

# carbon capture journal

March / April 2009

Issue 8

## CATO CO2 catcher: first pilot results

EPRI - meeting the challenge of  
affordable low carbon energy

Public awareness - efforts  
need more attention

From oilsands to quicksands?  
- Canada's oilsands dilemma

TOTAL's Lacq pilot - update

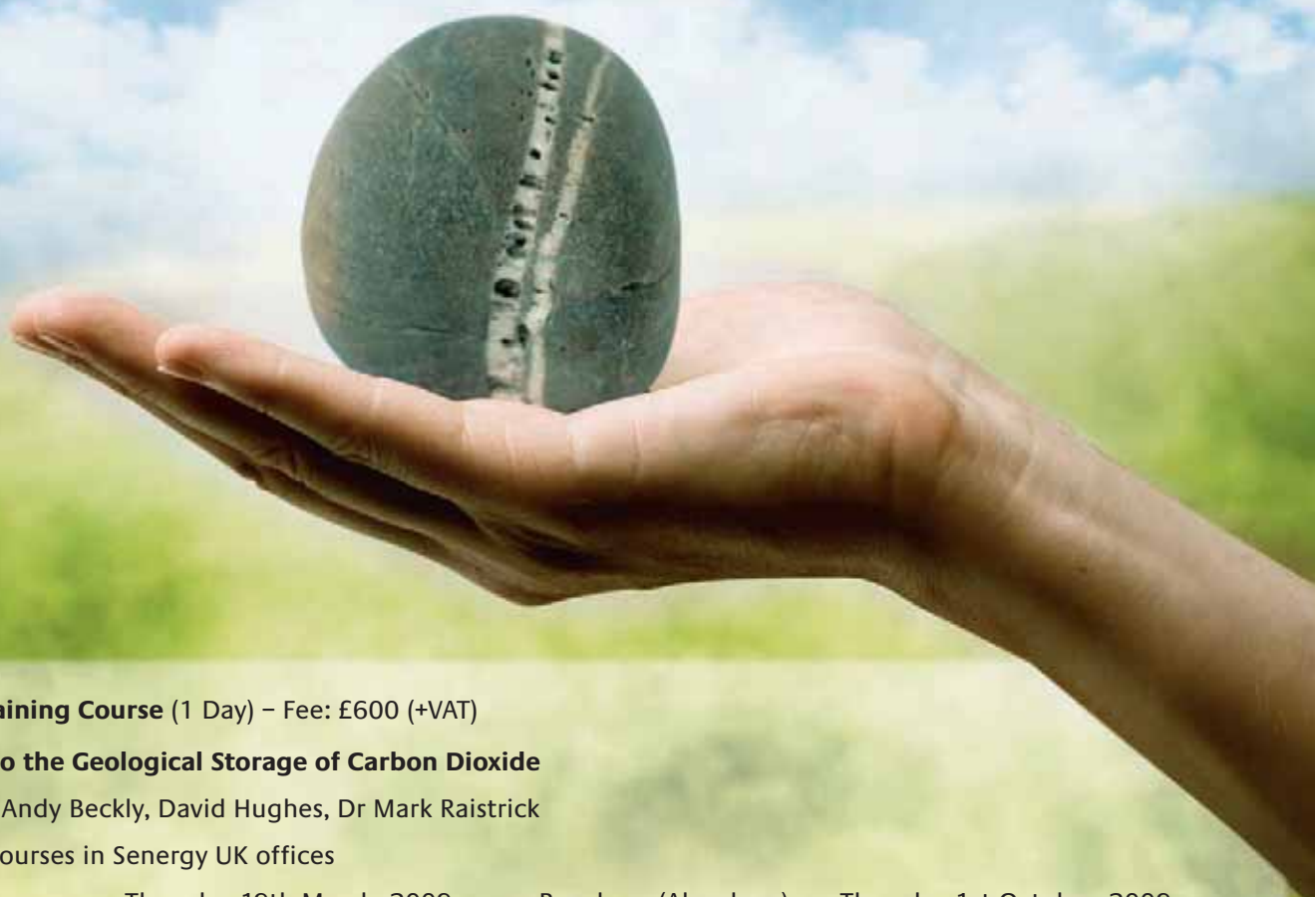


EER report: CO2 storage market analysis

The role of depleted gas fields in CO2 storage

Risk analysis for well integrity in CO2 storage

# Your answer to carbon storage is here



## **NEW CSS Training Course** (1 Day) – Fee: £600 (+VAT)

### **Introduction to the Geological Storage of Carbon Dioxide**

Instructors: Dr Andy Beckly, David Hughes, Dr Mark Raistrick

Location: All courses in Senergy UK offices

London Thursday 19th March, 2009

Banchory (Aberdeen) Thursday 26th March, 2009

Banchory (Aberdeen)

London

Thursday 1st October, 2009

Thursday 8th October, 2009

For full course description and details visit [www.senergyworld.com/training](http://www.senergyworld.com/training) or email [Sarah.McPhee@senergyworld.com](mailto:Sarah.McPhee@senergyworld.com)

Over 400 leading geological, geophysical, reservoir engineering and well engineering consultants across more than 12 international locations, engineering the smart solutions to your carbon storage challenges.

**Senergy - results driven by Brainergy®**

Site selection, injectivity, storage capacity, reservoir integrity, flow/phase studies, storage simulation, enhanced hydrocarbon recovery, monitoring, facilities requirements, commercial services.

United Kingdom Ireland Norway Russia United Arab Emirates Malaysia Australia New Zealand

**Oil & Gas Survey & GeoEngineering Alternative Energy Technology Training Investments**



March/April 2009

Issue 8

### Carbon Capture Journal

213 Marsh Wall, London, E14 9FJ, UK  
www.carboncapturejournal.com  
Tel +44 (0)207 510 4935  
Fax +44 (0)207 510 2344

### Editor

Keith Forward  
editor@carboncapturejournal.com

### Publisher

Karl Jeffery  
jeffery@thedigitalship.com

### Subscriptions

subs@carboncapturejournal.com

### Advertising sales

Alec Egan  
Tel +44 (0)207 510 4944  
aegan@onlymedia.co.uk

Carbon Capture Journal is your one stop information source for new technical developments, opinion, regulatory and research activity with carbon capture, transport and storage.

Carbon Capture Journal print magazine is mailed to over 2,000 power company executives, government policy makers, investors and researchers, with a further 500-1000 copies distributed at trade shows, as well as being downloaded approx. 2,000 times as a pdf.

Subscriptions: £195 a year for 6 issues. To subscribe, please contact Karl Jeffery on subs@carboncapturejournal.com Alternatively you can subscribe online at www.d-e-j.com/store

Front cover:  
The CATO  
pilot plant, at  
the site of  
E.ON

Benelux's  
coal-fired  
power plant  
at the  
Maasvlakte,  
Rotterdam where up to 250 kg/hr of CO<sub>2</sub> is  
captured



## Leaders

### First pilot results from TNO's solvent development workflow

Since the official opening in April 2008, the CATO CO<sub>2</sub> Catcher, TNO's pilot plant at the Rotterdam site of E.ON Benelux, has more than 3000 test hours on the clock. Time to report some first pilot results concerning some amino acid salts that evolved from lab to pilot scale in TNO's solvent development workflow

2

### Public awareness needs more attention

A panel of industry, regulators and NGOs discussed why 'public acceptance' often gets left behind when planning a project and how best to ensure the public understand and support CCS

4

### EPRI - meeting the challenge of affordable, coal-based electricity generation in a carbon-constrained world

The Electric Power Research Institute (EPRI) is conducting a broad range of research, demonstration and pilot projects to develop and prove carbon capture technologies for full scale deployment. By George R. Offen, Electric Power Research Institute

7

### From oilsands to quicksands?

The profitability of huge investments in Canada's oilsands will hinge not just on the oil price, but on the industry's response to environmental risks, argue Rob Foulkes and Daniel Litvin

10

## Projects and policy

### TOTAL's Lacq pilot - project update

After its largest ever public consultation effort, TOTAL has '99% support' for its Lacq pilot

13

### EER report - Global Carbon Sequestration Markets and Strategies, 2009-2030

A new study from Emerging Energy Research analyzes the role of carbon policies in driving sequestration development, evaluates the strategies of stakeholders and measures the sequestration industry's long-term growth outlook

14

### UK 'Low Carbon Industrial Strategy' launched

Gordon Brown has set out the government's vision for the UK's low carbon strategy, which includes ambitions for a second CCS pilot plant

15

## Separation and capture

### CO<sub>2</sub>CRC report says capture costs can be cut by 25%

New research from the Cooperative Research Centre for Greenhouse Gas Technologies (CO<sub>2</sub>CRC) suggests that the cost of capturing carbon dioxide from Australian power stations could be reduced by 25 percent

20

### ION Engineering introduces ionic liquid CO<sub>2</sub> capture technology

Founded by University of Colorado scientists, ION Engineering is a new company set up to commercialise ionic liquid solutions for carbon capture and emissions control

21

## Transport and storage

### What role could CO<sub>2</sub> storage in depleted gasfields play?

With global estimates of total storage capacity varying by orders of magnitude, and a generally accepted view that the biggest uncertainty relates to aquifer storage, depleted gasfields may offer a safer bet for decision makers, at least in the short term. By Kate Harland and Harsh Pershad, Element Energy

22

### Performance and risks analysis for well integrity in CO<sub>2</sub> geological storage

One of the key challenges for CCS technology deployment is to assess well integrity performance towards possible gas leakages. By Vincent Meyer, Oxand

24

### StatoilHydro confirms CO<sub>2</sub> storage site is not leaking

New seismic data from the Utsira formation in the North Sea indicates that the CO<sub>2</sub> being pumped into it is not leaking out

27

# First pilot results from TNO's solvent development workflow

Since the official opening in April 2008, the CATO CO<sub>2</sub> Catcher, TNO's pilot plant at the Rotterdam site of E.ON Benelux, has more than 3000 test hours on the clock. Time to report some first pilot results concerning some amino acid salts that evolved from lab to pilot scale in TNO's solvent development workflow.

**By Dr Earl Goetheer, technology manager and Lodewijk Nell, business development manager at TNO**

### Development strategy

TNO, one of Europe's largest research organizations located in the Netherlands, had already started to work on CO<sub>2</sub> capture in the nineties. However, gradually a shift has been made from capturing CO<sub>2</sub> for climate control and application in green houses towards large scale post combustion capture (PCC).

The research strategy for TNO on PCC is focused on improving solvent systems and developing efficient contactors. In this article the focus is on how TNO is approaching the task of developing and improving absorption liquids using a workflow for moving fast track from lab idea to pilot proven results.

Moreover, as a follow-up to the article in the 5th issue of Carbon Capture Journal on the CATO CO<sub>2</sub> Catcher, TNO's pilot at the Rotterdam site of E.ON Benelux, we also present some first pilot results.

### Solvent Development Workflow

The workflow consists of four main steps:

1. Design
2. Lab experiments
3. Mini plant process set-up
4. Pilot testing

**Step 1** is concerned with the smart selection and design of absorption molecules on the basis of the TNO developed QSAR (Quantitative Structure-Activity Relationship) methodology. The basic idea is to incorporate methodology, which is developed for the pharmaceutical sector, in post-combustion research.

**Step 2** is the characterization of solvents based thermodynamic and kinetic considerations using lab scale equipment. Based on these results, using in-house developed models, it is possible to assess the potential of the newly developed solvent system

**Step 3** is focused on determining solvent stability and process parameters. Typically, autonomous operating continuous absorber/desorber installation is used.

In **Step 4**, pilot scale test runs using



*Figure 1 - The pilot plant, at the site of E.ON Benelux's coal-fired power plant at the Maasvlakte, Rotterdam where up to 250 kg/hr of CO<sub>2</sub> is captured*

the CATO CO<sub>2</sub> catcher are performed to generate key parameters, assess long term stability and validate process models.

### The CATO CO<sub>2</sub> Catcher

The pilot plant was opened in April 2008 and is part of CATO, a national publicly and privately funded programme that unites efforts to research, assess and prepare for the implementation of CO<sub>2</sub> Capture & Storage (CCS) technologies.

The objective is to test novel CO<sub>2</sub> gas scrubbing processes under real industrial conditions. This includes solvents, absorbers and novel process concepts. The construction of the pilot plant at the coal fired power plant at the Maasvlakte (Rotterdam) has been a joint effort between TNO and E.ON Benelux.

The pilot facility enables performance evaluation and benchmarking of different CO<sub>2</sub> capture techniques under real industrial flue gas conditions. The pilot plant is connected to the stack of the second unit of the power plant after desulphurization. Part

of the flue gases is directed to the CO<sub>2</sub> capture pilot plant for carbon dioxide removal. The CO<sub>2</sub> is then removed at a maximum rate of 250 kg CO<sub>2</sub> per hour. A complete monitoring of the process conditions (temperature, pressure, flows, content of CO<sub>2</sub>, SO<sub>2</sub>, soot, etc.) is possible. Also other parameters (such as solvent stability) can be measured separately.

Modelling tools are used at every step for the evaluation of the different technical and economic aspects and also the effect on conceptual and detailed design of large scale post combustion capture facilities.

### Amino acid salts

Normal CO<sub>2</sub> scrubbing solvents based on amines have the disadvantage of being volatile and susceptible to degradation.

To overcome these drawbacks TNO is developing the CORAL family of absorption solvents based on amino acid salts. This family of absorption solvents is dedicated to the removal of CO<sub>2</sub> with a low amount of energy consumption in the re-

generation step and a minimal environmental impact.

The amino acids are commercially easily available, biodegradable and moreover, chemically and thermally highly stable. Due to the fact that the CORAL family is based on the salt of these amino acids, they have no vapour pressure. Therefore, no evaporation of these components is possible and no emissions to the atmosphere will occur.

## First pilot plant results

TNO has demonstrated the potential of some first solvent compositions of the CORAL family in the pilot plant.

In total more than 3000 hours of operation leads to the conclusion that CORAL XPT (one of the first CORAL compositions) is remarkably stable under industrial conditions (degradation losses below 0.15 kg per ton of CO<sub>2</sub>). Minute amounts of degradation products can be found in the vent gasses. Also great potential has been found for the further reduction of energy consumption in the regeneration step.

In figure 2 the progress which has been made is depicted. It is important to note that the results presented are based only on the bare performance of the solvent in

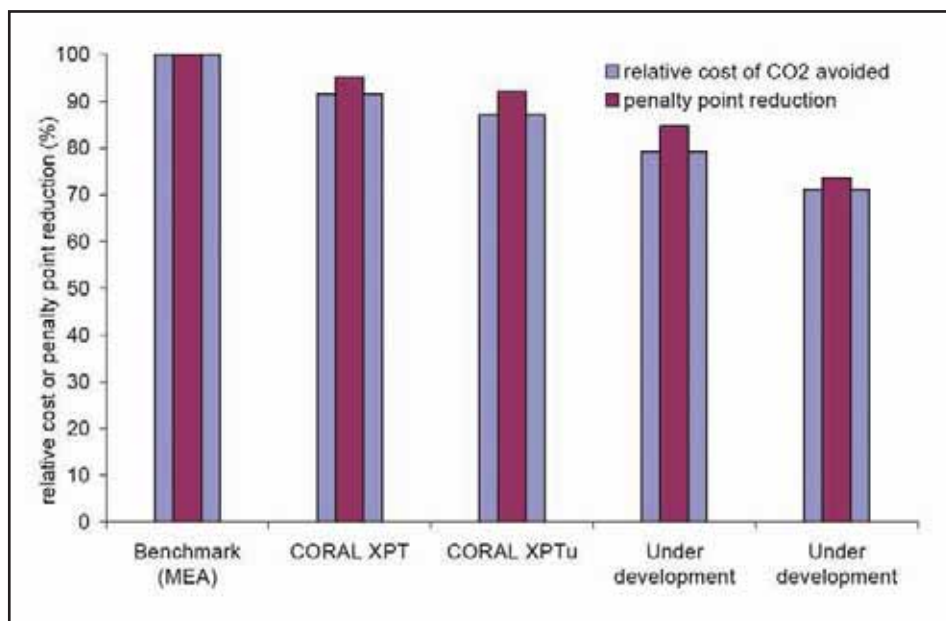


Figure 2: cost of CO<sub>2</sub> avoided and energy penalty relative to a MEA benchmark. Energy. The calculations are based on the guidelines of the European Benchmarking Taskforce

a conventional CO<sub>2</sub> scrubbing facility. Obviously an additional gain can be made with improving the process design.

