carbon capture journal

CSIRO launches capture pilot in Beijing

Shell's CO2 reduction strategy

ETI finances CCS projects

TNO pilot project in Rotterdam

Norway begins major capture research program

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Energy Minister Malcolm Wicks on UK CCS plans

CO2 injection begins in New Mexico coalbed study

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Front cover: CSIRO and its Chinese partners have officially launched a post-combustion capture (PCC) pilot plant in Beijing. It begins the process of applying the technology to Chinese conditions and evaluating its effectiveness.

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CCS - the next step

Over the past month the UK has taken major steps in pushing CCS forward with the publication of a consultation 'Towards Carbon Capture and Storage' and the announcement of the successful bidders at the pre-qualification stage of the UK CCS competition.

By Malcolm Wicks, UK Minister for Energy, Department for Business, Enterprise and Regulatory Reform (BERR)

Energy demand across the world is increasing at an unprecedented rate. Renewables are not capable of catering for all of our energy needs - it is clear that fossil fuels will continue to form a part of our generation mix for the foreseeable future.

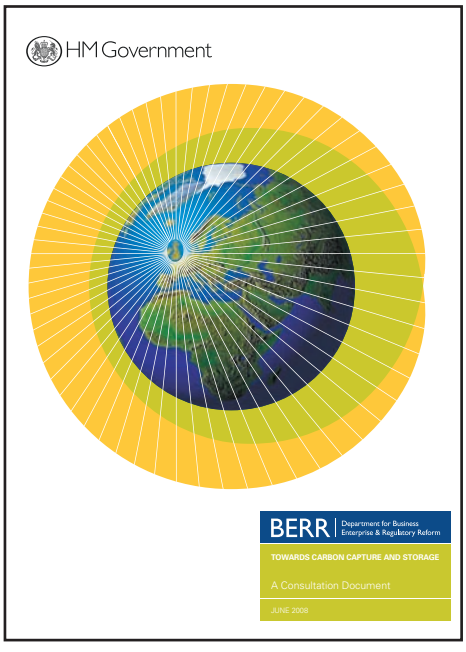
With the challenge of climate change firmly on the agenda it is important that we act to make fossil fuels cleaner.

Carbon Capture and Storage (CCS) is currently the main technology option with the potential to significantly reduce carbon emissions from fossil fuelled power stations.

The International Energy Agency suggests that CCS could contribute up to 28% of the global CO2 mitigation required to achieve stabilisation at 550 particles per million (PPM) by 2050, making it a key technology in our fight against climate change.

Over the past month the UK has taken major steps in pushing CCS forward. With the recent publication of our consultation 'Towards Carbon Capture and Storage' and announcement of the successful bidders at the pre-qualification (PQQ) stage of the UK CCS competition, we are maintaining the UK's global leadership role in developing CCS.

The success of EON UK, Scottish Power Generation, Peel Power and BP Alternative Energy International at the PQQ stage has been well publicised. We will now work with each bidder to take forward our understanding on some of the issues vital to the CCS demonstration.



The project itself remains on track to be operational by 2014, making it one of the first commercial-scale demonstrations of the full chain of CCS technology in the world.

The importance of this commercial scale demonstration cannot be underestimated; indeed the lack of real examples of CCS in action is one of the major barriers to CCS.

But we need to think beyond the demonstration project if we are to realise our ambition of CCS deployment by 2020. In short, we need to focus on the creation of a CCS industry.

Firstly, power plants will need to be equipped with new technology - technology that will impact on net output and will involve design, construction, programme management, supply chain management and operational challenges.

"Suppliers and operators need to get to grips with not only the technology but with developing new ways of working together to turn the technical concept of CCS into a business - commercially, contractually and financially."

The supply chain has not yet formed to meet the challenges of CCS. Suppliers and operators need to get to grips with not only the technology but with developing new ways of working together to turn the technical concept of CCS into a business - commercially, contractually and financially.

I understand that this will be a huge challenge for the power sector. But the potential value of a fully fledged CCS industry poses significant opportunities for businesses such as design consultancies, manufacturers, system integrators, programme managers, and professional service firms – and the UK is well placed to benefit from these opportunities.

"We must now build on the momentum gathering around CCS." Malcolm Wicks, UK Minister for Energy

Suitable regulatory regimes will be another cornerstone in facilitating carbon capture. Our consultation will address some of the details of this regulatory regime and will help to ensure that the final regulations are effective, safe and encourage investment in CCS.

The results of the consultation will also inform our negotiating position on the EU's draft Directive on the geological storage of carbon dioxide, including what is meant by carbon capture readiness (CCR) and whether CCR should be addressed when designing new fossil fuel power stations with a capacity of 300 MW or above - so I would urge all of those with an interest to take part.

Given the importance of demonstrating CCS, we have been actively pursuing ways to ensure that support for further domestic CCS demonstration can be secured at European level. We are considering, with industry and other stakeholders, possible incentive mechanisms and will consider future policy towards CCS demonstration projects in light of ongoing EU negotiation.

We must now build on the momentum gathering around CCS. I am convinced that as early developers of this technology, we can secure ourselves a place in what has the potential to be a significant global industry.

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New funds available to accelerate CCS development

The Energy Technologies Institute (ETI) is a new, unique Public/Private Partnership created less than a year ago with project funding resources of up to £1 billion. Industrial partners include BP, Caterpillar, E.ON, EDF, Rolls Royce and Shell. Flexible in its approach towards each programme, the ETI has initially operated via Calls for Expressions of Interest (EoI) in energy projects. The next Call will be for EoIs for Carbon Capture and Storage.

Andrew Green, the ETI Programme Manager for Carbon Capture and Storage, explains some of the challenges and opportunities that lie ahead.

The ETI was formed to accelerate the deployment of projects to meet the UK's energy targets.

According to the IEA, CCS has the potential to reduce carbon dioxide emissions from fossil fuel power stations by as much as 90%, and could contribute up to 19% of global carbon dioxide mitigation by 2050, so it is an obvious area for investment by the ETI.

Dr. Fatih Birol, Chief Economist at the IEA, recently described a commitment to CCS as a 'litmus test' on how seriously governments are addressing climate change.

Many organisations and governments are now considering carbon capture projects. EPSRC, The Technology Strategy Board and others are working in this area and so it's important to make clear where the ETI fits in.

Deploying the technology

The ETI is focused on enabling deployment of technology; we do not fund basic research, but rather we work in what is sometimes called the 'Valley of Death' in technology development: taking ideas proven in the laboratory through to a point where they are ready for full scale demonstration.

The way we do this is significantly different from other organisations. We focus on a particular area of technology – such as Wind, Marine, etc. – and engage with potential project partners in a way that is best suited to that area.

Ours is always a collaborative process – we work actively with our prospective partners throughout, through workshops, and individual discussions, helping them to shape and accelerate their projects.

Soon, the ETI will ask for Expressions of Interest (EoIs) in the area of Carbon Capture and Storage, seeking to work with companies (large and small) and academics to create projects.

We have the exciting prospect of selecting project partners from across the world. This means the ETI can access the very best the world has to offer, and that, I believe, makes us pioneering in the breadth of the search we can undertake to find the answers the UK needs to meet its 2020 and 2050 CO2 targets.

Register your ideas

When we publicise the Call for CCS, we will not ask for detailed project ideas. We ask for EoIs that will allow us to bring together a practical mix of people to create consortia that have access to all the resources – from technical to commercial – to create, deliver and ultimately commercialise CCS projects.

I urge you to keep a lookout on the ETI website, where the Calls for projects are published. Calls are usually open for six weeks, and within a month of closure we aim to hold our first project Workshop.

> **"Ours is always a collaborative process – we work actively with our prospective partners throughout, through workshops, and individual discussions, helping them to shape and accelerate their projects."**

You can register on the ETI website, to be kept informed of when a Call is due to be announced. We are currently developing a "road map" showing what Calls will be announced and when; we expect this to be published early in 2009.

Once the date for submission of EoIs is past, we select a balanced group of 30-40 organisations to attend a Workshop. At this, the ETI provides a strategic focus for ideas for CCS projects, and encourages the formation of project consortia that can develop the ideas further.

"We have the exciting prospect of selecting project partners from across the world." - Andrew Green, ETI Programme Manager for Carbon Capture and Storage

Delivering the goods

My job as Programme Manager is to work closely with these consortia to build a portfolio of high-quality CCS projects, from capture to storage, and ensure that they remain focused on the outcomes we need to meet UK CO2 reduction targets.

In CCS, the ETI projects are likely to be sizable, attracting investment of between £5 and £25 Million each. The ETI has the ability to fully fund projects – even at this scale, although in some cases project teams may provide some funding from their own sources.

In return for our support, we expect projects to deliver what they promise. Our monies are released against project milestones to make sure that we manage the ETI's investment wisely.

As a further safeguard to ensure priorities are right, and to guard against potential conflict of interest, the projects themselves will only begin after review by an independent selection panel of CCS experts from around the world. These panel members are already being recruited but further nominations from Journal readers would be most welcome.

The BP experience

The quality of this panel and reputation of our Partners will be of immense benefit to the CCS projects we support.

A great example is BP, which is behind one of the few large-scale CCS projects currently up and running in the world today.

The In Salah gas field in Algeria, operated by BP (and its partners Sonatrach and StatoilHydro), is already capturing and storing one million tonnes of CO2 per year in a deep geological formation 2km below the Sahara desert – a reduction in emissions equivalent to taking a quarter of a million cars off the road.

It is the ETI's access to this type of world-class experience that leads me to be very confident that the ETI project teams will be able to make an exceptional contribution in CCS.

Making CCS work

Since joining the ETI and becoming involved in our CCS work, I have been struck by the challenge and the speed at which we need to act to build what is, in effect, a complete new industry the size of the UK's current oil and gas production.

The planned UK government-supported demonstration unit, which uses today's technology, is an excellent start. However if we are to maximise our impact on emissions, from the current UK 40 GW of fossil-fuel generation (not to mention other significant industrial CO2 sources) we will need to develop new lower cost capture technologies with a smaller performance impact.

We must be assured that we have sufficient high-integrity sinks available, and understand how an integrated electricity grid and CO2 transport network will operate. The ETI is likely to address all these aspects of CCS.

CCS may prove to be an interim solution to the world's energy needs, but it is a critical one, and we need organisations with expertise and commitment to become actively involved in the ETI's programmes.

So when you see our Call for Expressions of Interest this autumn, please assess whether you may be able to participate. We look forward to hearing from you.

Aerial view of In Salah *the world's first full-scale carbon dioxide capture project at a gas field, BP, Krechba, Algeria.*

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Shell - going underground with greenhouse gas

Shell is providing some of the finance and major technical assistance to the CO2SINK project in Ketain, Germany. Meanwhile the company plans to apply for funds to help finance a project that would capture and store about one million tonnes of CO2 from Shell's Scotford Upgrader, which processes oil from oil sands in the province of Alberta, Canada.

With the turn of a pipe valve, three researchers began silently pumping carbon dioxide (CO2) captured from a German refinery more than 700 metres (almost 2,300 feet) into the earth beneath a former natural gas storage reservoir.

For the assembled onlookers at the site outside the town of Ketzin near Berlin last month, there was little to actually see.

So after the formalities, local residents, the mayor and other officials at the ceremony discussed the significance of the day over beer and goulash and posed for photographs, while journalists conducted interviews with the research team.

Despite the lack of drama, the event was an important milestone for this study, known as CO2SINK, into the feasibility of storing CO2 underground as a way to reduce greenhouse gas emissions that cause climate change.

It is the first of its kind onshore in Europe. Geologists and scientists from 18 European power producers, universities, government agencies and energy companies -- including Shell – participating in the small-scale project will spend the next several years steadily injecting the gas and monitoring its movement over time.

The hope for carbon capture and storage (CCS) technology is huge. If proved to work on a commercial scale, it could be used at big industrial facilities like power plants, cement factories, refineries, chemical plants, and iron and steel works that account for a large share of global greenhouse gases.

A recent report by the United Nations Intergovernmental Panel on Climate Change (IPCC), says that capturing CO2 may one day contribute up to 55% of the emission reductions that scientists believe necessary to address global warming.

