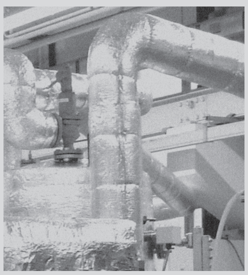
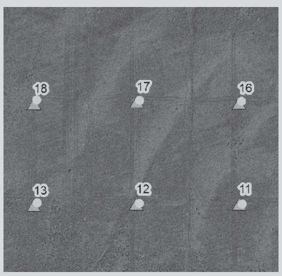
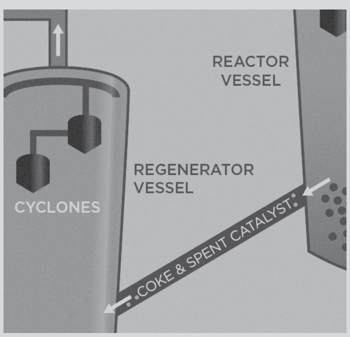
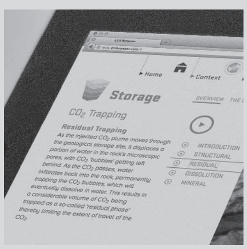
CO_2 Capture Project®

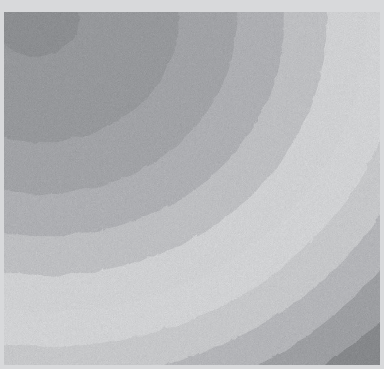
ANNUAL REPORT 2012

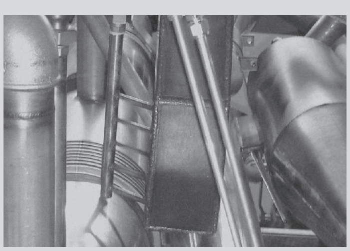


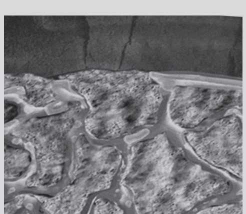












CAPTURE

Reducing the cost of CO_2 capture from the in-situ extraction of bitumen, oil refining and natural gas power generation

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STORAGE, MONITORING & VERIFICATION

Increasing understanding and developing methods for safely storing and monitoring CO_2 in the subsurface

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POLICY & INCENTIVES

Providing technical, economic and social insights to inform the development of legal and policy frameworks and to helping public understanding

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COMMUNICATIONS

Taking content from the on-going work of other teams and delivering it to government, industry, NGOs and the general public

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Published by the CO_2 Capture Project. April 2013.
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Front Cover

(Clockwise from top)
140kW chemical looping pilot, CCS Browser, Borehole to Surface EM Model, CCS Browser animation, chemical looping combustion unit, CCP 2012 Regulatory Study, FCC unit diagram, PS InSAR surface deformation results

CO_2 Capture Project PhaseThree participating organizations, 2012

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INFORMATION KEY

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MORE INFORMATION ONLINE

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The CCP was formed in 2000 to advance technologies and improve operational approaches to help make CCS a viable option for CO_2 mitigation.

Today, this partnership of several major energy companies is focused on delivering results from its demonstrations, field trials and studies. This Annual Report provides an update from the teams that make up the CCP – Capture, Storage, Policy & Incentives, and Communications.

2012 HIGHLIGHTS

CAPTURE

Details finalized for 2013 field demonstration of oxy-firing in a heavy oil/oil sands scenario
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Extensive development and testing underway for pre-combustion MWGS technology
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Phase III economic baselines completed, including main technologies for refinery, NGCC and heavy oil scenarios
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Demonstration and testing completed to understand oxy-firing technology in oil refinery environments
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STORAGE, MONITORING & VERIFICATION

Preliminary results from Capillary Entry Pressure and Relative Permeability studies
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Further results from satellite monitoring program at Decatur, Illinois, US
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First two stages of Storage Contingencies program underway
READ MORE ON PAGE 18

Modular Borehole Monitoring technology successfully deployed at Citronelle Dome, Alabama, US
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POLICY & INCENTIVES

CCS Regulatory Study: Challenges and Key Lessons Learned from Real-World Development of Projects completed
READ MORE ON PAGE 21

Shared regulatory study insights at IETA side-event at UN Conference of the Parties (COP18, Doha)
READ MORE ON PAGE 21

Scoped out next major study, focusing on local community benefit options, to be delivered in 2013
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COMMUNICATIONS

Continued to inform the industry and wider public via factsheets, online registrant updates and exhibits at 11th Annual CCUS Conference and GHGT-11
READ MORE ON PAGE 23

Launched online version of In Depth brochure and embarked on larger digital project – the CCS Browser
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CHAIRMAN'S INTRODUCTION

2012 Members of the CCP3 Executive Board

Chairman
Nigel Jenvey
(BP) – from October 2012
(Chairman)
Brian Williams
(BP) – 2011-2012

Members
Rodolfo Dino
(Petrobras)
Stephen Kaufman
(Suncor)
Vincent Kwong
(Chevron)
Mario Vito Marchionna
(eni)
Ad Punt
(Shell)

Without doubt, 2012 has been an important year in the history of the CCP. We formed as a group in 2000, with a commitment to advancing technologies and improving operational approaches to help CCS become a viable option for CO_2 mitigation. Significant progress has been achieved by our teams over the intervening period and these final years of CCP3 are now seeing exciting progress on the delivery of important projects, including our first major capture demonstration.

CCP Chairman
Nigel Jenvey (BP)

There has been intense activity in 2012 across all CCP Teams – Capture, Storage, Policy & Incentives and Communications. The Capture Team continues to work to develop a suite of economically viable next generation technologies – focusing on oil refinery, oil production and power generation scenarios. Last year saw the CCP hold an oxy-firing test at a pilot-scale Fluid Catalytic Cracking (FCC) unit at a Petrobras research facility in Parana state, Brazil. This demonstration has indicated the technical viability of retrofitting an FCC unit to enable CO_2 capture through oxy-firing. It has underlined oxy-firing technology as the preferred route for FCC CO_2 capture and is a crucial achievement for the CCP and its member companies, who have closely collaborated to bring this to fruition. The team also made progress in developing a range of other capture technology tests and studies that will be delivered in 2013, while greater clarity was achieved around the baseline cost implications of the three main capture technologies.

It has also been an important year for the Storage Team, which has continued its work on addressing key issues for industry and regulators through a mix of experiment, analysis, modeling and field trials. The team guided a number of important monitoring field trials to completion with the successful deployment of innovative Modular Borehole Monitoring technology at Citronelle Dome in the US, and further results from a satellite monitoring program at Decatur, Illinois. The team's work on contingencies, contributing to the understanding of detection and remediation of unexpected CO_2 or brine migration has also progressed well. This work has the potential to be a key input to help assure stakeholders that storage can be performed safely and securely.

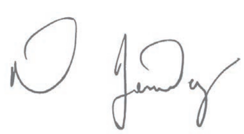
The Policy & Incentives Team has continued to further contribute to an understanding of government and institutional policies influencing the development of CCS. Its 2012 CCS Regulatory Study has given valuable insight into the evolution of legal frameworks in key jurisdictions and into how project managers and regulators are finding pathways for regulatory approvals.

The Communications Team had a busy year working closely with the technical teams to share the knowledge gained from their projects with industry and the wider CCS world. The team also undertook an ambitious digital education project – the CCS Browser – to help non-technical audiences explore CCS in more depth. We hope that the wider industry will find this website of use in their work to help engage communities and other sections of the public who may have an interest in CCS, and the continuing work that lies ahead on this front.

With great pride, I took over the CCP chairmanship from Brian Williams in October and would like to acknowledge the fantastic job my predecessors have done. I bring with me more than 17 years' experience working in upstream oil and gas operations, where I focused on CO_2 capture and storage, along with the utilization from Enhanced Oil Recovery. At this important stage in the history of the CCP, I am grateful to our member companies, both past and present, for all their help supporting this unique collaborative effort. I also want to take this opportunity to thank all those Team members, partners and suppliers who have made extraordinary efforts to deliver these crucial projects as the CCP3 reaches its final year.

