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Front cover:
A Linc Energy employee operates UCG Gasifier 4 at the Chinchilla Demonstration Facility. Syngas from a UCG facility will be used to generate power from an alkaline fuel cell and the CO_2 will be captured for storage in a UK project planned by B9 Coal

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IEA - progress of CCS must be speeded up

A global level strategic outlook reveals that plenty of progress has been made with carbon capture and storage technology and policy over the past two years. But many critical aspects of the technology still require solutions and continued political backing.

Juho Lipponen, Head of IEA CCS Unit

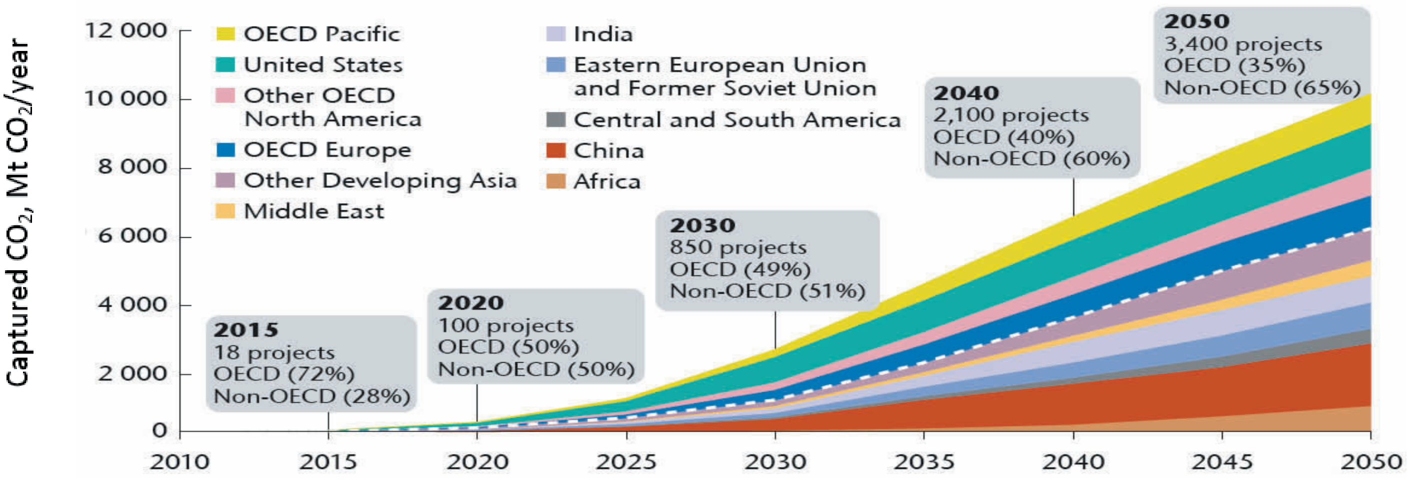


Figure 1. Global deployment of CCS 2010-2050 by region

It's been nearly a year since the IEA CCS Technology Roadmap was published in October 2009. The roadmap builds on the IEA Energy Technology Perspectives "BLUE Map" scenario analysis, which foresees a very significant role for CCS technologies in stabilising CO2 emissions at 450ppm by 2050. Alongside greater energy efficiency, increased renewable energy technologies and nuclear power, carbon capture and storage would achieve 19% of the total emissions reductions required until 2050.

To reach this level of contribution, there will be a need to capture and store 10 Gt of CO2 per annum in 2050. Cumulatively, we would need to capture over 120 Gt of CO2 during the next four decades, if CCS was to play the role the ETP analysis suggests. As regards commercial-size projects, such level of emission reductions would require some 100 projects by 2020, and a staggering 3400 projects in 2050.

The essential purpose of the IEA CCS roadmap is to show what is needed in practice if CCS is to deliver those 19% of required reductions, or rather, to be able to deploy those over 3000 projects. The roadmap makes recommendations on what is required to achieve this level of deployment not only technically, but also from a financial and regulatory point of view as well as in terms of public engagement and international collaboration.

So, from a strategic viewpoint, has CCS advanced in the past year?

Significant progress is being made to launch large-scale demonstration facilities across the globe. A study commissioned by the Global CCS Institute in the spring of 2010[1] identified 80 large-scale integrated demonstration projects at various stages of development around the world, many of them having been initiated only during the past two years.

These projects are located primarily in developed countries in Europe, the United States, Australia, Canada and Korea. It is encouraging to note that seven of the projects are in developing countries: four in China, two in the Middle East and one (in operation) in Algeria. Overall around two-thirds of the projects identified are in the power generation sector. Other industrial projects include those associated with the separation of CO2 from natural gas.

Nine large-scale projects are currently in operation, while the rest are in various stages of development and planning. The IEA considers five[2] of the nine operational projects to be CCS projects, with the other four being Enhanced Oil Recovery (EOR) projects that do not have complete monitoring systems to assess the viability of the long-term storage of the CO2. Another project, the Gorgon project in Australia, is now under construction.

A number of other projects have progressed through various phases of the project development cycle and are moving towards being 'investment ready', notably in Canada, in the US and in the European Union[3]. EOR is emerging as an important factor in driving progress on a number of potential 'early mover' projects.

Significant progress has been made in relation to government commitments. Over the past two years, a number of governments (notably Australia, Canada, the European Union, Japan, Norway, the Republic of Korea and the United States), have committed substantial funding and are actively facilitating the deployment of large-scale CCS demonstration projects. As of April 2010, public funding commitments were in the range of USD 26.6 billion to USD 36.1 billion.

Moreover, governments have announced a commitment to launch 19 to 43

1&3. Global CCS Institute, The Status of CCS Projects, Interim Report 2010, 2010

2. In Salah (Algeria), Sleipner and Snohvit (Norway) Rangely (USA) and Weyburn-Midale (Canada/USA).

large-scale integrated projects before 2020. In many jurisdictions, a significant portion of economic stimulus spending has focused on developing, demonstrating and deploying clean energy technologies, such as CCS. These commitments, however, are generally contingent on industry taking a full and active role.

Progress has also been achieved in the legal and regulatory area. In the European Union, the Directive on the Geological Storage of CO2 and the EU Emissions Trading Scheme Directive provide a framework for legislation and regulation of CCS within the region, which must be transposed into individual Member State law by 2011.

In Australia, comprehensive CCS legislation has been put in place at the federal level to cover offshore storage and, in a number of states, to cover CCS onshore. In the United States, a number of states have implemented CCS legislation in parallel with ongoing work at the federal level by the Environmental Protection Agency. In addition to these early movers, a number of other countries have begun the process of reviewing and amending legislation, including Canada, Japan and Norway.

The first movers in establishing legal frameworks have generally been OECD countries. It is now important that the large emerging economies start developing their legal and regulatory frameworks.

But despite much tangible progress, many challenges remain:

- More demonstration projects are needed in the cement, aluminium and iron and steel industries, as CCS is often the only solution for them to achieve deep cuts in CO2 emissions. According to the roadmap, in 2050 up to 45% of global CO2 captured will come from sources other than power generation. Demonstration and deployment of CCS in industrial sectors is therefore critical. The UN Industrial Development Organisation is currently coordinating a major analysis of industrial CCS opportunities, which will result in a global Industrial CCS Roadmap by end of 2010.
- While specific CCS laws have been put in place, an international framework is still limited. Discussions are underway on post-2012 climate change arrangements. Governments must maintain their efforts to ensure that CCS is not excluded from the incentive mechanisms under the post-Kyoto arrangements. Without access to such mechanisms, it is unlikely that the deployment of CCS will expand at the pace required in developing countries.
- While a lot has been done to map and characterise potential CO2 storage sites, the status and availability of data on CO2 storage vary significantly around the world and this is potentially a major constraint to CCS deployment. A concerted effort will be required to characterise storage sites in sufficient detail. More joint planning of CO2 transportation infrastructure is also required globally;
- Public engagement processes are vital to ensure public acceptance of CO2 transport and storage. Public awareness of the technology also remains very low;
- Governments and industry must build capacity that will enable the delivery of CCS at the scale, time and magnitude necessary, and ensure active sharing of knowledge on the experience gained;
- Absolutely critical is the need to reach a broadly supported international agreement on a global response to climate change.

Country	Funding committed to date (billion USD)	Number of projects committed by 2020
Australia	2 to 6	3 to 5
Canada	3.5	up to 6
European Commissiona	4 to 6	6 to 12
Japan	0.1	1 to 2
Norway	1	1 to 2
Korea, Republic of	1	1 to 2
United Kingdomb	11 to 14.5	4c
United States	4	5 to 10
TOTAL	**26.6 to 36.1**	**19 to 43**

Table 1. Funding and project announcements from governments and international organisations
Notes:
a. This includes the 300 million permits that are set aside under the EU-ETS for demonstration of CCS and of innovative renewable energy, and EUR 1 billion from the EC energy recovery package.
b. UK funding includes operational support for 10 to 15 years of CCS operations. Note that UK funds may be used in conjunction with EC funds where one or more of the UK projects are co-funded from EC funds.
c. Within the 'TOTAL' range, the lower number considers 2 of these 4 projects are counted within the EC figure; in the larger number, they are all considered additional to EC projects.

The last few years have seen a much increased political interest in CCS technologies, even at the highest levels. Since their 2005 Gleneagles summit, the G8 Leaders have committed to 'work to accelerate the deployment and commercialisation of Carbon Capture and Storage technology'. In 2008, the G8 Leaders recommended that 20 large-scale CCS demonstration projects should be launched by 2010 with a view to beginning broad deployment of CCS by 2020.

The next decade, from 2010 to 2020, will be a crucial watershed period for the future of CCS. Continued political leadership is absolutely essential at both national and international levels to achieve the levels of CCS deployment required. A lot of progress has been made, but this progress must now be speeded up.

Flexible CCS for power generation

This article is the third in a series that considers features of the future power markets in which CCS will be competing with a view to understanding the potential implications for the here and now. This article focuses on how the value of flexible generation is expected to increase over time and what implications this has for generation using CCS

Barry Ladbrook and Oliver Pearce, Pöyry Energy Consulting

Achieving the renewable and greenhouse gas emission reduction targets being set in a range of markets is expected to significantly increase the use of intermittent[1] and less flexible[2] low carbon generation. This has important implications for power systems, as the level and timing of the peak hour, net of intermittent generation, could differ markedly from one day to the next.

As the level of intermittent generation increases, there is likely to be an increase in the frequency of unforeseen supply side shocks, which will impact the balancing of the system, the level and distribution of wholesale power prices, the type of investments that are likely to be made, and potentially the need to revise the market rules.

As an example, our analysis suggests that an increase in intermittent generation will lead to more volatile electricity prices and greater occurrences of extreme prices. This can be seen in Figure 1, which shows price duration curves from Monte Carlo simulations for a high renewables deployment scenario in the British market in 2020 and 2030.

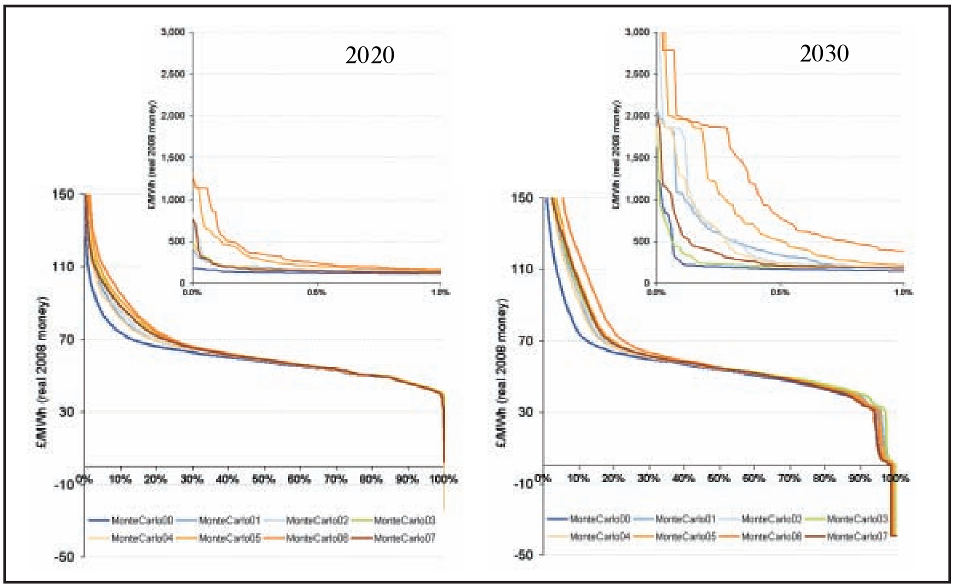


Figure 1 – Price duration curves for the British market in 2020 and 2030

This indicates that by 2020 there could be times of negative prices, due to wind generators valuing its output at the opportunity cost of -1 Renewable Obligation Certificate, while at the other extreme, prices could reach almost £1,300 MWh.

By 2030 there is an increased likelihood of both negative prices and the possibility of prices reaching almost £8,000 MWh. However, there is a very narrow window of opportunity for capturing these higher prices – and missing the window could have a significant impact on the economics of generating plant.

It can be expected that increased levels of intermittent generation will increase the importance and value of flexible generators, as they will be relied upon to help system operators balance supply with demand, and consequently should capture higher revenues.

The extent to which this occurs depends in part on whether other developments mitigate the impact of intermittent generation, such as greater use of interconnectors, the deployment of smart grids, options for energy storage, and demand side management (DSM) techniques.

Much of the discussion of the economics of CCS concludes that it will be important that CCS units operate at a high load factor to facilitate the recovery of the higher capital costs. However, due to their higher operating costs relative to wind and nuclear, they may be forced to run as mid merit rather than base load. The discussion also concludes that while it is technically possible to increase the flexibility of CCS units, such moves will incur greater costs that may be difficult to recover.

This article considers what options exist for CCS units to increase their flexibility, and how it may be advantageous for operators to pursue these options in markets that attribute high value to flexible generators.

Value from flexible operation

Flexible generation is able to accommodate promptly external events and follow the demand profile, net of intermittent generation, meaning that units must be able to ramp output up and down over short timescales and switch on and off rapidly. Currently flexible operators use this ability to capture higher prices through spot and balancing markets when the wholesale price is high, and in some cases through regular 'availability' payments from the system operator through a reserve market. Central to the prospects for CCS units will be how the market rules evolve to facilitate increased low carbon generation, and in particular what on-going support they will receive.