That – along with energy efficiency measures – would help allow modern societies to keep burning fossil fuels while renewable energy matures and expands, providing a bridge to a low-carbon energy future.

But it will likely take years before the technology sees widespread use. Technical questions still remain, like how best to inject large volumes of CO2 and how to ensure that it stays underground.

The main obstacle however, is not technology, but economics. The dozens of large-scale demonstration projects that experts believe are necessary to fine-tune the technology will cost hundreds of millions of dollars each.

And at present companies have no way to recoup their investment in the equipment to capture and store CO2 – a major obstacle to the widespread adoption of the technology by industry.

Overcoming these hurdles will take time and means that even if it works, CCS is unlikely to make much impact on CO2 emissions before perhaps 2020. "CCS is not a silver bullet," says Leo Meyer, a senior author of the IPCC report. "Theoretically its potential is enormous, but there's a long way to go."

No time to waste

And time is short. As global demand for electricity accelerates, particularly in Asia, so do CO2 emissions. Although renewable energies like solar and wind are growing fast, they can't keep up with demand, prompting the use of more fossil fuels, especially coal.

According to Xinhua press agency, in 2007 China added 91 gigawatts of capacity in the power sector, more than the total existing capacity of the UK. More than three-quarters was coal-fired. Yet burning coal for power accounts for about a quarter of the world's total emissions of CO2.

To tackle climate change seriously, 90% of power plants in the developed world and half of those in the developing world will need to capture and store their CO2 emissions by 2050, estimates Shell's energy scenarios team.

New use for old skills

Many of the building blocks of storage and capture technology are well known. A number of industrial processes already capture CO2. Some chemical plants that produce methanol, for example, use liquid chemicals to absorb CO2 from gas.

Prof. Dr. Dr. h.c. Reinhard F.J. Hüttl Scientific Executive Director of GFZ is opening the ventile to start the CO2 injection. To the left: project manager of CO2SINK: Prof. Frank Schilling, GFZ (middle) and Dr. Friedrich von Bismarck, chairman: Geschäftsstelle des Steuerungs- und Budgetausschusses der Braunkohlesanierung (Image: ©GFZ)

Once captured, CO2 is used for a range of purposes. It is an ingredient in products such as fertiliser and chemicals. Some of the carbon dioxide from Shell's Pernis refinery in the Netherlands puts the fizz into soft drinks and is pumped into local greenhouses to help grow tomatoes.

Transporting large amounts of CO2 via pipeline and injecting it underground is also common. For decades oil companies have done so to extract more oil from ageing fields.

But the final step in CCS – permanently storing CO2 underground – is less common and now the focus of more research.

One of the largest storage operations is the Sleipner project operated by Statoil-Hydro off the coast of Norway. Each year StatoilHydro separates one million tonnes of CO2 from natural gas produced at an offshore field and stores it in a deep layer of

permeable rock containing salt water.

That helps StatoilHydro comply with Norway's regulations on CO2 levels in the national gas system. CO2 is non-combustible and so must be removed before gas is sold into the grid.

Demonstration plants are key

Storing CO2 this way uses the same geological trapping mechanisms that have contained large reservoirs of oil, gas and CO2 underground naturally for millions of years. The technique involves injecting CO2 into permeable rock.

The CO2 displaces salty water and is held securely by tightly-spaced pores in the rock, invisible to the human eye, while a layer of impermeable rock above prevents it from rising to the surface and escaping into the atmosphere.

But researchers need to learn more about what happens to the CO2 once underground. At depth and under pressure, CO2 behaves like a fluid. So researchers in Ketzin are using a range of techniques, such as time-lapse seismic analysis and sensors, to track its movement, study how it dissolves in salty water and reacts with minerals, and test for leakage.

"We already know a lot about these reservoir rocks and the fluids in them but CCS requires long-term storage of thousands of years," says Wolf Heidug, Shell's General Manager for CO2 Policy and senior co-author of the IPCC report. "CO2SINK's extensive monitoring and simulation - both during injection and after it has stopped - will help us better understand the long-term fate of the injected CO2."

The CO2SINK project will be the first of its kind onshore in Europe to study underground storage of CO2.

The Ketzin project will store approximately 30,000 tonnes of the gas over the next two years. That's a small amount compared to the approximately eight million tonnes of CO2 produced by a conventional 1,000-megawatt coal-fired plant each year.

Teams at other projects around the world are already working on the challenges of storing far greater quantities.

One of the largest is the Weyburn-Midale project in Saskatchewan, Canada. Led by the International Energy Agency and co-sponsored by Shell, it is monitoring the storage of well over one million tonnes annually of CO2 piped from a coal-gasification plant in North Dakota, USA.

In Queensland, Australia, Shell engineers are providing the technical assistance on another demonstration project known as ZeroGen that will test CCS technology at a coal-fired power plant.

The renovated Olympic Stadium in Berlin sits on a large gas store (Image: ©Stahl-Zentrum)

Research is now focused on finding the most efficient method to inject the CO2. Although tightly-spaced pores in permeable rock help store CO2 securely, they can also make pumping it in more difficult.

To overcome this problem, a team of engineers from Shell and ZeroGen has been trying a new technique called "punch and go".

A drill mounted on a mobile truck bores down to the layer of permeable rock. Small explosive charges then punch multiple injection arms into the surrounding rock, increasing the amount of CO2 that can be pumped in. When one well is complete, the mobile unit moves to the next site.

As well as answering technical questions and establishing the safety of the process, such demonstration projects provide the information necessary to set rules for CO2 storage.

"The data collected at Ketzin and other demonstration projects is important to help politicians and policy makers as they design a regulatory framework for CCS," says Heidug.

For example, companies and governments still need to agree the ownership and liability for buried CO2 before industry will deploy the technology commercially.

As safe as Mother Nature?

Carbon dioxide occurs naturally in small concentrations in the atmosphere, is exhaled by people and animals as they breathe and is essential to plant growth. It is not dangerous in low concentrations.

The IPCC says it is likely that 99% of CO2 stored underground using CCS would remain there for over a thousand years.

The report also states that with appropriate systems in place, the local health, safety and environmental risks of storing CO2 would be comparable to storing natural gas – a practice that is common already. Indeed, the Olympic stadium in Berlin (pictured) that hosted the football World Cup in 2006 sits on a large gas store.

Nevertheless, using CCS at industrial facilities and power stations may mean pipelines pass through communities, and storage sites may be located close to populated areas – hence the importance of more demonstration projects to show the practice is safe.

"Public perception is perhaps the biggest potential hurdle for CCS," says Meyer, who believes people may worry that there are unknown safety risks associated with storing CO2. "Unless these issues are handled right, CCS will likely not live up to its potential."

Making CCS a commercial reality

Finding the money to build demonstration projects has so far proven difficult. That's partly because environmental concerns are behind the drive to store CO2 underground, rather than the technology's commercial potential. CO2 has little value as a commodity and few consumers have so far been willing to pay a premium for "green" energy.

Moreover, power plants equipped with CCS produce 10-15% less power than those without because of the energy necessary to capture and store CO2. And the additional equipment can add hundreds of millions of dollars to a power plant's price tag. Together, this would push up the cost of producing electricity. Although the cost is likely to fall as the technology becomes more widespread, it will remain more expensive than current technology.

With no obvious way to recoup their investment, companies and shareholders view CCS as an added cost. That often translates into a go-slow approach to storage projects.

To stimulate investment and encourage large-scale carbon dioxide storage, some executives and experts argue that companies

need strong government-mandated incentives, such as carbon taxes or credits for stored CO2 that can be traded in emission trading schemes.

"An important prerequisite is that there is a significant price for CO2 in the international business environment," says Meyer.

Making industries pay for the CO2 they put into the air should encourage them to find cheaper ways to reduce emissions, he says. But governments could take years to agree on a cost for CO2 and a payment mechanism, delaying the technology's adoption.

To accelerate it, some governments are helping to finance demonstration projects. The European Union, for example, has contributed €8.7 million ($13.6 million) to CO2Sink while the German government has provided €6 million ($9.3 million).

Shell, meanwhile, is providing some of the finance and significant technical assistance to the project.

And in July, the government of Alberta, Canada announced a fund of 2 billion Canadian dollars to accelerate CCS projects in the province.

Shell plans to apply for funds to help finance a project that would capture and store about one million tonnes of CO2 from Shell's Scotford Upgrader, which processes oil from oil sands in the province.

"The costs of CCS at the moment are prohibitive and the financial risks are high," says Paal Frisvold, Chair of Bellona Europa, a Brussels-based international environmental organisation that is encouraging the EU to finance construction of up to 12 CCS-equipped power plants by 2015.

Celebrating the start of the CO2-injection (from the left: Prof. Dr. Günther Borm (founder of the CO2SINK project), Bernd Lück (mayor of Ketzin), Michael Richter (State Secretary in the ministry of economics of the State of Brandenburg), Dr. Klaus Freytag (President of the state institute for mining, geosciences and Natural Resources of the state of Brandenburg), Prof. Dr. Frank Schilling (Project manager CO2Sink of the GFZ) und Prof. Dr. Dr. h.c. Reinhardt Hüttl (GFZ-Executive Board). (Image: ©GFZ)

"It's unfair to ask companies to make the first move without incentives. We need to encourage them to dare to be first and to make the leap." Frisvold stresses that public funds should only be used to kick-start CCS and should be limited to the earliest projects.

This autumn, the researchers from CO2SINK will invite politicians and officials from the EU to Ketzin to see the project for themselves – a useful opportunity as they decide whether to support the large-scale flagship programme.

In the meantime, the scientists at Ketzin will continue to study the carbon dioxide slowly filling the ground beneath the natural gas reservoir – a small but important part of global efforts to develop a technology that could help build that bridge to a low-emission energy future.

This article was first published at Shell World online on 15 August 2008.
www.shell.com/swonline

Carbon capture cannot be rushed

Stephen Salaff interviews Kim Trew, Saskatchewan New Democratic Party Caucus Critic for SaskPower

Mr Trew, the international carbon capture industry is studying carefully Saskatchewan's experience with carbon capture and sequestration. Some are enthused that SaskPower has advanced CCS to the near-commercial stage. Other stakeholders are perplexed at the apparent start-stop development in Saskatchewan, during which the utility's CCS project was cancelled and then relocated to another, nearby plant. As the official opposition Critic for SaskPower, how would you address these mixed concerns?

"The Saskatchewan New Democratic Party (NDP) was an early champion of carbon capture, back in 1992, and we remain fully committed to this promising environmental and economic concept. The NDP Caucus today in opposition still critically supports CCS in Saskatchewan and Canada."

"In particular, I requested Saskatchewan Premier Brad Wall of the Saskatchewan Party on April 2 to illuminate the finances of SaskPower's Boundary Dam CCS demonstration. I asked Mr Wall for due diligence and disclosure of the terms and conditions of Canadian Prime Minister Stephen Harper's 26 February 2008 federal budget commitment of $240 million to SaskPower's Boundary Dam CCS demonstration project. I asked them for a public Memorandum of Understanding regulating the Harper-Wall arrangement."

"Especially, I regretted Harper's insistence that Ottawa won't cover any cost overruns, and I deplored our provincial government's announcement that all project partners would need to share any cost overruns in this demonstration project."

"I believe that a major project like CCS commercialization should be developed much more deliberately, and with less haste." - Kim Trew, Saskatchewan NDP Caucus Critic for SaskPower

"Beyond the federal $240 million commitment and SaskPower's $758

million budget for Boundary Dam CCS, Saskatchewan Premier Wall announced that private sector partners would help share project costs, but no such private partners have yet emerged."

"Saskatchewan taxpayers deserve some assurance that Brad Wall has not rushed into a bad deal and simply signed a blank check in the process. While Saskatchewan consumers are prepared to do their part to help clean the environment, they cannot be expected to do so at any cost."

"Ironically, I raised these problems moments after April Fool's Day, when it felt like a joke was then being played on Saskatchewan taxpayers."

It seems like SaskPower's CCS demonstration has been quite rushed.