The performances indicated are relative to a benchmark with a 30wt% MEA solution in a conventional capture process with only basic heat integration.

## Testing solvents & mixtures

In the coming period, TNO will also employ the pilot to test other solvents. In this way industry can be provided with a sound

benchmark, and support can be given to the development and up scaling of different solvent systems. In the end, only a set of successful solvent systems can together provide a total solution for energy efficient and environmentally responsible CO<sub>2</sub> scrubbing under variable conditions.

It is the mission of TNO to support industry in finding the best scrubbing solvents for their specific process and to provide data that will assist in the modeling and scaling up of solvent systems.

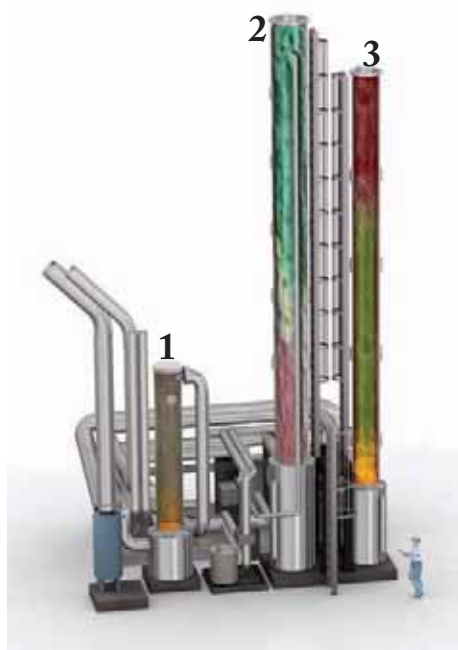


Figure 3 - A graphic of the plant showing 1 - SO<sub>2</sub> scrubber column, 2 - Absorber column, 3 - Desorber column. In the first stage the SO<sub>2</sub> is removed from the flue gas, the treated flue gas is then transported to the absorber where the CO<sub>2</sub> is removed by absorption in a liquid. The purified flue gas is emitted to the stack of the power plant. The absorption liquid is regenerated in the desorber and is ready for use again in the absorber

## About the authors

**Dr Earl Goetheer** is a technology manager at TNO. He is responsible for the technological development of post combustion CO<sub>2</sub> capture.



[earl.goetheer@tno.nl](mailto:earl.goetheer@tno.nl)

**Lodewijk Nell** is a business development manager at TNO. His main responsibility lies with the development of projects related to the energy sector (pictured right)

[lodewijk.nell@tno.nl](mailto:lodewijk.nell@tno.nl)  
[www.tno.nl](http://www.tno.nl)

## TNO (Netherlands Organization for Applied Scientific Research)

is a not-for-profit organization in The Netherlands that focuses on applied science. TNO is a contract



research organization for companies, government bodies and public organizations. Approximately 5000 employees are working to develop and apply knowledge. The organization also provides contract research and specialist consultancy as well as grants licenses for patents and specialist software.



# Public awareness needs more attention

A panel of industry, regulators and NGOs discussed why 'public acceptance' often gets left behind when planning a project and how best to ensure the public understand and support CCS.

**From a panel discussion at Platts' 3rd Annual European Carbon Capture and Storage conference in Brussels, Feb 26-27, 2009.**

### Dan Meredith

**Coordinator - Politics and Communications, Carbon capture and storage Implementation Network, E.ON AG**

E.ON has set up a Carbon capture and storage Implementation Network to coordinate communications around CCS. "We have a lot of activity within E.ON but we did not have a central point of coordination."

"There are challenges in technology, but we can deal with that. There are huge challenges on funding and policy, but we can handle that. What we don't know how to deal with is public acceptance."

"There is a lot we can learn from the UK case of building wind farms. The lessons are that things can happen very quickly, he said. With the renewables obligation in the UK suddenly there was a huge demand for wind installations and the natural reaction is to say, 'hang on lets think about this a bit longer.'"

"From the company point of view, delays mean extra costs so there is a natural conflict of needs. Uncertainty is the key, as a business we need to be as open and transparent as we can about what we want to achieve and the risks."

"The problem with Kingsnorth is that the CCS element was not well communicated; it was not generally known that there even was a CCS plan. 'No new coal' is a simple message and when I was a student I'd probably be protesting myself."

"We have a strange dichotomy that every study, maybe excepting Greenpeace's, are saying that CCS is essential, so we know we are going to do it. However we are not there yet, we don't know what the funding is and we don't want to commit to a project, there is such a rate of change and we are struggling to catch up as a business."

### Jeff Chapman

**Chief Executive, Carbon Capture and Storage Association**

"I've been engaging in industry meetings on CCS since 2001, and over that last eight years every meeting has said public acceptance is very important and we need to do something about it, then everyone goes away and doesn't do anything about it."

"Is that because you don't need to do something about it or just because it is too



*The proposed Kingsnorth plant in the UK - the CCS element was not well communicated to the public*

difficult and it goes into the 'too difficult' box when you go back to your office."

"To say the public want to know is not correct, the public just want to know that the lights are staying on. But when they do get to know something it appears that the first reaction is 'what is this terrible thing that might kill us all' without thinking that the CO<sub>2</sub> is going into the atmosphere anyway and anything is better than that."

"But when it is generally explained that there is a climate problem and an energy issue they become quite accepting of the situation. Who should tell them that? I suspect industry is not the right vehicle for telling the public that – the public don't trust industry."

"Certainly governments will have to explain why they will be putting public money into CCS and that's an important vehicle."

"I spend a lot of time talking to the press and making sure they understand the subject. It seems that when journalists don't understand the subject we get terrible press, but mostly when CCS is explained to them we get good press."

### Scott Brockett

**European Commission, DG Environment**

"When we were developing the EU directive on geological storage we did an internet consultation to find out what the main

public concerns were and there were two."

"The first was safety. It's important to set the risks in context. There is quite a lot of evidence both from EOR in the US and from natural gas storage in Europe that the risks of transport and storage of CO<sub>2</sub> are likely to be no higher than that for natural gas."

"The second issue is to convince the public that the risks will be properly regulated and this really is our task. The EU has now agreed on a directive that says you can not use a storage site unless there is a negligible risk of leakage or adverse impacts on human health and the environment."

"We have also issued something unusual which an EU level review of the permit issued by the national competent authority, so its not just industry and national governments that are saying that a storage site is safe, it's a panel of experts and the EU that is saying it."

"The review is not binding, but it will have a very strong public role. It would be very difficult for nation competent authorities to go against doubts raised about individual projects that are raised at EU level."

"In terms of building public confidence, a general outreach campaign is likely to be of limited value. Communication in the context of individual projects is likely to be more effective. For each project there will have to be an environmental impact assess-

# Leading the World in Carbon Capture and Storage

## Pureenergy CCS™ CO<sub>2</sub> Capture System



*"The world's first  
pre-engineered modular  
CO<sub>2</sub> Capture System  
sequestering CO<sub>2</sub> from power plants  
for enhanced oil recovery (EOR)."*



### HTC PUREENERGY

Suite 001, 2305 Victoria Avenue  
Regina, Saskatchewan S4P 0S7  
Telephone: (306) 352-6132 • Fax: (306) 545-3262  
Jeff Allison: jallison@htcenergy.com

**Asia Pacific:** Sydney, Australia  
Graeme Lynch: glynch@htcenergy.com

**United States:** Montgomery Center, Vermont  
John Osborne: josborne@htcenergy.com

[www.htcenergy.com](http://www.htcenergy.com)

TSX-V: HTC



## *Providing Solutions to the Puzzle of CO<sub>2</sub> Capture and Energy Security*





Bellona has developed a website to communicate information about CCS - it has a database of CO2 emissions sources and CCS projects around the world

ment.”

“We need to get the press involved at an early stage. There have been examples where the press was brought in too late when things had already started to get out of control. I’m thinking of a case where the industry tried to communicate the risks directly, but the public would not take industry’s word for it.”

“The media were not involved at the initial stage, the public reacted adversely and it became a national issue.”

## Paal Frisvold

Chairman, Bellona Europa

“We are faced with a cultural issue, in the sense that the former enemies of climate change, the industry, are now going to become our friends. We have to acknowledge that they are going to be part of the solution and enter into a constructive dialogue.”

“I think we should do what Napoleon did in France, he took the word ‘problem’ out of the dictionary and replaced it with ‘challenge’. We need to stop using the word ‘acceptance’. We do not want to impose that people should accept something.”

“We should engage in a dialogue to provide information and awareness and promote enthusiasm for this very important technology without which we will not reach our goal to stay below two degrees temperature change.”

“We have to take for granted that the public is intelligent, that journalists are intelligent but have a lot to cover. It is our duty as stakeholders to provide a vehicle, a platform and to provide some objectivity.”

“What we need to do now is to be very careful about how we talk about CCS. We have to talk about CCS in the context of climate change, about CCS being a bridging technology so we can make all the steel to build wind turbines and move towards renewable energy sources.”

“There will be a clear shift in industry, he said, CCS is so far

well anchored in the R&D departments of petroleum companies and utilities. We will now see the emphasis shift into core business opportunities because now we have two funding streams.”

“The emissions trading scheme will provide incentives for the demonstration projects but it is not enough. That is why we are pushing for an emissions performance standard. Industry has the opportunity now to get involved in developing the standard and not wait until it is imposed.”

## Jason Anderson

Head of Climate change programme, Institute for European Environmental policy (IEEP)

“You have to divide the public into different groups depending on their level of engagement.”

“We found NGOs in particular are one of the most important mediators of public opinion. There have been some disagreements between the NGOs about the method of tackling climate change. Its important for industry not to marginalize and particular group but to deal with the objections head on.”

“You have to deal with the difficult issues because they are the first things that will come into the mind of the public. It surprises me that anyone would take on a CCS project without first considering how the public will react.”

“There are a few general points:

- Advertising CO2 storage as a clean technology rubs people the wrong way.
- Uncertainty about the added value

of CO2 storage against alternatives. You can’t isolate it without referring to all the other methods that people know to be clean alternatives.

- Long term storage – people are concerned about what it means not just today but for a thousand years.

- The international commitment to the environmental and climate problem. If you are not showing that you are serious about climate change why should we be giving you public money? This is where industry as a mediator for this information is a terrible idea – why should people believe the companies that have been causing the problem all along?”

“The fundamental point is that people do not believe that their concerns are the concerns of those behind the project. They are being asked to believe something for which there is no real evidence, that industry is a partner in tackling climate change.”

## Joris den Blanken

EU Climate and Energy director, Greenpeace

“We have produced a report describing how we can reduce emissions by 80% without CCS or nuclear. We have also been involved with the CATO project in the Netherlands with public acceptance. We have a campaign against the building of new coal fired power plants in Europe.”

“Kingsnorth is planned in the UK without CCS and it is not certain that it will ever happen. The UK can meet its targets without new coal by implementing its renewable targets.”

There are risks to CO2 storage, he said, experts say that there is no way to prove with seismic mapping that all the CO2 injected actually stays in the reservoir. “There is a proven way to reduce emissions and that is with renewable energy.”

There are risks, responded Frisvold, that is why we need to allow for the construction of full scale demonstration projects so we can go through all the risks and deal with them one by one.

“There might be leakages, EU assessments have found that you may have twenty to two hundred casualties from a major leakage. But over 300,000 die every year from complications related to NOx emissions from diesel cars. So we have to put this into context.”

“We have read the Greenpeace report, you have excellent prospects of reaching 50% reductions by 2050, but 50% is not enough and you can not do it without carbon capture and storage,” he concluded.



# EPRI - meeting the challenge of affordable, coal-based electricity generation in a carbon-constrained world

The Electric Power Research Institute (EPRI) is conducting a broad range of research, demonstration and pilot projects to develop and prove carbon capture technologies for full scale deployment.

**George R. Offen, Senior Technical Executive, the Electric Power Research Institute**

## An Energy Portfolio for a Carbon-constrained Environment

The Electric Power Research Institute (EPRI) has examined current and potential options for reducing greenhouse gas (GHG) emissions from the electric sector. EPRI's analysis shows a significant contribution from advanced coal power systems with carbon capture and storage (CCS) will likely be required to achieve economical GHG reductions. However, CCS technology is not yet commercially available.

A "full portfolio" of innovative technology approaches is needed to make substantial CO<sub>2</sub> emissions reductions, while minimizing economic impacts. A significant part of that portfolio is commercially viable CO<sub>2</sub> capture and storage for coal generation within a timeframe consistent with public policy.

In collaboration with other organizations, EPRI is pursuing critical-path activities to help ensure that multiple, competitive, advanced coal generation and CCS technologies become a commercial reality by 2020, a date often cited by policymakers as the start date for wide-scale deployment of CCS.

The power industry is working with EPRI to launch major demonstrations of advanced coal and CCS technologies, the kinds of "big steps" urgently required for commercial readiness of CCS in this timeframe.

The challenge lies in how to fast-track the development and deployment of technologies that could meet those goals.

To examine the technical feasibility and potential economic impact of achieving large-scale CO<sub>2</sub> emissions reductions while meeting growth in electricity demand, EPRI performed two related analyses:

- PRISM analysis, which determined the technical potential for reducing CO<sub>2</sub> emissions based on the assumption of successful development and deployment of a full portfolio of advanced technologies
- MERGE analysis, which modeled the economic value of deploying a full technology portfolio, and projected the least-

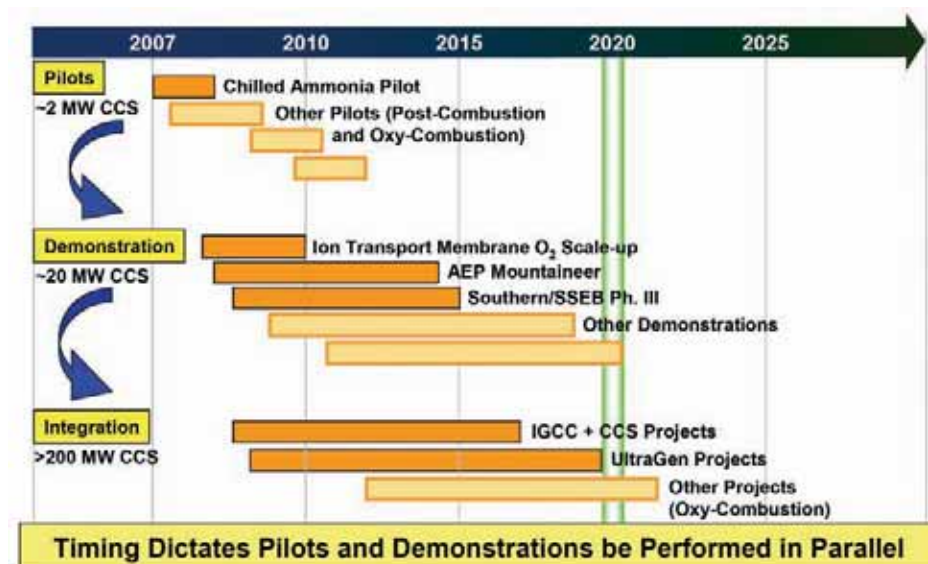


Figure 1 – Steps in Technology Validation and Scale-Up Projects to Meet CURC-EPRI Roadmap Goals for Advanced Coal Technologies with CCS

cost combination of technologies needed to meet an economy-wide CO<sub>2</sub> emissions reduction requirement.

EPRI applied these analysis tools first to the United States and found that deployment of a full portfolio of advanced technologies could reduce U.S. electric sector CO<sub>2</sub> emissions by 2030 to a level below 1990 emissions. Although EPRI's initial analyses focused on the United States, work currently under way on a global analysis is expected to show similar energy mix changes and significant economic impacts.

Importantly, EPRI's findings indicate that, even with aggressive development and deployment of alternative energy sources, coal-based electricity generation will remain an important part of the power portfolio, especially in rapidly expanding economies like those of China and India.

## EPRI Steers a Course to Advanced Coal-Based Generation with CCS

Technically, it is possible to incorporate equipment to capture CO<sub>2</sub> in all types of new coal-based power plants. Depending on available space and other considerations, such equipment also can be retrofitted to existing coal-fired plants.

The drawback to adding CO<sub>2</sub> capture, beyond its added cost, is a reduction in plant output and efficiency. For this reason, research into less expensive, less energy-intensive, and more flexible capture technologies is the focus of major research, development, and demonstration programs at EPRI and elsewhere.

CO<sub>2</sub> capture and/or reduction is only part of the CCS picture. Important work is proceeding around the world to identify potential storage sites and capacities, verify predicted CO<sub>2</sub> behavior in target geologic formations, minimize or eliminate environmental impacts, and assess the cost and performance of monitoring instruments. EPRI is an active participant in a number of these projects.

