# Carbon Sequestration Newsletter

April 2009


## What's Inside?



# 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*, "Carbon Sequestration Partner Initiates Drilling of $CO_2$ Injection Well in Illinois Basin."**

The Midwest Geological Sequestration Consortium (MGSC), one of the U.S. Department of Energy's (DOE) seven Regional Carbon Sequestration Partnerships (RCSPs), has begun drilling the injection well for their large-scale carbon dioxide ($CO_2$) injection test in Decatur, Illinois. The large-scale project will capture $CO_2$ from the Archer Daniels Midland (ADM) Ethanol Production Facility and inject it more than one mile underground into a deep saline formation. The injection, which will occur over a three-year period and is slated to start in early 2010, will compress up to 1 million metric tonnes of $CO_2$ from the ADM ethanol facility into a liquid-like, dense phase. The targeted rock formation, the Mt. Simon Sandstone, is the thickest and most widespread saline reservoir in the Illinois Basin, with an estimated $CO_2$ storage capacity of 27 to 109 billion metric tonnes. A comprehensive monitoring program, which will be evaluated yearly, will be implemented after the injection to ensure the injected $CO_2$ is stored safely and permanently. The RCSP Program was launched by the Office of Fossil Energy (FE) in 2003 to determine the best approaches for the permanent capture and storage of greenhouse gases (GHGs). MGSC is the first of the RCSPs to begin drilling a Development Phase injection well. The drilling is expected to take approximately two months to complete. To view the MGSC website, go to: http://sequestration.org/. To visit the National Energy Technology Laboratory's (NETL) RCSP website, click: http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html. February 17, 2009, http://www.fossil.energy.gov/news/techlines/2009/09008-CO2_Injection_Well_Drilling_Begins.html.

***Fossil Energy Techline*, "DOE Partner Begins Injecting 50,000 Tons of Carbon Dioxide in Michigan Basin."**

DOE's Midwest Regional Carbon Sequestration Partnership (MRCSP), led by Battelle, has begun injecting 50,000 tons of $CO_2$ into the Michigan Basin near Gaylord, Michigan. The activity builds upon an initial injection project of 10,000 metric tons of $CO_2$ in the same formation and will take place in a deep saline formation, the Silurian-age Bass Island dolomite. The project is expected to last six months, with injections happening at an average rate of 250 tons per hour up to a maximum rate of 600 tons. The first test will take place at an existing oil and gas field, which would also allow for continued enhanced oil recovery (EOR) operations. This area is ideal for the injection test as it already contains $CO_2$ compressors, injection systems, existing wells, pipelines, and other needed infrastructure. During the injection process, the team will record geochemical changes to the system and the distribution of the $CO_2$ along the wellbore. The $CO_2$ will be transported to the well via an eight-mile pipeline. As the depth of the injection is 3,500 feet, the injection will occur well below the 1,000-foot level of drinking water sources. When complete, the total 60,000-metric ton injection will mark the largest deep saline reservoir injection in U.S. history. The 6-month project and related activities are expected to create more than 230 jobs and 2,900 total project job years. To view the MRCSP website,click: www.mrcsp.org. February 27, 2009, http://www.fossil.energy.gov/news/techlines/2009/09012-DOE_Partners_Begin_CO2_Injection.html.

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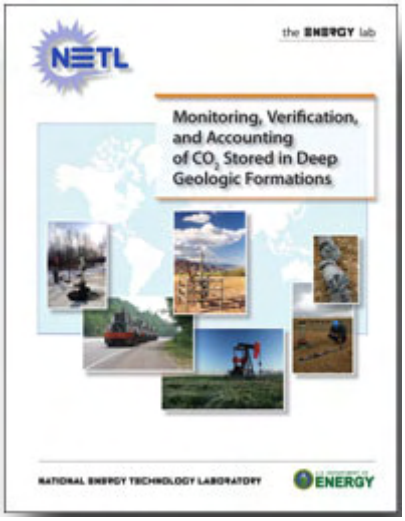
# Highlights (Continued)

***Fossil Energy Techline*, "DOE Regional Partnership Initiates $CO_2$ Injection in Lignite Coal Seam."**

The Plains $CO_2$ Reduction Partnership (PCOR) has begun injecting $CO_2$ into a deep lignite coal seam in North Dakota to demonstrate the economic and environmental viability of geologic $CO_2$ storage in the U.S. Great Plains Region. PCOR's Lignite Field Validation Test, one of four tests PCOR is conducting under the Validation Phase of the RCSP program, will inject approximately 400 tons of $CO_2$ into a 10-foot thick lignite seam approximately 1,100 feet deep. In 2007, a five-spot well configuration was drilled in collaboration with Eagle Operating Inc., consisting of a center injection well surrounded by four monitoring wells. In addition to evaluating the lignite seam's $CO_2$ storage potential, the project will also study coalbed methane extraction. The results of PCOR's Phase I characterization activities, which showed that the region's low-rank coal seams have the capacity to store up to 8 billion tons of $CO_2$, also suggested that more than 17 trillion cubic feet of methane could be produced from low-rank coal seams. This will be the first field study conducted on the ability of lignite coal seams to store $CO_2$. To view the PCOR website, go to: http://www.undeerc.org/pcor/. March 10, 2009, http://www.fossil.energy.gov/news/techlines/2009/09015-CO2_Injection_Begins.html.

