

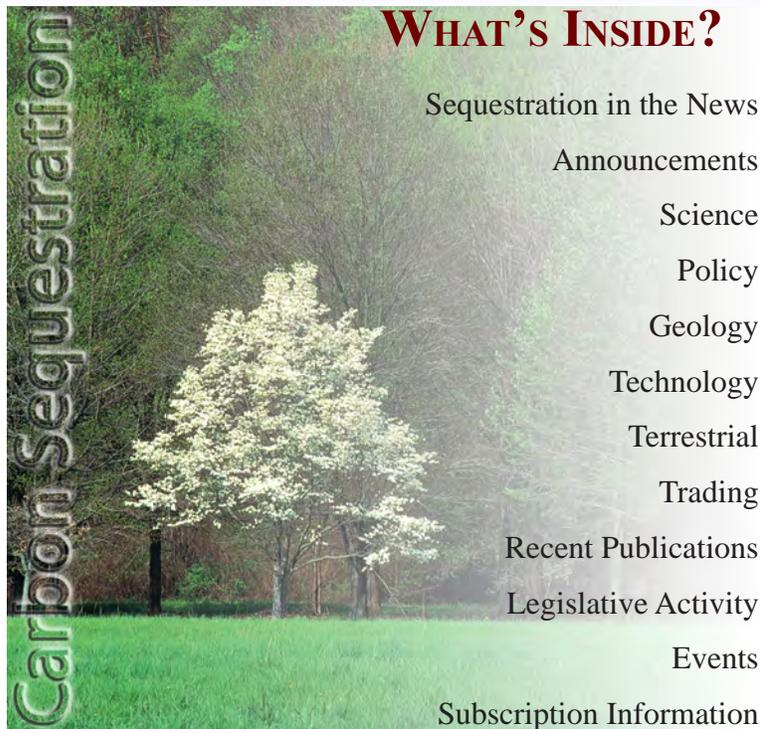


# Carbon Sequestration Newsletter



see page 3

MARCH 2011



## WHAT'S INSIDE?

- Sequestration in the News
- Announcements
- Science
- Policy
- Geology
- Technology
- Terrestrial
- Trading
- Recent Publications
- Legislative Activity
- Events
- Subscription Information

would encourage private construction of CO<sub>2</sub> pipelines through incentives, would also be important in the future. The report, titled, “A Policy, Legal, and Regulatory Evaluation of the Feasibility of a National Pipeline Infrastructure for the Transport and Storage of Carbon Dioxide,” analyzes a potential pipeline network that would transport CO<sub>2</sub> from large CO<sub>2</sub> stationary sources to underground storage locations. A pipeline network is believed to be an important component to commercialize and deploy carbon capture and storage (CCS) technology to reduce the buildup of CO<sub>2</sub> in the atmosphere. The report, which was undertaken by the DOE-funded Pipeline Transportation Task Force (PTTF), was developed by the Southeast Regional Carbon Sequestration Partnership (SECARB), one of seven DOE Regional Carbon Sequestration Partnerships (RCSPs), and the Interstate Oil and Gas Compact Commission (IOGCC). The data collected for the report is expected to improve commercialization efforts by analyzing current CO<sub>2</sub> storage situations and identifying what is needed for viable transport to storage areas. (Ugg'T gegpv Rvdhlec vlpv' tgevkpp 'hqt 'vj g' Cduw cev't pf 't'' n'pntv' b' C'Rqle{ . 'Ngi cn't pf 'T gi wv vt { 'Gxcwv vlpv' qh'vj g' Hgcukhls { '' qh't 'P cvlpv cn'Rlr g'lpv' k'p'lt cvw wewt g' hqt 'vj g' Vt cpur qt v't pf 'Uvqt ci g' qh' Ect dqp' F'kz'k' g'6) February 1, 2011, [http://www.fossil.energy.gov/news/techlines/2011/11007-New\\_Report\\_Analyzes\\_CO2\\_Pipeline\\_S.html](http://www.fossil.energy.gov/news/techlines/2011/11007-New_Report_Analyzes_CO2_Pipeline_S.html).

## INTRODUCTION

This Newsletter is created by the National Energy Technology Laboratory and represents a summary of carbon sequestration news covering the past month. Readers are referred to the actual article(s) for complete information. It is produced by the National Energy Technology Laboratory to provide information on recent activities and publications related to carbon sequestration. It covers domestic, international, public sector, and private sector news.

## HIGHLIGHTS

**Fossil Energy Techline, “State Regulatory Framework Will Most Likely Result in Robust CO<sub>2</sub> Pipeline System, New Study Says.”**

According to a new report funded by the U.S. Department of Energy’s (DOE) National Energy Technology Laboratory (NETL), the approach most likely to result in a strong carbon dioxide (CO<sub>2</sub>) pipeline system in the United States will be a private sector model with a state-based regulatory framework. However, the study also notes that a Federal role, which

## SEQUESTRATION IN THE NEWS

**Reuters, “Petrobras to Begin Offshore CO<sub>2</sub> Sequestration.”**

Petrobras, a Brazilian state oil company, will begin storing CO<sub>2</sub> in the offshore Lula oil field. Brazil’s offshore oil fields are located in the subsalt region, which contains large quantities of CO<sub>2</sub>. Petrobras will re-inject CO<sub>2</sub> back into the oil reservoirs to boost production through enhanced oil recovery (EOR) or into sub-sea salt caverns to prevent it from being released into the atmosphere. When the platform moored at the Lula field, which is approximately 186.4 miles from the coast of Rio de Janeiro, reaches full production, Petrobras could re-inject as much as 1 million cubic meters of CO<sub>2</sub> per day. February 3, 2011, <http://www.reuters.com/article/2011/02/03/us-petrobras-co-idUSTRE7124PJ20110203>.