RD&D also is needed to improve the thermodynamic efficiency of coal power plants as a way to reduce CO<sub>2</sub> emissions. Increased efficiency reduces the amount of CO<sub>2</sub> generated per unit of plant output (approximately 2.5% per 1% point increase in thermal efficiency), meaning that plants that are more efficient can use smaller, less-expensive CO<sub>2</sub> capture systems.

Economic analyses show that the dual strategy of improving efficiency and im-

proving CO<sub>2</sub> capture system performance is the optimal path to competitive advanced coal power systems with CCS. Materials development and testing to support higher efficiency designs is under way, to be followed by full-scale demonstrations.

To meet these challenges, EPRI is formulating a major collaborative program of RD&D projects for critical-path CO<sub>2</sub>-reducing technologies. The aggressive, interrelated schedule for these projects, developed jointly by the U.S.-based Coal Utilization Research Council (CURC) and EPRI and shown in Figure 1, reflects the consensus from experts that the industry objectives are attainable provided the requisite investments are made.

The figure shows pilot programs, which are early deployments of technology on a smaller scale, then demonstration projects, which are larger-scale validations of technology, followed by integration, where the vetted technology is integrated into a commercial plant at full scale.

By managing risk through staged development and shared costs among collaborative participants, EPRI's demonstrations enable the type of large efforts needed to usher coal-based technologies into the next phase of commercial deployment.

## Advanced Combustion with Post-Combustion Capture

To reach goals for reduction of CO<sub>2</sub> and other emissions from coal-combustion power plants, EPRI is conducting or planning the following pilot- and commercial-scale projects:

- A Technology Watch for breakthrough processes that offer significant reductions in energy demand and, therefore, in cost-of-electricity increases. Examples of processes being followed by EPRI are catalyst-enhanced amines, organic-based sorbents, methods to reduce the liquid quantity fed to the regenerator, and membranes in novel flow configurations for separation of the CO<sub>2</sub> from the flue gas.

Also of interest are technologies that produce a commercial product (e.g., cement) or a solid that can be landfilled instead of being a gas that needs to be compressed, transported, and stored underground. EPRI is developing process simulation modeling capability to support developers of separation materials (solvents, sorbents, etc.) with guidance on how their material could be used in an actual system.

- CO<sub>2</sub> capture pilots to evaluate the use of advanced solvents, sorbents, membranes and other approaches that can reduce the steam and auxiliary power consumption requirements of CO<sub>2</sub> capture systems.



*American Electric Power's product validation of the Alstom chilled ammonia process at its Mountaineer station in West Virginia is scheduled for start-up in September 2009*

Specific projects include:

- Participation and technical advisor to multi-year programs at two facilities offering testing capabilities for advanced CO<sub>2</sub> capture processes at scales from 0.03 MWe to 2 MWe and treating actual combustion flue gas

- Management of the test and evaluation effort of Alstom's chilled ammonia process at We Energies' Pleasant Prairie Power Plant. Alstom began start-up and commissioning of this 1.7 MWe R&D pilot in mid 2008 and will conduct parametric operation during the second quarter of 2009.

- Management of the test and evaluation effort at two sites with 20-25 MWe pilot CO<sub>2</sub> capture systems and integrated geologic storage of the captured CO<sub>2</sub>: (1) American Electric Power's product validation of the Alstom chilled ammonia process at its Mountaineer station in West Virginia, scheduled for start-up in September 2009; and (2) Southern Company's demonstration of an advanced amine process at one of its plants (southeastern U.S.), scheduled to start by early 2011. Both projects will inject over 100,000 tons/yr CO<sub>2</sub> into underground saline formations for one to five years and will monitor the location of the injected CO<sub>2</sub> for at least two years after the end of injection.

- EPRI is discussing similar roles with other CO<sub>2</sub> capture process developers and potential host sites in order to stimulate the advancement of the technology and ensure that electricity generation plants have the best possible information available on the options that may be offered to them in

the near future.

- The UltraGen program, an EPRI-initiated shared-risk effort to demonstrate competitive, highly efficient ultrasupercritical pulverized coal (USC-PC) plants with near zero emissions (NZE) and CO<sub>2</sub> capture through a series of three commercial projects that progressively achieve NZE, higher generating efficiencies and CO<sub>2</sub> capture rates as technological advances become available.

The ultimate goal is main steam conditions of 760°C and 290-345 bar using high-nickel alloys. The efficiency for UltraGen III before capture will be from 48-51% (lower heating value basis), depending on coal type and system design parameters.

- Continuing and new oxy-combustion pilots operated by boiler suppliers and others will develop knowledge needed to implement this technology in new and retrofitted PC and circulating fluidized bed combustion (CFBC) boilers.

EPRI has identified the key focus areas and developments needed in the near term (<10 years) to bring oxy combustion to technical readiness as a competitive option.

These include: minimization of excess air (possibly with oxygen lances at burner tip) and in-leakage (e.g., via tubular heat exchangers); ability to remove NO<sub>x</sub> without the use of selective catalytic reduction (SCR) as far as needed for compression and injection of the CO<sub>2</sub>; firing through cyclone burners to reduce ash fouling and the costs of coal preparation; heat integration of the boiler, air separation unit, and purification



and compression stages to maximize energy utilization; evaluation of approaches for drying recycle flue gas to increase adiabatic flame temperature, improve in-furnace heat transfer, and reduce attemperation requirements; etc.

The methods for removing or managing residual oxygen contained in the CO<sub>2</sub> rich stream will also need to be investigated. Over the longer term, improving energy efficiency and economic performance will require a lower-energy oxygen separation process than currently available (see below).

## IGCC with CO<sub>2</sub> Capture and Storage

To accelerate IGCC technology with CCS through the critical development stages, EPRI has formulated a three-project program to demonstrate integrated operation of commercial IGCC power plants with CO<sub>2</sub> capture, compression, injection, and monitoring.

- IGCC with CCS Project 1 is a retrofit of a single-stage water-gas shift reactor ("sour shift") and a chemical solvent-based acid gas removal system on a syngas slipstream at an existing IGCC unit. The project will demonstrate a two-stage methyl diethanol amine (MDEA) solvent system well suited for medium-pressure (i.e., ~30 bar) gasifiers. Captured CO<sub>2</sub> will be compressed and injected, at a nominal rate of 300,000 tonnes CO<sub>2</sub>/yr (TPY), for permanent storage in an underlying saline reservoir. Start-up is targeted for 2013

- IGCC with CCS Project 2 will take place at a new IGCC plant currently under construction and will include the addition of equipment to "skim" CO<sub>2</sub> from the syngas with a relatively high inherent CO<sub>2</sub> content (as produced in the gasifier). Applying this approach to the entire syngas stream will result in the capture and storage of approximately 1 MTPY CO<sub>2</sub> in a suitable geologic formation and/or for use in enhanced oil recovery. This activity will demonstrate integrated IGCC with CCS at the scale advocated by leading researchers as a crucial commercialization stepping stone. The project is expected to be on-line by 2014–15.

- IGCC with CCS Project 3 will be a new plant designed from the beginning to include "full," or 80–90%, CCS. Based on two stages of water-gas shift and a physical solvent acid gas removal system applied to the full syngas stream, this project will produce a high hydrogen content fuel gas and, therefore, demonstrate a hydrogen-fired gas turbines. Through "full" capture, this project will produce approximately 3.5 MTPY CO<sub>2</sub> for injection into geologic storage formations and/or use in enhanced oil recovery. By partnering with a project

that is already under development, this demonstration could be on-line by 2016–17, meeting the aggressive targets of the EPRI PRISM analysis for wide-scale deployment of IGCC with CCS after 2020.

## Scale-up and Integration of Low-Energy Oxygen Production Technology

Improvements that reduce cost and energy consumption of air separation units would have a significant impact on the competitiveness of IGCC and oxy-combustion power generation plants. Various membrane-based alternatives have been suggested by industrial gas companies and others, including the Ion Transport Membrane (ITM) technology under development by Air Products and a team of industry partners.

In a full-scale IGCC plant, the use of ITM could result in an overall capital cost decrease of about 7% and an auxiliary power consumption decrease of about 6%. ITM oxygen plants are also more compact than cryogenic plants and require significantly less cooling water.

This project builds on prior investments by Air Products and the U.S. Department of Energy to assess and scale-up ITM technology. The project team is now beginning to design and construct a 150 ton-O<sub>2</sub>/day test unit integrated with a 5–15 MWe turbomachinery system. By providing essential information relating to the design, manufacture, integration, operation, and durability of a first-of-kind integration of ITM with a turbomachinery unit, this project, and EPRI's participation in it, will enable a more thorough evaluation of the potential role ITM technology could play in producing more cost-effective IGCC and oxy-combustion systems.

## EPRI Helps Shape the Future

Through its PRISM/MERGE analyses, EPRI has identified a significant role that advanced coal power plants with carbon capture and storage can play in reducing GHG emissions while continuing to supply affordable electricity. The technological advances that would allow coal-based power plants to operate in a low-carbon future have been identified and the path to their commercial deployment is understood.

Collectively, EPRI's integrated approach of technology mining, early support to promising processes, and technology demonstrations represent the overlapping small and "big steps" needed to deploy advanced coal-based generation with CCS widely after 2020, to help meet society's increased demand for affordable, environmentally responsible electric power.

## Acknowledgements

This article was prepared by George R. Offen, Senior Technical Executive, the Electric Power Research Institute (EPRI) based on information provided by EPRI colleagues Neville Holt, Andrew Maxson, Jack Parkes, Jeff Phillips, Ron Schoff, and Rob Steele. Their assistance is gratefully acknowledged.



Dr. Offen's research focuses on the reduction of air pollutants from coal-fired power plants; his group has developed/evaluated controls for mercury emissions and begun to address CO<sub>2</sub> capture and storage.

Dr. Offen joined EPRI in 1985 as a Project Manager focusing on low-cost SO<sub>2</sub> controls and NO<sub>x</sub> reduction by selective catalytic reduction systems.

Before joining EPRI, Dr. Offen was Manager, Energy Engineering at Acurex Corporation. Earlier positions include teaching at Stanford and Santa Clara Universities, research assignments at Chevron Research and the French Institute of Petroleum, and three years as an officer and test engineer with the U.S. Air Force.

Dr. Offen received his BS and PhD degrees in mechanical engineering from Stanford University and his MS in mechanical engineering from MIT.

### George Offen

Senior Technical Executive  
(650) 855-8942  
[goffen@epri.com](mailto:goffen@epri.com)

### Karl Bindemann

International Business Development Manager  
+44 (0)1899 221089  
[kbindemann@epri.com](mailto:kbindemann@epri.com)  
[www.epri.com](http://www.epri.com)



## From oilsands to quicksands?

The profitability of huge investments in Canada's oilsands will hinge not just on the oil price, but on the industry's response to environmental risks, argue Rob Foulkes and Daniel Litvin

For a country with the world's second largest oil reserves, Canada until recently received little attention on the energy security agenda. Its enormous resources – an estimated 175 billion proven barrels of oil – are almost all in the form of oilsands, a mixture of sand and thick, oily bitumen which can be upgraded to “synthetic crude”. They were not attractive while “lighter” and more easily accessible oil was freely available elsewhere.

But since early this decade, resource nationalism in oil-rich countries and historically high prices have pushed big oil companies to pursue such “unconventional” reserves with great determination. The resultant rush has been described as “the biggest industrial project on Earth”: capital spending on oilsands development in Alberta topped C\$50 billion (US\$ 47 billion) from 2000-2007, with well over C\$100 billion in addition planned until recently.

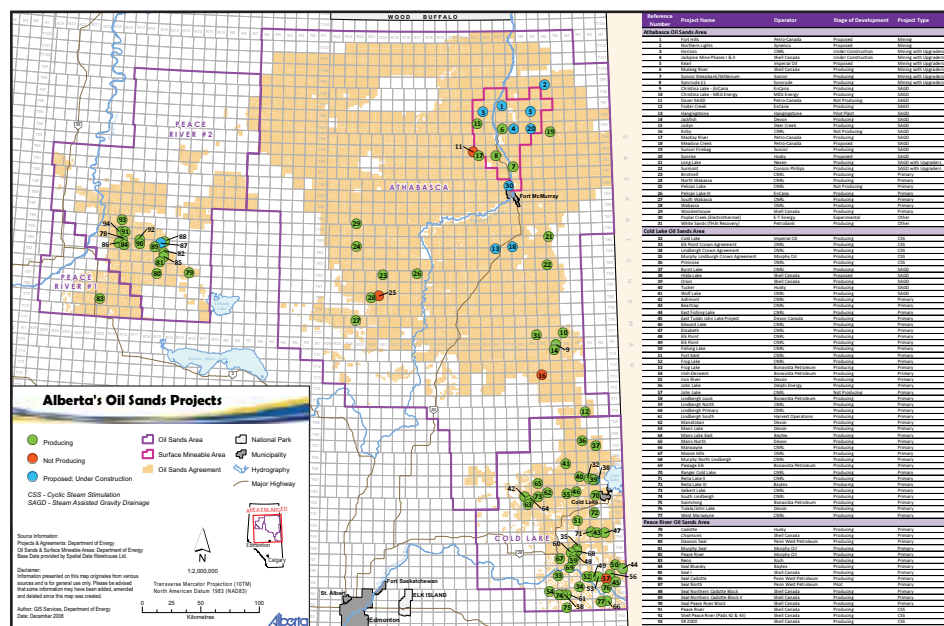
Now, rising costs together with the fall in the oil price over the last several months have stalled much of this investment. But when the oil price revives – as many expect it to – the rush could well resume.

For all their potential, however, the oilsands involve significant environmental challenges which – if not adequately addressed over the long term – could undermine the very value of these enormous investments.

Research using Critical Resource's LicenseSecure™ methodology (which rates the health of resource projects' “socio-political license to operate” – including stakeholder pressures driven by environmental concerns – on a scale from AAA-D) scores the Canadian oilsands industry as a whole between B and CC. This suggests exposure that may be greater than the companies involved believe.

The environmental challenges have been well documented: for example, the heavy water usage and inevitable impact on Alberta's boreal forest involved in oilsands production have attracted strong criticism, though the industry vigorously defends its performance. More significantly from a commercial perspective, there are also substantial risks around greenhouse gas (GHG) emissions which companies may not be taking fully into account.

Producing a barrel of synthetic crude from oilsands emits, according to some estimates, three to five times as much CO<sub>2</sub> as



Huge investments in the Alberta oilsands could depend on how the industry manages environmental risk (Image: Alberta oil sands projects ©Alberta Energy)

producing a barrel of conventional crude. While the difference narrows considerably once emissions from the actual use of the oil (in cars, for example) is taken into account, developments in GHG regulation or carbon pricing nonetheless could impact heavily on the industry's economic calculations.

### Crude assumptions

Supporters of the oilsands tend to downplay this concern. As Alberta Premier Ed Stelmach put it, “I'm confident that by the time the regulations are put in place, we will meet or exceed” them. Such self-assurance appears to rest on two assumptions: that carbon constraints will not take effect for many years (especially given the world's continuing need for secure oil supplies); and that by the time they do, oilsands production will be clean enough to comply. Experience may well prove both assumptions correct, but neither can be taken for granted.

While robust carbon regulation and pricing remain a distant prospect, there are signs that progress in this area could already be building momentum. In addition to moves by the Canadian and Albertan governments to begin cracking down on carbon emissions from industries in their jurisdiction, regulators have also been busy in the key market across the border, potentially restricting oilsands producers' ability to sell their products

in the US.

California is leading the way, having recently adopted a low carbon fuel standard requiring all transport fuel supplied to the state to meet a carbon-intensity standard over its life-cycle; numerous other states and the US Conference of Mayors (a club of major cities acting at the federal level) have also supported curbs on the use of high-carbon unconventional fuels.

Importantly, Barack Obama has proposed similar legislation nationally, while the US Congress has upheld, though not yet enforced, a separate 2007 law prohibiting the federal government from buying carbon-intensive fuels. Even the EU recently amended its Fuel Quality Directive, also with the aim of reducing the life-cycle emissions of its fuels.

It is not yet clear exactly how these new and proposed regulations will affect the sale of oilsands products; besides, as the industry has hinted, there is likely to be ample demand elsewhere should the US choose to close its markets.