Flexibility in the CCS chain

A major factor for CCS units is the need to use 20-30% of energy produced in the capture process; such as providing steam for a water-shift-reactor in a pre-combustion process, regenerating amine in a post-combustion process, running an air separation unit (ASU) in a pre-combustion or oxy-fuel process and compressing the captured CO2. If this energy could temporarily be used to provide power to the grid rather than used in the capture process, it would give CCS units the ability to engage in spot, balancing and reserve markets. This section provides a brief overview of the ways in which this additional flexibility can be provided by the CCS chain.

The easiest means of using this energy

1. Generation is considered intermittent if it is not possible to control its dispatch, and includes wind and solar.

2. Nuclear generation has traditionally been seen as inflexible, due to the long periods needed to ramp its operation up and down.

to dispatch power to the grid would be to turn off the capture facilities and vent the CO2. However, depending on the carbon price, relative to the electricity price, and any emission limits regime, this option may not be very attractive. An alternative option for a post combustion process is to store the CO2 rich amine and regenerate it after the period in which prices are high and/or the system operator requires. This will require additional storage facilities and volumes of amine.

Pre-combustion processes involve gasifing coal or reforming natural gas to produce a syngas, which is carbon monoxide and hydrogen. This gas is put through a water-shift-reactor where is it mixed with steam under high pressure to produce hydrogen and CO2, which are then separated. It is possible to run this process to produce more hydrogen than is typically required, enabling some of it to be stored. At times of high prices, or when the system operator requires it, the stored hydrogen could be used to:

- fire turbines that are not in use or increase the loading of those in use, producing additional energy; or
- substitute for the hydrogen produced in the water-shift-reactor, and diverting the steam used in this process to be used to generate power.

Such measures would require additional storage facilities for the hydrogen, and possibly for the syngas that the gasifier or reformer will continue to produce. Further, it will be necessary to develop the skills and processes for managing the production and use of the various gases.

In addition, it would be possible to use blend natural gas and/or syngas into the fuel mix to operate turbines not in use or increase the load of those in use, and temporarily divert the steam used in the water-shift-reactor to generate power. However, this would increase CO2 emissions, requiring the purchase of carbon allowances and may contravene emissions standards. Further, it would require turbines to operate on a range of fuels, which could have an impact on their cost and operating efficiency.

Finally, power is diverted to an ASU to produce oxygen used in gasification and oxy-fuel processes. It is possible to store additional oxygen to maintain these processes without using the ASU, meaning that operators could dispatch this power to the grid for period when prices are high and/or the system operator requests.

The above options provide some scope for CCS generators to respond to external events and potential gain additional revenue. Questions remain about the cost of providing this flexibility, the speed at which it can be delivered, and the value that could be captured.

The options outlined will result in varying the flows of CO2 through the transport and storage parts of the chain, which has important implications for these stages. It should be possible to resolve these issues through developing a network that transports CO2 from a large number of sources, and involved on-shore CO2 storage facilities that can regulate the flow to storage sites. However, there are clear challenges in the development of such a network that may limit the flexibility of CCS units in the early stages.

Alternative flexible low carbon forms of generation

There are a number of existing and potential technologies that can provide flexibility to the power system that enable it to meet sudden changes in demand, or demand net of intermittent generation. Example of current technologies include: pumped storage, compressed air, fossil fuel-fired peaking units, hydro, demand reduction from industrial operations, interconnection links and network reinforcements.

Examples of future technologies include: fuel cells, flywheels, super capacitors, demand side management techniques such as intelligent appliances, electric vehicles, and flexible nuclear. While some of these can be expected to have an important role in a future low carbon world, it is unclear which ones, their costs, the timing and magnitude of their deployment and their impact on the market.

With regard to CCS, the advent of technologies that help smooth demand profiles will lessen the value that flexible generators can capture and hence reduced the incentive for CCS units to increase their flexibility. Consequently, the optimum degree of flexibility to be built into CCS units is likely to vary depending on conditions within the relevant market. This uncertainty raises challenges in prioritising how flexibility should be incorporated into CCS units in the transition from a demonstration phase, where baseload operation is envisaged, to a commercial technology.

Summary

This article has examined how CCS units can operate in a flexible manner through storing inputs, such as hydrogen and oxygen, or outputs, such as CO2 rich solvent, which enables them to increase the level of output available to the grid.

The viability of such measures will depend on their costs, the speed at which the energy can be converted into dispatchable power, how the market rules evolve and especially how flexibility will be valued, and what other technologies and techniques emerge. The uncertainties over these drivers add another dimension of complexity to the evolution of CCS as a viable low carbon technology.

B9 Coal UCG with fuel cells CCS project

B9 Coal, based in the UK, has developed a novel project which involves using syngas from Underground Coal Gasification (UCG) to generate power from alkaline fuel cells.

About a third of UK electricity is generated from coal, a feed stock which emits more CO2 per unit of electricity than any other form of generation. Tackling emissions from coal therefore must be a priority for the UK. In 2007 the Department of Energy and Climate Change (DECC) opened a government funded competition, demonstrating the UK's call to action to tackle climate change. With cutting greenhouse gasses a top priority, carbon capture and storage (CCS) projects were called for to secure future energy supplies whilst minimizing the environmental impact.

In August 2010, B9 Coal, a UK based clean energy company, introduced a 500 megawatt (MW) project aimed at meeting DECC's call for CCS in industry. According to the company, the key combination of technologies behind the project are a world first. The proposal brings together alkaline fuel cells and underground coal gasification, two technologies which receive little attention in power generation, but B9 Coal says that by combining them CO2 capture upwards of 90% can be accomplished at no extra cost.

The project has huge partner support, including WSP Group, AFC Energy and Linc Energy, all key players in their industries, plus a proposed Rio Tinto Alcan site in the North East.

"I firmly believe that we cannot afford to simply put a sticking plaster on old, dirty technologies" explained Alisa Murphy, Director at B9 Coal. "Our combination of technologies is truly game-changing, and if the government is to achieve their stated aim of showing global leadership on CCS, the competition needs to support new, emerging technologies that are built for the future."

Underground coal gasification

Underground Coal Gasification (UCG) is the process of gasifying coal in-situ, where it lies under the ground. UCG provides access to coal 'stranded' deep underground, eliminating the need to mine it and process it through a surface gasification plant. The process produces a high quality synthetic gas (syngas), containing carbon monoxide, hydrogen and methane.

The technology has evolved through numerous trials since the early 1900s. Commercial scale UCG sites for power generation have been operating in the former Soviet Union for over 40 years. In the UK alone, UCG could potentially give access to an extra 17 billion tonnes of coal, without the major environmental impacts of conventional mining. The process could therefore have immense benefit in terms of UK energy security and the ability to power the country from indigenous resources.

Last month, the Environment Agency released a position statement on UCG explaining that, "the UK has significant coal reserves that are believed to be suitable for UCG and cannot be accessed using conventional techniques such as deep shaft or open cast mining," and stating that, "the government supports the development of UCG."

B9 Coal is working with Linc Energy, a forward-thinking energy company and Australia's leader in clean coal technology. Linc Energy is well-positioned to take their proven technologies to UCG-suitable locations around Australia and the world. With significant coal deposits suitable for UCG technology, Linc Energy can provide alternative sources of liquid fuels and power generation well into the foreseeable future.

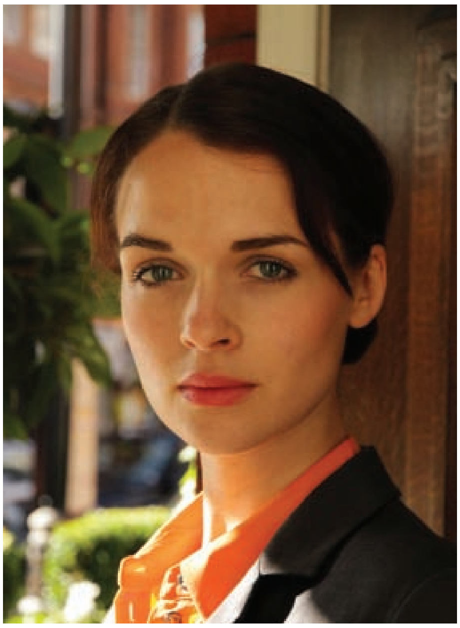
Alkaline fuel cell technology

The alkaline fuel cell was first demonstrated by Sir William Grove in 1839. In 1939, Sir Francis Bacon resurrected the technology from its former design and created the first working model, producing 5KW of power. Alkaline fuel cells work by passing hydrogen and oxygen over a catalyst to create water, heat and electricity.

Since 'Bacon's Fuel Cell', the technology has been used by NASA to fly man to the moon in the 1960s, but as companies speculatively took it to market, the expensive materials and heavy weight slowed progress, labelling the technology as unviable for commercialisation.

UK Company AFC Energy have taken this out-of-fashion technology and created a commercially viable method for clean power generation. Their fuel cell is low-cost, low-temperature and low-pressure. Uniquely, the technology is also fully scalable and modular, giving the B9 Coal model the ability to load follow to meet peak demand.

A recent technical review of AFC Energy's technology from Dr. Jon Helliwell, Project Manager of Fuel Cell Applications at the Centre for Process Innovation (CPI), highlighted the substantial strides the company has made over the last 5 months, as well as the significant headway achieved in commercialising the system and delivering on partner expectations. AFC Energy boasts world-leading partners including AkzoNobel, Ineos, Centrica, Air Products, WSP Group and Linc Energy. The technolo-



"We believe we have a world-leading template that delivers on DECC's key requirements: delivering value for money, demonstrating international leadership on CCS, and proving the potential of this technology." - Alisa Murphy, Director, B9 Coal

AFC Energy's alkaline fuel cell

gy is gaining momentum across a range of markets including chlor-alkaline, waste-to-energy, clean coal and natural gas.

AFC Energy's technology is focused on large-scale industrial applications and the objective of producing the lowest possible unit cost electricity. AFC Energy's alkaline fuel cells convert hydrogen to electricity at up to 60% efficiency and, when combined with UCG, can provide a possible cost per kWh of as low as 4p.

Ian Balchin, CEO of AFC Energy described the B9 Coal project as, "an impressive integration of technologies which addresses the energy challenges we are currently facing. It gives us the opportunity to maximise our coal resources but in an environmentally sensitive way."

In June 2010, AFC Energy's fuel cell system was successfully deployed and operated at Linc's underground coal facility in Chinchilla. This was the first time that an alkaline fuel cell had been deployed with UCG and represented a major step towards the world wide opportunity of establishing UCG partnered with alkaline fuels cells as a breakthrough technology.

"This effectively demonstrates that combining the AFC Energy's fuel cell technology with hydrogen from Linc Energy's syngas, produced from the world-class UCG at Chinchilla, is a feasible route to achieve the ultimate in clean electricity from stranded, sub-economic coal, of which there is an abundance in the world," explained Linc Energy CEO Peter Bond.

The B9 Coal project in action

The B9 Coal proposal would mark the first-ever large scale deployment of these technologies in a CCS project. UCG produces syngas which is then passed through a clean-up process resulting in separate streams of hydrogen and carbon dioxide. The hydrogen is used to power the highly efficient fuel cells whilst the carbon dioxide is ready for transport and storage. The project will offer greatly enhanced efficiency conversion of coal to electricity, whilst enabling upwards of 90% carbon capture.

Rio Tinto Alcan's Lynemouth Plant in Northumberland has been announced as a potential site for the plant. The proposal has the support of the North East Process Industry Cluster (NEPIC) and RENEW, the organisation tasked with commercial energy and environmental technology projects across North East England.

"Together these technologies have the potential to transform coal from the dirtiest fossil fuel to the cleanest," remarked Alisa Murphy. "We believe we have a world-leading template that delivers on DECC's key requirements: delivering value for money, demonstrating international leadership on CCS, and proving the potential of this technology."

Linc Energy's UCG flare and Gas to Liquids facility at its Chinchilla Demonstration Facility, Queensland, Australia

Commenting on the project, Neil Crumpton, a UK energy specialist working for the Bellona Foundation environmental group said, "the B9 project is revolutionary and undoubtedly world-leading. An early successful demonstration at scale of AFC Energy's remarkable fuel cell and underground gasification with CCS would open up several strategic-scale opportunities to the UK in terms of variable power generation, energy security, climate policy and UK manufacturing jobs."

"As this project proposal becomes more widely noticed, power generators around the world, even some governments, will start watching closely to see how the UK Government responds to this unique and huge opportunity," he continued.

Natural gas CCS

B9 Coal, and its affiliate B9 Gas, also recently announced their intention to create a unique, climate-friendly natural gas power station in response to the Committee on Climate Change (CCC) call for the application of CCS to natural gas to be included in the DECC competition.

The project would use the known technology of steam methane reforming (SMR) to convert natural gas to hydrogen which is then fed to AFC Energy's alkaline fuel cells to create a modular, on-demand, decarbonised power plant.

"The proposal would offer significant advantages over conventional natural gas power plants with turbines, primarily the ability to load follow," said B9 Coal. "Excess hydrogen can be stored overnight and used to generate electricity to meet peak demand, guaranteeing a consistent and reliable supply of power. The scaleable nature of the fuel cell system ensures that there is no loss of efficiency during up and down cycles, unlike conventional gas turbines."

B9 Gas is in talks to acquire an existing hydrogen generating plant with potential CCS and hydrogen storage facilities. By using existing facilities with operating permits in force, the B9 Gas plant has the potential to be operational within 3 years.

"The B9 Gas project is a technically advanced solution to the problem of carbon emissions and climate change," explained Alisa Murphy. "The combination of natural gas with alkaline fuel cell technology is another exciting template for clean energy generation with carbon capture. Our model offers CCS without inflated cost or loss of efficiency, as well as major implications for UK energy security, job creation and technological achievement."

More information

B9 Coal was established in 2009 with the objective of developing projects combining underground coal gasification (UCG) with Carbon Capture and Storage (CCS) and alkaline hydrogen fuel cells.