***Fossil Energy Techline*, "DOE Releases Report on Techniques to Ensure Safe, Effective Geologic Carbon Sequestration."**




NETL has prepared and released a comprehensive report describing existing and emerging monitoring, verification, and accounting (MVA) techniques for $CO_2$ stored in geologic formations. The report, titled, "Monitoring, Verification, and Accounting of $CO_2$ Stored in Deep Geologic Formations," was prepared with input from the seven RCSPs in order to provide an overview of MVA techniques in use and under development; summarize DOE's MVA research and development (R&D) program; and ensure the safety and effectiveness of carbon storage projects. (*See Recent Publications section in this newsletter to view a portion of the Introduction and a link to DOE's "Monitoring, Verification, and Accounting of $CO_2$ Stored in Deep Geologic Formations."*) For more information on DOE's Carbon Sequestration Research Program, visit: http://www.fossil.energy.gov/programs/sequestration/index.html. March 17, 2009, http://www.fossil.energy.gov/news/techlines/2009/09016-DOE_Releases_MVA_Report.html.

# Sequestration in the News

***Fossil Energy Techline*, "DOE Seeks Applications for Tracking Carbon Dioxide Storage in Geologic Formations."**

On February 19, 2009, DOE issued a Funding Opportunity Announcement (FOA) to enhance the capability to simulate, track, and evaluate the potential risks of $CO_2$ storage in geologic formations. Depending on Fiscal Year 2009 appropriations, up to $24 million may be available for multiple projects that would last up to four years. Some of the project objectives under this FOA are to: (1) develop tools and protocols for MVA of $CO_2$ stored in geologic formations; (2) improve simulation tools to predict the behavior of geologically stored $CO_2$; and (3) develop risk assessment models associated with geological $CO_2$ storage. The selected projects will be managed by NETL and will become part of the Carbon Sequestration Program's research portfolio. February 19, 2009, http://www.fossil.energy.gov/news/techlines/2009/09009-DOE_Issues_FOA.html.

***StatoilHydro Press Release*, "Greenhouse Store Staying Sealed."**

New seismic data from the Utsira Formation in the North Sea shows that the $CO_2$ injected by StatoilHydro and partners Exxon Mobil and Total is spreading through the formation as expected. StatoilHydro, which extensively monitors and controls the $CO_2$ in the subsurface store to identify the behavior of the gas in the formation, collects four-dimensional seismic data every other year. The data from the 2008 survey confirms that the seven geophysical measurements conducted to date show a stable trend, with the $CO_2$ spreading upwards from the injection site and slowly through the rock; it is maintaining the same dispersion speed as it did in 2006, indicating the gas is remaining in the formation and not escaping to the surface. StatoilHydro extracts 2,600 tonnes of $CO_2$ from Sleipner West production and stores it 1,000 meters beneath the seabed, rather than releasing it into the atmosphere. Since Fall 1996, more than 10 million tonnes of $CO_2$ have been injected into the Utsira sandstone formation. The injected $CO_2$ covers approximately three square kilometers of the roughly 26,000 square kilometers available in the Utsira Formation. March 5, 2009, http://www.statoilhydro.com/en/NewsAndMedia/News/2009/Pages/03MarSleipner.aspx.

***Reuters*, "E.ON, Siemens to Build Pilot Carbon Capture Plant,"** and ***E.ON Kraftwerke Press Release*, "Siemens and E.ON Kraftwerke to Build Pilot $CO_2$ Capture Plant for Coal-Fired Power Plants."**

German utility E.ON and the industrial group Siemens reached a joint agreement on February 19, 2009, to build a pilot plant to capture $CO_2$ emissions. The plant will be built at E.ON's Staudinger power station in Grosskrotzenburg near Hanau, east of Frankfurt, and will be tested in a coal-fired unit, Staudinger's Unit 5. Operations are slated to start in Summer 2009 for the pilot plant, which would have a capacity of one megawatt (MW); commercial-size plants would be required to have at least a 400-MW capacity. The pilot plant will be operated with part of the flue gas from Unit 5 and E.ON and Siemens intend to operate it on the Staudinger site until the end of 2010. The project is part of the 5th Energy Research Program, "Innovation and New Energy Technologies," and promotes R&D in the field of low-$CO_2$ power plant technologies. E.ON plans on using industrial-scale carbon capture and sequestration (CCS) starting in 2020, when the European Union (EU) requires coal plans to use the process. February 19, 2009, http://uk.reuters.com/article/oilRpt/idUKLJ41964320090219?sp=true, and February 18, 2009, http://www.eon-kraftwerke.com/pages/ekw_en/Media/Press_Releases/Latest_Press_Releases/Pressemitteilung.htm?id=1379437.

# Announcements

**DOE Planning Solicitations in Support of the American Recovery and Reinvestment Act of 2009.**

In response to the American Recovery and Reinvestment Act of 2009, NETL released Notice of Intent to issue four FOAs for improving techniques to clean, capture, or store $CO_2$ emissions from industrial sources. The four areas of interest include: geologic sequestration training and research; CCS from industrial sources; site characterization of promising geologic formations for $CO_2$ storage; and an amendment to re-open the FOA "Clean Coal Power Initiative – Round 3." To follow FE's progress in implementing the Recovery Act, go to: http://www.fossil.energy.gov/aboutus/budget/stimulus.html.