Nonetheless, when viewed alongside broader trends pushing for lower GHG emissions – not least the wider environmental reforms promised by Obama and ongoing efforts at the UN to agree a post-Kyoto emissions regime – such regulations may suggest that the world is moving against CO<sub>2</sub> faster



**"Overall conference was very interesting – gave a good overview of all of the issues"**

**Michael Quinn, Manager, Asset Technology, Electricity Supply Board (ESB)**

Organised and Produced by



SMi present their 2<sup>nd</sup> annual conference...

# Gasification

## Gasifying Coal for Power Generation

**Wednesday 17<sup>th</sup> – Thursday 18<sup>th</sup> June 2009**  
**Copthorne Tara Hotel, London, UK**

Rising energy demand and concerns over security of energy supply are driving interest in coal Gasification. SMi's 2nd annual Gasification conference brings together leading industry experts to share information and discuss the challenges facing the industry.

Attend this popular conference to improve your industry knowledge, meet leading practitioners and assess the commercial opportunities for IGCC and UCG. Featuring speakers from key projects around the world and providing in-depth analysis of the issues facing the sector, this comprehensive conference provides essential information for the coal and power industries.

### KEY SPEAKERS INCLUDE:

- **Albert Bloem**, Project Development Manager, **Essent**
- **Maarten Berkhout**, Project Director, Nuon Magnum, **Nuon**
- **Andy Brown**, Engineering Director, **Progressive Energy Ltd**
- **Karl-Josef Wolf**, Researcher, Gasification Group, **RWE Power AG**
- **Judith Shaprio**, Policy Officer, **CCSA**

### KEY TOPICS INCLUDE:

- Key success factors for UCG projects
- The Shell/Essent IGCC + CCS project in the Netherlands
- Coal Gasification for Poland – secure future?
- Siting for power plants and CCS
- Dealing with public opinion towards CCS and clean coal
- CCS – kill or cure?

**Half Day Pre-Conference Workshop:**

**UCG PARTNERSHIP WORKSHOP ON UNDERGROUND COAL GASIFICATION**

In Association with UCG PARTNERSHIP

Tuesday 16th June 2009, Copthorne Tara Hotel, London



**Book by 31st March 2009 to receive a £200 early bird discount**

REGISTER ONLINE AT:

**[www.smi-online.co.uk/09gasification](http://www.smi-online.co.uk/09gasification)**

Alternatively fax your registration to **+44 (0) 870 9090 712**

or call **+44 (0) 870 9090 711**

Group discounts available, please contact us for more information



than some oilsands executives assume. Reliance on countries' thirst for oil consistently trumping environmental concerns may, especially regarding the US, be an increasingly risky strategy.

To an extent, to give due credit, the industry has taken this on board; companies accept that eventually their projects will need to get cleaner. Their greatest hopes are pinned on carbon capture and sequestration (CCS), which removes CO<sub>2</sub> from emissions and injects it (hopefully permanently) underground; according to proponents this could eventually reduce some oilsands operations' CO<sub>2</sub> emissions by 75%.

Encouragingly, Alberta's government is taking a global lead on developing the technology, announcing in 2008 a C\$2bn fund to support CCS projects in oilsands and other heavy industries.

## Capturing carbon and value

But it is far from clear that current efforts will prove sufficient to allow oilsands companies to meet forthcoming regulations. The first stage commercial plants are expected to take several years, and the technology seems unlikely to have a substantial impact much before 2015.

This delay is partly inevitable due to the construction and testing times involved, but insufficient funding also may be holding back faster development. Companies have so far been reticent to commit substantial sums without government backing; given the investments at stake, it may be in their interests to take more responsibility for ensuring that CCS is developed quickly.

The case for doing so is strengthened by continuing doubts from some quarters that the technology will ever work effectively in oilsands projects. A recent Canadian-

Albertan government joint report, for example, concluded that in oilsands operations "only a small percentage of emitted CO<sub>2</sub> is 'capturable' since most emissions aren't pure enough". From the companies' perspective the only way to dispel such doubts may be to quickly build CCS plants that demonstrably work.

Alongside more strenuous efforts to prove the technology, meanwhile, the industry also needs to engage energetically and over the long term with regulators to ensure that emissions reductions derived from CCS are taken into account when the life-cycle carbon intensity of oilsands products are assessed. Otherwise their CCS investments may not protect demand for their product as they intend.

Insufficient activity in these areas could be leaving some oilsands producers with little margin of error should carbon regulations hit harder and sooner, or should CCS present more difficulties than expected.

The potential business impacts of the environmental risks for oilsands are also beginning to be acknowledged by investors – both "ethical" and mainstream funds (albeit mostly the former). Co-operative Asset Management, a major UK investor, fears that "companies investing heavily in unconventional are too focused on short-term profit and their strategy is too defensive"; F&C, Calpers and Calstrs (California's public pension funds), among others, have also expressed concern that environmental performance could undermine the projects' profitability.

In fact, it may perversely prove to be a blessing for the companies involved that the recent collapse in the oil price and the drying-up of finance, has brought new investment in oilsands almost to a standstill.

With the competitive imperative to keep pace diminished, companies can take time to test their assumptions about the long-term viability of their investments, and if necessary step up their work on CCS.

Some may even decide against further investment until there is more certainty around the technology and around imminent regulations. If such approaches are adopted, the industry might emerge from the current slowdown less frenzied but with its long-term prospects considerably more secure.



## About the authors

Rob Foulkes is an associate and Daniel Litvin is director of Critical Resource, an advisory firm specialising in sustainability and stakeholder issues in the natural resources sector.

Critical Resource rates the health of the "socio-political license to operate" of resource projects using its own methodology, LicenseSecure™. Ratings are based on a range of factors, including potential risks surrounding the project, the views of stakeholders (including customers and regulators), and also the way in which the company itself manages these issues.

Please note this article provides a provisional rating for the oilsands industry, based on publicly-available information, and hence sets out a range of potential scores. A full rating has yet to be calculated.

First published in Ethical Corporation - [www.ethicalcorp.com](http://www.ethicalcorp.com)

[Rob.Foulkes at c-resource.com](mailto:Rob.Foulkes@c-resource.com)  
[Daniel.Litvin at c-resource.com](mailto:Daniel.Litvin@c-resource.com)  
[www.c-resource.com](http://www.c-resource.com)

# carbon capture journal

**Subscribe to Carbon  
Capture Journal**  
**Six issues only £195**

[subs@carboncapturejournal.com](mailto:subs@carboncapturejournal.com)

Carbon Capture Journal is your one stop information source for new technical developments, opinion, regulatory and research activity with carbon capture, transport and storage

**Carbon Capture journal covers:**

- The latest technology developments
- Government initiatives and the regulatory environment
- Commercial issues affecting carbon capture and storage
- Views of leading industry figures

Sign up to our free e-mail newsletter at  
[www.carboncapturejournal.com](http://www.carboncapturejournal.com)





# TOTAL's Lacq pilot - project update

After its largest ever public consultation effort, TOTAL has '99% support' for its Lacq pilot.

**From a presentation by Luc de Marliave, Climate Change Coordinator, Total at Platts' 3rd Annual European Carbon Capture and Storage conference in Brussels, February 26-27, 2009.**

Total operates a daily production of more than 2.5 billion barrels per day supplying 2% of heating and automotive fuels worldwide. CO<sub>2</sub> emissions to the atmosphere are about 60Mt CO<sub>2</sub> equivalent per year, but if you include CO<sub>2</sub> emissions of users of the fuels it would be about nine times as large.

"CCS is one of the important and very promising solutions for our facilities beyond what we do today." Total is conducting activities to reduce its gas flaring and improving energy efficiency in new and existing facilities.

"Expertise for CO<sub>2</sub> storage is available in the oil & gas industry and we have a responsibility to make this technology happen. Three domains are very important, site characterisation, anything related to injecting fluids and extracting fluids is something oil & gas companies are good at, and of course understanding and managing uncertainties is something we have been doing for decades."

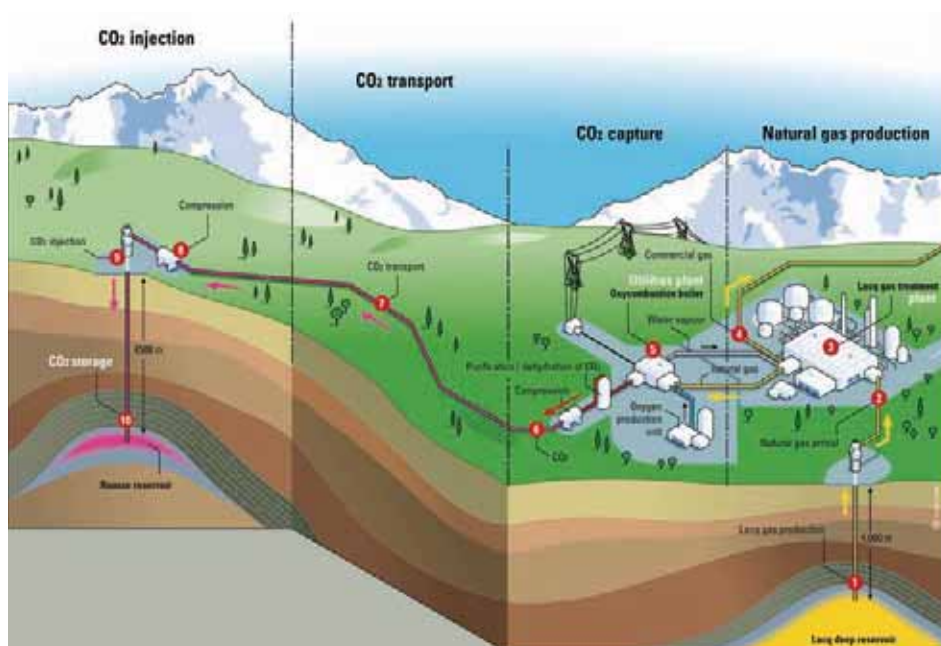
"So there are a lot of opportunities for CCS but also we see there are a lot of obstacles. We have been developing our own procedures for the past couple of years, how to design and qualify a site, how to be really sure that this is going to be a safe storage site, and of course you want to test this workflow on real cases."

"There will be a progressive development of storage up to full commercial size, you have to test the pressure and behaviour at each step. Well integrity in the long term is really a new issue and there is a lot of work to be done and also public acceptance is not granted."

"Our experience in Lacq in France is that people are ready to do something for climate change, they are willing to accept some constraints at a local level as long as it's for climate change and as long as you can demonstrate that you are using a proven technology and that you are a responsible company."

"At Lacq you have an almost depleted gas field with a very large gas treatment plant where one of the 50 year old 30 MW boilers has been converted to oxyfuel. It is interesting that this can be done as this boiler must exist in thousands of examples all over the world.

The idea is to extract the natural gas from the 4000m deep reservoir, burn it in the oxyfuel process, transport the CO<sub>2</sub> in an existing pipeline and inject it into the Rouse



*The Lacq pilot in South West France where CO<sub>2</sub> from an oxyfuel boiler will be piped and injected into a depleted gas reservoir*

reservoir which is 4500m deep."

"The project was first started in 2005, we have had a public consultation and now we are commissioning the boiler and we will start the injection in June 2009. We have had a long consultation period and we do not yet have the final authorisation, this is expected in April 2009."

"The Rouse reservoir has very favourable characteristics for CO<sub>2</sub> storage, There is a 2000m cap rock and the pressure has fallen from an initial 485 bar to just 30 bar so the surrounding rocks have a much higher pressure. The CO<sub>2</sub> would face a very high pressure barrier to escape, apart from the well of course which is always a potential leak point."

## Public consultation

"We talked to the local people and the mayor and the first question of course was 'is it safe, or is it going to explode like a champagne cork or something?' Our first answer was rather naïve, our reservoir engineer said we have been producing natural gas from this field for 35 years and it was full of H<sub>2</sub>S, CO<sub>2</sub>, explosive gases like methane and so injecting CO<sub>2</sub> is a lot safer than this."

"The answer was, 'Well we did not fully realise this was so dangerous what you are doing!' Then we said its OK its not going to burst the CO<sub>2</sub> will be supercritical and it will

behave like a liquid. The answer was, 'Critical is already dangerous but supercritical must be very dangerous.'"

"So public perception can be a matter of wording it is not always easy. We never before had to make such a public perception effort, we conducted three open meetings we contracted a specialist company to liaise between us and the audience to make sure people were able to make comments."

"We created a scientific council on this with members from the French national academy, to show as much as possible transparency and openness to get gain confidence of the public that this was a safe activity. We now have something like 99% support for the project."

## Monitoring

"We also have a monitoring plan of course. Seismic data such as in Sleipner will not do the job here as it is a very deep reservoir and there is already some CO<sub>2</sub> in the reservoir so the addition will not be seen."

"What we plan to do is install as many sensors as we can for pressure, temperature and flowrate. We are also adding some passive micro-seismic sensors in wells all around the injection well and soil measurement campaigns. The data will be made available on the Internet."







## Policy, company and regulation news

### UK 'Low Carbon Industrial Strategy' launched

[www.hmg.gov.uk/lowcarbon](http://www.hmg.gov.uk/lowcarbon)

**Gordon Brown has set out the government's vision for the UK's low carbon strategy, which includes ambitions for a second CCS pilot plant.**

An accompanying report, 'Low Carbon Industrial Strategy: A vision', commissioned by the government from environmental consultancy Innovas, analyses the market for low carbon services.

It says that the UK is sixth in the world for low-carbon and environmental goods and services (LCEGS) and the sector was worth £106.5 billion to the UK economy in 2007/8 and could grow by around 5% a year.

"Low carbon is not a sector of our economy, it is, or will be, our whole economy, and a global market," said the Business Secretary Peter Mandelson at the launch.

Ed Miliband, the Energy and Climate Change Secretary, emphasised developing "the energy infrastructure for the UK's low carbon future - in renewables, nuclear, Carbon Capture and Storage and a 'smart' grid."

He has previously talked about ambitions to host a second CCS pilot in the UK, with help from EU funds.

Businesses and others with an interest are asked for their input to inform a final strategy to be published before the summer of 2009.

The Carbon Capture and Storage Association (CCSA) has welcomed the launch, however it says it is disappointed that the vision delivers no further detail on policy or funding for Carbon Capture and Storage.

"[...] the Government risks further delays by another round of consultations with industry and we urgently need the final Low Carbon Industrial Strategy to bring decisive action and policy to support new low carbon technologies, especially CCS," said Jeff Chapman, Chief Executive of the CCSA.

"Industry stands ready to deliver on CCS and as 2009 is a critical year in terms of tackling climate change and building green jobs, the Government needs to move quickly to ensure CCS can fulfil its climate change potential as well as delivering prosperity and jobs," he continued.

### EU to spend €1.15 billion on CCS?

**The EU proposal to reallocate \$5 billion of unspent money including €3.5 billion to clean energy projects is now in doubt.**

There is now no clear indication of where the money will come from, after it was decided that the unspent money from the 2008 budget is 'legally unavailable'.

Several member states also raised objections as to how the money would be distributed, but according to EurActiv.com agreement is now more likely as many of these demands have been taken on board.

EurActiv reports that several countries have received more money, while the amount available for CCS has been reduced by €100 million.

There is further disagreement over the timeline of how the funds would be spent. France favours mature projects that could be implemented quickly, while the UK would prefer a staged approach that would give help to CCS projects that may not be ready in time as they must wait for regulatory obstacles to be removed.

The proposal will be discussed further in March with agreement expected by April.

Germany, the Netherlands, Poland, Spain (with Portugal) and the UK will each receive €250m to apply CCS to coal fired power plants.

In the UK the Kingsnorth plant in Kent, Longannet in Fife, Tilbury in Essex and Hatfield in Yorkshire would all share the €250m.

### Alberta authorises \$2 billion CCS funding

[www.energy.alberta.ca](http://www.energy.alberta.ca)

**The Government of Alberta has introduced new legislation that provides the legal authority to administer the \$2 billion in provincial funding for CCS announced by Premier Ed Stelmach in July 2008.**

The Carbon Capture and Storage Funding Act, Bill 14, will enable the province to administer funding to support three to five large-scale carbon capture and storage projects. Companies vying for the funding are completing full project proposals, which will be submitted to government by March 31. The selected projects will be announced by June 30.

