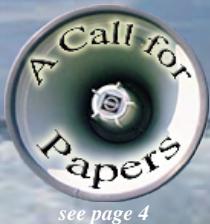




# carbon CSN sequestration Newsletter



MARCH 2009

Carbon Sequestration

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## 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, “DOE Regional Partner Initiates CO<sub>2</sub> Injection Study in Virginia.”**

The U.S. Department of Energy’s (DOE) Southeast Regional Carbon Sequestration Partnership (SECARB), one of the seven Regional Carbon Sequestration Partnerships (RCSPs), will determine the feasibility of carbon dioxide (CO<sub>2</sub>) storage and the



potential for enhanced coalbed methane (ECBM) recovery in unmineable coal seams by injecting CO<sub>2</sub> into coal seams in the Central Appalachian Basin. The Central Appalachian Basin, a 10,000-square mile area located in southern West Virginia and southwestern Virginia, was selected because, according to researchers, it has the capacity to store 1.3 billion tons of CO<sub>2</sub> while increasing natural gas production up to 2.5 trillion cubic feet. SECARB initiated CO<sub>2</sub> injection in mid-January at its test site in Russell County, Virginia. An existing coalbed methane (CBM) well was converted for CO<sub>2</sub> injection and the two wells were drilled to monitor reservoir pressure, gas composition, and the CO<sub>2</sub> plume. The targeted coal seams, which are in the Pocahontas and Lee formations, range from 1,400 feet to 2,200 feet in depth and from .7 feet to 3.0 feet in thickness. Over a 45-day period, 1,000 tons of CO<sub>2</sub> will be injected. Through the exploration of the multiple uses of subsurface storage volume and the injection of CO<sub>2</sub> into coal seems, the Central Appalachian Basin CO<sub>2</sub> Storage Project will boost CBM recovery, provide commercial benefit, and offset infrastructure development costs while providing long-term CO<sub>2</sub> storage. The results of the study will be used to assess the potential of carbon storage in coal seams as a safe and permanent method to mitigate greenhouse gas (GHG) emissions while enhancing production of natural gas. It is one of four pilot-scale tests that SECARB is sponsoring for the RCSP Program’s Validation Phase. To learn more about DOE’s RCSP Program, visit: <http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html>. February 11, 2009, [http://www.fossil.energy.gov/news/techlines/2009/09006-Coal\\_Seam\\_Injection\\_Begins.html](http://www.fossil.energy.gov/news/techlines/2009/09006-Coal_Seam_Injection_Begins.html).

## SEQUESTRATION IN THE NEWS

*Mid-Columbia Tri-City Herald*, “Wallula Project Aims to Trap Greenhouse Gases,” and *MSNBC.com*, “Carbon Dioxide Sequestration Project in Wallula Could Help Prevent Climate Change.”

As part of the first phase of a joint, pilot-scale project headed by the Big Sky Carbon Sequestration Partnership (BSCSP), Boise Inc. and Battelle researchers have started drilling a layer of basalt approximately three-quarters of a mile underground near Wallula, Washington, to determine if the formation can store CO<sub>2</sub>. If successful, the Pacific Northwest National Laboratory-based researchers will apply for a state permit to inject nearly 1,000 tons of CO<sub>2</sub> into the well, which they are building at Boise Inc. pulp and paper mill. The basalt formation, believed to be 13 million years old, is a result of 300 lava flows and includes layers of rock abundant with sponge-like holes. According to researchers, the





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## SEQUESTRATION IN THE NEWS (CONTINUED)

CO<sub>2</sub> will flow through the layers covered with holes, infusing itself with non-potable water that is trapped in the rock. The carbonated water would then react with the basalt elements and turn into calcium carbonate, allowing the top layer of hard basalt to serve as a caprock. January 22, 2009, [http://www.tri-cityherald.com/kennewick\\_pasco\\_richland/story/453735.html](http://www.tri-cityherald.com/kennewick_pasco_richland/story/453735.html), and January 22, 2009, <http://www.msnbc.msn.com/id/28781701/>.

### *Montana State University News Release, "MSU Shares in \$1.4 Million Grant for Carbon Sequestration Research."*

A \$1.4 million DOE grant has been awarded to researchers at Montana State University, the University of Montana, and Montana Tech University to study the effects carbon sequestration sites may have on the surrounding environment. The researchers will study the effects of injecting large volumes of liquefied CO<sub>2</sub> into porous rocks deep underground for storage. The injections could affect the rock's pore structures, material properties, or microbial activity, all of which play a role in how well the CO<sub>2</sub> is sequestered. Project researchers will also monitor microbes and plants near the sequestration sites to determine whether a site is containing CO<sub>2</sub>. The grant is derived from DOE's Experimental Program to Stimulate Competitive Research (EPSCoR). January 22, 2009, <http://www.montana.edu/cpa/news/nwview.php?article=6730>.

