, Nobuo Tanaka, Executive Director of the IEA said: 'New technologies are needed worldwide. China's role in developing them is critical.' The report lists the opportunities that China can grasp, but stresses that developed countries need to move quickly to establish markets for technologies that are currently too expensive and not fully demonstrated, such as carbon capture and storage (CCS).

Coal currently accounts for 70% of primary energy consumption in China. Tanaka stressed that the country's rapidly expanding coal use has brought a new urgency to deploying the full range of clean coal technologies – from those that reduce sulphur dioxide and dust emissions, to more advanced technologies like CCS. Existing examples of these technologies can be found in China:

- Half of China's coal-fired power generation capacity is fitted with flue gas desulphurisation.
- The 4,000 MW Yuhan power plant sets a global benchmark for the efficiency of coal-fired power plants.
- One of the world's first pilot demonstrations of carbon capture from a coal-fired power plant is located on the outskirts of Beijing.

Tanaka says that the country needs to use these technologies more effectively and more widely. To do this, a higher number of skilled people are needed across the coal sector to adapt technologies to local circumstances; to build, install and operate new equipment; and to staff the independent regulatory authorities that oversee the whole process. This is also important in the administration of coal mine safety.

China's coal production now provides more energy to the global economy than the whole of Middle Eastern crude oil production, according to Tanaka. 'While we welcome China's important contribution to global energy supply security, it is in everyone's interests to ensure that environmental concerns associated with coal can be managed, even in these times of economic uncertainty,' he said.

New wind projects planned for Europe; stimulus act helps US wind development

The proposed Çanakkale-Mahmudiye wind farm in the North Western part of Turkey is to receive 13 of the new Siemens SWT-2.3-101 wind turbines by the year 2010. The turbines have been specifically designed for low to medium wind speeds, and are therefore suitable for the site. The contract will see Siemens deliver, install, commission and maintain the turbines.

Siemens has also agreed to supply 21 of its SWT 2.3-93 wind turbines for the Baltic 1 offshore wind farm – Germany's first commercial offshore wind farm in the Baltic Sea. The wind farm will be located approximately 16 km north of the Darss/Zingst peninsula and will cover an area of approximately seven square kilometres. The wind farm is predicted to have a total capacity of 48.3 MW and is scheduled to come online in the last quarter of 2010. '2009 promises to be a record year for offshore wind power,' said Dr René Umlauft, CEO of the Siemens Renewable Energy Division. 'The order for Baltic 1 shows that the German market is now slowly picking up speed.'

Elsewhere, in Poland, DONG Energy has bought the 51 MW Karcino wind farm project from the Eurotrust A/S-owned company Aktiv Wind APS. The wind farm is expected to commence operation in 2010. The required official authorisation and building permits have already been issued for the project, which is situated in the northwestern corner of Poland near the Baltic Sea.

Last, the US wind industry will soon see the initial benefits of President Obama's economic stimulus plan in the form of the first wind energy project expected to benefit from the investment. The Grand Ridge Energy Centre, in LaSalle County, Illinois, will receive forty-four 1.5 MW GE Energy wind turbines in a development by Invenergy Wind, resulting in an additional 110 MW of installed capacity. Under the terms of the American Recovery and Reinvestment Act, there are a number of provisions to encourage the development of wind projects, including a three-year Production Tax Credit (PTC) extension, an option to elect a 30% Investment Tax Credit (ITC) in place of the PTC, a temporary programme that includes an option to convert the ITC into a Treasury grant and a new DOE loan guarantee programme.

Economic climate results in capability refocus for BP

BP Solar has announced that it will refocus its manufacturing activities in order to reduce costs and improve competitiveness. As a result, solar module assembly will be phased out of its Frederick, Maryland facility in the US, and BP cell manufacture and module assembly facilities in Madrid, Spain will close. Silicon casting, wafering, sizing and solar cell production will continue at Frederick. The loss of positions in Frederick will total 140 jobs out of 600. In Spain 480 positions out of 575 will be lost.

'This comes at a time when solar markets are unsettled by the impact of the global economic environment, an over-supplied market, increased competition and rapidly falling prices,' said Reyad Fezzani, CEO of BP Solar. 'The decision is part of the long-term strategy to reduce the cost of solar power to that of conventional electricity.'

Elsewhere, following headlines in the press that Shell have 'dumped renewables', the company has stated that it remains committed to tackling climate change, and that it has made choices that are most appropriate to its strategy and capabilities. The technologies that the company regards as its strong points, and on which it will focus, are carbon capture and storage and the 'right kind of biofuels'. It reiterates that it is committed to energy security and tackling climate change, advocates carbon pricing and low carbon standards, and has reduced the emissions from its operated facilities by 30% since 1990.

EU carbon emissions down 6% – slump partly to blame

In 2008, 2,111mn tonnes of greenhouse gases were emitted by the 27 countries participating in the EU's emissions trading scheme (ETS), a reduction of 6% from the 2007 figure of 2,245mn tonnes. The figures come from market intelligence provider for the energy and environmental markets, Point Carbon. They are based on verified emissions data published by the European Commission via its Community Independent Transaction Log.

The figures show that while emissions are down in all sectors, the largest relative change is found in the cement, lime and glass sector; and the pulp and paper sector – both showing reductions of 9%. Point Carbon speculates that this could indicate that these are the sectors worst hit by the recession. The power and heat sector emitted 6% less in 2008 than 2007, oil and gas 1% less, and metals 1% less.

Kjersti Ulset, Manager of European Carbon Analysis at Point Carbon Trading Analytics and Research said, '[the] numbers tell us two things. They confirm that the recession is leading to lower emissions, with both industry output and power demand down. But they also show that the carbon markets work as intended. The emission reductions we see in the power sector are partly a result of the high carbon price we had for the first half of 2008. Although the recession plays the lead role in [the] story, it is obvious that the EU ETS is leading to emission reductions.'

Istanbul to host 35 MW waste gas-to-energy plant

One of the world's largest landfill gas-to-energy plants has been formally unveiled in Istanbul by Turkey's Prime Minister Recap Tayyip Erdogan. The project, owned by Ortadoğu Enerji Sanayi Ve Ticaret AŞ, was developed as part of a national initiative to reduce the environmental impacts of solid waste facilities and use the landfill's gas to generate electricity.

The project will be located at two sites in Istanbul – Odayeri and Komurcuoda. The sites will be powered by 23 of GE Energy's Jenbacher landfill gas engines. The first nine units have been commissioned and the final systems are scheduled to be delivered in 2010.

The two landfills in Istanbul are themselves among the largest in the world, with a total waste disposal volume of 47mn tonnes and a daily disposal rate of around 14,000 tonnes of material. As the landfill's organic solid waste gradually breaks down, methane-rich landfill gas is created. To protect uncontrolled venting of the gas, it is extracted via a network of pipes, processed, and then fed into the engines to generate electricity.

The capture and usage of the gas will help to reduce the landfill's annual emissions by an average of 1mn tonnes of carbon dioxide equivalent (a measure of the global warming potency of the waste gas) during the 22-year life spans of the plants, according to the project owner. The project is also being registered for international carbon credits to help provide financial support through a carbon trading system.

A new Whole Foods Market store in the US is to generate around 90% of its power on-site with a 400 kW fuel cell from UTC Power. The 5,500 square metre market to open in Dedham, Massachusetts will also generate all of its hot water from the fuel cell.

The store is the second Whole Foods Market to use a fuel cell system as an on-site power resource – in March 2008 the supermarket's store in Glastonbury, Connecticut became the first in the world to generate most of its power with a fuel cell.

The Dedham system will be highly efficient, capturing any waste energy for local cooling and heating, says UTC. The company will install, own, operate and maintain the PureCell Model 400 fuel cell system, which is also capable of providing standby power if there is a grid disruption. The fuel cell project was approved for a $400,000 grant from the Massachusetts Renewable Energy Trust Large Onsite Renewables Initiative (LORI) – a programme that awards grants for feasibility studies as well as design and construction projects for qualifying renewable energy systems greater than 10 kW.

US 'green power' sales up 20% in 2008

More than 850 utilities across the US now offer 'green power' programmes, allowing customers to support additional electricity production from renewable sources. Green power sales in 2008 increased by around 20% from 2007, and represent more than 5% of total energy sales for some of the most popular programmes. The findings are from research carried out by the US Department of Energy's (DOE) National Renewable Energy Laboratory (NREL).

Ranked by renewable energy sales (kWh/year), the green power programme of Austin Energy (Texas) reached the number one spot. Portland General Electric (Oregon), PacfiCorp (Oregon and five other states) and the Sacramento Municipal District (California) also scored highly. In terms of the percentage of customer participation, the top utilities are the City of Palo Alto Utilities (California), Lenox Municipal Utilities (Iowa) and Portland General Electric.

NREL analysts attribute the success of many programmes to persistent marketing and creative marketing strategies, including some utility partnerships with independent green power marketers. In addition, the rate that customers pay for green power continues to drop.

US wind power industry increases employment by 70%

The US wind power industry today employs 85,000 people, a 70% increase from one year ago, according to American Wind Energy Association's (AWEA) annual wind industry report, which found that 10 new manufacturing facilities were set up in the last year, while 17 expanded and 30 new facilities were announced. The new facilities are located in 24 states, allowing the economic benefits to be distributed around most of the country.

The report shows that of the markets in the US, GE Energy continues to dominate the market share for wind turbines, although it faces competition from an increasing presence of foreign companies. The US market for small (100 kW or less) wind turbines nearly doubled in 2008, as more than 10,000 turbines were sold, adding around 20 MW of new capacity. The US continues to command around half of the global market for small wind turbines, and is the location for one third of global manufacturers.

The record growth experienced last year – 8.5 GW of installed capacity – is predicted to drop to 5 GW in 2009. The American Recovery and Reinvestment Act (see page 3) is expected to help, but grid access is currently an issue for projects, with an estimated 300 GW of proposed projects currently waiting for access. AWEA estimates that most of the projects cannot be accommodated by the current grid system.

Europe's largest fossil power plant to be modernised

Unit 6 of the 4.4 GW Belchatów power plant, Europe's largest and the world's second largest fossil-fuelled power plant, is to receive a retrofit which will result in an increase in power output, economic efficiency and safety.

The retrofit is the result of a €160mn contract between PGE, the biggest energy group in Poland, and technology provider Alstom Power. It will allow the unit to work within the frame of new regulations (Directive 2001/80/EC), with a 50% reduction of nitrous oxide emissions and a reduction in carbon dioxide emissions of over 400,000 tonnes per year, while ensuring a 20 MW increase in power output and an increase in efficiency to over 41%. Furthermore, the modernisation will improve availability and reliability, as well as extending the unit's lifetime by 20 years, says Alstom.