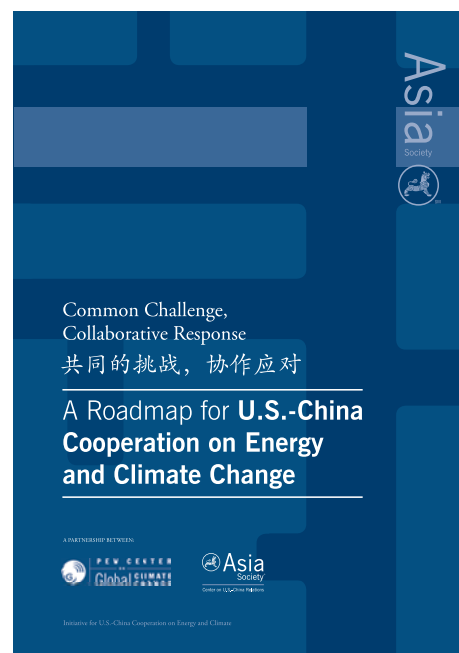
The funding and the legislation support Alberta's Provincial Energy Strategy and its key outcomes of clean energy production, wise energy use and sustained economic prosperity.

### Pew report on US-China collaboration

[www.pewclimate.org](http://www.pewclimate.org)

**The Pew Center on Global Climate Change has published a report, 'Common Challenge, Collaborative Response: A Roadmap for U.S.-China Cooperation on Energy and Climate Change'.**

The report presents a vision and a concrete roadmap for U.S.-China collaboration focused on reducing greenhouse gas emis-



*Pew Center on Global Climate Change report*

sions to mitigate the effects of climate change.

The report was produced in partnership between the Pew Center on Global Climate Change and the Asia Society's Center on U.S.-China Relations, in collaboration with The Brookings Institution, Council on Foreign Relations, National Committee on U.S.-China Relations, and Environmental Defense Fund.

Experts and key stakeholders from the worlds of science, business, civil society, policy, and politics in both China and the United States contributed to the report, that explores the climate and energy challenges facing both nations and recommends a concrete program for sustained, high-level, bilateral engagement and on-the-ground action.

### DOE issues CCS funding announcement

[www.fossil.energy.gov](http://www.fossil.energy.gov)

**The DOE's National Energy Technology Laboratory has issued four Funding Opportunity Announcements for improving techniques to clean or capture and store the emissions from coal-fired power plants and other industrial sources.**

The finds are a result of the American Recovery and Reinvestment Act of 2009 (Recovery Act) which resulted in legislation to create jobs and restore economic growth.

The areas of interest are:

- Geologic Sequestration Training and Research

# Projects and Policy

- Carbon Capture and Sequestration (CCS) from Industrial Sources including coal-fired power plants and other industrial sources such as cement plants, chemical plants, refineries etc

- Site Characterization of Promising Geologic Formations for CO<sub>2</sub> Storage

An amendment to re-open the FOA "Clean Coal Power Initiative - Round 3" has also been tabled for March 2009.

It seeks "advanced coal-based projects that have progressed beyond the research and development stage to a point of readiness for operation at a scale that, once demonstrated, can be readily replicated and deployed into commercial practice within the electric power industry."

## EPA to review regulation of CO<sub>2</sub> emissions

[www.epa.gov](http://www.epa.gov)

**The Environmental Protection Agency (EPA) under Barack Obama has taken the first step toward regulating carbon dioxide emissions from coal-fired power plants.**

EPA, under the new leadership of Administrator Lisa Jackson, granted a petition from the Sierra Club and other groups calling for reconsideration of an unlawful, mid-night memo issued by former EPA Administrator Stephen Johnson which sought to prohibit controls on global warming pollution from coal plants.

EPA announced in a letter to the Sierra Club that it will publish a proposed rule making in the Federal Register and seek public comments on the decision in the near future.

The decision is consistent with a previous ruling by the EPA's Environmental Appeals Board (EAB) in the Bonanza case, which found that there was no valid reason for the Bush administration's refusal to limit carbon dioxide emissions from new coal-fired power plants. The so-called Johnson Memo sought to unlawfully overturn that decision.

EPA says it will vigorously review the Johnson memo to ensure that it is consistent with the Obama Administration's climate change strategy and interpretation of the Clean Air Act.

Sierra Club, the Natural Resources Defense Council, and the Environmental Defense Fund filed suit against the Bush administration to overturn the Johnson Memo. That litigation will now be put on hold as a result of the announcement.

The EPA is also revisiting the decision, made under the Bush administration, to deny California the ability to set its own CO<sub>2</sub> emission limits.



*Novacem won the overall Rushlight Award for its carbon negative cement process*

## Carbon negative cement from Novacem wins Rushlight Awards

[www.rushlightawards.co.uk](http://www.rushlightawards.co.uk)

**Novacem, a spin-out from Imperial College, London, won the overall award for its CO<sub>2</sub> capturing cement process.**

The Rushlight Awards are a celebration and a promotion of new technology, innovation and best practice that has an environmental benefit for organisations throughout UK and Ireland.

It is designed to highlight innovation and the holistic environmental benefit of technologies that are most likely to or are already creating a stir in the market, and is a means of disseminating the successes to support further development.

The award was presented at a gala dinner attended by investors, city advisers, specialist and general media, trade associations, government departments, agencies and particularly companies and organizations that are leading the way in clean technology. The key note speech was given by Dr David Clarke, CEO of the Energy Technologies Institute.

According to Novacem, the annual production of ~2.5 billion tonnes of Portland cement is already responsible for ~5% of global CO<sub>2</sub> emissions and cement volumes are expected to double by 2050.

In contrast to Portland cement, the Novacem process causes minimal CO<sub>2</sub> emissions. It then hardens by absorbing CO<sub>2</sub> and so locks atmospheric CO<sub>2</sub> into construction materials.

This means that for every tonne of Portland cement replaced by Novacem cement, ~1 tonne of CO<sub>2</sub> is captured and stored in-

definitely. This would transform the cement industry from a significant emitter to a significant absorber of CO<sub>2</sub>.

The judges commented, "The potential impact of the Novacem technology is huge - providing an exciting opportunity to move an industry from being a significant climate change problem to being part of the solution."

As well as Novacem, the other group awards winners were OpenHydro (Natural Energy), Pursuit Dynamics plc (Clean Energy), Shaw Water Engineering (Water Innovation), G&P Batteries (Waste Innovation) and Connaught Engineering (Pollution Management).

## Australian report says energy research needs \$6 billion

[www.atse.org.au/uploads/EnergyClimateChange.pdf](http://www.atse.org.au/uploads/EnergyClimateChange.pdf)

**A study by the Australian Academy of Technological Sciences and Engineering (ATSE) titled 'Energy Technology for Climate Change – Accelerating the Technology Response' says \$6 billion needs to be spent on RD&D on new power generation technologies by 2020.**

The report says this investment by government and industry will require follow-up expenditure on technology deployment, and no single new technology for stationary energy production will achieve the projected CO<sub>2</sub> reductions.

ATSE also called for the establishment of a new national Energy Research Council to fund the necessary RD&D (research, development and demonstration) proposals and recommends "relentless application of cost-



effective energy efficiency and conservation strategies so that stationary energy demand growth is less than one per cent a year, over a sustained period."

ATSE also recommends continued support of existing Australian programs, including the Global Carbon Capture and Storage Institute.

The aim of the ATSE study is to identify those technologies that can most efficiently and effectively reduce carbon emissions for stationary power generation in both technical and financial terms.

## USDA approves loan for CO<sub>2</sub> capture project

[www.usda.gov](http://www.usda.gov)

The United States Department of Agriculture has approved up to a \$300 million loan to Basin Electric Power Cooperative for a CO<sub>2</sub> capture project at a coal fired power plant.

The money will be used to finance development of a demonstration project for capturing CO<sub>2</sub> at Basin Electric's Antelope Valley Station near Beulah, North Dakota.

USDA believes it will be the first of its type in the US to operate on a commercial scale.

The Antelope Valley Station is located adjacent to the Great Plains Synfuels Plant, the only commercial-scale coal gasification plant in the United States, where more than three million tons of CO<sub>2</sub> are captured annually and piped to Canada for use in enhanced oil recovery.

The demonstration project being developed at Antelope Valley would capture about a million tons of CO<sub>2</sub> per year from a portion of the plant's exhaust stream and send it to oil fields along the pipeline being used by the Synfuels Plant.

Basin Electric also intends to inject a small percentage of the gas into a deep saline formation to determine the viability of that sequestration method.

## Flurry of US State, Federal policies advance CCS

[www.emerging-energy.com](http://www.emerging-energy.com)

According to Emerging Energy Research (EER), a consultancy specialising in clean energy, the US federal stimulus bill signed into law by President Obama promises to increase the number of CCS demonstration projects as more funding becomes available.

Several US states have introduced or passed CCS legislation in the past three months. The most significant legislation – in Illinois and Texas – target IGCC+CCS technology, and are expected to boost the industry after the market setback in 2007 and



US CCS activity accelerates with recent state policy activity (source: Emerging Energy Research)

2008.

Despite the dire near-term economic outlook, uncertain carbon policy framework, and sagging natural gas prices, EER expects that more than 10 US CCS power projects will be positioned to begin construction by 2013.

CCS activity received a much-needed boost from the federal stimulus bill (American Recovery and Reinvestment Act) which will provide \$3.4 billion for carbon capture and sequestration demonstration projects, increasing federal CCS support in the US by 70% to over US \$8 billion.

Several US states including Illinois, Texas, Pennsylvania, North Dakota, and Kansas, have introduced or passed CCS legislation in the past three months.

According to EER's recently completed study, Global Carbon Sequestration Markets and Strategies, 2009-2030, CCS could emerge as a viable, cost-competitive option suitable to fulfill minimum coal plant demand in developed power markets by 2016.

The same study reports that carbon sequestration project investment could reach between US\$30 billion and US\$70 billion per year by 2030.

## Wyoming moves ahead with CCS bills

[www.trib.com](http://www.trib.com)

The Wyoming Senate has approved three bills designed to regulate underground storage of carbon dioxide in Wyoming, according to a Caspar Star Tribune article.

House Bill 57, which was most recently approved, clarifies how underground CO<sub>2</sub> storage fits into Wyoming's existing split-estate laws governing land and mineral-estate rights.

The bill passed on a vote of 17-12. It already won House approval and now moves to a House Senate conference committee to address minor discrepancies between the two versions of the bill.

The Senate also granted initial approval to House Bills 58 and 80 on Tuesday.

HB58 assigns liability for sequestered carbon dioxide to the companies that inject the carbon in the ground.

HB 80 creates a system for compensating landowners for carbon storage under their property.

It includes provisions that would allow projects to move forward in cases where a small percentage of the owners object to the project.

## CCS - don't ignore the waste connections

[www.lexology.com](http://www.lexology.com)

Lawyers CMS Cameron McKenna argue that the waste sector has expertise to offer the energy sector, but may be in danger of missing an opportunity.

In an article first published by the Chartered Institute of Wastes Management, CMS Cameron McKenna argue that CO<sub>2</sub> is really a waste and its management should not be seen solely as an extension of the energy industry.

"Neither the waste management sector nor the energy sector is likely to have all the skills for CCS," says the article. "Careful analysis will be required of the potential opportunities. It is not inconceivable that there could be partnering between players in the waste and energy sectors. It is also conceivable that skilled personnel in one sector might be poached by the other sector."

## StatoilHydro delivers Mongstad 'master plan'

[www.statoilhydro.com](http://www.statoilhydro.com)

StatoilHydro has submitted its plan for carbon capture at Mongstad to the Norwegian Ministry of Petroleum and Energy and the Ministry of the Environment.

StatoilHydro has delivered its 'master plan' to the Norwegian government for future carbon capture at Mongstad.

The master plan addresses the most important challenges and sums up key issues associated with the technical feasibility of carbon capture at Mongstad.

The purpose of the master plan is to provide the best possible basis for the further process with full-scale carbon capture from the combined heat and power (CHP) station and other substantial sources at the refinery. In addition to the CHP station, it addresses if the refinery's cracker is suitable for carbon capture.

The report describes the facility, technology and the most important risks associated with realising full-scale carbon capture. The plan addresses the principal challenges and summarises the need for studies and verification of individual technical solutions.

The master plan confirms that carbon capture is possible and describes two main alternatives as to how this can be done at Mongstad:

- Alternative 1 allows carbon capture from the CHP station as quickly as possible based on the amine technology available today, normal industry practice for safe and rational project performance and an acceptable HSE risk level. Carbon capture from the cracker follows based on stepwise technology development.

- Alternative 2 allows simultaneous development of carbon capture from the CHP and the cracker, based on a stepwise technology development.

Carbon capture and storage (CCS) is one of StatoilHydro's six priority areas in technology development.

## The Bellona Foundation launches CCS web

[www.bellona.org/ccs](http://www.bellona.org/ccs)

The Bellona Foundation, an international environmental NGO based in Oslo, Norway, has created a new web resource answering common question about CCS from a public awareness angle.

The Bellona Foundation regards CCS as one of the main solutions to combat global warming.

The website seeks to answer question such as:

- Is underground CO<sub>2</sub> storage safe?
- What are the different opinions on



StatoilHydro has submitted its plan for carbon capture at Mongstad to the Norwegian Ministry of Petroleum and Energy and the Ministry of the Environment (image © Harald M. Valderhaug / StatoilHydro)

CCS?

- Are there any CCS projects close to where I live?

- Can CCS be made mandatory?

Bellona has published several reports on CCS including most recently 'Burying CO<sub>2</sub> - The New EU Directive on Geological Storage of CO<sub>2</sub> from a Norwegian Perspective'

## NV Energy postpones 1,500MW coal-fired plant

[www.nvenergy.com](http://www.nvenergy.com)

NV Energy has postponed plans to build a 1,500 MW ultra-supercritical coal-fired power plant in eastern Nevada. The company says it will not move forward until carbon capture and storage technologies are commercially feasible.

The company cited growing environmental and economic uncertainties surrounding the Ely power plant development, which has already been delayed for several years due to permitting issues.

## Leeds and China Universities collaborate

[www.leeds.ac.uk](http://www.leeds.ac.uk)

Academics from the University of Leeds are working with counterparts from Zhejiang University in China to develop clean coal technologies.

The partnership will operate under the name UoL-ZJU International Centre for Sustainable Energy Sciences and Technology

It will address issues such as clean coal use, pollution control, carbon capture and sequestration, alternative fuels and the devel-

opment of new energy-related technologies in fuel and solar cells.

The centre will also encompass associated research areas, in particle, environment and chemical engineering, drawing on the combined strengths of the two universities.

This is the third strategic research alliance the University of Leeds has signed with leading research institutions in China.

## UK launches £13 million energy training centre

[www.midlandsenergyconsortium.org](http://www.midlandsenergyconsortium.org)

A new training centre is being established to create a new breed of engineers and scientists capable of developing new low-carbon technologies in the UK.

The Midlands Energy Graduate School (MEGS) will be run by the Midlands Energy Consortium (MEC) — a collaboration between the Universities of Birmingham, Loughborough and Nottingham.

The centre will provide training in energy systems and a wide range of technologies, including energy efficiency in the built environment, hydrogen and fuel cells, carbon capture, renewable energy, transport and electrical infrastructure, as well as policy issues.

MEGS will receive core funding of £3 million from the Higher Education Funding Council for England (HEFCE) and a further £10 million from the Engineering and Physical Sciences Research Council (EPSRC) to train graduate students in clean fossil fuels and hydrogen and fuel cells.



# CARBON CAPTURE AND STORAGE

## Creating Advanced Affordable Technology for Commercial Use



May 13<sup>th</sup>-14<sup>th</sup>  
2009  
Berlin, Germany

EVENT SPONSOR

**Schlumberger**

### Event Highlights:

- 12th of May – Site Visit at Vattenfall's Swarze Pumpe Pilot Plant - spaces are limited!
- Case study about Vattenfall's Swarze Pumpe Pilot Plant by Sascha Lüdge, R&D Deputy Project Manager, Vattenfall
- Leading industry speakers from Vattenfall, International Energy Agency, British Geological Survey, ALSTOM, IEA Greenhouse Gas R&D Programme, Yorkshire Forward and many more

**Make sure you don't miss this exclusive event!**

TO GET A FULL BROCHURE OR TO REGISTER CONTACT  
JUSTYNA KORFANTY ON +44 207 981 2503 or email [jkorfanty@acius.net](mailto:jkorfanty@acius.net)

Thanks to our supporting partners

## Capture news

### EPRI to study carbon capture in existing coal power plants

[www.epri.com](http://www.epri.com)

The Electric Power Research Institute (EPRI) has announced that five electric utilities in the United States and Canada have joined EPRI to host studies of the impacts of retrofitting amine-based post-combustion CO<sub>2</sub> capture technology to existing coal-fired power plants.