### *EPRI News Release, "EPRI to Study Adding Carbon Capture to Existing Coal Power Plants."*

Electric Power Research Institute (EPRI) announced that five electric utilities will participate in a series of studies to determine the impact(s) of retrofitting amine-based, post-combustion CO<sub>2</sub> capture technology to existing coal-fired power plants. The five host companies and sites are Edison Mission Group's Powerton Station in Pekin, Illinois; Great River Energy's Coal Creek Station in Underwood, North Dakota; Nova Scotia Power's two units at its Lingen Generating Station in Lingen, Nova Scotia; Intermountain Power Agency's Intermountain Generation Station in Delta, Utah; and FirstEnergy's Bay Shore Plant's circulating fluidized bed boiler Unit 1 in Oregon, Ohio. The studies will examine challenges such as the limited space for new plant equipment, limited heat available for process integration, additional cooling water requirements, and potential steam turbine modifications. The sites were selected because they present a variety of unit sizes and ages, existing and planned emissions controls, fuel types, steam conditions, boilers, turbines, cooling systems, and options for CO<sub>2</sub> storage. A report for each site will: (1) assess the CO<sub>2</sub> capture efficiency configuration based on site constraints; (2) determine the space required for the CO<sub>2</sub> capture technology; (3) estimate performance and costs; and (4) assess the features of each plant that affect retrofit cost and feasibility. January 27, 2009, [http://my.epri.com/portal/server.pt/gateway/PTARGS\\_0\\_2\\_317\\_205\\_776\\_43/http%3B/uspalecp604%3B7087/publishedcontent/publish/epri\\_to\\_study\\_adding\\_carbon\\_capture\\_to\\_existing\\_coal\\_power\\_plants\\_da\\_626651.html](http://my.epri.com/portal/server.pt/gateway/PTARGS_0_2_317_205_776_43/http%3B/uspalecp604%3B7087/publishedcontent/publish/epri_to_study_adding_carbon_capture_to_existing_coal_power_plants_da_626651.html).

# SEQUESTRATION IN THE NEWS (CONTINUED)

## Norway Post, “ESA Approves Carbon Capture and Storage Project at Kaarstoe.”

The European Free Trade Association (EFTA), through the EFTA Surveillance Authority (ESA) of Norway, authorized funding for establishing a carbon capture and storage (CCS) facility in Kaarstoe, Norway. The CCS facility, which will be owned and managed by the state-owned company Gassnova SF, will capture and store CO<sub>2</sub> emitted from the Naturkraft Power Plant. The goal of the Kaarstoe project is to reduce energy costs and contribute to the global deployment of CCS technologies. Gassnova SF will be the direct recipient of the state funding, which will cover operating costs of the CCS facility for 10 years. ESA believes that testing the technology and learning from the results is an essential step to cutting CCS operating costs. The Norwegian state hopes the Kaarstoe project will contribute to making CCS technology more cost effective. January 30, 2009, <http://www.norwaypost.no/content/view/21561/1/>.

*Times Online*, “National Grid to Pipe Carbon Dioxide Emissions under North Sea.”

According to its Director of Network Operations, National Grid is planning to construct a \$2.9 billion carbon transport and storage network near the Humber estuary of Northern England to pipe CO<sub>2</sub> emissions from power stations to geological formations beneath the North Sea. Under the proposed plan, the network would pipe CO<sub>2</sub> emitted from coal- and gas-fired stations such as Drax, Eggborough, Ferrybridge, and Killingholme. The plan calls for the network to be operational within three years, which would aide Britain’s goal to have its first commercial-scale, CCS-equipped power plant operational by 2012. The official also said National Grid would use existing pipes and other infrastructure formally used to transport natural gas when possible. February 11, 2009, <http://www.timesonline.co.uk/tol/news/environment/article5705182.ece>.



## ANNOUNCEMENTS

### **Research Experience 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 and participants will gain hands-on experience designing a carbon storage pilot project and utilizing CO<sub>2</sub> monitoring equipment. 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](mailto:recesco2@mac.com) or at (202) 390-8896.

### **SECARB Partnership Meeting.**

SECARB’s 4<sup>th</sup> Annual Stakeholders’ Briefing will be held on March 3-4, 2009, in Atlanta, Georgia. The Southern States Energy Board (SSEB) and Schlumberger will team to offer a classroom course providing intermediate-level training on field data collection and interpretation processes. Included is a special session on technologies for CCS at anthropogenic sources. For more information, visit: <http://www.secarbon.org/nonpublic/SECARBinvitation.pdf>.

### **Annual NETL CO<sub>2</sub> Capture Technology for Existing Plants R&D Meeting.**

Scheduled for March 24-26, 2009, in Pittsburgh, Pennsylvania, the Annual National Energy Technology Laboratory (NETL) CO<sub>2</sub> Capture Technology for Existing Plants R&D Meeting will address the state of technologies for capturing CO<sub>2</sub> emissions from existing coal-fired power plants. The conference will include current progress from existing projects and project details from recent award selections from DOE CO<sub>2</sub> capture technology research conducted through NETL’s Existing Plants, Emission, and Capture (EPEC) Program. For more information, visit: <http://www.netl.doe.gov/events/09conferences/co2capture/index.html>.