It certainly is an exciting time to be chairman of the CCP. Our focus now is on delivering results from the demonstrations, field trials and studies which will conclude in 2013. We are also in discussions about the future of CCP beyond this phase and will keep you updated. Meanwhile, if you have any questions about the CCP program, I encourage you to contact our program manager, Mark Crombie, who will be able to assist you.

Yours faithfully,



CCP Chairman
Nigel Jenvey *(BP)*

CCP 2012 STRUCTURE

For more than a decade, the CCP has brought together major energy companies to work together and share expertise to help CCS become a viable option for CO_2 mitigation for their industry.

The CCP is made up of four teams – Capture; Storage, Monitoring & Verification; Policy & Incentives; and Communications. It includes geologists and other subsurface specialists, engineers, policy and regulatory specialists and communications experts drawn from each of the member organizations.

Each member organization is represented on the CCP Executive Board, that comes together quarterly. The CCP is supported by an independent Technical Advisory Board who reviews the groups' progress and results, offering recommendations for future direction.

In 2012, the CCP members were: BP, Chevron, Eni, Petrobras, Shell and Suncor. The CCP is in its third phase of activity – CCP3 – scheduled to finish in 2013.

THE CCP TEAM 2012

CCP3 Executive Board
Chair – Nigel Jenvey *(BP)*
Rodolfo Dino *(Petrobras)*
Stephen Kaufman *(Suncor)*
Vincent Kwong *(Chevron)*
Mario Vito Marchionna *(eni)*
Ad Punt *(Shell)*

CCP3 Advisory Board
Chair – Vello Kuuskraa *(Advanced Resources International Inc.)*

Program Manager
Mark Crombie *(BP)*

Capture

Mark Bohm *(Suncor)*
Dan Burt *(Suncor)*
Jonathan Forsyth *(BP)*
Karl Gerdes *(Chevron)*
Mahesh Iyer *(Shell)*
Raja Jadhav *(Chevron)*
Jamal Jamaluddin *(Shell)*
Cliff Lowe *(Chevron)*
Leonardo de Mello *(Petrobras)*
Ivano Miracca *(eni)*
Gustavo Moure *(Petrobras)*
Gerald Sprachmann *(Shell)*
Evert Wesker *(Shell)*

Storage, Monitoring & Verification

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Marco Brignoli *(eni)*
Andreas Busch *(Shell)*
Mark Chan *(Suncor)*
Walter Crow *(BP)*
Rodolfo Dino *(Petrobras)*
Kevin Dodds *(BP)*
Craig Gardner *(Chevron)*
Grant Duncan *(Suncor)*
Scott Imbus *(Chevron)*
Dan Kieke *(Chevron)*
Claus Otto *(Shell)*
Alessandra Simone *(Shell)*

Economic modeling

David Butler *(David Butler & Associates)*

Communications

Lucy Almond *(BP)*
Morgan Crinklaw *(Chevron)*
Renato De Filippo *(eni)*
Christhiaan Greco *(Petrobras)*
Alexander Ratcliffe *(Shell)*
Leonardo da Silva Ribeiro *(Petrobras)*
Joel Thompson *(Suncor)*

Policy & Incentives

Lucy Almond *(BP)*
Eric Beynon *(Suncor)*
Mark Bohm *(Suncor)*
Dan Burt *(Suncor)*
Mark Crombie *(BP)*
Renato De Filippo *(eni)*
Christhiaan Greco *(Petrobras)*
Arthur Lee *(Chevron)*
Alexander Ratcliffe *(Shell)*
Leonardo da Silva Ribeiro *(Petrobras)*

TECHNICAL ADVISORY BOARD

2012 Members of the CCP3 Technical Advisory Board

Chairman
Vello Kuuskraa
(President, Advanced Resources International Inc., US)

Members
Olav Bolland
(Head of Department/Professor, NTNU, Norway)
Michael Celia
(Professor and Chair, Civil and Environmental Engineering, Princeton University, US)
Pierpaolo Garibaldi
(Independent consultant, Peschiera Borromeo, Italy)
Christopher Higman
(Independent consultant, Schwalbach, Germany)
Larry Myer
(Independent consultant, Benicia, CA, US)
Dale Simbeck
(Vice President, Technology, SFA Pacific, Inc. Mountain View, CA, US)

The Technical Advisory Board (TAB) independently reviews the progress and results of the CCP and makes recommendations for future direction. In its latest review (October 2012), the TAB noted the effect of the macro-economic, political and commercial climates on the CCS industry and recognized that the CCP had taken significant steps to adapt its program. The result is a CCP program with: (1) strong emphasis on technologies with near-term use by the oil and gas industry (2) increased attention on productive utilization of captured CO_2, particularly for Enhanced Oil Recovery; (3) a balanced effort on identification and support of novel, lower cost capture technologies.

STORAGE, MONITORING & VERIFICATION (SMV) PROGRAM:

The program addresses three areas – Storage Assurance R&D, Field Trials and Stakeholder Issues. The TAB was highly complimentary of the SMV Team's work on the critical issues for CO_2 storage.

The TAB recommends:

- Storage Contingencies – continue innovation, emphasizing early detection of CO_2 migration and developing reservoir remediation solutions
- Modular Borehole Monitoring (MBM) – conduct a rigorous cost-benefit study to determine the cost-efficiencies and data quality benefits of using the MBM technology against more traditional monitoring technologies
- Relative Permeability Studies – further experiments on pore space trapping of CO_2 by different rock types.

The TAB also recommends using coordinated technical papers to communicate the findings of the high quality work on well integrity.

CAPTURE PROGRAM:

The TAB recognizes that the Capture Team has narrowed its focus to technological solutions most directly benefitting the oil and gas industry. These include: (1) prioritizing lower-cost, near-term technologies capturing CO_2 from refineries; (2) field trialing CO_2 capture from steam generation plants used in oil sands recovery; (3) pursuing cheaper methods for CO_2 capture from natural gas-fired power generation.

The TAB recommends:

- Hydrogen Production – prioritize 'step change' technologies such as Membrane Water Gas Shift (MWGS), which lower the cost of CO_2 capture from hydrogen production by refineries
- New Solvents and Sorbents – comprehensively evaluate emerging solvents and sorbents such as phase-change systems and amino acids
- Novel Technologies – pursue high-risk, high-reward technologies such as Chemical Looping Combustion, ionic and non-aqueous solvents, and enzyme solvent enhancement.

The TAB recommends sharing R&D costs of expensive pilot and field tests through partnerships with other entities. For example, the Capture Team already uses the CO_2 capture test facilities of EERC for post-combustion testing.

GLOBAL OVERVIEW

Harnessing the power of CO_2 Capture and Storage (CCS) to reduce global CO_2 emissions

It can be said that 2012 was another rather mixed year for the development of CCS. The global economy continues to struggle, with the focus on environmental issues remaining low on the agenda as a consequence. The annual Global CCS Institute report into the state of the industry shows an increase of only one in the number of large-scale integrated CCS projects planned, while globally there remains a lack of incentive to stimulate its growth. However, there have been some encouraging developments. A recent study from the CCP Policy & Incentives Team has shown progress made by some project developers and regulators across jurisdictions, closing gaps in regulation and policy to allow projects the potential to go ahead. There has also been increased interest in CO_2 Enhanced Oil Recovery (EOR) and other utilization options as a commercially focused way of bridging gaps and building technical knowledge.

PROJECT DEVELOPMENTS AND INVESTMENTS

Although nine new large-scale integrated CCS projects were announced during the year, a total of eight existing projects have been canceled or put on hold. It is notable that project developments were set back significantly by the failure of CCS applicants to win monetary awards in the first round from the European Commission's NER300, intended to be the world's largest CCS funding mechanism. There is still, however, an opportunity for investment as a second round was announced in the first half of 2013.

However, there have been a number of positive examples of projects progressing. The Quest Athabasca Oil Sands project is going ahead with support from the Canadian government and the Province of Alberta. Australia built its first oxy-fuel capture pilot plant, also the first to be retrofitted to an existing power station, and China saw its first carbon capture project reach over 40,000 tons of CO_2 captured in the past 15 months.