**Research Experiment in Carbon Sequestration.**

The Research Experience in Carbon Sequestration (RECS) 2009 will be held in collaboration with the Southwest Regional Partnership (SWP) on July 19-29, 2009, in Albuquerque, New Mexico. The 10-day program combines classroom instruction; a geology field tour; and visits to a power plant, coal mine, and geologic storage test site. Topics cover a range of scientific, technical, and policy issues associated with CCS deployment. Applications are being accepted through May 10, 2009. For information on how to apply or become a corporate sponsor, go to: http://www.recsco2.org, or contact RECS Director Pamela Tomski at recesco2@mac.com or at (202) 390-8896.

**The Bellona Foundation Launches CCS Website.**

The Bellona Foundation, an international, non-government organization based in Oslo, Norway, has launched an interactive website designed to educate the public on CCS. The website also includes an interactive map that explores all of the current CCS projects worldwide, as well as $CO_2$ sources that have the potential to apply CCS. To view the Bellona website, click: http://www.bellona.org/ccs.

# Announcements

**15th European Symposium on Improved Oil Recovery.**

The theme of this symposium will reflect the challenges facing EOR, such as identifying which technologies can economically and quickly turn resources into reserves and searching for new methodologies that are more energy-efficient and safeguard valuable gas resources, while also having a minimal environmental footprint. To learn more, click: http://www.eage.org/events/index.php?eventid=105&Opendivs=s2.

**Carbon Finance and Analytics Program.**

Point Carbon and the London Business School have developed this joint-educational initiative for professionals in the global carbon and energy markets. The Carbon Finance and Analytics Program will consist of four, three-day seminars held in London, England, at the London Business School campus. The first seminar, titled, "Institutions, Science, and Politics," will begin on May 14, 2009. For more information on the four advanced professional training seminars, visit: http://www.pointcarbon.com/events/carbonfinance/.

# Science

***Reuters*, "Scientists Map U.S. Rocks that Soak up $CO_2$,"** and ***Earth Institute at Columbia University Press Release*, "Geologists Map Rocks to Soak $CO_2$ From Air."**

According to a study conducted by scientists at Columbia University's Earth Institute and the U.S. Geological Survey (USGS), certain rocks abundant on the East and West Coasts of the United States may someday absorb $CO_2$ emissions at a rate capable of slowing potential climate change. The study reports that approximately 6,000 square miles of ultramafic rocks that could be supercharged to absorb $CO_2$ lie on or near the surface of California, Oregon, Washington, and the Appalachian belt of eastern North America, spanning from Alabama to Newfoundland. These rocks originate deep in the earth and contain minerals that react with $CO_2$ to form solid minerals. Over thousands of years, rocks naturally absorb $CO_2$ by binding it with minerals to form solids such as calcium carbonate, a substance found in rocks and the main component of snail shells and eggshells. When their surfaces dissolve due to weathering or natural cycles, the $CO_2$ re-crystallizes, at which point it is absorbed by rocks. Scientists say the U.S. rocks could potentially absorb 500 years worth of U.S. $CO_2$ emissions. The report, titled, "Mapping the Mineral Resource Base for Mineral Carbon-Dioxide Sequestration in the Conterminous United States," is available at: http://pubs.usgs.gov/ds/414/. March 6, 2009, http://www.reuters.com/article/environmentNews/idUSTRE52552W20090306, and March 5, 2009, http://www.earth.columbia.edu/articles/view/2393.

***Reuters*, "Forests Absorb 20 Percent of Fossil Fuel Emissions: Study,"** and ***Guardian News*, "Fifth of World Carbon Emissions Soaked Up by Extra Forest Growth, Scientists Find."**

Over the past 40 years, tropical trees have grown larger and now absorb 20 percent of fossil fuel emissions, according to British researchers. The researchers used data collected from nearly 250,000 trees in the world's tropical forests over the last 40 years, and found that the tropical forests across the world remove approximately 4.8 billion metric tons of $CO_2$ emissions each year. Data also showed that the average total mass of the trees, which is mostly in their trunks, is increasing. Researchers are unsure why the trees are becoming larger and absorbing more $CO_2$, but offer the hypothesis that the extra $CO_2$ in the atmosphere may be acting like a fertilizer. However, they have concluded that tropical forests now make up more than half of the world's land carbon sink. The Intergovernmental Panel on Climate Change (IPCC) estimates that human activity produces approximately 32 billion tons of $CO_2$ each year, with 15 billion tons released into the atmosphere. February 18, 2009, http://www.reuters.com/article/environmentNews/idUSTRE51H5KE20090218, and February 18, 2009, http://www.cbc.ca/technology/story/2009/02/18/tropical-forests.html.