The scope of the modernisation covers the reconstruction of the boiler and its auxiliary equipment, replacement of the high- and intermediate-pressure part of the turbine, increasing the power output of the generator and the installation of new high-pressure heaters.

In December 2008, PGE and Alstom signed a memorandum of understanding for the development and implementation of carbon capture and storage (CCS) technology at Unit 12 of the Belchatów Power Plant 9.

A team of private companies and non-profit organisations have proposed an energy retrofit programme for the Empire State Building that will reduce its energy use by 38%. The plans include a 33% reduction in cooling load and a 3.5 MW reduction in peak electricity demand.

The project is part of a $500mn upgrade for the New York City landmark and will reduce energy load by upgrading windows and lighting and by adding radiative barriers behind the radiators. The chillers for the building will be upgraded, and others removed, while variable speed handling units are installed. Half of the savings will be implemented by the end of 2010, with the remainder being achieved by 2013.

The creation of the retrofit programme used an advanced method from the Clinton Climate Initiative whereby existing and newly created modelling enabled a full understanding of energy use and functional efficiencies and deficiencies. The method has the potential to be used for other building retrofits.

'An end to unabated coal' as up to four CCS plants are to be built in UK

No new coal-fired power plants will be built in Britain unless they include a demonstration of carbon capture and storage (CCS) technology – on at least part of their output – from the day of their commissioning. And these plants will be required to fit full-scale CCS technology within five years of the technology being proved to work commercially.

These were the main messages from a statement made by Energy and Climate Change Secretary Ed Miliband on the day following the Government Budget statement in April. He also announced plans to fund up to four CCS demonstration projects to help drive the technology to commercial viability. A competition to identify the original one demonstration project continues.

The Government said that the moves will see the UK lead the world in the development of CCS technology and the four proposed demonstration projects will represent the biggest global contribution of any country in developing this technology.

Miliband certainly moved the coal/CCS debate forward, perhaps further than many commentators expected, saying that: 'This signals the era of unabated coal is coming to an end, and a new low carbon future for coal with CCS can begin.'

The Department of Energy and Climate Change (DECC) statement set this framework on which coal fired power which will be permitted in the future:

- No new coal without CCS demonstration from day one. Alongside the Government's ongoing competition to build a post-combustion demonstrator, up to three further projects including pre-combustion technology, will be funded by a new levy mechanism.
- Full scale retrofit of CCS within five years of the technology being independently judged as technically and commercially proven. The Government envisages an important role for the Environment Agency in making an independent judgement of when the standard is met.

The Government said it will also seek views on whether it is possible to implement these conditions through an emissions performance standard. The proposals form part of a consultation that will be released in the summer, alongside an environmental report.

Ed Miliband said: 'the future of coal in our energy mix poses the starkest dilemma we face: it is a polluting fuel but is used across the world because it is cheap and it is flexible enough to meet fluctuations in demand for power. In order to ensure that we maintain a diverse energy mix, we need new coal-fired power stations but only if they can be part of a low carbon future. With a solution to the problem of coal, we greatly increase our chances of stopping dangerous climate change. Without it we will not succeed.'

'CCS is the only technology with the potential to reduce emissions from fossil fuels by up to 90%,' he added: 'but there must be a global effort to develop this technology and the UK is in a strong position to lead this charge.'

The new demonstration projects will be funded by an incentive mechanism as announced by the Chancellor in the Budget – see page 10. Proposals for how the incentive will work are being developed.

The measures will, says DECC, help create in Britain a new high tech, low carbon industry characterised by more jobs in advanced green manufacturing:

- CCS clusters in the regions where we can achieve the greatest emission reductions most economically. For example Thames, Humberside, Teesside, Firth of Forth and Merseyside;
- a new future for the North Sea industry, capitalising on the UK's abundance of offshore storage sites for carbon dioxide; and
- research suggests that carbon abatement technologies could sustain 50,000 jobs by 2030.

Miliband's announcement was widely welcomed. The CCS Association welcomed the clarification on developing CCS technology, but warned that any funding mechanism must be sustainable over the long term and warned against any further delays caused by yet more consultation. National Grid suggested that the Government now needs to focus on how carbon dioxide will get from power stations to offshore storage fields – it suggested a shared pipeline network, a technology it knows well. Greenpeace suggested that Miliband was: 'at last demonstrating some welcome signs of climate leadership in the face of resistance from Whitehall officials and Cabinet colleagues.' The environmental group also wants to know if new coal plants will be allowed to operate for a decade while still pumping three-quarters of their emissions to the atmosphere. E.ON committed to fit carbon capture technology to its proposed Kingsnorth coal-fired plant, as long as the extra plant 'is properly funded.'

Coal currently accounts for 37% (29 GW) of the UK's electricity capacity, actually generating 31% of the UK's electricity in 2008. That is set to decline to 21 GW as stations close in accordance with EU controls on sulphur and nitrogen emissions.

The Government also published its response to last year's consultation: *Towards Carbon Capture and Storage*, which sets out its approach to carbon capture readiness. This will apply to all new gas, oil, biomass, waste-to-energy and also coal power station applications on or above 300 MW. The Government will only consider applications if they:

- confirm sufficient space available to retrofit CCS;
- identify a suitable potential offshore area to store carbon dioxide;
- map a feasible potential transport route from the power station to the storage area; and
- do not have foreseeable barriers to retrofitting CCS.

Together, these criteria will prove, says DECC, that a power station is 'carbon capture ready'.

Green light for waste-to-energy plant

Northamptonshire County Council planners have given the go-ahead for a recycling and waste-to-energy energy plant which is expected to handle 120,000 tonnes of waste a year and bring over 100 jobs to the Corby area. The facility, at Gretton Brook Road, will divert municipal, commercial and industrial waste from landfill to be recycled or turned into energy.

The project by Shore Energy is expected to take 15 months to build. Shore aims to begin construction early next year.

The plant will save costs by generating its own energy and is the first of a number of facilities planned by Perth-based Shore Energy specifically designed to meet the targets set by UK and Scottish Governments.

National carbon budgets and new support for low carbon industries

The UK has become the first country in the world to legally bind itself into a long-term framework to limit its greenhouse gas emissions. Announcing the UK's first three 'carbon budgets' alongside his fiscal Budget in April, Chancellor Alistair Darling also set out new measures designed to help low carbon industries capitalise on opportunities presented by the UK's target to cut greenhouse gas emissions to at least 80% below 1990 levels by 2050.

Detailed plans to meet the carbon budgets have still to be finalised, but the proposed figures are a cut of 22% from 1990 emissions levels by 2008-12, 28% by 2013-2017 and 34% by 2018-2022.

The Chancellor announced:

- legally binding carbon budgets for the first three five-year periods 2008-2012, 2013-2017 and 2018-2022;
- a revised target to reduce emissions to at least 34% below 1990 emissions by 2018-22;
- an aim to meet the carbon budgets through domestic action alone and, consistent with this, setting a zero limit in the non-traded sector on offsetting through international credits for the first budget period; and
- a commitment to tighten the budget after Copenhagen this December, once a global climate change agreement is in place.

The UK's carbon budgets will be met through collective action across Government, says the Department for Energy and Climate Change (DECC). All departments will be involved in delivering the carbon budgets, through formulating policies to reduce emissions and through reducing emissions from the public sector estate. Key departments and the Devolved Administrations will work with DECC to set out our proposals and policies for meeting these carbon budgets. These will be published in an Energy and Climate Change Strategy this summer.

The Chancellor announced new support for low carbon industries, ranging from energy efficiency and renewables through to carbon capture and storage, to the tune of more than £1.4bn of extra targeted support. These measures will, together with announcements made since last autumn, he said, enable an additional £10.4bn of low carbon investment over the next three years.

New support announced in the Budget for green industries falls into five categories, says the Treasury:

- *Carbon capture and storage* – see separate news story on page 6.
- *Support for energy companies through the credit crunch* – UK renewable and energy projects stand to benefit from up to £4bn of new capital from the European Investment Bank (EIB) through direct lending to energy projects and intermediated lending to banks. The Government believes that this initiative can bring forward £1bn worth of consented small and medium sized UK renewables projects to deployment.
- *Renewables and low carbon industries* – the Government is launching a review into the support for offshore wind under the Renewables Obligation (RO). If the review confirms the evidence it has seen, it proposes to provide more incentive to offshore wind in the form of two renewable obligation certificates (ROCs). This builds on the recent uplift to 1.5 ROCs. The Government is also allocating £405mn of targeted support for priority sectors. Over the next two years there will be £70mn for decentralised small-scale and community low-carbon energy, including £45mn for small-scale renewable electricity and heat, primarily through the Low Carbon Buildings Programme, and £25mn for at least 10 community heating schemes.
- *Energy efficiency* – the Government is to invest an additional £65mn over the next year to achieve a step change in the energy efficiency of schools, hospitals and other public sector organisations. There will also be an additional £100mn of interest-free energy efficiency loans for small and medium businesses over the next two years.
- *Oil and gas* – the Government will be introducing a 'Field Allowance' for new small and technically-challenged oil and gas fields which should encourage continued investment in the UK Continental Shelf.

Energy industry teams fuelled up for the BG Energy Challenge

Over 45 teams from the energy industry are making their final preparations ahead of this year's BG Energy Challenge, which is due to take place from 9-11 July. The unique fundraising and networking event for the energy industry will take place in Bangor, Wales, with monies raised benefiting CARE International, the overseas development agency and Sparks, the children's medical research charity.

With the starting line up including teams from BG Group, Centrica, Hess, Nexen, Petro Canada and Venture Productions, the competition is likely to be fierce and teams have been investing in tough training schedules. Aberdeen-based teams from BG Group and Venture Productions even held a mock event to ensure their required skills are finely honed. Over the course of the two days, the participants are likely to face challenges ranging from kayaking, orienteering and mountain biking to complex construction and code breaking.

As well as improving their fitness, the teams have all embarked on fundraising activities to help raise the minimum £5,000 required for charity. Efforts have ranged from online auctions, to chilli plant growing and golf competitions. With the largest ever participating field, host the BG Group is confident about topping the £190,000 raised for charity in 2008. As part of the worldwide series, this year's BG Energy Challenge – the UK will add to the more than £4.6mn raised over the past 14 years through events in Brazil, Egypt, India, Kazakhstan, Oman and Trinidad & Tobago.

In addition to raising funds for deserving causes, teams will take advantage of the unique platform the event provides for companies to network and bond internally. Colleagues will have trained together, organised fundraising events and, come July, will face gruelling physical and mental challenges that will test their teamwork skills in ways no other situation can. The rewards will be invaluable and experiences unforgettable.

www.bg-energychallenge.com.

npower/E.ON joint venture buys sites for new nuclear power stations

The UK's new nuclear power sector gained an important new player with a joint venture between RWE npower and E.ON UK successfully purchasing potential sites for new nuclear power stations at Wylfa in Wales and Oldbury in South Gloucestershire.