### **NETL Released Video on CCS/RCSP Program.**

NETL has released a video documenting the safe implementation of CCS by their seven RCSPs. The RCSPs, which were formed by DOE in 2003, focus on assessing geologic formations suitable for storage and determining the best approaches to implement carbon sequestration in each of their respective regions. To watch the video, click: <http://prod-mmedia.netl.doe.gov/Video/CCS2008.wmv>.

## ANNOUNCEMENTS



### **Call for Papers.**

The Society of Exploration Geophysicists' (SEG) 2009 Summer Research Workshop, titled, CO<sub>2</sub> Sequestration Geophysics, is seeking abstracts addressing CO<sub>2</sub> sequestration and the role of geophysics; rock physics for CO<sub>2</sub>, brine, and oil mixtures; geophysical site characterization; seismic data acquisition techniques for CO<sub>2</sub>, and a variety of other topics. The deadline for abstract submission is April 2, 2009. For abstract information and guidelines, go to: <http://www.seg.org/SEGportalWEBproject/prod/SEG-Meetings/Mtgs-Upcoming-Mtgs/SRW2009Alberta/Documents/SRW09CallandApp.pdf>.

### **CCS/Response to Climate Change Workshop.**

The second CO2NET EAST regional workshop on CCS, slated for March 3-4, 2009, in Bratislava, Slovakia, will cover topics such as European CCS policy, risk assessment, safety issues, and public acceptance. The workshop will also offer research, pilot, and demonstration project presentations. To learn more, visit the workshop website at: <http://www.geology.cz/co2net-east/workshop>.

## **SCIENCE**

### **Science Daily, "All Earth's Seasons Now Arrive Two Days Earlier, Researchers Report."**

According to a study conducted by scientists from the University of California, Berkley and Harvard University, the hottest day of the year has shifted forward nearly two days, which opposes current Intergovernmental Panel on Climate Change (IPCC) models that predict the annual temperature cycle. While the researchers are unclear of the cause, they believe that GHGs may be responsible for this shift in the cycle of seasons. The study reveals that a pattern of winds has also changed over the same time period. This pattern of atmospheric circulation, known as the Northern Annular Mode, is important for controlling why one winter in the Northern Hemisphere is different from another. However, researchers have found that the mode is also important when it comes to controlling the arrival of the seasons each year. As temperatures can be different on land compared to the ocean, a change in wind strength and direction can move heat from the ocean onto land, which could affect the timing of the seasons. Researchers also found that during the same 50-year period that was used to study the seasons, summer and winter land temperatures have decreased, with winter temperatures warming more than summer temperatures. January 22, 2009, <http://www.sciencedaily.com/releases/2009/01/090121144053.htm>.

### **Science Daily, "Global Warming: Tree Deaths Have Doubled Across the Western U.S."**

Tree deaths in the Western United States have more than doubled in recent decades, according to a study led by the U.S. Geological Survey (USGS). The study documented the tree deaths, which researchers believe is a cause of regional warming and related drought conditions, in all sizes and at varying elevations in the interior west, including Colorado and Arizona, and northwest regions, such as northern California, Oregon, Washington,



and Southern British Columbia. The study speculates that the high level of tree deaths could lead to ecological and wildlife population changes in the west. According to USGS researchers, climate records of Colorado's subalpine forests, which are roughly 8,500 feet to 10,000 feet in elevation, show an increase in temperatures during all seasons of the year over the past 50 years. The 76 western forest plots used for the study contained nearly 59,000 living trees, which researchers studied during two periods – from 1955 to 1994 and from 1998 to 2007. Researchers also believe that the tree deaths could lead to potential increases in atmospheric CO<sub>2</sub> levels, which could be the result of lower CO<sub>2</sub> storage from smaller trees and increased CO<sub>2</sub> emissions from dead trees. To read the study, titled, "Widespread Increase of Tree Mortality Rates in the Western United States," go to: <http://www.sciencemag.org/cgi/content/abstract/323/5913/521>. January 25, 2009, <http://www.sciencedaily.com/releases/2009/01/090122141222.htm>.