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CCS legal and policy – Sept / Oct 2010

The past two months have been interesting for those involved in the commercial evaluation of CCS projects with the emergence of informative developments regarding two of the major revenue streams which affect the viability of those projects, says Calum Hughes, principal consultant in CCS regulation and policy at Yellow Wood Energy. calumhughes@yellowwoodenergy.com

At the end of July, DECC published initial guidance on its intended approach to the short-listing of those UK CCS projects wishing to apply for a tranche of the European Commission's fund of 300 million EUAs which have been set aside from the EU ETS's New Entrants' Reserve in order to support CCS and renewable demonstration projects (the 'NER300 fund'). The fund was instigated by the 2009 ETS Amending Directive (2009-29-EC) as part of the European Commission's stated aim of encouraging the development of up to 12 CCS demonstration projects within the territory of the Union.

No monies from the fund have, as yet, been distributed but a draft Decision was published by the European Commission earlier this year regarding, inter alia, the timetable for the distribution of the funds and how individual projects would be assessed and selected. The first stage of the selection process is a short-listing by each member state, of applicant projects from within its territory, against criteria laid down in the draft Decision coupled with national preferences. It is to this process that the new DECC guidance applies.

The guidance contains some instructive information. For example, in a short section entitled 'How much could the UK benefit from the NER300?' it is pointed out that 'the maximum return to the UK would be achieved by securing funding for the three largest demonstration projects'. It is not clear what purpose this statement serves as part of the guidance document generally and, whilst it is not explicitly stated that DECC would seek to maximise returns to the UK from the fund, one might assume this to be the case and therefore infer that large projects would be preferred by DECC.

What DECC has made explicitly clear is that it will short-list, for the NER300 fund competition, all applicant projects which meet the eligibility criteria for both that competition and the UK's CCS demonstration programme. Projects which do not meet the requirements for the UK funding may be short-listed for the EC funds but there are strong hints that they would not if three or more large projects meeting both sets of criteria were forthcoming.

So the inference seems to be that DECC would prefer large projects which meet the aims, and therefore the requirements, of both itself and the EC. This, however, raises potential difficulties for those preparing NER300 fund applications; DECC has not yet published its criteria for UK demonstration programme funding applications and will not be in a position to do so until the end of October, when its market sounding process is completed. However, the applications for the NER300 fund monies must be in by the end of December, potentially leaving prospective applicant projects with two months to modify their bids if any substantive changes are made by DECC to the criteria it has historically set out for UK funding eligibility.

A DECC spokesperson has informed me that:

"We recognise the difficulties our current proposed timing for publication of objectives for the UK demonstration programme may have for project developers wishing to bid for NER funding but it is important to design the UK programme in a way which delivers the best benefits for the UK in terms of projects. This means taking time to analyse the many substantive inputs we are receiving through our market sounding process, which does not complete until mid-September. We are in close contact with the European Commission regarding the NER and will take all possible steps to ensure that information regarding the UK demonstration programme is available at the earliest possible opportunity."

Whilst this is an entirely reasonable stance and probably as much as DECC can do given the way the timings of the two schemes have developed, the period running up to the formal publication of DECC's criteria looks like being a nervous one for some project teams.

Access to public subsidy aside, the economics of all CCS projects depend, to a large extent, upon the restrictions on, and commoditisation of, the right to emit CO2 emissions currently imposed by the Kyoto Protocol. The protocol lapses at the end of 2012 and, following the disappointing outcomes of the Copenhagen Conference last year, the challenges for the parties in agreeing a replacement in time for a seamless transition at the beginning of 2013 look increasingly insurmountable. Hopes have now moved to the upcoming Cancun Conference and the snappily named Ad Hoc Working Group on Further Commitments for Annex 1 Parties under the Kyoto Protocol ('AWG-KP') met in Bonn in August to develop texts that it is hoped will form the basis for negotiations in Tianjin, China in October and, in turn, of an agreed extension of the Kyoto Protocol at the Cancun Conference of the Parties in December.

Calum Hughes, Yellow Wood Energy

The proceedings of the Bonn meetings do not make happy reading for those hoping for an agreed Protocol amendment in time to avoid a gap in Protocol commitment periods. The growing acceptance that such a gap must be recognized and addressed, even if this is politically unpalatable, is obvious from the meeting records. Documents issued by the AWG-KP in association with the meeting reflect this. The Chair of the Group has issued draft texts, for adoption by the parties to the Kyoto Protocol, to amend the Protocol and thereby extend it operation until 2020. However, the group has also prepared, and considered at the meeting, legal options for dealing with a commitment period gap should it occur; these have an air of desperation about them.

The legal consequences of a gap are complex and, I suspect, wholly esoteric for most CCS project developers, but they have a great potential to affect the price of carbon emissions and this is of far more practical importance. On a positive note, at the Bonn meeting, the EU representative emphasised that 80% of global emissions trading is based on the EU's Emissions Trading Scheme and that the intention is for this to continue operating regardless of any gap in Protocol commitment periods. What the practicalities of this are and how much statements like this will breathe confidence into the markets is yet to be seen.

US Federal Task Force concludes CCS is viable

President Obama's Interagency Task Force on Carbon Capture and Storage (CCS), co-chaired by the U.S. Environmental Protection Agency (EPA) and the Department of Energy (DOE), has delivered a series of recommendations on overcoming the barriers to the widespread, cost-effective deployment of CCS within 10 years.

The report concludes that CCS can play an important role in domestic greenhouse gas (GHG) emissions reductions while preserving the option of using coal and other abundant domestic fossil energy resources.

In February 2010, the president charged the task force with proposing a plan to overcome the barriers to the widespread, cost-effective deployment of carbon capture and storage within 10 years, with a goal of bringing five to 10 commercial demonstration projects online by 2016.

The report reflects input from 14 federal agencies and departments as well as hundreds of stakeholders and CCS experts. It addresses the incentives for CCS adoption and any financial, economic, technological, legal, institutional, or other barriers to deployment. The task force also considered how best to coordinate existing federal authorities and programs, as well as identify areas where additional federal authority may be necessary.

The report's main findings and recommendations include:

- CCS is Viable: There are no insurmountable technical, legal, institutional, or other barriers to the deployment of this technology.

- A Carbon Price is Critical: Widespread cost-effective deployment of CCS is best achieved with a carbon price, but there are market drivers and actions that can and are taking place now, which are essential to support near-term CCS demonstration projects that will pave the way for broader deployment after a carbon price is in place.

- Federal Coordination should be Strengthened: With additional federal actions and coordination, the task force believes our nation can meet the president's near-term goal and get 5-10 commercial demonstration CCS demonstration projects online by 2016. The report recommends the creation of a standing federal agency roundtable and expert committee to facilitate that goal.

- Recommendations on Liability: The task force conducted an in-depth analysis of options to address concerns that long-term liability could be a barrier to CCS deployment. It concluded that open-ended federal indemnification is not a viable alternative but that four approaches merit further consideration: relying on existing frameworks, limits on claims, a trust fund, and transfer of liability to the federal government (with contingencies). Efforts to improve long-term liability and stewardship frameworks led by EPA, DOE and the Department of Justice (DOJ) will continue in order to provide evaluation and recommendations in these areas by late 2011.

Additional recommendations include setting up an effort by DOE and EPA – in consultation with other agencies – to track regulatory implementation for early commercial CCS demonstration projects and consider whether additional statutory revisions are needed.

The report also encourages leveraging existing efforts among federal agencies, states, industry, and NGOs to gather information and evaluate potential key concerns about CCS in different areas of the United States and develop a comprehensive outreach strategy that would include: (1) a broad plan for public outreach targeted at the general public and decision makers; and (2) a "more focused engagement with communities that are candidates for CCS projects, to address such issues as environmental justice."

The full report can be downloaded at: www.fe.doe.gov

Book review

Developments and innovation in carbon dioxide (CO2) capture and storage technology
- Carbon dioxide (CO2) capture, transport and industrial applications (Volume 1)
- Carbon dioxide (CO2) storage and utilisation (Volume 2)

Edited by Professor Maroto-Valer, Director of the Centre for innovation in Carbon Capture and Storage at the University of Nottingham in the UK, these two volumes present a comprehensive reference resource on the current state of research, development and demonstration of CCS technologies for power plants and industry.

Those looking to gain a thorough understanding of the economics, regulation and planning of CCS projects (Volume 1) and the geological sequestration or reuse of CO2 (Volume 2) will find a wealth of information covering virtually every conceivable subject area, with a detailed index for ease of access.

Most chapters finish up with a Future Trends section looking ahead to possible work taking the subject forward. They also contain very detailed reference resources for seeking out further information.

Both volumes also open with a useful article by S. Bouzalakos and the Editor summarising the major points of the climate change argument for CO2 emissions control, the role CCS is expected to play in a CO2 reduction strategy and the current plans for deploying CCS and obstacles that must be overcome. The chapter concludes by listing general sources of further information and advice (including this magazine!)

The final section of each volume deals with more advanced or less widely known subject areas: CCS in industrial applications in Volume 1 and alternative or complementary proposals for CO2 capture or reuse in industry for Volume 2.

Each volume is available to purchase for £155 from Woodhead Publishing.
www.woodheadpublishing.com

International clean energy initiatives launched

At the world's first Clean Energy Ministerial, U.S. Energy Secretary Steven Chu announced that the U.S. is helping launch more than 10 international clean energy initiatives, including one for CCS.

www.energy.gov

The overall aim is to eliminate the need to build more than 500 mid-sized power plants world-wide in the next 20 years.

Ministers pledged to establish a Carbon Capture Use and Storage Action Group to be led by the United Kingdom and Australia to "facilitate political and business leadership and develop a Global Strategic Implementation Plan to examine how to overcome key barriers to the deployment of Carbon Capture Use and Storage (CCUS)".

The Action Group will be made up of Australia, Canada, China, France, Germany, Japan, Korea, Mexico, Norway, South Africa, the United Arab Emirates, the United Kingdom, and the United States. Business and other partners include Aker Clean Carbon, the Carbon Capture and Storage Association, the Center for American Progress, the Global Carbon Capture and Storage Institute, the International Energy Agency, Sasol, Scottish Power, Shell, the World Coal Institute, and the World Resources Institute. Additional partners are invited to get involved.

Through the Global Strategic Implementation Plan, governments, businesses, and organisations will seek to develop recommendations for the next Clean Energy Ministerial, to be held in the UK in 2012, on overcoming barriers to CCS deployment under five key themes: strategic direction, financing, use and storage, regulation, and knowledge sharing.

A number of countries have already announced new activities to progress these themes:

Use and Storage

1. The United States has announced the selection of five new projects in the third round of the Clean Coal Power Initiative program. The projects will demonstrate advanced coal technologies with carbon capture utilization and storage at commercial scale. These projects represent an investment of more than US$1.25 billion, including funds from the American Recovery and Reinvestment Act, which will be leveraged by more than US$4.5 billion in private capital cost share. When operating, the five projects will capture and sequester or beneficially reuse a total of nearly 8 million tons of CO2 per year.

2. The United States will be selecting key projects for pilot scale development for phase two of the Industrial CCS (ICCS) program, which is part of a US$1.4 billion effort to capture CO2 from industrial sources for storage or beneficial use.

3. The United States of America and Australia launched a project to examine CO2 reuse opportunities and their commercial value, which could play a transitional incentive to offset the cost of capture. This will be supported by a UK-funded study on the abatement potential of CO2 Enhanced Oil Recovery with permanent storage.

4. South Africa announced a new national storage atlas which will be published in August, which sets out a high-level storage assessment of South Africa. This will be further developed through a collaboration with the UK to map selected basins in detail.

5. The North American Carbon Atlas Partnership (NACAP), comprised of Canada, Mexico, and the United States, announced the development of an atlas of North America that identifies the major sources of CO2 and the potential geological formations available for its storage. They have agreed to compatible methodologies and identified geological basins suitable for storing CO2, and are working to ensure that the applicable information technology systems in our respective countries can be linked to provide the complete North American database.

6. The UK, Norway, and Germany announced the findings of a study on behalf of the North Sea Basin Task Force (which also includes the Netherlands), highlighting that the North Sea Basin could play a significant role in the deployment of CCS in Europe and that cross-border CO2 transport and storage would be an important factor in the North Sea Area if CCS is deployed widely from 2020.

7. The United States and Canada announced US$5.2 million in new funding for the Weyburn-Midale CO2 Monitoring and Storage Project, which will further the knowledge and research in measurement, monitoring and verification of CO2 storage in depleted oil reservoirs, and the creation of a Best Practices Manual to guide all aspects of CO2 geological storage projects in depleted oil fields worldwide.

U.S. Energy Secretary Steven Chu

Regulation

1. The Action Group acknowledged the principles developed by the IEA/CSLF in cooperation with the Global CCS Institute on CCS readiness and will consider them in developing locally appropriate guidelines.

2. The UK will support Indonesia in undertaking a study on the feasibility of designing new coal-and gas-fired units as CO2 capture-ready in Indonesia, with a report due in March 2011.

Knowledge Sharing

1. The Action Group acknowledged principles developed by the IEA/CSLF in cooperation with the GCCSI on knowledge sharing and agreed to consider how they can be taken forward as part of the Action Group.

A considerable amount of work is already underway through existing forums such as the IEA, the CSLF and the Global CCS Institute. The Action Group will complement and build on these activities and request the IEA, CSLF, and Global CCS Institute to continue to provide analysis as necessary, and to track the progress of CCS development. As part of this support, the Global CCS Institute is developing a stocktake of progress against the MEF Technology Action Plan to highlight what is already being done and identify gaps.

Paying for CCS in oil refineries

This paper addresses the seemingly separate issues of carbon capture and maximizing power generation in modern fluid catalytic crackers, and proposes a way to overcome the energy penalty for CCS.

By David McKeagan, PhD

Cat cracking is a major source of CO2 emissions from oil refineries; capture and sequestration becomes a problem if a carbon tax is imposed but could also be an opportunity when an active market trading carbon credits exists. Power generation from regenerator exhaust is a related subject because it can significantly reduce the costs of capturing carbon.

Fluid catalytic cracking has been an important part of integrated oil refineries since the 1940s. The basic concept of the process has hardly changed since then although improvements in catalyst chemistry has broadened the range of feeds which can be successfully processed and increased the flexibility in controlling product composition. Numerous hardware improvements have advanced plant reliability and throughput limits.