**American Electric Power News Release, “AEP to Receive Funds from Global CCS Institute for Commercial-Scale Carbon Dioxide Capture and Storage Project.”**

The Global CCS Institute will provide \$4.01 million



## National Energy Technology Laboratory

626 Cochran Mill Road  
P.O. Box 10940  
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road  
P.O. Box 880  
Morgantown, WV 26507-0880

13131 Dairy Ashford Road, Suite 225  
Sugar Land, TX 77478

1450 Queen Avenue SW  
Albany, OR 97321-2198

2175 University Ave. South, Suite 201  
Fairbanks, AK 99709

**John T. Litynski**  
412-386-4922  
john.litynski@netl.doe.gov

**Dawn M. Deel**  
304-285-4133  
dawn.deel@netl.doe.gov

Visit the NETL website at:  
[www.netl.doe.gov](http://www.netl.doe.gov)

Customer Service:  
**1-800-553-7681**

### Disclaimer

This Newsletter was prepared under contract for the United States Department of Energy's National Energy Technology Laboratory. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily reflect those of the United States Government or any agency thereof.

## SEQUESTRATION IN THE NEWS (CONTINUED)

in funding to support American Electric Power's (AEP) installation of a commercial-scale CCS system on AEP's Mountaineer coal-fired power plant in New Haven, West Virginia. The funding will support the initial engineering and characterization phase of the CCS system, which uses Alstom's chilled ammonia process to capture at least 90 percent of the CO<sub>2</sub> released from 235 MW of the 1,300-MW Mountaineer power plant. The 1.5 million metric tons of CO<sub>2</sub> captured per year will be treated, compressed, and injected into suitable geologic formations for safe, permanent storage approximately 1.5 miles below the surface. Commercial operation of the system is expected to begin in 2015. February 16, 2011, <http://www.aep.com/newsroom/newsreleases/?id=1673>.

### **Bloomberg, "Abu Dhabi Studying Proposal to Expand Carbon Capture and Storage."**

After a pilot project injected 60 tons of CO<sub>2</sub> per day into the Rumaitha field, Abu Dhabi National Oil Company (Adnoc) is studying a proposal to inject 1,750 tons of CO<sub>2</sub> per day into larger areas for EOR. Abu Dhabi Company (Adco) is looking for ways to reduce its use of the 5 billion cubic feet of natural gas produced daily in the United Arab Emirates (UAE) by as much as 40 percent. According to officials, potential CO<sub>2</sub> sources include Emirates Steel Industries PJSC and the Habshan field. January 18, 2011, <http://www.bloomberg.com/news/2011-01-18/abu-dhabi-studying-proposal-to-expand-carbon-capture-and-storage.html>.

### **The Engineer, "SSE, Shell, Petrofac Plan Peterhead Carbon Capture and Storage Project."**

A proposal has been submitted by Scottish and Southern Energy plc (SSE) to develop a CCS project at its gas-fired power station in Peterhead, Aberdeenshire. The offshore transport and storage elements of the proposal will be provided by Shell UK Ltd and Petrofac subsidiary CO<sub>2</sub> DeepStore. The proposed project will design and develop a full chain, post-combustion CCS facility capable of capturing CO<sub>2</sub> from a 385-megawatt (MW) combined cycle gas turbine unit at Peterhead power station. The CO<sub>2</sub> will then be transported via an existing underground pipeline to St. Fergus for further compression, and then via an undersea pipeline to an existing gas reservoir in the North Sea. February 11, 2011, <http://www.theengineer.co.uk/sse-shell-petrofac-plan-peterhead-carbon-capture-and-storage-project/1007394.article#ixzz1Dwtd20Vs>.

### **Carbon Capture Journal, "Alberta Government Concludes CCS Agreement with Enhance Energy."**

Enhance Energy and the Alberta Government reached an agreement on the Alberta Carbon Trunk Line (ACTL), a pipeline that will deliver CO<sub>2</sub> captured from a refinery to be used for EOR. The ACTL project will receive \$495 million under the Government of Alberta's Carbon Capture and Storage Funding Act and construction is

# SEQUESTRATION IN THE NEWS

## (CONTINUED)

expected to begin in 2012; engineering and procurement are currently underway. A contract with North West Upgrading/Canadian Natural

Resources Limited (CNRL) Partnership will lead to construction of a new bitumen refinery in Alberta's Industrial Heartland as part of the Government of Alberta's bitumen royalty-in-kind (BRIK) initiative. Construction of Phase One of the bitumen refinery is expected to be completed in mid-2014. February 18, 2011, <http://www.carboncapturejournal.com/displaynews.php?NewsID=741>.

## ANNOUNCEMENTS

### **DOE Program Offers Opportunity to Gain Carbon Capture and Storage Knowledge.**

DOE's Research Experience in Carbon Sequestration (RECS) Program, scheduled for June 5-15, 2011, in Birmingham, Alabama, is now accepting applications for graduate students and early career professionals interested in gaining knowledge in CCS. RECS 2011 is a science-based program that combines classroom activities with visits to geologic storage test sites, power plants, and the National Carbon Capture Center (NCCC). For application information, visit: <http://www.recsco2.org/11app.html>.