## **POLICY**

### **Zurich Financial Services Group News Release, "Zurich Creates Two New Insurance Policies to Support Greenhouse Gas Mitigation Technologies, Addressing the Unique Needs of Carbon Capture and Sequestration."**

Zurich Financial Services Group announced the availability of CCS Liability Insurance and Geologic Sequestration Financial Assurance (GSFA), which are intended to facilitate future CCS usage. The products cover the long-term liabilities posed by CCS technology, ranging from geologic storage site design, operational phases, site closure, and post-closure. Zurich's CCS Liability Insurance covers pollution events, business interruption, control of the well, liabilities related to carbon transmission, and geomechanical liabilities during the operational life of the CO<sub>2</sub> storage facilities. GSFA is intended to cover the decades after the closure of the facility, including funding to close the covered well(s) and to monitor CO<sub>2</sub> storage after site closure. Officials believe these products can be applied to clean coal operations and a variety of onshore and offshore industrial processes. Zurich officials also said the coverages were developed in collaboration with customers, academic

# POLICY (CONTINUED)

experts, and government officials. January 19, 2009, [http://www.zurichna.com/zna/media/news\\_releases/current\\_releases/releases011909.htm](http://www.zurichna.com/zna/media/news_releases/current_releases/releases011909.htm).

## Reuters, "Norway Plans \$750 Mln Carbon Technology Centre."

On January 30, the Norwegian government proposed spending \$750 million to build a center for the development of CCS technology at StatoilHydro's Mongstad refinery. Under the proposal, Norway and StatoilHydro would have stakes of 80 percent and 20



percent respectively, although industrial partners could enter into the project and reduce Norway's portion. Norwegian officials expect that the center will take approximately 2.5 years to build. StatoilHydro has been burying 1 million tonnes of CO<sub>2</sub> per year at the Sleipner field in the North Sea since 1996; however, the CO<sub>2</sub> is stripped from a natural gas well stream, not captured from an industrial plant. More information about the Mongstad facility can be found at: <http://www.statoilhydro.com/en/eurooperations/terminalsrefining/prodfacilitiesmongstad/pages/default.aspx>. January 30, 2009, <http://www.reuters.com/article/rbssEnergyNews/idUSL62914620090130>.

## "Evaluating CO<sub>2</sub> reduction strategies in the US."

The following is the abstract of this article: "[The authors] constructed a model to simulate emissions of CO<sub>2</sub> from electricity generation in the [United States] and, using the model, [the authors] developed 20-year projections of emissions under various regulatory scenarios. [The authors] concluded that the State renewable portfolio standards (RPS) adopted by 23 States will decrease emissions by a mere 4.5 [percent] relative to [business-as-usual (BaU)] conditions. By comparison, possible national GHG control strategies such as applying the California standards to the entire [United States] or imposing a 2000-level cap on CO<sub>2</sub> emissions would result in a reduction of 34 [percent] relative to BaU. Finally, imposing a 1990-level cap on CO<sub>2</sub> emissions would result in a reduction of 49 [percent] relative to BaU. Notwithstanding these findings, [the authors] demonstrate that, even the most ambitious GHG reduction strategies being contemplated in the [United States] for the energy generating sector will not reach the 60 [percent] reduction, generally regarded as necessary, on a global scale and from all CO<sub>2</sub>-emitting sectors to prevent an atmospheric warming of about 2 [degrees]. [The authors] conclude that efforts now need to focus, not only on reducing GHG emissions, but equally on preparing for the inevitable climate change. Beyond the scenarios evaluated in this research, the model can serve as a flexible tool for determining whether a given strategy will achieve the desired CO<sub>2</sub> emission reduction goal." **Joseph I. Arar and Douglas Southgate, Ecological Modelling**, Available online January 20, 2009, doi:10.1016/j.ecolmodel.2008.12.005, <http://www.sciencedirect.com/science/article/B6VBS-4VDS47T-4/2/e650234a0d9d37206a110162023b7e81>. (Subscription may be required.)

# GEOLOGY

## "The hydromagnesite playas of Atlin, British Columbia, Canada: A biogeochemical model for CO<sub>2</sub> sequestration."

The following is the abstract of this article: "Anthropogenic [GHG] emissions may be offset by sequestering CO<sub>2</sub> through the carbonation of magnesium silicate minerals to form magnesium carbonate minerals. The hydromagnesite [Mg<sub>5</sub>(CO<sub>3</sub>)<sub>4</sub>(OH)<sub>2</sub>•4H<sub>2</sub>O] playas of Atlin, British



