carbon capture journal

May / June 2013 Issue 33

CCS in Canada

Alberta Government - leading the CCS charge

CCEMC - supporting technology innovation

Carbon Management Canada research

Aquistore project

CO2 Solutions - capturing carbon with enzymes

AspenTech software in action at TCM Mongstad

IEA - global progress on clean energy stalled

Bellona - the future of CCS in the European Union

Reducing the costs of carbon capture - CCJ conference report

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Reducing the cost of carbon capture & storage

Conference presentations now available online

What is the potential for reducing the costs of CO2 capture? How do we make CCS cost competitive?

Agenda

- Philippe Micone, global sales manager, Cansolv, with an update on the SaskPower Boundary Dam Project

- Harsh Pershad, energy consultant, Element Energy - latest developments with carbon capture

- Gernot Schneider, director marketing and sales, Carbon Capture Sequestration, Siemens - on technical challenges and cost reduction potential for post-combustion carbon capture

- Prateek Bumb, CTO, Carbon Clean Solutions, on developing new CO2 capture solvents

- Basia Kielska, Business Development manager, ClydeUnion Pumps, on developments with centrifugal pump design

- Dr Mathieu Lucquiaud, Associate Programme Director, MSc in Carbon Capture & Storage, The University of Edinburgh, on reducing the cost of absorber columns, DECC sponsored research

- Lord Oxburgh, honorary president of the Carbon Capture and Storage Association, and former chairman of Shell - where we are with carbon capture

- Panel discussion - how do we get people talking more about carbon capture and how has carbon capture developed over the past year

Download talks at: carboncapturejournal.com/mar2013.htm

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Front cover: Installing the permanent seismic monitoring array at the Aquistore site. Aquistore will serve as the storage site for the world's first commercial post-combustion CO2 capture, transportation, utilization, and storage project from a coal-fired electric generating facility.

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Innovation and leadership – Alberta's carbon capture and storage program

The Alberta government is investing $1.3 billion in two projects to advance CCS - Enhance Energy's Alberta Carbon Trunk Line connecting North West Upgrading's refinery with EOR projects near Edmonton, and the Quest project to capture and store CO2 from a bitumen upgrader involving Shell, Chevron and Marathon Oil.

Alberta has drawn a lot of attention – both internationally and within Canada – for its oil sands reserves, which are also the bulk of Canada's oil reserves. Oil sands are a naturally occurring mixture of bitumen, sand, clay or other minerals and water. A heavy and extremely viscous oil (an API gravity of less than 10), bitumen must be extensively upgraded before it can be used. Of Alberta's total oil reserves of 168.7 billion barrels, about 99 per cent is oil sands and the remaining one per cent is conventional crude oil.

Alberta's carbon capture and storage story begins with the province's boom in oil sands development, and a growing worldwide demand for greener energy production and reduced greenhouse gas emissions. The majority of Alberta's greenhouse gas emissions were from large industrial emitters, including oil sands, conventional oil and gas and coal-generated electricity.

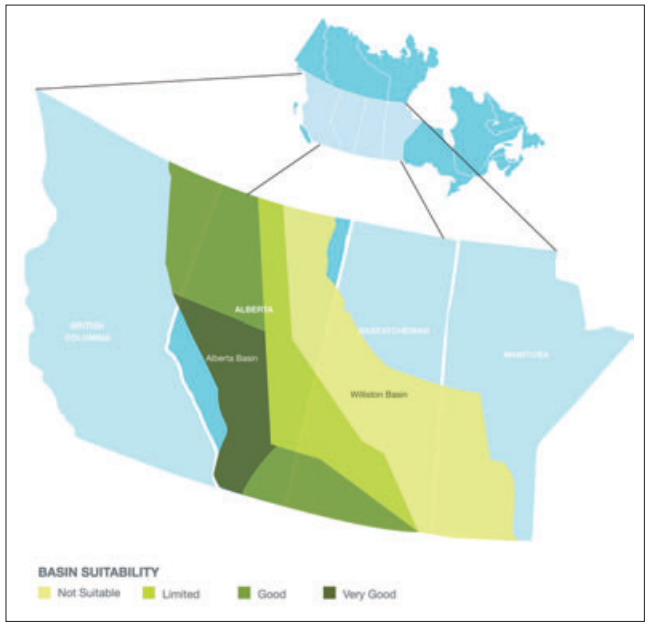
Because of this, Alberta became the first jurisdiction in North America to regulate emissions reductions from all large industrial emitters and put a price on carbon. In the Alberta government's Climate Change Strategy, carbon capture and storage was identified as a key technology in reducing the province's contribution to climate change, alongside energy conservation and greening energy production initiatives.

Fortunately, the same geology that provides the province with its oil and gas wealth is also ideal for carbon capture and storage, and CCS became a key plank in helping the province meet its climate change goal. The Alberta Sedimentary Basin, part of the Western Canadian Sedimentary Basin, is estimated to have a 46 gigatonne CO2 sequestration potential. It includes several types of formations suitable for long-term sequestration, including deep saline formations, depleted oil and gas reservoirs and unmineable coal seams.

Leading the CCS Charge

In 2008, the provincial government formed the Alberta Carbon Capture and Storage Development Council, which recommended Alberta take concrete steps to enable CCS in the province. In 2009, the Alberta government passed a bill that dedicated up to $2 billion towards large scale CCS projects. The funding was intended to incentivise and expedite the development of CCS in the province.

From there, steps were made to update several pieces of legislation to allow for CCS, including a contentious move to declare all pore space property of the Crown. While many landowners perceived that pore space was being taken away from them, the legislation defined ownership of pore space for the first time in Alberta, and allowed lease of that space to companies undertaking large scale carbon sequestration projects.



The map of Canada's western provinces shows that Alberta has the ideal geology for CCS

Another bold step taken by the Alberta government in its CCS program was agreeing to assume the long-term liability of post-closure sequestration sites. In the same amendments that clarified pore space ownership, the government made a policy decision to take on liability for the sequestration sites once a post-closure certificate had been issued.

This was based on the length of time the carbon dioxide was to be stored, and the assumption that the government is a more permanent entity than companies that might undertake CCS activities. The monitoring, measurement and verification guidelines outlined in the revised act help to minimize risks associated with the sequestered CO2.

Political support for CCS has also meant ongoing government commitment to funding large-scale projects, even with fiscal pressures and competing potential uses for the funding. Despite calls to put an end to the program, Ken Hughes, Alberta's Energy Minister does not waver: "CCS remains a key part of Alberta's commitment to reducing greenhouse gas emissions and the responsible development of our energy resources," he says. Hughes has not lost sight of Alberta's climate change commitments and the need to spur innovation in the province's multi-billion dollar oil sands industry.

Alberta has taken a collaborative approach in the development of its CCS program, participating in information sharing through global organizations such as the International Energy Agency, Plains CO2 Reduction Partnership, the Global CCS Institute and the Carbon Sequestration Leadership Forum.

Additionally, Sandra Locke, an Assistant Deputy Minister with Alberta Energy, is chairing the development of the world's first international standards for CCS for the International Organization of Standardization. In this process, 16 countries will be focusing on developing standards across several areas, including capture, transport and storage.

Alberta's Large Scale Carbon Capture Projects

With $2 billion allocated to spur large-scale CCS projects, the Alberta government announced four projects in 2011. The initial

projects were meant to reduce five million tonnes per year from oil sands upgrading and coal fueled electricity generation.

Unfortunately, in 2012 and 2013, private sector partners decided not to move forward with the coal-fired electricity projects due to market conditions. Despite the availability of government funding, this showed that these projects still need to make economic sense to the companies investing thousands of manpower hours and millions of dollars in undertaking them.

In total, the Alberta government will invest $1.3 billion over a 15-year period (2010 to 2025) on the two projects underway. The funding program has been designed in a way that the projects receive funding only when certain benchmarks have been achieved and verified. This provides the safeguards to provincial taxpayers that the projects are meeting the targets they set. The verification activities are ramping up as the companies undertaking the projects are entering their construction phase.

Enhance Energy is building a 240-kilometre Alberta Carbon Trunk Line connecting North West Upgrading's planned Sturgeon Refinery and a fertilizer plant just outside of Edmonton with enhanced oil recovery projects south-east of Edmonton. The Sturgeon Refinery will focus on upgrading bitumen, and will be the first refinery in Canada to have built-in carbon capture capacity. The project is estimated to cost nearly $1.2 billion, with the company contributing $640 million, the Alberta government investing $495 million over 15 years, and the Government of Canada contributing $63.3 million.

The Quest project, a partnership of Shell, Chevron and Marathon Oil, involves retrofitting an existing bitumen upgrader outside of Edmonton for CCS and then piping the CO2 64 kilometres north where it will be permanently sequestered more than two kilometres below the surface. The project is estimated to cost $1.35 billion, with the Quest partners contributing $485 million, the Government of Canada $120 million and the Alberta government $745 million.

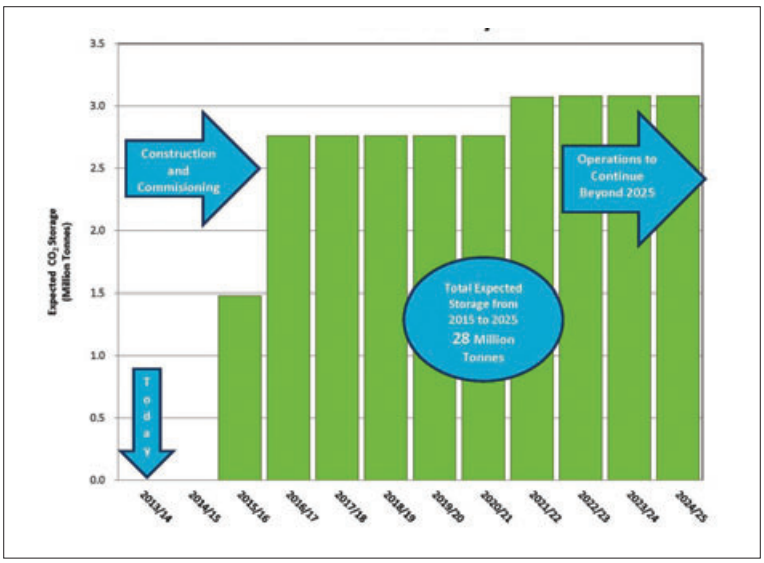
Each year, project proponents are required to share detailed information with the Alberta government, which will be reviewed and then shared on a public website. Through this process, the specialized technical knowledge gained through capturing carbon dioxide from bitumen upgraders is expected to drive down the cost of future technologies.

This in turn will drive down the cost of reducing carbon emissions from the oil sands. Another hallmark feature of the projects is information sharing requirements, which have been built into each of the funded projects to allow them to inform future CCS projects in Alberta and around the world.

Workers at an in situ oil sands operation in northern Alberta, Canada

Committed to Success

The government-funded projects will begin injecting CO2 in 2015, and by 2016, they are expected to reduce emissions by a total of 2.76 million tonnes per year, which is the equivalent of taking 550,000 cars off the road. The province is focused on the projects' success, and ensuring that they are carried out in the safest and most environmentally responsible way possible.



Alberta's CCS projects are slated to begin injecting CO2 in 2015. This graph outlines Alberta's projected annual emissions reductions from CCS

Over the past two years, the Alberta government has conducted a Regulatory Framework Assessment that looked at the current rules for CCS in Alberta and best practices from around the world. Over 100 global experts on CCS, including representatives from industry, environmental groups, scholars and government worked on this review.

The final report from the Assessment has not been released yet, but it is expected that its findings and recommendations will help strengthen all aspects of CCS within Alberta – including planning, monitoring, safety, environmental protection and the long-term needs of the storage site.

While the report itself is awaiting public release, Alberta's Department of Energy is being lauded for the collaborative process it used to complete the Regulatory Framework Assessment. For the Assessment, four working groups examined key areas of CCS regulation in-depth and developed recommendations, which were then vetted by a panel of five world-renowned experts for technical feasibility and refinement.

A steering committee made up of senior leaders from industry, academia and government was responsible for leading the process and approving the final conclusions and recommendations. This robust process, with many feedback loops between the steering committee, expert panel and working groups, has created a report that will be a roadmap to a comprehensive and efficient regulatory process for CCS in Alberta.

By the time projects begin injecting CO2 in 2015, the combined output of Alberta's conventional oil and crude bitumen will equal three billion barrels per day. Carbon capture and storage, alongside the province's existing environmental regulations, will help the province reduce its greenhouse gas emissions and maintain its social license for ongoing resource development. Through ongoing planning and leadership, the projects could be just the beginning for CCS in Alberta.

More information
alberta.gov.ca

CCEMC supports carbon capture in Alberta

The Climate Change and Emissions Management (CCEMC) Corporation has launched an international $35 million grand challenge to find innovative uses for carbon.

The world's growing demand for energy presents an opportunity for Canada and for the province of Alberta. Alberta has tremendous energy resources including coal, shale gas, natural gas and of course, oil. According to some estimates, there is between 1.7 to 2.5 trillion barrels of bitumen in the Alberta oil sands.

But there is more to this story than supply and demand. Concerns about climate change impacts are continuing to escalate. When we factor in the need for the world to continue to increase energy production from fossil fuels to support growing demand, it becomes very clear that the world must reduce greenhouse gas emissions.

Canada is responding. The country is a signatory to the Copenhagen Accord with a national target of 17% reduction in greenhouse gas emissions by 2020 against a 2005 baseline.

Meeting that target is no small challenge. In Alberta's oil sands, emissions per barrel continue to drop, but increasing production from the oil sands to meet rising global energy demand means that absolute emissions are going up.

"The solution to lowering emissions in strong fossil fuel economies rests with the development of innovative new technology," says Climate Change and Emissions Management (CCEMC) Corporation Chair Eric Newell. "Carbon capture will play a critical role in efforts to reduce emissions from fossil fuels in Alberta."

The CCEMC provided $2 million for an initiative led by GE, the University of Alberta and Alberta Innovates–Technology Futures for a demonstration project using ceramic membrane-based technology for the capture of sequestration quality carbon in syngas streams. Dr. Steve Kuznicki (second from left) from the University of Alberta led the effort.

The need for clean technology

The main sources of emissions in Alberta are all tied to fossil fuels. Roughly 20 per cent of the province's emissions are from the oil sands, with an additional 20 per cent from fossil fuel production and an additional 20 per cent from power generation.

Energy is the backbone of the province's economy. While resources are developed by the private sector, they are owned by Albertans and energy is the main source of revenues in the province.

Alberta has made tremendous strides in its efforts to reduce greenhouse gas emissions. The province created its first Climate Change Action plan in 2002 and it was the first jurisdiction in North America to legislate mandatory greenhouse gas emissions reductions for large emitters.

The effort has resulted in progress and in February, the province indicated that it has reduced greenhouse gas emissions by 32 megatonnes over the past six years.

Carbon capture in Alberta

Alberta's goal is to reduce annual emissions by 200 megatonnes by 2050. Based on current plans, carbon capture and storage is expected to achieve up to 70 per cent of that target.

Carbon capture is a priority given the growing demand for fossil fuels and the global imperative to reduce greenhouse gas emissions. The technology also holds enormous potential because the province has the right geological formations needed to sequester carbon dioxide.

There are two direct applications for carbon capture in the oil sands - upgrading and Steam Assisted Gravity Drainage, or SAGD.

Shell Quest is the world's first oil sands carbon capture project. It aims to capture and store about 1 million tonnes of carbon dioxide per year from an oil sands upgrader. It is scheduled to begin operations in 2015.

Shell Quest will be a watershed moment for industry. By all indications this project will prove that carbon capture and storage technology can be applied to upgraders in the oil sands.

The other direct application for carbon capture is linked to the biggest source of emissions in the oil sands, SAGD. SAGD uses steam to reduce the viscosity of bitumen so it can be pumped to the surface. There are a number of carbon capture tech-

nologies being tested for SAGD. At this point the costs are still considerable and applying carbon capture to SAGD could prove to be even more costly than applying carbon capture to upgrading.

Funding for carbon capture through CCEMC

Alberta's provincial government is providing financial support for two significant projects, Shell Quest and the Alberta Carbon Trunk Line, a 240-km pipeline that will carry carbon dioxide from a fertilizer plant and oil sands refinery to central Alberta, where it will be used for enhanced oil recovery.

In addition to support for these significant carbon capture projects, Alberta is also fostering the development of clean tech and carbon capture through the Climate Change and Emissions Management (CCEMC) Corporation. It's an independent not-for-profit organization that provides ongoing, dedicated funds to support the discovery, development and deployment of transformative technology.

Funding for the CCEMC is collected from industry. Since 2007, Alberta companies that annually produce more than 100,000 tonnes of greenhouse gas emissions are legally required to reduce their greenhouse gas intensity by 12 per cent.

Companies have three options to meet their reduction target. They can improve the efficiency of their operations, buy carbon credits in the Alberta-based offset system or pay $15 dollars into the Climate Change and Emissions Management Fund for every tonne they emit over the reduction limit.