Following the auction run by the Nuclear Decommissioning Authority (NDA), the RWE and E.ON joint venture set out plans to develop both sites and the aim of delivering at least 6 GW of new nuclear capacity in the UK, with the first station coming online at around 2020. Added to EDF Energy's plans to build 6.4 GW, this takes the total declared plans for the first phase of new build to 12.4 GW – enough to meet a quarter of the total UK electricity demand and more than the UK's existing nuclear fleet, all but one of which will have closed by 2023.

Land at a third site, at Bradwell in Essex, was bought by EDF Energy, next to land it acquired in January with the acquisition of British Energy. EDF Energy's preferred new build sites are Hinkley Point in Somerset and Sizewell in Suffolk. Subject to various conditions being met, including the level of progress at these two sites, EDF Energy has agreed to sell its land at Bradwell.

EDF Energy is also committed to offer land at either Heysham or Dungeness to potential new build developers.

Energy and Climate Change Secretary Ed Miliband said: 'The successful outcome of this site auction is yet more evidence of major energy players gearing up for investment in low carbon energy in the UK. Nuclear power is low carbon, secure, affordable and will remain an important part of the UK's electricity mix alongside renewables and cleaner fossil fuels. These benefits go hand in hand with substantial opportunity for British firms and skilled workers in the supply chain to capitalise on the shift to low carbon.'

The Nuclear Decommissioning Authority (NDA), which owns the three sites next to existing and old nuclear plants, had run an online auction.

Potential sites for new nuclear power stations will still need to be subject to the regulatory and other consenting processes for nuclear power stations and will also need to be considered as part of the Government's Strategic Siting Assessment. All of the above mentioned sites have been nominated as part of this process.

Alstom to build UK's largest CCGT power plant for RWE

Alstom has been awarded a contract worth approximately €1bn by RWE npower for the design and construction of a full turnkey, gas-fired combined-cycle power plant in Pembrokeshire, Wales. With an output of approximately 2,000 MW, the new plant will be the biggest and one of the most efficient of its kind in the UK.

The plant will be built on the site of the previous oil-fired power station and will include five Alstom GT26 turbines. The plant will be able to be run as efficiently at low load as at full capacity during peak hours, says Alstom, allowing the operator to respond to fluctuating energy demands.

The project is the second that Alstom has signed with RWE npower in the UK, following the contract won in 2007 for the gas-fired 1,650 MW Staythorpe power plant, currently under construction in Nottinghamshire. In addition to Staythorpe, Alstom is also building Centrica's Langage and E.ON's Grain power plants. Including the Pembroke plant, these four power plants will add close to 6 GW of new electrical power to the UK grid.

Approximately 40% of the UK electricity generating fleet was built before 1975 and will need replacement in the short to medium term. The Pembroke power plant is part of RWE npower's plan to renew its power generation fleet with new, more efficient power plants.

E.ON withdraws from Wave Hub project

E.ON and partner Ocean Prospect have withdrawn from the Wave Hub project off the north Cornish coast. The company was one of four developers looking at using Wave Hub to 'plug in' marine power projects, with the two companies looking at using the Pelamis wave power device at the site, which is due to be built next year.

Following E.ON's purchase of a next generation Pelamis device to be tested in Orkney, the companies decided to withdraw from Wave Hub for the time being so that other developers could take advantage of the project.

Dave Rogers, Regional Director of Renewables for E.ON, said: 'Our aim is to concentrate on testing our Pelamis device, which means that it was unlikely we'd be in a position to connect to Wave Hub in the short term. We still believe Wave Hub is an excellent project – and we may well return to it in the future – but our initial goal is to get a machine into the water as quickly as possible, which we'll be able to do in Orkney.'

Nick Harington, Head of Marine Energy at the South West RDA (Regional Development Agency), which is developing Wave Hub, said: 'Wave Hub is on course to be built and commissioned next year. We are currently in detailed negotiations with three wave device developers and look forward to the first device being deployed at Wave Hub in 2011.'

National Grid loses Competition Appeal Tribunal

Energy regulator Ofgem has welcomed the Competition Appeal Tribunal's (CAT's) decision to uphold Ofgem's finding that National Grid was in breach of competition law, restricting the development of competition in the domestic gas meter market.

Shortly after the domestic gas metering market was opened to competition, National Grid struck long-term contracts with five of the six major energy suppliers to supply and maintain gas meters. These contracts included financial penalties that apply if suppliers replaced more than the small number of meters allowed under contract by National Grid. These contracts severely restricted the rate at which suppliers can replace even National Grid's older meters with cheaper or more advanced, smarter meters from rival competing meter operators, says Ofgem. By restricting competition, National Grid has deprived gas suppliers and gas customers of access to lower prices and improved service.

In its decision, the CAT has ruled that National Grid should face a £30mn financial penalty – although lower than the £41.6mn fine imposed by Ofgem it is the highest penalty for abuse of dominance imposed to date in the UK. In its judgment, the CAT also upheld Ofgem's directions which require National Grid to bring these multi-million pound contracts into compliance with competition law.

Help for motorists and industry to go low carbon

Motorists are to be offered help worth £2,000–£5,000 towards buying the first electric and plug-in hybrid cars when they hit the showrooms, expected from 2011 onwards, as part of a new Government scheme to promote ultra low carbon transport over the next five years.

The Government recently committed to placing low carbon transport at the centre of its vision for the UK economy, and Business Secretary Peter Mandelson and Transport Secretary Geoff Hoon launched the scheme in April. The announcement is expected to promote infrastructure and support technology development and encourage manufacturing in the UK, whilst incentivising consumers, says the Department for Transport (DfT).

The funding is included in a £250mn scheme to deliver a green motoring transformation, part of the wider Government support to help consumers and businesses make the transition to low carbon.

The strategy also includes plans to provide £20mn for charging points and related infrastructure to help develop a network of 'electric car cities' throughout the UK and an expansion of an electric and ultra-low carbon car demonstration project on the UK's roads. This project will mean that over 200 motorists throughout the country will have the opportunity to drive a cutting-edge car, says DfT.

Transport Secretary Geoff Hoon said: 'Less than 0.1% of the UK's 26mn cars are electric, so there is a huge untapped potential to reduce emissions. The scale of incentives we're announcing today will mean that an electric car is a real option for motorists as well as helping to make the UK a world leader in low carbon transport.'

- The British Wind Energy Association welcomed the announcement, suggested that the scheme only makes sense as a measure to lower carbon emissions if the electricity for electric vehicles comes from renewable energy sources. The association added that policy makers need to ensure that the net saving in greenhouse gasses emissions, made by switching to electric vehicles, is not cancelled by increased emissions from fossil fuel power plants supplying carbon-intensive electricity.

New improved Warm Front Scheme

The Department of Energy and Climate Change's (DECC's) Warm Front Scheme, which provides grants for people on qualifying disability or income related benefits to install insulation or energy efficient heating in their homes, has been changed to improve the quality of service for its customers.

Following a review of the contract with eaga, the Warm Front Scheme Manager, a number of alterations have been agreed which will open the Scheme up to greater competition to provide best value for money. Households connected to the gas grid are now eligible for grants of up to £3,500, up from £2,700, while those in areas off the gas grid can apply for funding up to £6,000, an increase of £2,000.

The Scheme is also being expanded to include the installation of low carbon heat and power technologies such as solar thermal heating and air source heat pumps. These technologies will initially be trialled in small-scale pilot programmes.

Funding to the Warm Front Scheme has been increased by £174mn since September 2008, bringing total funding to £959mn for the three years to April 2011, says DECC.

Can Britain lead the way in carbon capture and storage?

Dr Phil Goddard *of the Energy Industries Council*

studies the current status of carbon capture and storage in the UK, and concludes that the pressing need is to get some British projects off the ground very quickly.

In recent months, carbon capture and storage (CCS) has risen up the political agenda in the race for a low carbon economy due to its potential to curb greenhouse gases and meet emissions targets. In this article, I will look at how proposed UK projects are progressing against the current legislative and economic backdrop and will examine Britain's ability to be a key player in the global CCS marketplace.

The future landscape for CCS in Britain hinges firmly on Government and industry working together more closely and with urgency to finance projects, in particular fully-functional large-scale demonstration projects. While the individual components of CCS are largely tried and tested, the technology as an integrated commercial solution is still unproven. At present there are only four full-scale CCS projects in the world and none of these currently capture carbon dioxide from a coal-fired power plant.

Until recently in the UK, the Government had only committed to fund one demonstration plant, targeted to be operational by 2014. The increasing urgency of the climate change challenge and lessons learned from the bidding process to date have led the Government to put forward a new and more ambitious policy on CCS. The Government's 2009 budget announced the intention to put in place a mechanism to deliver up to four CCS demonstration projects, including both pre- and post-combustion coal projects. This is a welcome boost to CCS, given that progress up until this budget had been fairly slow.

In March this year, the European Commission finalised a proposal to allocate surplus budget of €3.5bn to clean energy projects in a move to help reboot Europe's economies. €1.05bn of this has been ring-fenced for CCS technology development in Europe, with the UK securing €180mn for a carbon capture project.

This process of finalising the EU economic recovery plan was fairly drawn out, with the initial proposal being for a larger CCS spend of €1.25bn which had been earmarked for 11 coal-fired plants across Europe, including four in Britain. Under the two-year scheme, four British power stations – Kingsnorth in Kent, Longannet in Fife, Tilbury in Essex and Hatfield in Yorkshire – would originally have shared €250mn.

UK project status

The UK currently has six active and eight planned CCS projects with a value of $8.75bn and $8.24bn respectively (see **Figure 1**). If we look at CCS projects in Europe and on a worldwide scale, the UK is currently the leading country in terms of investment in active and proposed CCS-related projects.

On paper, these figures are encouraging but are of course open to change as new projects come online. It is a concern that Britain is behind other countries in developing a full-scale demonstration project. We are, in essence, only a leader on paper at present, in that many large-scale CCS-related projects are being mooted but none are yet off the ground. In contrast, other countries have made significantly more progress.

In order to be at the cutting edge, we must prove our credibility in the home market. Government support for the demonstration (and other) projects must remain intense and sensible decisions must be made swiftly. Britain needs to step up a gear or it will be in danger of missing an opportunity to become a leader in the experience of all the new technologies for CCS, and could run the risk of falling behind in the quest for a low carbon economy.