Columbia, Canada provide a natural model to examine mineral carbonation on a watershed scale. At near surface conditions, CO<sub>2</sub> is biogeochemically sequestered by microorganisms that are involved in weathering of bedrock and precipitation of carbonate minerals. The purpose of this study was to characterize the weathering regime in a groundwater recharge zone and the depositional environments in the playas in the context of a biogeochemical model for CO<sub>2</sub> sequestration with emphasis on microbial processes that accelerate mineral carbonation. Regions with ultramafic bedrock, such as Atlin, represent the best potential sources of feedstocks for mineral carbonation. Elemental compositions of a soil profile show significant depletion of MgO and enrichment of SiO<sub>2</sub> in comparison to underlying ultramafic parent material. Polished serpentinite cubes were placed in the organic horizon of a coniferous forest soil in a groundwater recharge zone for three years. Upon retrieval, the cube surfaces, as seen using scanning electron microscopy, had been colonized by bacteria that were associated with surface pitting. Degradation of organic matter in the soil produced chelating agents and acids that contributed to the chemical weathering of the serpentinite and would be expected to have a similar effect on the magnesium-rich bedrock at Atlin. Stable carbon isotopes of groundwater from a well, situated near a wetland in the southeastern playa, indicate that ~12 percent of the dissolved inorganic carbon has a modern origin from soil CO<sub>2</sub>. The mineralogy and isotope geochemistry of the hydromagnesite playas suggest that there are three distinct depositional environments: (1) the wetland, characterized by biologically-aided precipitation of carbonate minerals from waters concentrated by evaporation, (2) isolated wetland sections that lead to the formation of consolidated aragonite sediments, and (3) the emerged grassland environment where evaporation produces mounds of hydromagnesite. Examination of sediments within the southeastern playa-wetland suggests that cyanobacteria, sulphate reducing bacteria, and diatoms aid in producing favorable geochemical conditions for precipitation of carbonate minerals. The Atlin site, as a biogeochemical model, has implications for creating carbon sinks that utilize passive microbial, geochemical and physical processes that aid in mineral carbonation of magnesium silicates. These processes could be exploited for the purposes of CO<sub>2</sub> sequestration by creating conditions similar to those of the Atlin site in environments, artificial or natural, where the precipitation of magnesium carbonates would be suitable. Given the vast quantities of Mg-rich bedrock that exist throughout the world, this study has significant implications for reducing atmospheric CO<sub>2</sub>.

concentrations and combating global climate change.” **Ian M. Power, Siobhan A. Wilson, James M. Thom, Gregory M. Dipple, Janet E. Gabites, and Gordon Southam**, *Chemical Geology*, Available online January 24, 2009, doi:10.1016/j.chemgeo.2009.01.012, <http://www.sciencedirect.com/science/article/B6V5Y-4VFK7YX-3/2/82a3d4a55a01e47ba6845982a9aceb2d>. (Subscription may be required.)

## GEOLOGY (CONTINUED)

**“Water-rock-CO<sub>2</sub> interactions in saline aquifers aimed for carbon dioxide storage: experimental and numerical modeling studies of the Rio Bonito Formation (Permian), southern Brazil.”**

The following is the abstract of this article: “Mineral trapping is one of the safest ways to store CO<sub>2</sub> underground as [carbon] will be immobilized in a solid phase. Carbon dioxide will be, therefore, sequestered for geological periods of time, helping to diminish greenhouse gas emissions and mitigate global warming. Although mineral trapping is considered a fairly long process, owing to the existence of kinetic barriers for mineral precipitation, it has been demonstrated both experimentally and by numerical modeling. Here the results of experimental and numerical modeling studies performed in sandstones of the saline aquifer of the Rio Bonito Formation, Paraná Basin, are presented. The Rio Bonito Formation consists of paralic sandstones deposited in the intracratonic Paraná Basin, southern Brazil, during the Permian (Artinskian-Kungurian). These rocks have the largest potential for CO<sub>2</sub> storage because of their appropriated reservoir quality, depth and proximity to the most important stationary CO<sub>2</sub> sources in Brazil. Here it is suggested that CO<sub>2</sub> can be permanently stored as carbonates as CO<sub>2</sub> reacts with rocks of the Rio Bonito Formation and forms [calcium carbonate (CaCO<sub>3</sub>)] at temperatures and pressures similar to those encountered for CO<sub>2</sub> storage in geological formations. Results of this work will be useful for studies of partitioning mechanisms for [carbon] trapping in CO<sub>2</sub> storage programs.” **J.M. Ketzer, R. Iglesias, S. Einloft, J. Dullius, R. Ligabue, and V. de Lima**, *Applied Geochemistry*, Available online January 14, 2009, doi:10.1016/j.apgeochem.2009.01.001, <http://www.sciencedirect.com/science/article/B6VDG-4VCH6VV-1/2/086dca8c49236e594d034f96d9ab0742>. (Subscription may be required.)

hypothetical mature oil reservoir through EOR operation. Simulations based on mass, energy and entropy balances, as well as economic analysis, were assessed for the process of CO<sub>2</sub> Sequestration combined with EOR. This model takes into account the energy requirements for the whole CO<sub>2</sub> sequestration process, as well as the emissions inherent to the process. Additionally, a breakdown cost methodology is proposed to estimate the main financial determinants of the integrated EOR with CO<sub>2</sub> sequestration (costs of CO<sub>2</sub> purchase, compression, transportation and storage). Project evaluation is derived from a cash flow model, regarding reservoir production profile, price and costs, capital expenditures (CAPEX), operating expenditures (OPEX), carbon credits, depreciation time, fiscal assumptions etc. A sensitivity analysis study is carried out to identify the most critical variables. Project feasibility, as expected, is found to be very sensitive to oil price, oil production, and CAPEX. Moreover, there is the contribution from the mitigation of the GHG by storing a significant amount of CO<sub>2</sub> in the reservoir where it can remain for thousands of years.” **A.T.F.S. Gaspar Ravagnani, E.L. Ligero, and S.B. Suslick**, *Journal of Petroleum Science and Engineering*, Available January 10, 2009, doi:10.1016/j.petrol.2008.12.015, <http://www.sciencedirect.com/science/article/B6VDW-4VBMGN-1/2/9f1ad8ee9341c9ce0e31933d7a4c6e73>. (Subscription may be required.)