### **Funding Opportunity Announcement: Small-Scale Field Tests Geologic Reservoir Classes.**

This Funding Opportunity Announcement (FOA) (DE-FOA-0000441) is competitively seeking (cost-shared) applications to conduct small-scale CO<sub>2</sub> injection field projects within various depositional systems in both conventional and unconventional reservoirs as defined in DOE's recent "Geologic Storage Formation Classification: Understanding Its Importance and Impacts on CCS Opportunities in the United States" Best Practices Manual (BPM). Responses are due by April 5, 2011, at 8:00 PM ET. For more information, go to: <https://www.fedconnect.net/fedconnect/?doc=DE-FOA-0000441&agency=DOE>.

### **Documents Now Available on the NETL Reference Shelf.**

The following documents are available for download on the NETL Carbon Sequestration Reference Shelf: the "Carbon Sequestration Atlas of the United States and Canada – Third Edition (Atlas III)"; the "DOE/NETL Carbon Dioxide Capture and Storage RD&D Roadmap"; "Carbon Sequestration Program FY2008-2009 Accomplishments"; the "Site Screening, Site Selection, and Initial Characterization for Storage of CO<sub>2</sub> in Deep Geologic Formations" BPM; and "Best Practices for Terrestrial Sequestration of Carbon Dioxide." To view these documents, go to: [http://www.netl.doe.gov/technologies/carbon\\_seq/refshelf/refshelf.html](http://www.netl.doe.gov/technologies/carbon_seq/refshelf/refshelf.html).

### **Call for Papers for 10<sup>th</sup> Annual CCS Conference.**

The 10<sup>th</sup> Annual CCS Conference, held at the David L. Lawrence Convention Center in Pittsburgh, Pennsylvania, on May 2-5, 2011, is accepting papers/posters for peer review. Topics include: RCSP large-scale field testing, U.S.-Canadian CCS collaboration, and American Recovery and Reinvestment Act of 2009 (Recovery Act) investments. For more information, including a complete list of topics, visit: <http://www.carbonsq.com/callforpapersccs2011.pdf>.

### **IEA GHG Summer School.**

Applications are now being accepted for the 2011 International Energy Agency Greenhouse Gas (IEA GHG) Summer School in Champaign, Illinois. This event is open to Ph.D. students and post docs; selected students will receive travel and training expenses for five days of class work and a site visit to the Midwest Geological Sequestration Consortium's (MGSC) Decatur, Illinois, site to view an operational CCS facility. To submit an application or view additional information, go to:

<http://www.ieaghg.org/index.php?/20110121240/summer-school-2011-test.html>.

### **NETL-Developed Process Wins National Award for Excellence in Technology Transfer.**

The NETL-developed Basic Immobilized Amine Sorbent (BIAS) Process, which improves the capture of CO<sub>2</sub> emissions from power plants while reducing costs, has received a 2011 Award for Excellence in Technology Transfer. The national award is presented annually by the Federal Laboratory Consortium for Technology Transfer (FLC) in recognition of outstanding work by researchers in the transfer of technology from Federal laboratory to the commercial marketplace. To learn more, visit: [http://www.fossil.energy.gov/news/techlines/2011/11009-NETL\\_Process\\_Wins\\_Award.html](http://www.fossil.energy.gov/news/techlines/2011/11009-NETL_Process_Wins_Award.html).

# SCIENCE

## **The Telegraph, “Polar Bears Having Fewer Cubs Due to Global Warming.”**

According to a new study conducted by researchers at the University of Alberta, potential climate change could result in less polar bears as females give birth to fewer cubs due to the loss of sea ice. Researchers studied the effect of melting sea ice on the breeding success of polar bears in the 1990s, finding that the early melting of the ice made it more difficult for the bears to hunt for food sources. As a result, there was less chance of a successful pregnancy; in the 1990s, 28 percent of energy-deprived, pregnant polar bears in the Hudson Bay region failed to give birth. Using mathematical equations, researchers found that, in future years, if the ice breaks up one month earlier than it did in the 1990s, 40 to 73 percent of pregnant female polar bears will not reproduce. According to researchers, Arctic sea ice reached its lowest level this January since records began in 1979. The current polar bear population in western Hudson Bay is estimated to be approximately 900, down from 1,200 a decade ago. February 8, 2011, <http://www.telegraph.co.uk/earth/environment/climatechange/8311137/Polar-bears-having-fewer-cubs-due-to-global-warming.html#>.



## **AFP, “Global Warming Means Longer Allergy Seasons: Study.”**

According to a new study, warmer temperatures and later fall frosts have led to ragweed allergy season lasting two to four weeks longer than usual in North America. The study states that the most dramatic rise in allergy season length appeared in northern parts of the United States and Canada from 1995 to 2009. For example, the city of Saskatchewan, Canada, saw the longest pollen season, with 27 more days in 2009 compared to 1995; during the same time frame, Winnipeg, Manitoba, saw a 25-day increase. Pollen measurements from the U.S. National Allergy Bureau and Canada’s Aerobiology Research Laboratories were used for the study, as was data from U.S. weather stations, Environment Canada, and the Canadian National Climate Data and Information Archive. According to researchers, the changes in the northern latitudes were consistent with the United Nation’s (UN) Intergovernmental Panel on Climate Change (IPCC) projections of more intense warming in areas closer to the Arctic. February 22, 2011, <http://www.google.com/hostednews/afp/article/ALeqM5h-sw1E5MXotK5BB3I3ovhlir8xQg?docId=CNG.f6bbc13595f98b74300029280925e216.5d1>.