A number of inherent limitations must be considered in optimizing existing operations and the design of new facilities. Reactor temperature ranges from 950 to 1050°F and is typically set by refinery economics, with product yields, gasoline octane number, and catalyst costs being the principal variables. Advances in catalyst knowhow have pushed the upper limit on catalyst regeneration temperature to about 1400°F. This has allowed larger temperature differentials between reactor and regenerator and lower catalyst/oil circulation ratios. Economics favor increasing conversions and lower feed API gravity; this leads to higher coke yields which cannot always be dealt using oxygen enrichment and catalyst cooling in the regenerator. Higher conversion also leads to further reaction of primary products and lowering of the endothermic heat of reaction which would otherwise be a useful heat sink in burning off the extra coke produced.

An important innovation which adds significant flexibility in handling varying coke yields is two-stage regeneration[1]. In the first regenerator stage, coke is partially burned to carbon monoxide which generates less heat than full combustion. In the second stage the remaining coke is burned to carbon dioxide and water and regeneration is completed. The proportion of carbon removal can be varied between stages.

This approach can readily be adapted to carbon capture. Here a mixture of CO2 and O2 is used instead of air as the oxidant. In the first stage of regeneration, oxygen feed is used to control the proportion of coke burn-off. In the second stage complete burn-off can be achieved with low levels of excess O2 because of the high temperatures which are practicable without affecting catalyst activity. Heat can be recovered by traditional methods from the two regenerator off-gas streams. Once cooled to reduce the water content, the off-gas can be compressed to be recycled as regenerator diluent or further compressed for sequestration. An additional benefit can be achieved by completely oxidizing the combined off-gas to maximize the temperature and send it to a co-generation facility for power recovery.

Carbon capture will be driven in the future by imposition of a carbon tax or from opportunities to trade carbon credits. As a basis for comparison between options to deal with this, the fluid catalytic cracker proposed in study for a bitumen upgrader published by the Alberta government was selected[2]. Feed is composed of 25,500 bpsd of heavy vacuum gas oil and 49,250 bpsd of heavy coker gas oil which are combined and pretreated to reduce sulphur and nitrogen. The following conditions were assumed:

Feed Rate (bpsd)	75,300
API	19.1
Conversion (%)	80
Coke Yield (wt %)	6.3
Feed Temp. (°F)	450

Reactor and regenerator calculations followed approximately the model proposed by McKetta[3] and Nelson.[4] The heat of reaction assumed figures published by Dart and Oblad.[5]

The "base case" power output was determined as shown in Case 1 below which was a single stage regenerator using air as the oxidizing gas with the expander operating at about the regenerator outlet temperature. A flow through cooler generating 600 psi steam was assumed on the regenerator. Steam generated from the flow through cooler and the expander exhaust was superheated and sent to a steam turbine. Gas turbine calculations used the approach of Bathie[6] while efficiencies and physical limitations were determined from published figures on GE gas turbines.[7]

In Case 2 there are 2 regenerator stages using air. More air is added after leaving the regenerator in order to oxidize remaining CO to CO2. The combined gases are cleaned up in a cyclone and sent to the expander gas turbine. The net power output is not changed; however a maximum of 24% could be converted in stage 1 and still maintain the heat balance. The gas flows are so large in either case that it would not be realistic to build a single cat cracker of this throughput. The vessel size can be significantly reduced using O2 enrichment in the regenerator, as shown in Case 3 (77% conversion in stage 1). Despite the higher temperature realized at the expander, the overall power is only marginally greater since the mass flow to the expander is much reduced compared to Cases 1 and 2.

Suppose instead the cat cracker with 2 regeneration stages is designed to burn a mix of O2 and CO2 . As with O2 enriched air, increased flexibility is afforded with the ability to vary the proportion of O2 and diluent (N2 or CO2). As shown in Case 4 (70% coke conversion in stage 1), the net power output

	Case 1	Case 2	Case 3
Oxidant	air	air	air + O2
Reactor Operating Pressure (psig)	25	25	25
Regenerator stages	1	2	2
Gas Turbine Inlet (°F)	1408	1547	2582
Pure O2 (k lb/hr)			134
Air/CO2/O2 Compression Required (MW)	11.5	11.5	5.3
Gas Turbine Power (MW)	13.6	13.6	12
Steam Turbine Power (MW)	31	31	31.4
Net Power Out (MW)	33.1	33.1	38.1
Regenerator gas flow rate (kacfm)	230		
Stage 1		59	93
Stage 2		175	18

is slightly better than in Case 1 and 2. The cost of the O_2 ($10.8 MM/year) is partly balanced by the marginal electricity benefit ($3.3 MM/year at $0.08/kwh). The carbon tax penalty of Cases 1-2 ($38.9 MM/year at $50/MT) more than overcomes the O_2 cost penalty.

Additional benefits for power generation could only come from operating gas turbines at higher pressure differential, since 2600°F is the current upper operating limit. The pressure ratio between inlet and outlet should not exceed about 15, so an inlet pressure of about 300 psi is a maximum. The reactor and regenerator hydraulics would change somewhat compared to conventional pressures; however equipment would be significantly smaller. The mass and energy balances for the reactor would be essentially unchanged. An additional power generation benefit would come from expanding the reactor effluent and generating steam upstream of the product separation section. The distillation section would be considerably simplified compared to a conventional catalytic cracker. Reactor effluent would flow to a "naphtha stabilizer" running at 180-200 psig where C4s and lighter in the overhead would go to further processing. The bottoms of this tower would flow to an atmospheric tower where naphtha would be taken overhead, a diesel fraction taken as a side draw, and a heavy fraction from the bottoms would be recycled to the catalytic cracker or sent to further processing. The conditions for 72% conversion are summarized as Case 5 below.

	Case 5
Oxidant	CO_2+O_2
Catalyst/oil ratio	8.0
Reactor Operating Pressure (psig)	300
Temperature (°F)	1050
Regenerator Stage 1	
Temperature (°F)	1264
Gas rate (kacfm)	2.8
Regenerator Stage 2	
Temperature (°F)	1400
Gas rate (kacfm)	9.8
Gas Turbine Inlet (°F)	2580
O_2/CO_2 Compression Required (MW)	13.2
Gas Turbine Power (MW)	53.2
Regenerator Steam Turbine Power (MW)	19.6
Reactor Outlet Expander (MW)	4.7
Reactor Steam Turbine Power (MW)	45.4
Net Power Out (MW)	109.7

One legitimate concern about high pressure operation is the promotion of secondary reactions. Based on pilot plant data, Vermilion showed that going from 0.7 to 2.7 atmospheres hydrocarbon partial pressure increased conversion from 69.3 to 75.7% and coke yield from 7.4 to 12.4%.[8] Reducing reactor temperature and increasing catalyst/oil ratio would counteract this. Case 6 shows that the impact on overall power generation would be marginal.

The table below summarizes the economic evaluation in ($MM/year).

	Case 1 & 2	Case 3	Case 4	Case 5
	Conventional	air + O_2	CO_2+O_2	300 psi
Net Power (MW)	33.1	38.1	38.1	109.7
Less Sequestration Compression(MW)			(8.1)	(8.1)
Net Power Benefit($MM/year)	21.2	24.4	19.2	65
O_2 Cost ($MM/year)	-	-8	-10.9	-10.9
Carbon tax ($MM/year)	-38.9	-38.9	-	-
Net vs. Case 1($MM/year)	-	-22.1	47.2	93
Incremental Capital ($MM)			12.3	137.7
After Tax Payback (years)			0.5	3

This study demonstrates that a cat cracker designed to operate at about 20 atmospheres instead of the conventional maximum of about 3 atmospheres can generate enough power to overcome the cost of capturing all the CO_2 produced in regeneration.

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Policy, company and regulation news

DOE Recovery Act funding for 22 CCS projects

www.fossil.energy.gov

$575 million from the American Recovery and Reinvestment Act is being invested in a further 22 R&D projects to complement the industrial demonstration projects already being funded.

The funds will go to projects from four different areas of carbon capture and storage (CCS) research and development:

1) Large scale testing of advanced gasification technologies;

2) advanced turbo-machinery to lower emissions from industrial sources;

3) post-combustion CO_2 capture with increased efficiencies and decreased costs;

4) geologic storage site characterization.

Large Scale Testing of Advanced Gasification Technologies – $312 million

The Department is awarding $312 million from the Recovery Act for expanding three projects to accelerate the development of industrial carbon capture and storage technologies at large-scale. These projects support the Department's goal of developing industrial facilities with near-zero emissions by reducing the cost and improving the efficiency of capturing CO_2.

The projects will accelerate the technology development by conducting tests at larger prototype, engineering scales. Following successful completion, these technologies will be ready for scale-up to commercial size.

One of the projects being funded is:

- Air Products & Chemicals, Inc. (Allentown, PA) - Development of Ion Transport Membranes (ITM) Oxygen Technology for Integration with Advanced Industrial Systems

Air Products will accelerate commercial manufacture of ion transport membranes modules and initiate the development of a 2,000 tons per day (TPD) pre-commercial scale facility ahead of schedule, enabling this technology to enter the marketplace at least two years earlier than previously projected.

Advanced Turbo-Machinery to Lower Emissions from Industrial Sources – $123 million

These four projects will develop turbo-machinery and engines that will help improve carbon capture and storage when applied to industrial processes. The projects will integrate with carbon capture in industrial-based systems to optimize CCS.

One of the projects being funded is:

- Ramgen Power Systems (Bellevue, WA) - Ramgen Supersonic Shock Wave Compression and Engine Technology

This additional project expansion will focus on incorporating the supersonic compression technology into an engine. By following a dual track development on the compressor for applications of CO_2 compression only and incorporation into an engine that can run with oxygen and fuel, producing a high concentration of CO_2 for subsequent supersonic compression, the technology risk is greatly reduced leading to a higher potential of success for the base compressor design and its ability to be used in industrial CCS applications. This project will receive $30 million in funding.

Post-Combustion CO2 Capture with Increased Efficiencies and Decreased Costs – $90 million

Five projects will develop technologies for carbon dioxide capture for industrial systems and also application to power plants. These projects will advance state-of-the-art CO_2 capture technologies with increased efficiencies and decreased costs that can be applied as part of an integrated carbon capture and storage system.

The Department is developing these advanced CO_2 capture technologies to ensure that CCS can be an affordable and efficient greenhouse gas emission mitigation strategy for both the industrial and utility sectors.

One of the projects being funded is:

- Membrane Technology and Research, Inc. (Menlo Park, CA) - Pilot Testing of a Membrane System for Post-Combustion CO_2 Capture

Membrane Technology and Research (MTR) and partners will demonstrate a membrane process to separate CO_2 from industrial- and utility-scale processes including boilers, cement manufacturing, steel and aluminum production and chemical refining.

MTR will design, construct and test a 1 MWe equivalent gas flow membrane skid capable of 90 percent CO_2 capture from a slipstream of coal-fired flue gas. A six-month field test using the test skid will be conducted at Arizona Public Service's (APS) Cholla Power Plant. Additionally, a small slipstream test will be performed at the National Carbon Capture Center to validate membrane performance.

Geologic Storage Site Characterization – $50 million

The 10 projects previously selected under ARRA funding will be expanded to increase the scientific understanding and locations of geologic formations for safe and permanent carbon dioxide storage from industrial sources.

Projects in this category will collect data to determine the potential to store large volumes of CO_2 in geologic formations; provide support to augment the National Carbon Sequestration (NATCARB) database through support of state geologic surveys and other research institutions; and participate in technical working groups on best practices for site characterization and approving storage site selection.

One of the projects being funded is:

- University of Texas at Austin (Austin, TX) - Gulf of Mexico Miocene CO_2 Site Characterization Mega Transect

The University of Texas at Austin will conduct a regional evaluation of storage opportunities in Miocene aged formations with a focus on specific reservoirs once identified. The project will lease currently available regional 3D seismic data and acquire a new seismic acquisition system (P-Cable) that is optimized for ultra-high resolution 3D and 4D seismic imaging of shallow and mid-range depths to allow detection of shallow structural features.

Both types of data will help to develop baseline assessments of the target formations to measure and monitor their characteristics and validate them for future industrial CCS injection operations. This project will receive $5 million in funding.

China joins Global CCS Institute

www.globalccsinstitute.com

China's lead governmental body responsible for industrial sector policy development and management, including CCS, has become a legal member of the Global CCS Institute.

"China's commitment to the Institute and to CCS is an important step in the right direction towards cleaner energy and working to curb global greenhouse gas emissions," said Dale Seymour, Vice President for Strategy at the Institute. "Our initial engagement with China through the National Development and Reform Commission has been very positive and sets the tone for increased collaboration with government and industry along a clean energy agenda."

China is the latest of a vast majority of G20 governments as well as large industry players and global financial institutions to become an Institute member.

Members can help shape the organisation's strategic direction through participation in meetings, working groups and sharing knowledge, information and expertise that can facilitate the commercial deployment of CCS.

CO2CRC carbon capture projects extended

www.co2crc.com.au

\$855,000 in additional funding has been awarded for two carbon dioxide capture projects developed by the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) in Australia.

The projects were two of five to receive funding from Brown Coal Innovation Australia (BCIA), under the Victorian Government's Energy Technology Innovation Strategy (ETIS). They are researching cost-effective ways to capture carbon dioxide from large industrial sources such as power stations.

"BCIA's extension funding will allow us to collect more valuable real-world data on these technologies, as well as supporting our highly skilled research teams from the University of Melbourne, Monash University and the University of New South Wales," said Professor Dianne Wiley, CO2CRC Capture Program Manager.

The CO2CRC/HRL Mulgrave Capture Project is researching pre-combustion carbon capture from a stream of syngas at HRL Developments Pty Ltd research gasifier.

The CO2CRC H3 Capture Project is investigating ways to improve post-combustion carbon capture from Hazelwood power station as part of the Latrobe Valley post-combustion capture (LVPCC) project.

The projects are trialling three technologies, solvents, membranes and adsorbents, in order to find the most effective and economic for application to Victorian brown coal.

Vacuum swing adsorption is one of three carbon dioxide separation technologies being evaluated through the CO2CRC H3 Capture Project. (Image: CO2CRC)

DOE launches Carbon Capture and Storage Simulation Initiative

U.S. Secretary of Energy Steven Chu has announced the creation of the Carbon Capture and Storage Simulation Initiative with an investment of up to \$40 million from the American Recovery and Reinvestment Act.