**“Modeling vertical stratification of CO<sub>2</sub> injected into a deep layered aquifer.”**

The following is the abstract of this article: “The vertical stratification of CO<sub>2</sub> injected into a deep layered aquifer made up of high-permeability and low-permeability layers, such as Utsira aquifer at Sleipner site in Norway, is investigated with a Buckley-Leverett equation including gravity effects. In a first step, [the authors] study both by theory and simulation the application of this equation to the vertical migration of a light phase (CO<sub>2</sub>), in a denser phase (water), in 1-D vertical columns filled with different types of porous media: homogeneous, piecewise homogeneous, layered periodic and finally heterogeneous. For each case, [the authors] solve the associated Riemann problems and propose semi-analytical solutions describing the spatial and temporal evolution of the light phase saturation. These solutions agree well with simulation results. [The authors] show that the flux continuity condition at interfaces between high-permeability and low-permeability layers leads to CO<sub>2</sub> saturation discontinuities at these interfaces and, in particular, to a saturation increase beneath low-permeability layers. In a second step, [the authors] analyze the vertical migration of a CO<sub>2</sub> plume injected into a 2-D layered aquifer. [The authors] show that the CO<sub>2</sub> vertical stratification under each low-permeability layer is induced, as in 1-D columns, by the flux continuity condition at interfaces. As the injection takes place at the bottom of the aquifer the velocity and the flux function decrease with elevation and this phenomenon is proposed to explain the stratification under each mudstone layer as observed at Sleipner site.” **Mohamed Hayek, Emmanuel Mouche, and Claude Mügler**, *Advances in Water Resources*, Available online January 14, 2009, doi:10.1016/j.advwatres.2008.12.009, <http://www.sciencedirect.com/science/article/B6VCF-4VCH71J-1/2/b9d3a371370d84fc8ca77dac756b8f4>. (Subscription may be required.)

## TECHNOLOGY

**“CO<sub>2</sub> Sequestration Through Enhanced Oil Recovery In A Mature Oil Field.”**

The following is the abstract of this article: “Recent advances in [enhanced oil recovery (EOR)] technology create new opportunities for CO<sub>2</sub> sequestration. This paper proposes a technical-economic model for underground storage of CO<sub>2</sub> emitted by a fertilizer industry in the Northeast of Brazil, in a





## TERRESTRIAL

**“Modelling how carbon affects soil structure.”**

The following is the abstract of this article: “This paper presents a mechanistic model, named Struc-C, which describes how the soil organic carbon (SOC) influences the dynamics of soil structure, and consequently, soil physical behavior. The model is partly inspired from the Rothamsted Carbon model, RothC-26.3, divided into three sub-models; the first describes SOC dynamics, followed by how aggregates can be created from the combination of the SOC with the soil clay, and finally, how this process influences soil porosity. Soil aggregates are regarded as the elementary bricks building soil structure, which comprise of organo-mineral associations that are subsequently bound together by more SOC to form the skeleton of larger aggregates. This is modeled by using two plant material pools from the RothC-26.3 model to create four new pools; three for increasing physical protection (or increasing aggregation), and one for the non-protected SOC (or non-aggregated). Struc-C has been tested over a simulated time of 200 years with input data from Rothamsted (England) and the Australian Capital Territory (Australia), and the output from the carbon model compared with RothC-26.3 outputs for both datasets. Although the model is still in its infancy, the simulations look promising when compared to RothC. Further improvements are also contemplated.” **Karim Malamoud, Alex. B. McBratney, Budiman Minasny, and Damien J. Field, *Geoderma*, Available online January 13, 2009, doi:10.1016/j.geoderma.2008.10.018, <http://www.sciencedirect.com/science/article/B6V67-4VC743W-1/2/b5bb25b870f81829a6970f4353611119>.** (Subscription may be required.)