"Yes, regrettably. I believe that a major project like CCS commercialization should be developed much more deliberately, and with less haste. I also think that SaskPower's initial 2006 announcement and public promotion of their first CCS commercial venture at Shand may have been somewhat rushed. The utility was unfortunately unable to deliver the project within the publically-estimated timeframe and Shand CCS was then cancelled. It might have been preferable for SaskPower to commercialize CCS somewhat more quietly and modestly at first."

Please comment on another apparent and competing obstacle to Saskatchewan CCS – the nuclearization of SaskPower.

"The Saskatchewan NDP urges Premier Brad Wall to ensure broad public discussion on Saskatchewan's nuclear future by appointing an expert panel to provide a report on the economic, environmental and social impact of a nuclear reactor."

"My caucus colleague Frank Quennel, our Critic for Enterprise and Innovation, argued in June: 'The Sask Party says it wants to be open and transparent, but within a matter of several weeks it has gone from claiming it was in initial discussions with Bruce Power (CCJ 4, page 5) to making a public announcement with Bruce Power. As a result, Saskatchewan people are feeling like the government is forging ahead without them.'"

"Quennel added: 'If nuclear is the right energy option for Saskatchewan the Sask Party should have nothing to hide. The government should convene an expert panel, let them report their findings and then engage the public in an informed debate. In April, the Government of Alberta appointed an expert panel to prepare a comprehensive and objective report on nuclear energy. The report will look at environmental, health and safety issues; waste management; a comparison of nuclear generation to other electricity sources; current and future nuclear generation in Canada and worldwide; as well as Alberta's future electricity needs.'"

"The Sask Party claims it likes to learn from Alberta. Let's hope it takes a page from the Government of Alberta on this one "

What is your personal opinion on nuclear reactors in Saskatchewan?

"I am against nuclear reactors for several reasons. First, the Saskatchewan electricity grid is too small to accommodate a nuclear power reactor. We do not need and cannot utilize the 800 megawatts a nuclear reactor would generate."

"Second, owing to our north-south geographic expanse, SaskPower's transmission lines are relatively long. The sites thus far proposed for a nuclear reactor are quite far from southern Saskatchewan load centers."

"Our currently largest electricity generator is the coal-fired Boundary Dam station on Saskatchewan's USA border with North Dakota. Boundary Dam has served our load centers quite well until now."

"Third, I oppose any Saskatchewan role in the storage of nuclear fuel waste, and I would not like to see this risky process begin here. Used nuclear fuel cannot be stored under water at reactors indefinitely."

"Finally, I am uncomfortable with Atomic Energy of Canada Limited's long-standing efforts to sell a nuclear reactor in western Canada, which seems like a part of AECL's Candu reactor marketing strategy."

Kim Trew is a member of provincial parliament from a constituency in Regina, the provincial capital.

Prior to his first election to provincial parliament in 1986, Trew served twelve years as a safety officer at the Saskatchewan Wheat Pool. Trew was an active trade unionist, as an executive member of the Grain Services Union and an occupational safety officer.

Saskatchewan NDP leaders Roy Romanow and Lorne Calvert have successively appointed Trew to numerous caucus portfolios, including responsibilities regarding publicly owned corporations like SaskPower. In Saskatchewan and Canada, such corporations are often called Crown Corporations, or "Crowns."

In addition to his caucus oversight of SaskPower, Trew currently serves as Critic for Crown Investments Corporation, SaskEnergy and SaskTel.

SaskPower's 20th August 2008 Request for Proposals for carbon capture technology

www.saskpower.com/cleancoal

Six months after announcing its carbon capture & sequestration demonstration project at unit 3 of the lignite-fuelled Boundary Dam power station in south-eastern Saskatchewan, (CCJ 3, page 6), Saskatchewan Power Corporation issued a request for project proposals on August 20.

SaskPower's 2007 Annual Report controversially claimed precedence as the "first utility in the world to complete a workable demonstration for a large scale near-zero emissions pulverized coal plant." (CCJ 4, page 4)

According to the Report, policy for the 2.969 megawatt utility is set by the Crown Investments Corporation of Saskatchewan, and the SaskPower Board of Directors is accountable to the Government of Saskatchewan's Minister of Crown Corporations.

SaskPower stated on August 20 that "ten companies from across Canada and around the world have been invited to submit proposals for consideration. A shortlist will be compiled by the end of the year, with a carbon capture system to be selected later in 2009."

SaskPower added: "The $1.4 billion government-industry partnership between the Government of Canada, Government of Saskatchewan, SaskPower and private industry will fully integrate a coal-fired generation unit with carbon capture and an enhanced oil recovery operation, resulting in low-emission electricity and CO2 for oil extraction."

SaskPower's "clean coal" statement (see website) scopes Boundary Dam 3 technology and finances:

"If proven viable, the clean coal/carbon capture demonstration project would rebuild Boundary Dam 3 with carbon capture technology, extending its life by approximately 30 years."

SaskPower continues by identifying a key source of unease with Kim Trew's critical Saskatchewan New Democrats:

"In the 2008 budget, the federal government committed $240 million in trust in support of the demonstration project."

In fact, no "trustee" has yet been named publically for the $240 million benefit.

TNO - testing post combustion capture

Dutch knowledge institute TNO has developed a unique multi-purpose pilot plant for testing and developing liquids, contactors and process integration concepts for CO2 capture. TNO is currently testing its 'CORAL' absorption liquid, which promises significant improvements on standard amine solvents.

In April 2008, TNO, the largest knowledge institute in the Netherlands, opened the first multi-purpose post combustion pilot plant in Europe.

The plant was constructed and is being operated by TNO in collaboration with E.ON Benelux, which is also hosting the facility on the site of its coal-fired power plant at the Maasvlakte, part of the harbour and industrial area of the city of Rotterdam.

The test facility is part of CATO, a national publicly and privately funded knowledge network that unites efforts to research and assess the development and implementation of CCS technologies.

The purpose of the pilot plant is to test novel gas scrubbing methods and technologies that can capture CO2 from flue gases under real industrial conditions.

The reliability of process models that have been developed by TNO on the basis of bench scale test data can also be assessed.

The project will give E.ON, TNO and the other CATO partners useful information which they say will help to substantially improve the environmental and economic performance of existing and newly developed processes.

"With this pilot we will prove the industrial performance of a new type of solvent developed by TNO," says Earl Goetheer, Technology Manager CO2 capture, TNO.

"By the end of this year we expect to report significant improvements compared to common amine alcohol based solvents like MEA."

So far, around €2 million has been invested in the plant, about 1/3 financed by the Dutch Ministry of Economic Affairs via the CATO programme.

The pilot plant, at the site of Benelux's coal-fired power plant at the Maasvlakte, Rotterdam where up to 250 kg/hr of CO2 is captured

The pilot plant

The pilot plant is connected to the stack of the second unit of the Maasvlakte power plant after the desulphurisation process.

There are two main elements, an absorption unit with a 20m high column, and a desorption unit with a 16m high column.

At maximum capacity, a 1250 Nm^3/hr flue gas stream is directed to the pilot, where the CO2 is then removed at a rate of 250 kg/hr.

A complete monitoring of the process conditions (temperature, pressure, flows, content of CO2, SO2, soot, etc.) is available for evaluation of test results. Other parameters (such as solvent stability) can be measured separately.

Approximately 90% of the CO2 is captured from the flue gas.

Test Programme

The test facility is first and foremost intended for gaining experience with new absorption liquids, starting with the CORAL absorption liquid developed by TNO, which it says has a low energy requirement and high stability compared to conventional amine-based solvents.

"TNO aims to have its technology ready for full scale implementation in 2015-2020," says Lodewijk Nell, Business Development Manager Energy Sector.

"This pilot is a first step in our scale-up strategy and enables us to deliver our technology to industry for an intemediate scale demonstration in the order of 30-100 MW CO2 equivalents."

"From there we can work towards full scale demonstration. Our novel solvent alone will however become commercially available sooner."

Other, alternative absorption liquids can also be tested. Equally, innovative techniques like membrane contactors can be tested.

The membrane contactors will be located in a bypass flow of the absorption column. The membranes in membrane contactors are nonselective and simply allow for a substantial and guaranteed contact surface in a relatively low-volume unit.

This can make the absorber more compact and cheaper, says TNO.

CATO

The CATO test programme will run until the end of 2008 at least. However, extension of the programme is envisaged.

A workgroup led by TNO has been formed to come up with a proposal for a new programme, dubbed CATO-2.

The main ambition of CATO-2 is to help support the realisation of one or more demo sites where the complete integration of CO2 capture, transport and storage will be demonstrated in The Netherlands before 2015.

In CCJ November / December 2008

A follow-up article, including an update on progress in the test program, will appear in the next isssue of Carbon Capture Journal.

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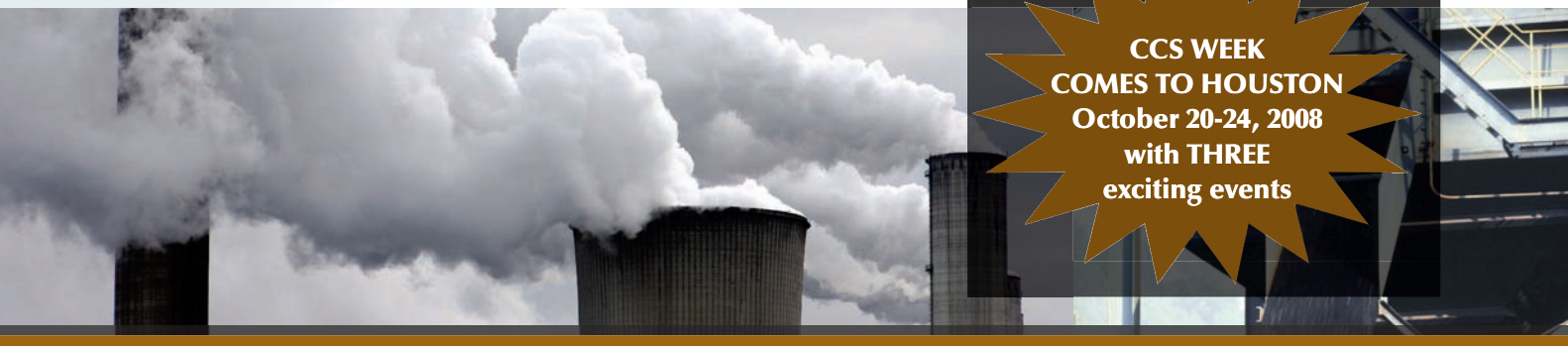

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IEA CCS finance meeting in New York

The IEA Clean Coal Centre, World Coal Institute and the IEA Greenhouse Gas R&D Programme with sponsorship from Chevron held an Expert Meeting on Financing Carbon Capture and Storage (CCS) Projects in New York on 28-29 May.

The meeting was attended by around 80 participants including representatives from the mining, insurance, academic, finance and utility sectors.

The purpose of the meeting was to increase the involvement of US experts from the financial sector in the development of CCS projects.

The meeting provided an opportunity for discussion on the issues that are restricting the development of CCS projects from a financial perspective in North America.

Many of the speakers thought the difficulties and technology issues surrounding CCS can be resolved. However, financial issues were another matter and a major point was that currently in North America from a private investment viewpoint CCS remains a marginal financial option without Government loan guarantees and a legal framework in place to deal with liability issues.