The National Energy Technology Laboratory (NETL) and NETL's Regional University Alliance (Carnegie Mellon University, Penn State University, University of Pittsburgh, Virginia Tech, and West Virginia University) are partnering with Lawrence Berkeley National Lab, Los Alamos National Lab, Pacific Northwest National Lab, and Lawrence Livermore National Lab to develop validated, predictive simulation tools to accelerate the development and deployment of industrial CCS technology.

The initiative will develop:

(1) a comprehensive, integrated suite of validated computational models for accelerating CO2 capture technology development and deployment

(2) a defensible, science-based methodology and tools that can be used to quantify residual risk and long-term liability at CO2 storage sites post-closure.

Using advanced modeling and simulation, researchers will develop science-based methods aimed at lowering the cost of carbon capture while reducing risks associated with its storage. This will build upon the efforts of DOE's National Risk Assessment Partnership (NRAP). The CCS Simulation Initiative will allow NRAP to accelerate the development of a defensible, science-based methodology for quantifying and minimizing potential risks associated with long-term storage of CO2.

Summit Power begins FEED study for Texas IGCC-CCS project

texascleanenergyproject.com

The Summit Power Group has launched a pre-construction FEED study for its Texas Clean Energy Project (TCEP), located in Penwell, Texas.

The FEED team formally launched the study on June 30, 2010 and construction is currently scheduled to begin on the project in the second half of 2011 upon completion of the FEED study.The

Texas Clean Energy Project will be a first-of-its-kind integrated gasification combined cycle (IGCC) 400 MW power/polygen plant sited in West Texas's Permian Basin.

Participants in the Texas Clean Energy Project FEED study include Siemens Energy Inc., Fluor Corporation, and Selas Fluid Processing Corporation, a Linde Group subsidiary. Siemens is the primary equipment provider for the project's gasifiers, power island and controls, and will also supply O&M services for the facility.

Fluor Corporation, based in Irving, Texas, is the project's design engineer. Linde will be designing and costing the handling of the synthesis gas, produced by the Siemens gasifiers.

The project is intended as a model for carbon capture projects elsewhere in the U.S. and abroad, the company said. The project has already received a \$350M award, including funds from the American Recovery and Reinvestment Act, from the DOE Clean Coal Power Initiative (CCPI) – Round 3 to demonstrate the commercial integration of large-scale IGCC with CO2 capture and geologic storage.

Summit said it chose Texas for its project due to the strong commitment of state and local elected officials, who believe that the state's unique and longstanding experience in carbon sequestration – thanks to federally supported work by the University of Texas Bureau of Economic Geology (BEG) and 30 years experience importing natural CO2 into the Permian Basin from surrounding states for enhanced oil recovery (EOR) – positions it as the national leader for carbon capture and sequestration.

Because of the opportunity to earn revenue from CO2 for EOR, Texas is a particularly attractive site for these types of projects. Salt Lake City-based Blue Source, a leading emissions reduction project developer, will market the nearly 3 million tons of CO2 that The Texas Clean Energy Project will capture annually.

£5M from Scottish Power for UK CCS Alliance

www.scottishpower.com

ScottishPower has announced its sponsorship of the UK's first alliance between industry and academia to focus specifically on carbon capture and storage (CCS), the ScottishPower Academic Alliance (SPAA).

SPAA has been designed to match the needs of the UK's fast developing CCS industry with the research capacity of some of the country's leading academics from Imperial College London and the University of Edinburgh. It will focus specifically on technical innovation around the capture and offshore storage of CO2, the policy and regulatory aspects of CCS and look at what the UK needs to do to capitalise on the commercial opportunities the technology offers – especially in developing a national skills capacity.

ScottishPower is investing almost GBP5 million over the next five years which will fund up to 12 full-time researchers working at University of Edinburgh and Imperial College London. ScottishPower will seek to leverage this funding through further contributions from Government and international sponsors which it hopes will consolidate the UK's growing reputation as a centre of excellence for this embryonic industry.

Nick Horler, ScottishPower's Chief Executive, said: "This is a terrific step forward for ScottishPower and will help us in our ambitions to make CCS a reality in the UK by 2014."

Professor Stuart Haszeldine, ScottishPower Chair of CCS at University of Edinburgh, said: "Developing a CCS industry in the UK will capitalise on our established offshore and engineering expertise and make a significant contribution to the economy of the country, creating new jobs and skills. I am pleased to be building on the CCS research results the University of Edinburgh has already achieved with ScottishPower, and to welcome Imperial College London as partners. The expertise of all three organisations will help to maintain the UK's leading position in CCS."

Bellona holds CCS roundtable in Budapest

www.bellona.org

A roundtable event on CO2 capture and storage (CCS) deployment in Hungary was held on June 21 in Budapest, reports Tristan Azbej from Bellona.

More than 30 participants representing governmental departments, major power companies, environmental NGOs and research institutions gathered to discuss essential issues such as CCS safety, long-term responsibility, and economic efficiency.

The meeting was hosted by the British Embassy and co-organised by Bellona and Hungarian environmental NGO Energia Klub.

Four keynote discussions were held. Eivind Hoff, director of Bellona Europa, presented the 'Bellona Scenario' and shared his thoughts on the role of CCS as one of the range of emission reduction solutions (which also include lifestyle change, energy efficiency, use of renewable energy sources and land-use change). The Bellona Scenario suggests that while there is no single solution for reaching a carbon neutral economy, CCS and carbon negative energy could contribute with 30% emission cut to long-term climate mitigation targets.

Péter Kardos, climate change expert from Energia Klub, summarized some of the key unanswered concerns related to CCS deployment. Amongst these issues are the boundary costs of emission reduction by CCS compared to that of other climate mitigation tools, and the length of the time period during which abated coal will be competitive with renewable energy production.

Chris Littlecott, from NGO Green Alliance, offered insight into the UK's CCS policy and argued that CCS was pivotal to a sustainable energy future. György Falus, from Eötvös Loránd Geophysical Institute, contributed by discussing the state of CCS in Hungary in terms of its geological settings, technological background and readily available expertise and data.

Hungarian utilities MVM Hungarian Power Co., MOL Hungarian Oil Co., Mátra Power Plant Co. and research centre Eötvös Loránd Geophysical Institute confirmed that they have formed a consortium that is currently assessing the options for CCS deployment at Hungary's largest lignite-fired power plant. The project is currently at the stag of carrying out pre-feasibility studies and mapping external funding opportunities.

In the debate that ensued the competitiveness of abated coal versus renewable energy sources was further discussed, together with the importance of abatement cost calculations. Most of the attendees agreed on the manageable nature of the technical risks related to CCS. Concern was nevertheless expressed regarding long-term liability issues linked to CCS.

The project consortium recognised the great expertise and experience gained throughout decades of Enhanced Oil Recovery (EOR) operations in Hungary. Towards the conclusion of the roundtable discussions, attendees agreed it was important to participate in the EU 'New Entrants Reserve 300' programme – the so-called NER300 – in order to secure funds for the CCS and renewable energy demonstration projects in Hungary.

Carbon Management Canada issues call for research proposals

www.carbonmanagement.ca

Proposals are invited from researchers working in or with Canadian organisations in the field of greenhouse gas control in fossil fuel use.

Carbon Management Canada (CMC) is a not-for-profit corporation, funded substantially by the Canadian Government Networks of Centers of Excellence (NCE) program, the Government of Alberta and by industry. The mandate of CMC is to promote and support research by Canadian academic and research organisations into carbon management in the extraction and use of fossil fuels.

Research is focused on five major objectives:

- Creation of carbon-efficient oil, gas and coal recovery, processing and use technologies (CERP);
- Design of technologies, protocols and tools for safe, secure, and verifiable carbon storage;
- Reduction in the cost of carbon capture and storage (CCS) through innovative solutions;
- Analysis of risks, business and regulatory options to inform policy and investment, engage the public, and develop the supportive frameworks necessary to develop and deploy viable technologies at appropriate scale to decarbonise fossil fuel use;
- Facilitating and accelerating social and technical innovation processes across industry, academia and government in the areas of fossil fuel carbon management.

Research proposals are invited for innovative ambitious research to make a real impact on greenhouse gas emissions in fossil fuel recovery and use and specifically to:

- Create carbon-efficient recovery, processing and use technologies (CERP) that are dramatically more carbon efficient than current systems;
- Reduce the cost of carbon capture and storage (CCS) and seek novel carbon capture and storage routes including biological, geochemical and air capture approaches with the potential use of novel carbon storage vectors in addition to carbon dioxide;
- Design protocols and tools for safe, secure and quantitatively verifiable carbon storage;
- Develop business and regulatory options to enable deployment of publicly ac-

ceptable technologies at large scale;

- Inform policy and investment, engage the public, and develop the supportive social, legal and political frameworks necessary to permit deployment of effective carbon mitigation technologies at appropriately large scale to substantially mitigate emissions from fossil fuel recovery and use;

- Bring into the fossil fuel energy recovery and carbon management sectors technical and policy advances in innovative sectors of our scientific, technical and social revolution, including but not limited to, natural and synthetic biology, nanotechnology, artificial intelligence and robotics, highly networked computing, social networked innovation and internet science.

The completed proposal form must be signed by all applicants and received by CMC by the end of the day on October 22, 2010.

Scottish and Southern Energy and Mitsubishi cooperate on CCS

www.scottish-southern.co.uk

Mitsubishi (Mitsubishi Heavy Industries Ltd and Mitsubishi Power Systems Europe Ltd) and SSE (Scottish and Southern Energy plc) have entered into a strategic agreement to co-operate on low carbon energy developments.

The agreement will enable the partners to explore a range of technologies including offshore wind farms, advanced technology for smart electricity grids and low carbon vehicles, carbon capture and storage and high-efficiency power generation.

Mitsubishi and SSE are working together to become strategic partners in low carbon electricity production and management and in low carbon transport technology. They hope to establish joint development projects, ventures, investments and supply arrangements through this agreement.

SSE established a Centre of Engineering Excellence in Renewable Energy in partnership with the University of Strathclyde in 2009, with over 300 skilled professional jobs to be created by SSE over three years.

The agreement with Mitsubishi will build on this, and is expected to lead to up to 100 additional new, highly-skilled, engineering-based jobs being created at the Centre. Employment at the Centre is expected to grow further, as other suppliers of services and products related to offshore wind energy development and other partners join SSE and Mitsubishi in locating engineering-related jobs there. It is on course to reach around 1,000 jobs over the next five years, the company said.

Great Plains Synfuels Plant (left) and where CO2 emerges at Weyburn 200 miles away (right)

Subject to the progress of the agreement, SSE and Mitsubishi intend to focus on, in the first instance, the delivery of renewable energy from offshore sites and the deployment of low carbon vehicles.

U.S. and Canada renew funding for Weyburn-Midale project

www.fossil.energy.gov

The U.S. Department of Energy (DOE) and Natural Resources Canada have committed $5.2 million to enable the CO2 storage project to conclude in 2011.

Natural Resources Canada (NRCan) and DOE will partner to renew funding for the International Energy Agency (IEA) Greenhouse Gas Weyburn-Midale CO2 Monitoring and Storage project.

The money will allow the project's final phase to focus on best practices for the safe and permanent storage of CO2 with enhanced oil recovery (EOR). DOE is providing $3 million in funding and the Government of Canada has committed $2.2 million.

Weyburn-Midale is conducted in conjunction with $2 billion of commercial CO2 injection operations, which have so far stored 18 million tonnes of CO2 into the Weyburn and Midale oil fields in Saskatchewan, Canada.

Launched in 2000 by the Government of Canada, the Government of Saskatchewan, Cenovus Energy (formerly called Pan Canadian Petroleum and later EnCana) and the Petroleum Technology Research Centre in Regina, Saskatchewan, Weyburn-Midale studies the geologic storage of CO2 in conjunction with EOR.

In the United States, CO2 injection has already helped recover nearly 1.5 billion barrels of oil from mature oil fields, yet the technology has not been deployed widely. It is estimated that a further 400 billion barrels of oil could be potentially recoverable through EOR.

By injecting CO2 roughly 5,000 feet (1,500 meters) underground, operators at the Weyburn and Midale fields are able to force some of the remaining oil into wells where it is harvested, nearly tripling oil production. CO2 for injection comes from the Dakota Gasification Company's synfuels plant in Beulah, N.D. and is delivered via a 200-mile (320-kilometer) pipeline.

A projected 40 million tonnes of CO2 will be stored over the life of the EOR operations in the Weyburn and Midale oil fields. For the Weyburn oil field, 155 million additional barrels of oil are expected to be recovered by 2035 while storing 30 million tonnes of CO2 over the next 30 years. The adjacent Midale oil field is projected to store 10 million tonnes of CO2 while yielding an additional 60 million barrels of oil during 30 years of operation. In the two fields, the CO2 stored will be equal to taking nearly 9 million cars off the road for an entire year.

Weyburn-Midale represents the largest full-scale CCS field study ever conducted and has resulted in pioneering research, including studying the mile-deep seals that securely contain the CO2 reservoir, predicting the CO2 plume movement, and monitoring permanent storage.

Demonstrating CCS technologies is a top priority of President Obama's U.S.-Canada Clean Energy Dialogue. The Weyburn-Midale project – part of a multinational effort involving both public and private entities, including a U.S.-Canadian research team – is playing an important role by helping advance the science of large-scale CCS technology.

The project has attracted 16 sponsors from government and industry that, aside from DOE and NRCan, include IEA, Alberta Innovates, Saskatchewan Ministry of Energy and Resources, Japan's Research Institute of Innovative Technology for the Earth, and 10 industry sponsors from Canada, the United States, the Middle East, and Europe.

Carbon capture through biochar in soils

The School of GeoSciences, University of Edinburgh, has broadened the scope of its research, with research into carbon capture and storage as biochar in soils. The UK Biochar Research Centre (UKBRC) is a partnership involving the University of Edinburgh, Newcastle and Rothamsted Research.

Biochar is defined as the black carbon material produced from the thermal decomposition of biomass in a low or zero oxygen environment (i.e. pyrolysis or gasification). When biomass is converted to biochar, it is much more stable than uncharred organic matter, having a potential soil residence time in the order of thousands of years. Consequently, biochar is considered a method of long term storage of carbon in soils.