# POLICY

## **Washington Department of Ecology News Release, “Washington, British Columbia Expand on Climate Action Partnership.”**

Environmental representatives from Washington and British Columbia signed joint action plans to better prepare for potential climate change. Under the signed action plans, the partnership aims to promote public awareness of sea level rise and the impacts on coastal areas and

limiting CO<sub>2</sub> emissions from government operations and facilities. The agreement builds on existing climate-related partnerships between Washington and British Columbia, including: the Pacific Coast Collaborative, a joint effort on energy, transportation, climate change, and ocean issues; the Washington-British Columbia Memorandum of Understanding (MOU) on Coastal Climate Change Adaption, which includes the exchanging of information on sea level rise projections and mapping; and the Western Climate Initiative (WCI), a cooperative effort to reduce GHG emissions in seven U.S. states and four Canadian provinces. February 2, 2011, <http://www.ecy.wa.gov/news/2011/034.html>.

## **“Techno-economic appraisal of fossil-fueled power generation systems with carbon dioxide capture and storage.”**

The following is the Abstract of this article: “CCS facilities coupled to power plants provide a climate change mitigation strategy that potentially permits the continued use of fossil fuels whilst reducing the CO<sub>2</sub> emissions. This process involves three basic stages: capture and compression of CO<sub>2</sub> from power stations, transport of CO<sub>2</sub>, and storage away from the atmosphere for hundreds to thousands of years. Potential routes for the capture, transport and storage of CO<sub>2</sub> from United Kingdom (UK) power plants are examined. Six indicative options are evaluated, based on ‘Pulverized Coal,’ ‘Natural Gas Combined Cycle,’ and ‘Integrated Gasification Combined Cycle’ power stations. Chemical and physical CO<sub>2</sub> absorption capture techniques are employed with realistic transport possibilities to ‘Enhanced Oil Recovery’ sites or depleted gas fields in the North Sea. The selected options are quantitatively assessed against well-established economic and energy-related criteria. Results show that CO<sub>2</sub> capture can reduce emissions by over 90 [percent]. However, this will reduce the efficiency of the power plants concerned, incurring energy penalties from 14 to 30 [percent] compared to reference plants without capture. Costs of capture, transport and storage are concatenated to show that the whole CCS chain ‘cost of electricity’ (COE) rises by 27-142 [percent] depending on the option adopted. This is a significant cost increase, although calculations show that the average ‘cost of CO<sub>2</sub> captured’ is [\$20.85]/tCO<sub>2</sub> in 2005 prices (the current base year for official UK producer price indices). If potential governmental carbon penalties were introduced at this level, then the COE would equate to the same as the reference plant, and make CCS a viable option to help mitigate large-scale climate change.” **G.P. Hammond, S.S. Ondo Akwe, and S. Williams, Energy**, Available online January 13, 2011, doi:10.1016/j.energy.2010.12.012, <http://www.sciencedirect.com/science/article/B6V2S-51XWW14-3/2/346cace4ef33b51fc47c229ffc3a7a5d>. (Subscription may be required.)

öVj g'E Q4S WCNUVQT G'i wlf gllpg' hqt 'ugrgevlqp.'ej ct cevgt k cvlqp''  
 cpf 's wclllec vlqp'qh'ltsgu'epf 'r t qlgew' hqt 'i gmqi kecnltqt ci g'qhEQ4ö

The following is from the Abstract of this article: “The CO<sub>2</sub>QUALSTORE guideline has been developed by DNV in collaboration with industrial partners and with input from a number of national regulators. The guideline is globally applicable and adopts a risk based approach to the selection, characterization and qualification of sites and projects for geological storage of CO<sub>2</sub>. This article summarizes the guideline and describes how the document may assist project developers in passing project management milestones during a CO<sub>2</sub> storage project life cycle, simultaneously demonstrating compliance with regulations

## POLICY (CONTINUED)

and stakeholder expectations. A primary objective of the qualification workflow contained in the guideline is to assist operators, authorities, verifiers and other stakeholders in assuring that storage sites are qualified following a transparent, consistent and cost-effective process. The guideline lays the groundwork for a risk-based approach where monitoring programs and contingency measures are derived from preceding risk assessments.” **Michael Carpenter, Knut Kvien, and Jørg Aarnes**, *International Journal of Greenhouse Gas Control*, Available online January 22, 2011, doi:10.1016/j.ijggc.2010.12.005, <http://www.sciencedirect.com/science/article/B83WP-520VCVK-1/2/1866ad069ff1b6bf0e22d8b7920fa38e>. (Subscription may be required.)

## GEOLOGY

### “On the potential of CO<sub>2</sub>-water-rock interactions for CO<sub>2</sub> storage using a modified kinetic model.”