## TRADING

### Carbon Market Update, February 10, 2009

CCX-CFI 2008 (\$/tCO<sub>2</sub>)  
\$2.05 (Vintage 2008)

EU ETS-EUA DEC 2008  
(\$/tCO<sub>2</sub>) \$12.04

(Converted from € to US\$)



***Forbes, “Ore. Governor Pitches Plan to Cut Carbon Emissions.”***

Oregon Governor Ted Kulongoski proposed a cap-and-trade plan before a legislative panel on February 5, 2009, aimed at reducing CO<sub>2</sub> emissions from utilities and other sources. Under the governor’s bill, the state Environmental Quality Commission will develop a plan and present it to Oregon’s State Legislature in 2011. The governor also discussed implementing a new western regional plan to reduce GHGs. Oregon is already part of the Western Climate Initiative (WCI), which was created to establish a regional market to trade carbon emissions credits, allowing industries that emit GHGs to buy and sell credits. WCI’s goal is to reduce the region’s carbon emissions below the 2005 levels by approximately 15 percent by 2020. To learn more about WCI, visit their website at: <http://www.westernclimateinitiative.org/>. To view Oregon’s Department of Environmental Quality website, click: <http://www.deq.state.or.us/aq/climate/rulemaking.htm>. February 6, 2009, <http://www.forbes.com/feeds/ap/2009/02/06/ap6018979.html>. (Subscription may be required.)

## RECENT PUBLICATIONS

### “Global Carbon Sequestration Markets & Strategies, 2009-2030.”

The following is a summary of this document: “Driven by industry and government urgency to preserve coal as part of the global power generation mix, carbon sequestration is poised for significant growth over the next two decades. The pace of carbon sequestration project development has escalated from a few sporadic demonstrations to a geographically dispersed pipeline growing in scale. Over 110 sequestration projects were in the development stages as of year-end 2008, but significant economic and commercial challenges remain. A new study from Emerging Energy Research, Global Carbon Sequestration Markets & Strategies, 2009-2030, analyzes the role of carbon policies in driving sequestration development, evaluates the strategies of oil and gas players, power companies and entrepreneurial upstarts, and measures the sequestration industry’s long-term growth outlook.” A full summary and the Table of Contents can be viewed at: [http://www.emerging-energy.com/user/CarbonSequestrationMarketsandStrategies2009203050428395\\_pub/CarbonSequestrationStudyPromo.pdf](http://www.emerging-energy.com/user/CarbonSequestrationMarketsandStrategies2009203050428395_pub/CarbonSequestrationStudyPromo.pdf). (Purchase required).

## RECENT PUBLICATIONS (CONTINUED)

### “A Blueprint for Legislative Action.”

The following is from the Introduction of this document: “The United States faces an urgent need to transform our Nation’s economy, make the country more energy secure, and take meaningful action to slow, stop, and reverse GHG emissions to address climate change. The economic, energy, and global warming realities facing the Nation are characterized by a detrimental dependence on foreign oil, economic instability, and a growing recognition that the impacts of a warming planet are being felt today. To address these challenges successfully will require a fundamental shift in the way energy is produced, delivered, and consumed in the U.S. and around the globe. [Americans] need a new vision and policy direction to transition from the technologies and practices [Americans] relied upon in the 20th century to the technologies and practices America will need in the 21st century. [Americans] must: increase the overall energy efficiency of our economy; utilize responsibly our domestic supplies of coal, oil and natural gas; develop and export the transportation technologies and fuels of the future; and ensure the Nation has an adequate supply of electricity produced from low-carbon resources, including wind, solar, next generation nuclear technology, and coal with [CCS]. New and emerging technologies can put [Americans] on the right path, and the potential for other continued technology improvement is high. But to assure success, [Americans] need well-aligned national energy and climate policies that set out a new direction for the country. These policies must establish an orderly and predictable schedule of GHG reductions that will move the private sector to develop and deploy the new and advanced energy technologies of tomorrow. Thoughtful and comprehensive national energy and climate policy will help secure [the] economic prosperity and provide American businesses and the Nation’s workforce with the opportunity to innovate and succeed.” To read the complete United States Climate Action Partnership (USCAP) document, click: [http://www.us-cap.org/pdf/USCAP\\_Blueprint.pdf](http://www.us-cap.org/pdf/USCAP_Blueprint.pdf).

### “A Roadmap for U.S.-China Cooperation on Energy and Climate Change.”

The following is an excerpt from the Introduction of this document: “A new comprehensive program for cooperation between the United States and China that focuses on reducing [GHG] emissions, and thus mitigating the potentially catastrophic effects of climate change, is both necessary and possible. Indeed, as this Report suggests, if human beings hope to avoid the worst consequences of global climate change, the United States and China – respectively the world’s largest developed and developing nations, the two largest energy consumers, and the two largest producers of [GHGs] – have no alternative but to become far more active partners in developing low-carbon economies. To prevail in such a common effort, both countries will need not only bold leadership and a new set of national policies, but also a path-breaking cooperative agenda that can be sustained over the long run. The advent of a new U.S. presidential administration in Washington, D.C., coupled with a central leadership in Beijing that is increasingly aware of the destructive impact and long-term dangers of climate change, presents an unparalleled opportunity for this new strategic partnership. While the current global economic crisis could make joint action between the United States and China more difficult, it could also provide an unexpected impetus. If wisely allocated, funds invested by both governments in economic recovery can help address climate change while also advancing the “green technologies” and industries that will lead to a new wave of economic growth. Stronger bilateral collaboration on energy and climate change has at the same time the real prospect of helping to build a new, more stable, and constructive foundation under Sino-American relations, the most important bilateral relationship in the 21st century world.” To read the entire Pew Center and Asia Society report, go to: <http://www.pewclimate.org/docUploads/US-China-Roadmap-Feb09.pdf>.