The funding is segregated from public accounts and by legislation must be dedicated to reducing GHG emissions or projects that will support the province in adapting to climate change. Funding is also sustainable as industry must renew their compliance annually.

As of January 2013, the CCEMC had received about $316 million from the fund. Each year, revenues flow to CCEMC from the fund and each year, the CCEMC invites proposals for new projects.

Since 2003, the organization has committed more than $181 million to 48 clean tech projects that are valued at nearly $1 billion. To date, the CCEMC has announced support for nine carbon capture projects and with an investment of more than $21.5 million, it represents an important part of the organization's portfolio.

The CCEMC has focused on projects that have the potential to reduce the costs associated with carbon capture. One of the CCEMC carbon capture projects that is now complete was led by HTC Purenergy. They've developed a modular carbon capture plant, the Purenergy CCS® System that captures emissions generated from natural gas-fired boilers at oil sands SAGD operations.

"The more oil sands operations expand, the more need there is for a good capture solution," explained Jessie Inman, who served as Executive Director of Corporate Development with HTC Purenergy when she spoke about the project in 2010. "These units allow companies to scale their CO2 emissions capture over a number of years instead of installing one mega project to capture them all at once."

Once captured, the carbon dioxide can be transported and used to help enhance oil recovery in other locations. "One modular plant can capture up to 1,000 tonnes of CO2 a day," said Inman. HTC Purenergy used the CCEMC funding to demonstrate the feasibility of the approach.

Other CCEMC carbon capture projects include a bench scale project by CO2 Solutions that draws on technology that is based on the use of an enzyme that functions in humans to manage carbon dioxide during respiration, called carbonic anhydrase. When introduced in a packed tower scrubbing system, the technology improves carbon dioxide capture efficiency with low energy solvents. It has strong potential as an economic solution to large-scale reduction of carbon dioxide emissions, particularly from in situ oil sands operations.

A pilot at Cenovus' Christina Lake called the Suncor OTSG Oxy-fuel demonstration project captures carbon dioxide from once-through steam generators (OTSG) that can be deployed at commercial scale for in-situ bitumen production.

Another project, led by Inventys captures carbon dioxide in a steam boiler and has the capacity of transporting it and using it in for enhanced oil recovery. It is a novel technology to capture low concentration carbon dioxide from flue gas [rotary adsorption technology] and could provide cost effective solutions for carbon capture in coal and natural gas fired power plants.

$35 million Grand Challenge for innovative carbon uses

Now the CCEMC is seeking innovative ideas from around the world for a $35 million open innovation challenge. The grand challenge aims to create new, carbon-based products and markets. It is expected to identify multiple technologies that could provide significant reductions in greenhouse gas emissions by transforming carbon from a liability into an asset.

If captured carbon is repurposed and becomes an enabling starting material instead of a waste stream, new markets will arise and may serve to create revenues that would offset costs associated with carbon capture.

"We are seeking credible, bright ideas from around the world that will repurpose carbon and use it as a starting material, helping Alberta to create a market for carbon use," said CCEMC Chair Eric Newell. "The approach could deliver significant reductions in greenhouse gases, complement other greenhouse gas reduction strategies, strengthen our economy and enhance Alberta's competitiveness."

For the CCEMC, ultimate success in the challenge will result in technologies that can provide or exceed a net reduction in greenhouse gas emissions of one megatonne.

The CCEMC Grand Challenge offers three rounds of funding that total $35 million over a five-year period. The first round, with submissions due by July 15, 2012, offers grants of $500,000 each, for up to 20 projects. The winners will be announced in March 2014.

While submissions are being invited from around the world, all technologies must be applicable to Alberta. All technical solution providers will maintain their intellectual property.

The second round of the competition is also an open call for submission and will provide $3 million each for up to five projects that have successfully advanced their technologies. The final round will identify a winner of the Grand Challenge, selected from the second round finalists, who will be provided a $10 million grant to assist in establishing and commercializing their technology.

The CCEMC will help connect winners of each round of funding with an ecosystem of support that includes mentors, business developers, venture capitalists and potential partners.

"We are witnessing how industry-wide open innovation and collaboration can dramatically accelerate and improve environmental performance in the oil sands, a key economic driver for Canada," said Dr. Dan Wicklum, chief executive of Canada's Oil Sands Innovation Alliance (COSIA). "The grand challenge represents a unique opportunity to bring the same kind of leading-edge thinking to the development of new technologies to unlock the potential of Canada's energy economy in an environmentally responsible way."

More information

www.ccemc.ca

Carbon Management Canada builds reputation for research excellence

In the short three years since its inception, Carbon Management Canada (CMC) has established a reputation as the 'go to' organization for research and information about carbon management R&D in the Canadian academic sphere.

"We are working closely with major Canadian emitters who have identified us as the portal of choice to the Canadian and world academic community," says Dr. Steve Larter, Scientific Director of the national research network headquartered at the University of Calgary.

The network, which got its start in 2009 with $25 million from the Canadian government's Networks of Centres of Excellence program and a further $25 million from the Government of Alberta Environment's Ecotrust Department, funds research to develop technologies to reduce carbon emissions in the fossil energy sector and from other large industrial emitters.

CMC currently funds 44 research projects for a total committed contribution of $22 million. Although the majority of projects focus on the development or improvement of technologies, researchers are also working in the social sciences including economics, policy, risk communication and at use-inspired basic research.

"While many people consider carbon management as 'carbon capture and storage', and we have invested a lot in the CCS area, we are much broader than that," says Larter.

The network funds research in four separate but overlapping areas or themes.

Theme A research focuses on reducing emissions by developing more energy efficient operations and CO2 capture in plants that extract and process fossil fuels and in material processing plants such as cement.

Theme B scientists are looking for insights that will lead to breakthrough technologies in areas not traditionally associated with the energy industry – disciplines like biology, nanotechnology and genomics.

Theme C is focused on safe and secure storage of CO2 related to geological sequestration and Enhanced Oil Recovery, but also in binding CO2 to mine tailings and other means of storage and transformation.

Theme D researchers are examining areas such as policy studies, public engagement, innovation strategies and regulatory and pricing mechanisms.

But, points out Richard Adamson, CMC's Managing Director, to be effective research must move beyond the walls of the lab. So the company is also intent on helping researchers develop partnerships or working relationships with industry stakeholders. "We are focused on identifying transfer to practice opportunities and then working with those researchers to find appropriate ways to further develop their technologies. The objective is to reduce carbon emissions, not just to publish papers."

Dr. Greg Dipple, University of British Columbia, with Dr. Ian Power, PDF, and Anna Harrison, PhD student

Reducing energy consumption in industrial processes

A key direction in carbon mitigation is reducing energy requirements in industrial plant processes. Theme A leader John Grace, Canada Research Chair in Clean Energy Processes at the University of British Columbia, points out that decreasing energy demand is a key way to reduce greenhouse gas emissions.

One particularly promising project within Theme A is a large multi-university endeavor to develop a novel integrated gasification and CO capture process using new composite sorbent pellets for use in pre and post-combustion processes to generate a pure stream of CO2 for storage. The new system is intended to both improve energy efficiency and reduce the costs of capturing carbon by utilizing chemical looping of solid sorbents in dual fluidized beds.

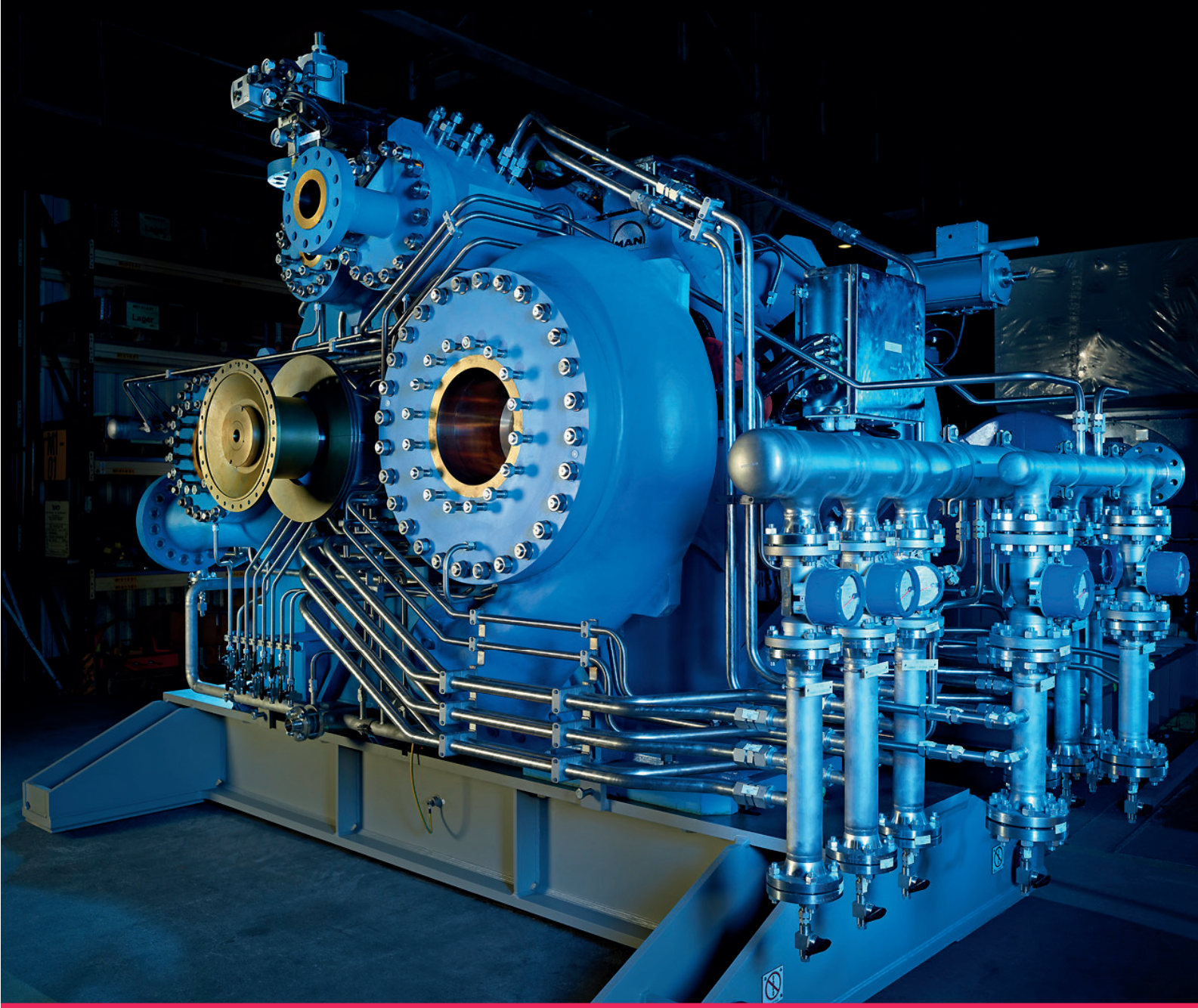
"This project is ambitious and unique in combining the efforts of researchers from nine universities working to radically revise a process that has been practiced for decades by both integrating gasification with solid sorbent CO2 capture and using novel catalysts," says Grace.

A second Theme A project focuses more narrowly on solid sorbents for CO2 capture, using modern nano-particle technology and advanced computer modeling to guide the choice and design of metal organic frameworks (MOFs). The MOFs is intended to trap and release CO2, in the presence of water vapor, with more efficiency and at lower cost than existing methods.

Two projects under the Secure Carbon Storage umbrella (Theme C) are working to accelerate CO2 removal through carbon mineralization processes in hard rock min-

Actions speak louder than words

High pressure CO_2 gas compression



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ing wastes and in mine tailings. Dr. Greg Dipple, at the Earth, Ocean and Atmospheric Science Department in the University of British Columbia, is accelerating mineralization processes in tailings by increasing the concentration of CO2 supplied to a slurry similar in chemical composition to tailings process water. Results show a 200-fold increase in rate over atmospheric weathering of some minerals by increasing the concentration of CO2 in the slurry to 10%.

In Quebec, Dr. Guy Mercier is using waste mine rock to capture CO2 from industrial flue gases. The chemical reaction that occurs in the flue gas stream turns the rock (concrete can be used as well) into a carbonate byproduct that can be sold for use as a refractory material or as an alkaline agent in waste treatment. So companies in the steel, coal, cement and oil and gas industries might profit while sequestering CO2.

Tracking injected CO2

Much of CMC's work focuses on improving CO2 measurement, monitoring and verification methods. The goal, says Don Lawton, head of Theme C and Canadian Society of Exploration Geophysicists Chair at the University of Calgary, is to develop protocols and technologies for tracking what injected CO2 is doing in the reservoir as well as what is happening in the cap rock. "Ultimately we want to know, if you have a containment issue at depth, how quickly can you see it."

Not all potential reservoir rock beds are the same and CMC researchers are developing techniques and technologies that will provide better monitoring in difficult situations. "At Sleipner for instance," says Lawton referring to the Sleipner gas field and carbon storage site off the coast of Norway, "they are using only seismic to monitor CO2 and are getting good results." In Alberta with a different geology, seismic is not sensitive enough on its own to detect small changes. Refining seismic and developing other complimentary monitoring methods is therefore critical to the advancement of CCS in Canada and confidence in CCS around the world.

One researcher is undertaking one of the world's first studies of the effects of in-situ CO2 phase changes (gas, liquid and super critical) on the seismic properties of rock. While seismic monitoring has been able to detect the motion of CO2 underground at different sites, there is insufficient knowledge about the effects of CO2 phase changes on the seismic rock properties to properly interpret field observations.

On the east coast of the country, Dr. David Risk of St Francis Xavier University is developing patented sensor housings, called forced diffusion chambers, that allow for direct sensing of CO2 at the surface above storage sites in extreme conditions such as harsh Arctic and Antarctic winters.

In a next step, Risk has joined with Dr. Peter Wild, at the University of Victoria, to couple forced diffusion chambers with fibre-optic CO2 sensors to create a novel direct sensing technology. Combining membrane-based housings with fibre-optic sensors will offer numerous advantages, including the ability to estimate rates of CO2 migration and possibly also to act as selective filters, allowing CO2 to touch the sensors, but filtering out unwanted gases.

At the University of Toronto, Dr. Giovanni Grasselli leads a team developing a new computational system able to estimate the rate at which CO2 can be injected into rock formations without compromising the storage integrity of the formation. The system, which will incorporate micro-scale level thermo-hydro-mechanical and chemical processes, will also predict the nature and extent of stable plumes that develop as injection proceeds as well as their possible interaction with potable groundwater systems.

In Quebec, a researcher is testing new geo-electric techniques that could complement seismic monitoring methods. Researchers will be working in a lab and then in the field to examine the electrical properties of CO2 and to understand cross relationships between seismic and electric properties.

Geosciences Field Research Station

To test developments such as these in the field, Lawton is leading CMC in the development of a Geosciences Field Research Station (GFRS). When complete, researchers within the CMC fold and from around the world, including technology vendors and developers, will be able to test their products.

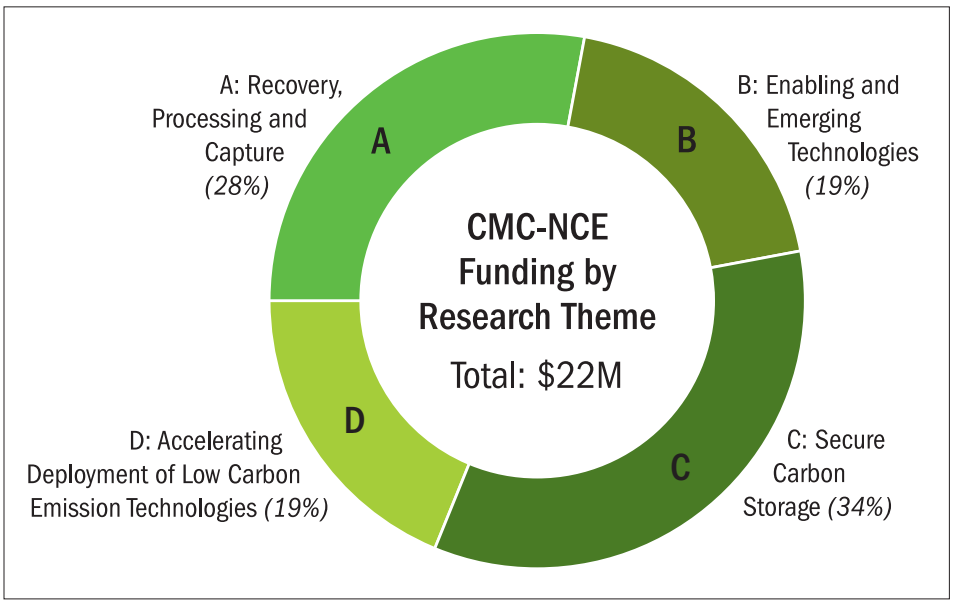
"We'll be able to take research out of labs into the field where you are dealing with real rocks and pressures so we can test, at very small scale, all of these technologies."