# Policy

***Greenwire*, "EPA Proposes Greenhouse Gas Reporting Rule,"** and ***Reuters*, "EPA Offers First Carbon Reporting Plan."**

On March 10, 2009, the U.S. Environmental Protection Agency (EPA), proposed a new rule that requires industries to report their GHG emissions. Covering any upstream suppliers of fuels or direct emitters that emit at least 25,000 metric tons of GHGs per year, the rule would affect a range of industrial plants and operations, such as power plants, refineries, coal mines, and auto and engine makers – approximately 13,000 facilities, or 85 to 90 percent of all U.S. emissions. The rule is expected to cost industries $160 million for the first year, and $127 million annually in the following years. EPA plans for the new reporting requirements to go into effect by 2010, with the first annual report submitted in 2011 for the 2010 calendar year, with the exception of the vehicle and engine makers, who would begin reporting with model year 2011. According to a draft EPA presentation, the agency also plans to issue an "endangerment finding" in mid-April that will address the relation between GHG emissions and human health. After public hearings, EPA could be allowed to regulate GHG emissions under the Clean Air Act, which mandates the collecting of data on emissions

# Policy (Continued)

from power plants. Information sheets for each of the source categories covered in the proposed EPA rule are available at: http://www.epa.gov/climatechange/emissions/ghg_infosheets.html. To read EPA's proposed rule, click: http://www.epa.gov/climatechange/emissions/downloads/MRR-Rule.pdf. March 10, 2009, http://www.eenews.net/Greenwire/2009/03/10/2/, and March 11, 2009, http://www.reuters.com/article/environmentNews/idUSTRE5294M920090311.

***Reuters*, "U.S., Canada to Agree on Energy Pact: Official,"** and ***The Toronto Star*, "Canada, U.S. to Open Clean Energy 'Dialogue.'"**

According to a White House official, the United States and Canada announced plans to work together on clean energy technology, including CCS, as a way to meet their goal of cutting emissions from within their countries. As part of the agreement, both countries will advance technologies and collaborate on a Smart Grid. The focus of the plan is to mitigate emissions from existing energy sources, specifically from Alberta's oil sands and America's vast coal deposits. Funding will come from both governments' respective stimulus packages, which have a portion set up for clean energy. The agreement is viewed as the first step towards bringing together Canadian and American environmental regulations to limit GHGs. February 19, 2009, http://www.reuters.com/article/GCA-BusinessofGreen/idUSTRE51I4X520090219, and February 19, 2009, http://www.thestar.com/News/Canada/article/590043.

**"Economic and Environmental Costs of Regulatory Uncertainty for Coal-Fired Power Plants."**

The following is the Abstract of this article: "Uncertainty about the extent and timing of $CO_2$ emissions regulations for the electricity-generating sector exacerbates the difficulty of selecting investment strategies for retrofitting or alternatively replacing existent coal-fired power plants. This may result in inefficient investments imposing economic and environmental costs to society. In this paper, [the authors] construct a multiperiod decision model with an embedded multistage stochastic dynamic program minimizing the expected total costs of plant operation, installations, and pollution allowances. [The authors] use the model to forecast optimal sequential investment decisions of a power plant operator with and without uncertainty about future $CO_2$ allowance prices. The comparison of the two cases demonstrates that uncertainty on future $CO_2$ emissions regulations might cause significant economic costs and higher air emissions." **Dalia Patiño-Echeverri, Paul Fischbeck, and Elmar Kriegler**, *Environmental Science & Technology*, Available online January 12, 2009, doi: 10.1021/es800094h, http://pubs.acs.org/doi/pdf/10.1021/es800094h. (Subscription may be required.)

# Geology

**"Potential environmental issues of $CO_2$ storage in deep saline aquifers: Geochemical results from the Frio-I Brine Pilot test, Texas, USA."**

The following is from the Abstract of this article: "Sedimentary basins in general, and deep saline aquifers in particular, are being investigated as possible repositories for large volumes of anthropogenic $CO_2$ that must be sequestered to mitigate global warming and related climate changes. To investigate the potential for the long-term storage of $CO_2$ in such aquifers, 1600 t of $CO_2$ were injected at 1500 m depth into a 24-m-thick "C" sandstone unit of the Frio Formation, a regional aquifer in the U.S. Gulf Coast. Fluid samples obtained before $CO_2$ injection from the injection well and an observation well 30 m updip showed a Na-Ca-Cl type brine with ~93,000 mg/L TDS at saturation with [methane ($CH_4$)] at reservoir conditions; gas analyses showed that $CH_4$ comprised ~95 [percent] of dissolved gas, but $CO_2$ was low at 0.3 [percent]. Following $CO_2$ breakthrough, 51 h after injection, samples showed sharp drops in pH (6.5 to 5.7), pronounced increases in alkalinity (100 to 3000 mg/L as $HCO_3$) and in Fe (30 to 1100 mg/L), a slug of very high DOC values, and significant shifts in the isotopic compositions of $H_2O$, DIC, and $CH_4$. These data, coupled with geochemical modeling, indicate corrosion of pipe and well casing as well as rapid dissolution of minerals, especially calcite and iron oxyhydroxides, both caused by lowered pH (initially ~3.0 at subsurface conditions) of the brine in contact with supercritical $CO_2$." **Yousif K. Kharaka, James J. Thordsen, Susan D. Hovorka, H. Seay Nance, David R. Cole, Tommy J. Phelps, and Kevin G. Knauss**, *Applied Geochemistry*, Available online February 20, 2009, doi: 10.1016/j.apgeochem.2009.02.010, http://www.sciencedirect.com/science/article/B6VDG-4VNH3WD-2/2/45c11e8c8082c8f8e508e10ce103068b. (Subscription may be required.)