There was also a view that if the US implemented an emissions trading system it was important to use part of the revenue for CCS projects. Relying on just a carbon price would still not be enough to make CCS a financially viable option in the near to medium term

Other important points at the meeting were:

- The view from the investment banks was that there would be no major private investment in CCS in the USA over the next five years unless they can be offered a secure return on their investment, such as loan guarantees or tax credits.
- Development of CCS regulatory frameworks is well underway internationally in a number of regions. The speed of development may be enhanced with the launch of the IEA CCS International Regulatory Network.
- The Interstate Oil and Gas Compact Commission (IOGCC) recommends that in the USA CO2 storage should be regulated as a commodity to allow the application of oil and gas conservation laws to facilitate development of storage projects. The IOGCC has a Task Force that also produced a set of guidelines on permitting CCS projects.
- There are a number of CCS projects underway in North America and future possibilities through the restructuring of FutureGen. In Canada, the Government intends to have new coal fired plants capture ready by 2018.
- There is a perception that an emissions trading scheme will not be enough to accelerate deployment of commercial CCS projects in the future and that other incentives will be required.
- There are several proposals in the USA investigating how to facilitate the deployment of CCS. For instance the proposed bill by Lieberman-Warner has use of some of the revenues from sale of allowances to fund low carbon technology projects including CCS. Further proposals discussed at the meeting were the use of the Bond market and setting up a Trust Fund for CCS.
- There is a clear gap in the USA about a lack of information on CCS with the general public and within the financial sector and hence an urgent need to provide further information and educate people about the risk and benefits of CCS in an informed manner.
- Legal and environmental liability is seen as an issue. Insurance companies do currently have several models that could be applied to CCS but there is no actual template which covers the post operational liabilities.
- Quantifying the actual liability of CCS projects in dollar terms would assist and allow insurance companies a better means of assessing what underwriting is needed. Otherwise until more information is available in the storage and leakage area there is likely to be limited insurance on a 1-2 year revolving contract.
- If financing of CCS is to occur from the private sector then the 30 trillion dollar bond market must be used and this will take time and is unlikely to occur until there are guarantees from the USA Government.

A panel discussion chaired by Preston Chiaro, Chairman of WCI; including Gary Loop, Dakota Gas; Anthony Tarr, Zerogen; and Bruce Braine, AEP

Insurance Panel: Lindene Patton, Chief Climate Product Officer, Zurich Financial Services, Rick Hawkinberry, Senior Vice President, Willis Environmental Practice, Adrienne Atwell, Senior Vice President, Swiss Reinsurance America Corporation, Chiara Trabucchi, Principal, Industrial Economics

Preston Chiaro the Chairman of the meeting thanked the speakers and the World Coal Institute, IEA CCC and IEA GHG for organizing the meeting and Chevron for sponsoring. He said it was interesting to see how the discussion had matured since the meeting in London last year commenting that it was important to recognize that there has been progress, but a lot is still needed to establish CCS projects in terms of regulations, insurance and practical experience in operating CCS plants.

There are also a lot of players ready to move forward but there is a need for urgency and direction from Governments In particular, Governments will need to provide financial support for the first CCS projects.

IEA CCS Summer School

The IEA will be holding a second CCS summer school at Tigh-Na-Mara, near Vancouver, BC, Canada between the 24th and 30th August 2008.

www.co2captureandstorage.info

Carbon capture - leading news

Alberta launches $2 billion CCS fund

environment.gov.ab.ca

The Alberta government is moving forward with its climate change action plan with two new funds totalling $4 billion.

The province will create a $2 billion fund to advance carbon capture and storage (CCS) projects while a second $2-billion fund will foster energy saving public transit initiatives in Alberta.

"We will continue to demonstrate leadership and encourage the federal government and Alberta industries to make real investments in carbon capture and storage" - Premier Ed Stelmach

Funds for the two initiatives will come from this year's surplus, which the province expects will be significantly larger than predicted due to higher than forecast oil and gas prices.

Premier Ed Stelmach said that while other jurisdictions talk, his government's Climate Change Strategy has legislated real targets and real action. "With this announcement we will continue to demonstrate leadership and encourage the federal government and Alberta industries to make real investments in carbon capture and storage."

Alberta's Climate Change Action Plan, which aims to cut projected GHG emissions in half by 2050, is based on three key areas: carbon capture and storage; energy conservation and efficiency; and 'greening' energy production.

Funds will be allocated to encourage construction of Alberta's first large-scale CCS projects. The province has issued a request for expressions of interest to begin identifying those CCS proposals with the greatest potential of being built quickly and those which provide the best opportunities to significantly reduce greenhouse gas emissions.

With the potential to reduce emissions at facilities such as , The $2-billion fund will support CCS projects at coal-fired electricity plants, oil sands extraction sites and upgraders that are expected to reduce emissions by up to five million tonnes annually. That is the equivalent of taking a million vehicles off the road, or one-third of all vehicles registered in Alberta.

In addition, the government estimates that thousands more Alberta vehicles will be taken off streets and highways through $2 billion in public transit investments.

The Green Transit Incentives Program (Green TRIP) will promote the use of local, regional and inter-city public transit. The program will support new public transit alternatives throughout the province that will significantly reduce the number of vehicles on Alberta roads and reduce GHG emissions.

DOE seeks applications for third round of clean coal power initiative

www.netl.doe.gov

The U.S. Department of Energy (DOE) has issued the final Funding Opportunity Announcement (FOA) for Round 3 of the Clean Coal Power Initiative (CCPI) which seeks to accelerate the commercial deployment of advanced coal technologies.

In a statement, the DOE said it anticipates making multiple awards under this FOA and, depending on fiscal year 2009 appropriations, may be able to provide up to $340 million to be distributed among selected recipients.

The projects will be cost-shared, with the award recipients providing at least 50 percent of funds for the project. Applications are due to DOE on January 15, 2009, and selection announcements are anticipated for July 2009.

The FOA is aimed at cooperative agreements between the Government and industry to demonstrate, at commercial scale, new technologies that capture carbon dioxide emissions from coal-fired power plants and either sequester the CO2 or put it to beneficial use.

For Round 3, a draft FOA detailing the goals and requirements was released in October 2007 for comment. To garner input, a public workshop was held on November 1, 2007, with 105 attendees representing utilities, technology vendors, and project developers.

Changes to the final FOA include:

• Carbon capture technologies must operate at 90 percent carbon capture efficiency.

• At least 300,000 tons per year of CO2 must be captured and sequestered or put to beneficial use.

• Projects must show significant progress toward carbon capture and sequestration with less than 10 percent increase in electricity costs.

• Projects must use domestic mined coal or coal refuse for at least 75 percent of energy input.

• Projects must produce electricity as at least 50 percent of the gross energy output.

• Repayment of the Government's share of project costs is not required.

Norway receives EU backing for Mongstad

www.regjeringen.no

Aerial view of Mongstad Photo: Øyvind Hagen / StatoilHydro

The Norwegian government has received the go-ahead from the EU to put more public money into the Mongstad project according to a report from Reuters.

The Mongstad project involves building a CO2 technology test centre in the first stage, followed by a full scale CCS plant capturing CO2 from the flue gas of a CHP (Combined Heat and Power) plant.

The project is a joint venture between the Government, DONG Energy, Shell, StatoilHydro and Vattenfall, with the state owned company Gassnova representing the Norwegian Government.

State aid rules prohibit governments giving more than 50% public aid, but the EU has agreed to waive the rule because the plant will deliver technology vital in the fight against climate change.

Norway is expected to provide up to 80% of the project costs.

Bow City Power Project continues with CCS plans

environment.alberta.ca

The proposed Bow City Power Project (Bow City), a 1,000 megawatt coal-fired power plant located approximately 185 km east of the City of Calgary, will include CCS.

The project is being developed by Bow City Power Ltd. (BCPL) and an application is expected to be submitted Q3 2008, with an estimated on-line date of 2014.

BCPL says Bow City has been designed from the outset to have the smallest feasible carbon footprint, using super-critical combus-

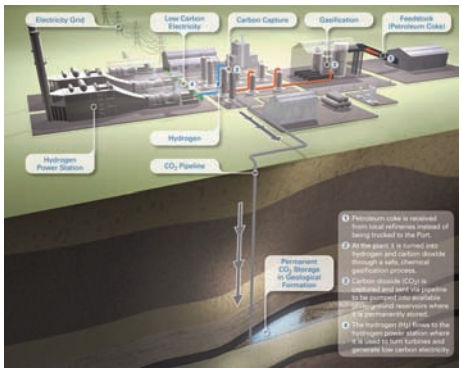
tion technology to generate the lowest level of CO2 emissions per unit of power of any coal-fired power plant in Canada.

The project is continuing with plans to incorporate an amine scrubbing system capable of removing up to 90% of the project's CO2 emissions.

This will move Bow City's carbon emissions well below the requirements being proposed by government and make it Canada's first true "clean coal" power project, said BC-PL.

The scrubbed CO2 is proposed to be permanently disposed of into nearby oil fields for enhanced oil recovery.

Hydrogen Energy applies for hydrogen fuel electric generating facility with CCS



The proposed hydrogen fuel production facility and power plant in Kern County, California.

www.hydrogenenergy.com

Hydrogen Energy International has filed an AFC (Application for Certification) before the California Energy Commission for a proposed hydrogen fuel production facility and power plant in Kern County, California.

Hydrogen Energy International is a joint venture of BP Alternative Energy and Rio Tinto.

The filing initiates a comprehensive regulatory review process and, upon approval, grants permission for the construction of the nation's first industrial-scale low-carbon power plant with carbon capture and sequestration.

The proposed facility will use Integrated Gasification Combined Cycle (IGCC) technology to manufacture hydrogen from petroleum coke (a by-product of the refining process) or blends of petroleum coke and coal, as needed.

The hydrogen will be used to generate nearly 400 gross megawatts of base-load low-carbon electricity. Over 2 million tons of CO2 is expected to be captured and stored in deep underground geological formations annually.

"While we had planned to site the project in Carson, we have concluded that the project will become a reality much faster by locating it in close proximity to Occidental's nearby Elk Hills operations where the CO2 can be injected and stored," said Jonathan Briggs, Regional Director of Hydrogen Energy in North America.

Occidental Petroleum hopes to use the CO2 for enhanced oil recovery in the Elk Hills oil field.

Hydrogen Energy said it is siting this new facility in California because of the State's leadership role in requiring greenhouse gas emission reductions in policy initiatives supported by the Governor, Legislature, and energy regulatory agencies, including the California Public Utilities Commission and the California Air Resources Board.

Additionally, it said it sees Kern County as an ideal location because of the many oil fields that can provide ideal storage conditions for CO2 thus ensuring environmental benefits, as well as providing the opportunity for enhanced oil recovery, thus producing additional economic benefits.

EPCOR and Siemens partner to design near-zero emission IGCC plant

www.epcor.ca

EPCOR Utilities has selected Siemens Fuel Gasification Technology as the technology provider for the design of a coal gasification facility.

It is part of a three-year initiative to design and engineer Canada's first near-zero emission thermal power plant.

The selection is the latest step in the EPCOR-led Front End Engineering and Design (FEED) of an Integrated Gasification Combined Cycle (IGCC) power plant.

Siemens will licence its SFG-500 coal gasifier technology to the FEED project. If subsequent investment and construction decisions go as planned, a 270-megawatt (net) generating station using the new technology would be targeted to commence operations in 2015.

Siemens has operated its gasification technologies for more than 20 years, using a wide variety of energy sources as feedstocks for the conversion process. In 2007, as part of the FEED study, 18 tonnes of coal from Genesee were shipped to Siemens Gasification Test Centre in Freiberg, Germany for performance testing.

The Alberta Energy Research Institute, Natural Resources Canada and EPCOR have each contributed $11 million to the $33 million FEED project, which is located at EPCOR's Genesee Generating Station, 70 kilometres southwest of Edmonton, Alberta.

The FEED project is being conducted in conjunction with the Canadian Clean Power Coalition, which is chaired by Dr. David

EPCOR's Genesee Generating Station, 70 kilometres southwest of Edmonton, Alberta.

Lewin.

In October 2007 the Genesee FEED study became the first project to be supported by the federal government's ecoENERGY Technology Initiative.

The FEED project is currently in its second phase, which is scheduled for completion in 2009. Following completion of the technology design work and financing decisions, EPCOR can enter into an agreement with Siemens to supply the gasification reactor and system components.

EPCOR is preparing an Expression of Interest for the Genesee IGCC project, seeking to qualify under the Province of Alberta's $2 billion program for large-scale carbon capture and storage projects.

E.ON partners for three new pilot plants

www.vattenfall.com/ccs

E.ON Energie will work together with international partners to further develop technologies for separating CO2 from flue gases in three of its power stations in Germany.

E.ON Energie and Cansolv Technologies of Canada will construct one of the new pilot plants in the Heyden power station.