"While many people consider carbon management as 'carbon capture and storage', and we have invested a lot in the CCS area, we are much broader than that"- Dr. Steve Larter, FRS, CMC Scientific Director

While a real-world site might involve sequestering CO2 at a depth of over two kilometers, the GFRS site aims to drill an injection well to a depth of just 300 to 600 metres paired with two nearby observation wells. Likewise, the plume of injected CO2 will be small – 600 to 1,000 tonnes per year and will simulate the effects migrating gas phase CO2.

Fundamental research a key area

At the level of more basic research, CMC's Theme B investigators are working on emerging and enabling projects according to John M. Shaw, Theme B lead and NSERC/AB Innovates Industrial Research



Breakdown of CMC funding per theme

Chair in Petroleum Thermodynamics at the University of Alberta.

"Theme B investigators typically work on precompetitive projects that target knowledge and insight, and enable process technologies to emerge, rather than on technologies for commercialization directly. Research and enabling technology outcomes feed into the development and commercialization of projects in Themes A and C, as the new knowledge is applied," says Shaw.

As examples, he points to projects that allow industry or other researchers to visualize, measure and understand fluid movement and deposition dynamics within rock pores when CO2 is injected. In one project researchers are developing a high-resolution ultrasound mapping technique, where interfaces and the movement of gas and liquid are tracked in sandstone and other natural porous materials at the pore scale.

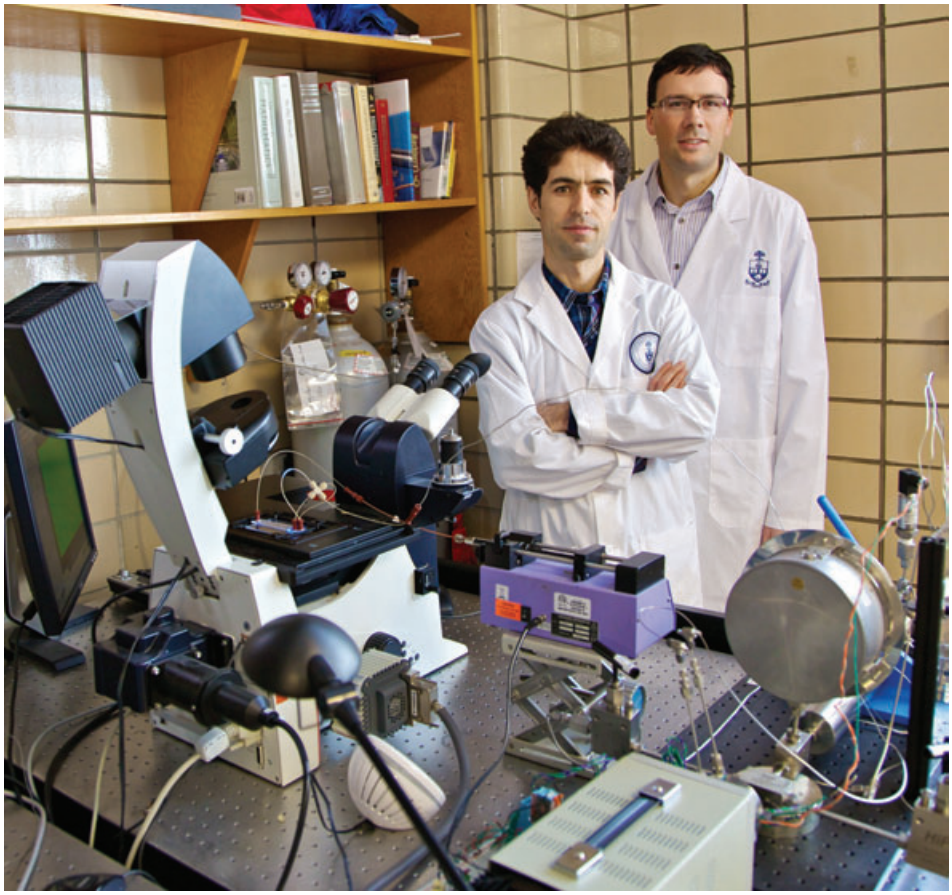
In another project a team led by David Sinton, University of Toronto, is applying microfluidics concepts to simulate processes arising within individual rock pores. Their approach, using microfluidic chips, provides rapid and robust pore level measurement of diffusion and deposition processes. Their new measurement techniques and devices simplify, speed up and greatly reduce the cost of measurements. CO2 diffusion into heavy oil measurements, for example, are performed in a matter of minutes rather than days. The savings in time and expense are dramatic and the microfluidic devices could be game changing for lab testing of CO2 storage and petroleum engineering systems.

Developments such as these take time. "The teams are moving in the right direction but we are looking at longer term horizons," says Shaw who expects that work at this fundamental level will ultimately provide ground-breaking discoveries in the field of carbon management.

Society/technology interface

No matter what is developed or discovered in the field of carbon management research, society must be willing and able to implement discoveries and technologies. That society/technology interface is the purview of researchers in Theme D.

There has been a trend in the last decade to more closely integrate research in social sciences – economics, law, communications, politics, etc. – into projects focused on technology and hard science. In this regard, CMC stands out as an example where a real effort is being made to do that integration well, says James Meadowcroft, head of this stream and also Canada Research Chair in Governance for Sustainable Development at Carleton University.



Dr. David Sinton, University of Toronto, and Dr. Hossein Fadaei, PDF

In fact, close to 20% of CMC's research funds have been allocated to social and policy projects (see figure). "Our level of funding is not insignificant. Some of the other networks I've participated in typically have 5 or 10 per cent of research funds expended in this area," says Meadowcroft.

He sees research under his portfolio as being critical to the development and deployment of new carbon mitigation technologies. "Sometimes technological development is just presented as a series of scientific discoveries and scientific innovation, with one new development just flowing from another. But if we look at how technologies develop, societal reception is as important as the technological innovations themselves. There are plenty of technologies people have tried to deploy but we never went down that pathway. The reasons are complex, but technology is always employed in a social context."

To that end, CMC funds innovative projects in which investigators are developing economic models, new frameworks and studying public attitudes toward carbon mitigation strategies and alternative energy sources.

One group is using general equilibrium economic models that examine geographic variations in the economic impact of carbon abatement strategies and the implications of carbon pricing models. Another large project is looking at various risk dimensions and risk assessment methods to develop a CCS risk management framework in which the public can have confidence. Another group is looking at public attitudes toward energy technologies in general and is making comparisons across provinces and technologies.

Moving forward

Having built up its research network, and with 44 research projects progressing steadily, CMC is eyeing the next phase of its development.

"As we move forward," says Larter, we realize we have to improve our rate of taking basic research to invention and then to technology – together with industry. We are now exploring an expanded model with industrially funded research and technology development institutes built on our successful network of use-inspired basic research.

More information

For information about CMC and future developments contact Richard Adamson: richard.adamson@cmc-nce.ca or view the website: www.cmc-nce.ca

CO2 storage at the world's first integrated CCS Project

2012 was a busy year for the Aquistore project. Major project infrastructure was installed, and baseline monitoring work began in earnest. Early in 2013, project researchers are engaged in cross-well seismic surveys, making use of Aquistore's unique permanent seismic array. With CO2 injection anticipated in late 2013, the project is preparing for another busy summer of research and visitors.

The Aquistore project is Canada's first targeted deep saline formation carbon dioxide (CO2) storage project. As an independent research project Aquistore will demonstrate that storing CO2 in a deep geological formation is a safe, economical, and feasible solution to reducing greenhouse gas emissions.

Aquistore will capture CO2 from a nearby coal-fired power plant and transported to the site to be injected into a sandstone formation for storage. Canada, with its abundance of natural and energy resources is leading international carbon capture and storage (CCS) efforts.

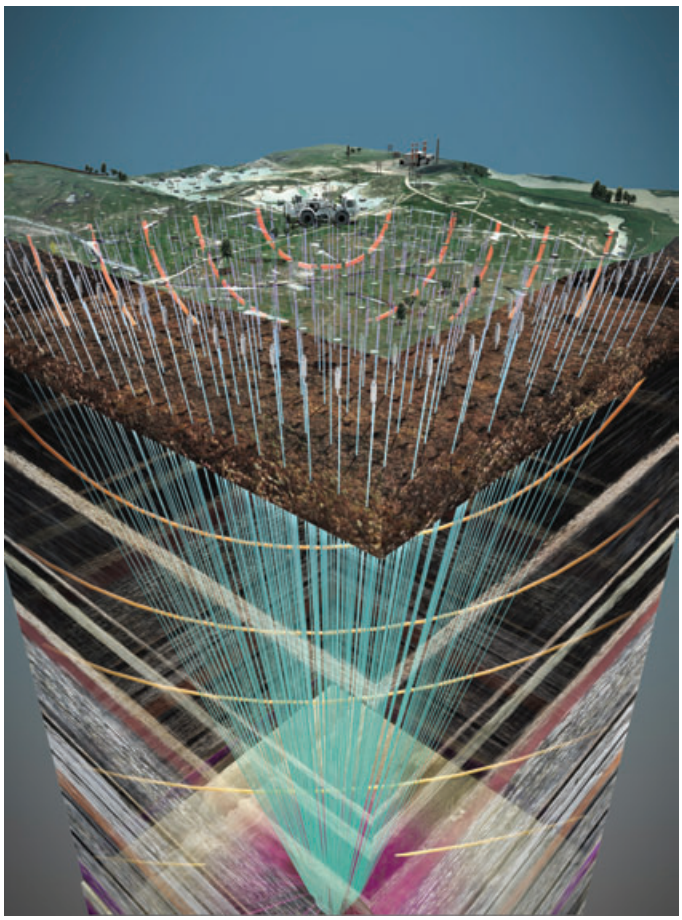
While there is global recognition of the significance of CCS, there are few industrial-scale active projects. In the next decade, geologic storage work is vital. The necessary work involves demonstrating storage in diverse settings so that it can be deployed on a widespread global basis.

Located in south-eastern Saskatchewan, Canada, Aquistore will serve as the storage site for the world's first commercial post-combustion CO2 capture, transportation, utilization, and storage project from a coal-fired electric generating facility. Integrating storage into full chain CCS, Aquistore is providing Canada and the world with valuable insight and lessons learned in commercial CO2 storage. Aquistore learnings are applicable to any large, stationary industrial emitter within Canada and across the world.

Aquistore is managed by the Regina, Saskatchewan based Petroleum Technology Research Centre (PTRC). The PTRC is a not-for-profit with over ten years of experience managing CO2 monitoring and storage. Aquistore is the PTRC's second flagship project following the IEAGHG Weyburn-Midale CO2 Monitoring and Storage Project.

That project was launched in 2000 and studied carbon dioxide injection and storage into two depleted oilfields in south-eastern Saskatchewan. To date over 22MT of CO2 has been permanently stored. Built upon the research and expertise of the Weyburn-Midale project, Aquistore is helping to build capacity for CCS both in Canada and around the world.

One of only a handful of active projects internationally, Aquistore has brought together the interests of research and industry. The research and learnings emerging from Aquistore will have global applicability. Aquistore is a leading industrial laboratory in Canada and one of only a handful internationally conducting a pioneering research and technical program focused on buffer storage of CO2. As the monitoring phase of the project commences in earnest, Aquistore is considering new sponsorship applications.



An illustration of Aquistore's permanent seismic array

Aquistore, 2012-13: CCS begins on the Canadian Prairies

As spring arrives on the frozen Canadian prairies, Aquistore is warming up for what will certainly be another busy summer.

In 2012, site construction and installation began. Last year, over 250 international visitors came to watch the installation of the wells and explore the project site. Capitalizing on the uniqueness of the Aquistore project, in 2012, Aquistore hosted CCS experts and guests from around the world. From Japan to South Africa, visitors and researchers came to build capacity and learn from this pioneering CCS project.

As well as research and capacity building opportunities, the summer of 2012 saw the installation of major project infrastructure. Working alongside Schlumberger Carbon Services, the project drilled two wells. The first well serves as the project's injection well, while the second serves as an observation well. Located 150 metres apart, these two wells were drilled to a depth of 3.4 km, incidentally making them the deepest wells in the province of Saskatchewan.

Aquistore's wells will provide real-time data and validation for predictive long-term modeling, and provide down-hole monitoring and CO2 tracking. With the two deepest wells in Saskatchewan, Aquistore will serve as a rigorous trial and demonstration for effective down-hole technologies.

While many CCS projects are in the plenary stages, in 2013 Aquistore will finish

site installations. CO2 injection is expected in autumn 2013. Aquistore's CO2 source is SaskPower's Boundary Dam Integrated CCS Demonstration Project, the largest project of its kind in the world. Boundary Dam is an active, industrial scale power plant, which is being retrofitted to capture CO2 for EOR off-takers and for dedicated storage in the Aquistore site. As a CO2 storage project, Aquistore is expecting variable CO2 rates from 0 - ~2000 tns per day. The injection rate is expected to change with the operational fluctuations of SaskPower's facility.

With CO2 injection expected in autumn 2013, and Boundary Dam's capture facility moving closer to completion, interest in the Aquistore project is rising. As the wells are now drilled and instrumented, Aquistore is working with its science and research team to complete the installation of the project's monitoring technologies. Both surface and subsurface monitoring technologies are being installed, and the project is acquiring baseline measurements.

Leading Research: CO2 Monitoring, Measurement and Verification

Critical to CO2 storage is the suite of monitoring techniques deployed. CCS projects can have an inherently high capital cost, but when well designed and managed the CO2 storage component represents only a small percentage of the overall cost of carbon capture and storage. Aquistore's monitoring, measurement, and verification (MMV) program will test and develop effective methods for monitoring CO2 storage sites and ensure conformance of the storage process through continuous monitoring.

This program addresses the risk associated with any potential leakage of CO2 from the storage reservoir through early detection. Located in the Williston Basin, Aquistore has ideal depth, injectivity, and the presence of a regionally expansive salt layer as an ultimate sealing unit. The geologic characteristics of the Aquistore site make it a typical yet ideal site for CO2 storage.

As Aquistore is one of the first commercial-scale deep saline storage projects globally, many MMV techniques have been developed specifically for the project. Due to site characteristics the learnings and technologies in the Aquistore MMV program will have global applicability for other CO2 storage programs.

Built upon the learnings of the IEAGHG Weyburn-Midale CO2 Monitoring and Storage Project Aquistore's MMV program has included an added focus on integrated monitoring methods such as the in-

A geophone, part of Aquistore's permanent seismic array, prior to installation

clusion of non-seismic methods and constraints from reservoir flow simulations are also being incorporated. Aquistore will provide a field-tested basis for designing effective MMV programs for other similar projects worldwide.

As Aquistore continues, the MMV and research program will be ongoing over the course of the project's decade-long life. Additional partners and research collaborators are being sought to add to the already robust monitoring program. The techniques utilized and tested on site will provide the basis for best practices in monitoring for dedicated CO2 storage projects both for efficacy and for economic efficiency.

Groundbreaking Work: Aquistore's Permanent Seismic Array

One of the unique elements of Aquistore's MMV program is the project's permanent seismic array. Traditionally, 3D seismic is the primary technology for CO2 monitoring. Though effective, 3D seismic can be quite expensive; Aquistore's permanent array aims to demonstrate a significantly more-cost-effective seismic acquisition method. In March 2012, the project installed a permanent seismic array. This installation will be used in and comparison with traditional 3D seismic.

Permanent seismic arrays are composed of many permanently installed geophones. Geophones are acutely sensitive listening tools which use frequency response to track minute underground movement. Permanent arrays have been used in a limited number of oil field operations. Primary uses include marine settings such as the Valhall field in the North Sea.

In addition, geophones have been used for passive monitoring such as for earthquakes, and interestingly for nuclear explosion detection and monitoring in support of nuclear test ban treaties. Quite separate from nuclear armistices, the installation of a permanent seismic array at the Aquistore site represented the first attempt to use this technology for CO2 tracking.

Installation of the permanent array began in March 2012. In frozen and muddy spring conditions, 630 geophones were installed at a depth of 20 metres. Over the course of six weeks, these geophones were installed on a 5 kilometre grid around the project area.

This permanent array was designed and installed for two central purposes. Primarily to ensure that recording conditions are as repeatable and accurate as possible from survey to survey for time lapse imaging. This effort ensures that changes in the seismic images are associated with CO2 induced changes in the subsurface as opposed to subjective changes in the recording conditions.

The Aquistore site: the calm before. Installation of project infrastructure began in 2012

Essentially – the 'repeatability' promised by a permanent array can help ensure more accurate CO2 tracking by providing a clearer picture. Secondly, Aquistore's permanent array allows for continuous passive micro seismic monitoring. The array is constantly monitoring local microseismicity.

Currently, Aquistore's research team is out in the field conducting baseline seismic work. A baseline cross well seismic tomography was conducted. This baseline test produces an image showing the detailed geology within the storage reservoir and the cap rock. This tomographic image will be used as a baseline for post-injection time-lapse imaging.