CO_2 ENHANCED OIL RECOVERY (EOR)

In this environment, EOR is being increasingly recognized as important to helping fund CCS technology demonstrations on a commercial scale. EOR uses injected CO_2 to produce otherwise trapped and hard-to-access oil, with a portion of that CO_2 remaining stored permanently in the subsurface. Therefore, EOR can provide an important source of income for project developers in the absence of other financing mechanisms to make CCS commercially viable. According to the Global CCS Institute, most of the newly identified large-scale integrated projects in 2012 were investigating EOR, with five of the eight operating projects already selling CO_2 to EOR customers.

LEGAL FRAMEWORK AND POLICIES

There have been a number of encouraging regulatory and policy developments around the world during the course of the last 12 months. In Australia, the introduction of a carbon tax in July 2012 was a significant development. Victoria State's offshore regulations also came into play at the start of the year, making it the first Australian state to finalize its CCS regulatory framework for both onshore and offshore CO_2 storage.

China's twelfth Five-Year Plan has reinforced its targets for carbon intensity – the amount of CO_2 emitted per unit of GDP – to 21% below 2010 levels by 2015. Beijing province has also submitted a draft of rules and regulations for an emissions trading scheme.

The UK introduced its first CCS Roadmap, *Supporting deployment of CCS in the UK*, which highlights steps that should be taken to ensure a competitive CCS industry by 2020. In October 2012, the UK also announced the shortlist for its £1bn-funded CCS Commercialisation competition, with the successful demonstration projects due to be announced in early 2013.

In the US, four permit applications for the new category of Class VI injection wells have been submitted to the Environmental Protection Agency (EPA) that follow the 2010 Underground Injection Control (UIC) rule for CO_2 geological sequestration. In September 2012, legislation was introduced that would serve to modify the existing CCS tax incentive in tax code 45Q to make it more transparent for companies to use.

However, across all jurisdictions significant gaps for the regulatory approval of CCS remain. Encouragingly, the CCP Policy & Incentives Team's latest study, focusing on real-life projects, has shown that on-the-ground project developers and regulators have been coming together to find a pathway forward.

THE UN CONFERENCE OF THE PARTIES (COP18)

Held in Doha in December 2012, the UN Conference of the Parties (COP18) resulted in a second commitment period for the Kyoto Protocol. The legally binding international carbon emissions agreement, which had been due to conclude in 2012, has been extended until 2020. Negotiations took place at the Conference on the issue of allowing the eligibility under the Clean Development Mechanism (CDM) of CCS projects which involve the transport of CO_2 across national boundaries or which involve geological storage sites that are in more than one country, and setting aside a Global Carbon Reserve of CDM credits from CCS projects. No decisions were reached and discussions have been deferred until 2016.

CAPTURE PROGRAM

DEMONSTRATION RESULTS

Completion of significant demonstrations, tests and evaluations – with particular relevance to CO_2 capture from oil refineries – has been the highlight of the 2012 CCP Capture program. The demonstration run of oxy-firing capture technology on a pilot-scale Fluid Catalytic Cracking (FCC) unit delivered significant results, while a project testing oxy-combustion for CO_2 capture from oil refinery process heaters was also completed during the year.

The detail of a range of other CCP capture test studies was also finalized, with results of these due to be delivered in 2013, the last year of CCP3. This work included the revised scoping of an oxy-firing demonstration project in another of the CCP's main capture scenarios – heavy oil/oil sands steam assisted gravity drainage – and the finalization of Membrane Water Gas Shift (MWGS) and Chemical Looping Combustion (CLC) tests.

Greater clarity has also been achieved around the cost implications of the main capture technologies with the completion of Phase III of CCP's *Economic Evaluation Study*, comparing baseline costs for oxy-firing, post-combustion and pre-combustion across the main oil and gas capture scenarios.

"2012 was the first year of CCP3 in which some of the major projects came to their conclusion, making a large quantity of valuable results available to the Capture Team. I would like to mention in particular the excellent results of the first CCP capture demonstration, the fluid catalytic cracking project. I thank all of the personnel at Petrobras involved in the project, as well as the supporting FCC experts of the other CCP member companies who contributed to this success.

"The techno-economic studies performed in 2012 will help in planning future developments, concentrating efforts on the most promising techniques for each application.

"Many more results are due during the final year of CCP3, from both demonstration and R&D projects – targeting assessment of novel technologies, completing evaluations for each application scenario and paving the way toward different applications."

Ivano Miracca, eni, CCP Capture Team Lead

2012 Members of the CCP3 Capture Team

Team Lead
Ivano Miracca
(eni)

Members
Mark Bohm
(Suncor)
Dan Burt
(Suncor)
Jonathan Forsyth
(BP)
Karl Gerdes
(Chevron)
Mahesh Iyer
(Shell)
Raja Jadhav
(Chevron)
Jamal Jamaluddin
(Shell)
Cliff Lowe
(Chevron)
Leonardo de Mello
(Petrobras)
Gustavo Moure
(Petrobras)
Gerald Sprachmann
(Shell)
Evert Wesker
(Shell)

CAPTURE HIGHLIGHTS

Details finalized for 2013 field demonstration of oxy-firing in a heavy oil/oil sands scenario

Extensive development and testing underway for pre-combustion MWGS technology

Phase III economic baselines completed, including main technologies for refinery, NGCC and heavy oil scenarios

Demonstration and testing completed to understand oxy-firing technology in oil refinery environments

THE 2012 CAPTURE PROGRAM

Process Heaters

(Left image) COOLstar® burner.
(Right image) PSFG burner. Images courtesy of John Zink Hamworthy Combustion.

Once-Through Steam Generators (OTSG)

(Below) Firebag oil sands facility, Alberta, Canada. Image courtesy of Suncor.

REFINERIES

FCC oxy-firing demonstration

The demonstration of oxy-firing capture technology in a pilot-scale FCC unit at a Petrobras research facility in Parana State, Brazil is complete. The results confirm the technical viability of retrofitting an FCC unit.

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Process Heaters

The CCP, working in conjunction with John Zink, carried out modeling and pilot-scale testing of the operation of oil refinery process heaters in oxy-firing mode, with conventional burners typically used in normal operation.

Final reports were produced and it was confirmed that conventional burners (with minor modifications) can indeed be used for oxy-firing operation in process heaters.

Simulations showed that steady state operation may be achieved, recycling around 70% of the flue gas to the combustion chamber, with efficiency of the heaters increasing by a factor of four percentage points (for heaters with air pre-heating) to 15 percentage points (for heaters with no pre-heating).

Single burner testing was performed in a 13ft wide, 7ft long and 31ft high pilot furnace at John Zink test facilities in Tulsa (Oklahoma, US). Two different fuels (natural gas and refinery fuel gas) were tested with two different commercial burners.

Combustion and heat transfer performances similar to air firing were achieved and NOx formation was strongly decreased. A high level of air in-leakage was experienced, partly caused by the specific test conditions. It is estimated that during oxy-firing operation, nitrogen in the flue gas would be at a 10% (wet) volume concentration, requiring further purification before storage.

HEAVY OIL/OIL SANDS PRODUCTION

Once-Through Steam Generators (OTSG)

The CCP's second large-scale demonstration of capture technologies is due to take place in 2013, at an oil sands production facility in Alberta, Canada. Once-Through Steam Generators (OTSGs) are used in the in-situ extraction of heavy oils and bitumen using steam assisted gravity drainage and are the main source of CO_2 emissions in this increasingly important source of hydrocarbons.

The CCP project – led by Suncor and with support from Cenovus Energy, Devon Canada, MEG Energy, Praxair and Statoil – aims to assess the effectiveness of oxy-firing in capturing CO_2 emissions. The project is co-funded by the Climate Change and Emissions Management Corporation (Alberta). It will provide cost and design estimates for a commercial-scale unit with CO_2 capture, purification and compression and seeks to examine these factors in light of the presumed advantages of oxy-firing in terms of retrofitting capability and NOx reductions.

During 2012, further work took place to refine the scope of work and the contract. A single burner will now be tested during the demonstration. Engineering preparation and installation of gas supply systems also took place during the year and the project is set for completion by the end of 2013.

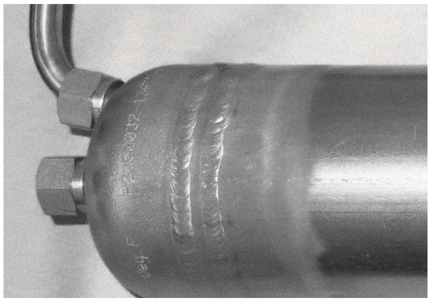
OTSG Factsheet Available

CO2CAPTUREPROJECT.ORG/REPORTS/FACTSHEET_OTSG.PDF

THE 2012 CAPTURE PROGRAM

Membrane Water Gas Shift

(Right) Close-up of hydrogen membrane module. Image courtesy of Pall Corporation.