The following is from the Abstract of this article: “During CO<sub>2</sub> storage, mineral trapping is the safest long-term storage mechanism, and it is therefore important to estimate the correct CO<sub>2</sub> portion trapped in secondary mineral phases. The storage potential for cold, quartz-rich reservoirs, hereafter termed Utsira-type reservoirs, were solved using the numerical code PHREEQC, using a rate model that took into account both nucleation and growth of secondary mineral phases. This represented a modification of earlier simulations where growth rates were calculated from dissolution rate data. Because growth rate and nucleation rate parameters were largely unknown for the secondary carbonates, [the authors] did a sensitivity study on the potential for carbonate growth on rate parameters. The simulations suggest that the total amount of CO<sub>2</sub> trapped as mineral carbonates is given by the amount of glauconite, chlorite, and smectite present in the reservoir prior to injection, as they were nearly completely dissolved. The fast dissolution of the silicates provided divalent cations for the growth of ankerite and siderite. The timing of precipitation and the secondary mineral assemblage were seen to be highly sensitive to the nucleation and growth rates. Moreover, at high nucleation rates, the secondary carbonates started to precipitate at fairly low supersaturations and formed rapidly after the dissolution of the primary minerals. Finally, a comparison of earlier simulations on the Utsira-type system with the present model and natural analogues, suggests that the earlier models have largely overestimated the growth potential of carbonates such as dolomite, magnesite and dawsonite.” **V.T.H. Pham, P. Lu, P. Aagaard, C. Zhu, and H. Hellevang**, *International Journal of Greenhouse Gas Control*, Available online January 15, 2011, doi:10.1016/j.ijggc.2010.12.002, <http://www.sciencedirect.com/science/article/B83WP-51YB6H1-1/2/bd7732c2383fd9a8510bbc2e66f5c8a3>. (Subscription may be required.)

### “Safe Storage Of CO<sub>2</sub> Together With Improved Oil Recovery By CO<sub>2</sub>-Enriched Water Injection.”

The following is the Abstract of this article: “The 2007 IEA World Energy Outlook report predicts that the world’s energy needs will grow by 55 [percent] from 2005 to 2030, with fossil fuels accounting for 84

[percent] of this massive projected increase in energy demand. An undesired side effect of burning fossil fuels is CO<sub>2</sub> emission which is now widely believed to be responsible for the problem of global warming. Various strategies are being considered for addressing the increased in demand for energy and at the same time developing technologies to make energy greener by reducing CO<sub>2</sub> emissions. One of these strategies is to ‘capture’ produced CO<sub>2</sub> instead of releasing it into the atmosphere. Capturing CO<sub>2</sub> and its injection in oil reservoirs can lead to improved oil recovery as well as CO<sub>2</sub> retention and storage in these reservoirs. The technology is referred to as CCS. Large point sources of CO<sub>2</sub> (e.g. coal-fired power plants) are particularly good candidates for capturing large volumes of CO<sub>2</sub>. However, CO<sub>2</sub> capture from power plants is currently very expensive. In addition to high costs of CO<sub>2</sub> capture, the very low pressure of the flue gas (1 atm) and its low CO<sub>2</sub> content (typically 10-15 [percent]) contribute to the high cost of CO<sub>2</sub> capture from power plants and the subsequent compression. This makes conventional CO<sub>2</sub> flooding (which requires very large volumes of CO<sub>2</sub>) uneconomical in many oil reservoirs around the world which would otherwise be suitable candidates for CO<sub>2</sub> injection. Alternative strategies are therefore needed to utilize smaller sources of CO<sub>2</sub> that are usually available around oil and gas fields and can be captured at lower costs (due to their higher pressure and higher CO<sub>2</sub> concentration). [The authors] investigate the potential of carbonated (CO<sub>2</sub>-enriched) water injection (CWI) as an injection strategy for improving recovery from oil reservoirs with the added benefit of safe storage of CO<sub>2</sub>. The performance of CWI was investigated by conducting high-pressure flow visualization as well as coreflood experiments at reservoir conditions. The results show that CWI significantly improves oil recovery from water flooded porous media. A relatively large fraction of the injected CO<sub>2</sub> was retained (stored) in the porous medium in the form of dissolved CO<sub>2</sub> in water and oil. The results clearly demonstrate the huge potential of CWI as a productive way of utilizing CO<sub>2</sub> for improving oil recovery and safe storage of potentially large cumulative quantities of CO<sub>2</sub>.” **Mehran Sohrabi, Nor Idah Kechut, Masoud Riazi, Mahmoud Jamiolahmady, Shaun Ireland, and Graeme Robertson**, *Chemical Engineering Research and Design*, Available online February 5, 2011, doi:10.1016/j.cherd.2011.01.027, <http://www.sciencedirect.com/science/article/B8JGF-523V3NP-3/2/908ab65aa70abf2068a0192a95725056>. (Subscription may be required.)

## TECHNOLOGY

### “Evaluation of power generation schemes based on hydrogen-fuelled combined cycle with carbon capture and storage (CCS).”

The following is from the Abstract of this article: “[Integrated gasification combined cycle (IGCC)] is a power generation technology in which the solid feedstock is partially oxidized to produce syngas. In a modified IGCC design for carbon capture, there are several technological options which are evaluated in this paper. The first two options involve pre-combustion arrangements in which syngas is processed, either by shift conversion or chemical looping, to maximize the hydrogen level and to concentrate the carbon species as CO<sub>2</sub>. After CO<sub>2</sub> capture by gas-liquid absorption or chemical looping,

## TECHNOLOGY (CONTINUED)

the hydrogen-rich gas is used for power generation. The third capture option is based on post-combustion arrangement using chemical absorption. Investigated coal-based IGCC case studies produce 400–500 MW net power with more than 90 [percent] carbon capture rate. Principal focus of the paper is concentrated on evaluation of key performance indicators for investigated carbon capture options, the influence of various gasifiers on carbon capture process, optimization of energy efficiency by heat and power integration, quality specification of captured CO<sub>2</sub>. The capture option with minimal energy penalty is based on chemical looping, followed by pre-combustion and post-combustion.” **Calin-Cristian Cormos**, *International Journal of Hydrogen Energy*, Available online January 12, 2011, doi:10.1016/j.ijhydene.2010.12.042, <http://www.sciencedirect.com/science/article/B6V3F-51XNX4S-4/2/e2af9974f317c0b9c82d4a6a8fde3c27>. (Subscription may be required.)