Importantly, the addition of biochar to soils can bring many potential co-benefits. Biochar incorporation can act as a soil enhancer, improving agricultural productivity, particularly in low-fertility and degraded soils. It can improve soil water and nutrient holding capacity, which means less dependence on artificial fertilizers.

The production of biochar via pyrolysis or gasification also means the production of bioenergy as electricity and/or heat, which can be translated as further potential for carbon abatement from avoided fossil fuel use. This combination of factors means that biochar has been labeled as carbon negative mitigation technology by many.

Interest in the benefits of adding biochar to soils has arisen through studies of terra preta (Portuguese for dark earth) soils found in the central Amazon basin, where soils amended with, among other things, charred animal and plant remains, show much higher fertility and more water and nutrient retention than adjacent soils.

Subsequent studies have shown that addition of biochar can increase crop yield, on average by 10% but more in the case of addition to very poor depleted tropical soils. Application of biochar to agricultural soils could therefore decrease dependency on fertilizers. There is also emerging evidence that biochar can suppress emissions of methane and nitrous oxide from soils, in addition to reducing nitrate leaching (a major problem in heavily fertilized agricultural regions).

Although biochar has huge potential for carbon sequestration, there remain many uncertainties regarding its long-term storage, and how to control production conditions to maximize specific properties. Current research has shown that biochar soil residence time differs with different biochar and soil types. It is also important to fully understand how it enhances soil quality. According to a recent study, biochar could offset 1.8 billion tonnes of annual carbon emissions by its most optimistic scenario without endangering food security, habitat or soil conservation. This would equate to a potential 12% of global greenhouse gas emissions that could be offset by the use of biochar.

A range of biochar samples

Biochar research is still in its infancy and the 15-person strong UKBRC team based at the University of Edinburgh is tackling these fundamental questions. The UKBRC has recently published the first UK report[1] on biochar for DEFRA and DECC which outlines the potential benefits and uncertainties.

Current research is focused on the soil science for biochar (i.e. biochar-soil-plant interactions, as well as understanding the longevity and nutrient value of biochar), systems and policy analysis (Life Cycle Assessment, techno-economic modeling, spatial analysis and land-use modeling, policy development, etc.) and engineering assessment (i.e. understanding the production conditions of biochar and scale-up of technology).

1. DEFRA and DECC, 2010, Review of the Potential Benefits, Costs and Issues Surrounding the addition of Biochar to Soil: An Expert Elicitation Approach

The centre was opened in early 2009, and now has its own dedicated laboratories and equipment that can produce varying amounts of specific biochar from different feedstocks, under highly controlled conditions. Three facilities are available for producing biochar (capacity ranges from 10g to 100kg per day) and we welcome enquiries regarding provision of biochar for research and deployment in field trials.

More information

For further information, please visit www.biochar.org.uk or contact Dr Ondrej Masek (ondrej.masek@ed.ac.uk).

Scottish Carbon Capture and Storage (SCCS) is the largest carbon storage group in the UK, comprising more than 65 researchers, at the University of Edinburgh, Heriot-Watt University and the British Geological Survey. Consortium membership includes a wide range of industries and businesses, and helps to sponsor PhD research and MSc training. SCCS is unique in its connected strength across the full CCS chain and unique in its biochar capability.

www.sccs.org.uk

Capture news

RWE, BASF and Linde claim flue gas CO2 capture 'breakthrough'

www.rwe.com

The companies claim new technology saves 20 percent on energy input and clearly reduces solvent consumption.

Since 2009 RWE, Linde and BASF have been testing a new technology for separating CO2 from flue gas in a pilot plant at RWE's Niederaussem power station near Cologne. The results of the practical test are now available: compared to processes commonly run today, the new chemical solvents can reduce energy input by about 20 percent and have clearly superior oxygen stability, which reduces solvent consumption significantly.

The pilot plant is part of the Coal Innovation Center of RWE Power. BASF is testing the newly developed solvents while Linde was responsible for pilot plant engineering and construction.

Now the partners are working on solutions for demonstration and large-scale power plants. RWE Power will spend about nine million euros in total while the German Federal Ministry of Economics and Technology contributed about four million euros to the cost of the pilot plant.

RWE's Niederaussem power station near Cologne, the site of the Coal Innovation Center

Funding for 6 DOE projects for CO2 reuse

fossil.energy.gov

$106 million from the American Recovery and Reinvestment Act is being invested in projects to find ways of converting captured CO2 emissions from industrial sources into useful products such as fuel, plastics, cement, and fertilizers.

The funding will be matched with $156 million in private cost-share investment.

The projects were initially selected for a first phase funding in October 2009 as part of a $1.4 billion effort to capture CO2 from industrial sources for storage or beneficial use. Over the succeeding months, the project teams have performed experiments on innovative concepts and produced preliminary designs for pilot plants to study the feasibility of capturing and using CO2 exhausted from industrial processes. The selected projects now enter a second phase in which researchers design, construct, and operate their innovations at pilot-scale and evaluate the technical and economic feasibility of applying them commercially.

The projects selected to demonstrate the beneficial use of CO2 include:

- Alcoa, Inc. (Alcoa Center, Pa.) Alcoa's pilot-scale process will demonstrate the high efficiency conversion of flue gas CO2 into soluble bicarbonate and carbonate using an in-duct scrubber system featuring an enzyme catalyst.

- Novomer Inc. (Ithaca, N.Y.) Teaming with Albemarle Corporation and the Eastman Kodak Co., Novomer will develop a process for converting waste CO2 into a number of polycarbonate products (plastics) for use in the packaging industry.

- Touchstone Research Laboratory Ltd. (Triadelphia, W. Va.) This project will pilot-test an open-pond algae production technology that can capture at least 60 percent of flue gas CO2 from an industrial coal-fired source to produce biofuel and other high value co-products.

- Phycal, LLC (Highland Heights, Ohio) Phycal will complete development of an integrated system designed to produce liquid biocrude fuel from microalgae cultivated with captured CO2.

- Skyonic Corporation (Austin, Texas) Skyonic Corporation will continue the development of SkyMine mineralization technology—a potential replacement for existing scrubber technology.

- Calera Corporation (Los Gatos, Calif.) Calera Corporation is developing a process that directly mineralizes CO2 in flue gas to carbonates that can be converted into useful construction materials.

Pre-combustion process 'saves 30-40% energy'

www.arnoldkeller.com

London Management, Inc. has a US patent pending for pre-combustion CO2 capture from a gas which it claims could use up to 40% less energy than existing processes.

The new process results in a pure stream of CO2 pressurized to supercritical pipeline pressure and a pressurized hydrogen gas stream, suitable for blending with nitrogen and combusting in a gas turbine, used in a combined cycle process.

Company President Arnold Keller has developed this new CO2 capture process as the result of an extensive review and examination of the state of the art CO2 capture processes, commonly employed today, following coal/coke gasification, and CO-shift reaction. Keller realized there was an opportunity to make significant improvements not disclosed by larger competitors.

The new CO2 capture process will achieve significant cost reduction in both CAPEX and OPEX, compared to current state of the art technology, Mr. Keller claims.

One of the features of the process is that it requires only equipment that is available in the market place today from multiple vendors, and will not require any new R&D effort to develop new technology, such as new solvents, new catalysts, or new techniques.

"In comparison to the state of the art process, the new process is designed to better integrate the processing steps downstream from the gasifier, all the way to the delivery of supercritical CO2 to the battery limits of the CO2 pipeline, and also the high pressure hydrogen stream used to fuel the gas turbine," said Mr. Keller.

"The significance of this feature is that the design can be independently confirmed, and that the new process is fundable by banks or by investors. This is because the technology is based on existing, proven technology, assembled in a more cost effective processing sequence, compared to how other organizations are doing it today. The process assembles existing known technology, in which, each element of the process is commercially demonstrated. It is the manner of the sequence and the integration of the process which will be covered by the patent."

Prospective clients are invited to evaluate the process under a Non Disclosure Agreement (NDA).

Preliminary design simulations of the new CO2 capture process have identified over 30–40% savings in parasitic power consumption of the total power needed for combined CO2 capture and compression. The new process was compared to the DOE/NETL benchmark publication regarding IGCC with carbon capture and sequestration. {Ref: Cost and Performance Baseline for Fossil Energy Plants - DOE/NETL 2007/1281. - Volume 1: Bituminous Coal and Natural Gas to Electricity Final Report (Original Issue Date, May 2007) Revision 1, August 2007}.

Mr. Keller said that he is currently seeking independent organizations which are capable of quantifying the CAPEX savings and will independently verify the energy savings. These organizations will have full access to the process technology through a NDA.

Process Group receives contract for "multi-solvent" CO2 capture system

www.processgroup.com.au

Process Group Pty Ltd, based in Australia, has been awarded the contract for the design and engineering for CO2 capture at the QER Shale to Liquids Project.

The plant will capture carbon dioxide from syngas associated with the QER Shale to Liquids Project with the aim of developing low carbon footprint shale oil technology.

Process Group has been awarded Phase 2 of the contract which is for the detailed design of the carbon capture plant including provision of a fixed price to complete the plant construction.

The contract is based on the use of solvent based carbon capture technology and includes the requirement for the provision of a "Multi-Solvent" Design. That is, a plant which can operate with a number of commercial carbon capture solvents.

The plant will demonstrate two new generation carbon capture solvents. Process Group has joined forces with Siemens to demonstrate the POSTCAP solvent as well as the CO2CRC Uno process.

The plant will also be the world first pilot demonstration of the WES Froth Absorber Technology developed by WES LLC. This technology uses micro froth matrix technology to reduce the packed height of the carbon dioxide absorber by more than 50%.

"Solvent technology for carbon capture is rapidly evolving," said Process Group's Managing Director Mr Craig Dugan. "It seems new solvents are coming into the marketplace every six months. Offering a plant which can operate with a number of solvents provides customers with assurance they can access new solvent technologies as they are developed. Process Group is unique in this area in that it is not tied to any one solvent technology."

The ability to test these solvents using conventional absorber technology and the new WES Froth Absorber technology will enable QER to minimise the potential cost of future large scale CCS for the project.

As this is the first field demonstration of the WES technology, the company is expecting considerable international interest in the trial outcomes.

Process Group and WES believe the WES absorber technology offers potential to reduce the cost of CCS by up to 30% through dramatic reductions in absorber size and by facilitating higher solvent CO2 loadings.

Carbon storage using salt compounds research update

www.uq.edu.au

A new study by Sirius Exploration and the University of Queensland demonstrates how salt and potash mines could help to prevent CO2 from entering the atmosphere.

The organisations have completed a nine month proof-of-concept study exploring the method which converts salt and CO2 into sodium carbonates (e.g. bi-carbonate of soda) which can be safely stored in empty underground mine caverns preventing that CO2 from entering the atmosphere.

Key points of the study are:

* Potash and nickel processing can be enhanced to provide a long-term storage solution for CO2 emissions;

* for potash processing, the energy requirements can be met by the heat already present in the salt brine; and

* the output includes clean water that can be recycled back to the mine, improving the overall water consumption of the mine.

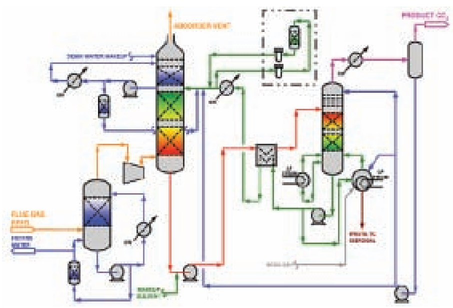
Sirius and the University of Queensland designed this technology to work in conjunction with potash solution mining. Besides providing a long-term storage solution for CO2, an attractive feature of this new process is that it finds a use for the sodium rich salt solution generated from the solution mining of potash, providing both a storage solution for sodium and clean water that can be reused back down into the cavern.

In addition to potash brines, a variant on the process using magnesium silicate ore, common to nickel mining, was explored and demonstrated.

Further details cannot be released at this stage pending a review by the parties of possible patent applications.

Tenaska chooses Fluor carbon capture technology

Tenaska has chosen Fluor Corporation's Econamine FG Plus carbon capture technology for use in its proposed Tenaska Trailblazer Energy Center, being developed near Sweetwater, Texas.



Fluor Corporation's Econamine FG Plus process

Trailblazer will be a 600-megawatt (net) electricity generating plant fueled by pulverized coal and is expected to be among the first full-scale commercial power plants in the nation, and the first in Texas, to capture 85 to 90 percent of its CO2 emissions and send them via pipeline to the Permian Basin to be used in enhanced oil recovery.

Based on the projected rate of capture, the plant will emit significantly less CO2 than an equivalent capacity natural gas-fueled plant.

Econamine FG Plus is a Fluor proprietary, amine-based technology for large-scale, post-combustion CO2 capture. The technology is one of the first and among the most widely applied commercial solutions proven in operating environments to remove CO2 from high-oxygen content flue gases.

Tenaska's initial design and engineering work for Trailblazer is also being performed by Fluor, the project's engineering, procurement and construction contractor.

British Geological Survey - providing sub-surface expertise

Scottish Carbon Capture and Storage (SCCS) is the largest carbon capture and storage grouping in the UK. The 3 core partner organisations are the University of Edinburgh, Heriot-Watt University and the British Geological Survey (BGS). BGS is a key member of SCCS, bringing a wealth of sub-surface knowledge.

The British Geological Survey (BGS) is the UK's principal supplier of objective, impartial and up-to-date geological expertise. It houses the National Geoscience Data Centre and is a European centre of excellence for the study of underground CO2. BGS in Edinburgh is a key member of Scottish Carbon Capture and Storage.

Expertise and capacity

BGS has played a leading role in the field of underground CO2 storage since the early 1990s and has provided a lead author to the IPCC Special Report on CCS. In the last two years BGS has carried out more than 40 CO2 storage projects for the EU, industry and the UK and overseas governments including the first assessment for geological CO2 storage for the whole of Ireland and evaluating the potential for geological storage of carbon dioxide in north-east China with Chinese and European partners.

BGS is active in a number of research areas including:

- character and capacity of potential underground storage reservoirs;
- potential chemical interactions of injected CO2 with the surrounding rocks;
- site performance prediction via flow modelling and history-matching;
- integrated interpretation and modelling of time-lapse monitoring datasets;
- storage site monitoring methodologies and integrated monitoring strategies;
- assessment of long-term site performance including evaluating potential ecological impacts of leakage.