NATURAL GAS POWER GENERATION

Post-combustion has been identified by the CCP as the preferred choice for capturing the low concentrations of CO_2 inherent in natural gas power station flue gas. Screening for novel breakthrough technologies is underway to assess options for the longer term. As reported in the 2011 Annual Report, CCP joined Phase II of the Partnership for CO_2 Capture (PCO_2C), organized by the Energy and Environment Research Centre (EERC) of the University of North Dakota. The PCO_2C is made up of about 20 partners, including solvent and technology providers, as well as utility producers, and enjoys US$1.5 million of co-funding from the US Department of Energy (DoE). Comparative testing of novel solvents (partly identified by the CCP as a result of the screening of novel technologies) in a pilot-scale facility at EERC is one of the main tasks of PCO_2C. This is a powerful tool for assessing the potential of novel technology, measuring regeneration energy and net heat input requirements. The work of Phase II of PCO_2C is scheduled for conclusion by April 2013.

In a separate project, the EERC pilot plant will be modified for extended testing of a novel amine solvent in a mixed aqueous/organic solution. Reduced water evaporation in the amine stripper would be a major advantage here.

Screening of a solid adsorption technology, characterized by the use of rotary machines, showed that competing with liquid absorption would be difficult in the application to flue gas streams with low concentrations of CO_2, as is typical of NGCC environments.

OTHER TECHNOLOGIES

Membrane Water Gas Shift (MWGS)

MWGS is a pre-combustion technology that uses metallic membranes permeable to hydrogen to separate hydrogen from CO_2 and other components in the syngas, produced by the reforming of a fossil fuel. It may have good potential for use in the refinery scenario and the plan in CCP3 is to develop membrane modules for use in a field pilot unit.

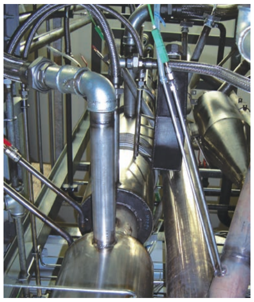
The main phase of the project started in 2012, using proprietarymembranes by Pall, characterized by a micron-thin layer of palladium alloy deposited on a porous stainless steel support. Several 12-inch-long tubes were produced and assembled into membrane modules. Modules are under testing (with conclusion scheduled in early 2013) with different synthesis gas compositions both for separation performance and durability. The work program also includes the design and costing of modules for field pilot and commercial units. Results will be used in the economic evaluations of the technology.

Chemical Looping Combustion (CLC)

CLC is an oxy-firing technology that has a potential for use in capturing CO_2 produced during steam production for heavy oil extraction. It is characterized by a solid carrier that alternately adsorbs oxygen from air and releases it for combustion of a gaseous fuel.

The CCP has been supporting development of this technology since 2001 and is now addressing some specific key issues in a project which started in 2011 and is scheduled for conclusion in 2013. This project is running in parallel with an R&D project called INNOCUOUS that is funded by the European Union with mutual exchange of information. INNOCUOUS is run by a partnership including Chalmers University of Technology, CSIC, VITO, Vienna University of Technology (TUV), Johnson Matthey, Bertsch, and Shell serving as a link between INNOCUOUS and the CCP.

Chemical Looping Combustion



(Left image) The 140kW chemical looping pilot at Vienna University of Technology.
(Right image) The chemical looping combustion unit without thermal insulation sheeting.
Images courtesy of Institute of Chemical Engineering, Vienna University of Technology.

The main targets of the CCP in this project are:

- Optimization of the solid carrier both in performance and in environmental impact
- New design for a commercial-scale unit for steam production in the heavy oil scenario with techno-economic evaluation

The program includes bench and pilot-scale testing, as well as hydrodynamic optimization in a dedicated cold model unit.During 2012, comparative pilot-scale testing of Ni- and Cu-carriers was carried out by TUV. A cold mock-up of a demonstration unit was designed and constructed to test different engineering solutions for an optimized design of the next scale demonstration unit. Design of a commercial unit will also be carried out by Bertsch to support an economic evaluation of the technology.

ECONOMIC BASELINES

The CCP's work in establishing economic baselines for oil refinery, heavy oil and natural gas scenarios has continued, with Phase III now completed by Foster Wheeler.

Post-combustion, pre-combustion and oxy-firing results have now been established, subject to some checking and adjustment following CCP demonstration projects. The following conclusions may be reliably drawn:

- The competitiveness of FCC oxy-firing compared to post-combustion is confirmed. Results and implications of FCC demonstration are now being considered
- In an oil refinery, a full fuel de-carbonization using pre-combustion technology would be economically competitive (and favoured from the plant lay-out viewpoint) compared to post-combustion for capturing most of the CO_2 emitted by heaters and boilers
- In the oil sands extraction scenario, post-combustion is favoured from an economic point of view, and pre-combustion might play a role if larger clusters of boilers are envisaged in the future
- For the NGCC scenario, post-combustion was already identified as the preferred route. The potential of oxy-combustion for future new-build will be assessed in Phase IV.

Phase IV of Foster Wheeler studies will be mostly dedicated to novel technologies to assess potential reduction in CO_2 avoided costs vs. baselines.

The scenarios include:

Oil Refinery
- Set of three fired heaters with a duty of 100 million BTU/hr each
- Fluid catalytic cracking unit with a capacity of 60,000 barrels per day of feed
- Steam methane reformer (SMR) producing 50,000 NM^3/hr of hydrogen (approx. 44.8 million standard cubic feet/day (MMSCFD)

Heavy Oil Production
- Set of four once-through steam generators, each with a firing duty of 250 million BTU/hr, producing steam for steam assisted gravity drainage oil extraction

Natural Gas Power Generation
- 400MW natural gas combined cycle power station.

IN FOCUS: REFINERIES

Case Study: FCC oxy-firing demonstration

FCC unit
(Left) Petrobras research facility in Parana, Brazil. Image courtesy of Petrobras.

OVERVIEW

The CCP's first large-scale capture demonstration project took place at a Petrobras research facility in Parana, Brazil. Testing of oxy-fired capture technology on a pilot-scale Fluid Catalytic Cracking (FCC) unit was conducted during 2011 and early 2012 and full assessment of the results was delivered during the year, with some key presentations of those results made at the ERTC-17 (European Refinery Technology Conference) and GHGT-11 (Greenhouse Gas Technologies) conferences.

The work has confirmed the technical viability of retrofitting an FCC unit to enable CO_2 capture through oxy-firing and this route is considered by the CCP as the preferred technology option for CO_2 capture from FCC. The demonstration proved that the FCC unit can be operated steadily in oxy-firing mode and that oxy-firing can enable a higher throughput or allow switching toward the processing of heavier feeds while keeping the same product yield.

This work is of particular importance given the proportion of CO_2 emissions for which the FCC is responsible. The test brings closer a technology capable of capturing up to 95% of the FCC's CO_2 emissions, equating to some 20–30% of total CO_2 emissions from a typical refinery.

GOALS

- Test start-up and shut-down procedures
- Maintain stable operation of the FCC unit in oxy-firing mode
- Test operational conditions and process configurations
- Obtain reliable data for scale-up

EQUIPMENT

The pilot FCC unit has the capacity to process up to 33 bpd of hydrocarbon feed (emitting 1 metric ton/d of CO_2), and it consists of an adiabatic riser, stripper and regenerator, which allows simulation of a commercial FCC unit, including the energy balance.

The retrofit of the unit for oxy-firing operation involved the design, construction and installation of an Oxygen Supply System (OSS) and a CO_2 Recycle System (CRS). There was also a need to develop and design a control strategy for start-up and continuous operation.