In addition to the five host site companies, 15 other companies and organisations, including six from Canada and one from Australia, have joined the project.

The five host companies and sites include Edison Mission Group's 1,536-megawatt (MW) Powerton Station, operated by Midwest Generation, in Pekin, Ill.; Great River Energy's 1,100-MW Coal Creek Station in Underwood North Dakota; Nova Scotia Power's two 160-MW units at its Lingan Generating Station in Lingan, Nova Scotia; Intermountain Power Agency's 950-MW Intermountain Generation Station in Delta, Utah, and the 176-MW circulating fluidized bed boiler Unit 1 at FirstEnergy's Bay Shore Plant in Oregon, Ohio.

Retrofit to an existing plant presents significant challenges, including limited space for new plant equipment, limited heat available for process integration, additional cooling water requirements and potential steam turbine modifications, says EPRI.

Each site offers a unique combination of unit sizes and ages, existing and planned emissions controls, fuel types, steam conditions, boilers, turbines, cooling systems, and options for CO<sub>2</sub> storage. The variety of data from the studies will provide the participants with valuable information applicable to their own individual power generating assets.

These five studies will be conducted in 2009 and a report for each site will:

- assess the most practical CO<sub>2</sub> capture efficiency configuration based on site constraints;
- determine the space required for the CO<sub>2</sub> capture technology and the interfaces with existing systems;
- estimate performance and costs for the PCC plant; and
- assess the features of each plant that materially affect the cost and feasibility of the retrofit.

EPRI's CoalFleet for Tomorrow program is already conducting technical and economic assessments of ways to reduce CO<sub>2</sub> emissions in new, advanced coal-based generation.

This new program will apply that



*Nova Scotia Power's Lingan Generating Station in Lingan, Nova Scotia where one of EPRI's studies will be hosted*

knowledge to assess the suitability of retrofitting advanced amine capture to plants currently in operation and to guide the design of plants under development.

### CO<sub>2</sub>CRC report says capture costs can be cut by 25%

[www.co2crc.com.au](http://www.co2crc.com.au)

New research from the Cooperative Research Centre for Greenhouse Gas Technologies (CO<sub>2</sub>CRC) suggests that the cost of capturing carbon dioxide from Australian power stations could be reduced by 25 percent.

"Currently about 80 per cent of the cost of CCS systems is in capturing the CO<sub>2</sub>," said Barry Hooper, CO<sub>2</sub>CRC Chief Technologist. "Reducing capture cost is therefore the most effective way to make significant savings to the overall cost. Process integration is one of several pathways our research teams are pursuing to drive down capture costs."

The CO<sub>2</sub>CRC team, which included researchers from Monash University, used process integration studies to identify minimum energy targets. They considered the heat and cooling requirements of the power plant and capture plant holistically, rather than individually, and found that initial energy penalty estimates could be significantly reduced.

According to the CO<sub>2</sub>CRC this is the first such comprehensive study in the CCS area and the technique is applicable to both retrofitted and new carbon capture plants.

The findings were discussed with Victorian Government and power industry representatives at a recent CO<sub>2</sub>CRC research showcase in Melbourne. The showcase provided an update on the latest developments in CO<sub>2</sub>CRC CCS research and demonstration projects, and issues surrounding large scale CCS projects in Victoria.

This work has been performed by CO<sub>2</sub>CRC as part of the Latrobe Valley Post Combustion Capture Project (LVPCC) under the Victorian Government ETIS Brown Coal R&D fund and in association with consortium partners International Power, Loy Yang Power and CSIRO.

### Mitsubishi licenses CO<sub>2</sub> capture technology to Samsung

[www.mhi.co.jp/en/index.html](http://www.mhi.co.jp/en/index.html)

Mitsubishi Heavy Industries (MHI) has signed a license agreement for its CO<sub>2</sub> recovery technology with Samsung Engineering, a major engineering company in Korea.

Samsung Engineering will use MHI's proprietary "KM-CDR Process" in the CO<sub>2</sub> recovery system which Samsung will construct at the PetroVietnam Fertilizer and Chemicals Corporation (PVFCCo) Phu My fertilizer plant, to be completed in 2011.

The CO<sub>2</sub> recovery facility aims at increasing on-site urea production by using 240 tons of 99% purity CO<sub>2</sub> per day to be captured from the flue gas emitted from the plant's primary reformer, which is fuelled on natural gas, using MHI's proprietary KS-1



solvent.

The CO<sub>2</sub> is then synthesized with ammonia for use as feedstock for urea production. The technology, jointly developed with Kansai Electric Power Company, can recover approximately 90% of the CO<sub>2</sub> in flue gas, and MHI says it uses less energy than other processes.

## Atmospheric carbon capture - a cost effective alternative?

[www.miller-mccune.com](http://www.miller-mccune.com)

In a recent paper, Roger Pielke Jr. of the University of Colorado's Center for Science and Technology Policy Research asserts that 'air capture' – that is, direct removal of carbon dioxide from the air – deserves far more serious consideration than it has received to date.

Tom Jacobs reports on Miller-McCune.com, a nonprofit website focused on new academic research, that extracting CO<sub>2</sub> from the atmosphere and sequestering it underground is potentially more economical than other proposed methods of dealing with the problem.

In the paper Pielke goes on to say that "the costs over the 21st century of deploying air capture to fully stabilize greenhouse gas emissions are comparable to, and under some assumptions more favorable than, the costs of stabilization presented by the Intergovernmental Panel on Climate Change."

He argues that "more attention should be paid to research, development and deployment" of this technology.

## ION Engineering introduces ionic liquid CO<sub>2</sub> capture technology

[www.ion-engineering.com](http://www.ion-engineering.com)

Founded by University of Colorado scientists, ION Engineering is a new company set up to commercialise ionic liquid solutions for carbon capture and emissions control.

ION Engineering has an exclusive agreement with the University of Colorado (CU) to use the technology, which was developed by Jason Bara, Dean Camper, Richard Noble and Douglas Gin, all researchers in CU-Boulder's Department of Chemical & Biological Engineering.

The company is headed by Dr. Alfred "Buz" Brown, also a founder, who brings more than 30 years of technology commercialisation experience.

"ION Engineering aims to implement the lowest total cost solution for carbon capture using ionic liquids to optimize and enhance well-known and established processes," said Buz Brown.

The company will also receive a \$100K proof of concept investment from the CU Technology Transfer Office and the CU-Boulder Energy Initiative. Using this funding, ION Engineering has constructed a continuously operating demonstration unit, and is scaling the technology for industrial CO<sub>2</sub> capture and natural gas processing.

Ionic liquids are molten salts that do not evaporate and can be used to replace current aqueous (water-based) amine technology. According to ION Engineering its



*"ION Engineering aims to implement the lowest total cost solution for carbon capture using ionic liquids to optimize and enhance well-known and established processes" - Buz Brown, CEO and founder*

ionic solutions are the most efficient way to capture carbon from coal-fired plant emissions.

Based in Boulder, ION Engineering was formed in 2008 by Bara and Camper, along with Christopher Gabriel, a research associate at CU. Jason Bara and Dean Camper published a recent article about the process in the American Chemical Society's Journal.

## carbon capture journal

Meet people involved in similar projects - learn and share experiences - meet and discuss with possible business partners - get known in the industry - connect with experts around the world.

## Join our social network!

[network.carboncapturejournal.com](http://network.carboncapturejournal.com)



# What role could CO<sub>2</sub> storage in depleted gasfields play?

With global estimates of total storage capacity varying by orders of magnitude, and a generally accepted view that the biggest uncertainty relates to aquifer storage, depleted gasfields may offer a safer bet for decision makers, at least in the short term.

**Kate Harland, Energy Consultant and Harsh Pershad, Consultant, Element Energy**

### Gasfields for CO<sub>2</sub> storage

The presence of natural gas demonstrates a degree of integrity of the cap rock, and these gasfields have been characterised. For all producing gasfields, models exist which reflect the reservoir geometry and fluid migration pathways and how the reservoirs have responded to changes in pressure as gas is produced.

A forthcoming study from the IEA Greenhouse Gas R&D Programme quantifies the importance of timing and the proximity of gasfields to sources of CO<sub>2</sub> in determining how gasfields could be used.

This joint study by Poyry, Element Energy, and the British Geological Survey, is the first project that (a) matches worldwide large sources to depleted gasfields for each decade up to 2050 and (b) compares the costs of the resulting pipeline networks.

The study adopts conventional 'static' calculations for storage capacity, and makes plausible assumptions for the rate at which pipeline infrastructure could grow. Importantly it accounts for the availability of gasfields based on their close of production dates, and aligns results with the Carbon Sequestration Leadership Forum's definitions of resource availability.

This study finds the worldwide matching of sources and gasfields is heterogeneous – and as a result the 'matched' capacity is only a fifth of the theoretical capacity. Parts of the world – such as Siberia and the Middle East – have redundant capacity because gasfields are clustered together with few large sources nearby.

This makes it easier for sources to plan for capture. Importantly, if one field fails to meet the likely stringent criteria regulators may place on storage, there may be capacity available in a nearby field.

Other parts of the world – including the North Eastern United States, much of India and China, and parts of Europe – have many large sources and few large gasfields.

The modelling considers the competition between sources for sinks. The conclusion is that major expansion of CCS would need to include less well characterised sites to supplement depleted natural gas field storage.

The study shows that the cost of transport and storage can be less than \$10/t CO<sub>2</sub> if new pipeline networks are carefully planned and optimised. This requires long project lifetimes, large sources, and use of the largest sinks.

This price excludes the cost of initial capture and compression – which are expected to be much higher, and site specific costs (e.g. for remediating existing wells).

The results can best be expressed on regional marginal abatement cost curves. This shows cumulative capacities (Gt CO<sub>2</sub> on the x-axis) from different projects available at different prices (\$/t CO<sub>2</sub> on the y-axis).

A comparison can be drawn at high level between the potential for CO<sub>2</sub> storage in depleted gas fields in different parts of the world. Figure 2 shows that the most cost effective storage opportunities are in Asia and Oceania, Eastern Europe and the CIS, and North America. Transport and storage are more expensive for Europe because of the higher costs of offshore infrastructure.

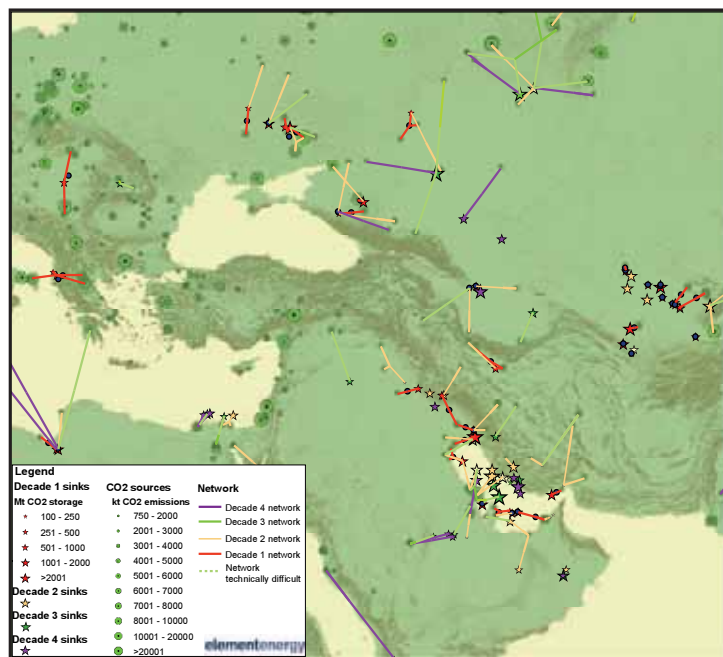


Figure 1- the results of reactor simulations employing palladium as the catalytic metal and a feed gas composed of carbon dioxide and methane

There does appear to be sufficient worldwide storage capacity in gasfields to meet the IEA's challenging 'Act' and 'Blue' Map CCS targets for 2050, and with reasonable costs for transport and storage. Individ-

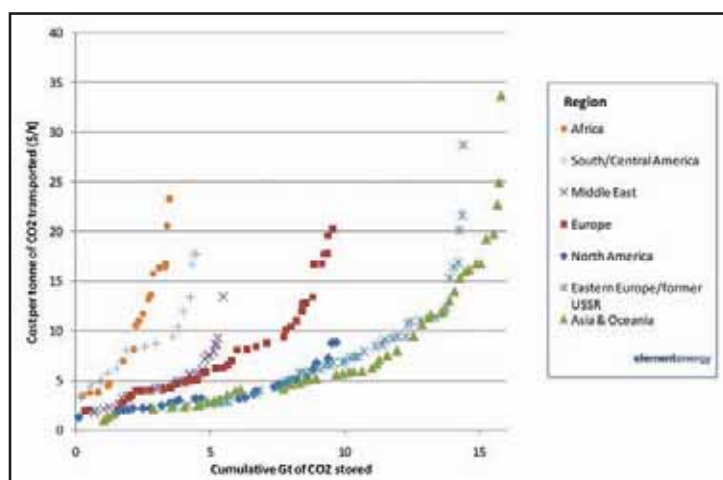


Figure 2 Comparison of the transport and storage costs for CCS projects in different parts of the world. Costs cover pipelines, injection facilities, drilling and monitoring only. 30 year project lifetimes are assumed. Costs exclude capture, compression, commercial financing, and assume new infrastructure is used throughout. Each point corresponds to a CCS network involving one giant gasfield, and between one and twelve sources (>1Mt).



Third Annual

# New Build Europe 2009

Evaluating the challenges and opportunities in a carbon constrained world

Tuesday 30<sup>th</sup> June and Wednesday 1<sup>st</sup> July 2009, Hotel Vierjahreszeiten Kempinski, Munich, Germany

**INTERACTIVE CASE STUDY BASED PRESENTATIONS WILL COVER ALL THE ISSUES YOU ARE CURRENTLY FACING**

**Lothar Balling**, VP Gas Turbine Power Plant Solutions Europe/CIS, **SIEMENS ENERGY, GERMANY**

**Dr. Erich Schmitz**, Member of the Executive Board, **E.ON KRAFTWERKE, GERMANY**

**Dr. Johannes Ewers**, Head of CCS and New Technologies, **RWE, GERMANY**

**Jan van der Marel**, Senior Development Engineer, **NUON, THE NETHERLANDS**

**Leonardo Arrighi**, Director of Planning New Construction, **ENEL, ITALY**

**Mogens Skov**, Director Machinery and Process, **DONG ENERGY, DENMARK**

**Martin Hector**, CEO and Head of Project Development, **TRIANEL, GERMANY**

Event Partner:

**SIEMENS**

Associate Sponsors:

**e-on** | Kraftwerke

**HITACHI**  
Inspire the Next

Silver Sponsor:



**Do not miss our site visit to  
"Irsching power plant" home of the  
world's largest and most efficient  
combined cycle gas turbine.**



Increase your network  
at our Evening drinks  
reception hosted by  
our Event partner

**SIEMENS**

**Register before the 1st May 2009 and save €100 when quoting CCJ**  
**Register online at: [www.modernpowersystems.com/newbuild2009](http://www.modernpowersystems.com/newbuild2009)**

For more information please email [book@vibeevents.com](mailto:book@vibeevents.com)

For sponsorship opportunities please contact [JackDacombe@vibeevents.com](mailto:JackDacombe@vibeevents.com) or call **+44 (0)207 753 4259**



Kate Harland, Energy Consultant, Element Energy

ual countries, however, differ greatly in their sensitivity to capacity and pipeline infrastructure assumptions. Developing global policies to manage these differences will require care.

The study goes a long way to identifying an 'accessible' storage capacity, but there remain significant issues. At the most basic level, there is a lack of high quality, relevant and comprehensive data available in the public domain. More importantly, the re-use of depleted gasfields is not without challenges.

There is scope to improve storage cost and capacity estimates – accounting for compartmentalisation, dynamic capacity (i.e. feasible injection rates and therefore number of new wells required), remediation of existing wells, structural integrity and other factors. The good news is that interest within the oil and gas industry in solving these problems is growing fast.

## About the authors

Element Energy Limited is a strategic energy consultancy practice specialising in the areas of hydrogen, fuel cells, renewables and other low-carbon energy technologies.

Its work on CCS has included techno-economic assessments of opportunities at regional, national and global levels, screening viable carbon sinks, and undertaking an economic appraisal of CCS options for a major oil and gas company.