Developing a suitable regulatory framework for CO2 storage is a high priority, and BGS has a key advisory role, providing expert technical advice to policymakers and regulators in the UK, Europe and Australia. BGS also undertake expert peer-reviews for international CCS demonstration projects on behalf of governments or industrial project consortia including the UK competition to build the first 'full chain' CCS system, where they are acting as technical advisors to the UK Government Department of Energy and Climate Change in the bid evaluation process.

BGS measuring surface gas flux at the CO2 injection site at In Salah, Algeria (Image ©British Geological Survey)

BGS is a key contributor to European CCS research as co-ordinator of the RISCS project and CO2GeoNet and partner in many major collaborative ventures such as CO2STORE, CASTOR, Dynamis, GeoCapacity and CO2ReMoVe projects. In 2008 BGS co-ordinated and produced the CO2STORE Best Practice Manual for the Storage of CO2 in Saline Aquifers.

SCCS research projects

Within the SCCS BGS has contributed: knowledge in many aspects of UK onshore and offshore geology; established skills and expertise in the interpretation of geological datasets and 3D structural geological modelling; and project leadership and management.

CASSEM project: appraisal and selection of sites, geological interpretation and modelling, analysis and interpretation of saline aquifer mineralogy for two potential UK storage sites, assessment of possible impacts on potable aquifers and interpretation and benefit of reprocessing old seismic data.

Scottish CCS Joint Study: by leadership of multi-contractor research, assessment of CO2 sources in Scotland and northern England, collation and screening of hydrocarbon field and saline aquifer store sites in Scotland, review of regulatory regime for CCS, compilation and presentation of summary publicly available report.

Scottish CCTS Development Study: as consortium leader, appraisal of candidate areas for selection of a key site for saline aquifer research, mapping and 3D geological modelling also appraisal of seabed conditions and safety case at selected site, compilation and presentation of summary publicly available report.

More information

For further information, please visit www.bgs.ac.uk or www.sccs.org.uk

Risk management: methodology compliant with ISO 31000 standard for CO2 storage

Risk Management is one of the key aspects of regulations slowly being put in place worldwide to allow CO2 injection and storage in geological reservoirs. Methodological developments are underway to respond to authorities demands, but Risk Management must also be considered as a tool for improving project performance regarding issues such as cost, time, H&S and environment.

By Stéphanie DIAS, consultant engineer in risk management, OXAND, France

Risk management must be viewed as essential for CO2 storage projects and can serve both operator and authorities' needs as its main principles are:

– To contribute to the achievement of the project's global objectives (regarding, for example, health and safety, environment, investments) and the improvement of project performance,

– To support decision making for risk treatment and definition of MVA (monitoring - verification - accounting) program: define priority among treatment actions and justify the choices,

– To provide the authorities with proof of project compliance with regulation, and

– To provide consistent, comparable and reliable results of risk evaluation on the basis of a transparent and structured methodology.

The risk is the combination of (i) the severity (or the impact) of a threat on the project objectives and (ii) the likelihood of occurrence of this threat. It is important to note that risk doesn't necessarily have a negative impact, therefore, even if risks are identified, it doesn't mean that the project is endangered, neither that certain actions have to be carried out. Risks can be considered in terms of their potential impacts on project objectives both at the organizational level (e.g. respect delay and cost) and at the technical level (e.g. ensure confinement of the storage complex, ensure integrity of casings).

The risk management process aims at:

– Identifying and evaluating all the risks that could impact project objectives;

– Establishing treatment and monitoring actions or plans to reduce the severity and/or the likelihood of risks and strengthen project performance; and

– Ensuring that defined actions are properly carried out, and that risk levels are under control.

CO2 storage remains a new challenge; thus very few results from experience are available to test and strengthen current risk methodology compared to other industrial activities, particularly for saline aquifers that have not been greatly considered by the petroleum industry so far.

The risk-based process proposed by OXAND is in compliance with the international Risk Management standards ISO 31000 coming from the International Organisation for Standardization ([1]). The process is presented in Figure 1 and detailed in next sections.

The methodology has already been applied to several demonstration projects. This methodology is in particular being applied within the MUSTANG[1] project, which received funding from the European Community's Seventh Framework Program[2]. This project launched in June 2009 aims at developing methods and models for the characterization of deep saline aquifers for a long term CO2 storage based on a solid scientific understanding of the underlying critical processes.

Within this project, OXAND is work package leader for the development and application of a risk-based approach for the qualification of CO2 storage sites to ultimately provide guidelines for further industrial storage projects. Several experimental sites are studied within the MUSTANG project.

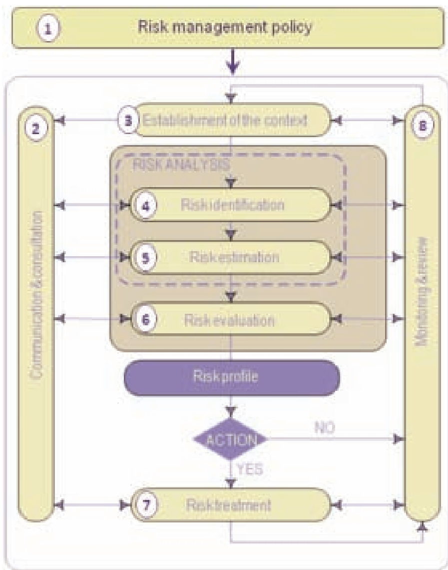


Figure 1: Risk management process (adapted from the ISO 31000)

Description of the risk management methodology

There are 8 major steps in the risk management process proposed by ISO 31000: risk management policy, communication and consultation, establishment of the project context, risk identification and estimation (risk analysis), risk evaluation, risk treatment (if some risks require to be treated) and risk

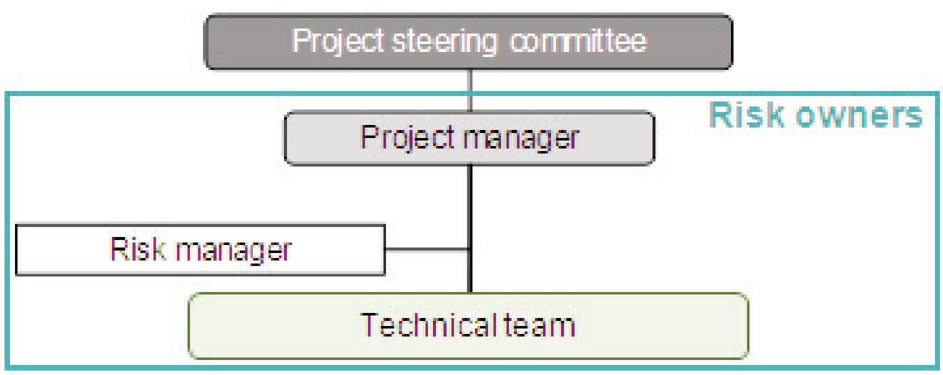


Figure 2: Example of an organizational chart for defining people responsibilities

1. MUltiple Space and Time scale Approach for the quaNtification of deep saline formations for CO2 storaGe, www.co2mustang.eu

2. FP7/2007/2010 under grant agreement n°227286

monitoring and review.

(1) Risk management policy: description of the project objectives and of the commitment of the CO2 site operator toward risk management, definition of the overall project (process, methods, tools), type of risks to be considered and responsibilities and relation between people involved in the project. Figure 2 presents an example of an organisational chart required to define the roles and responsibilities of a project team.

(2) Communication and consultation: description of how the people involved in the risk management process have to communicate and work together at each step of the risk management process. Management team and communication actions ensure that this policy is understood, implemented and maintained at all levels of the organization.

(3) Establishment of the project context: definition of the stakes and objectives associated to the project (technical, financial, social, etc.), description of the studied system in time and space, the internal and external entities involved in the project (project team, suppliers, public, etc.) and finally, definition of the likelihood and severity grids that will be used for risks quantification.

The **objectives** for a CO2 storage project can for example be as follows, for technical aspects: capability to transport and to safely store CO2 for a long-term period within the storage complex; and for health and safety aspect: ensure that the technical staff or the local population will not be endangered by any of the activities related to the CO2 project.

The **description of the system** aims at collecting and analyzing specific information and data to characterize the site regarding reservoir, aquifers and wells in particular. The data can include for example: characteristics of the wells (type, position, depth, crossed layers, casings, etc.), description of major geological units (age, depth, thickness, etc.), description of the reservoir (depth, thickness, permeability, porosity, etc.), description of the aquifers in the area (position, dimensions, water salinity). The data will be used to define the storage system, which is one of the first steps in the risk management process.

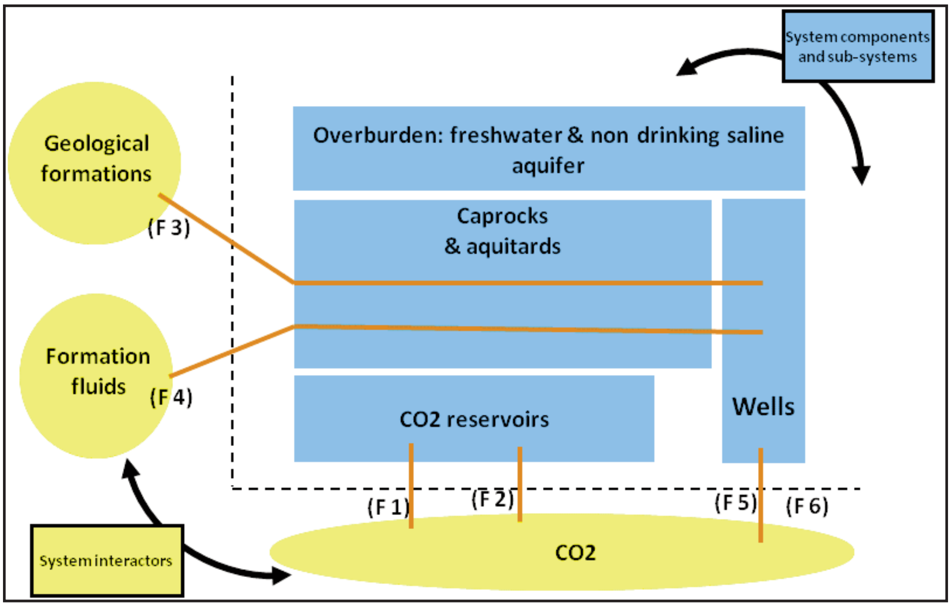


Figure 3: Example of functional representation

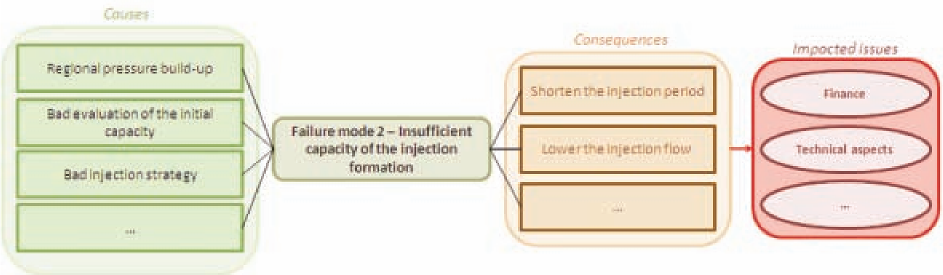


Figure 4: Example of a bow-tie diagram

		Stakes			
		Health & Safety	**OPEX - Financial**	**Corporate Perception of know how**	**Environment**
Severity levels	**1: Minor**	/	< 0.1 M$	no impact	
	2: Low	no impact	[0.1 – 0.5] M$	Technical skill non affected (project is considered as a test)	
	4: Major	Medical treatment	[1 – 5] M	Lack of confidence from Top Management - Request for a demonstration of technical feasibility	
	5: Critical	Serious personal injury	[5 – 10] M$	Questioning from the Top Management about the technical capability to assume CO2 storage projects	
	6: Extreme	Serious personal injury, possible permanent injury	>= 10 M$	Stop of the project - Field is not considered as a CO2 storage field	

Table 1 : Example of a "Consequence grid" (adapted from [2])

The **consequence grid** provides a description of the different severity levels for each project objective identified. The objectives are expressed using performance indicators to define the different severity levels. It must be developed closely with each stakeholders associated to the project, it is therefore specific to each project. An example of such grid adapted from another project [2] is given in Table 1

(4) Risk identification: definition of all risks that could impact the project.

A comprehensive identification based on a well-structured and systematic process is essential to ensure that all risks are considered. Different methodologies can be used to identify risks: FMEA (Failure Mode and Effects Analysis), fault tree analysis, event tree analysis, or FEP (Features, Events and

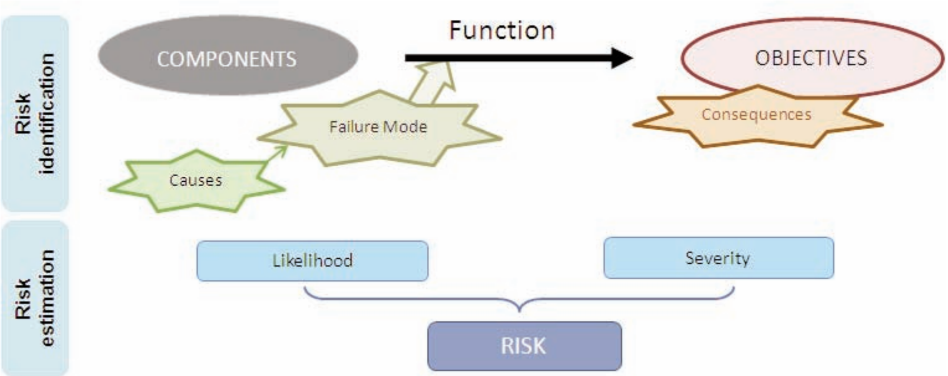


Figure 5 : Pattern of risk identification and estimation

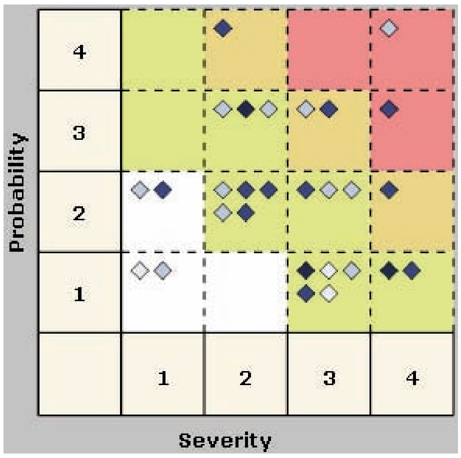


Figure 6 : Example of a risk map (SIMEO™-ERM)

Processes) analysis ([3]). We propose to use the F.M.E.A., a systemic approach that focuses on the function to be fulfilled by the systems components to reach project objectives.