The two systems consisted of the following equipment:

Oxygen Supply System (supplied by Linde Gas)

- Liquid O_2 tank
- Vaporizer system
- Flow and pressure control skid
- Gaseous O_2 injector
- Piping

CO_2 Recycle System (supplied by TecnoProject Latina)

- Catalyst fines and SOx removal unit
- Recycle compressor
- CO_2 storage tank
- Gas analysers
- Piping

RESULTS

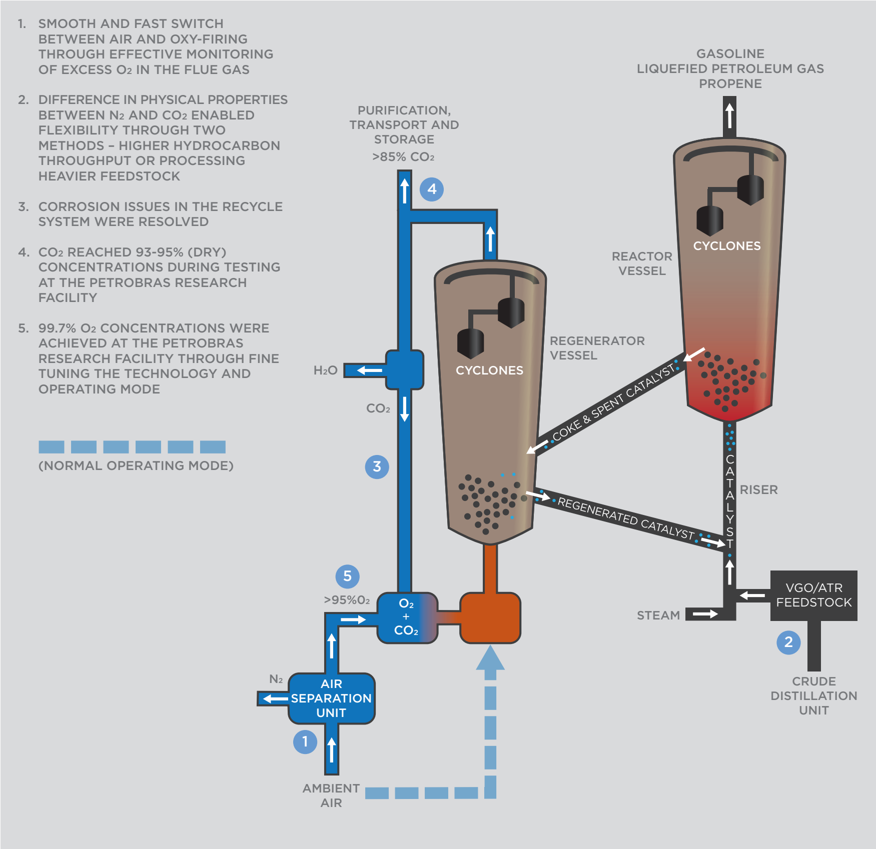
Effective monitoring of excess oxygen in the flue gas resulted in a smooth and fast switch between air and oxy-firing.

The difference in physical properties between nitrogen and CO_2 enabled flexibility of the plant through two methods – allowing either a higher hydrocarbon throughput (e.g. 10% higher flow-rate with the same conversion) or processing heavier feedstock (i.e. lower-cost feeds keeping the same product yield). This flexibility of the plant would help mitigate the cost of CO_2 capture.

Potential corrosion issues were revealed in the recycle system due to the presence of NO_2 and SO_2 impurities in the flue gas. These issues were fully understood and are manageable through proper design.

FCC oxy-firing demonstration

(Below) This diagram is a simplified representation of oxy-firing in an FCC unit.



CO_2 concentrations reached 93–95% (dry) in the tests. Further purification may be needed and a dedicated test program may be required for optimization of the purification section, depending on achievable and required CO_2 purities.

Stable operation was successful in all conditions and the evaluations performed in parallel confirmed that oxy-combustion is viable and economically competitive with state-of-the-art post-combustion technology.

FCC Factsheet Available

CO2CAPTUREPROJECT.ORG/REPORTS/FACTSHEET_FCC.PDF

STORAGE, MONITORING & VERIFICATION PROGRAM

2012 Members of the CCP3 Storage, Monitoring & Verification Team

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DEPLOYMENTS AND RESULTS

The Storage, Monitoring and Verification (SMV) Team has continued to work through the main themes of the program during 2012 – Assurance R&D, Field Trialing and Contingencies. With a year of CCP3 remaining, the focus is on following through on new initiatives and delivering ongoing projects aimed at providing the technical basis and tools for improving CO_2 storage assurance. During 2012, a number of CCP3's projects have generated substantial and occasionally unexpected results. In 2013, the SMV Team will evaluate these and remaining study results, with an aim of making publications available.

CO_2 storage stakeholder assurance remains a key barrier to large-scale and widespread deployment of CCS. The CCP, with its heritage in the oil and gas industry, has a unique pool of knowledge and experience to draw upon, gained from decades of subsurface exploration, production and site decommissioning. It understands, however, that gaps in knowledge need to be filled if these concerns around CO_2 storage are to be minimized. Hence its program of activities under CCP3 are now in the demonstration phase following earlier years of screening and technology development.

"Progress in the CCP3 storage program, particularly that related to field trialing of monitoring technologies, has exceeded the SMV Team's expectations. We also believe that our fundamental work on CO_2 trapping and containment at the pore-scale level has paid off in terms of re-examining widely held assumptions. Our initiative in CO_2 contingencies, or detection of, and intervention in, unexpected CO_2 or brine migration, has been well received by the CCS community. At the conclusion of CCP3, we will make a concerted effort to make the results of our studies available to stakeholders through presentations and publications."

Scott Imbus, Chevron, CCP SMV Team Lead

SMV HIGHLIGHTS

Preliminary results from Capillary Entry Pressure and Relative Permeability studies

Further results from satellite monitoring program at Decatur, Illinois, US

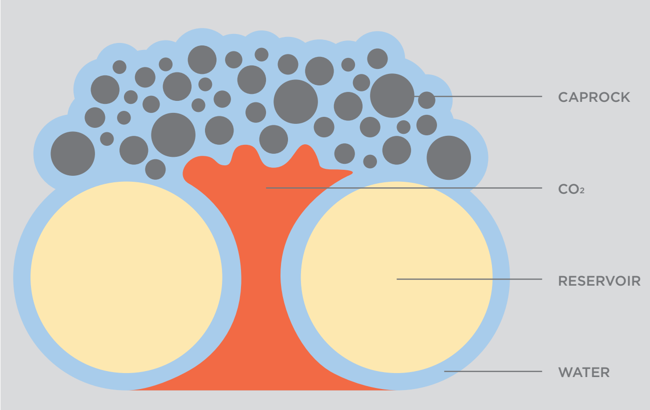
First two stages of Storage Contingencies program underway

Modular Borehole Monitoring technology successfully deployed at Citronelle Dome, Alabama, US

THE 2012 STORAGE, MONITORING & VERIFICATION PROGRAM

Capillary trapping of CO_2

(Right) Illustration of capillary trapping of CO_2, in which narrow pore throats prevent the CO_2 from migrating up from the larger pores in the reservoir formation. Image courtesy of Statoil.



STORAGE ASSURANCE THEME

Further work on well integrity was not possible during 2012 due to the lack of availability of CO_2-exposed wells to conduct surveys (logging, sampling, and testing), despite a number of options being examined. However, work has continued in the Subsurface Processes workstream, which aims to improve understanding of the physico-chemical processes that impact CO_2 flow and containment. Ongoing experiments and simulations are currently producing interesting results.

Relative Permeability

A Relative Permeability (Krel) study with Corelabs seeks to document fluid flow characteristics of CO_2 in comparison to water. Relative permeability of rock in the subsurface influences the rate at which CO_2 moves through the reservoir, the pressures required to inject CO_2 and how far the CO_2 plume might move. Preliminary experimental results diverge significantly in terms of potential storage capacity from those found in the literature. Additional experiments show a range of rock types and experimental conditions are being considered for 2013 to qualify these initial results.

Capillary Entry Pressure

Capillary Entry Pressure (Pc) is an approach to predicting the height of a CO_2 column that a seal rock can safely retain without infiltration or breaching in situations where CO_2 accumulates in geologic structures prior to migrating and eventually being permanently trapped by dissolution and capillary forces. This study, being run with the RTWH-Aachen (Germany), is nearing completion with indications of diverging values of this measure despite homogeneity of the rock examined. Full results and with interpretation will be available in 2013.

CO_2 Impurities

This study examines the effects of impurities in injected CO_2 on injection, migration and pressure evolution. Work was completed in 2012 by The University of Texas Bureau of Economic Geology. Systematic flow simulations on Gulf of Mexico Basin sandstone rocks and on Alberta carbonate rock (representing different depths) have been used as an approach to assess tradeoffs between potentially lower capture costs and increased storage costs (e.g. need to extend the 'area of review' in cases where the impurities-rich gas migrates further than pure CO_2).