The recent Government report: *Low Carbon Industrial Strategy: A vision*, put together by environmental consultancy Innovas, reveals that the UK is sixth in the world for low-carbon and environmental goods and services. The sector was worth £106bn to the UK economy in 2007/8 and could grow by around 5% a year. Business Secretary Lord Peter Mandelson has publicly said that: 'Low carbon is not a sector of our economy, it is, or will be, our whole economy, and a global market.'

Government competition projects

Let's take a look at some of the most significant UK CCS projects. Firstly, the Government-funded demonstration plant which, until recently, appeared to be moving relatively slowly. In 2006, the Government announced a competition to fund the construction of a CCS demonstration project with a minimum capacity of 300 MWe that would go on line in 2014.

However, the Government's 2009 budget in April gave the competition a shot in the arm with the announcement that it will now invest in up to three further demonstration plants, funded by a levy on energy consumers. In addition the scope has expanded to now include both pre- and post-combustion coal plants. The original remit was only for post-combustion.

As part of the budget, the Government has also announced the availability of £90mn to fund companies in the current competition to undertake detailed preparatory studies for CCS. The objective of this funding is to help industry gain a greater understanding of the technologies for CCS projects and give greater clarity on costs – it will also ensure that preparations for construction start at the earliest possible date. It would be a requirement of funding that information from the studies is made available to promote global understanding of CCS.

The decision on the UK's first CCS demonstration is due to be made in 2009, after the results of an ongoing consultation into how to implement the technology. At present, there are three candidates left in the bidding for this project. Firstly, there is E.ON, with its new coal plant at Kingsnorth in Kent. Secondly RWE npower, the UK-based subsidiary of German utility RWE, for a new clean coal power station at Tilbury in Essex, and finally, Scottish Power for its existing plant at Longannet in Fife. All of these proposals are for post-combustion carbon capture.

The Kingsnorth power plant project is for the construction of a 1,600 MWe super critical coal-fired power plant comprising two 800 MWe units. The plant would employ direct estuary cooling and would be fitted with flue gas desulphurisation (FGD) and selective catalytic reduction (SCR) technology for SO_2 and NO_x clean-up. The plant may also employ carbon capture technology at a later stage using an amine scrubber pre-treatment system. The plant would be built adjacent to the existing four-unit 1,940 MWe plant at Kingsnorth on the Medway estuary in Kent, which would be demolished once the new plant becomes operational. It is possible that local district heating could be viable within the project scope.

The Tilbury power plant will be a replacement of the existing older coal-fired plant with a new build, 1,600 MWe super critical clean coal plant comprising two 800 MWe

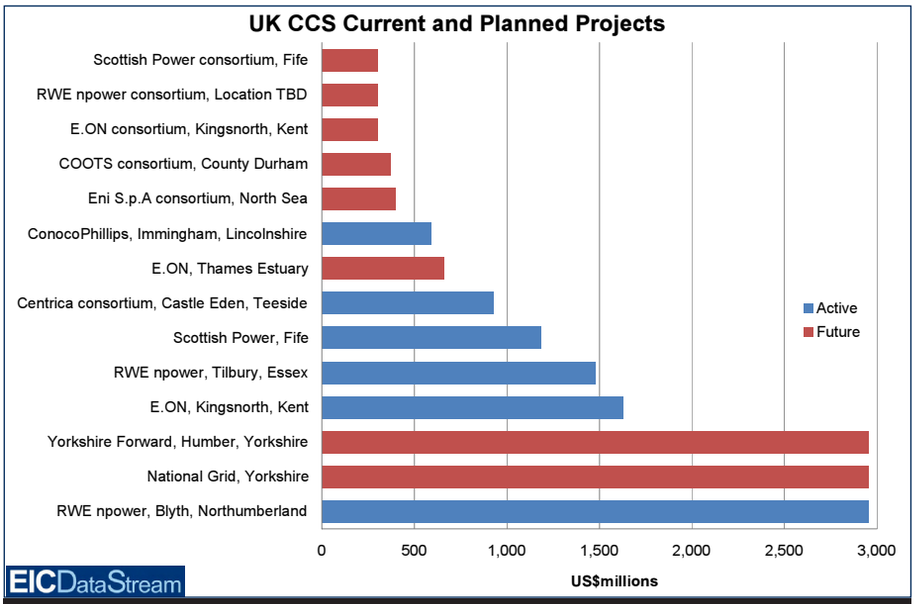

Figure 1: The value of individual current and planned projects in the UK
Source: EICDataStream

units and will be designed to accommodate CCS. RWE npower has estimated that the construction of the new facility will cost over £1bn and that it will have the capacity to reduce carbon emissions by 22% per unit of electricity generated. This reduction in emissions would result in a carbon dioxide reduction of almost two million tonnes per year, as compared to the existing coal fired plant.

Finally, Scottish Power is looking to extend the operational life of its two main coal fired assets, Longannet and Cockenzie, by applying clean coal technology. The technology employed will utilise super critical boilers with CCS. Carbon dioxide would be injected into coal bed seams at the Longannet mine-mouth site to enhance coal-bed methane recovery. Also, the Scottish Power-led consortium has identified a rock formation in the North Sea which could potentially store emissions for 600 years.

Critics have argued that the Government's plans were originally too small-scale and too slow, despite Government claims that the country is in a perfect place for CCS due to the easy access to suitable burial sites for carbon dioxide in the North Sea.

Key infrastructure projects

In addition to the contenders for the Government-funded pilot project, a number of additional CCS infrastructure projects are on the table. Of particular significance is National Grid, which is drawing up plans for a new business unit that will pipe carbon dioxide emissions from UK power stations for storage in geological formations beneath the North Sea. Suitable storage sites include saline aquifers and depleted gas fields. The group is developing plans to construct a £2bn carbon transport and storage network around the Humber estuary in Yorkshire, where five of Britain's largest coal and gas-fired power stations are located.

The proposed Humber capture and storage network would handle gaseous carbon dioxide emitted from coal and gas-fired stations such as Drax, Eggborough, Ferrybridge and Killingholme and would provide the potential to reduce the UK's carbon dioxide emissions to the atmosphere by up to 60mn tonnes per year. Where possible, National Grid plans to use existing pipes and North Sea infrastructure formerly used to transport natural gas.

The Yorkshire and Humber region produces around 90mn tonnes of industrial carbon dioxide emissions per year, according to AMEC. As a region, it has the biggest carbon dioxide output in Europe. The Department for Environment, Food, and Rural Affairs (DEFRA) quotes UK carbon dioxide emissions for 2005 as 554.2mn tonnes.

National Grid is thought to be in talks with the major generators in the Humber region, including E.ON, Drax Power and Scottish & Southern Energy, as well as Yorkshire Forward, the regional development agency, about the proposed Humber capture and storage network. This plan could be replicated at other locations around the UK where clusters of coal-fired power stations exist, including Scotland and East Anglia. A technical team from National Grid is working with academics at Newcastle University to study methods of storing and moving carbon by pipe, while a commercial business development team is examining different ways that the new unit could be structured and financed.

If the Humber project proceeds, with the Yorkshire study representing the first step, this massive investment could put the UK in a leading position.

UK poised for leadership?

In the medium term, I believe there is an opportunity for the UK to take the lead from a technical and commercial perspective, if UK Government and industry are prepared to work together closely and ensure adequate investment is made in the skills, technology and infrastructure that are urgently required.

The Government's new ambitions for up to four CCS demonstration projects covering pre- and post-combustion technologies will certainly help us to establish ourselves as a credible player and capitalise on the global shift to clean energy. Now that the Government has stepped up a gear in its commitment to CCS, we need to ensure it follows through with its ambitions in a timely manner. Funding and incentives will be key, despite the economic conditions, and it will be important for the Government to make decisions quickly in order to meet our Kyoto treaty and EU-ETS framework commitments.

Initial reaction to the budget is mixed among the energy industry supply chain. In my opinion, there is a lack of clarity in a number of areas, such as what proportion of the four plants need to be equipped with CCS (many report 300 MWe still) and what timescales are involved.

So where does this leave Britain as a potential global contender? I believe the UK will find it hard to be a major supplier of the larger plant items involved in CCS as there are few suppliers or manufacturers of this type of equipment in the UK. There are, however, a number of opportunities for the UK across the supply chain. Britain is likely to be involved in feasibility studies, 'soft skills' such as management and consultancy, balance of plant and possibly front end engineering design studies, giving us a tremendous opportunity to become experienced in plant operations and system design.

The announcement from the Climate Change Secretary Ed Miliband in April that no new coal-fired power stations will be built in Britain from now on unless they capture and bury at least 25% of greenhouse gases immediately and 100% by 2025, will help put the UK at the forefront of the race to decarbonise fossil fuels and give us a leadership position in the global CCS industry.

Clearly, we need to ensure UK projects get off the ground swiftly if we are to maintain a credible reputation and associated supply chain. The global CCS market is estimated to be worth $100bn dollars per year for the next 20 years, according to Nick Horler, Chief Executive, ScottishPower. Britain needs to move quickly if we are to take a significant slice of the pie. ●

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Europe's race for CCS

With recent announcements of funds available to kick-start carbon capture and storage, Europe is taking steps in the journey to commercialise the technology. But, with a wide consensus that CCS needs to be up and running by 2020, time is of the essence. Mark Rowe *reports on developments from the continent.*

The principle of carbon capture and storage (CCS) is well established amongst energy suppliers – polluting industries, such as coal, would be able to continue to burn fossil fuels, but carbon dioxide, rather than being expelled into the atmosphere, would be harvested in the energy production cycle and securely locked away. The technology is regarded especially by the European Union (EU) as one of the tools, along with energy reduction and renewable technologies, that will help Europe – and indeed the planet – to reduce emissions of harmful carbon dioxide.

The objective may be clear, but just how best to go about capturing carbon before it enters the atmosphere remains uncertain. Methods developed in principle include pre-combustion capture (applicable to gasification systems), post-combustion capture, and oxy-fuel combustion.

To address this issue, the EU has already set up a body to co-ordinate research into CCS. This organisation, the European Technology Platform for Zero Emission Fossil Fuel Power Plants – more commonly referred to as ZEP – has been charged with investigating up to 12 different technologies that could be applied to CCS.

ZEP's members include European utilities, petroleum companies, equipment suppliers, scientists, geologists, academics and environmental NGOs. Several companies, such as Vattenfall, Shell, RWE and Statoil have announced industry-led CCS initiatives in the EU partly as a result of this EU-led promotion of these technologies.

Major research activity coordinated by ZEP and its members is to focus on the following:

- carbon dioxide capture and hydrogen production from gaseous fuels;
- monitoring and verification of carbon dioxide geological storage;
- preparing for large-scale hydrogen production from decarbonised fossil fuels, including carbon dioxide geological storage;
- advanced carbon dioxide separation techniques;
- mapping geological carbon dioxide storage potential;
- matching sources and sinks; and
- European coordination in the cross-border dispersal of CCS.