Fluor Corporation will partner for the development of a retrofitted coal-fired CO2 capture pilot plant in Wilhelmshaven.

The third plant will be installed in another of E.ON's German power stations in cooperation with Mitsubishi Heavy Industries.

The three projects join four existing projects that E.ON is pursuing together with Alstom, Hitachi Power Europe, Siemens and TNO.

The goal of all seven pilot projects is to optimise the post combustion capture of CO2 from flue gas. E.ON says its aim in cooperating with different partners is to compare various plant construction methods.

Based on findings from the pilot projects, E.ON Energie plans to determine which of the tested technologies is the best one to further develop for large-scale series production. A key objective is to reduce energy consumption in the capture process.

Cansolv

The goal of the project is the engineering development and testing of an innovative technology for carbon capture from coal fired power plants.

The start-up of operation of the pilot plant, which will be installed at the German Heyden power plant (near Minden in Northrhine Westphalia), is scheduled for the end of 2009.

The fully modularised pilot plant will be delivered by Cansolv completely pre-assembled to Heyden and the total project will cost around EUR 10M.

For the test phase of two or three years, the plant will be operated on a slipstream of roughly 20,000 cubic meters per hour of flue gas – representing nearly one percent of the total flue gas of the plant unit, which has a gross capacity of 920 MW.

Fluor Corporation

The Wilhelmshaven pilot plant will use Fluor's Econamine FG+ carbon capture technology and commence operation in 2010. This will be the first demonstration of the technology on a coal-fired power plant.

One advantage of the chosen CO2 scrubbing technology is the ability to retrofit conventional power plants already in operation, said E.ON.

Fluor's patented and proprietary technology has been demonstrated at commercial-scale facilities for nearly 20 years. The technology uses monoethanolamine (MEA) as the solvent for capture of C02.

Fluor's will further develop the technology for the pilot to adapt this well-proven process to the flue gas conditions of coal-fired power plants.

The pilot plant will be designed for a flue gas volume flow of about 16,000 cubic meters per hour.

At the same Wilhelmshaven site a second project is also planned, called "50plus", to develop a coal-fired power plant which is expected to achieve an efficiency of more than 50 percent by 2014, the highest of any coal plant in the world at this time.

Mitsubishi Heavy Industries

This pilot, at an undisclosed plant in Germany, will establish a new MHI design for the first time. It will be operated on a slipstream of around 20,000 cubic meter per hour from the flue gas of a coal fired power plant, starting operation in 2010.

The test program will look at reductions in steam demand and steam quality requirements for the CO2 separation processand investigate the behaviour of the solvent operated with typical flue gas from coal combustion.

Overall costs of the pilot project are estimated to be EUR 10M.

HTC Purenergy signs global licensing agreement with Doosan

HTC Purenergy has signed a Global Licensing Agreement for carbon capture and storage technology with Doosan Babcock Energy of the UK, and with Doosan Heavy Industries and Construction of South Korea.

The agreement includes the right to use CCS products and technologies developed by HTC in collaboration with the University of Regina's International Test Centre for Carbon Dioxide Capture (ITC) in Regina, Saskatchewan, Canada.

Doosan Babcock and Doosan Heavy will also subscribe to a CDN $10 million Private Placement for a 15% equity share ownership in HTC, and a seat on HTC's Board of Directors.

The CDN $10 million investment will primarily be used by HTC at the University of Regina to integrate leading edge CO2 capture technology and with supplemental engineering resources from Doosan, will further technology development for efficient carbon capture capable power plants.

The agreement means that Doosan Babcock now has both pre and post combustion technology capabilities within its portfolio to reduce CO2 emissions from power stations.

Policy, company and regulation news

WCI welcomes G8 emphasis on CCS

www.worldcoal.org

The World Coal Institute (WCI) has welcomed G8 support for the role of technologies in tackling climate change, specifically the importance of CCS technology.

The coal industry has widely embraced CCS technology as a way to maintain coal as a primary source of fuel in power production in a carbon constrained world.

Milton Catelin, Chief Executive of WCI, congratulated G8 leaders on their commitment to tackling climate change, whilst emphasising the importance of sustainable economic development and energy security objectives.

"G8 leaders have clearly acknowledged that we cannot tackle climate change without investment in and acceleration of clean energy technologies. G8 support of carbon capture and storage technology, in particular, is vital and the coal industry welcomes the positive statements from Hokkaido," said Mr Catelin.

However, more is needed, he said, "Governments should be under no illusions. A low carbon energy system - regardless of the technology – is more expensive than existing energy systems."

"Indeed, a low carbon energy system is even more expensive if CCS is excluded. But early investment in CCS saves money over the long run and, even more importantly, it speeds up our ability to make a significant difference in climate change mitigation."

"It is therefore essential that climate rhetoric is matched with action by investing more in CCS technology."

The World Coal Institute has outlined 'Five Key Steps Needed to Implement CCS':

1. Government support for early commercial-scale CCS demonstration projects
2. Regulatory and policy clarity
3. Inclusion of CCS in the Kyoto Protocol and National Emissions Trading Schemes
4. Public education around the risks and benefits of CCS
5. International cooperation on CCS

"As the International Energy Agency has repeatedly emphasised over the past few months, the deployment of CCS should be a 'litmus' test for the seriousness of environmental negotiators dealing with the climate challenge. They have highlighted that without CCS, climate policy will not succeed," continued Mr Catelin.

"The commercial availability of CCS by 2020 will only be possible with the early deployment of multiple commercial-scale CCS demonstration plants. Public policy intervention in the form of additional financing mechanisms is required to address the higher costs associated with first-of-a-kind power plants."

"Benefits from CCS demonstration projects will accrue to the whole of society in the form of lower climate stabilisation costs," concluded Mr Catelin.

Australia publishes Carbon Pollution Reduction Scheme green paper

www.climatechange.gov.au

The green paper outlines the Australian Government's approach to the design of a national emissions trading scheme – Australia's Carbon Pollution Reduction Scheme.

This will be a cap and trade system which it says is a market based approach that is more flexible and lower cost than regulation alone.

The Government intends to reflect its final decisions in a white paper, accompanied by exposure draft legislation, to be released in December 2008.

The Government proposes to provide a limited amount of direct assistance to existing coal-fired electricity generators, because it says they will be the firms most likely to be strongly affected.

It will deliver this assistance, in part, through a new mechanism called the Electricity Sector Adjustment Scheme (ESAS).

To ensure a simple system that does not require detailed knowledge of individual asset characteristics, any assistance would be determined on the basis of the generator's capacity, and whether it uses black or brown coal.

The reports highlights the potential benefits from developing new clean coal technologies, in particular the development of commercially viable carbon capture and storage (CCS).

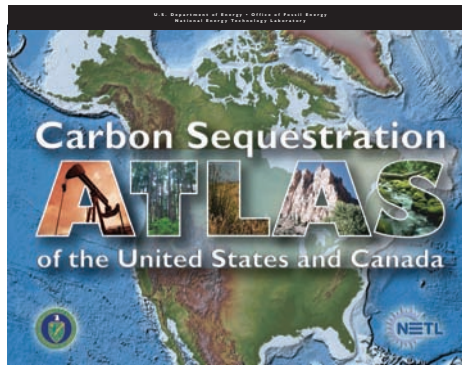
Commercially viable CCS would assist current coal-dependent regions to grow and prosper, it says. As a major coal exporter, Australia has a key interest in supporting the development of CCS to enable coal to be used in a way that does not compromise the global climate change objective.

The Government has already provided funding to CCS via its $500 million Clean Coal Fund.

Stakeholders are encouraged to engage in the consultation process by registering their interest and making a written submission by 10 September 2008.

DOE sequestration atlas wins publications award

www.fossil.energy.gov



The U.S. Department of Energy's Carbon Sequestration Atlas of the United States and Canada has won an APEX Grand Award recognising publication excellence.

The atlas, the first coordinated assessment of carbon capture and storage potential across the majority of the United States and portions of Western Canada, is presently being updated and is expected to be re-released in November 2008.

Communications Concepts Inc., which sponsors the APEX awards, selected the winning entries based on "excellence in graphic design, editorial content, and success of the entry . . . in achieving overall communications excellence and effectiveness."

The Carbon Sequestration Atlas earned a Grand Award in the category of non-profit, one-of-a-kind publications.

DOE's National Energy Technology Laboratory created and jointly developed the atlas with its Regional Carbon Sequestration Partnerships, along with the National Carbon Sequestration Database and Geographical Information System.

The atlas provides an overview of carbon dioxide's lifecycle through the entire capture and sequestration process. It also summarizes DOE's sequestration activities, as well as the activities of DOE's Regional Partnerships, and it details the most current and best available estimates of geologic carbon dioxide storage potential.

UK Environmental Audit Committee reports on CCS

www.parliament.uk

The UK Government must set a deadline for coal-fired power stations to adopt CCS or face closure, said the Environmental Audit Committee (EAC) in its Ninth Report of Session 2007-08.

The EAC said the Government cannot rely on the carbon price alone to create the incentives necessary to drive the development and deployment of CCS.

It must set a deadline after which the operation of unabated coal-fired power stations will no longer be permitted. Without such action the Government will be very unlikely to meet its own carbon reduction targets, the EAC concluded.

The Committee said that CCS has the potential to contribute significantly to emissions reductions, and could play a decisive role in reducing emissions both domestically and internationally.

However progress on CCS has been regrettably slow, it said. The future take-up of the technology is far from certain and it is not clear when, or if, CCS will be available.

The Committee concluded that the current momentum for new coal-fired plant is failing to take adequate account of the environmental impact of coal and the challenges of developing CCS.

There is a very real danger that the development of new coal-fired power stations could leave the UK 'locked-in' to high levels of emissions for decades to come. Coal must be seen as a last resort, and the possibility of CCS technology must not be used as a fig leaf to give unabated coal-fired power stations an appearance of acceptability.

The Committee insisted the Government should make clear to industry that it will not permit the operation of unabated coal-fired power stations in the longer-term. There is no guarantee that the carbon price will reach a sufficient level to make CCS cost-effective.

It called on the Government to set a date by which emissions from all power stations will have to a particular standard or face closure.

By setting such a deadline and making its intentions clear the Government will send a vital signal to the power generation industry about the future of coal and the importance of developing and retrofitting carbon capture and storage.

The Committee also considered the definition of 'CCS ready', where a power station is granted planning permission on the condition that it can accommodate the retrofitting of CCS technology and infrastructure at a future date.

It concluded that there was no guarantee that a plant approved on this basis would actually be willing or able to retrofit CCS once the technology had been demonstrated on a commercial scale. Without a deadline for the retrofitting of CCS, the Committee believes that planning permission granted on the condition of CCS readiness is meaningless.

New CCS research group at Durham University

www.dur.ac.uk

Durham University has started the Carbon Storage Research Group, which will be led by the newly-created position of Professor of Carbon Capture and Storage (CCS) and Energy.

Researchers aim to find efficient and reliable ways of gathering CO2 from fossil-fuel fired power plants and storing it in former oil and gas fields or aquifers indefinitely so it cannot add to global warming.

The new professorship is a three-way partnership between Durham University's Centre for Research into Earth Energy Systems (CeREES), DONG Energy and Ikon Science.

Durham hopes to attract a leading figure in the area of carbon capture and storage to take on the role.

Durham's work in the field of green energy includes research into wind and wave power, solar energy, biofuels and the social implications of new and renewable energy

Professor Chris Higgins, Vice-Chancellor of Durham University, Brent Cheshire, Managing Director of DONG Energy (UK) Ltd and Martyn Millwood Hargrave, Chief Executive of Ikon Science, signed an agreement confirming the professorship in a ceremony at Hollingside House, Hollingside Lane, Durham City, in July 2008.

Oklahoma gives carbon credits for CO2 injection

www.cco2.org

The State of Oklahoma is the first state in the US to formally authorize issuance of carbon credits for underground injection of CO2.

The Carbon Council of Oklahoma (CCO2) assisted the Oklahoma Conservation Commission in establishing a procedure approved by the Governor earlier this month for issuing carbon credits for underground injection of carbon dioxide (CO2) and other emission reduction activities.