**“A dual poroelastic model for CO<sub>2</sub>-Enhanced coalbed methane recovery.”**

The following is from the Abstract of this article: “Although CO<sub>2</sub>-enhanced coalbed methane (ECBM) recovery has been comprehensively investigated, the impact of coal matrix-fracture interactions on the evolution of coal permeability under in-situ conditions is still unclear. In prior studies on this issue, the influences of coal matrix-fracture interactions have not rigorously coupled with the binary gas transport system. In this work, general porosity and permeability models are developed to explicitly quantify the interactions between binary mixtures (CO<sub>2</sub> and [methane (CH<sub>4</sub>)]) and dual solid media (coal matrix and fracture) under the full spectrum of mechanical conditions spanning prescribed in-situ stresses through constrained displacement. These models are implemented into a fully coupled finite element (FE) model of coal deformation, binary gas flow and transport in the matrix system, and binary gas flow and transport in the fracture system. The FE model represents important non-linear responses due to the effective stress effects that cannot be recovered where mechanical influences are not rigorously coupled with the binary gas transport system. The FE model is applied to simulate the results of a single well injection micro-pilot test performed in the anthracitic coals of the South Qinshui basin, Shanxi Province, China. The modeled CH<sub>4</sub> production rates are in good agreement with the observed production history. In addition to this agreement, model results also demonstrate (1) CO<sub>2</sub> injection increases the total pressure gradients; (2) as the CO<sub>2</sub> injection progresses the partial CO<sub>2</sub> pressure increases while the partial CH<sub>4</sub> pressure decreases; (3) without CO<sub>2</sub> injection the CH<sub>4</sub> content at a specific point decreases almost linearly while with the CO<sub>2</sub> injection the CH<sub>4</sub> content at a specific point decreases exponentially; (4) without CO<sub>2</sub> injection the CH<sub>4</sub> production rate decreases linearly while with CO<sub>2</sub> injection the CH<sub>4</sub> production rate increases dramatically; (5) without CO<sub>2</sub> injection coal permeability increases almost linearly while with CO<sub>2</sub> injection coal permeability decreases near exponentially; (6) CO<sub>2</sub> injection enhances cumulative CH<sub>4</sub> production and the enhancement is proportional to the injection pressure; and (7) cumulative CO<sub>2</sub> injection volume is also proportional to the injection pressure.” **Yu Wu, Jishan Liu, Zhongwei Chen, Derek Elsworth, and Denis Pone**, *International Journal of Coal Geology*, Available

online January 22, 2011, doi:10.1016/j.coal.2011.01.004, <http://www.sciencedirect.com/science/article/B6V8C-520TJJS-1/2/3214b23b0c4b84704eff69a9bc9a5aa5>. (Subscription may be required.)



## TERRESTRIAL

**“Bayesian hierarchical models for soil CO<sub>2</sub> flux and leak detection at geologic sequestration sites.”**

The following is the Abstract of this article: “Proper characterizations of background soil CO<sub>2</sub> respiration rates are critical for interpreting CO<sub>2</sub> leakage monitoring results at geologic sequestration sites. In this paper, a method is developed for determining temperature-dependent critical values of soil CO<sub>2</sub> flux for preliminary leak detection inference. The method is illustrated using surface CO<sub>2</sub> flux measurements obtained from the AmeriFlux network fit with alternative models for the soil CO<sub>2</sub> flux versus soil temperature relationship. The models are fit first to determine pooled parameter estimates across the sites, then using a Bayesian hierarchical method to obtain both global and site-specific parameter estimates. Model comparisons are made using the deviance information criterion (DIC), which considers both goodness of fit and model complexity. The hierarchical models consistently outperform the corresponding pooled models, demonstrating the need for site-specific data and estimates when determining relationships for background soil respiration. A hierarchical model that relates the square root of the CO<sub>2</sub> flux to a quadratic function of soil temperature is found to provide the best fit for the AmeriFlux sites among the models tested. This model also yields effective prediction intervals, consistent with the upper envelope of the flux data across the modeled sites and temperature ranges. Calculation of upper prediction intervals using the proposed method can provide a basis for setting critical values in CO<sub>2</sub> leak detection monitoring at sequestration sites.” **Ya-Mei Yang, Mitchell J. Small, Brian Junker, Grant S. Bromhal, Brian Strazisar, and Arthur Wells**, *Environmental Earth Sciences*, Available online January 21, 2011, doi:10.1007/s12665-011-0903-5, <http://www.springerlink.com/content/y06q3364p4611x09/>. (Subscription required.)

## TRADING

**Reuters, “UK CO<sub>2</sub> Auction Income Seen Over [~\$90 Bln] by 2020.”**

According to a report by carbon offsetting firm Carbon Retirement, total UK revenues from auctioning off European Union (EU) carbon permits could rise to more than \$88 billion from 2013 to 2020. The current EU Emissions Trading Scheme (EU ETS) caps emissions of heavy industries and allows them to either buy EU Allowances (EUAs) to cover excess emissions, or sell them when they reduce their emissions. Rules allow member states to auction up to 10 percent of their EUAs from 2008 to 2012. Starting in 2013, the EU ETS will make emitters pay for the majority of their allowances, which

## TRADING (CONTINUED)

is expected to result in the auction of at least 50 percent of permits every year (currently, seven percent of permits are auctioned off).