In addition, the first repeat 3D seismic survey will be conducted this spring using the permanent array. The data from this test will be compared against the baselines from both the 3D and permanent seismic surveys acquired in March 2012. This initial monitor time-lapse survey will quantify natural variability. By occurring prior to the start of injection, this test will account for the amount of variability between surveys which is unrelated to CO2 injection.

As the monitoring program begins in earnest, the project's research team expects to repeat these surveys annually.

2013 and Beyond: Moving Forward towards ~2000tns / day

Dedicated CO2 storage projects are now gaining global recognition as necessary elements of our energy future. In anticipation of CO2 emission regulations, CO2 storage may be the only option available for operators of coal-fired plants and other set point sources of emissions to offset emissions or costs.

Utilizing an exclusive permanent seismic array, Aquistore's CO2 monitoring, measurement and verification program is moving towards the goal of quantifying stored CO2. The year of 2012 saw Aquistore break-ground and complete two wells unique to Saskatchewan, as well as a public education and outreach program, and a first of its kind seismic monitoring installation. With CO2 injection expected in late 2013, the project anticipates more companies and jurisdictions will take advantage of this unique opportunity.

The research and learnings emerging from Aquistore will have global applicability. Linked to SaskPower's Boundary Dam Integrated CCS Demonstration Project, Aquistore is the only fully integrated, industrial scale, CO2 storage project based at an electrical generating station. With an ideal project site, pioneering MMV program, and positive support from the local, provincial and federal government, Aquistore is helping to build capacity for CCS both in Canada and around the world.

Come for a visit – we look forward to hosting you.

Webinars, site tours, and executive and exploratory project consultations are available. Use the contact details below to arrange your webinar session, site-visit, or for more information about Aquistore.

More information

www.aquistore.ca
information@aquistore.ca

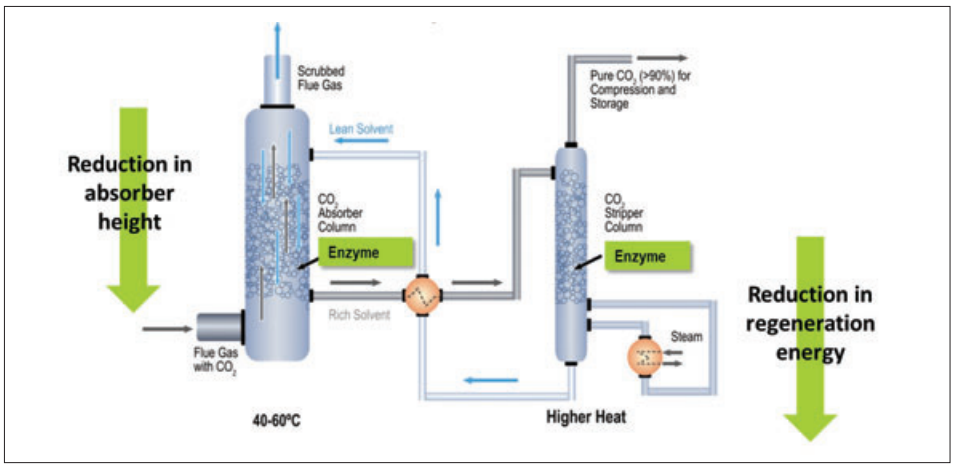
CO2 Solutions - harnessing nature for efficient carbon capture

CO2 Solutions patented enzyme catalyst could improve the efficiency of CO2 capture with common solvents such as MEA by up to 40%.

By Jonathan Carley, Vice Pesident, Business Development, CO2 Solutions

Post-combustion, solvent-based carbon capture is widely accepted as the nearest term technology option as part of an overall carbon capture and sequestration (CCS) solution with or without enhanced oil recovery (EOR), for large emitters.

However, conventional solvents such as monethanolamine (MEA) that offer favorable capture kinetics require significant amounts of heat to release the captured CO2. This energy requirement creates a highly inefficient process and negatively impacts operating costs. This cost barrier has been identified as one of the major reasons currently limiting the wider deployment of CCS to mitigate carbon emissions.



Process diagram for CO2 capture using solvents combined with CO2 Solutions' enzyme catalyst

A biotechnological solution

CO2 Solutions Inc. is a Quebec based company that has taken a very innovative approach to solving this energy and cost challenge. The company's technology is built around the use of the extremely powerful enzyme catalyst, carbonic anhydrase (CA), which efficiently manages carbon dioxide in living organisms.

In an industrial CO2 removal system, CA dramatically accelerates energy-efficient, but kinetically limited solvents. Based on this principle, low-energy solvents such as tertiary amines, carbonates and tertiary amino acids can be efficiently utilized to provide a process with both attractive capital costs and lower energy consumption with a direct positive impact on operating costs.

Also importantly, the technology is designed to be used with existing packed tower gas scrubbing architecture well understood and accepted by industry, providing the opportunity for retrofits as well as greenfield installations.

CO2 Solutions was the first to recognize and patent enzymatically enhanced carbon capture and currently has 32 issued and 52 pending patents in Canada, the U.S., Australia, Europe, and emerging markets encompassing the use and application of carbonic anhydrase or analogs thereof in various process configurations and with key low-energy solvents.

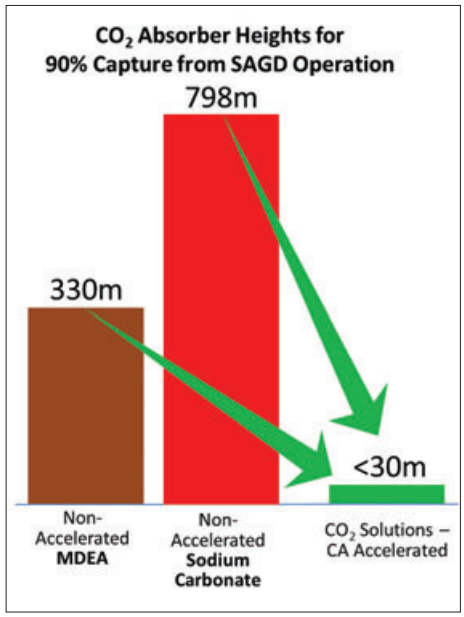
Work to date by CO2 Solutions has shown that by combining CA with a number of commercially available solvents (such as MDEA, AMP and Sodium Carbonate) to capture CO2 from coal-fired power plants and large natural gas combustion sources in the oil industry can make use of absorbers that are very similar in size to the ones used with a fast primary amine process such as MEA. From rate-based simulations, the company predicts that with appropriate plant energy integration, overall cost savings of 30-40% can result from the use of the technology vis-à-vis a state-of-the-art MEA process.

Also, compared to chemical CO2 capture accelerants such as piperazine, the use of the enzymatic technology is more economically and environmentally advantageous. With the use of piperazine, the formation of stable carbamates results and therefore solvent regeneration energy is negatively impacted.

Piperazine also results in the formation of carcinogenic nitrosamine air emissions when reacting with nitrogen oxides contained in many flue gases. Conversely, CA is a pure catalyst that does not lead to carbamate formation or harmful air emissions, achieves equivalent kinetic enhancement without increased regeneration energy requirements, and is less expensive on a mass basis.

Applying the technology in the Canadian oil sands and beyond

In Canada, the company has recently turned its attention to the country's fastest growing source of carbon emissions: The Alberta oil sands. The environmental footprint of unconventional hydrocarbon production from the Alberta oil sands has been a subject of growing interest both in Canada and internationally.



CO2 Solutions' technology could significantly reduce the necessary absorber height

Much of this interest has been focused on the industry's higher overall carbon footprint vis-à-vis conventional oil production, largely resulting from the combustion of natural gas to produce steam which is injected underground to produce the oil in-situ. This in turn has led to concerns, particularly in the U.S. and Europe about importation of oil sands crude.

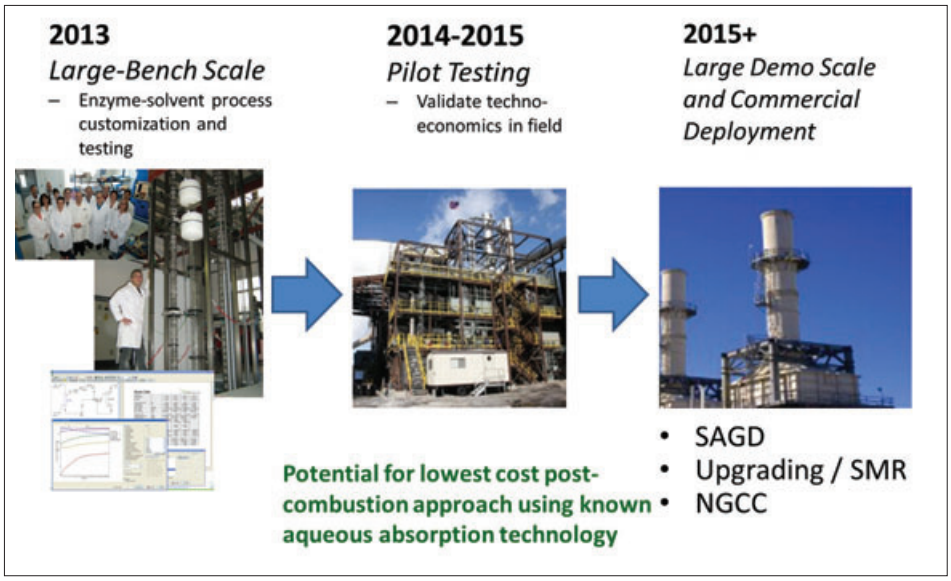
A central focal point has been the pending U.S. government decision regarding the approval of the Keystone XL pipeline project which would see a significant expansion of Alberta crude flowing into the U.S. for refining in Texas. Strong environmental opposition in the U.S. has led policy makers to suggest that perhaps any approval of the pipeline be linked to increased carbon regulation of the oil sands. Moreover, without increased access to export markets for its product, the industry faces a significant financial penalty where oil sands crude is currently selling at a significant discount to benchmark wold oil prices.

With the combined impact of growing public concerns about the effects of global climate change brought about by rising CO2 emissions, market access challenges faced by industry and the potential for additional carbon regulations, carbon capture has become an emissions management option of significant interest.

In this regard, however, the Alberta oil sands face an enormous cost challenge in utilizing conventional CO2 capture technology. In the case of in-situ production (typically Steam Assisted Gravity Drainage technology, or SAGD), CO2 generated from gas combustion is contained in flue gas at approximately only 4-10% concentration. Due in part to this, associated capture costs are very high. This challenge also exists when natural gas or field gas is combusted for Steam Methane Reforming (SMR) facilities as part the heavy oil upgrading process, and in co-generation plants.

In January, 2013, CO2 Solutions announced the award of $4.7 million from the Harper Government towards a 2.5 year, $7.5 million project which will see the company's technology customized and pilot tested for the low-cost capture of carbon emissions from natural gas combustion in the Alberta oil sands. The project is further supported by up to $500,000 in grant funding from Alberta's Climate Change and Emissions (CCEMC) Corporation.

In financial collaboration with major oil sands producers including BP, Suncor, Shell and others through the CO2 Capture Project, and Statoil, CO2 Solutions has embarked on the initial pre-pilot phase of the project which involves the selection of an optimized CA-solvent process for treating flue gases from SAGD installations.



Running through the end of 2013, this initial phase will see the chosen process tested at large-bench scale to achieve at least 25% cost savings vs. MEA while achieving a 90% CO2 capture rate. Following large-bench testing, the process will be tested at pilot scale on a slip stream of flue gas at an operational oil sands site with completion by mid-2015. CA enzymes for the project have already been industrially engineered through previous work and have been proven stable to coal-fired flue gases, minimizing development risk.

As an additional project benefit, results from the project will also support the broader application of the Company's technology at other large natural gas combustion sources, such as gas-fired power plants, an important fact considering the current 'dash-to-gas' resulting from the low price natural gas environment driven by booming U.S. shale gas production.

A successful field pilot test would pave the way for larger demonstration and commercial deployment after 2015 in conjunction with the development of CO2 pipeline and storage infrastructure in Alberta and expected further carbon regulation.

Importantly, CO2 Solutions believes that by addressing the cost barrier to the CO2 capture component of CCS, which is commonly estimated at about 70-80% of the total cost of CCS, its viability as a carbon mitigation tool could be effectively realized at the large-scale needed for substantive emissions reductions.

This is turn would support the Government of Canada's goal of a 17% overall reduction in Canada's greenhouse gas emissions by 2020, the Government of Alberta's proposed expanded emissions reductions framework, and could help significantly to address the oil sands industry's market access challenges.

On this last point, based on the current approximate $30/barrel discount to the West Texas Intermediate (WTI) price, a significant financial benefit would be accrued by the industry assuming commercial implementation of CO2 Solutions' technology at a cost of approximately $2/barrel of production. In this regard, there is the potential for the enzymatic technology to provide the lowest cost post-combustion CO2 capture approach using known solvent absorption technology, providing a strong technical pathway to rapid and reliable commercial adoption.

A Promising Future for this Innovative Company

This all leads towards a bright future of growth for this small Canadian company. Jonathan A. Carley, CO2 Solutions' Vice-President of Business Development summed it up as follows: "The world is finally waking up to the fact that climate change is a pressing concern and that carbon capture must be part of the solution if we want to continue to utilize our abundant fossil fuel resources towards continued economic growth."

"We're helping to solve this challenge with a made-in-Canada innovation that uses nature's own power to efficiently manage emissions from oil & gas production, electricity generation and other large fossil intensive industries which constitute nearly half of all global emissions of CO2."

More information
www.co2solutions.com

Technology to demonstrate economically viable carbon capture

AspenTech's aspenONE software enables process industry companies to optimise their engineering, manufacturing and supply chain operations.

By Paul Taylor, Senior Vice President, Europe, Russia and Africa, AspenTech

Carbon capture technologies have progressed significantly in recent years in the quest to add commercial value to the process industries. Pilot plants funded by government and private organisations across the world are playing their part in the development of operational excellence and regulatory compliance. The drive to reduce carbon emissions more economically is essential if manufacturers wish to lower plant operating costs and minimise impact on the environment.

Weighing up the options between meeting environmental needs and commercial goals is one of the dilemmas for many companies. However, the industry can progress low-carbon energy technologies and help reduce CO2 capture energy penalties imposed by regulatory authorities by working collaboratively. Cooperation between owners and technology vendors leads to a clear commitment to promote competition among suppliers and this also strengthens the initiative to reduce energy and capital costs.

Organisations adopting innovative technology can improve their environmental footprint from a production viewpoint and use cleaner fossil fuel technologies like carbon capture and storage (CCS). With more projects dedicated to demonstration on an industrial scale, the more likely that CCS will become commercially viable.

AspenTech is working with Norwegian based Technology Centre Mongstad (TCM), testing and improving CO2 capture technologies at the world's largest industrial-scale facility.

Facing the challenge

While business leaders may worry that green taxes on pollution could drive companies to re-think their commercial strategy, it is worth reflecting that CCS can represent an opportunity. If CCS technology is to become a standard, then there has to be an opportunity for businesses to generate profit. Just storing CO2 is a cost unless by storing it you can create value. That is what Enhanced Oil Recovery (EOR) adds to the equation. EOR is a good option because large volumes can be used and the technology is proven. The Apache Weyburn-Midale Project and in the Permian basin in the Southwest USA has demonstrated for years.

This is crucial for the development of the industry and for its long-term future. If the CO2 is simply stored in the ground or dissolved in the ocean, there will be little incentive for companies to invest, other than avoiding the need to pay fines for non-compliance with government regulation. The consensus of opinion across the process industries is that reducing CO2 is a positive move and there is growing interest around the world in the potential of carbon capture and storage (CCS).

Engineers can help reduce emissions in several ways: altering manufacturing processes, such that they require less energy to produce the materials we need; improving the efficiency of the entire supply chain, so that energy consumption over the manufacturing lifecycle of a product is reduced and, finally, the efficient removal of CO2 from industrial flue gases and its pipeline transportation to safe disposal locations. Thus, reducing risk and minimising project costs.

The tools for modelling these complex interactions, like process simulation and supply chain optimisation applications, are already in use today worldwide.

For any energy or carbon saving technology there has to be a financial benefit for companies operating in market economies. Whilst reducing energy consumption and supply chain efficiency have an obvious commercial incentive, for CCS technology to become a standard, then there has to be an opportunity for businesses to generate profit. Carbon related legislation is still at the development stage, but the consequences of industry and government policy will have economic impact on global oil markets for many years to come.

European refineries are facing the combined challenges of declining regional oil demand and the burden of carbon costs as part of their greenhouse gas (GHG) emissions. Many refineries are constantly under the threat of being sold or closed due to market forces. Concerns could also increase regarding the issue of 'carbon leakage' if European refineries are subjected to international competition and the potential CO2 cost versus gross margin.