The projects will address technological, operational, geographical, political, economic and commercial issues, backed up by R&D activity.

An ambitious timescale

This process' aim is to make CCS commercially viable by 2020 and kick-start its wide-scale deployment. Last year, the European Parliament's environment committee backed an amendment to a proposed directive on the geological storage of carbon, requiring member states to oblige power companies to install or retrofit CCS equipment, in particular on their coal-fired power plants, and setting limits on the carbon dioxide performance of power stations. A vote on the legislation by the full is hoped for before parliament is dissolved ahead of its June elections this year.

This law is separate from the demonstration programme however, and ZEP aims to have 12 demonstration projects on CCS operating by 2015, using a variety of technologies, to help 'de-risk' CCS. While ZEP will recommend and identify sites, the ultimate decision rests with the European Commission, although the EU executive will be influenced both by the emphasis that ZEP places on the projects, and the degree of support from the potential host member state. ZEP is currently reassessing some potential projects to see if they can be designed to help answer technical unknowns about CCS.

'In an ideal world, only seven projects would be needed to satisfy these criteria,' said Eric Drosin, Director of Communications for ZEP. 'But an ideal combination does not exist and the high-risk profile of some of these projects means they are unlikely to materialise.' ZEP is confident that eight projects will suffice to answer most questions about CCS. 'There is no guarantee that the final number will be between 10 and 12,' said Drosin. Despite this pragmatism, he still admits the timescale is 'incredibly ambitious'. The aim is that by the end of 2010 all the projects will have been specified. 'In political terms, that is the equivalent of tomorrow,' said Drosin. Funding would then need to be in place by 2011 to ensure that the plants could be built within the typical four-year timescale for such plants.

In Europe, two European Commission departments are involved in the project – the Directorate Generals (DG) for energy and transport and also for research. 'We cannot reduce EU or world carbon emissions by 50% in 2050 with energy efficiency and renewables alone,' said a spokesperson for DG energy and transport. 'We must also use the possibility to capture and store carbon dioxide – but major fossil fuel use in the developing world must be addressed. CCS could contribute around 14% of all reductions needed by 2030, and by 2050 almost 60% of emissions from the power sector should be captured, compared with none today. More than 90% of all coal-fired electricity generation would be from plants equipped with CCS. If the technology can initially be deployed in developed countries, then we anticipate that rapid uptake in developing countries will follow.'

The provisional portfolio of what these CCS plants should explore has been drawn up. They include a variety of hard coal and lignite power plants (different coal types result in substantially different emission streams); pre-combustion, post-combustion and oxy-fuel plants (to establish the advantages of each technology in terms of costs, total potential applicability, estimated potential for cost breakthrough and maturity of the technology); and storage technologies of depleted oil and gas fields and deep saline aquifers. Deep saline aquifers have the largest storage potential, but the availability and technical feasibility still needs to be tested for most areas. Depleted oil and gas fields are most likely available more quickly, so can provide storage in the short term.

Another plant will investigate co-firing different percentages of biomass: ZEP is also aware that this project may well secure more political and public support for CCS. Other projects include transportation by ship, which may free up smaller storage fields and sources; open and structural deep saline aquifers; and retrofitting CCS onto an existing plant. 'We are seeking to identify the functional, technical and operational issues,' said Drosin. 'All these technologies have been identified but they have not yet been integrated by any power plants. It's about how all these blocks fit together.'

A costly matter

Funding however is a major issue. Industry has already declared its willingness to cover a major portion of the costs. And the challenges are significant. ZEP acknowledges that the incremental costs of the first large-scale CCS demonstration projects will be exceptionally high – too high to be fully justifiable to shareholders. Financial concerns centre on unrecoverable costs, from making accelerated investments in scaling up the technology,

Boiler assembly at Vattenfall's Schwarze Pumpe pilot CCS plant. For more on the Schwarze Pumpe project, turn to page 15 *Photo: Vattenfall*

and the simple fact that it is not yet known which CCS technologies will prove the most successful.

A study undertaken last year by consultants McKinsey & Company calculated that the demonstration projects would cost an accumulative €7–12bn in additional funding. In practice, this would mean industry taking on the base costs of the power plant and the risks, while the incremental costs of CCS are covered by public funding.

There are also economic costs and challenges that surround the actual storage of carbon dioxide once the plants are operating. The International Energy Agency estimates today's costs of CCS 'at between US$40–90 per tonne of carbon dioxide captured and stored depending on the power plant fuel and the technology used'. Capture of carbon is estimated by the EU's DG for energy and transport to represent 70–80% of costs. However, technology development and economies of scale should drive the cost of CCS down, and it is expected to fall from its current level to €35–50 per tonne of carbon dioxide in the early commercial phase (2020+) and to €30–45 per tonne of carbon dioxide when total installed capacity increases to around 80 GW.

One boost came at the end of 2008, when a European Council summit of EU leaders substantially backed the construction of CCS demonstration plants and agreed that national governments would provide 300mn allowances from the EU Emissions Trading Scheme to subsidise the CCS plants' construction and other technologies, such as innovative renewables.

'In order to get off the ground, the schemes are going to need public-private partnerships,' said Drosin. 'Industry has made it clear that it is prepared to meet the construction costs of the plants and take on the risks, but their funds won't cover all elements. We have to be honest about the extent of funding that is needed if we want 12 power plants,' he added.

However, a spokesperson for the UK-based Carbon Capture and Storage Association (CCSA) questioned whether the funding would be sufficient, or even practicable. 'When will the EU allowances be paid? If they are to be paid for carbon stored then that could be quite late on in the programme, after the companies have had all the commitment to investment. I feel there is a bit of a mismatch,' she said.

Several countries have indicated that, despite the concerns over costs and risks, they are willing in principle to engage with the programme. But while this willingness exists, there have been delays identifying the actual demonstration plants, and even the criteria by which they will be selected.

Planned plants

Nevertheless, in March this year, another EU summit confirmed it would earmark €1.05bn to develop carbon capture storage at 11 coal-fired plants. This included spending:

- €180mn on projects in Britain at Kingsnorth in Kent (using pulverised coal capture technique; oil and gas fields storage), Longannet in Fife (pulverised coal; saline aquifer storage), Tilbury in Essex (pulverised coal; oil and gas fields) and Hatfield in Yorkshire (integrated gasification combined cycle; oil and gas fields);
- €180mn on two projects in Germany – at Huerth (integrated gasification combined cycle; saline aquifer) and Jaenschwalde (oxy-fuel; oil and gas fields);
- €180mn in the Netherlands at three plants – two in Rotterdam (both pulverised coal; both oil and gas fields) and one in Eemshaven (integrated gasification combined cycle; oil and gas fields);
- €180mn at Poland's Belchatow plant (pulverised coal; saline aquifer);
- €100mn at Porto Tolle in Italy (pulverised coal); and
- €180mn at Spain's Compostella plant (oxy-fuel; saline aquifer).

The European Council also approved a further €50mn to develop France's Florange plant for the transport of carbon dioxide from an industrial installation (steel plant) to underground storage (saline aquifer).

Some projects drawn up by individual countries may end up informing or complementing ZEP demonstration projects. In February, Siemens AG and E.ON Kraftwerke announced that they were to jointly build a pilot post-combustion capture plant at E.ON's Staudinger power plant near Hanau in Germany. The pilot plant is expected to begin operating in the summer this year and will run until the end of 2010. The project is being sponsored by the German federal ministry of economics. Spain is also planning to publish a draft regulatory framework for CCS activities later this year.

Meanwhile, the chemical company ZAK is to work with the Polish power generator PKE to build a CCS plant in Kedzierzyn-Kozle that could include co-firing with biomass. Both companies have applied to the European Commission for part-funding for the €1.5bn plant under the demonstration programme.

Germany, the Netherlands, France, Poland and Norway have been identified by the CCSA as among the most enthusiastic countries for CCS technology. 'Some countries are very involved in the process,' said the CCSA spokeswoman. 'It's clear there is an appetite for the projects.'

Safe storage potential

Another concern for would-be funders is the question of how CCS might fit into international environmental treaties, such as Kyoto and a raft of international marine protection agreements. Would stored carbon dioxide be legally classified as waste? And storage too is another concern – can the carbon dioxide be retained for long periods? Carbon dioxide storage options include geological-based storage in aquifers, depleted oil and gas reservoirs (with the possibility of enhanced oil recovery) and deep un-mined coal beds (that offer the benefit of enhanced coal bed methane recovery).

Current storage projects such as the Statoil Sleipner project in the Norwegian North Sea (see front cover) have only stored carbon dioxide since 1996 and therefore can as yet deliver no proof that this kind of storage is safe in the long term. Liability relating to any leakage is another issue that ZEP is keen to address. NGOs such as Greenpeace have labelled some projects as illegal – they argue that carbon dioxide is waste and thus the existing rules against burying waste at sea should apply.

However, the spokesperson at the EU's DG energy and transport was optimistic that such challenges could be overcome. 'Most oil and gas fields have contained high-pressure carbon dioxide for millions of years,' he said. 'There is significant storage potential. The technical potential is likely to exceed 2,000 GT (2,000bn tonnes of carbon dioxide) while total carbon dioxide emissions are currently around 24 GT per year.' ●

Pilot carbon capture plant planned for West Virginia

A pilot plant is planned to capture carbon dioxide from the flue gas of a coal-fired generator in the US. The proposed plant – a result of a collaboration between The Dow Chemical Company and Alstom – will be built at a Dow-owned facility in South Charleston, West Virginia.

The plant is expected to capture approximately 1,800 tonnes of carbon dioxide per year from the flue gas. It will be designed, constructed and operated by Alstom. Dow will provide the site and utilities, as well as the chemicals and its amine technology expertise. The pilot plant is expected to be operational by Q3 2009.

In 2008, Dow and Alstom entered into a joint development agreement to develop advanced amine technology for carbon capture. Currently, Alstom is working with Dow to develop a commercial offering of an advanced amine-based scrubbing technology for industrial sources that produce exhaust or flue gases containing carbon dioxide and high levels of oxygen. The new process will significantly reduce the amount of energy required for carbon dioxide separation and capture, say the companies. The West Virginia pilot plant aims to validate this new technology.

The coal used in the pilot will be sourced locally in West Virginia. Alstom and Dow aim to prove that coal can remain an important, as well as sustainable part of the US' energy security.

Janet Giesselman, President and General Manager of Dow Oil & Gas said: 'This technology has immense potential – for the local community, industry, environment and our business. Developing advanced amine technology will provide sustainable energy solutions now and into the future.'