**"Dissolution of Columbia River Basalt under mildly acidic conditions as a function of temperature: experimental results relevant to the geological sequestration of carbon dioxide."**

The following is the Abstract of this article: "Increasing attention is being focused on the rapid rise of $CO_2$ levels in the atmosphere, which many believe to be the major contributing factor to global climate change. Sequestering $CO_2$ in deep geological formations has been proposed as a long-term solution to help stabilize $CO_2$ levels. However, before such technology can be developed and implemented, a basic understanding of $H_2O$-$CO_2$ systems and the chemical interactions of these fluids with the host formation must be obtained. Important issues concerning mineral stability, reaction rates, and carbonate formation are all controlled or at least significantly impacted by the kinetics of rock-water reactions in mildly acidic, $CO_2$-saturated solutions. Basalt has recently been identified as a potentially important host formation for geological sequestration. Dissolution kinetics of the Columbia River Basalt (CRB) were measured for a range of temperatures

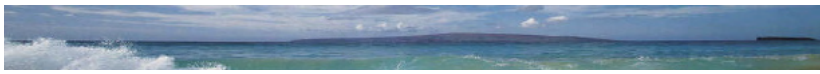
# Geology Cont'd

(25° to 90°C) under mildly acidic to neutral pH conditions using the single-pass flow-through test method. Under anaerobic conditions, the normalized dissolution rates for CRB decrease with increasing pH ($3 \leq pH \leq 7$) with a slope, $\eta$, of $-0.15 \pm 0.01$. Activation energy, Ea, has been estimated at $32.0 \pm 2.4$ kJ mol-1. Dissolution kinetics measurements like these are essential for modeling the rate at which $CO_2$-saturated fluids react with basalt and ultimately drive conversion rates to carbonate minerals in situ." **H. Todd Schaef and B. Peter McGrail**, *Applied Geochemistry*, Available online March 5, 2009, doi: 10.1016/j.apgeochem.2009.02.025, http://www.sciencedirect.com/science/article/B6VDG-4VS405T-1/2/b63d927b86505bfcd32ce192220e716b. (Subscription may be required.)

# Technology

**"Design and off-design analyses of a pre-combustion $CO_2$ capture process in a natural gas combined cycle power plant."**

The following is the Abstract of this article: "In this study, a cycle designed for capturing the [GHG] $CO_2$ in a natural gas combined cycle power plant has been analyzed. The process is a pre-combustion $CO_2$ capture cycle utilizing reforming of natural gas and removal of the carbon in the fuel prior to combustion in the gas turbine. The power cycle consists of a H2-fired gas turbine and a triple pressure steam cycle. Nitrogen is used as fuel diluent and steam is injected into the flame for additional [nitrogen oxide ($NO_X$)] control. The heat recovery steam generator includes pre-heating for the various process streams. The pre-combustion cycle consists of an air-blown auto-thermal reformer, water-gas shift reactors, an amine absorption system to separate out the $CO_2$, as well as a $CO_2$ compression block. Included in the thermodynamic analysis are design calculations, as well as steady-state off-design calculations. Even though the aim is to operate a plant, as the one in this study, at full load there is also a need to be able to operate at part load, meaning off-design analysis is important. A reference case which excludes the pre-combustion cycle and only consists of the power cycle without $CO_2$ capture was analyzed at both design and off-design conditions for comparison. A high degree of process integration is present in the cycle studied. This can be advantageous from an efficiency stand-point but the complexity of the plant increases. The part load calculations is one way of investigating how flexible the plant is to off-design conditions. In the analysis performed, part load behavior is rather good with efficiency reductions from base load operation comparable to the reference combined cycle plant." **Lars Olof Nord, Rahul Anantharaman, and Olav Bolland**, *International Journal of Greenhouse Gas Control*, Available online March 17, 2009, doi: 10.1016/j.ijggc.2009.02.001, http://www.sciencedirect.com/science/article/B83WP-4VVN50Y-1/2/2657cfd3e9a9d13ad57291da6c6dad0c. (Subscription may be required.)



# Terrestrial

**"Carbon capture and sequestration by a treatment wetland."**

The following is the Introduction of this article: "The role of $CO_2$ in global warming is one of the most important environmental issues, and for this reason, it is necessary to develop technologies that minimize the discharge of $CO_2$ into the atmosphere. Atmospheric levels of $CO_2$ have been greatly affected by human activities, and these increases in $CO_2$ are accelerating global climate change. Scientists have recently developed several approaches to manage the levels of anthropogenic $CO_2$ emitted into the atmosphere, but one of the most understudied of these is CCS. A variety of CCS technologies exist for reducing anthropogenic $CO_2$ emission, including chemical absorption, membrane separation, chemical adsorption, and geologic formations including depleted oil and gas reservoirs, deep saline reservoirs, unminable coal seams and ocean disposal. Agroforestry and reforestry are two methods of phytotechnology currently being studied. However, there is much less research on the use of aquatic plants for removing anthropogenic $CO_2$. In particular, there is little information available about the use of wetlands as public remediation-sites for the purposes of CCS. Depending on environmental and treatment conditions, wetlands can be sources or sinks of $CO_2$. Many natural wetlands are known to be important sinks of $CO_2$, while wetlands created for wastewater purification are known to be sources of $CO_2$. The ability of treatment wetlands to sequester $CO_2$ depends on their design, dimensions, and the substrate used. In order to design such a CCS system, it would be useful to know detailed kinetic information that would help provide accurate descriptions of reaction mechanisms of both phytoremediation of $CO_2$ and plant-$CO_2$ interaction. Additionally, the question of which plant types are the most effective at sequestration is equally important, but has not yet been thoroughly studied. Utilizing different types of plants may result in different $CO_2$ removal rates. The aim of this study is to investigate the $CO_2$ removal performance by different types of plants in batch and continuous operations of treatment wetlands and to determine biokinetic coefficients of plants by applying saturation reaction and first-order reaction kinetic equations." **Jae Seong Rhee and Janjit Iamchaturapatr**, *Ecological Engineering*, Available online January 30, 2009, doi: 10.1016/j.ecoleng.2008.10.008, http://www.sciencedirect.com/science/article/B6VFB-4VGVX5K-1/2/74cd8da89dad5584947f8fe80e4f4c47. (Subscription may be required.)