Japan, on the other hand, has a long history of carbon regulation. In 1997 the Japan Business Federation (Japan Keidanren) developed and agreed to the 'Keidanren Voluntary Action Plan on the Environment', a voluntary emissions cap and trade programme. The goal was to reduce the emission levels of 2010 below those of 1990,

with members of the Voluntary Action Program (VAP) setting their own emissions targets.

The programme was integrated into Japan's Voluntary Emissions Trading Scheme (JVETS) in 2005 and was then expanded in October 2008. China, however, has opposed initiatives to set a stringent cap on carbon emissions and is moving toward regulation on carbon per unit of GDP.

Leading by example

The principle of knowledge sharing is fundamental to CCS demonstration programmes for accelerating technology development and reducing costs. The know-how and learning from these projects is often a balance between commercial and environmental preservation. However, accelerating the understanding of CCS projects will gain trust by global communities from both the public and companies involved.

A prime example of a leading carbon capture project is Technology Centre Mongstad (TCM), which is using aspenONE® software at the world's largest industrial-scale facility for testing and improving CO2 capture technologies. TCM uses Aspen Plus® and Aspen IP.21® for planning, follow-up and verification of test programs and results. TCM's use of the Aspen Plus and Aspen IP.21 product families shows that process manufacturers can reduce carbon emissions more economically, resulting in lower plant operating costs and reduced environmental impact.

TCM is owned by the Norwegian Government and leading global energy companies. TCM's goals are to: 1) test, verify and demonstrate CO2 capture technology owned and marketed by vendors, 2) reduce costs, technical, environmental and financial risks, 3) encourage the development of the market for CO2 capture technology, and 4) aim at international deployment.

aspenONE software enables process industry companies to optimise their engineering, manufacturing and supply chain operations. As a result, the world's leading manufacturers are better able to increase capacity, improve margins, reduce costs and become more energy efficient. The market-leading Aspen Plus process simulator, part of the aspenONE Engineering software suite, helps process manufacturers to model, track and reduce CO2 emissions.

The software can transform greenhouse gas emissions from a challenge to an opportunity. As process manufacturers face increasing regulatory requirements, emissions penalties and rising operating costs, manufacturers can turn these challenges into business advantage through reduced energy and emissions costs and by enabling the creation of alternative fuel sources from the emissions.

TCM has shown that process manufacturers can significantly reduce carbon emissions more economically, lower plant operating costs and reduce environmental impact

For example, they can use Aspen Plus to create better carbon capture and biofuel process models powered by the most comprehensive physical property database. Improved amine solvent models enable users to make closer process predictions. With the new Aspen Plus models, customers can improve their designs and optimise them for energy use and carbon loading.

Carbon and energy management software helps companies to understand the complexity that sustainability signifies and facilitates the business toward long-term stability. According to a recent report published by Forrester on The Evolution Of Enterprise Carbon And Energy Management Software (2010): In the global market, the estimate for the Software category was at $395 billion of information and communications technology (ICT) purchases.

The report identifies that the key drivers are spearheaded by cost and efficiency improvement opportunities and reflects the fact that companies are more comfortable with finance-led initiatives. A rapid return on investment is the primary driver and sustainability improvements are considered as a 'positive by-product'.

Economic viability

Uncertainty still remains about how carbon legislation will evolve and its impact on the oil markets around the globe, including the refining industries. Costs for manufacturers governed by carbon initiatives across the regions are likely to increase. The European Union and the United States have recognised the need to enforce higher efficiency standards without affecting competitiveness.

Compliance for companies could mean the implementation of new operational procedures leading to greater complexity. Software applications, therefore, can help define a company's sustainability strategy and provide transparency into their carbon footprint. The ability to now measure energy consumption and related carbon emissions means that firms can monitor the sustainability strategy in tangible terms.

The ground-breaking work conducted at the TCM test facility will also help the process industries produce commercially viable carbon capture methods on a broad scale. It has demonstrated how process engineers can effectively model carbon capture systems, predict and reduce emissions using aspenONE optimisation software. This results in tremendous benefits for process manufacturers and the environment. Business value derives from developing effective energy and carbon management capabilities for applied across operations and the supply chain.

Organisations with a structured strategy to improve energy and carbon management across operations and the supply chain will optimise assets, reduce emissions and become government and industry compliant. With advanced technology, carbon capture initiatives play an integral role in demonstrating environmental benefits and economic viability in the process industries.

More information

www.aspentech.com

Reducing the costs of carbon capture

Lord Oxburgh gave the final address at Carbon Capture Journal's second conference in London on March 26th, which focussed on reducing the costs of carbon capture.

The conference featured presentations from:

- **Philippe Micone, global sales manager, Cansolv**, with an update on the SaskPower Boundary Dam Project
- **Harsh Pershad, energy consultant, Element Energy** - latest developments with carbon capture
- **Gernot Schneider, director marketing and sales, Carbon Capture Sequestration, Siemens** - on technical challenges and cost reduction potential for post-combustion carbon capture
- **Prateek Bumb, CTO, Carbon Clean Solutions**, on developing new CO2 capture solvents
- **Basia Kielska, Business Development manager, ClydeUnion Pumps**, on developments with centrifugal pump design
- **Dr Mathieu Lucquiaud, Associate Programme Director, MSc in Carbon Capture & Storage, The University of Edinburgh**, on reducing the cost of absorber columns, DECC sponsored research
- **Lord Oxburgh, honorary president of the Carbon Capture and Storage Association, and former chairman of Shell** - where we are with carbon capture

Lord Oxburgh

If one stands back and takes the big view, what we are or what governments around the world are trying to do is satisfy a global environmental or if you like philanthropic objective using conventional capital investment criteria with the technology somewhere in between, he said. This is not an easy circle to square.

If one looks at the broader political background, the reason for doing this in the UK, even in Europe is not because we are going to save the world, it must be to develop technologies which can find their applications in China and other developing countries, India and others as well.

It will not be very long before China's emissions exceed those of the US and Europe combined and China is still building coal fire powered stations for perfectly good internal reasons, but they are dominating what I might describe as the world CO2 economy. And the reason for western government putting efforts and investment into CO2 must really be, if you stand back and look at the big game, to get these technologies down to a cost that they are realistically deployable in these rapidly developing markets, that is the big game.

Now there's a secondary game of course and that is within Europe and indeed within North America to some extent, we have all, particularly in Europe, accepted emission targets that we have to meet and we are developing technologies today which look as if they can do this in the best available way with the best available technologies.

But what we have to recognize is that these technologies and the costs associated with them, cannot be those which we are trying to offer to the developing world, because they are just too expensive. And if you like that is the background in a way of today's meeting.

If I talk to people who generate power, power station operators in China they will say, "Yes we understand about CO2, we understand about the environmental problems, yes we know there's a lot of CO2 up there! I wonder how it got there? Didn't you have an industrial revolution in the 19thcentury? Followed by massive expansion in North America."

So to some extent and this is not official politics but it is what is said, "Look you got me into this difficulty, you maybe best get us out," which is what probably I would be saying in their position.

We are actually going to have to invest quite a lot in helping with this problem in China. What we can say to the Chinese government, the Indian government, to other governments, OK we inadvertently caused this problem but now we know about it, and you have a responsibility not to invest more in the sense of making the problem worse. So if you like that's the bigger picture.

I said that we were in the West trying to achieve these objectives with traditional capitalist and business type methods. Which means that projects have to be investable. Now if you look at lets say a simple project in the UK, in the North sea, what you have to

do is take three broadly separate technological challenges and handle them together.

You've got to take the capture technology, which at the moment looks like the biggest element in CCS total cost, you've got the pipeline and pumping technology which is probably the most mature in the system, and then you've got to take the subsurface management of CO2. We don't really know enough about this yet, there's quite a lot been learnt obviously through EOR abot management of CO2, how it behaves in the long term, lots of questions to be solved. So there are three separate kind of activities there which will call on different kinds of expertise.

Now one way of approaching this is to say that each of these projects is funded separately and it might well be, in which case you actually have a real challenge for any investor who says, "Well if I invest in a CO2 store how will I know that the CO2 will be available, that the pipelines will be available, and so on in time?"

So the real concern in doing this in separate bits particularly early on is a stranded asset problem. Because we all know that all sorts of projects, particularly difficult projects will have delays on them. So I suspect that the only way these things will happen in Europe perhaps only in the early stages but the only way they won't happen is if there is an integrated approach with a single entity project managing the whole process from capture through to storage.

Probably the only body that can do this will be a government body or some government sponsored body. The government actively in these early stages taking a big chunk of the risk, that's what I think and in a way one of the contributions that we can make globally is demonstrating what is involved here and effectively de-risking this process for application elsewhere.

The final point I would make is to go back to something I said a moment ago. I said that I think that the technologies that we have today will not solve the problems of the developing world. Fundamentally the solvent capture technologies which we've been talking about today are great and you can improve the performance of the solvents, you can reduce their degradation. But I think there is a serious question whether solvent based technologies are in fact the long term solution here? There was an urgency to do something about CCS and the chemical engineering industry said, "Yes we can certainly do it, we've got this bit and this bit and we can certainly put them together and we'll get you a CCS system."

That is different from saying, "Well I want to design a power plant which will produce a CO2 stream and a stream of nitrogen and oxygen as outputs." And you perhaps go about it a different way. And there are one or two interesting technologies which still have to be proven and the one that intrigues me is the one associated with understanding the base chemistry of power station emissions and then decompressing your exhaust gases along a carefully planned time temperature pressure path so that in fact you first start to condense those gases into a mist and for fairly obvious reasons the first minute liquid droplets are enriched in the most condensable element in your gas mixture and then separating those mechanically and then running it through several times. Now this has been done on a laboratory basis, can it be done on a large scale? Very interesting question, but it enormously reduces the footprint and the CAPEX associated with the capture, there are others as well.

More presentations

Free videos of the presentations and pdfs of the slides are available at:
www.carboncapturejournal.com/mar2013.htm

EU CCS demonstration project network

John Scowcroft, Coordinator of the The European CCS Demonstration Project Network Secretariat, discusses how stakeholder dialogue is pivotal if we are to see the rollout of commercially viable CCS technologies by 2020.

To what extent does the European Carbon Capture Storage (CCS) Demonstration Project Network seek to inform and advise the public regarding developments in CCS? How are you engaging with society at large?

As a body, the Network primarily seeks to engage with society at large through the provision of fact-based information at conferences, seminars and online, illustrating the progress that the European Demonstration projects are making. It provides answers to questions and directly links the most suitable bodies that hold the relevant information. While such high-level information is important, it is on a local level that it is of the most value, and it is here that the projects themselves are best-placed to comment. To underline its importance, the provision of factual, relevant and appropriate information to the public has been continually discussed by the projects since the Network's inception.

In what ways does the Network function beyond its European focus? Are you forming cooperative partnerships with similar initiatives internationally?

The Network is actively seeking to strengthen links with projects and experts across the world. The sharing of knowledge is the most important role the Network can provide. This is a two-way process and constitutes real dialogue. The lessons that have been learnt from the projects will be vital in driving down costs, reducing the development times and risks and addressing the problems and management issues being faced by projects across the world. Equally, European initiatives can learn much from any mistakes, achievements and steps made by others. The Network and its secretariat strive to facilitate this transfer of understanding and know-how, as it is only through global cooperation that CCS will be deployed successfully at scale.

The Network has recently undergone a change in Secretariat. Who comprises the new Secretariat, what expertise do they bring to the table, and what impact will this have?

The Global CCS Institute is a not-for-profit independent entity owned by its members, comprising 350 governments, industry, and academic and research organisations from around the world. It focuses on accelerating the deployment of CCS through knowledge sharing and assisting projects. It is joined by three leading R&D organisations in Europe: IFP Energies nouvelles (IFPEN) is a public sector research, industrial innovation and training centre active in the fields of energy, transport and the environment; TNO applies scientific knowledge with the aim of strengthening the innovative power of industry and government; and SINTEF is one of the largest independent European research institutes, focusing on power generation and energy conversion technologies, distribution and end use. This unique consortium has been created to bring together extensive technical and research expertise in CCS, facilitation, project knowledge-sharing and data analysis.

Do we remain on course to witnessing commercially viable CCS technologies by 2020?

We very much hope that commercially viable CCS in Europe will be realised by 2020; however, there are clearly many significant challenges in achieving this goal. The Network's makeup clearly demonstrates the commitment of industry to this environmental technology. While first-of-a-kind projects in the power sector will face hurdles, there are no fundamental technical reasons preventing the development of CCS, and all elements have been individually proven.

However, the wide-scale deployment of CCS in Europe and globally will require strong, clear, consistent and immediate policy actions. While commercial-scale CCS would be cost-competitive with other low-carbon technologies, it is an innovative technology that markets cannot yet deliver alone, though in certain circumstances enhanced oil recovery (EOR) can act as a bridge to future commercialisation. Nevertheless, as has been the case with other low-carbon technologies, appropriate long-term incentive signals and first-mover support are required for this activity to be adopted and deployed at scale.

How might you challenge the preconceptions of those who argue that research and funding on CCS should instead be focused on the development of renewable energy technologies to facilitate the transition to a fossil-free economy?

We passionately believe that both research and funding should be directed to renewables, bioenergy, energy efficiency and CCS, as each will have an extremely important role to play in combating climate change. We cannot do without any of them. According to the International Energy Agency (IEA), in Europe, CCS will be responsible for achieving 24 per cent of the total effort required to meet our climate change targets. Without CCS in the power sector the overall cost to society would be substantially more. While it is the only option for many industrial plants, CCS only receives a fraction of financial incentives provided to renewables.

An important consideration here is that CCS is the only technology that can reduce emissions from the industrial sector, which includes the steel industry and the gas processing, refining, paper and pulp, and cement sectors. The combined use of biomass and CCS is the only technology that can be 'CO2 negative' and actually extract CO2 from the atmosphere.

John Scowcroft, Coordinator of the Network's Secretariat, is the General Manager – Europe of the Global CCS Institute. Prior to this, he was Head of the Environment and Sustainable Development Policy Unit at Electricity EURELECTRIC, the association which represents the European electricity industry.

Supporting CCS projects

As CCS looks set to become a vital part of a sustainable ecological future, the European CCS Demonstration Project Network is providing a support base to encourage the success of large scale projects.

In 2009 the European Carbon Capture Storage Demonstration Project Network was established in order to support and accelerate large-scale CCS projects across the continent in a safe and commercially viable way. As part of an initiative of the European Commission, the intention of the Network has been to establish a community of leading demonstration CCS projects. By uniting these projects through sharing knowledge and experience, the Network is dedicated to achieving successful, safe and economically viable CCS.

The Network aims to provide support to these key projects in a number of ways. It facilitates contact between the project advocates, drawing focus onto the key topics that can assist their development – from issues

such as detailed technical issues to wider project management considerations, as project head, Daniel Rennie, explains: "Confidential knowledge-sharing takes place through workshops, topic-specific online forums, workspaces and libraries, and a detailed survey that the projects complete every six months". This knowledge-sharing is then supported by an analysis of the project data, which leads to benchmarking, comparisons and a clear tracking of progress.

Occurring on average two or three times a year, the Network's knowledge-sharing events focus on core topics such as monitoring techniques and their development, public engagement, project and storage risk-management, and regulatory issues. Public reports are then produced to facilitate dissemination. Much of the information gathered from the projects via the Network is shared among other projects, stakeholders and the wider public in order to encourage understanding and acceptance of CCS technology and promote its potential as an essential technology in the fight against climate change.

Overcoming industrial challenges

The biggest challenge in the development of this technology is finding sufficient political and financial support for projects. "Funding problems are being experienced in many sectors, largely due to the global financial crisis, but the need to mitigate against climate change remains," Rennie observes.

Although there are no fundamental technical barriers to this technology, its integration into operating industries can be challenging. With this in mind the successful public demonstration of the technology in action is one of the key objectives of the Network members.

Looking towards the future

CCS is expected to play an important and influential role in Europe's future energy mix. From the European Commission's Energy Roadmap 2050, in which different energy scenarios are explored, it is clear that the contribution of CCS is central to Europe's future energy security.

"The Roadmap is comparable to the International Energy Agency (IEA)'s overall vision for Europe, which also indicates that the contribution of CCS in industry will be of equal if not greater importance," Rennie notes. The implementation of CCS technologies is paramount if Europe is to achieve future environmental global goals. Yet the technology also presents economic opportunities: it is estimated that by the late 2020s UK firms alone could benefit from £3-6.5 billion of new business.

The projects

The initiative is currently supporting six European projects.

DON VALLEY, UK

Run by 2Co Energy, the Don Valley project will build a new coal-fired, 900 MW gross integrated gasification combined cycle (IGCC) plant in Stainforth, UK, with pre-combustion capture of at least 90 per cent of the CO2 from the full plant. The preferred storage option is to use the CO2 for Enhanced Oil Recovery which, through the generation of incremental oil taxation revenue, will help offset the cost to the UK of the incentive needed to support the cost of the low-carbon power.