Harsh.Pershad @  
Element-Energy.co.uk  
Tel: 01223 227 532

Kate.Harland @  
Element-Energy.co.uk  
Tel: 0207 462 5224  
[www.element-energy.co.uk](http://www.element-energy.co.uk)

## Performance and risks analysis for well integrity in CO<sub>2</sub> geological storage

One of the key challenges for CCS technology deployment is to assess well integrity performance towards possible gas leakages.

By Vincent MEYER, consultant engineer, OXAND, France.

### Well integrity assessment in CO<sub>2</sub> geological storage

For a commercial scale deployment of CCS technologies, barriers in relation to the specifics of CO<sub>2</sub> geological storage remain to be overcome: storage must be ensured over a very long time frame taking into account the remaining uncertainties in the description of the geological environment.

For thousands of years geological for-

mations have contained fluids (hydrocarbons, water, H<sub>2</sub>S...) from the surface. Nevertheless, among other issues, public acceptance with respect to CO<sub>2</sub> geo-sequestration still constitutes a major challenge.

Wells constitute the only man-made intrusive objects that could compromise the system containment and directly connect CO<sub>2</sub> to water resources, biosphere, or atmosphere.

The well integrity can be defined as the capability to ensure a good zonal isolation in order to contain the injected CO<sub>2</sub> in the geological reservoir over the intended lifespan of a storage site. In a CO<sub>2</sub>-based subsurface environment, casing corrosion and cement leaching processes will affect well integrity (Figure 1). Therefore, the performance of the well to confine CO<sub>2</sub> gas within the reservoir may be impacted and risks associated with CO<sub>2</sub> leakage over the storage time period may increase.

Another key challenge to be overcome with relation to the specifics of CO<sub>2</sub> geological storage is uncertainties that will always be present in the description of the wellbore environment (ageing processes, data...).

Therefore, it is of paramount importance to be able to assess the well's integrity performance and to demonstrate that the well



Vincent MEYER, consultant engineer, OXAND

will ensure a good zonal isolation over the long term.

In order to quantify well performance and to take into account the two notions: uncertainty and failure towards CO<sub>2</sub> containment, risk-based solutions can be used. Indeed risk involves the two previous notions; it constitutes a quantifiable metric based on the combination of the likelihood of a failure event (i.e. Probability P) and the magni-

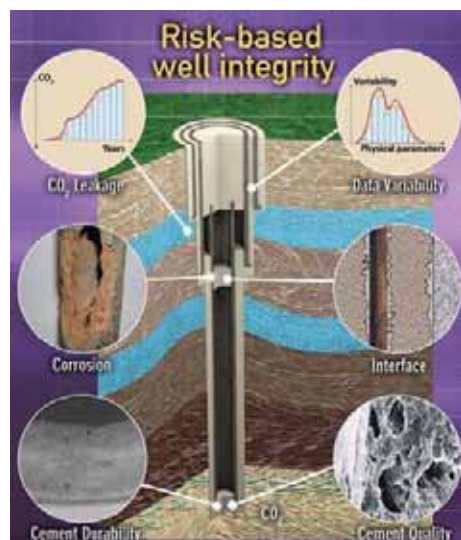


Figure 1: Illustration of well integrity key challenges



tude of its impact (i.e. Severity S).

A presentation of the P&R™ methodology and an illustrative case study are described below.

## Performance and Risks (P&R™) methodology – main steps

For the P&R™ approach developed by Oxand, risk is defined as the combination between:

- A probability of failure event occurrence which represents specific well integrity conditions;
- The magnitude of impact of a simulated leakage assessed with respect to all the stakes involved in a project (public acceptance, financial, reputation, know-how, health and safety, preservation of potable aquifers...).

The methodology (Figure 2) gathers different steps to go through for risk quantification and for recommending operational actions for risk mitigation [1-5]. It is based on a technological platform SIMEO™ STOR.

Data is collected to build a static model of the well. This model takes into account information about the well (description of geometrical and integrity parameters including uncertainties) and its nearest environment (geology). A functional approach of the well enables then to identify the functions of each well component and the processes that can impact the system performance.

Wells are usually composed of two major components contributing to the confinement performance: tubulars and cement sheaths/plugs (if the well is abandoned) subject to degradations.

Cement based materials are reactive porous media. When in contact with acidic aqueous solutions as dissolved CO<sub>2</sub> or formation fluids, cement leaching/carbonation take place. These processes involve a degradation front (mineral dissolution/precipitation) within cement bulk (according to axial and radial directions) involving a change in poro-mechanical properties of the material (Figure 3) leading to possible leakage pathways.

Casing tubulars are exposed to corrosion process (Figure 3). Two different mechanisms can be observed: generalized corrosion that occurs mostly at the casing surface, and pitting corrosion, which mainly takes place in presence of chlorides. CO<sub>2</sub> corrosion can be significant in presence of CO<sub>2</sub> dissolved in water or in a partially saturated vapour but becomes insignificant in dry flows.

Such degradation kinetics are dependant on environment and materials properties. Models parameters (corrosion rates, ce-

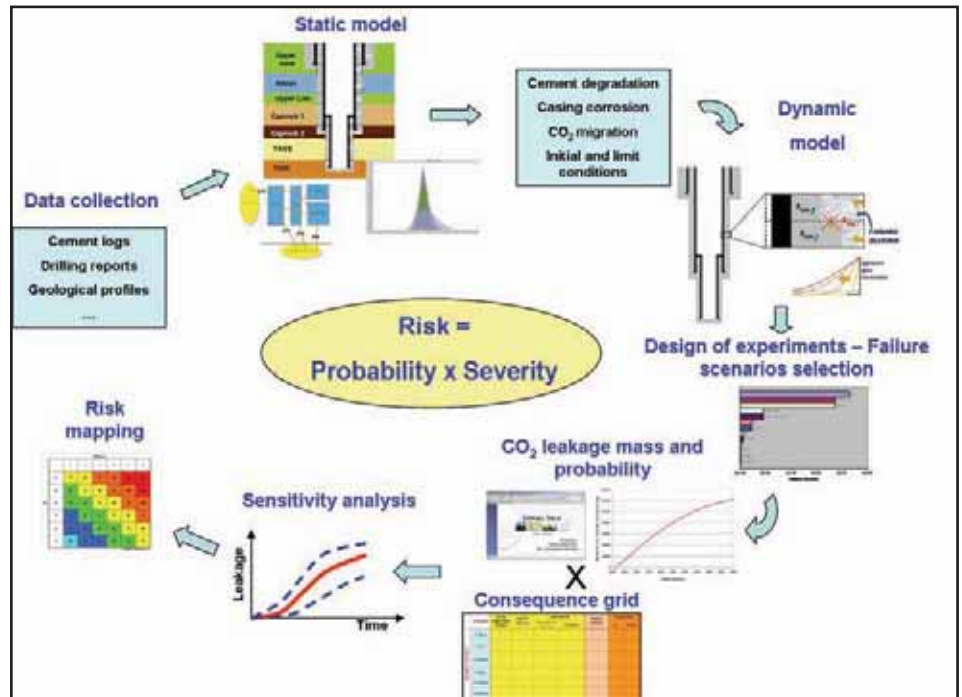


Figure 2: P&R™ methodology workflow (in partnership with Schlumberger Carbon Services)

ment leaching/carbonation kinetics) can be calibrated through simulations and experimental tests including accelerated testings and time-lapse well integrity monitoring measurements.

Combining the initial and limit conditions, the degradation phenomena and their associated kinetics to the static model, constitutes the second step of the methodology: a dynamic model is built.

Moreover, the dynamic model also involves the uncertainties associated to the modelling (geometry, initial cement qualities, degradation kinetics, incomplete data related to some well components...) which are interpreted as ranges of values (Figure 4). A “scenario” approach can be introduced to account for such ranges. Practically, a scenario represents possible well integrity conditions which parameters take a given value within the defined ranges.

Taking into account all the uncertain-

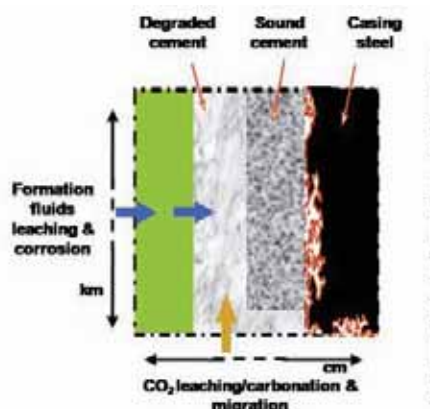


Figure 3: Schematic 2D axisymmetric representation of well components degradations

ties associated to the well could lead to an exponential number of scenarios to simulate. Therefore a design of experiments (DoE) approach is used to identify the most influencing uncertain parameters and to reduce the number of simulations (the most relevant to evaluate the risk envelope).

The outcome of these simulations is a CO<sub>2</sub> leakage amount from the reservoir along the well and provides the possible leakage pathways and the targets impacted (surface, connected aquifer, other geological formations). The CO<sub>2</sub> leakage quantificator implemented in the software SIMEO STOR combines porous media flow modelling (2-phases Darcy's flow) and degradation models (evolution of components properties over time) [3].

Each leakage amount is then translated into a severity level by assessing the negative impacts vs. a set of specific stakes dedicated to the CO<sub>2</sub> storage project by means of a consequences grid. This grid gathers all the stakes involved in a project and assesses the severity level associated to a failure for each of the stakes.

A global probability is assessed to each scenario by combining the probabilities assessed for the different parameters describing the whole system. This probability is then translated into a frequency level (from a frequency grid).

By crossing both severity and frequency levels of each scenario, risk levels are generated and populate a risk matrix (Figure 7).

The definition of a Risk Acceptance Limit (RAL) brings forward the non accept-

able risk levels. The analysis of the non acceptable scenarios allows identifying what are the contributors to the risk. Recommendations [5] are finally provided to treat these contributors and thus to mitigate the risks considered as unacceptable for the project:

- Characterization/inspection (work-over actions),
- Design solutions (well abandonment optimization, new wells drilling...),
- Operational solutions (work-over actions, injection strategy...),
- Monitoring solutions (failure detection, well components integrity evolution...)

## A case study: an abandoned well intersecting a depleted hydrocarbon reservoir

The case study presented considers an abandoned well which could be in contact with a CO<sub>2</sub> plume. A static model representing the well components and its nearest environment is proposed (Figure 5). The key question is to assess the well integrity performance over 500 years.

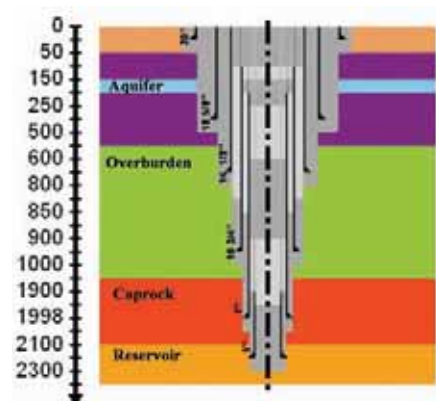


Figure 5: Static representation (SIMEO-STOR) of an abandoned well (not at scale)

For this application, the design of experiments has highlighted that the most influencing parameters corresponds to the ones describing cement zones qualities, that's why only these parameters have been considered as probabilistic.

Different cement zones have been defined by cementation data interpretation (Figure 4) and probability laws describing their qualities have been assessed. A randomization of each zone quality leads to sev-

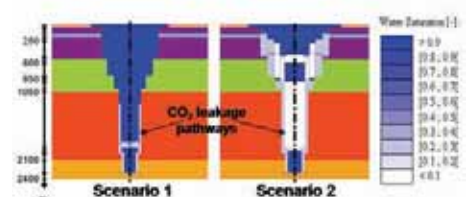


Figure 6: Water saturation for the well for 2 scenarios after 500 years (snapshots from Simeo-Stor)

eral scenarios describing possible well integrity conditions.

Cement water saturation evolution (initially full saturated) is a relevant indicator for identifying leakage pathways along the well.

Figure 6 illustrates 2 snapshots of cement water saturation evolution for 2 different scenarios (different degradation rates). Two main CO<sub>2</sub> leakage pathways can be identified: through the cement sheaths (scenario 1) and through the inner part of the well (scenario 2). This difference between the two pathways highlights the complexity of the CO<sub>2</sub> flow up along the well.

The behaviour of the well components towards CO<sub>2</sub> and the other aggressive fluids can change drastically the leakage pathway. Therefore, CO<sub>2</sub> pathways are not obvious to assess: uncertainties of specific parameters can have a strong influence on them, and consequently on the risk value assessed.

Figure 7 presents the risk matrix obtained after all the scenarios simulations. The risk value assessed for the 2 scenarios presented in Figure 6 are really different.

Even though the probability of a failure event is lower than another, the severity can be greater which increases the risk value. Indeed for scenario 2, the aquifer is reached by CO<sub>2</sub> (Figure 4) but scenario 2 is less probable than scenario 1. Nevertheless its global risk value is higher than the one assessed for scenario 1.

In order to take into account all these aspects, a robust methodology such as the

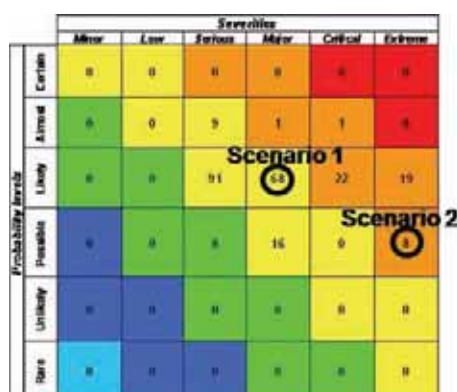


Figure 7: Population of the scenarios in the risk matrix dedicated to well integrity (after 500 years) (snapshot from Simeo-Stor)

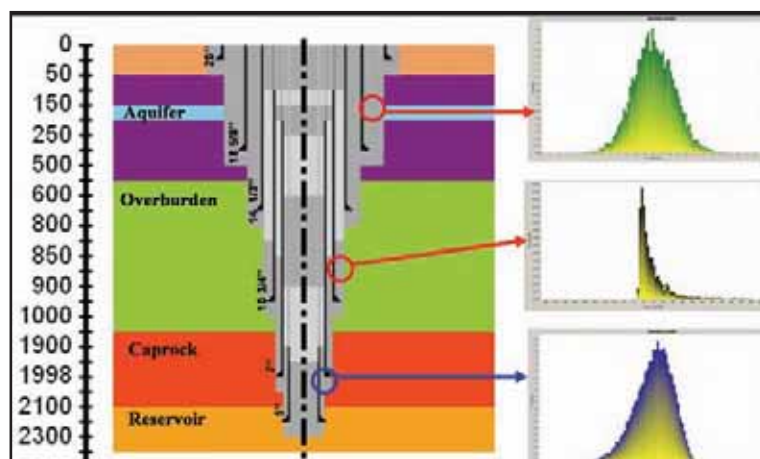


Figure 4: Distribution laws for well zones (3 zones represented) (an example)

P&R™ is required. The system complexity requires assessing the uncertainties associated to well integrity and the severity of failure events towards the stakes involved in a project.

## Conclusions

One of the key challenges for CCS technology deployment is to assess well integrity performance towards possible gas leakages. A quantitative performance and risk methodology is proposed to provide an operational response to this issue. It has been illustrated in this paper from a case study application.

Different outcomes are provided by such an approach:

- A static overview of the well integrity based on the available data and an uncertainty assessment associated to these data;
- Resulting CO<sub>2</sub> leakage rates along the wellbore are quantified at any point of interest (shallower aquifer, surface...) for different scenarios (integrating uncertainties associated to the well system);
- Possible CO<sub>2</sub> leakage pathways can be identified. Degradation processes are key elements to consider: they can modify the CO<sub>2</sub> leakage pathways and the CO<sub>2</sub> cumulative leakage mass towards targets;
- Predictive risk mappings can be drawn at any time of interest (from tens to hundreds of years) and enables the user to identify which risks are unacceptable. Sources of risks can be identified in an objective way.
- Operational recommendations can be formulated to reduce risks below an acceptable threshold.

The presented P&R methodology has been applied on numerous industrial projects. The risk-based process allowed asset managers to set up decisions and provide a strong support for optimizing remediation workplan strategies to mitigate risks and/or for long term safety demonstration to the authorities.



## References

1. **Le Guen, Y. 2008** CO2 Storage – Managing the Risk Associated With Well Leakage over Long Timescales, SPE 116424, 2008
2. **Le Guen, Y., et al. 2008** « Quantitative risk management of wells integrity for CO2 storage ». Proceedings of the 7th Annual Conference on Carbon Capture & Sequestration, Pittsburgh, Pennsylvania, USA.
3. **Meyer, V., et al. 2008**, “Quantitative risk evaluation related to long term CO2 gas leakage along wells”, Proceedings of the 9th Greenhouse Gas Technology Conference, Washington, USA
4. **Frenette, R., et al. 2006**. « Managing the Performance and Risks associated with Well Leakage ». Proceedings of the Fifth Confer-

ence on Carbon Capture & Sequestration, Alexandria, VA, USA.