Oklahoma has been using CO2 for enhanced oil recovery (EOR) since the early 1980s, and federal government estimates show that Oklahoma has between 9 and 20 billion additional barrels of oil reserves that could be produced by injecting carbon dioxide into depleted reservoirs.

The Carbon Council of Oklahoma (CCO2) is a non-profit trade association promoting the economic development of the carbon industry in Oklahoma by encouraging carbon capture and storage of CO2 for enhanced oil recovery (EOR), assisting government officials in developing proper CO2-related policies, aiding EOR operators in obtaining carbon credits, and facilitating educational efforts regarding carbon dioxide.

MHI receives FEED contract for Norway Kårstø plant

www.mhi.co.jp

Aerial view of Kårstø Photo: Øyvind Hagen / StatoilHydro

Mitsubishi Heavy Industries (MHI) has signed a contract with Gassnova to carry out Front End Engineering and Design (FEED) studies for the planned CO2 capture plant at Kårstø, Norway.

If the FEED study meets the qualification criteria, MHI will take part in the competition for constructing the CO2 capture facility.

The planned facility will capture approximately 3,000 tons of CO2 from flue gas emitted from an existing 420 MW gas fired power generation plant in Kårstø, which is located on Norway's southwest coast.

Based on the FEED contract, MHI will compete with other companies on CO2 capture technology, performance of the facility and construction and operation costs of the planned CO2 recovery plant.

While CCS facilities with recovery capacities of several hundred tons/day have already been operated in other countries, including the U.S., the planned facility in Norway will be approximately ten times larger.

MHI says its technology for absorbing and desorbing CO2 from flue gas using its proprietary KS-1 solvent involves considerably lower energy consumption compared with other processes.

Since delivering its first overseas CO2 recovery plant to Malaysia in 1999, the company has provided or is providing the technology to India, the United Arab Emirates, Bahrain and Pakistan.

Blue Source get $500 million funding for CCS investments

Blue Source, North America's portfolio of greenhouse gas verified emission reductions and CCS projects, has formed a strategic investment partnership with affiliate investment funds of Och-Ziff Capital Management Group to fund the development of carbon infrastructure projects.

Norway launches major CO2 capture research program

A scientific research and development program worth more than NOK 300 million is being launched in Norway with the aim of generating more cost effective technology for CO2 capture

SINTEF, the independent research organisation, The Norwegian University of Science and Technology (NTNU) and Aker Clean Carbon, the industrial technology company, have signed an agreement for an eight-year science and development program called SOLVit.

The program has a total financial value of NOK 317 million.

"SOLVit makes SINTEF and NTNU able to consolidate the position as Europe's leading science cluster for CO2-management," says Ms Unni Steinsmo, chief executive of SINTEF.

Gassnova, the Norwegian government's vehicle for CO2 management, has approved financial support of NOK 34 million for the first phase of the project, which runs until the end of 2010.

The research will focus on chemical processes that can capture CO2 from the process industry and emissions from coal and gas powered power stations.

The SOLVit program aims to generate better and more cost effective processes and chemicals to manage CO2 emissions from these facilities.

International energy companies have been invited to participate in the program. These will provide useful input from the perspective of the facility operator.

Results from the development research in the new laboratory in Trondheim will be tried out in test centres and hopefully also in full-scale facilities already in the first phase of the program.

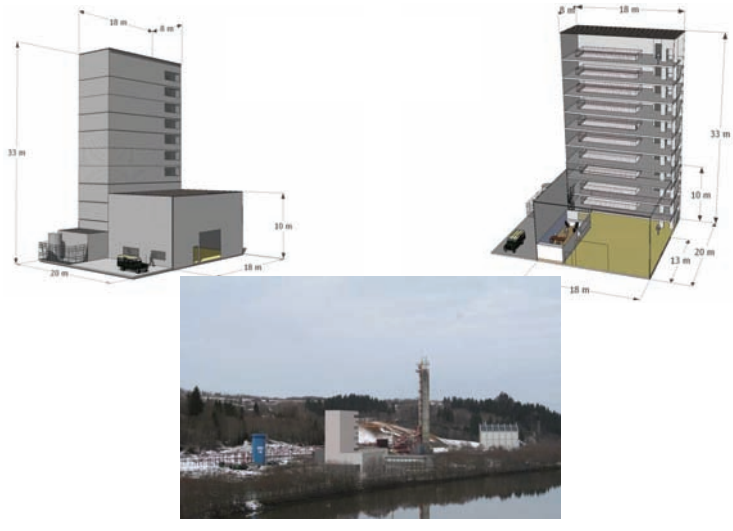
"The programme includes building a large laboratory facility that will strengthen our standing in the international arena and improve our position in competition for financial support for scientific research from institutions such as the European Union," says Ms Steinsmo

Aker Clean Carbon and SINTEF have together developed many chemical solutions based on amines, a chemical that has the ability to cleanse CO2. One of these solutions is already ready to use. Phase one of SOLVit will be used to test the other amine solutions under development by Aker Clean Carbon and SINTEF.

"We have a clear goal to bring the cost of CO2-capture and cleansing down significantly. In phase two and three of SOLVit, the parties will try to introduce new chemical solutions and elements to the process in order to generate cost cuts. The aim is to come up with a process facility for CO2-capture that can operate on half the energy consumption of today's processes," says Jan Roger Bjerkestrand, chief executive of Aker Clean Carbon.

The program also includes building a new laboratory at Tiller in Trondheim, which will cost NOK 42 million. SINTEF will provide NOK 25 million of the equity for the new laboratory, which will be situated next door to SINTEF's multi-phase laboratory.

The lab will be a test centre for pilot projects, including a 30 metre tall tower and processing column 25 metres high, identical to the height needed in full-scale industrial facilities. The lab will also be available for other of SINTEF's domestic and international customers and partners.



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"Results from the research in the new laboratory in Trondheim will be tried out in test centres and hopefully also in full-scale facilities already in the first phase of the programme." - Ms Unni Steinsmo, chief executive of SINTEF.

The SOLVit-programme will also involve the testing of chemicals and processes in a mobile capture facility, which has been developed by Aker Clean Carbon and is currently being built at Aker Verdal. The mobile facility is large enough to process parts of emissions from power stations and industrial sites in periods of several months at the time.

SINTEF and NTNU have already established laboratories for small-scale testing of CO2-capture. This means Norway will be among the few countries with a complete set of laboratories in this area, from testing in the lab to pilot runs at semi-industrial scale.

Using the program as a basis, NTNU will offer positions to six doctoral candidates and ten master students within the subject of CO2 capture.

SOLVit has a budget of NOK 317 million and is led by Aker Clean Carbon. The financing is a joint effort by Aker, which is the main partner, and other industrial partners, Gassnova SF which participates through the public CLIMIT program, and SINTEF and NTNU.

CSIRO launches post combustion pilot in Beijing

CSIRO and its Chinese partners have officially launched a post-combustion capture (PCC) pilot plant in Beijing. It begins the process of applying the technology to Chinese conditions and evaluating its effectiveness.

www.csiro.au

The pilot plant at the Huaneng Beijing Co-Generation Power Plant is designed to capture 3000 tonnes per year of CO2.

CSIRO's partners in the Beijing pilot project are China's Huaneng Group and the Thermal Power Research Institute (TPRI).

The project will focus on assessing the performance of an amine-based pilot plant under Chinese conditions.

"It will allow PCC technology to be progressed in the Chinese energy sector which will have a much greater impact than operating in Australia alone," says Dr David Brockway, Chief of CSIRO's Energy Technology Division.

"The next steps in the research would be moving to a much larger demonstration phase, before then progressing to a full scale system."

The installation of the PCC pilot plant in Beijing is a CSIRO Energy Transformed Flagship research project which receives funding from the Australian Government through the Asia Pacific Partnership on Clean Development and Climate initiative (APP).

The APP program for PCC also includes a pilot plant installation at Delta Electricity's Munmorah power station on the NSW Central Coast, with an additional Queensland site currently under negotiation.

The Australian Government's APP support for PCC research is $12 million, $4 million of which supports this work in China.

CSIRO is also undertaking PCC research outside the scope of the APP program with a A$5.6 million project in the Latrobe Valley, which focuses on brown coal.

The pilot plant at the Huaneng Beijing Co-Generation Power Plant

Capture news

StatoilHydro and Nordic Mining collaborate on CO2 capture

www.basinelectric.com
www.powerspan.com

Nordic Mining and StatoilHydro have entered into a cooperation agreement for development of new technology for capture of CO2 in minerals.

The agreement comprises a joint program for development and testing of the use of CO2 in processing of various minerals, hence increasing the value of the extracted minerals.

New commercial mineral products may emerge from the technology development.

The companies will conduct laboratory tests, and design a pilot plant which could lead to further industrial activity.

Initially, the scope of work includes testing and development based on Nordic Mining's anorthosite deposit in Gudvangen in the Sogn and Fjordane county.

The companies will also explore possibilities of CO2 capture using eclogite from the Engebøfjellet rutile deposit, also in Sogn and Fjordane.

"The agreement is a part of our focus and initiatives related to new alternatives for carbon capture from energy production. A main goal in the project is to transfer CO2 from waste to a valuable product," says Brage W. Johansen, StatoilHydro New Energy.

DOE to provide $36 million to advance CO2 capture

The DOE will provide $36 million for 15 projects aimed at furthering the development of new and cost-effective technologies for the capture of CO2 from the existing fleet of coal-fired power plants.

Some of the technologies to be investigated include:

Membrane-based CO2 capture using permeable or semi-permeable materials that allow for the selective transport and separation of CO2 from flue gas.

Solvent-based CO2 capture involving chemical or physical sorption of CO2 from flue gas into a liquid carrier. Solvent-based systems are in commercial use today scrubbing CO2 from industrial flue gases and process gases; however, they have not been applied to removing large volumes of CO2, as would be encountered in the flue gas from a coal-fired utility boiler.

Solid particles can be used to capture CO2 from flue gas through chemical absorption, physical adsorption, or a combination of the two. Possible configurations for contacting the flue gas with the solid particles include fixed, moving, and fluidized beds.

Oxycombustion systems combust a fuel in pure or nearly pure oxygen, producing a flue gas that has high CO2 concentration but may also include water, excess oxygen, nitrogen, sulfur oxides, nitrogen oxides, mercury, and other contaminants.

The characteristics of oxycombustion have not yet been fully developed. Oxycombustion flame characteristics, burner and coal-feed design, and analyses of the interaction of oxycombustion products with boiler materials are all areas needing further work.

Chemical looping involves the use of a solid oxygen carrier particle in the combustion of fuels. The oxygen carrier particle is oxidized in one reactor and is used to combust the fuel in another reactor.

Solvent Degradation in CO2 Capture Process from Power Plant Flue Gas

The efficiency of the CO2 absorption process in power plants can be affected by solvent degradation through a range of contaminants. This paper looks at the consequences and how a range of additives can help remediate the problem.

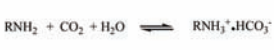
Maoqi Feng, Division of Chemistry and Chemical Engineering, Southwest Research Institute, San Antonio, Texas

Flue gas from power plants is responsible for more than 1/3 of the US emissions, and for about 7% of the world's carbon dioxide (CO2) emissions.

CO2 comprises approximately 15% of flue gas from conventional fossil fuel combustion processes, therefore, it is important to separate the CO2 from other flue gas components prior to storage, because it is too expensive to compress and store the total flue gas output from a power plant.

The most widely used method for the capture and separation of CO2 on an industrial scale is chemical absorption by scrubbing using an aqueous solution of monoethanolamine (MEA), or blended with secondary amine, diethanolamine (DEA), or tertiary amine, methyldiethanolamine (MDEA), as a solvent.

In this method, the amine solution, e.g., MEA absorbs CO2 through chemical reaction in an absorber column (Equation 1). Heating the CO2-rich amine in a separate stripper column can drive off the CO2 absorbed by MEA because the reaction is reversible. The MEA is then recycled back in the process.



(1)

However, a major problem in the chemical absorption using MEA is the degradation of the solvent through irreversible side reactions with CO2 and other flue gas components, which leads to some problems with the process.