The Yorkshire and Humberside region, where Don Valley is based, has the UK's largest concentration of coal and gas-fired power generation and the CO2 emissions from those plants will have to be reduced dramatically if they are to continue to operate. The plant at Stainforth and the infrastructure it will create have important roles to play in enabling the region to continue to generate power from fossil fuels and to allow other energy intensive industries, such as steel and cement, to also install CCS technology. It is anticipated that new projects will cluster with the Don Valley project to share infrastructure and therefore bring down the cost of CCS.

ROAD, THE NETHERLANDS

Based at the 1,100 MWe coal-fired power plant located in the port of Rotterdam, the Rotterdam Capture and Storage Demonstration Project (ROAD) is a joint venture between E.ON Benelux and GDF SUEZ Energie Nederland. The captured CO2 will be transported 5 km over land and 20 km across the seabed via pipeline to the P18-A platform in the North Sea and stored in expended gas reservoirs. The pipeline has a transport capacity of around 5 million tonnes per year. These gas reservoirs are located in block P18 of the Dutch continental shelf, approximately 20 km off the coast. The depleted gas reservoirs are at a depth of around 3,500 m under the seabed of the North Sea and have an estimated storage capacity of approximately 35 million tonnes.

COMPOSTILLA, SPAIN

The Compostilla power plant will be a coal-fired plant owned by Endesa and located in Ponferrada. It is expected that the capture efficiency at the plant will be 91 per cent and approximately 1.6 MtCO2/year will be captured and then transported over a distance of 150 km via pipeline to an onshore saline aquifer storage site. The technology for this plant is first being tested on a new 30 MWth Technology Development Plant (TDP) close to Compostilla. Once testing is complete, the CCS regulations will be fully developed and an adequate financial structure will be settled; the technology will then be scaled up at Compostilla.

PORTO TOLLE, ITALY

The CCS demo plant will be installed on a USC 660 MWe unit of the Porto Tolle power plant, owned by Enel, which will be co-firing coal and biomass. The demonstration plant will separate about 1 Mt/y of CO2 (capture efficiency >90 per cent) which will be transported by an offshore pipeline to a deep saline aquifer located about 100 km south-east of the power unit. In order to help develop the Porto Tolle project, Enel completed a pilot capture station at a coal-fuelled plant in Brindisi, southern Italy, where the technology can be tested on a significant scale. The pilot has now been running for over 5,000 hours with promising efficiency results.

SLEIPNER, NORWAY

Sleipner, which has captured and stored approximately 1 million tonnes of CO2 per year since 1996, is the only project in the Network which is not a power plant; it is a light oil and gas field. The gas in the field has a very high CO2 content (up to 9 per cent), so the field operator, Statoil, in agreement with the licence partners ExxonMobil E&P Norway and Total E&P Norge, decided to strip the CO2 from the well stream and inject back into the Utsira (saline aquifer) Formation. CO2 is removed from the unprocessed gas using conventional amine capture technology installed on the offshore platform and the CO2 is injected back underground into the Utsira saline aquifer.

BELCHATÓW, POLAND

A 5.3 GW lignite-fired power station owned by PGE, Belchatów is the largest thermal power plant in Europe. A post-combustion capture plant will be integrated with the newly built (2011) 858 MW power unit at the plant. This is expected to capture approximately 1.8 million tonnes of CO2 per annum (design value), which will then be compressed and transported via onshore pipeline and stored in a saline aquifer.

More information

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IEA - progress towards clean energy stalled

The rapid expansion of renewable technologies is one of the few bright spots in an otherwise bleak assessment of global progress towards low-carbon energy, the International Energy Agency (IEA) said in an annual report to the Clean Energy Ministerial (CEM).

"The drive to clean up the world's energy system has stalled," IEA Executive Director Maria van der Hoeven told the CEM, which brings together ministers representing countries responsible for four-fifths of global greenhouse-gas emissions. "Despite much talk by world leaders, and despite a boom in renewable energy over the last decade, the average unit of energy produced today is basically as dirty as it was 20 years ago."

To illustrate this inertia, the report, Tracking Clean Energy Progress, introduces the Energy Sector Carbon Intensity Index (ESCII), which shows how much carbon dioxide is emitted, on average, to provide a given unit of energy. The ESCII stood at 2.39 tonnes of CO2 per tonne of oil equivalent (tCO2/toe) in 1990, and had barely moved by 2010, holding at 2.37 tCO2/toe.

"As world temperatures creep higher due to ever-increasing emissions of greenhouse gases like carbon dioxide – two thirds of which come from the energy sector – the overall lack of progress should serve as a wake-up call," Ms. Van der Hoeven said. "We cannot afford another 20 years of listlessness. We need a rapid expansion in low-carbon energy technologies if we are to avoid a potentially catastrophic warming of the planet but we must also accelerate the shift away from dirtier fossil fuels."

In a world that continues to rely heavily on fossil fuels, carbon capture and storage (CCS) deployment is ever more critical. While CCS technologies are mature in many applications, the report stresses that they are unlikely to be deployed commercially until governments make a strong commitment in the form of appropriate policy.

While 13 large-scale CCS demonstration projects are in operation or under construction, progress is far too slow to achieve the widespread commercial deployment envisioned in the 2DS. Governments must make real commitment to demonstration and increase financial and policy support for deployment, including strong, credible emissions reduction policies, the report says.

While noting that progress remains alarmingly slow for a majority of technologies that could save energy and reduce carbon dioxide emissions consistent with international climate goals, the IEA's report did find some recent, positive signs.

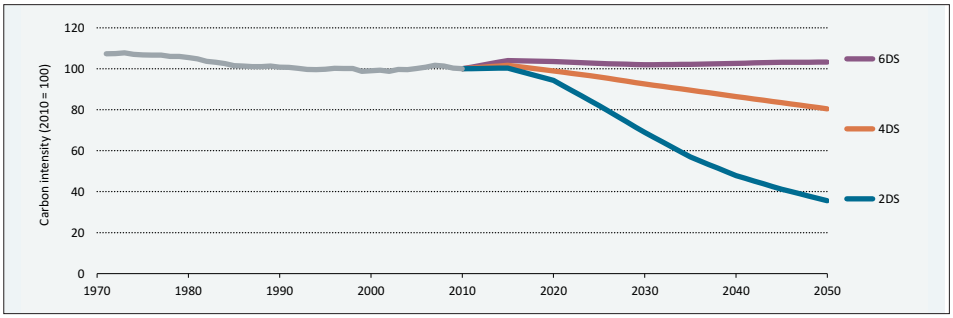
The IEA Energy Sector Carbon Intensity Index (ESCII)

The IEA Energy Sector Carbon Intensity Index (ESCII) tracks how many tonnes of CO2 are emitted for each unit of energy supplied. It shows that the global aggregate impact of all changes in supply technologies since 1970 has been minimal.

Responses to the oil shocks of the 1970s made the energy supply 6% cleaner from 1971 to 1990. Since 1990, however, the ESCII has remained essentially static, changing by less than 1%, despite the important climate policy commitments at the 1992 Rio Conference and under the 1997 Kyoto Protocol as well as the boom in renewable technologies over the last decade.

In 1990 the underlying carbon intensity of supply was 57.1 tCO2/TJ (2.39 tCO2/toe); in 2010 it was 56.7 tCO2/TJ (2.37 tCO2/toe). This reflects the continued domination of fossil fuels particularly coal - in the energy mix and the slow uptake of other, lower-carbon supply technologies. The ESCII shows only one side of the decarbonisation challenge: the world must slow the growth of energy demand as well as make its energy supply cleaner.

To meet 2DS targets, aggressive energy efficiency improvements are needed as well as a steep drop in the global ESCII. The index needs to break from its 40-year stable trend and decline by 5.7% by 2020, and 64% by 2050.



The IEA Energy Sector Carbon Intensity Index (ESCII) ©IEA

From 2011 to 2012, solar photovoltaic and wind technologies grew by an impressive 42% and 19%, respectively, despite ongoing economic and policy turbulence in the sector. Emerging economies are also stepping up efforts in clean energy. Brazil, China and India were among the countries that enhanced policy support for the renewable electricity sector in 2012, for example.

The revolution in shale gas technology has triggered a switch to gas from coal in the United States – important to reducing emissions in the short term – but this is still a regional phenomenon. Coal use expanded elsewhere, in particular in Europe, where the share of coal increased in the power generation mix at the expense of natural gas.

The report gives policy recommendations, technology by technology. At the highest level, it stresses that the true cost of energy must be reflected in consumer prices, through carbon pricing and the phase-out of fossil-fuel subsidies. Technologies like electric vehicles, wind and solar will need support for several years more, but policies should be flexible and transparent. More stringent and broader energy performance standards, building codes and fuel economy standards can drive energy efficiency.

"The CEM governments represent 4.1 billion people and three-quarters of global GDP," Ms. Van der Hoeven said. "Together, they have the power to set the clean energy transition in motion, and now it is time for them to use it."

More information

www.iea.org

Bellona Europa launches discussion on the future of CCS in the European Parliament

On 16th April Bellona Europa and Chris Davies, MEP organized a hearing on the future of CO2 capture and storage during the plenary session of the European Parliament. Bellona reports on the meeting.

Driving CO2 Capture and Storage in the EU

The open hearing, co-hosted by Chris Davies, British MEP from the ALDE Group, launched a discussion on new ways of enabling CCS to help the EU achieve its climate goals. New instruments to promote and fund the CCS technology were presented by the co-authors of the CCS Market Incentives Report of Bellona Europa, Ivan Pearson, Project Manager at Bellona Europa and Keith Whiriskey of Bellona Foundation, Oslo.

The event, attended by the representatives from major political groups and key stakeholders opened a discussion on the future of CCS in light of the recent publication of the CCS communication by the European Commission

The European Parliament's coordinators for environmental policy agreed on 21 March to a proposal from Chris Davies, that the future of CO2 capture and storage (CCS) in the EU will be the subject to a 2013 Implementation Report by the Environment Committee.

The report, entitled Developing and Applying Carbon Capture & Storage Technology in Europe, will propose new instruments to promote and fund the development of CCS. It will also analyse the reasons for the failure to secure approval for demonstration projects in the first round of the NER300 competition.

"We are losing it out on the solar market compared to China, we cannot make it happen with the CCS technology as well," said Chris Davies, ALDE MEP, who wasnominated to be a rapporteur for the report.

The hearing took in place in the afternoon of the back loading vote in which the MEPs refused to give the EU executive the power to intervene in the carbon market to boost prices.

The representative of the Global CCS Institute, John Scowcroft underlined "[...] any fixes that could help contribute to the longer-term operational costs of CCS projects in addition to capital expenditures will likely have a larger effect than a higher CO2 price, as are efforts to level the playing field for demonstration plants."

Bellona recommends a core EU CCS policy framework comprised of:

- An overarching EU-wide CCS target
- Complementary market incentive schemes at the national-level

Every EU CCS projects so far has relied upon a tailor-made blend of several funding mechanisms, suggesting that the policy measures will almost inevitably be deployed in overlap with each other, says Bellona. The proposed EU policy framework pays special attention this fact, as well as to the politico-economic context within the Union, where parallel layers of government can complicate the design and administration of energy policies.

The need for effective targeted support to CCS

"The European Commission's current view is that ETS and the NER programmes are the primary tools that are available to drive CCS. CCS is the only established abatement technology that does not benefit from effective support in the current suite of EU-level policies," said Paal Frisvold, Chairman of Bellona Europa.

"Until a structural reform of the ETS can be realized, targeted support for CCS will be necessary. Because of the low CO2 price and the failure of the NER300, CCS is the only established abatement technology that does not benefit from targeted support in the current suite of EU-level policies," he explained.

Ivan Pearson, Project Manager at Bellona Europa and co-author of the report said : "The current suite of EU-level policies provides effective, targeted support to wind, solar, biomass, cogeneration and energy efficiency abatement opportunities – but not CCS. Bellona supports backloading, as well as the long term reform of the ETS to provide an effective and neutral price signal for investment in low-carbon technologies."

The CCS Market Incentives Report elaborates on several options of CCS incentives such as: grant schemes, loan guarantees, green certificates, capacity auctions, purchase contracts and feebates.

The cost of tackling climate change is moving up the political agenda. At this stage in the long-term transition to low-carbon energy, CCS may be able to cost-effectively deliver large amounts of CO2 abatement. Without timely and bold action, however, the EU will lag behind other regions in the world in the deployment of CCS, needlessly increasing the cost of decarbonisation to EU taxpayers and consumers.

Bellona Europa recommends a core EU CCS policy framework comprised of an overarching EU-wide CCS target and a complementary market incentive schemes at the national level.

The overarching EU-wide target should be coupled with a complementary blend of CCS market incentive schemes at the national level able to better cater to the significant differences between Member States in terms of the structure of their electricity markets.

CCS milestone analogous to '20% by 2020' renewable energy target

A legally binding EU requirement for Member States to capture an agreed percentage of their total CO2 emissions by 2030 would be a politically salient and mobilizing goal, driving CCS deployment in both the power and non-power sectors – the authors of the report argue.

"It would reassure investors of the political commitment to CCS, but still be flexible enough to complement other policy initiatives at the EU- or national-levels. It would also accommodate Member State differences in ability and willingness to deploy CCS," Ivan Pearson concluded.

More information

The CCS Market Incentives report and other links can be found at:
www.bellona.org

Policy, projects and regulation news

Global CCS Institute factsheets

www.globalccsinstitute.com

The Global CCS Institute has produced a series of factsheets and images covering topics related to CCS which can be used as educational resources for the wider community.

The resources are available free online. Topics include CCS projects, carbon capture methods, geological storage, CO2 storage with enhanced oil recovery, CO2 transport and CCS in developing countries.

Preferred bidders announced in UK's £1bn CCS Competition

www.gov.uk/decc

They are the Peterhead Project in Aberdeenshire, Scotland, and the White Rose Project in Yorkshire, England.

The two projects selected in detail:

- Peterhead Project in Aberdeenshire, Scotland – a project which involves capturing around 90% of the carbon dioxide from part of the existing gas fired power station at Peterhead before transporting it and storing it in a depleted gas field beneath the North Sea. The project involves Shell and SSE.

- White Rose Project in Yorkshire, England – a project which involves capturing 90% of the carbon dioxide from a new super-efficient coal-fired power station at the Drax site in North Yorkshire, before transporting and storing it in a saline aquifer beneath the southern North Sea. The project involves Alstom, Drax Power, BOC and National Grid.

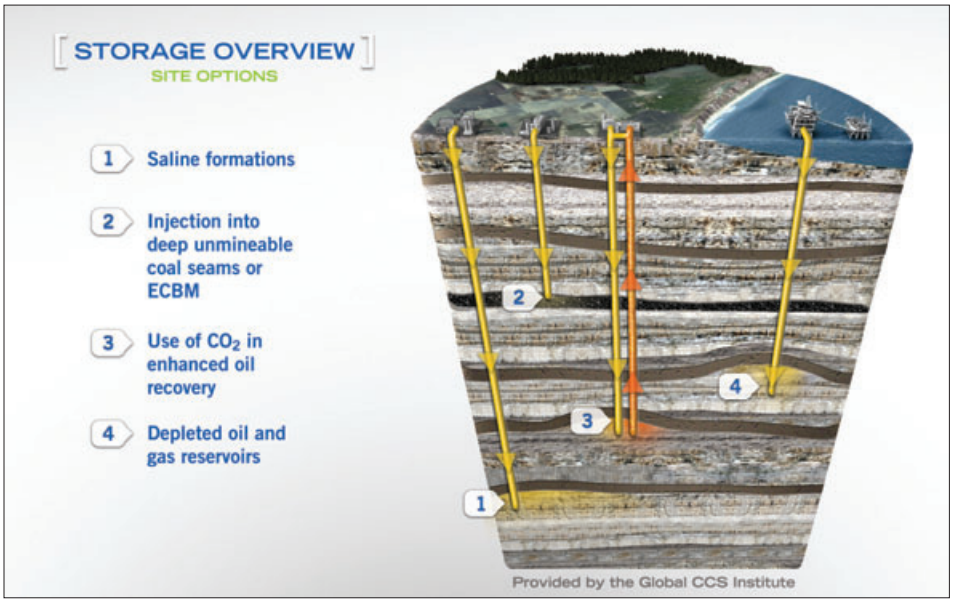
The two preferred bidders were selected following a period of intensive commercial negotiations with four projects shortlisted from an original eight in October last year.

The Government will now undertake discussions with the two preferred bidders to agree terms by the summer for Front End Engineering Design studies, which will last approximately 18 months. A final investment decision will be taken by the Government in early 2015 on the construction of up to two projects.

Captain Clean Energy and Teesside Low Carbon, the remaining two bidders with whom the Government has been in discussion, will be appointed as reserve projects. These bids may be called to participate in the next stage of the competition if one or both of the preferred bidders fails to enter into a FEED Contract by the summer.

Dr Jeff Chapman, Chief Executive of the CCSA, commented:

"This decision represents a watershed for CCS in the UK and in Europe.