5. **Van Der Beken, A., et al., 2007** « Well Integrity Assessment and Modelling for CO2 injection ». Proceedings of WEC07, Alger, Algeria.

carbon  
capture  
journal

## About the company

OXAND group is an independent international consulting company providing innovative services in expertise and risk management for CCS or EOR/EGR activities. OXAND group operates its own innovative tools and databases (Simeo™) for diagnosis/prognosis of infrastructures' performance.

With an experience in decision-making criteria based on Performance and Risk™ assessment methodologies (P&R™), coming from its nuclear experience, OXAND group develops its activities worldwide and its services are successfully acknowledged by Oil&Gas operators.

## Vincent Meyer

Consultant / Consultant Engineer

[vincent.meyer@oxand.com](mailto:vincent.meyer@oxand.com)

[www.oxand.com](http://www.oxand.com)

## Transport and storage news

### DOE seeks applications for tracking CO2 storage

[www.fossil.energy.gov](http://www.fossil.energy.gov)

The U.S. Department of Energy (DOE) has issued a Funding Opportunity Announcement (FOA) to enhance the capability to simulate, track, and evaluate the potential risks of CO2 storage in geologic formations.

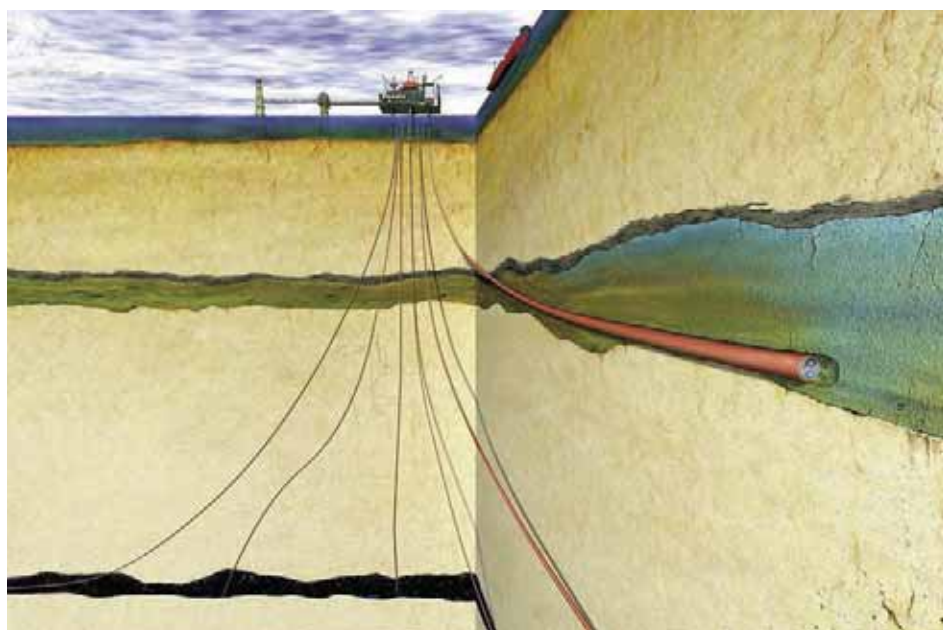
DOE said it anticipates making multiple project awards under this FOA and, depending on fiscal year 2009 appropriations, may be able to provide up to \$24 million to be distributed among selected recipients.

The investment is expected to create nearly 160 full-time jobs per year. These jobs will be supported throughout the life of the projects, which is anticipated to be up to four years.

The projects will be cost-shared, with the award recipient(s) providing at least 20 percent of the total funding required for each project.

DOE said the solicitation contemplates cooperative agreements among the Government, academia, and industry to develop and successfully apply innovative, advanced technology and protocols to improve understanding of the factors affecting CO2 storage permanence and capacity in geologic formations.

The specific objectives of projects funded under the FOA include: (1) developing tools and protocols for the monitoring, verification, and accounting of CO2 stored in geologic formations; (2) improve simulation tools to predict the behavior of geologically stored CO2; and (3) develop risk assessment models associated with geologic



CO2 injected into the Utsira formation is not leaking according to the latest seismic data from StatoilHydro (image © StatoilHydro)

CO2 storage. The selected projects will be managed by the Office of Fossil Energy's National Energy Technology Laboratory.

Projects selected under the FOA will become part of the research portfolio of the Office of Fossil Energy's Carbon Sequestration Program. The program goal is to develop technologies to safely and permanently store CO2 and reduce greenhouse gas emissions without adversely affecting energy use or hindering economic growth.

The program is comprised of four principal elements: (1) core research and development, (2) deployment, (3) demonstration, and (4) global partnerships and collaborations.

### StatoilHydro confirms CO2 storage site is not leaking

New seismic data from the Utsira formation in the North Sea indicates that the CO2 being pumped into it is not leaking out, but is spreading through the structure as expected.

As part of its monitoring responsibilities, StatoilHydro collects four-dimensional seismic data every other year, intended to identify the way the gas is behaving in the formation, and information from the 2008 survey has now been analysed.

The data shows that the carbon dioxide is spreading upwards from the injection site and slowly through the rock, maintaining the

same dispersion speed as in 2006. Monitoring has established that the gas remains in the formation with no leakage to the surface, said the company.

The injected carbon dioxide currently covers about three square kilometres of the roughly 26,000 square kilometres available in Utsira.

"In addition to seismic surveys, we monitor wellhead pressure," explained Edwin B Ytredal, vice president of operations for the Sleipner area.

"These measurements show stable results, which again demonstrate that the reservoir is well suited for storage."

Researchers from StatoilHydro and its partners – Sintef, the British Geological Survey and the Dutch Institute of Applied Geoscience – have created mathematical simulation models.

These are supplemented with forecasts for long-term storage of the greenhouse gas, which are based on experience and knowledge of seismic surveys and geophysical reservoir monitoring.

"Twelve years of data and seven surveys confirm the indications from the models and forecasts," said Eli Aamot, head of the new energy and ideas research programme in StatoilHydro.

"They show that long-term carbon storage in sub-surface geological formations represents a secure approach."

## Michigan Basin storage project starts second phase

[www.mrcsp.org](http://www.mrcsp.org)

**The U.S. Department of Energy's (DOE) Midwest regional partnership has begun injecting an additional 50,000 tons of CO2 into a Michigan Basin deep saline formation.**

This follows on from an initial injection project of 10,000 metric tons. The CO2 being injected comes from a natural gas processing plant owned by DTE Energy, located near Gaylord, Michigan and transported via an existing eight mile pipeline to the well.

Injections are expected to take place at an average rate of 250 tons per day up to a maximum rate of 600 tons. When the full 60,000 ton project is completed this will be the largest deep saline reservoir injection in the United States to date.

The team will record geochemical changes to the system, as well as the distribution of the CO2 along the wellbore. A larger volume of CO2 injected over a longer period of time will also provide scientists with additional insight into temperature and pressure responses in the geologic formation, as well as any seasonal changes to the system.

## Drilling begins in Illinois CO2 storage test

[www.mrcsp.org](http://www.mrcsp.org)

**The Midwest Geological Sequestration Consortium (MGSC) has begun drilling the injection well for their large-scale CO2 injection test in Decatur, Illinois.**

The project will capture CO2 from the Archer Daniels Midland (ADM) ethanol production facility in Decatur and inject it in a deep saline formation more than a mile underground.

Starting in early 2010, up to one million metric tonnes of CO2 from the ADM ethanol facility will be compressed and injected in the Mt. Simon Sandstone formation, at a depth between 6,000 and 7,000 feet, over a three-year period.

In January 2009, ADM — in collaboration with the Illinois State Geologic Survey at the University of Illinois, which leads the MGSC — was issued an Underground Injection Control permit by the Illinois Environmental Protection Agency for the injection well.

Obtaining the permit is significant because it allows the consortium to proceed with drilling, making the MGSC the first DOE Regional Partnership to begin drilling a development phase injection well. The drilling is expected to take about 2 months to complete.

Following injection, a comprehensive monitoring program will be implemented to ensure that the injected CO2 is safely and permanently stored. The position of the underground CO2 plume will be tracked, and deep subsurface, groundwater, and surface monitoring around the injection site will be conducted. The monitoring program will be evaluated yearly and modified as needed.

## CO2 injection begins in Virginia project

[www.secarbon.org](http://www.secarbon.org)

**DOE's Southeast Regional Carbon Sequestration Partnership (SECARB) began injecting CO2 at the test site in Russell County, Virginia, in mid January 2009.**

An existing coalbed methane well has already been converted for CO2 injection, and two wells have been drilled to monitor reservoir pressure, gas composition, and the CO2 plume.

The targeted coal seams are in the Pocahontas and Lee formations and range from 1,400 to 2,200 feet in depth and from 0.7 to 3.0 feet in thickness. One thousand tons of CO2 will be injected over a 45-day period.

The site was selected because it is representative of the Central Appalachian Basin, an area of about 10,000 square miles located in southern West Virginia and south-

western Virginia. This area has been assessed by researchers to have the capacity to store 1.3 billion tons of CO2 in the coal seams while increasing natural gas production up to 2.5 trillion cubic feet.

The Central Appalachian Basin CO2 Storage Project will explore the concept of multiple use of subsurface storage volume. Injecting CO2 into coal seams boosts coalbed methane recovery, which provides an immediate commercial benefit and offsets infrastructure development costs, while providing long-term storage of CO2 in the formation—a win-win situation.

## Santos Moomba CO2 storage project suspended

[www.bloomberg.com](http://www.bloomberg.com)

**Bloomberg reports that Santos has put its Moomba CO2 storage project, estimated to cost more than A\$700 million, on hold.**

Santos said that "the economic and financial factors are not in place at the moment to justify the heavy investment that it would require."

## University of Utah and Headwaters in carbon services partnership

[www.unews.utah.edu](http://www.unews.utah.edu)

**The University of Utah and Headwaters have entered into a joint venture, Headwaters Clean Carbon Services (HCCS), to offer carbon management services to CO2-emitting companies.**

HCCS, managed by Headwaters, will offer carbon storage engineering and risk and liability management. Utah has licensed its technologies to the company.

The first project for the joint venture will be to develop and operate a regional CO2 storage site that will serve several power plants in central Utah. HCCS engineers estimate that the proposed regional CO2 storage site could permanently store as much as 1 billion tons of CO2.

It would also provide a revenue stream for the community, as due to its location, the state's School and Institutional Trust Land Administration should be able to collect lease fees for CO2 storage, which will help fund Utah's school systems.

The technology behind HCCS is a direct result of the Utah Science Technology and Research Initiative (USTAR). The carbon sequestration technologies were developed under the U of U's fossil energy research team, led by USTAR faculty recruit Brian McPherson, associate professor of civil and environmental engineering.

Graduate students at the University of Utah's Lassonde New Venture Development Center helped perform market research and developed initial business models for the

carbon sequestration technology. The Lassonde Center was instrumental in identifying and bringing Headwaters into the joint venture, said the University.

## Montana State University receives \$1.4M grant

[www.montana.edu](http://www.montana.edu)

Researchers at Montana State University, Montana Tech and the University of Montana have been awarded a \$1.4 million grant from the US Department of Energy to study the effects carbon sequestration sites may have on the surrounding environment.

The project will study the environmental effects of geologic carbon sequestration.

Using magnetic resonance imaging techniques, researchers will study the effects of injecting large volumes of CO<sub>2</sub> into porous underground rocks. These injections could affect the rock's pore structures, their material properties or the microbial activity in the rocks, which could affect how well CO<sub>2</sub> is sequestered in those rocks.

The project's second goal is to understand how increased levels of carbon dioxide may affect microbes and plants near sequestration sites. Excess CO<sub>2</sub> can cause stress on plants and microbes.

Observing this stress can give scientists

an indicator of whether a sequestration site is leaking CO<sub>2</sub>. That study will be done through a series of field experiments at a test site just west of MSU.

The grant comes from the Department of Energy's Experimental Program to Stimulate Competitive Research, referred to as EP-SCoR. Five DOE national laboratories will also be involved in the funded research.

## Maersk Tankers ready to enter market for CO<sub>2</sub> transportation

[www.maersk.com/en](http://www.maersk.com/en)

Maersk Tankers, owned by the Danish conglomerate A.P. Moller – Maersk Group, says is prepared to enter into the CO<sub>2</sub> transportation market to help promote CCS.

Maersk Tankers says it has examined the business case for entering into the CO<sub>2</sub> transportation market for either offshore storage or enhanced oil recovery (EOR), using CO<sub>2</sub> to increase oil recovery rates in maturing fields.

"By using our experience in transporting liquefied petrochemical and natural gasses, we have developed a large scale case for transport of CO<sub>2</sub> for storage or EOR," said Martin Fruergaard, senior vice president, Maersk Tankers.

According to Maersk Tanker studies,

more than 750 million tonnes of CO<sub>2</sub> are emitted from large stationary power plants close to the sea in the North Sea region alone. Fifteen Handysize Gas Carriers (20,000 cbm) could transport more than half of Denmark's annual CO<sub>2</sub> emissions for storage in the North Sea, the equivalent of all CO<sub>2</sub> from large Danish stationary emission sources.

Furthermore, transporting CO<sub>2</sub> by sea is cost-competitive and more flexible than pipelines on longer distances or in smaller quantities, said the company.

Apart from Maersk Tankers, A.P. Moller – Maersk Group's Maersk Oil is also looking into the opportunities linked to CCS.

"Given our experience from the Danish underground in the North Sea and the high-level of knowledge we have gained from that, Maersk Oil is investigating CO<sub>2</sub> mitigation technologies for the geological storage of CO<sub>2</sub> to meet the expected demand," said Michael Engell-Jensen, senior vice president and head of Maersk Oil's Carbon and Climate Department.

Maersk Oil said it is in discussion with a number of potential partners to develop CCS projects that will remove CO<sub>2</sub> from point sources such as coal fired power plants, and store the CO<sub>2</sub> underground, either on-shore or offshore.



## A CCS worldwide experience

<http://www.oxand.com>

### PERFORMANCE & RISK™ MANAGEMENT solutions FOR CARBON CAPTURE & SEQUESTRATION PROJECTS

**Capture, Compression, Transport,  
Sequestration**

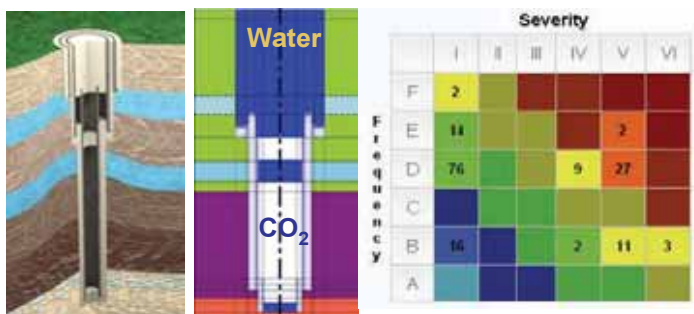
**From risk screening to risk quantification  
Project management & Technology evaluation**

From 0 to 10 000 years of risk control !



**Risk management training for CCS projects  
June 2009 in Paris**

**To register contact Eleonore Brunel at:  
[eleonore.brunel@oxand.com](mailto:eleonore.brunel@oxand.com)**



**Risk-based well integrity, durability, leakage modeling and scenarios ranking with SIMEO™-STOR**

**OXAND group assists CCS project leaders.**

**From feasibility studies to commercial operations,  
our consultants and technologies provide solutions  
to major projects.**

Contact: [rabih.chammas@oxand.com](mailto:rabih.chammas@oxand.com)

Calgary, Lausanne, Montréal, Paris, Utrecht, <http://www.oxand.com>



RPS



# What if...

you were thinking about **Carbon Capture and Storage**, but weren't certain of the best partner to work with?

Our energy and environmental experience is unique in being able to offer clients the immense breadth of support required to develop their CCS projects at each stage of the lifecycle.



## Just some of our areas of expertise:

- Integrated Carbon Management Services
- Technical and commercial counsel from source to sink
- Guidance in legislative and market developments
- Planning and consenting advice
- Environmental and monitoring assistance

**RPS are global specialists in managing major, complex, multi-disciplinary projects.**