Typically coal-fired power-plant flue gas is composed of 14% CO2, 5% O2, 81% N2, 300 – 3000 ppm SOx, and 100 – 1000 ppm NOx, and 1000 – 10000 mg/m^3 fly ash particulate, etc.[1]

Fly ash is fine particulates in flue gas that consist of inorganic oxides such as SiO2, Al2O3, Fe2O3, CaO, MgO, Na2O, K2O, and P2O5.

A typical composition of flue gas from a natural gas turbine contains 4% CO2, 15% O2, 81% N2, 1 ppm SOx, 100–500 ppm NOx, ~ 10 mg/m^3 particulate matter. Because of the complexity of the flue gas composition, MEA degradation by coal-fired flue gas is a complicated process.

MEA degradation by components in the flue gas

To achieve an economical and efficient process of CO2 absorption, it is essential to have a solvent that is stable under a wide range of conditions. However, the amine solvent undergoes degradation when exposed to coal-fired power-plant flue gas.

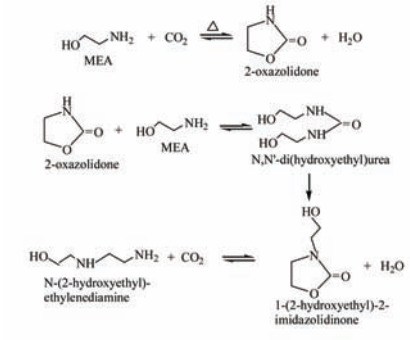
Typically there are three types of degradation for the amine solvent: thermal, carbamate oligomerization, and oxidative.[2]

Thermal degradation occurs at above 200°C, and acetaldehyde is an intermediate in the degradation of MEA. This might be a problem for CO2 capture from flue gas (Equation 2).

(2)

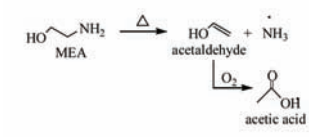
Carbamate oligomerization occurs in stripper column, which operates at higher temperature in the presence of CO2. 2-oxazolidone is formed at first (Equation 3), and it will react with another MEA molecule to form N-(2-hydroxyethyl)-ethylenediamine via intermediates of N,N'-di(hydroxyethyl)urea and 1-(2-hydroxyethyl)-2-imidazolidinone (Equation 4).[3]

Only primary amine and secondary amine will form carbamate with CO2, tertiary amine will not because there is no hydrogen atom bound to the nitrogen atom.



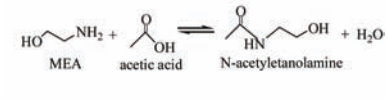
(3) (4)

Oxidative degradation occurs in the presence of oxygen, results in fragmentation of the amine solvent, which is catalyzed by the presence of dissolved metals such as iron or copper. In presence of O2, the primary degradation product of MEA is ammonia, followed by various aldehydes, which will be oxidized to carboxylic acids (Equation 5).[4]



(5)

The acetic acid produced will react with MEA to yield N-acetylethanolamine (Equation 6),



(6)

The rates of MEA solvent degradation, under typical CO2 capture conditions, increases with temperature.

The presence of SO2 and O2 in the flue gas drastically affects solvent stability. The rate of MEA degradation increases with SO2 and O2 concentrations.[5]

The percentage extent of MEA degradation can be evaluated based on the factors that affect the rate of MEA degradation, such as SO2 concentration, O2 concentration, and temperature. The percentage of MEA degradation can be calculated with the equation as shown below:

$$\text{MEA degradation (\%)} = 100 \times (C_i - C_t)/C_i$$

Where C_i is the initial concentration and C_t is the concentration at time t.

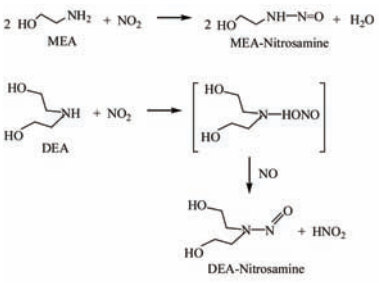
Experiments showed that MEA degradation increased with the rising of the concentrations of SO2 and O2 in the gas phase and MEA in the liquid phase,[4] whereas an increase in CO2 loading in the liquid phase produced an inhibition effect to MEA degradation. Sulfate may be produced by as a byproduct, which will precipitate to form a solid in the stripper bottom.

Carbonyl sulfide (COS) might present in flue gas.[6] DEA degrades by reacting with COS to form MEA. The formation of MEA and the low boiling degradation compounds appears to be initiated by the absorption and hydrolysis of COS.

In presence of CO2 and H2S, MDEA can be degraded in aqueous solution in the

same manner as DEA.

NO2 in the flue gas will react with MEA to yield nitrosamines (Equation 7), which are known carcinogens. Nitrosamines were found to be present at a concentration of 2.91 µmol/mL in lean MEA solution.[5]



(7)

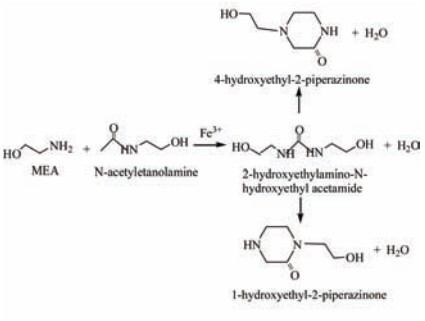
Halogen acid HX (typically HCl) is the combustion product of halogens that are present in the feed. HCl reacts easily with amines through simple acid-base reactions to form heat stable salts, which will precipitate to the bottom.

During the operation of CO2 capture, corrosion inhibitors are often added to the solution. Corrosion inhibitors used are primarily heavy metal based, such as copper salts and vanadium salts. The presence of a corrosion inhibitor vanadate, NaVO3, is detrimental to MEA and acts as a catalyst to accelerate MEA degradation.5

Fe^{3+} ions exist in the solution during the operation of CO2 capture from flue gas due to corrosion. Iron is a catalyst in oxidation of MEA to NH3 as shown in Equation 6.

In presence of Fe^{3+} cations, the N-acetylethanolamine formed in Equation 6 will react with another MEA molecule to form 2-hydroxyethylamino-N-hydroxyethyl acetamide, which may eliminate a water molecule internally to form a six-member ring.

There are two possible ways to eliminate a water molecule from 2-hydroxyethylamino-N-hydroxyethyl acetamide: a hydroxyl group on the left with a hydrogen atom on the right amine group to form 4-hydroxyethyl-2-piperizinone, or a hydroxyl group on the right with a hydrogen atom on the left amine group to form 1-hydroxyethyl-2-piperizinone (Equation 8).[3]



(8)

One obvious consequence for the degradation of MEA is valuable amine solvent loss. Typically it requires the replacement of ~2.2 kg of MEA per tonne of CO2 captured.[4] In the meantime, it leads to operational problems, such as foaming, fouling, and increased viscosity of the amine.

In the existing CO2 capture facilities that use MEA, the degradation products are separated in an evaporative reclaimer and disposed of as hazardous chemical waste, leading to increased disposal costs.

For carbon capture and sequestration by MEA absorption, the most significant problem rendered by MEA degradation is corrosion caused by the degradation products.

To keep machinery corrosion rates at an acceptable level, the concentration of MEA must be kept low (typically under 20% for coal boilers and ~30% for natural gas-derived flue gas if corrosion inhibitors are employed).

Because low MEA concentration reduces the effectiveness of the solvent, large equipment sizes and faster circulation rates are necessary in large scale. In addition, more energy is required in the stripping column to raise the temperature and regenerate the amine.

The increased parasitic load is of particular concern for carbon sequestration. In addition to being an additional cost, production of this extra energy leads to some CO2 emissions, which decreases the overall benefit of sequestration.

A sensitivity analysis in literature indicates that increasing the concentration of MEA from 20% to 70% will cut the parasitic load on a power plant by more than one-half.[5]

Remediation of MEA degradation

It is important for CO2 absorption industries to reduce various costs such as supplying new amines, replacing the lost amines due to evaporation or chemical degradation, repairing the corrosion damages, operation problems and also, regeneration of used amine solutions.

During the CO2 capture process of absorption and desorption, MEA degradation will cause contaminants accumulation in the system and reduction in efficiency and operational problems due to the closed loop nature of the system.

Piperazine is an effective promoter in industrial processes of CO2 absorption. However, piperazine can also react with CO2 directly and produce piperazine carbamate. Some piperazine derivatives, e.g., 1-methylpiperazine (MP), 1-benzylpiperazine (BP), 1-diphenylmethylpiperazine (BHP), were found to be effective as corrosion inhibitors for steel in acid media.[7]

The experimental order of inhibition efficiencies is BHP > BP > MP > piperazine. This trend of inhibition efficiencies is related to the geometric structures of the inhibitor molecules. An additional π–d orbital interaction with parallel phenyl group in BHP molecule results in better inhibition effect.

Piperazine

Besides the flue gas pretreatment, which will remove some contaminants, there are five types of remediation action:

(i) add inhibitors for the oxidation degradation of MEA. The possible O2 scavengers and reaction inhibitors are: quinine, manganese salts, ascorbic acid, Na2SO3, formaldehyde, etc;[8]

(ii) partially purge the contaminated solution and replace it with fresh amine;

(iii) inject caustic solution to free the amines bound up as heat stable salts and some CO2-induced degradation products;

(iv) add small amount of organic corrosion inhibitors, e.g., imidazole and/or piperazine derivatives, the latter act as a corrosion inhibitor and CO2 adsorption promoter;

(v) replace the entire volume of contaminated solution, this will be the most expensive method.[9]

Conclusions

During the post-combustion capture of CO2 by methanolamine (MEA) solvent for large fossil fuel fired power stations, due to the presence of a range of contaminants, solvent degradation is a problem for this process because the solvent recycle rate will be lower, thus it will greatly affect the efficiency of the amine unit operation.

Solvent degradation by the contaminants in flue gas can be remedied by pretreatment of the flue gas before entering the absorption tower.

To make the process of CO2 capture from flue gases more efficient and cost effective, additives are required to add into the solvent, such as oxidizing inhibitors to enable the solvent being used in an oxidizing environment, piperazine and derivatives to use as promoter making the CO2 absorption more efficient and as corrosion inhibitors as well.

Imidazole and piperazine derivatives are cost-effective, low-toxic corrosion inhibitors, which could replace highly toxic, heavy metal corrosion inhibitors (vanadium compounds), e.g., sodium metavanadate,

which is a conventional corrosion inhibitor and commonly used in amine absorption units.

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Transport and storage news

Enhance Energy to build Alberta CO2 pipeline

www.enhanceenergy.com

Enhance Energy, an Alberta-based energy company specialising in enhanced oil recovery (EOR), plans to build a new CO2 transmission system through the central part of Alberta.

The Enhance CO2 Pipeline System will be capable of gathering CO2 from several sources in Alberta's Industrial Heartland and transporting the CO2 to existing mature oil fields in South-Central Alberta.

The CO2 will be used for EOR to increase production and will ultimately be permanently stored in the reservoir. The initial supply of CO2 will by provided by North West Upgrading and Agrium.

The project establishes a cooperative partnership where one industry relies on the waste products of another. By storing their emissions, North West Upgrading and Agrium have the lowest CO2 profiles for projects of their type in the world.

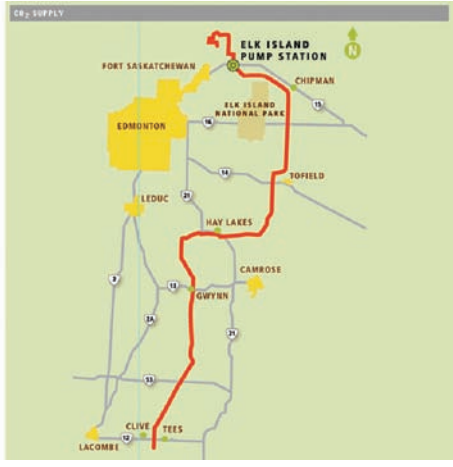
The system will be designed for capacity expansion and delivery flexibility, the company said.