Carbon dioxide purification research at Schwarze Pumpe

Vattenfall's Schwarze Pumpe carbon capture and storage pilot project in Germany, inaugurated in September 2008, will begin research into the purification and compression of its oxyfuel combustion flue gas.

Vattenfall has teamed up with gas material, equipment and services provider Air Products to carry out the research. Air Products will install its proprietary carbon dioxide capture, purification and compression system at the facility. The two companies have executed a joint research and development agreement related to the project. Air Products' pilot plant is scheduled to be operational at the site in December 2010.

At the oxyfuel pilot plant, Air Products will take flue gas directly off Vattenfall's 30 MW coal-fired boiler. It then aims to purify and compress the carbon dioxide, a portion of which will ultimately be transported for sequestration. The company's sour compression technology uses a staged compression process to optimise pressure, hold-up, and residence time to allow removal of impurities during the compression process. This allows cost savings in the oxyfuel combustion process and minimises the concentration of acidic components, important in preventing corrosion during the carbon sequestering process. The pilot project aims demonstrate the efficient purification of carbon dioxide and remove inert gases, in particular oxygen. In addition, it will incorporate novel membrane technology, targeting carbon capture rates at as high as 98%, says the company.

Aerial view of the pilot plant at the Schwarze Pumpe site

Air Products is also currently working on several other carbon capture and storage demonstration projects worldwide. In early March the company announced work with the US Department of Energy to design and construct a carbon dioxide purification system in support of an oxyfuel technology development project at a boiler simulation facility in Windsor, Connecticut. Also, in 2008 the company's oxyfuel sour compression technology was demonstrated in experimental work carried out by Imperial College London with flue gas from a 160 kW coal-fired combustion installation at Doosan Babcock's facility in Renfrew, Scotland, as part of the Oxycoal-UK Project.

Australian CCS institute gains further support

The Global Carbon Capture and Storage Institute (GCCSI) initiated by the Australian Government in September 2008 has gained extra support in the form of advanced coal technology provider GE Energy joining the institute as a founding member.

The institute's aims are to provide international policy and management oversight with a goal of delivering commercial scale CCS plants around the world. Australian Prime Minister Kevin Rudd's government has pledged to provide up to $100mn per year to fund the institute. Other members of the CCS Institute include other leading multi-national corporations.

The development of cleaner coal technologies is a particular priority in Australia as around 80% of Australia's electricity currently comes from coal-fired power generation.

'Coal is critical to Australia – and the world's – power supply, and it is a multi-billion dollar export that is important to Australia's economy and the thousands of jobs it supports. The long-term viability of this industry depends on our ability to use our technology and know-how to reduce carbon emissions in the process of generating electricity from coal,' said Steve Sargent, CEO of GE Australia & New Zealand. 'We applaud the Australian Government's commitment to work with industry to develop and implement solutions for reducing carbon emissions. Forming the CCS Institute underscores Australia's decision to take a leadership role in tackling the critical issues that threaten the long-term environmental health of our planet.'

UCG – getting the most out of coal

Burning coal above ground is one way of extracting energy from the resource. The gasification of coal is another method, which can also deliver valuable by-products – and it can be done underground, eliminating the need for mining. Steve Walters *argues the case for underground coal gasification, and discusses a project planned for Scotland which would be Britain's first.*

According to BP's Statistical Review, coal is still the fastest growing fossil fuel for power and feedstock utilisation. While proved reserves of coal remain high, probable reserves are higher still. Therefore coal could become a vast resource for power generation for at least 100 years or more. Winning probable coals requires more sophisticated technology while recognising that emissions need mitigation to reduce atmospheric impact.

This conundrum can be partially solved using underground coal gasification (UCG) when coupled with carbon capture and storage (CCS). With current concerns about energy security, UCG is resurgent, offering base load for power generation, and a wide range of derivative gas/gas to liquid products. For Scotland this could mean as much as 150 years of supply from the Firth of Forth alone. Scotland has abundant coal reserves, but most conventional deep mines are not commercially viable – although this is not necessarily the case for coking coal resources.

Coal gasification is not new. Prior to gas provided from North Sea reservoirs, 'town gas' (derived from coal, a mixture of carbon monoxide and hydrogen – synthesis gas or 'syngas'), was used for domestic supply. During the late 60s and 70s methane replaced town gas but in South Africa syngas remained important for the production of synthetic crudes, as in Germany during the 1940s. UCG's origin lies with a Scottish chemist William Ramsey but was adopted by the USSR. However, conventional oil and gas have been abundant over the last 100 years, so UCG has been less relevant until now.

Coal is abundant and is geopolitically less constrained than oil and gas. Like oil, its geochemistry changes depending on its deposition and burial history. Not all coal is suitable for gasification – in general terms the lower the rank or maturity of the coal the better the gasification process and products. Lignites tend to be associated with more difficult hydrogeological settings, while anthracites are common in more structurally difficult and igneous-prone settings. Anthracite, with the lowest hydrogen/carbon ratio, is the least suitable for gasification – although these coals tend to contain more trapped methane and are occasionally suitable for commercial coal bed methane extraction.

Gasification process

Two gasification technologies are under development. Integrated gasification combined cycle or IGCC, where the mined coal is gasified at the surface in a purpose-built reactor, eg Lurgi reactor. The second technology is gasification in situ through UCG. Both technologies have benefits and drawbacks. IGCC requires mining of coal and transportation but the gasification process can be controlled and monitored more easily. The pros and cons of UCG are explained below.

UCG relies upon extracting the energy in the coal rather than the coal itself. Converting the coal underground avoids the need for deep mine infrastructures, ash-handling, open cast and spoil disposal. Wells are drilled from the surface directly into the coal seam and, by pumping in air and steam, the coal is converted *in situ* to syngas. Syngas comprises mostly hydrogen and carbon monoxide with minor amounts of methane, nitrogen, carbon dioxide and hydrogen sulphide. With UCG the reaction cavity may be very deep and at some distance from the production point, so modelling is vital to the understanding of subsurface processes.

Oil industry-developed directional drilling is the key addition to the UK UCG trials performed in the 1940s, and 50s. The original technique was to drill two vertical wells – one injecting air (plus ignition source), the other producing gas. This process relied on the establishment of a gasification front using coal permeability (in conjunction with underburden/overburden temperature fracturing) to enable gas migration to the producing well. This was not always successful, due to reaction control at shallow depth (majority of wells) and required tight spacing of wells, ie high drilling costs.

However, the preferred method today, pioneered by Lawrence Livermore National Laboratory (LLNL) in California, is to drill a vertical well as the 'producer' then intersect this with a horizontal (~500 m) well, drilled in seam, which is designated as the injector well. Coil tubing is introduced to the horizontal well and ignition is started. As the coal is 'converted' to gas the coil tubing, which carries oxygen and steam, retracts back to the last casing point. This is known as the controlled retractable ignition point or CRIP. The produced gas migrates to the production well by differential pressure created by the gasification and the injected oxygen and steam. By using oxygen the process is much more efficient and controllable. Depending on the geology, a possible well configuration using the CRIP method could resemble that shown in **Figure 1**.

Figure 2 demonstrates that in some respects well configuration resembles conventional longwall mining by producing a 'mined' panel the length and width of which is determined by the coal volumetrics, geology (such as faults and partings) and its geo-

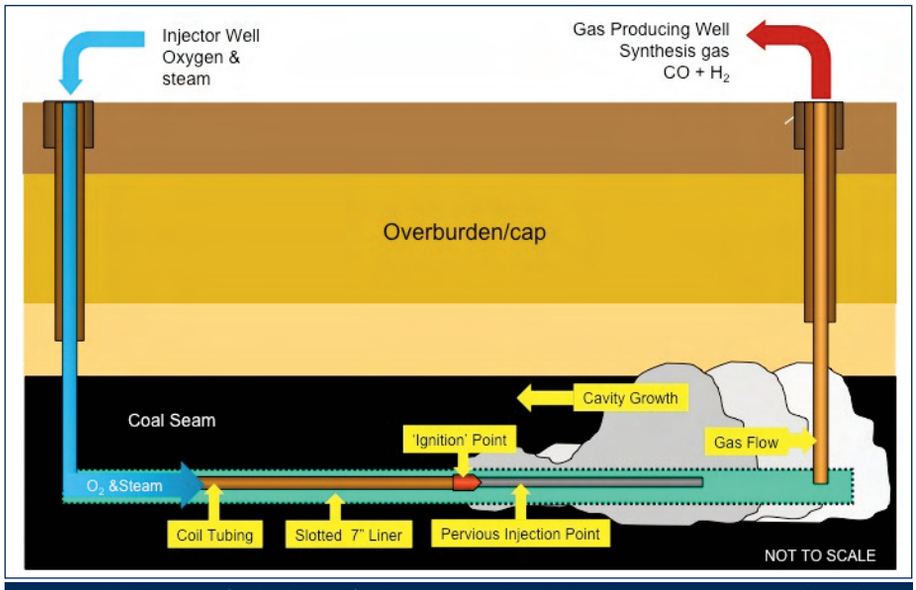

Figure 1: 2D diagram of a simple gasification system using CRIPs. There are plans to use the old style vertical wells in some modern UCG developments but they will be shallow and land based

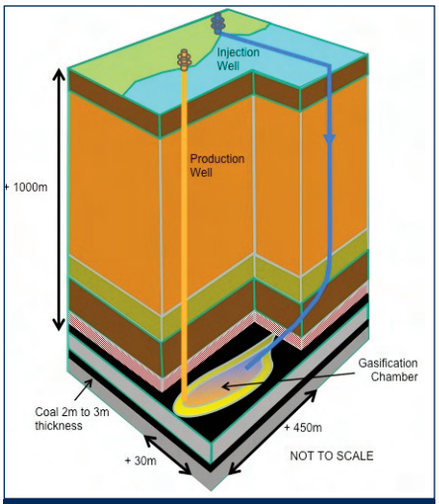

Figure 2: Possible well configuration for Firth of Forth gasification. The injection well can either be drilled as a deviated well or drilled vertically, then side tracked as a multi-lateral. This method of UCG resembles longwall mining

chemistry. In order to reduce drilling costs, optimisation of each gasification panel is modelled prior to drilling.

Water-saturated coal at depth will not easily gasify, therefore it is necessary to introduce steam and oxygen to get the coal to yield sufficient gas of the right chemistry. At depth, pressure can be used as part of the control process restricting water ingress to the gas reactor. Pressure can also be used as a method of quenching the reaction to halt gasification.

UCG at the Firth of Forth

Coal mining in Fife was established over 200 years ago. The mines have extended from the exposed coalfields in Fife and the Lothians to under the Firth of Forth (FoF), Scotland. With the decline in conventional coal mining, especially since the 1980s, large volumes of coals with multiple stacked seams of significant extent have remained undisturbed. Most of this coal lies at uneconomic depths for conventional mining.