CO_2 Impurities Factsheet Available

CO2CAPTUREPROJECT.ORG/REPORTS/FACTSHEET_CO2_IMPURITIES.PDF

Monitoring & Verification

A Value of Information (VOI) evaluation process is under development by the University of Texas, with the aim of systematizing approaches to selecting monitoring technologies on a storage risk-benefit basis. The traditional use of VOI methodologies is to assess the cost of data gathering versus the value that information brings to reducing uncertainty. In this research, the VOI methodologies will be used to quantify the benefit and cost of CCS monitoring and verification (M&V) technologies in terms of risk reduction of leakage. To help define the concepts, the study will use the experience in risk assessment of the In Salah CO_2 storage project (Algeria), initially in a simplified case of one monitoring technology and acquiring a high resolution seismic. Specifically, the objectives of this research are to:

1. Identify key information gathering activities/technologies (e.g. seismic) that have a bearing on risk reduction in the case of the In Salah field

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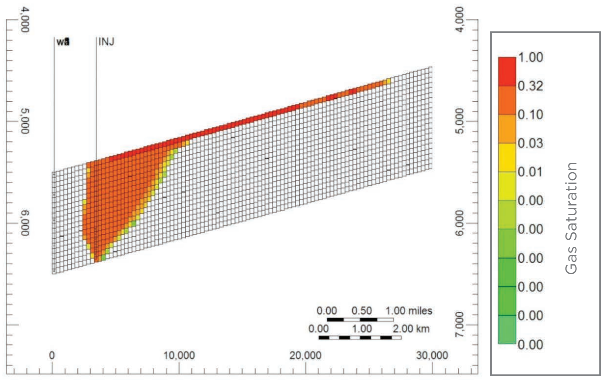

CO_2 with impurities After 100 years

CO_2 impurities

(Right) Diagram showing CO_2-stream impurities impact on lateral extent of CO_2 plume (shallow depth – axes in feet). Image courtesy of The University of Texas Bureau of Economic Geology.

2. Quantify the accuracy of this monitoring and verification technology within the context of In Salah. The definition of accuracy will be case dependent and developed during the project

3. Identify the operational decisions that would be informed by this technology

4. Develop a repeatable and scalable decision process that integrates objectives (1) and (2) to inform CCS monitoring and development decisions.

The project will include the following activities: Decision Framing, Value Mapping, Reliability Assessment, VOI Model Construction and Documentation.

The Monitoring & Verification scope also includes identification and development of emerging technology or integration of established technologies for field deployment

READ MORE ON PAGE 17

Storage optimization

Work continued during 2012 on further development of CCP's Certification Framework, which aims to provide a simple, transparent framework for site assessment and to inform monitoring technology selection. An economics component was added during 2012 and four case studies are now included, alongside the application of specialized simulation/tools to qualify risk.

Key ongoing activities include:

- The induced seismicity subproject is focusing on the Gulf Coast region and has started compiling information on faults in the region using public domain seismic data. In addition, historical data on earthquakes is being compiled along with information on seismic responses to fluid injections in the same area

- The native gas exsolution (e.g. theoretical evolution of methane from methane-saturated brines accompanying CO_2 dissolution) subproject has reviewed the literature on methane extraction from brines and identified some of the issues relevant to the exsolution process. A limited number of key parameters has been identified that can be used to generate a graph showing conditions under which methane exsolution may or may not occur

- The subproject on the prevalence of open vs. closed geologic systems is focusing on the San Joaquin Basin (SJB) of southern California and the Texas Gulf Coast region. Prior work on oil reservoir capacity in the SJB and data acquired for a study in the Texas Gulf Coast Miocene formation have been reviewed and provide a large amount of relevant data. A methodology has been developed where long-term production-pressure data will be emphasized, looking for pressure changes in response to production data

- The subproject looking at CO_2 EOR as an analogue for assessing storage capacity has developed a model that accounts for reservoir heterogeneity and connectivity. Predictive models have been used to match the results from a number of commercial CO_2 EOR floods and the CO_2 sweep efficiency has been extracted from these runs. The sweep efficiency identifies that portion of the reservoir volume accessed by injected CO_2 and is a key component in determining a storage capacity.

During 2013, these studies will be completed with interpretations on the findings of the impact risk assessment associated with CO_2 injection under various circumstances.

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PS InSAR

(Right) Surface deformation results over the area of the injection well and the artificial reflectors from the SqueeSAR monitoring. Image courtesy of TRE.

FIELD TRIALING THEME

Work during 2012 has seen the continued development and results from innovative CO_2 monitoring technologies, which are being assessed and deployed on a trial basis at third party injection sites. These projects are usually undertaken with the CCP collaborating with research organizations and operators.

Borehole Gravity Monitoring
(SECARB, Denbury Resources, Cranfield EOR Project)

The CCP's involvement in a borehole gravity monitoring project at the Cranfield SECARB EOR project (Mississippi, US) is now complete. During 2012, results from a post-injection timelapse survey have been submitted for publication by Colorado School of Mines. Data analysis and modeling of the borehole monitoring logging experiment shows a response consistent with the reservoir simulation plume models, although challenges were noted with respect to depth control and signal drift. This appears to be the first successful use of a borehole-based approach in CO_2 storage monitoring. Further extension of this work may provide a means to predict the approach of the plume through a non-invasive technology.

Modular Borehole Monitoring
(LBNL–SECARB, Denbury Resources Citronelle Dome)

The CCP-LBNL Modular Borehole Monitoring (MBM) system was successfully deployed in 2012 at the Citronelle Dome (Alabama, US) field prior to injection.

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PS InSAR
(MSGC, ADM Decatur Storage facility)

The CCP is funding satellite surveys aimed at detection of mm-scale ground movement associated with CO_2 injection at the ADM Decatur (Illinois, US) injection site. The project involves evaluating satellite (InSAR) technology in a mixed terrain (vegetation), industrial and residential development: sometimes snow-covered. Following injection of CO_2 at the site and a series of baseline satellite passes, TRE Canada provided its 4th report during 2012, with an assessment of ground movement.

Displacement was observed in the vicinity of the injection well and a few areas where land disruption may have taken place. The uplift near the well, however, is likely the result of normal changes associated with weather or other environmental factors. In close proximity to the well, uplift was modest (several millimeters) and initiated slightly later than the start of injection. Geomechanical modeling predicts very slight deformation of the order of several millimeters due to the initial small injection volume. Further satellite passes are due in 2013.

The University of Texas Bureau of Economic Geology
(UT-BEG) Soil Gas Monitoring

The CCP3 soil gas project aims to address the niche area of process-based monitoring developed by UT-BEG. The specific goal of the project is to assess a methodology that will estimate N_2 by reference to commercially available sensors for O_2, CO_2, CH4 and water vapor with data analysis, removing the need for expensive and logistically difficult field access to a gas chromatograph. The survey and assessments will be made at the Denbury Resources Hastings site in southeast Texas.

Surface Borehole Electromagnetic Monitoring
(Aquistore – Boundary Dam)

In 2012, the SMV Team contracted LBNL to model the feasibility of using surface-borehole electromagnetics for monitoring CO_2 at the Aquistore storage site at the Boundary Dam capture facility in southeastern Saskatchewan, Canada. The modeling considered borehole-to-surface and single-well

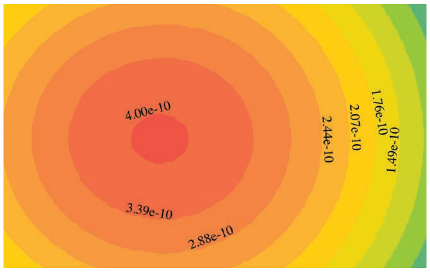
THE 2012 STORAGE, MONITORING & VERIFICATION PROGRAM

Soil Gas Monitoring

(Right) Transect of UT-BEG soil-gas monitoring stations in Gulf Coast, US. Image courtesy of The University of Texas Bureau of Economic Geology.