The price of EUAs is also expected to jump from the current rate of approximately \$19.50/tonne. Since the UK government began carbon auctions in November 2008, more than \$1.3 billion has been raised for the UK Treasury. February 10, 2011, <http://af.reuters.com/article/energyOilNews/idAFLDE7190KL20110210?sp=true>.

## RECENT PUBLICATIONS

### **“A Policy, Legal, and Regulatory Evaluation of the Feasibility of a National Pipeline Infrastructure for the Transport and Storage of Carbon Dioxide.”**

The following is the Abstract of this document: “The report focuses on the transportation of CO<sub>2</sub> through pipelines from a ‘source’ to a geologic [formation],’ the possibility of a Federal mandate requiring capture and storage of CO<sub>2</sub>. An overview of carbon capture drivers and the geologic means of storing CO<sub>2</sub> is provided. The report also describes the nature, size, and location of the significant CO<sub>2</sub> pipeline system that currently exists in the United States, and the state and Federal regulatory regime, under which it operates. An analysis of the regulatory status of CO<sub>2</sub> pipeline systems under the Interstate Commerce Act and the Natural Gas Act is included as well as a discussion of other prospective regulatory models. Potential business models and economic issues for future CO<sub>2</sub> pipeline build-out are also discussed. Conclusions and recommendations suggest that the market is responding to current CO<sub>2</sub> pipeline construction demand and that future build-out of CO<sub>2</sub> pipelines should occur with limited Federal regulatory intervention.” The full report is available at: <http://www.sseb.org/downloads/pipeline.pdf>.

### **“Integrated Management of Carbon Sequestration and Biomass Utilization Opportunities in a Changing Climate.”**

The following is from the Abstract of this document: “Forests can play a role in carbon sequestration and mitigating CO<sub>2</sub> emissions. However, what course of action needed to meet issues concerning carbon management and other ecosystem services for specific situations is not always clear. The National Silviculture Workshop, held in Boise, Idaho on June 15-18, 2009, focused on scientific information and management opportunities and strategies applicable for meeting a variety of objectives, while simultaneously addressing carbon sequestration and biomass utilization. The symposium and subsequent proceedings covered four general areas of interest: the role of climate change in science and management; silvicultural methods to address carbon sequestration and biomass utilization; alternative silvicultural strategies to address the growth and development of forests; and current applications of computer simulation models or modeling techniques designed to provide decision support.” The Proceedings of the 2009 National Silviculture Workshop is available at: [http://www.fs.fed.us/rm/pubs/rmrs\\_p061.pdf](http://www.fs.fed.us/rm/pubs/rmrs_p061.pdf).

### **“Investment of Proceeds from RGGI CO<sub>2</sub> Allowances.”**

The following is from the Executive Summary of this document: “In 2008, [10] states – Connecticut, Delaware, Maine, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Rhode Island, and Vermont – launched the first market-based regulatory program to reduce GHG emissions in the United States. Through the Regional Greenhouse Gas Initiative (RGGI), each participating state caps CO<sub>2</sub> emissions from power plants, auctions CO<sub>2</sub> emission allowances, and invests the proceeds in strategic energy programs that further reduce emissions, save consumers money, create jobs, and build a clean energy economy. Each RGGI participating state has developed its own plan for investment of CO<sub>2</sub> allowance proceeds. This analysis translates the investment plans of the ten RGGI participating states into common, comparable terms to identify regional trends and demonstrate the benefits of RGGI participating state investments.” For the entire report, visit: [http://www.rggi.org/docs/Investment\\_of\\_RGGI\\_Allowance\\_Proceeds.pdf](http://www.rggi.org/docs/Investment_of_RGGI_Allowance_Proceeds.pdf).

## LEGISLATIVE ACTIVITY

*BusinessWeek*, “Mississippi Considering Bills on Carbon Storage,” and *Mississippi Business Journal*, “Carbon Capture Bill.”

The Mississippi State Senate passed a bill to set up a regulatory structure that gives the Mississippi Department of Environmental Quality (MDEQ) the authority to oversee the process of considering bills to allow and regulate long-term underground CO<sub>2</sub> storage. The “Mississippi Geologic Sequestration of Carbon Dioxide Act” outlines duties of the state Oil and Gas Board, which currently oversees the use of CO<sub>2</sub> in oil wells. Under the bills, MDEQ and the Oil and Gas

Board would work out an agreement to store the CO<sub>2</sub> in oil and gas fields for EOR. Companies could apply for permits from MDEQ and the Oil and Gas Board to build storage facilities in the state. Mississippi Power Company, which is building a \$2.4 billion coal-fired plant in Kemper County that is expected to capture 65 percent of its CO<sub>2</sub> emissions and store them underground, will also monitor the legislation. To view Senate Bill No. 2723, click: <http://index.ls.state.ms.us/isysnative/UzpcRG9jdW1lbnRzXDIwMTFccGRmXHNiXDI3MDAtMjc5OVxzYjI3MjNpbi5wZGY=/sb2723in.pdf#xml=http://10.240.72.35/isysquery/irl8748/1/hilite>. February 4, 2011, <http://www.businessweek.com/ap/financialnews/D9L67GEO0.htm>, and February 6, 2011, <http://msbusiness.com/blog/2011/02/carbon-capture-bill/>.