The GCCSI has made easy to understand images available that explain aspects of CCS

We are immensely pleased to see that the Government has decided to move forward with two CCS projects in the UK and support further detailed studies on both these projects. These projects are both extremely exciting proposals and will deliver tremendous benefits for the UK, in terms of infrastructure investment, jobs and market value to the UK economy. They will form the basis of the first regional CCS clusters in the UK, which will deliver local prosperity into the future.

Clearly there is disappointment for the two projects that have not been selected to go forward at this stage as those companies have put significant efforts into developing their bids. However, the Government has an opportunity to ensure that these projects are kept alive by designing the Contract for Differences under the UK's Electricity Market Reform in a way that supports these CCS projects going forward.

CCS is extremely cost-effective compared with other low-carbon technologies – the interim report of the CCS Cost Reduction Task Force concluded that CCS can deliver low-carbon electricity at a cost below £100/MWh in the early 2020s. However to deliver these cost reductions, we must build CCS now."

EU seeks views on the future of CCS

ec.europa.eu

The European Commission, Directorate General Energy, has published a Consultative Communication on the future of carbon capture and storage in Europe and invited stakeholders to give their views.

The Communication summarises the state-of-play of CCS development to date, identifies barriers that have prevented the technology from progressing, and discusses some of the options to promote the demonstration and deployment of CCS under a strengthened long term business case.

The EU has committed to reducing greenhouse gas emissions by 80-95% by 2050 compared to 1990 levels. CCS is expected to contribute significantly to the decarbonisation of fossil fuel-based power generation and CO2-intensive industries, particularly as Europe's energy demand continues to grow. The Energy Roadmap 2050 and the Roadmap for moving to a low-carbon economy in 2050, both published by the Commission in 2011, indicate that Europe will use CCS as part of its energy mix in the future.

However, despite more than twenty small-scale projects successfully operating globally, none of the CCS technologies have been deployed on a large scale. Bringing costs down and securing long-term investment remains a challenge that looks likely to continue with the current low price of carbon.

Within this context, the Communication seeks stakeholder views on the best policy framework to ensure that the demonstration and further deployment of CCS, if proven commercially and technically viable, occurs without further delay.

Issues for consideration include whether Member States that are highly reliant on coal and gas should be required to develop a roadmap on restructuring their

power generation to low-carbon alternatives and a national strategy on preparing for CCS; whether the Emissions Trading System should be restructured to include more incentives for CCS; what other measures the Commission can provide to support early deployment; and how public acceptance can be increased.

UK and Canadian organisations announce CCS researcher exchange programme

www.ukccsrc.ac.uk

The UK CCS Research Centre (UKCCSRC) and Carbon Management Canada (CMC-NCE) have established an exchange program allowing Early Career Researchers (ECRs) from their respective organisations to collaborate with each other on CCS projects.

Up to £5,000 is available per proposal to fund graduate students and post doctoral researchers. The exchanges will build new or strengthening existing collaborations between the two countries' top researchers, share experimental facilities and exchange knowledge.

Prof. Jon Gibbins, UKCCSRC Director said, "the global scale of climate change demands global efforts in emission reduction research. This programme will allow talented UK researchers to build links with our Canadian colleagues, who are active in CCS. We anticipate this programme will establish cutting edge research collaborations which will advance CCS R&D and add value to both the UK and Canadian CCS research programmes."

"We at CMC are really excited about this program. Young researchers will be the ones to deliver breakthrough solutions to today's carbon management problems - but they won't do it working in isolation. Collaboration is a critical element in the innovation process and exchange programs like this one help our early career scientists build the relationships necessary for the development of ground-breaking, deployable technologies," said Dr. Steve Larter, CMC's Scientific Director.

This joint programme comes after researchers in both organisations met this summer on a visit to Canada supported by the UK Foreign and Commonwealth Office. Results and outcomes from these exchanges will be shared with organisation members.

It is expected that up to four UK and four Canadian early career researchers will be selected from applications submitted to a joint panel by mid-May, with applications chosen by end-May. The program will fund up to one-month of travel which must occur between July 1, 2013 and June 30, 2014.

In Canada, CMC will fund only those ERCs who are currently working on CMC-funded research projects. In the UK, ECRs should collaborate with Canadian colleagues involved in CMC-funded projects where applicable.

Scottish and South Korean researchers sign CCS collaboration deal

www.sccs.org.uk

The UK's largest grouping of CCS researchers, Scottish Carbon Capture & Storage (SCCS), has signed a strategic agreement with South Korea's leading CCS research institute that will see scientists from both countries work together to develop cutting-edge technologies for reducing carbon dioxide emissions from power generation and industry.

The Memorandum of Understanding (MoU) between Edinburgh-based SCCS and Korea Carbon Capture and Sequestration R&D Center (KCRC) is the first such agreement to be signed between UK and South Korean CCS researchers.

As well as creating a framework for a joint programme of research, it will also enable the flow of knowledge between the two institutes and provide training opportunities for researchers in both the UK and South Korea.

Professor Stefano Brandani, a member of the SCCS directorate and Chair of Chemical Engineering at the University of Edinburgh, said: "It is a pleasure to have the opportunity to build on our links with South Korea and establish a formal MoU with KCRC. International cooperation is an essential aspect for the successful deployment of CCS worldwide, and there are clear opportunities for fruitful joint research between KCRC and SCCS."

The MoU marks another milestone in CCS collaboration between SCCS and South Korea. In December 2011, researchers from the University of Edinburgh and Yonsei University embarked on a three-year joint project to design an advanced process for producing power and hydrogen from the gasification of coal feedstock.

Dr Sang-Do Park, Director of KCRC, said:

"Recognising the importance of CCS for the solution to climate change, the Korean government, as well as developed countries, makes significant investment to develop advanced CCS technologies. Being at the core of the Korean government's CCS project, KCRC is strengthening international collaboration and networking. I am happy to get this MoU between SCCS and KCRC to establish the framework for CCS cooperation. Based on this MoU, I look forward to promoting cooperation with SCCS on innovative CCS technologies."

Professor Brandani, who participated in the MoU signing ceremony on Friday in Jeju Island, South Korea, made a keynote speech at the 3rd Korea CCS Conference, the country's annual showcase of work already under way on CO2 capture and storage technologies. The national-level conference was attended by over 450 delegates, highlighting the value being attached to the future role of CCS in the country's energy sector.

The MoU between SCCS and KCRC will run for three years, with the potential to extend the collaboration.

B&W signs contract to begin second phase of FutureGen 2.0

www.babcock.com

Babcock & Wilcox Power Generation Group has reached an agreement with the FutureGen Industrial Alliance to begin initial engineering and preparation for full front-end engineering and design work on the U.S. Department of Energy's FutureGen 2.0 CCS project.

B&W's complete scope of work for FutureGen 2.0 includes the design of the near-zero emissions plant's oxy-coal combustion system, air quality control systems, boiler, steel and other control systems.

The contract authorizes B&W and the FutureGen Industrial Alliance to begin project Phase II-A for the 167 megawatt (gross) power plant in Meredosia, Ill. During this time, B&W and the Alliance will continue to negotiate additional contracts to proceed with full front-end engineering and design work.

The DOE earlier this month announced the beginning of Phase II project development and a new cooperative agreement with the FutureGen Industrial Alliance.

"Our contract with the FutureGen Industrial Alliance is a major milestone in the FutureGen project and we're excited to begin work on this new stage," said J. Randall Data, B&W PGG President and Chief Operating Officer. "As first-of-its-kind CCS technology, FutureGen will be groundbreaking for our team and for America."

The goal of the FutureGen 2.0 project is to upgrade an existing power plant located in Meredosia with B&W's oxy-coal combustion process to separate and capture more than 90 percent of the carbon dioxide (CO2) generated during the combustion process. Oxy-coal combustion uses oxygen mixed with recycled flue gas to replace the normal combustion air in a coal-fired boiler. As coal is burned, the resulting flue gas consists primarily of CO2, which is well-suited for compression and storage.

China becoming a global leader in CCS

China must be commended for its impressive approach to tackling the climate change challenge, including through large–scale investment in carbon capture and storage (CCS) technology, according to Global CCS Institute Chairman Professor Paul Dougas.

Speaking at the opening of the Institute's new office in Beijing, Professor Dougas acknowledged the Chinese Government for embedding climate change policy in its industrial and economic development agenda.

"There is a limited period in which the world can deal with the climate change challenge, which threatens our economic, social and environmental wellbeing," Professor Dougas said. "I applaud China's approach to dealing with this incredibly difficult problem through a range of ambitious policies and actions, emissions reduction targets, and inclusion of CCS in the 12th Five–Year Plan."

The Institute's CEO, Brad Page, said the decision to open an office in China reflected the important role the country was increasingly playing in combatting dangerous climate change through CCS technology.

"China has emerged as the recent fast mover in CCS," Mr Page said. "Indeed, it is establishing itself as a leader in CCS, accounting for more than half of all newly identified large–scale integrated projects [LSIPs] around the world in 2012.

"China now has 11 LSIPs in various stages of planning, as well as more pilot projects than in any other country. And, demonstrating both the technical and commercial viability of CCS, many of these smaller projects are already operating successfully."

A memorandum of understanding (MoU) between China's Department of Climate Change, National Development and Reform Commission (NDRC) and the Institute, signed a year ago, has opened the door for greater cooperation and significant progress on CCS. Collaborative projects, for example, have already included a capacity building workshop for stakeholders on storing carbon dioxide (CO2) and enhanced oil recovery, and public awareness activities.

"We owe a debt of gratitude to the NDRC for its strong support, which has also paved the way for a growing number of Institute Members from China," Mr Page said (refer to the attached list).

"A further important demonstration of increased cooperation is a new arrangement between the Institute and Yanchang Petroleum Group."

Under an MoU signed at the opening ceremony, the Institute and Yanchang intend to cooperate on pilot and large–scale CCS demonstration projects in the coal-to-chemicals sector. The aim will be to:

- increase technical and non-technical understanding of the application of CCS in the non-power sector, including regulations and permitting
- increase understanding of CO2 storage and utilisation, and monitoring, measurement and verification within China's unique geology
- enhance public awareness and acceptance of CCS technology development in China and globally
- share and disseminate key learnings to help advance other projects around the world.

Mr Page said the opening of the new Beijing office signified a more regionally focused, globally connected approach by the Institute to its business.

"There is a lot of work still to be done, but based on the strong support we've received from the Chinese Government and industry to date, I am very optimistic about the future," he said.

UK Carbon Capture and Storage Research Centre launches RAPID research projects

www.ukccsrc.ac.uk

The UK Carbon Capture and Storage Research Centre (UKCCSRC) has offered funding to 11 research projects totalling £1.65 million and is in discussions with two additional projects.

The projects will address current gaps in knowledge and contribute to the commercialisation of carbon capture and storage (CCS). Thirteen UK universities and research institutions will be involved in research delivery, and key project outcomes will be made publicly available on the UKCCSRC website.

"These projects will enhance our current knowledge of CCS, and they will have tangible results that may be used by industry, government and other CCS professionals," said Professor Jon Gibbins, UKCCSRC Director.

Four carbon capture projects totalling £582k will develop innovative approaches for:

- chemical looping for low-cost oxygen production;
- oxyfuel and exhaust gas recycling at gas-fired power plants;
- CFD modelling of oxy-coal combustion;
- post-combustion capture using membranes.

Four carbon dioxide (CO2) transport projects totalling £423k will deliver important knowledge and understanding for safe and cost effective design and operation of CCS networks with projects analysing:

- options and opportunities in developing flexible CO2 transport systems;
- behaviour of dense phase CO2 with impurities in pipelines (providing information needed for accurate risk assessment);
- water solubility limits in CO2 mixture (providing information needed for water specification levels for CO2 transport);
- improved options for generating equations of state for CO2 mixtures relevant to CCS applications.

Three storage, monitoring mitigation and verification projects totalling £337k will contribute to:

- improved characterisation of geological formations for CO2 storage in the North Sea;
- development of nano-seismic processes to monitor CO2 storage;
- planning for a second phase of the QICS project on quantifying and monitoring potential ecosystem impacts of geological carbon storage, which included a controlled CO2 release into the shallow marine environment.

Swan Hills Synfuels project discontinued

energy.alberta.ca

The Alberta government and Swan Hills Synfuels have agreed to discontinue their $285 million CCS funding agreement.

Lower than expected natural gas prices have pushed back timelines for Swan Hills Synfuels' production of synthetic gas and associated carbon capture plans. "At present, it's more economical to purchase natural gas than it is to manufacture synthetic gas," said Swan Hills Synfuels CEO Martin Lambert. "It's a market reality that has led to significant delays on the CCS side of the project."

Deferred project timelines move the carbon capture components beyond the scope of the government's funding requirements. To date, no money has been advanced by the province for the project.

In 2011, the province committed $285 million over 15 years for Swan Hills Synfuels to capture the carbon dioxide from the gasification of underground coal and sell it for use in enhanced oil recovery.

"Persistent low prices for Alberta's natural gas have driven this business decision," said Energy Minister Ken Hughes. "CCS remains a key part of Alberta's commitment to reducing greenhouse gas emissions and the responsible development of our energy resources."

Capture and utilisation news

CO2 Solutions announces agreement with Statoil

www.co2solutions.com

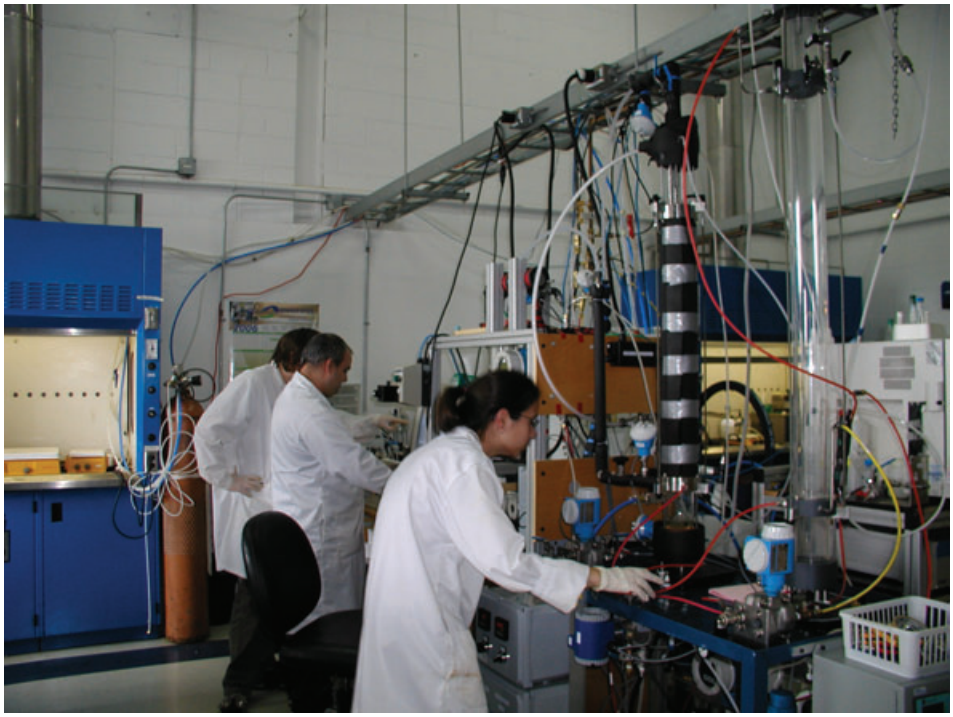
CO2 Solutions will provide Alberta oil sands project data to Statoil.

CO2 Solutions, an innovator in the field of enzyme-enabled carbon capture technology, has entered into an agreement with Statoil to provide certain project data and reports to the Norwegian-based international energy company. The data and reports are related to the pre-pilot phase of CO2 Solutions' Alberta oil sands project.

The value of this agreement is not being disclosed for competitive reasons and will be included in CO2 Solutions' calendar 2013 revenue.

CO2 Solutions is developing carbon capture technology for use in oil sands production, including in-situ methods such as Steam Assisted Gravity Drainage, and bitumen upgrading. Results from the project will also support the broader application of the Company's technology in other natural gas combustion sources, such as gas-fired power plants.

The Alberta oil sands project, previously announced by CO2 Solutions in January, 2013, is being partially funded via investments of $4.7 million from the Harper Government's ecoENERGY Innovation Initiative and $500,000 from Alberta's Climate Change and Emissions Management Corporation (CCEMC).



CO2 Solutions' scientists are developing carbon capture technology for use in oil sands production

Korea CCS Centre opens $20 million innovation challenge

www.kcrc.re.kr

Korea CCS Research Centre (KCRC) in South Korea is seeking innovative ideas from around the world for a $20 million open innovation challenge in order to develop advanced and core technologies regarding to carbon capture and sequestration.

This grand challenge represents a distinctive opportunity to bring the same kind of leading-edge thinking to develop new technologies to unlock the potential of Korea's energy economy in an environmentally responsible way.