It will have a design capacity of 25,000 tonnes per day with the initial throughput planned at 5,000 tonnes per day.

It will consist of:

• drying and compression facilities at the north end in the Heartland Industrial Region on the Agrium and North West Upgrader sites, which will process the CO2 that will be collected and bring the product up to pipeline specifications

• a pump station east of Fort Saskatchewan in the Heartland Industrial Region, to be called the Elk Island Pump Station, that will boost pressure on the pipeline system



The Enhance CO2 Pipeline System will be capable of gathering CO2 from several sources in Alberta's Industrial Heartland and transporting the CO2 to existing mature oil fields in South-Central Alberta.

• a pipeline operations and control centre located at the Elk Island Pump Station

• receipt facilities at the south end of the system which will allow distribution of the CO2 to the conventional oil and gas fields in the area

• a high vapour pressure (HVP) pipeline between the source and the delivery point, connecting the north and south facilities.

Enhance anticipates regulatory applications for the proposed project to be completed by spring of 2009, and depending on the timing of regulatory approval, construction is expected by the end of 2009, with operational startup in 2011.

Contracts for the design and project management of the new system have been awarded to Sunstone Projects. Other technical and support contracts have been awarded to Synergas Technologies for facilities engineering.

EPA proposes CO2 storage regulations

www.epa.gov

The US Environmental Protection Agency (EPA) has proposed the creation of a new class of injection well, Class VI, to regulate the long term storage of CO2.

The proposed rule lays out the technical criteria for geologic site characterisation, monitoring and corrective action, well construction and operation, mechanical integrity testing, post-injection site care and site closure for the purposes of protecting underground sources of drinking water.

The proposal builds upon the existing Underground Injection Control (UIC) regulatory framework, with modifications based on the unique nature of CO2 injection.

These include:

• Geologic site characterisation to ensure that GS wells are appropriately sited;

• Requirements to construct wells with compatible materials and in a manner that prevents fluid movement into unintended zones;

• Periodic re-evaluation of the area of review around the injection well to incorporate monitoring and operational data and verify that the CO2 is moving as predicted within the subsurface;

• Testing of the mechanical integrity of the injection well, ground water monitoring, and tracking of the location of the injected CO2 to ensure protection of underground

sources of drinking water;

• Extended post-injection monitoring and site care to track the location of the injected CO2 and monitor subsurface pressures;

• Financial responsibility requirements to assure that funds will be available for well plugging, site care, closure, and emergency and remedial response.

The proposal is open for public comment for 120 days, and the rule will be finalised in 2010 or 2011.

Schlumberger introduces CO2 resistant cement

www.slb.com/evercrete

Schlumberger has developed a new cement that is resistant to CO2 attack under the conditions found in CO2 storage projects underground.

EverCRETE CO2 resistant cement is specifically engineered to ensure long-term performance in wells with high concentrations of carbon dioxide in either wet or gaseous states.

It is highly resistant to CO2 attack under wet supercritical CO2 and CO2-saturated water conditions typically encountered in carbon geological storage projects or CO2 injection well applications, which cause rapid degradation of standard oilfield cements.

EverCRETE cement can be prepared in a standard bulk plant and its density can be tailored to most well requirements. The new system can be pumped as a tail-slurry across the CO2 injection zone or used as a lead-slurry to protect the casing string from CO2 attack in front of any reservoir with CO2 content, all using standard equipment.

Extensive lab-testing of EverCRETE cement was performed under diphasic conditions (wet supercritical CO2 and CO2 water saturated) up to 110°C (230°F) and 280 Bar (4,061 psig). These tests positively demonstrated no signs of degradation, said Schlumberger.

DNV developing first CO2 pipeline standard

www.dnv.com

DNV, together with major industry partners, is developing a new standard for transportation of CO2 in pipelines.

Specific issues related to CO2 in dense, high pressure phase are not covered in existing pipeline standards or regulations.

DNV has therefore initiated a specific industrial collaboration to develop a standard reference guideline for the onshore and submarine pipeline transmission of dense, high pressure CO2.

In order to meet the urgent needs of upcoming CCS initiatives, the guideline will be ready within 18 months.

The project's partners are StatoilHydro, BP, Shell, Petrobras, Vattenfall, Dong Energy, ArcelorMittal, Gassnova, Gassco and ILF. The Technical Reference Group consists of government representatives from the UK, the Netherlands and Norway. The European Commission is also supporting this DNV initiative.

The novel issues related to the onshore and submarine pipeline transmission of dense, high pressure CO2 will be covered. The point of departure will be existing pipeline standards for the transmission of hydrocarbons, such as ISO 13623 and DNV OS-F101.

The guideline is intended to help designers and operators limit and manage uncertainties and risks related to the pipeline transmission of CO2 by incorporating current knowledge related to both offshore and onshore operations.

It will state rules for managing risks and uncertainties throughout the pipeline's lifetime, including the design, testing, inspection, operation, maintenance and de-commissioning phases. It will also incorporate the lessons learned from existing and previous projects.

"Due to the features lacking in the current industry standards, this project's scope of work is related to issues like safety, fast propagating ductile fractures, fatigue crack growth, pipeline operation conditions, flow assurance, corrosion and material compatibility," says Mr Eldevik.

CO2 storage test begins in West Virginia

www.energy.vt.edu

The project team will inject around 1000 tonnes of CO2 into the Central Appalachian coal seams.

A test designed to prove that unmineable coal seams are suitable for CO2 storage has begun in Russell County, West Virginia, US.

Around 1000 tonnes of CO2 will be injected into the coal seam in a $4.4 million project. Monitoring to ensure the CO2 does not leak will continue until January 2009.

A further larger test involving injecting 100,000 tonnes of CO2 and costing up to $100 million is planned.

The Virginia Center for Coal and Energy Research (VCCER), Congressman Rick Boucher, CNX Gas and the Russell County Board of Supervisors hosted a formal groundbreaking ceremony at the site of what will be the first test of carbon storage in Central Appalachian coal seams.

The VCCER leads the research team for this project, which is funded by the National Energy Technology Laboratory of the US Department of Energy, through the Southern States Energy Board, and is part of the Southeast Carbon Sequestration Partnership (SECARB).

A similar test is planned for the Black Warrior Basin in Alabama.

Providence and Star Energy start Ulysses project

Providence Resources, an Irish oil and gas production and development company has started the 'ULYSSES Project', a study to evaluate the carbon sequestration and natural gas storage potential of the Kish Bank Basin, offshore Ireland.

The study is being carried out on a 50/50 joint venture basis with Star Energy Group, which is a wholly-owned subsidiary of Petronas, the Malaysian National Oil Company.

Star Energy is a leading UK gas storage company, with gas storage developments both onshore and offshore United Kingdom and Western Europe.

The Undersea Large-scale Saline Sequestration and Enhanced Storage (ULYSSES) Project has been designed to assess the potential use of Triassic aged saline sandstone reservoir sequences as possible sites for carbon sequestration.

The presence of saline reservoirs which are located around 1.5km below the seabed together with overlying sealing shale has been demonstrated in a number of oil and gas exploration wells which have been drilled in the Kish Bank Basin, approximately 20km offshore Dublin, over the past 30 years.

Providence and Star Energy were recently awarded a three year Licensing Option over eight blocks in the Kish Bank Basin by the Irish Government Department of Energy, Communications & Natural Resources.

The agreed work programme will focus on the oil and gas exploration potential of the basin while the ULYSSES Project will specifically assess the potential for underground saline reservoirs in the Kish Bank Basin to be used as sites for CO2 sequestration as well as natural gas storage.

CO2 injection begins in DOE New Mexico project

The U.S. Department of Energy (DOE) and its Southwest Regional Partnership (SWP) have begun storing CO2 in a large coalbed while simultaneously recovering natural gas

www.fossil.energy.gov

The SWP plans to inject up to 35,000 tons of CO2 in a 6-month demonstration at the San Juan Basin near Navajo City, New Mexico.

Unlike other enhanced coalbed methane recovery projects, this demonstration will develop ways to maximize permanent storage of the injected CO2.

Many coalbeds in the United States are saturated with natural gas (methane), but the gas is difficult to produce because methane chemically binds to coal. However, CO2 shares this same tendency to bind to coal.'

Injecting CO2 into the coalbed essentially displaces the methane and makes the gas easier to produce. This process is called enhanced coalbed methane recovery.

The San Juan Basin was selected for the project because it is considered one of the top-ranked basins worldwide for coalbed methane recovery and thus is also a prime candidate for value-added CO2 sequestration.

Its advantages include favorable geology, high methane content, available CO2 from nearby power plants, low capital and operating costs, and well-developed natural gas and CO2 pipelines.

The San Juan basin contains coals that are exceptionally permeable, at least compared to other regional coalbeds. Due to the tendency of coal to swell when in contact with CO2, high initial coal permeability is required to maintain effective CO2 injection rates (high injectivity) over time.

The DOE considers high injectivity as a program goal for large-scale, low-cost CO2 sequestration in coal.

The injection site consists of three coalbed methane–producing wells and a centrally located injection well. The coals, which occur at depths of approximately 3,000 feet, are about 75 feet thick and are split among three seams over a 175-foot interval. This area of the San Juan coalbed fairway had previously undergone significant coalbed methane production.

The San Juan Basin was selected for the project because it is considered one of the top-ranked basins worldwide for coalbed methane recovery and thus is also a prime candidate for value-added CO2 sequestration.

In addition to the CO2 injection, the SWP intends to make use of the project's produced water. Coalbed methane production typically results in a great deal of produced water. The SWP plans to take some of this produced water, desalinate it, and use it to irrigate nearby riparian areas stressed by prolonged drought. Resulting vegetation growth should induce additional CO2 uptake, another form of carbon sequestration.

The SWP is led by the New Mexico Institute of Mining and Technology, and includes the states of Colorado, Oklahoma, New Mexico, Utah, and portions of Arizona, Kansas, Texas, and Wyoming.

The partnership is currently conducting five field tests—three geologic and two terrestrial—all at various stages of planning and execution. Each is designed to validate the most promising carbon sequestration technologies and infrastructure concepts.

Carbon Capture & Storage

SHOWCASING THE OPPORTUNITIES AND NECESSITY FOR CO2 STORAGE

ABU DHABI, UNITED ARAB EMIRATES, 28-29 OCTOBER 2008

G8 is looking at investing more than US$10bn a year to support new technologies to reduce CO2 emissions, including CCS. Huge research and investment into CCS technologies is occurring worldwide. This event will showcase both international and regional case studies and provide a clear framework for what is happening in the rapidly changing world of CCS, bringing together global expertise.

The inaugural Carbon Capture & Storage conference has assembled a powerful panel of industry experts from global developments to showcase the opportunities and necessity for successful CO2 storage. The audience will be made up of keen investors from private equity and venture capital concerns, along with governmental representatives and executives from the utility and power generation industry. This forward looking event aims to bring timely issues to the fore and will provide delegates with a clearer picture of the role CCS will play in the future of the power generation industry.

Learn from leading CCS experts, including:

Jean Beaudoin, Executive Vice President, Office of the President, SNC-Lavalin

Peter Verhulst, Senior Technical Manager, Shell E&P International

Mohammed Al-Sabban, Senior Advisor to the Minister of Petroleum and Natural Resources, Saudi Arabia

Dr Hisham Khatib, Honorary Vice Chairman, World Energy Council and Chairman, Electricity Regulatory Commission of Jordan

Sam Draper, Engineering Technical Leader, GE Energy

Gilles Munier, Chief Executive Officer, Geogreen

Iain W Wright, Carbon Dioxide Project Manager, BP Alternative Energy

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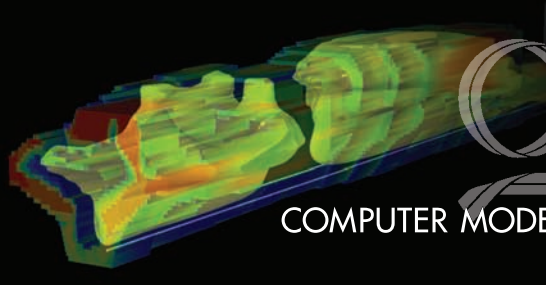

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