The viability of UCG around FoF was first demonstrated by a team from Heriot-Watt University, the DTI (now DECC) and Scottish Enterprise. The study concluded that by using existing data and utilising visualisation and geomechanical software available to the oil industry, coal could be characterised in a similar way to oil and gas reservoirs. This characterisation makes well-planning considerably easier, since the geology is very variable. Key variations include consistency of acceptable seam thicknesses, qualities and ranks; appropriate bedding dips; significant structural variations; and both intrusive and extrusive igneous features. All these functions affect optimum well-siting and operational design. The most suitable coals for UCG lie within the Leven Syncline, having a dip conducive to optimum gasification and rank suitable for economic gas derivatives.

The FoF is rich in legacy data. This includes mine shafts and exploration bore-hole core data, which can be digitised and integrated to produce an accurate 3D model. Modelling of the depositional variations, whether seam splits or the disposition of the many sand bodies etc, are particularly dependent upon high quality bed correlation. It is important to characterise the tectonic relationships in the FoF which will influence gasification field planning. Fault definition is crucial for determining well paths and environmental impacts – for this workflow legacy oil and gas exploration coverage of 2D seismic survey data is reasonable. A combination of data sets yields a good geological model that can be used to plan the horizontal wells which will require a reach of up to 1 km.

Compared to oil and gas extraction, gasification is carried out at low-pressure and ultra high-temperature, presenting considerable engineering challenges. Many contemporary gasification projects are performed at depths of less than 500 m, where control of the gasification process is a challenge. FoF gasification will be at depths in excess of 1 km, presenting engineering challenges, but gasification is more controllable.

To enable optimum gasification there needs to be good coal permeability. Therefore a linkage between the injection and production wells needs to be established to induce gas flow – permeabilities can be derived by the gasification process itself using cavity growth. This is achieved by allowing the reaction chamber to form along the 'horizontal' well path as shown in **Figures 1** and **2**.

Coal extraction in a bio-diverse area raises environmental issues. One of the major value drivers for UCG is demonstrating that coal can be exploited without significant environmental impacts. The Firth of Forth is an active conduit for industrial activities yet has some of the UK's finest fauna. The faunal diversity has improved in recent years with more cetacean species observed. Much of the coastline is designated SSSI (site of special scientific interest) and SPA (special protection area) therefore careful planning must be in place to avoid conflict with the natural environment. However, the Fife Coast has a long history of industrialisation with brownfield sites suitable for UCG operations.

UCG products

Syngas can be used directly to generate power. It has a lower calorific value than natural gas but can be used directly as a fuel for gas turbines. In addition, it can be processed to hydrogen, or chemicals such as methanol or ammonia, or derivatives such as ultra clean syn-diesel, naphtha and aviation fuels via the Fischer-Tropsch process, a well-known and commercial technology. The versatility of syngas makes it an attractive raw material for industry.

There is a strong demand in refineries for hydrogen and hydrogen-from-coal will be significantly more economic than by steam reforming of natural gas. The rapid development in hydrogen fuel cell technology should reduce costs sufficiently to allow the construction of carbon-free power stations.

Methanol and ammonia are key feedstocks for the plastics and fertiliser industries respectively. Syngas could provide a low-cost, long-term supply to avoid the swings in world prices caused by their current dependence on oil and natural gas as the manufacturing source.

Syn-diesel is extremely pure with little or no sulphur. It also has other unique advantages – a high cetane rating, long shelf life and clean combustion. Combustion of diesel in vehicles will still yield carbon dioxide but particulate pollution and unburned hydrocarbon emissions (mainly aromatics) are very much reduced. Its use for public transport would greatly reduce these active pollutants in city areas.

UCG plus CCS

A 'clean coal' strategy requires that carbon capture, transport and storage is linked to UCG. UCG lends itself to the 'pre-combustion' capture method, although the gas must be cleaned to yield a purer carbon dioxide gas stream for transport. Syngas can also be burned in a conventional turbine or comingled with methane using less efficient and more costly 'post-combustion' capture.

At present there is no disposal infrastructure or licensing system in place. Therefore CCS cannot be performed other than by using carbon dioxide for enhanced oil recovery. StatoilHydro's Sleipner sequestration project offshore from Norway is an exception. Carbon dioxide is stripped from natural gas on the platform and injected into the Utsira sandstone – a saline aquifer with a cap rock capable of resisting the buoyancy pressure of supercritical carbon dioxide. UCG operations in the Forth could participate in a proposed pilot CCS project which is adjacent to the coal field. A successful demonstration of both UCG and CCS should drive legislation to a more defined and regulated position.

The future for UCG

With the application of new technology, coal can yield abundant power and hydrocarbon feedstock for Scotland and the rest of the UK for the next hundred years or more. Furthermore, because coal is abundant and geographically diverse, UCG will be just as beneficial in countries which are largely dependent on coal as their prime energy source, particularly in the developing world.

There is little doubt that unrestrained utilisation of fossil fuels is adding to natural atmospheric concentrations of carbon dioxide, therefore, UCG may have an important role in low carbon power generation. The FoF project is the first in the UK to be granted a licence specifically for UCG. It is hoped that this project will demonstrate that these untapped coal resources can be exploited and that the impact on the environment can be substantially reduced. ●

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Biomass – carbon sink or carbon sinner?

In order to maximise carbon savings, biomass-to-energy plants need to produce both heat and power, and preferably from locally-sourced fuels. Indeed, it's perfectly possible for poorly-designed biomass plants to produce higher carbon emissions than gas-fired plant. A new report explains how it should, and can, be done properly.

Using energy crops or waste materials as fuel for generating electricity and heat could play an important role in meeting the UK's renewable energy and greenhouse gas emission reduction targets, but only if good practice is followed. So says: *Biomass – carbon sink or carbon sinner?* – a new report summarising research by AEA and published by the Environment Agency.

Using biomass to generate electricity and heat can deliver very large greenhouse gas emission savings compared with using gas or coal, but only if the fuel is produced in an environmentally sustainable way and used efficiently. Best practice can deliver up to 98% less emissions than using coal, but worst practice can result in more greenhouse gas emissions overall than using gas. The report estimates that greenhouse gas emissions of over three million tonnes of carbon dioxide per year could be saved by 2020 if good practice is followed.

To deliver these emissions reductions, the Environment Agency is urging Government to ensure that all generators publicly report the greenhouse gas emissions from producing, transporting and using biomass fuels and be ready to set minimum standards if required. It is also urging the Government to provide greater incentives for combined heat and power (CHP) than for electricity-only plant, through the proposed renewable heat incentive.

Overall, the best performing biomass schemes in terms of greenhouse gas emissions are those that deliver CHP rather than just electricity, which is the current trend. They also use wastes or energy crops that have not been transported too far. The worst performing schemes are those where energy crops are grown on what was previously grassland using a lot of nitrogen fertilisers. They expend energy in processing the biomass, for example into fuel pellets, and the fuel is transported thousands of miles and burned to generate electricity only.

Biomass heat and power is currently the largest source of renewable energy in the UK, accounting for 2.3% of the UK's electricity generation and 1% of our heat needs. It can be a low carbon renewable energy source because it is either based on wastes which would otherwise go to landfill or on energy crops and forestry that, after being harvested, continue to grow and absorb the carbon emitted when they are burned. The Government's renewable energy strategy envisages huge growth in energy generation from biomass so that, by 2020, it provides about 30% of renewable electricity and heat towards the UK's overall target of 15% renewable energy.

The Environment Agency believes that the biomass heat and power sector can play a key role in helping the UK meet its renewable energy and greenhouse gas commitments. To deliver this, however, the sector needs to use sustainable feedstocks and maximise greenhouse gas emission reductions. It recommends:

- The Renewables Obligation, the Renewable Heat Incentive and other relevant policies should provide greater incentives for CHP and heat-only plants than for electricity only as currently.
- Mandatory reporting on greenhouse gas emissions by generators receiving public support through the Renewables Obligation and the Renewable Heat Incentive.
- Development of mandatory minimum standards for the greenhouse gas savings achieved by biomass fuels used to generate heat and power.
- A review of energy conversion efficiency in biomass heat and power generation to ensure that current standards are adequate in ambition and scope.
- Further research to understand which technologies and production methods will produce the most renewable energy and least greenhouse gas emissions from a given amount of biomass. ●

Biomass-to-energy – the facts

- *Greenhouse gas emissions from energy generated using biomass are generally, but not always, less than from fossil fuels.*

For example, using short rotation coppice chips to generate electricity can produce 35% to 85% less emissions, whereas using straw can, in some cases, produce over 35% more than a combined cycle gas turbine power station per unit of energy delivered.

- *How a fuel is produced has a major impact on emissions.*

Transporting fuels over long distances and excessive use of nitrogen fertilisers can reduce the emissions savings made by the same fuel by between 15 and 50% compared to best practice.

- *Land use change can negate any emission savings.*

Using formerly fallow land to grow bioenergy crops can reduce emission savings from a fuel by up to 10%. Planting on permanent grassland is worse, with emissions savings significantly reduced and in some cases reversed.

- *Energy conversion efficiency is an important factor in reducing emissions.*

Factoring the efficiency of converting the energy stored in the fuel to electricity and heat into the life cycle analysis results in an even greater range of emissions savings. Efficiency standards already exist for many energy conversion technologies, but these will need to be improved.

- *Emission reductions of several million tonnes of greenhouse gases per year could be achieved by following good practice.*

Based on current market projections, we estimate that by 2020 the emission of greenhouse gases equivalent to several million tonnes of carbon dioxide per year could be avoided if good practice in fuel production, processing and transport, and energy conversion efficiency were to be followed.

- *By 2030, biomass electricity will need to be produced using good practice to avoid emitting more greenhouse gas emissions per unit than the average for the electricity grid indicated to be necessary by the Committee on Climate Change.*

In the short term, improvements in energy conversion efficiency and lifecycle emissions from biomass fuels will help to reduce emissions. However, by 2030 some fuels will be at risk of becoming redundant. While innovation may help to deliver good practice for biomass plant built in the future, the infrastructure the UK is developing now will form a major component of the country's generating capacity in 2030. It is difficult, if not impossible in some cases, to retrofit a CHP system, which makes it imperative that biomass plants – like all other new power stations – are designed to utilise heat from the outset. If they are not, and if the plants cannot be retro-fitted, operators risk being left with stranded assets within 20 years.

- *Co-firing biomass is a good short-term measure to reduce emissions, but unless carbon capture and storage can be deployed and preferably the heat utilised, it does not have a long-term role.*

Just as for dedicated biomass plant, by 2030 the carbon intensity of the electricity grid will mean that even with co-firing of biomass, coal-fired power stations will have to have carbon capture and storage operational. There should also be a strong presumption in favour of combined heat and power for new plant. ●

Whither the UK electricity grid?