# Trading

| Carbon Market Update, March 13, 2009 | |
|---|---|
| CCX-CFI 2008 ($/tCO$_2$) $1.50 (Vintage 2009) | EU ETS-EUA DEC 2008 ($/tCO$_2$) $15.90 (Converted from € to US$) |

***RGGI News Release,* "States Release Results of Third Auction for RGGI $CO_2$ Allowances."**

The 10 Northeast and Mid-Atlantic states participating in the Regional Greenhouse Gas Initiative (RGGI) announced the results of the third auction for RGGI $CO_2$ allowances, which was held March 18, 2009. All of the 31,513,765 allowances for the 2009 vintage sold at a clearing price of $3.51 per allowance. The RGGI states, which raised $117,248,629.80 for energy efficiency, renewable energy, and other consumer benefit programs, also auctioned allowances for the second three-year control period, beginning in 2012. The 2,175,513 allowances for the 2012 vintage cleared at a price of $3.05 per allowance. According to Potomac Economics, RGGI's independent market monitor who observed the auction and confirmed procedures were consistent and fair, 50 separate entities submitted bids to purchase 2.5 times the available supply of 2009 allowances, and 20 entities submitted bids to purchase 2.3 times the available supply of 2012 allowances. Forty-two entities won allowances for the 2009 offering, and 12 entities won allowances for the 2012 offering. Bid prices ranged from $1.86 to $10.00 for the 2009 offering, and $1.86 to $4.40 for the 2012 offering. By the end of 2009, the RGGI states will have offered five percent of the total supply of 2012 vintage allowances for sale. March 20, 2009, http://www.rggi.org/docs/Auction_3_News_Release_MM_Report.pdf.

***RGGI News Release*, "Report Shows Solid Foundation For Emerging Carbon Market."**

On March 4, 2009, the 10 states participating in RGGI issued a report showing that the competitive process is working as intended in the secondary market for $CO_2$ allowances. Furthermore, the report, titled, "Report on the Secondary Market for RGGI $CO_2$ Allowances," concludes that there is no evidence of anticompetitive conduct amongst participants. The report covers August 2008 to January 2009 and conclusions were based on analysis of data reported to the Commodity Futures Trading Commission (CFTC) and the Chicago Climate Futures Exchange (CCFE). Potomac Economics, RGGI's independent market monitor that prepared the report, also concluded that the average volume of allowance futures trading per day grew from 155,000 in September 2008 to 330,000 in January 2009. To view RGGI's report, go to: http://www.rggi.org/docs/Secondary_Market_Report_March_2009_FINAL.pdf. March 4, 2009, http://www.rggi.org/docs/PE_Secondary_Market_Report_News_Release_FINAL.pdf.

# Recent Publications

**"Monitoring, Verification, and Accounting of $CO_2$ Stored in Deep Geologic Formations."**

The following is from the Introduction of this document: "The storage of industrially generated $CO_2$ in deep geologic formations is being seriously considered as a method for reducing $CO_2$ emissions into the atmosphere. This growing interest has lead to significant investment by governments and the private sector to develop the necessary technology and to evaluate whether this approach to $CO_2$ control could be implemented safely and effectively. Depleted oil and gas reservoirs, unmineable coalbeds, and deep brine-filled (saline) formations are all being considered as potential storage options. Depleted oil and gas reservoirs are particularly suitable for this purpose, as they have shown by the test of time that they can effectively store buoyant fluids like oil, gas, and $CO_2$. In principle, storage in deep brine-filled formations is the same as storage in oil or gas reservoirs, but the geologic seals that would keep the $CO_2$ from rapidly rising to the ground surface need to be characterized and demonstrated to be suitable for long-term storage. Over hundreds to thousands of years, some fraction of the $CO_2$ is expected to dissolve in the native formation fluids. Some of the dissolved $CO_2$ will react with formation minerals and dissolved constituents and may precipitate as carbonate minerals, although this might take a long time. Once dissolved or precipitated as minerals, $CO_2$ is no longer buoyant and storage security may be increased. Coalbeds offer the potential for a different type of storage in which $CO_2$ becomes chemisorbed on the solid coal matrix." To view the complete MVA document, visit: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/MVA_Document.pdf.