An example of a functional model is shown in Figure 3; it constitutes the basis of the functional analysis leading to the risk identification. The functions identified in the scheme are for example, to ensure CO2 injectivity (F1) or to ensure CO2 storage capacity (F2).

Bow-ties will then be created to define the risks, their causes and consequences on the project. Figure 4 gives a non-exhaustive example of a bow-tie regarding the risk of "insufficient capacity of the target formation". Although the examples in Figure 3 and 4 may look simple, the F.M.E.A methodology becomes more and more specific while delving in the details of risks, their causes and consequences.

(5) Risk estimation: assessment of the likelihood and severity levels of all identified risks (Figure 5). The risk estimation could be assessed with expert opinions or simulations results for example. Risks can be ranked in a risk map (Figure 6).

(6) Risk evaluation: comparison of the criticality level of each risk to the acceptability level in order to define relevant treatment action plans. The acceptability level is defined by the operator for each project objective, it is therefore specific to a project. Unacceptable risks are those above the level of acceptability, they will have to be treated first.

(7) Risk treatment: description of the process of identifying relevant treatment options (i.e. that decrease risk likelihood, severity or both) for the unacceptable risks, and establishing a risk treatment plan to mitigate these risks with the selected options.

Possible risk treatment actions are defined by the project team during risk review meetings; however they are selected by project managers. Treatment actions can include for example: avoid the risk by deciding not to start or to stop any activity that contributes to the risk, change the nature and magnitude of likelihood (prevention, monitoring) or decrease the severity of the risk (protection, curative actions).

(8) Risk monitoring and review: description of the process to ensure that risk exposure is well known and controlled, and that treatment action are undertaken in an efficient manner.

Risk monitoring allows risk evolution to be tracked over time. In an operational way, risk monitoring is focused on processes and causes of risks.. Monitoring, review and reporting is an essential and integral step in the risk management process, it takes place throughout the risk management process (see Figure 1).

Conclusion

CO2 geological storage is one of the most promising solutions to mitigate CO2 emissions into the atmosphere, and to minimize the impact of greenhouse gas effects. Nevertheless, some key challenges relating to capacity, injectivity and confinement need to be overcome in order to validate the performance of the storage system during its lifecycle (from a few years to several hundred years). In the case of a CO2 storage operation failure, the environment, investments, and human health & safety may be at risk. It is therefore important to use risk management methods to ensure that these projects will meet their objectives, as highlighted in the EU directive regarding CO2 geological storage ([4]).

This paper proposes a methodology and tools compliant with ISO 31000 Risk Management guideline. It is currently being applied to international CO2 storage project. The application of this methodology on several demonstration projects have already identified some gaps and have contributed to minimize (as low as possible) the encountered risk.

References

[1] ISO/FDIS 31000 (2008) – Risk Management, Principles and guidelines, International Standard

[2] Y. Le Guen et al., 2008, CO2 Storage – Managing the Risk Associated With Well Leakage over Long Timescales, SPE-116424-PP

[3] A generic FEP database for the assessment of long-term performance and safety of the geological storage of CO2 – Quintessa [D. Savage, P. R. Maul, S. Benbow, R. C. Walke], June 2004, http://www.quintessa.org/co2fepdb/PHP/frames.php

[4] Directive 2009/31/EC of the European Parliament and of the Council on the geological storage of carbon dioxide – Official Journal of the European Union – 23rd April 2009

More information

OXAND group is an independent international consulting company providing innovative services and expertise for risk management of CO2 and gas storage projects. OXAND group operates its own innovative tools and databases (Simeo™ software platform) for diagnosis and prognosis of ageing infrastructures. With an experience in decision-making criteria based on performance and risk™ management methodologies (P&R™), coming from its nuclear experience, OXAND group develops its activities worldwide and its services are successfully acknowledged by Oil&Gas operators.

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Experimental observations of CO2 for storage

Experimental research into subcritical and supercritical CO2 for storage requires greater attention in order to predict fluid migration more effectively.

John Mills, PhD Candidate, IPE Heriot-Watt University

Researchers at the Institute of Petroleum Engineering at Heriot-Watt University have been applying their skills in numerical modelling and experimental research to CO2 storage. The transition from subsurface oil and gas research to CO2 storage is relatively seamless, though the step required is still a challenging one for the reasons discussed in this article.

The department's Joint Industry Project model has facilitated the procurement and development of new technologies to support the various research activities at the department. The Hydrocarbon Recovery Mechanism team benefits from such strong industry support, and is leading the investigation of fluid flow through reservoir rock samples known as 'cores'.

The team is led by Drs. Sohrabi and Jamiolahmady, who have conducted research into a number of challenges facing the industry such as: the flow of gas condensate near the wellbore, well deliverability improvement, water alternating gas (WAG) injection, carbonated water injection and more recently, CO2 for storage. These research projects have been delivered successfully through the use of unique core test facilities – often designed and developed internally – and numerical modelling techniques to understand complex fluid flow through porous media.

Proving that storage of CO2 is feasible is certainly made easier due to the quality of the 'toolbox' we have at our disposal. There is already a software platform created for the petroleum industry, which can be adapted for the purpose we require. At present, there are unanswered scientific questions we need to address using various experimental techniques and computational facilities: high-pressure and temperature behaviour of CO2 at the pore (microns) and core (inches) scale.

Conventional reservoir and laboratory gases do not exhibit the same dynamic behaviour we have observed with CO2. In a low pressure, depleted gas reservoir, CO2 behaves much like a highly mobile and buoyant gas; whereas at higher pressures, in an untapped saline aquifer for example, the CO2 passes a critical point thus becoming 'supercritical'. In this state it exhibits behaviour of both a gas and a liquid. This interacts chemically with the mineral components of the host rock; such behaviour is a challenge to represent accurately through simulation. Through various experiments, we have been to seeking to understand how CO2 behaves under such conditions. Our observations show a departure in typical physical and chemical behaviour from previous work done on hydrocarbon fluids.

There are numerous studies that have been published which seek to describe how much CO2 can be trapped under certain reservoir conditions. Authors who assume that major inputs can be taken from existing hydrocarbon literature may be short-siding themselves unless mitigated by determining and investigating the effects of the uncertainties. Experience tells us that simulations are only as good as the information they are built with, which underlines the need suitable for experimentally derived data.

Our observations confirm the importance of experimental observations to aid the understanding and development of realistic simulations of CO2 propagation and trapping in the reservoir. Empirical evidence is vital for us to understand the true processes at work under reservoir conditions to maximise the effectiveness and security of storage projects.

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Transport and storage news

DOE selects 15 CO2 storage projects for funding

fossil.energy.gov

15 projects have been chosen to develop technologies aimed at safely and economically storing CO2 in geologic formations, with funding of $21.3 million over three years.

Efforts are underway to demonstrate safety and permanence of geologic sequestration through initiatives such as DOE's Regional Carbon Sequestration Partnerships program. The 15 selected projects will complement ongoing efforts by developing and testing technologies that address critical challenges for geologic storage including injectivity of CO2 into the reservoir, storage capacity, plume migration, and containment by caprock and other trapping mechanisms.

The projects are focused on five types of formations: depleted oil and gas reservoirs; deep saline formations; unmineable coal seams; oil- and gas-rich organic shales; and basalts.

The funding recipients are:

- Advanced Resources International, Inc. (Arlington, Va.) — In this project investigators will assess factors influencing effective CO2 storage capacity and injectivity in selected Eastern gas shales.

- Board of Trustees of the Leland Stanford Junior University (Stanford, Calif.) — Researchers will investigate the feasibility of geologic CO2 sequestration in depleted shale gas reservoirs.

- Clemson University (Clemson, S.C.) — Clemson University researchers will evaluate the feasibility of using wellbore deformations to assess reservoir, caprock, and wellbore conditions.

- Colorado School of Mines (Golden, Colo.) — The objective of this project is to improve understanding of CO2-trapping mechanisms affected by formation heterogeneity.

- Fusion Petroleum Technologies, Inc. (The Woodlands, Texas) — This study will evaluate the applicability of the experimental design/response surface method, sensitivity analysis, and optimization method on the many factors that affect the successful char-

acterization, engineering design and operation of a saline formation site.

- Montana State University (Bozeman, Mont.) — This project will develop a biomineralization-based technology for sealing preferential flow pathways in the vicinity of injection wells.

- New Mexico Institute of Mining and Technology (Socorro, N.M.) — Researchers will assess caprock/reservoir interfaces of proposed CO2 injection sites.

- Paulsson, Inc. (Brea, Calif.) — The objective of this study is to develop a reservoir-assessment tool based on novel and robust borehole seismic technology that can generate ultra high resolution P and S wave images for detailed characterization and precise monitoring of CO2 storage sites.

- The Trustees of Columbia University in the City of New York (New York, N.Y.) — Columbia University researchers will test and evaluate carbon-14 as a reactive tracer to assess CO2 transport in a basaltic storage reservoir.

- The Trustees of Indiana University (Bloomington, Ind.) — Researchers will develop a reservoir-scale multi-phase reactive flow model for CO2 plume migration and dynamic evolution of trapping mechanisms at the Sleipner Project in the North Sea.

- University of Kansas Center for Research, Inc. (Lawrence, Kan.) — Investigators will evaluate the effectiveness of the volume curvature seismic tool to assess reservoirs and features such as sags, flexures, and fractures.

- University of Texas at Austin (Austin, Texas) — Researchers will develop a prototype of a new computational approach to assess plume migration in a reservoir.

- University of Texas at Austin (Austin, Texas) — In this project, researchers will complete simulations and experiments to establish proof-of-feasibility of a novel concept for assessing capillary trapping in reservoirs.

- University of Wyoming (Laramie, Wyo.) — Researchers will study the storage of supercritical CO2 and co-contaminants in deep saline formations of Wyoming.

- Yale University (New Haven, Conn.) — Yale University will study basic questions about the chemical and mechanical processes that must occur in basalt reservoirs for carbonation to be practical on a large scale.

UK subsea CO2 storage licensing plans published

www.decc.gov.uk

The UK Government has set out how it will license the storage of carbon dioxide under the sea bed, following responses to its recent consultation on the geological storage of CO2.

During the consultation, 29 developers, industry bodies and other interested parties gave their view on potential plans for the broad structure of the proposed licensing system. This includes a proposal for having a license which would cover all phases of such developments.

DECC will now lay the regulations in Parliament in order to comply with European rules on the underground storage of carbon dioxide and these will come into effect on 1 October.

Research partnership for UCG with CCS

www.cleanglobalenergy.com.au

Clean Global Energy Limited has entered into agreements with Australian and United States based universities to undertake further research into the technical and environmental applications of Underground Coal Gasification (UCG) and CCS.

Clean Global Energy, based in Australia, will provide grants to the Australian Centre for Sustainable Mining Practices and the School of Mining Engineering, at University of New South Wales (UNSW) and the Colorado School of Mines (CSM) in Golden, Colorado.

These Universities will focus on the further development of Clean Global Energy's Linear Controlled Retractable Injection Point (CRIP) UCG technology, in particular its application in deep coal seams where disused UCG cavities may be suitable for CCS.

Clean Global Energy's primary business focus is on providing a range of Syngas products for power generators, chemical, fertiliser and petroleum producers.

Other areas of focus will be on advanced water management techniques surrounding the UCG reactors and disused cavities, hydrology, low carbon emissions, and on-line support to control the UCG process in future commercial operations.

Clean Global Energy will bring the two schools together to formulate the research program, building on complimentary skills within both faculties, as well as forming a combined advisory panel.

Clean Global Energy currently has projects in Australia and Inner Mongolia, China. The US $400M Inner Mongolia project is the region's first major UCG project, scheduled for completion in stages over 3 years.

South Africa CO2 storage Atlas

www.cef.org.za

The South Africa Minister of Energy, Ms Dipuo Peters, has launched the first Atlas on the geological storage of carbon dioxide in Africa.

The Atlas is the result of cooperation and partnership between Government, State-Owned Entities and the private sector. These include the South African National Energy Research Institute (SANERI), PetroSA, Petroleum Agency of South Africa (all three companies are members of the CEF Group), plus Anglo American, Eskom, Sasol and the Council for Geoscience.

The Atlas will be incorporated into the work programme of the newly established South African Centre for Carbon Capture and Storage, which is also part of the CEF Group.

It provides an overview of the country's energy economy, a roadmap on carbon capture and storage, as well as the progress made to date in this regard. It includes geological maps and also makes reference to the potential and estimated carbon dioxide storage capacities of the geological formations that are found in South Africa.

Minister Peters said: "South Africa endeavours to play its part in the global effort to mitigate greenhouse gas emissions that are the main cause of climate change. We have domestic targets and mechanisms for increasing the usage of renewable energies and for achieving greater energy efficiency".

"However, our energy economy is largely based on its indigenous fossil fuels – primarily coal. Not only does coal provide the basis for electricity and the production of liquid fuels, it also serves as a foundation for most of our industries and, subsequently, forms a substantial portion of our exports."

"Our coal industry contributes significantly to employment opportunities, income generation, as well as accounting for huge foreign-exchange earnings for the country. We are firmly resolved to increase the use of renewable energy in a bid to diversify our energy mix; however, we recognise that coal will continue to be the basis for the provision of most of our primary energy needs for the next few decades.

"It is against this backdrop that Government has proactively and vigorously engaged in the issue of mitigating greenhouse gas emissions by carbon capture and storage (CCS)."

During 2007, South Africa, through the Department of Environmental Affairs, released the Long-Term Mitigation Scenarios report that described a number of actions that have to be under taken in order to decrease national carbon dioxide emissions between the present and 2050.

Included in these alternative interventions is the use of carbon capture and storage technologies.

While the Atlas is aimed at providing easily accessible information to decision-makers, a detailed technical report is also available for use by specialists.