Is Britain's electricity transmission and distribution network likely to be 'fit for purpose' for the next 20 years? The subject ranges from how power from remote offshore wind farms is to be delivered to consumers, to how 'smart meters' (and indeed a smart grid) will help deliver energy policy goals. Fine questions, all explored at a British Energy Association workshop held in London in March. Energy World's Marc Height *was there.*

John Scott from international consultant Kema started proceedings by outlining what he perceives to be some of the big network challenges in the coming years: finite gas and oil reserves, rising energy demand, impacts of climate change, government energy and sustainability targets, and a critical issue – the engagement and involvement of end-users.

In contrast to five or ten years ago, Scott argued that now communications are everywhere. We have smart metering programmes, a huge improvement on intelligence and automation capabilities, an ability to aggregate that we didn't have a few years ago, electric vehicles, intelligent appliances, a greater focus on communities, and a new vision for grids and networks. Scott regards this list, as well as renewable sources, distributed generation and ageing assets, as huge opportunities to seize upon.

'What is this new vision for networks?' Scott asked. Is there a silver bullet or a blueprint that companies can draw upon? He argued that we are still kneading the dough – the ingredients are coming together but it still isn't clear anywhere in the world what a 'smart grid' actually is.

'When I first heard the phrase *the third industrial revolution*, I thought it was a bit of an overstatement,' said Scott, 'but the more I look at this the more convinced I am that it is quite a helpful catchphrase.' He explained that the phrase was coined by futurologist Professor Jeremy Rifkin, who sees four elements to a sustainable society:

- renewable sources of energy;
- energy efficiency, including energy positive buildings;
- hydrogen and other forms of energy storage; and
- smart grids and plug-in vehicles.

Scott then looked at what provides the driving power for revolutions. He argued that early revolutions came about through a real concern about where people were, and a vision for a better way of doing things. You find some strong champions to hold the banner, with other people falling behind. Professional bodies and institutions were created at that time as self-help organisations and the Government kept its hands off.

Scott went on to display the difference between smart metering and smart grids, with the former covering measures on the demand side, and the latter including all aspects of the grid system. He gave the definition of a smart grid as 'an electricity network that can intelligently integrate the actions of users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies.'

One analogy of a smart grid is a more 'internet like grid', and Scott speculates that this is where we will be heading, with smarter grids drawn more like a mesh than a hierarchy. They will display the following properties:

- central and dispersed intelligence;
- multi-direction flows: power and information;
- central and dispersed sources;
- plug and play: seamless integration of the new;
- transparency for the user;
- automated payments through the value chain;
- end user real time information and participation; and
- they will be creative, dynamic, organic . . . but coordinated.

One should be able to connect a generator anywhere easily in the same way you can arrive in a foreign airport and your mobile phone synchronises to the communications grid without you having to phone a call centre, and all the people in the value chain, the roaming chain, get paid appropriately. This will have to be the same if you are generating at home, or if your electric vehicle is interacting with the grid. You will need to be paid for that in a seamless way.

Scott argued that we are moving from today's grids to something different. Transmission and distribution will become less meaningful in the future. The vision for the future has to be end-to-end. Challenges ahead include embedded intelligence, a whole new system of dynamics and transients, integrating DC and AC, and then the ability to model all of this.

International progress

Scott divided smart grid progression internationally between three categories: hot, lukewarm and cold. Under the hot column he listed President Obama, active stakeholder groups, lots of renewable sources of power, strong 2020 targets, the appearance of smart metering, electric vehicles and, lastly, free markets which should prove to be enormously helpful. The lukewarm column highlighted the current state of the capital markets, very limited regulatory engagement in the issues, and some good funded demonstration projects – but these are not being deployed commercially. On the cold side, Scott highlighted that there are very few commercial network projects; he sees transmission and distribution thinking continuing in traditional silos; and smart metering being lined up for wide area rollout, but not taking the opportunity to being lined up with the networks.

He flagged the soon to be published EU Technology Platform Smartgrid Strategic Deployment Document, which demonstrates that demonstration projects are key to progression in this area – the technology has to be proven on a real network somewhere. The document says that governments and regulators must provide assistance in commercialising this technology, and that smart grids are an essential factor to meet sustainability targets and security of supply policy goals. The final key message from the document is that deployment and research are needed to meet the targets at 2020, but that fundamental research is needed to meet 2050 targets – there are big gaps in capabilities.

He then showed some work carried out by his colleagues in Kema in the USA, which shows that smart grids have serious jobs potential, and are included in President Obama's stimulus package.

Will the UK seize the opportunity?

Scott began his last topic looking at the UK. He summarised the big issues by stating that distribution networks will need to become more active, or more transmission-like. Secondly, transmission must really integrate with renewables and active customers, not just accommodate them. Finally, end users need to really participate and engage with the problem.

How do you start a revolution with no silver bullet and no roll-out plan? Scott argued that market forces alone cannot deliver a step-change in the timescale required. There is the problem of inertia, and that any changes that take place will have to do so within existing networks and real customers. Innovation has risk, and companies avoid risk if they can. He also argued that it would be ineffective to look for a UK-only solution. According to Scott, what we need are incentives that attract management attention, bold smart grid innovation projects that will catch the attention of the media and the general public, and we need field demonstrations on real networks.

National Grid's Phil Lawton began the second talk by asking what the historic reasons were for the existence of the grid – the main factor being that it provided a central reserve to a local plant, rather than having two plants run on a local network. The grid also improved security of supply, and enabled the full use of efficient plant. The grid can thus be viewed as a tool to allow the minimisation of the *cost* of the generation portfolio.

In the future, Lawton speculated that the grid will provide a reserve for intermittent renewables, whilst still providing improved security of supply, and that it needs to make full use of future low-carbon plant. Thus, the grid will then become a tool to allow *carbon minimisation* of generation portfolio, rather than cost.

According to Lawton, we need an energy network that is sustainable, secure and affordable; the challenge is to deliver these three at the same time. National Grid's approach is to ask what the energy sources are going to be, and then ask what the market requires (if we require more intermittent generation, how do we get the balancing services that we need), how to meet the operational challenges, and lastly how to remove the network constraints.

Smart meters will provide automated meter readings, ending any disputes between customers and suppliers. They will also provide a customer display which could alter consumer behaviour, allow more complex tariffs – which is necessary in order to reward those that are feeding back into the grid – and also remote configuration capabilities, said Lawton. Smart grids involve things like post fault switching and inter-trips, temperature ratings based on actual temperatures of the circuit rather than having to make conservative assumptions, and higher quality data for maintenance and network design.

Lawton stated that, ironically, of most interest to those at National Grid is not smart grids but the concept of a 'smart home'. With this you start looking at automatic control of appliances, a key appliance being plug-in hybrid electric vehicles. If everyone plugged in their car at 6 pm, peak time, this would increase costs. As most individuals will not need their car until 8 am the following morning, this raises the possibility of charging overnight. A smart home would provide the facility to provide a general demand response to balance the network. With a varied generation side of nuclear, wind and supercritical coal stations, a demand side is needed where homeowners aren't sensitive to when demand is met.

According to Lawton, the main issues today are that there are a large number of proposed renewables schemes, relatively smaller projects with shorter lead times. With Sizewell B for instance, it was known for years that it was coming. The resultant issues are that it is much harder to link an individual generation project to an update on the grid that is needed. Whereas traditionally, one project would require one upgrade, now there are a multitude of projects wanting connection at any one time.

Build more transmission capacity faster

Lawton stated that the National Grid has been undertaking strategic investment in order to work on investments ahead of an actual application. This involves a collaborative approach between National Grid, DECC, Ofgem and Scottish transmission companies. Ofgem is currently consulting on how this will be funded in the longer term.

The areas being focussed on for strategic investment are Scotland (driven by onshore renewables), the east coast of England (offshore wind and potentially nuclear) and the south and west (nuclear and wind). The Scotland example involves the construction of offshore HVDC cables to get round planning constraints, with one located off the west coast, and another potentially off the east coast. There is also work planned within Scotland to upgrade existing or build new routes.

There are six CUSC (connection and use of system code) modifications now with Ofgem (which will run a regulatory impact assessment), which provide more transmission access options to generators. This is likely to come into force in April 2010. The CUSC modifications, in the short term, will see the implementation of the concept of connect and manage – you put everyone on the grid, and then deal with the constraints that result.

What does a generator want from a regime for transmission access? Speed (you get connected quickly), certainty (you know what your charges are going to be and what you're going to get) and you want the total cost to be low. Unfortunately, according to Lawton, it is hard to deliver all three at the same time.

Lawton showed that, currently there is a queue of around 16 GW of renewable offers to connect prior to 2020, and in popular areas this stretches beyond 2020. Moving from 2020 to 2030 this situation is likely to get worse due to round three offshore wind applications and plant needed to replace the generation gap post-2015.

There has been an attempt to do something about this in Scotland, where National Grid sought to identify potential gaps in the queue that they could use, and then invited people to move forward in the queue. However, with this approach there will be costs, and National Grid was requested by Ofgem in February to consult on constraint costs as a matter of urgency. Lawson said that they now are looking at locational BSUoS (balancing system use of system) to focus the costs back into the area.

Fundamental change needed

Lorraine Hamid from DECC (the Department for Energy and Climate Change) began her presentation by stating that her team's aim is to ensure that the UK's electricity networks efficiently deliver secure and clean energy in order to meet our energy security and climate goals for 2020 and beyond. The 80% target for reduction in carbon emissions by 2050 will require a fundamental change in the way we use energy and how we generate it. The networks are going to have to look, feel and be used in a different way, the question is, when do these changes have to take place?

She stated that there is a current focus within her team of making better use of the networks we currently have, and to put in place the right incentives and investment to meet longer term goals. The outcome should be the fact that in 2020 and 2050 our networks are not a barrier to new technologies that we need to be using, and should be more capable of active management.

To explain why DECC is focussed on some of the more short-term goals, Hamid showed a map of the UK which demonstrated that a lot of grid areas are congested, and there are few areas, located to the south, where new generation projects can be connected relatively quickly. However, in some areas where new generation is expected, such as in parts of northern Scotland, there is a weak or non-existent network. There are also planning problems.

DECC is also concentrating its thinking on smart grids. In the current policy, the Department is focussing mostly on smart meters, committing on installing them in all households by 2020 and major industrial users by 2015. This means a rapid timescale for investment and decisions now, which DECC will be consulting on. For new networks they will also be consulting on a new national policy statement for network infrastructure. ●

The British Energy Association is the UK Member Committee of the World Energy Council, **www.worldenergy.org/uk**

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