**"Developing a Pipeline Infrastructure for $CO_2$ Capture and Storage: Issues and Challenges."**

The following is from the Executive Summary of this document: "This study focuses on the pipeline infrastructure requirements for CCS in connection with compliance with mandatory [GHG] emissions reductions. The major conclusion of the study is that while CCS technologies are relatively well defined, there remain technological challenges in the [CCS] phases, and less so in transportation. Carbon capture is the most significant cost in the CCS process. The study forecasts that the amount of pipeline that will be needed to transport $CO_2$ will be between 15,000 miles and 66,000 miles by 2030, depending on how much $CO_2$ must be sequestered and the degree to which EOR is involved. The upper end of the forecast range is of the same order of magnitude as the miles of existing U.S. crude oil pipelines and products pipelines. While there are no significant barriers to building the forecasted pipeline mileage, the major challenges to implementing CCS are in public policy and regulation. Because a CCS industry can evolve in several ways, public policy decisions must address key

# Recent Publications - Continued

questions about industry structure, government support of early development, regulatory models, and operating rules. Such issues must be resolved before necessary investments in a CCS pipeline system can be made." To read the complete study, which was commissioned by the Interstate Natural Gas Association of America (INGAA) Foundation, click: http://ingaa.org/File.aspx?id=8228.

**"Designing a U.S. Market for $CO_2$."**

The following is the Abstract of this document: "In this paper [the authors] focus on one component of the cap-and-trade system: the markets that arise for trading allowances after they have been allocated or auctioned. The efficient functioning of the market is key to the success of cap-and-trade as a system. [The authors] review the performance of the EU $CO_2$ market and the U.S. [sulfur dioxide ($SO_2$)] market and examine how the flexibility afforded by banking and borrowing, and the limitations on banking and borrowing, have impacted the evolution of price in both markets. While both markets have generally functioned well, certain episodes illustrate the importance of designing the rules to encourage liquidity in the market." To read the complete report from the Massachusetts Institute of Technology (MIT) Joint Program on the Science and Policy of Global Change, go to: http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt171.pdf.

**"A Roadmap for a Secure, Low-Carbon Energy Economy."**

The following is from the Executive Summary of this document: "This 'roadmap' presents the results of a year-long effort by the Center for Strategic and International Studies (CSIS, an international policy and security-oriented think tank) and the World Resources Institute (WRI, an environmental policy think tank) to identify a set of policies to address energy security and climate change simultaneously. This document presents the results of a difficult process to reconcile the priorities of two sometimes conflicting constituencies. The resulting recommendations are designed to be implemented as a package. Policymakers must not simply pick the recommendations they favor or that are most politically palatable. The balanced approach recommended in this brief would greatly increase the United States' chances of meeting both its energy security and climate goals. It won't be easy. Shifting the United States to a secure, low-carbon economy will take decades. The costs will be high, but they will be even higher if immediate action is not taken. The United States has ample natural, human, and technological resources, and if policymakers get started promptly and make smart decisions, the benefits of this transformation can be great: economic opportunity, a healthier planet, and a more secure future for the United States." To read the complete roadmap, go to: http://pdf.wri.org/secure_low_carbon_energy_economy_roadmap.pdf.

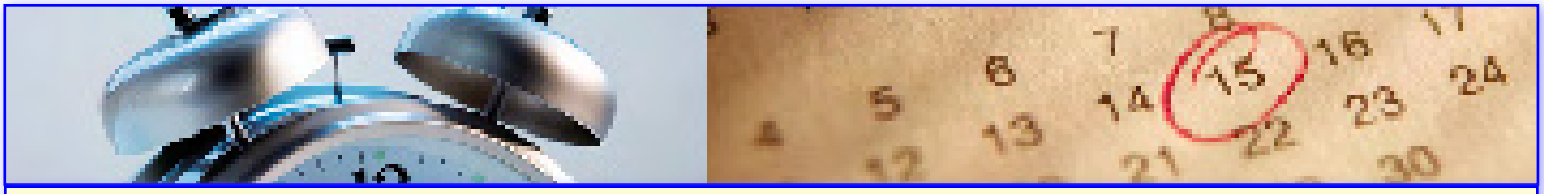
# Legislative Activity

***The Register-Herald*, "Manchin's Carbon Sequestration Bill Arrives in Senate,"** and ***The State Journal*, "Carbon Sequestration Bill Introduced in Legislature."**


West Virginia Governor Joe Manchin introduced a bill to the West Virginia House and the Senate on February 26, 2009, moving to expand the use of coal and lower the $CO_2$ emissions from coal-fired power plants. The bill is intended to set regulations, monitor sequestration, and allow permits for renewable and alternative sources projects. It emphasizes the importance of CCS technologies and would create construction standards for future sequestration operations. A study group would also be created under the bill to develop a strategy to regulate the process and clarify the ownership of pore space, which is an underground area used for storing substances such as $CO_2$. To view the bill, H.B. 2682, go to: http://www.legis.state.wv.us/Bill_Status/bills_text.cfm?billdoc=hb2682%20intr.htm&i=2682&yr=2009&sesstype=rs&btype=bill&docfrom=billtrack&list=Div%20of%20Energy. February 26, 2009, http://www.register-herald.com/local/local_story_057215805.html, and February 27, 2009, http://www.statejournal.com/story.cfm?func=viewstory&storyid=53253.