Surface Borehole Electromagnetic Monitoring

(Below) Borehole to Surface EM Model at Aquistore: Anomalous Surface horizontal electric field (Eh) due to 10 kt CO_2 with 360 amp-m, 1 Hz downhole source at 3+ km. Image courtesy of LBNL.



electromagnetic monitoring using a downhole vertical electric dipole source with realizable moments, located in a monitoring well 100m from the injection well. The overall conclusion of this study is that the land-based controlled source method with borehole source dipoles could be a useful monitoring tool for the planned Aquistore sequestration pilot. This feasibility forward modeling study supported a second project which provided a plan for implementation of a designed system that could be deployed at the Aquistore site. Both the survey design and the plan of the hardware requirements will be available for the final CCP3 reports.

CCP CONTINGENCIES THEME

The CCP Contingencies Program aims to increase public and regulatory confidence around storage integrity by understanding current versus needed capabilities to manage unexpected migration of CO_2 or displaced brine from a storage site.

Following initial planning work during 2011 (Phase 1), 2012 saw development of scopes of work and implementation of the first two work phases. Phase 2, in progress at Stanford University, consists of a modeling-based approach to detection, characterization and intervention of untoward fluid migration and has so far yielded interim results for one of four case studies to be conducted (Powder River Basin, low permeability reservoir). A comparison of plume evolution (via saturation and pressure) with and without faults is made with further comparison of intervention via above-seal water injection. Three other case studies will involve similar simulation approaches along with injection of sealants beneath the seal.

Phase 3 has been initiated and is aimed at identifying a suitable site to test an intervention technology with development of a detailed characterization, engineering, surveillance and analytical plan for potential future deployment (Phase 4). A number of scenarios are currently under discussion.

IN FOCUS: FIELD TRIALING

Case Study: Modular Borehole Monitoring (MBM) at Citronelle Dome

OVERVIEW

The aim of the project is to reduce the costs of well-based monitoring systems by designing a flexible modular package that can integrate the measurements that site-specific monitoring strategy has identified as being most effective and critical.

The CCP worked with LBNL within four phases – identifying technologies and tools; designing a modular deployment package; performing engineering studies and identifying vendor support; and field testing. The field testing was conducted at Denbury Resources Citronelle Dome via a collaborative partnership with the US Southeast Regional Carbon Sequestration Partnership (SECARB) and its technology partners, Advanced Resources International and LBNL.

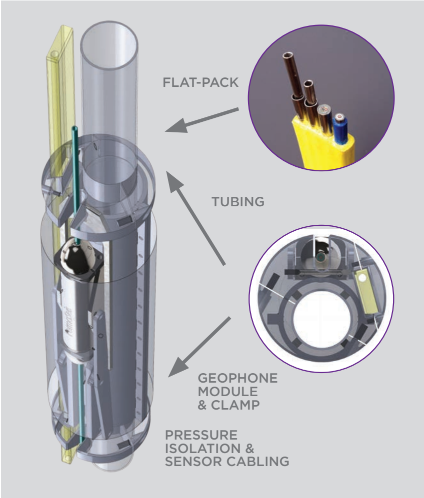
Well completion problems were successfully diagnosed by the MBM's own distributed temperature sensor (DTS) system monitoring changes in fluid temperature induced by the novel heating cable. The diagnosis provided the basis for feedback to and clearance from the regulators to proceed. A further diagnostic test using a fiber optic DTS as a distributed acoustic sensor (DAS) was run coincidently with a walkaway VSP survey. This was an opportune test of the signal to noise performance of the DAS as a possible cost-effective means to carry out VSP surveys in the future.

RESULTS

Frequent communication between team members and the development of a thoroughly vetted well completion procedure were important precursors that led to a successful deployment of the MBM system. The use of the flat-pack construction, as compared to running individual lines, proceeded more quickly and was notably less technically risky than handling individual lines. High quality geophone data collected indicate that the clamps are operating as intended. Within this process, the flat-pack has proved robust and operationally efficient.

All of the components were tested and baseline measurements were conducted prior to the onset of CO_2 injection in August 2012. This baseline activity included the acquisition and characterization of reservoir fluid samples, testing of the heat-pulse/DTS system, a continuous record of reservoir pressure and the acquisition of baseline vertical seismic profiles using the borehole geophone array. An early success for the MBM came in diagnosing well fluid entry above the packer. This was achieved by innovative use of induced heating through the heat-pulse cabling and temperature monitoring using the DTS. The depth-tied sensing of the temperature profile, together with pressuring up of the annulus, identified the perforation interval relative to the packer and verified fluid entry above the packer, establishing that an observed pressure bleedoff was not due to the MBM assembly. This data provided the Alabama authorities with the appropriate information for a decision to retain the tubing and MBM in the well. Subsequent fluid sampling was undertaken successfully with the U-tube.

MBM Factsheet Available
CO2CAPTUREPROJECT.ORG/REPORTS/FACTSHEET_MBM.PDF



Modular Borehole Monitoring
(Left) MBM system. Image courtesy of LBNL.

POLICY & INCENTIVES PROGRAM

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(Petrobras)
Alexander Ratcliffe
(Shell)
Leonardo da Silva Ribeiro
(Petrobras)

REGULATORY DEVELOPMENTS

Widespread deployment of CCS requires the development of a robust regulatory framework to allow the successful planning and implementation of projects.
In 2012, the Policy & Incentives (P&I) Team continued to provide insights in regulatory development through its updated *CCS Regulatory Study: Challenges and key lessons learned from real-world development of projects.* This study has shown that pathways for regulatory approvals of CCS projects do exist and that gaps and barriers in regulatory frameworks are being overcome.

"Policy and regulatory developments in CCS have continued to develop at a slow and steady pace in different countries. It certainly is encouraging that even where gaps and questions have remained in the regulatory frameworks, project developers have been able to work with regulators to find a way forward.

"If CCS is to play a major role in reducing CO_2 emissions, we will need the support of not only government and industry, but also of local communities; we hope this work will contribute to the body of knowledge already out there. In 2013, the P&I Team will be focusing its efforts on exploring local community benefit sharing options."

Arthur Lee, Chevron, CCP Policy & Incentives Team Lead

P&I HIGHLIGHTS

CCS Regulatory Study: Challenges and key lessons learned from real-world development of projects completed

Shared regulatory study insights at IETA side-event at UN Conference of the Parties (COP18, Doha)

Scoped out next major study, focusing on local community benefit options, to be delivered in 2013

THE 2012 POLICY & INCENTIVES PROGRAM

CCS Stakeholder Issues

(Below) The *CCS Stakeholder Issues Review and Analysis* Report.

2012 CCS Regulatory Study

(Below) The *CCS Regulatory Study* has shown that pathways for regulatory approvals of CCS projects exist.

LOCAL COMMUNITY BENEFIT-SHARING OPTIONS STUDY

Following the updated *CCS Stakeholder Issues Review and Analysis* Report published by the CCP in 2011, the Team identified the need to study further local community benefit sharing options.

The 2011 report suggested that public understanding and awareness of CCS technical issues are not as important as commonly believed by industry and government when engaging with local communities. Communities are more likely to become actively involved in opposing project developments when the activity has no apparent benefits for the local community itself. In such cases, having a value proposition for the local community from the outset of the project is vital and needs to be developed to respond to the local context. What works in one area may not be acceptable in another.

The study, due for publication in 2013, will take a practical look at local community issues where sharing project benefits with local stakeholders was considered in order to promote project acceptance. The aim will be to draw parallels for CO$_2$ storage projects and explore possible options.

A range of conceivable benefit-sharing mechanisms for CO$_2$ storage projects, from building educational capacity at community colleges to compensation-based mechanisms (such as paying a storage fee to local authorities), will be examined and discussed in this study.

CHALLENGES AND KEY LESSONS LEARNED FROM REAL-WORLD DEVELOPMENT OF PROJECTS

In 2010 the P&I Team undertook a review of selected regulatory issues for CO$_2$ capture and storage. The Team revised this report in 2012 to provide a practical and focused update of regulatory developments and issues, in particular CCS projects that have undergone or progressed significantly through the regulatory process. Insights for the report were shared at an IETA side-event at the UN Conference of the Parties (COP18, Doha). Eight CCS case studies across Australia, Canada, Europe, and the US were investigated as part of this study. Crucially, the study found that pathways for the regulatory approval of a CCS project do exist. Gaps and barriers in the regulatory frameworks are not insurmountable in the cases studied and projects have been able to progress with the relevant permits in place or anticipated.