# LEGISLATIVE ACTIVITY (CONTINUED)

## **Bloomberg, “Kentucky Senate Panel Advances Carbon Storage Bill.”**

Legislation was sent to the Kentucky Senate on February 23, 2011, calling for the state Energy and Environment Cabinet to seek one to five

demonstration projects to store CO<sub>2</sub> emissions from power plants. The bill was approved by the Senate Natural Resources and Energy Committee. The projects would require approval from environmental regulators, and landowners would receive royalties as a result of having CO<sub>2</sub> stored beneath their property. After completion, the CO<sub>2</sub> injection sites would be monitored by storage operators. Ownership of a storage facility could eventually be transferred to the Federal or state government. February 23, 2011, <http://www.bloomberg.com/news/2011-02-23/ky-senate-panel-advances-carbon-storage-bill.html>.



## EVENTS

April 4-8, 2011, **Greenhouse 2011**, Cairns Convention Centre, Queensland, Australia. Attendees of this conference will be presented with the latest information in climate change science from scientists and industry representatives. The program also covers topics such as climate modeling, climate change projections, and policy and economics. For a detailed program, visit the conference website at: <http://www.greenhouse2011.com/page.aspx>.

April 12, 2011, **Carbon Capture and Storage Business Forum**, Calgary TELUS Convention Centre, Calgary, Alberta, Canada. This one-day conference examines the latest developments and solutions to CCS deployment challenges by examining the latest business developments and leading edge technology updates from those active in current CCS projects. Visit the conference website, which includes a downloadable agenda, at: <http://www.conferenceboard.ca/conf/11-0073/default.aspx>.

April 12-14, 2011, **Energy Efficiency Global Forum**, SQUARE Brussels Meeting Centre, Brussels, Belgium. This three-day conference brings together members of the worldwide energy efficiency community to discuss the clean-energy economy. In its fourth year, the Energy Efficiency Global Forum (EE Global) also includes technology sessions focused on global energy policy, technology, and delivery. For more information, go to: <http://ee-globalforum.org/index.html>.

April 13-15, 2011, **3<sup>rd</sup> Annual China Clean Coal Summit 2011**, Qingdao, Shandong, China. In addition to providing updates in China's clean coal technology, coal-to-liquids (CTLs), CCS, and future integrated gasification combined cycle (IGCC) technology, this summit will offer case studies, future project information, site tours, and an international forum to help progress towards a successful and cleaner future. For more information, click: <http://chinacleancoalsummit.com/index.asp>.

May 2-5, 2011, **10<sup>th</sup> Annual Conference on Carbon Capture and Sequestration**, David L. Lawrence Convention Center, Pittsburgh, Pennsylvania, USA. This annual, DOE-hosted conference will focus on the potential of present and future CCS technologies deployed in the United States and North America. Members from the U.S. and international scientific and engineering communities will be present to share experiences on such technologies and systems. For more information, visit the conference website at: <http://www.carbonsq.com/index.htm>.

July 11-14, 2011, **Global Conference on Global Warming 2011**, Calouste Gulbenkian Congress Center, Lisbon, Portugal. This international conference discusses potential solutions to climate change issues and provides a forum for the exchange of the latest developments and technical information. To view a complete list of conference-related topics, click: [http://www.gcgw.org/gcgw11/documents/poster\\_GCGW11.pdf](http://www.gcgw.org/gcgw11/documents/poster_GCGW11.pdf).

July 21-22, 2011, **Third International Conference on Climate Change**, JW Marriot, Rio De Janeiro, Brazil. This conference will examine, among other topics, natural and human-generated causes of potential climate change, as well as CCS technological responses and carbon and taxes offsets. In addition, the conference will explore other social, ethical, and political responses to potential climate change. To learn more, visit: <http://on-climate.com/conference-2011/>.



## EVENTS (CONTINUED)

August 17-19, 2011, **COAL-GEN**, *Greater Columbus Convention Center, Columbus, Ohio, USA*. Covering the latest topics affecting the design, development, upgrading, operation, and maintenance of coal-fired power plants, COAL-GEN is the industry's largest event focused on the present and future of coal-fired generation. Visit the conference website at: <http://www.coal-gen.com/index.html>.

August 22-26, 2011, **NETL CO<sub>2</sub> Capture Technology Meeting**, *Sheraton Station Square Hotel, Pittsburgh, Pennsylvania, USA*. This DOE-hosted conference will present CO<sub>2</sub> capture technology development status and accomplishments made under NETL's Innovations for Existing Plants (IEP), Carbon Sequestration, and Demonstration Programs. Topics to be discussed include post-, oxy-, and pre-combustion carbon capture, as well as chemical looping and CO<sub>2</sub> compression technologies. For more information, click: <http://www.netl.doe.gov/events/11conferences/co2capture/>.

## FOR SUBSCRIPTION DETAILS...

Please visit <http://listserv.netl.doe.gov/mailman/listinfo/sequestration>, enter your email address, and create a password. This will enable you to receive a pdf version of the Carbon Sequestration Newsletter at no cost.

To view an archive with past issues of the newsletter, see: [http://www.netl.doe.gov/technologies/carbon\\_seq/refshelf/subscribe.html](http://www.netl.doe.gov/technologies/carbon_seq/refshelf/subscribe.html).

To learn more about DOE's Carbon Sequestration Program, please contact Sean Plasynski at [sean.plasynski@netl.doe.gov](mailto:sean.plasynski@netl.doe.gov), or Dawn Deel at [dawn.deel@netl.doe.gov](mailto:dawn.deel@netl.doe.gov).