***Associated Press*, "Wyoming Senate Moves on Carbon Capture Bills,"** and ***Casper Star-Tribune*, "Gov Signs $CO_2$ Storage Bills."**


Wyoming Governor Dave Freudenthal signed three bills this session aimed at jump starting an underground $CO_2$ storage industry in Wyoming. H.B. 80 would require companies to apply to the Wyoming Oil and Gas Conservation Commission for orders allowing them to proceed with underground storage and addresses pore space. The other two bills were H.B. 58, which would assign liability for underground storage of $CO_2$ to the injector, and H.B. 57, which would establish that the right to mine or drill for resources would supersede the right to store $CO_2$ underground. Wyoming lawmakers hope that creating a legal framework for the underground storage of $CO_2$ will encourage a carbon storage industry and offset the $CO_2$ produced by coal-fired power plants. To view H.B. 57, H.B. 58, or H.B. 80, click: http://legisweb.state.wy.us/2009/billindex/BillCrossRef.aspx?type=HB. February 18, 2009, http://finance.yahoo.com/news/Wyoming-Senate-moves-on-apf-14399731.html, and February 28, 2009, http://www.casperstartribune.net/articles/2009/02/28/news/wyoming/222972968061b3e68725756b0007d71f.txt.



# Events (Continued)

March 5-6, 2009, **$CO_2$ Capture, Sequestration & Utilization 2009**, *Crowne Plaza Park View Wuzhou, Beijing, China*. This conference presents attendees with an in-depth understanding of the economics and regulatory frameworks governing CCS. It will focus on technological advancements, investor outlook, and regulatory environment in the $CO_2$ value chain as a solution for $CO_2$ emission reduction. To learn more, click: http://www.cmtevents.com/aboutevent.aspx?ev=090313&.

April 2-3, 2009, **Navigating the American Carbon World**, *San Diego Marriott Hotel and Marina, San Diego, California, USA*. Navigating the American Carbon World (NACW) will bring together leaders from government, businesses, and environmental organizations to discuss the current conditions and future developments of climate change policy. To view the conference agenda, visit: http://www.climateregistry.org/resources/docs/NACW-Agenda-DRAFT.pdf.

April 7-8, 2009, **CMM Recovery and Utilization Workshop**, *ChengDu City, SiChuan Province, China*. This workshop aims to establish a network of coalmine methane (CMM) recovery and utilization among stakeholders, facilitate technology transfer, and develop business opportunities. For more information, go to: http://www.iea.org/textbase/work/2009/Methane/Agenda.pdf.

April 27-28, 2009, **CarbonWorld Doha 2009**, *Doha Marriott Hotel, Doha, Qatar*. This summit will provide insight into the modalities of building businesses on a low-carbon platform. It will cover the perspectives from government agencies, project developers, and carbon finance experts in carbon management and policy initiatives. Attendees will debate issues such as carbon trading trends, voluntary carbon markets (VCM), and CCS. For more information, go to: http://www.cmtevents.com/aboutevent.aspx?ev=090420.

May 4-7, 2009, **8th Annual Conference on Carbon Capture and Sequestration**, *Sheraton at Station Square, Pittsburgh, Pennsylvania, USA*. This NETL hosted conference will focus on CCS technologies that are being or could be deployed in the United States and North America; provide a forum for the exchange of experience(s) among United States and international scientific and engineering communities working on such technologies and systems; facilitate the necessary dialogue between technology developers, industry, and the public on the development and deployment of viable technologies; and work to develop the necessary capacity within the public and private sector to move the technology base forward. To learn more, click: http://www.carbonsq.com/index.htm.

May 12-15, 2009, **2nd Climate Change Technology Conference**, *McMaster University, Hamilton, Ontario, Canada*. The Climate Change Technology Conference (CCTC 2009) offers a forum for scientists, engineers, policy advisors, and industry to exchange new information with other stakeholders that deal with potential climate change issues. The conference includes a technical program that emphasizes the importance of developing practical engineering and administrative responses to address such issues. To view the conference website, visit: http://cctc2009.ca/en/index.html.

May 26-28, 2009, **POWER-GEN Europe**, *Koelnmesse, Cologne, Germany*. This event includes discussion of a range of technologies that can be employed to reduce $CO_2$ in power production while focusing on policies at a national and corporate level that would improve energy efficiency. To view the conference website, which includes a detailed program, visit: http://pge09.events.pennnet.com/fl/content.cfm?NavId=8447&Language=Engl.

May 27-29, 2009, **Carbon Expo**, *Barcelona, Spain*. This event will provide participants with an opportunity to explore local government's responses to the carbon market, while also offering industry, project and carbon finance agents, clean technology developers and providers, and other relevant stakeholders with a market place for clean urban development solutions. To learn more, click: http://www.carbonexpo.com/wEnglisch/carbonexpo2/index.htm.

May 27-29, 2009, **International Conference on Deep Saline Aquifers for Geological Storage of $CO_2$ and Energy**, *IFP in Rueil-Malmaison, France (suburbs of Paris)*. The conference will focus on the storage of natural gas in aquifers; aquifer thermal energy storage (ATES); and $CO_2$ storage in saline aquifers, including processes induced by $CO_2$ disposal and an evaluation of storage potential and assessment of suitable disposal sites. To read more, visit the conference website at: http://www.ifp.com/actualites/evenements/congres-et-conferences/organises-par-l-ifp/rs-deep-saline-aquifers.

# EVENTS (CONTINUED)

June 17-18, 2009, **Carbon Capture, Storage and Transport Summit 2009**, *Le Meridien Piccadilly, London, United Kingdom*. The 2nd Annual Carbon Capture, Storage and Transport Summit is a senior level forum directed at covering time-crucial, commercial, technical, legislative, and scientific challenges in carbon capture, storage, and transport implementation. To view the conference website, which includes a downloadable brochure, go to: http://www.iqpc.com/ShowEvent.aspx?id=173566.

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