IN FOCUS: PROJECT DEVELOPER INSIGHTS

Interviews with project developers highlighted a number of lessons learnt from going through the regulatory approval process. These lessons learned may be helpful both to regulators in different jurisdictions developing regulatory frameworks and to CCS project developers going through the regulatory approval process.

DEVELOPMENT OF REGULATORY FRAMEWORKS FOR CCS

- Projects already in existence, including small-scale demonstration projects, can help with regulatory development by providing insights based on technical knowledge and experience
- Projects to test a newly developed regulatory framework can play an important role in working closely with regulators to help shape the development of regulations
- Issues may arise when considering how and to what extent newly implemented regulations will be retroactively applied to existing projects
- It is important to be able to tailor regulatory requirements to projects of different sizes and contexts; a small-scale demonstration project may not be able to meet requirements needed for a large-scale CCS project.

P&I Reports Available

CO2CAPTUREPROJECT.ORG/REPORTS.HTML

COMMUNICATIONS PROGRAM

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(Petrobras)
Alexander Ratcliffe
(Shell)
Leonardo da Silva Ribeiro
(Petrobras)
Joel Thompson
(Suncor)

COMMITTED TO SHARING KNOWLEDGE

Sharing the knowledge and insights from the work of the CCP has been of critical importance in 2012 as the group delivered results from projects. The Communications Team has worked to disseminate the technical information throughout the industry via project factsheets, online registrant updates, exhibiting at the 11th Annual CCUS Conference and GHGT-11, and outreach to media and NGOs.

The Team has monitored responses to its work, gaining insight into how the group can better share information. It talked to key industry figures, surveyed CCP online registrants and exhibition visitors. A direct outcome of these conversations has been the adjustment of the Annual Report to sign-post technical information and provide a technical overview of some of the core projects.

The Communications Team has also continued its role of helping the wider public gain a greater understanding of CCS, and its importance in tackling climate change. In June, the Team launched the interactive In Depth brochure – bringing the popular print brochure to life in a digital format. A more ambitious digital project has also been undertaken in 2012 – the CCS Browser, an interactive website dedicated to explaining CCS to non-technical audiences, and which is due for launch in 2013.

The Making of the CCS Browser
READ MORE ON PAGE 24

"The CCS Browser has been one of the most significant pieces of communications work the CCP has undertaken. We have brought together a team of digital designers, capture, subsurface and communication experts to create a website to explain CCS to non-technical audiences. It is one of the first dedicated, interactive online sites focused solely on helping a non-technical audience gain an understanding of CCS. We want this to be a resource for the whole CCS industry to use – so get in touch to tell us what you think."

Mark Crombie, CCP Program Manager & Communications Team Lead
(mark.crombie@uk.bp.com)

COMMUNICATIONS HIGHLIGHTS

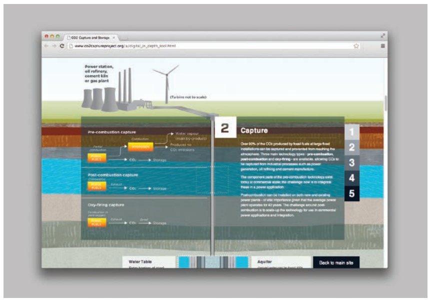
Continued to inform the industry and wider public via factsheets, online registrant updates and exhibits at 11th Annual CCUS Conference and GHGT-11

Launched online version of In Depth brochure and embarked on larger digital project – the CCS Browser

THE 2012 COMMUNICATIONS PROGRAM

Digital In Depth Tool

(Right) The digital In Depth tool allows online visitors to go on a journey underground to find out more about CO_2 capture and storage.



INDUSTRY CONFERENCES & EVENTS

The CCP was present at two major CCS conferences in 2012: the 11th Annual Carbon Capture, Utilization and Sequestration Conference (CCUS Conference, May 2012, Pittsburgh, US); and the Greenhouse Gas Technology Conference (GHGT-11, November 2012, Kyoto, Japan). The CCP exhibited at both conferences, sharing materials with a range of stakeholders visiting the stand.

The CCP also participated in the Carbon Sequestration Leadership Forum (CSLF) Technical Group meeting in Bergen, Norway in June – providing an overview of the CCP3 program. The CSLF recognized the contribution of the CCP's third phase during its ministerial meeting in Beijing in September 2011.

LITERATURE

In 2012, the CCP continued to make available popular publications such as the In Depth brochure and the *Technical Basis for Storage* book. In particular, the CCP took requests from industry bodies, NGOs and education providers for copies of the In Depth brochure – and liaised with bodies such as the South African CCS Association to share artwork from the In Depth brochure to help it create images that represented the depths involved in geological CO_2 storage. The CCP also produced a number of new materials including a 2011 Annual Report and factsheets on the following topics:

- Modular Borehole Monitoring design and field test
- CO_2 stream impurities: impacts on geological storage performance and assurance
- Updated Oxy-firing fluid catalytic cracking demonstration
- Updated Oxy-firing – once-through steam generators pilot test

All literature is available on the CCP website at:
CO2CAPTUREPROJECT.ORG

DIGITAL COMMUNICATION

An interactive In Depth brochure was launched in 2012 allowing online viewers to take a journey underground to gain a spatial perspective on CO_2 storage. This helped our total online registrants reach 5,000+ by the end of 2012.

Digital In Depth tool
CO2CAPTUREPROJECT.ORG/DIGITAL_IN_DEPTH_TOOL.HTML

MEDIA

The CCP continued to outreach to industry bodies and publications to share information, with articles featured in *Carbon Capture Journal*, the IEA Greenhouse Gas newsletter and the CCSA newsletter.

FOCUS FOR 2013

The Communications Team will continue to keep industry audiences updated on the results of demonstrations and field trials. We are aiming to make the online publications section more accessible to help aid this. The CCP will also be gathering feedback from the CCS Browser to help any further refinements needed.

IN FOCUS: DIGITAL COMMUNICATION

THE MAKING OF THE CCS BROWSER

The CCS Browser is due to be launched in 2013. It is an interactive resource that aims to explain the CCS story to a broader audience.

"We wanted to take on the challenge of explaining CCS comprehensively across PC, tablet and mobile platforms. We wanted to create a place for people to be free to explore the topic in the way that best suited them – by watching animations, listening to a verbal explanation, reading text or interacting with diagrams. We included links to other sources – NGOs, government bodies and project sites – to allow people to explore the topic in even greater depth if they needed. We've tried hard to approach the different topics without overcomplicating or dumbing down."

Mark Crombie
(CCP Program Manager & Communications Team Lead)

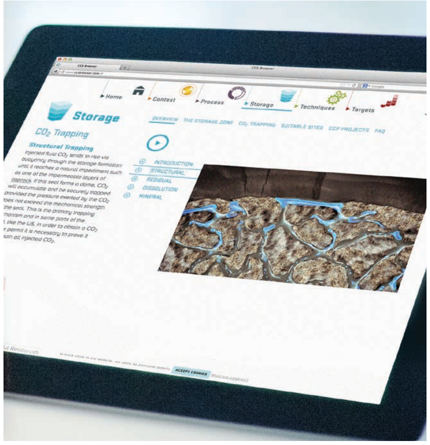
"Being new to the CCS industry I had many questions I wanted answered. Is CO_2 storage safe? How does it stay underground? What needs to happen for CCS to be a success? I set about trying to find out the answers online. I was overwhelmed by the amount of information – there are diagrams and animations available but they were often mixed up with more technical information. It was clear that our job was to create a one stop shop that provided a breadth of topics in a clear, concise and engaging format."

Ben Jeffreys
(Digital Creative)

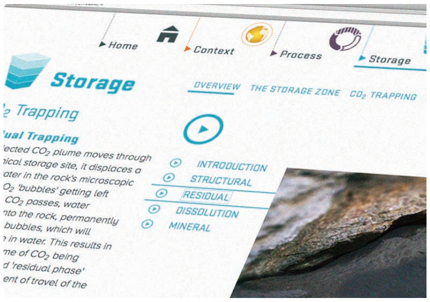
"Storage, how CO_2 stays securely underground, is often people's greatest concern. Storage had to be the focus for the site. We wanted simple animations to help make the subsurface accessible – giving people an insight into the scientific processes at work and also the experience of the industry."

Dan Kieke
(Chevron Subsurface Consultant)

(Below) CCS Browser screen showing structural CO_2 trapping.



(Below) CCS Browser screen showing residual CO_2 trapping.



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