It is expected to identify cost-effective technologies that could provide significant reductions in greenhouse gas emissions by carbon capture (solvent/sorbent/membrane), carbon storage technology, and CO2 conversion. Technical solution providers are encouraged to submit proposals to signify their interest.

Focus areas includ, for example:

- development of absorption and reproduction technology for enhancing the efficiency of wet capture processes
- designing liquid absorbents using computational chemistry
- development of CO2 absorbent deposition technology and porous metallic oxide host for fluidized bed reactor
- development of hybrid CO2 adsorbent for high temperature processes using Ca series nano crystalline metallic oxide
- development of technology that allow for evaluating the performance of CO2 sequestration membrane enable to separate CO2 from flue gas in the post combustion process
- development of novel CO2 sequestration membrane with CO2-phillic, development of innovative CO2 reforming technology for producing syngas
- development of formic acid production system with break-through CO2 conversion technology
- enhancement of microalgae cultivation efficiency using the concept of micro fluid
- establishment of metabolic engineering- and synthetic biology-based chemical production platform using recombination of cyanobacteria.

The Korean government has selected CCS technology as part of core technologies for significant reduction in greenhouse gases, and established the National Comprehensive Plan for CCS to commercialize and ensure the international competitiveness of CCS technology by 2020. As part of the plan, the Ministry of Science, Ict & future Planning established the Korea Carbon Capture and Sequestration R&D Center in December 22, 2011 to actively implement the 'Korea CCS 2020 Project'.

KCRC will play a key role in making Korea one of the world's strongest nations in CCS technology by gathering CCS research capabilities, securing core and ground-breaking technologies, and building-up the basis for research.

The KCRC is now offering three phases of funding that total $151 million over a nine-year period. The first, second, and third phases are November 1, 2011 ~ May 31, 2014, June 1, 2014 ~ May 31, 2017, June 1, 2017 ~ May 31, 2020, respectively. The third stage in the first phase, with submission due by 13:00, May 4, 2013 (Saturday, Korea Standard Time), offers grants of $20 million for up to 39 projects.

Transport and storage news

Ancient reservoir holds clues to CO2 storage

geology.gsapubs.org

Studies of the site, where tiny amounts of naturally generated CO2 gas have risen to the surface over the past 400,000 years, could help scientists develop safe methods for carbon capture and storage.

Researchers studied leakage from a natural underground reservoir of CO2 cut by two geological faults near Utah's Green River.

By examining deposits of natural travertine – a type of limestone – formed at natural CO2-rich springs over hundreds of thousands of years, they were able to map where leaks had occurred and calculate volumes and rates of leakage over time.

Professor Zoe Shipton, from the University of Strathclyde's Department of Civil and Environmental Engineering, said "This study gives us a remarkable record of how and where CO2 and water have moved up a geological fault zone over the last 400,000 years.

"The results are not just important for future CO2 storage sites, but will help us understand how metals such as gold accumulate in deposits along fault zones, and how faults can act as barriers or conduits to flow of other fluids such as hydrocarbons and waste water."

The study found that leaks from geological fault zones are more intense than leaks from the rocks through which the faults cut. They also found that man-made leakages, such as from abandoned oil wells, transmit higher volumes of CO2 than natural faults in rock.

Scientists say the study's long history of leakage through natural faults, and its finding that the leakage is concentrated in specific points along the faults, will help inform the design and monitoring of sites developed for storage. They also point out that that the wells in this study were abandoned without regard for CO2 leaks, and modern wells are much more carefully managed.

Their findings concur with results from recent fracking research, which indicate that well integrity represents the biggest risk to shale gas operations. The work also gives valuable insight into the impacts of leaks from well bores.

Dr Neil Burnside, of the University of Edinburgh's School of GeoSciences, said: "Studying an ancient natural CO2 reservoir has given us enormous insight into how man-made storage sites could behave in the long term. This work further highlights well-bore leakage is the largest risk to geological storage projects."

Scientists from the Universities of Edinburgh, Glasgow, Strathclyde and the Scottish Universities Environmental Research Centre carried out the work, which was published in the journal Geology and funded by the Natural Environmental Research Council.

Scottish researchers develop CO2 'fingerprinting'

www.sccs.org.uk

A project to develop a method for fingerprinting carbon dioxide captured from fossil-fuel burning facilities will see Scottish researchers work alongside two CCS initiatives in Canada.

The two-year project by scientists from the Scottish Carbon Capture and Storage (SCCS) partnership will examine how levels of natural tracers in CO2, such as noble gases like helium or argon, could provide a unique "fingerprint" linking CO2 to its capture facility. This, in turn, could help to identify the source of CO2 in the event of a leakage – an important aspect of the development of multi-user storage sites in the UK and further afield.

The study, which has secured part-funding from the Engineering and Physical Sciences Research Council (EPSRCC), will analyse CO2 from different capture facilities in the UK and North America, including CO2 captured from the Boundary Dam power plant in Saskatchewan province, Canada.

At Boundary Dam, the captured CO2 will be fingerprinted prior to its injection at the nearby Aquistore project's saline aquifer storage site. A comparison of CO2 recovered from a monitoring well will show whether the CO2 has retained its fingerprint after movement through the aquifer.

Dr Stuart Gilfillan, research fellow with Edinburgh-based SCCS, who will lead the study, said: "Ongoing debate about the possibility of CO2 leakage from storage sites includes concerns over reliably identifying ownership of CO2. Research to date has failed to identify a cheap and effective means of unambiguously identifying leakage of CO2 injected, or a viable means of identifying ownership of it.

"Our research will show if this is a viable technique for tracking the movement of CO2 in future storage sites, particularly offshore saline aquifers that will be used for storing large volumes of the UK's CO2 emissions."

Dr Gilfillan's project was highly rated by EPSRC and was awarded funding for the project on the grounds that it demonstrated a "distinctly different" approach from other proposals, and was considered "novel and timely with clear and appropriate aims".

Senergy makes new appointments to support growth

www.senergyworld.com

Energy services company Senergy has enhanced its senior management team with a number of key appointments to consolidate its position for future growth.

The Aberdeen-based company, which provides fully-integrated project and asset development services across the energy industry, anticipates creating up to 80 new positions by the end of May, as a result of increasing demand for its services.

Senergy applies its expertise and technology to develop and manage oil and gas fields and alternative energy projects in partnership with its clients. The company was recently ranked in the Sunday Times 2012 HSBC International Track 200 league table as well as that of its 2011 Virgin Fast Track 100 of Britain's fastest-growing privately owned companies.

The new appointments include Allan Mathieson becoming global technical head of project management and carbon capture and storage (CCS team leader) and Andrew Jones taking up the role of Asia Pacific energy services manager in power engineering.

Senergy has also appointed two subsurface managers - Don DiBenedetto for the Middle East and India region with Ronald Hoogenboom responsible for the Asia Pacific region.

As global technical head of project management, Mr Mathieson will be based in Edinburgh and will be responsible for instilling a sense of professional project management in the delivery of projects to clients – the focus will be on the application of scope, cost and time management principles to projects to enhance their value to Senergy.

Senergy's CCS business continues to flourish and there is strong demand for its services, says the company. "Mr Mathieson's appointment reflects the industry requirement for increasing expertise in this sector and is one of a number of exciting Senergy appointments in CCS to meet this need. Mr Mathieson is well known to Senergy having worked on a number of Senergy CCS projects in an Associate capacity, most notably in support of BP at the In Salah CO2 Storage project in Algeria over the past six years."

Status of CCS projects

The status of large-scale integrated projects data courtesy of the Global CCS Institute

For the full list, with the latest data as it becomes available, please download a spreadsheet at:
www.globalccsinstitute.com/data/status-ccs-project-database

Asset Lifecycle Stage	Project Name	Description
Operate	**Century Plant**	Occidental Petroleum, in partnership with Sandridge Energy, is operating a gas processing plant in West Texas that at present can capture 5 Mtpa of carbon dioxide for use in enhanced oil recovery. Capture capacity will be increased to 8.5 Mtpa in 2012.
Operate	**Enid Fertilizer CO2-EOR Project**	Since 1982, the Enid Fertilizer plant has sent around 680,000 tonnes per annum of carbon dioxide to be used in enhanced oil recovery operations in Oklahoma.
Operate	**Great Plains Synfuel Plant and Weyburn-Midale Project**	About 3 Mtpa of carbon dioxide is captured from the Great Plains Synfuel plant in North Dakota. Since 2000 the carbon dioxide has been transported by pipeline into Canada for enhanced oil recovery in the Weyburn Field, and since 2005 in Midale Field.
Operate	**In Salah CO2 Storage**	In Salah is a fully operational CCS project in Algeria. Since 2004, around 1 million tonnes per annum of carbon dioxide are separated from produced gas, transported by pipeline and injected for storage in a deep saline formation.
Operate	**Shute Creek Gas Processing Facility**	Around 7 million tonnes per annum of carbon dioxide are recovered from ExxonMobil's Shute Creek gas processing plant in Wyoming, and transported by pipeline to various oil fields for enhanced oil recovery. This project has been operational since 1986.
Operate	**Sleipner CO2 Injection**	Sleipner is the second largest gas development in the North Sea. Carbon dioxide is separated from produced gas at Sleipner T and reinjected into a deep saline formation above the hydrocarbon reservoir zone. This project has been in operation since 1996.
Operate	**Snøhvit CO2 Injection**	The Snøhvit offshore gas field and related CCS activities have been in operation since 2007. Carbon dioxide separated from the gas produced at an onshore liquid natural gas plant is reinjected into a deep saline formation below the reservoir zones.
Operate	**Val Verde Natural Gas Plants**	This operating enhanced oil recovery project uses carbon dioxide sourced from the Mitchell, Gray Ranch, Puckett, Pikes Peak and Terrell gas processing plants and transported via the Val Verde and CRC pipelines.
Execute	**Air Products Steam Methane Reformer EOR Project**	This project in construction will capture more than 1 million tonnes per year of carbon dioxide from two steam methane reformers to be transported via Denbury's Midwest pipeline to the Hastings and Oyster Bayou oil fields for enhanced oil recovery.
Execute	**Alberta Carbon Trunk Line ("ACTL") with Agrium CO2 Stream**	Agrium's fertiliser plant in Alberta is currently being retrofitted with a carbon dioxide capture unit. Around 585,000 tonnes per annum of carbon dioxide will be captured and transported via the Alberta Carbon Trunk Line (ACTL) for enhanced oil recovery.
Execute	**Alberta Carbon Trunk Line ("ACTL") with North West Sturgeon Refinery CO2 Stream**	Up to 1.2 million tonnes per annum of carbon dioxide will be captured at this new heavy oil upgrader in Alberta. In partnership with Enhance Energy, the carbon dioxide will be transported via the Alberta Carbon Trunk Line (ACTL) for enhanced oil recovery.
Execute	**Boundary Dam Integrated Carbon Capture and Sequestration Demonstration Project**	SaskPower is currently retrofitting a coal-based power generator with carbon capture technology near Estevan, Saskatchewan. When fully operational in 2014, this project will capture around 1 million tonnes per annum of carbon dioxide.
Execute	**Gorgon Carbon Dioxide Injection Project**	This component of a larger gas production and LNG processing project will inject 3.4 to 4.1 million tonnes of carbon dioxide per annum into a deep geologic formation. Construction is under way after a final investment decision was made in September 2009.
Execute	**Illinois Industrial Carbon Capture and Storage Project**	The project will capture around 1 million tonnes per annum of carbon dioxide from ethanol production. Carbon dioxide will be stored approximately 2.1 km underground in the Mount Simon Sandstone, a deep saline formation.
Execute	**Kemper County IGCC Project**	Mississippi Power (Southern Company) is constructing an air-blown 582 Mwe IGCC plant using a coal-based transport gasifier. Up to 3.5 million tonnes per annum of carbon dioxide will be captured at the plant and used for enhanced oil recovery.
Execute	**Lost Cabin Gas Plant**	This project will retrofit the Lost Cabin natural gas processing plant in Wyoming with CCS facilities, capturing around 1 million tonnes per annum of carbon dioxide to be used for enhanced oil recovery.
Execute	**Quest**	Quest will capture up to 1.2 million tonnes of carbon dioxide per annum from the Scotford upgrader, and transport it by pipeline for injection into a deep saline formation.
Define	**Belchatów CCS**	PGE EBSA intends to integrate a carbon capture plant into a new built 858 MW unit at the Bełchatów Power Plant, capturing around 1.8 million tonnes per annum of carbon dioxide.
Define	**Coffeyville Gasification Plant**	CVR Energy is developing a new compression facility at its fertiliser plant in Kansas. The plant currently produces approximately 850,000 tonnes of carbon dioxide which will be transported to the mid-continental region for use in enhanced oil recovery.

State / District	Country	Volume CO_2	Operation Date	Facility Details	Capture Type	Transport Length	Transport Type	Storage Type	Project URL
Texas	UNITED STATES	8.4 Mtpa	2010	Natural Gas Processing	Pre-Combustion (Gas Processing)	256 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.oxy.com/
Oklahoma	UNITED STATES	0.68 Mtpa	1982	Fertiliser Production	Pre-Combustion	225 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.kochfertilizer.com/
Saskatchewan	CANADA	3 Mtpa	2000	Synthetic Natural Gas	Pre-Combustion	315 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.cenovus.com/
Wilaya de Ouargla	ALGERIA	1 Mtpa	2004	Natural Gas Processing	Pre-Combustion (Gas Processing)	14 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	www.insalahco2.com/
Wyoming	UNITED STATES	7 Mtpa	1986	Natural Gas Processing	Pre-Combustion (Gas Processing)	190 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.exxonmobil.com
North Sea	NORWAY	1 Mtpa	1996	Natural Gas Processing	Pre-Combustion (Gas Processing)	0 km	Direct injection	Offshore Deep Saline Formations	www.statoil.com/en/
Barents Sea	NORWAY	0.7 Mtpa	2008	Natural Gas Processing	Pre-Combustion (Gas Processing)	152 km	Onshore to offshore pipeline	Offshore Deep Saline Formations	www.statoil.com/en/
Texas	UNITED STATES	1.3 Mtpa	1972	Natural Gas Processing	Pre-Combustion (Gas Processing)	132 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.exxonmobil.com/
Texas	UNITED STATES	1 Mtpa	2013	Hydrogen Production	Post-Combustion	101 – 150 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.airproducts.com/
Alberta	CANADA	Up to 0.59 Mtpa (initially 0.29	2014	Fertiliser Production	Pre-Combustion	240 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.agrium.com/
Alberta	CANADA	1.2 Mtpa	2015	Oil Refining	Pre-Combustion	240 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.northwestupgrading.com/
Saskatchewan	CANADA	1 Mtpa	2014	Power Generation	Post-Combustion	100 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.saskpower.com/
Western Australia	AUSTRALIA	3.4 - 4.1Mtpa	2015	Natural Gas Processing	Pre-Combustion (Gas Processing)	7 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	www.chevronaustralia.com
Illinois	UNITED STATES	1 Mtpa	2013	Chemical Production	Industrial Separation	1.6 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	www.adm.com/
Mississippi	UNITED STATES	3.5 Mtpa	2014	Power Generation	Pre-Combustion	75 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.mississippipower.com/
Wyoming	UNITED STATES	1 Mtpa	2013	Natural Gas Processing	Pre-Combustion (Gas Processing)	Not specified	Onshore to onshore pipeline	Enhanced Oil Recovery	www.conocophillips.com/
Alberta	CANADA	1.08 Mtpa	2015	Hydrogen Production	Pre-Combustion	84 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	www.shell.ca/
Łódź	POLAND	1.6 - 1.8 Mtpa	2017	Power Generation	Post-Combustion	101 – 150 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	www.bot.pl/
Kansas	UNITED STATES	0.85 Mtpa	2013	Fertiliser Production	Pre-Combustion	112 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.cvrenergy.com/

Three days to change the world

CCS Information and Planning Symposium

May 21-23, 2013 • Regina, Saskatchewan, Canada

The Boundary Dam Integrated Carbon Capture and Storage Demonstration Project is advancing rapidly. It's one of the world's largest carbon capture and storage facilities, and the very first to employ fully integrated post combustion CCS technology in a commercial scale coal-fired plant.

The project has generated a wealth of CCS knowledge that has never before existed. Now, the SaskPower CCS Global Consortium is preparing to bring Boundary Dam to the world.

Knowledge is power.

Join us for three days in May for our inaugural information and planning symposium to help shape SaskPower's CCS Global Consortium. This is a content rich event showcasing the knowledge of our Boundary Dam CCS project and the benefits of becoming a Consortium member. For those with a vested interest in the future of CCS, this is the very knowledge that is making a technical, environmental and economic case for the sustainable use of coal.

Organizations interested in joining the Consortium are encouraged to attend this symposium. To receive an invitation visit **saskpowerccsconsortium.com** and complete the Expression of Interest form.

SaskPower
Powering the future