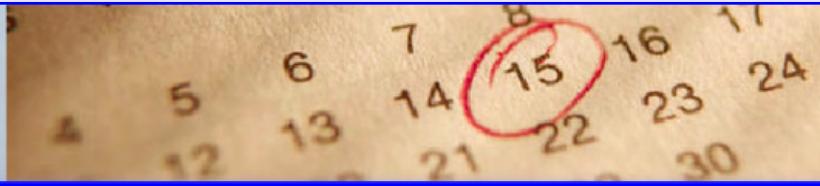
## LEGISLATIVE ACTIVITY

### *Odessa American Online, “Clean Coal Bill.”*

Texas officials filed a bill on January 15, 2009, to make clean coal projects economically viable through different incentives. Under the bill, which requires sequestering at least 60 percent of the CO<sub>2</sub> produced, the first three projects to qualify will receive up to \$100 million in franchise tax credits. The bill will also give a 30-year tax rate reduction to oil producers using CO<sub>2</sub> generated by clean coal plants for EOR. The Bureau of Economic Geology (BEG) at the University of Texas at Austin will perform monitoring, mitigating, and accounting (MVA) duties for the CO<sub>2</sub> sequestration at the first three clean coal sites selected. Colorado-based Summit Power is considering building a plant at a Penwell, Texas, site, but will need to secure the 600 acres where the project would be built. To view the bill, go to: <http://www.legis.state.tx.us/tlodocs/81R/billtext/pdf/HB00469I.pdf>. January 15, 2009, [http://www.oaoa.com/news/bill\\_24958\\_\\_article.html/coal\\_texas.html](http://www.oaoa.com/news/bill_24958__article.html/coal_texas.html).

### *Bismarck Tribune, “Carbon Capture Bills Presented.”*

On January 16, 2009, North Dakota’s Senate Natural Resources Committee heard testimony on SB 2095, which would establish a framework for carbon sequestration. The legislation stems from a two-year project that joined state and energy industry officials from North Dakota’s Department of Health to the North Dakota Petroleum Council. The bill would establish the criteria that an applicant must meet before the Industrial Commission can issue a permit to allow CO<sub>2</sub> storage, create a CO<sub>2</sub> storage facility administrative fund and a CO<sub>2</sub> trust fund, and set a fee that storage operators would pay for each ton of CO<sub>2</sub> stored. North Dakota’s Director of Mineral Resources said SB 2095 would provide oversight of CO<sub>2</sub> sequestration projects to the Industrial Commission, which would issue a certificate after at least 10 years have passed since CO<sub>2</sub> injected ended. The certificate would be issued after the project successfully passed several tests and transfer title of the CO<sub>2</sub> and liability from the storage operators to the state. SB 2095 can be viewed at: <http://www.legis.nd.gov/assembly/61-2009/bill-text/JQTA0100.pdf>. January 17, 2009, <http://www.bismarcktribune.com/articles/2009/01/17/news/topnews/174211.txt>.



## EVENTS

March 5-6, 2009, **CO<sub>2</sub> 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<sub>2</sub> value chain as a solution for CO<sub>2</sub> emission reduction. To learn more, click: <http://www.cmtevents.com/aboutevent.aspx?ev=090313&>.

March 6-7, 2009, **MIT Energy Conference**, *Marriott Hotel in Kendall Square, Cambridge, Massachusetts, USA*. The goal of this Massachusetts Institute of Technology (MIT) conference is to develop solutions for the challenges facing today's energy markets. This free event is designed to combine energy research with businesses that are contributing toward energy solutions. To learn more about the conference, visit: <http://www.mitenergyconference.com/friday.htm>.

March 10-11, 2009, **2<sup>nd</sup> CBM World**, *Hotel Mulia Senayan, Jakarta, Indonesia*. Attendees of this event will receive discuss an updated regulatory framework for the accelerating CBM developments in Indonesia. Other topics include the Chinese government's policy towards foreign investment in CBM, financing activities in relation to CBM, and developing a market for utilizing the coal seam gas. To read more about this event, go to: <http://www.cmtevents.com/aboutevent.aspx?ev=090315&>.

March 16-17, 2009, **International Standards to Promote Energy Efficiency and Reduce Carbon Emissions**, *OECD Conference Centre, Paris, France*. This workshop brings together leading policymakers, standardization professionals, and the private sector to discuss the areas of standardization that will be required to support energy efficiency and carbon reduction objectives. This event hopes to strengthen standardization efforts and the potential of energy efficiency gains. To learn more, click: [http://www.iea.org/Textbase/work/workshopdetail.asp?WS\\_ID=400](http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=400).

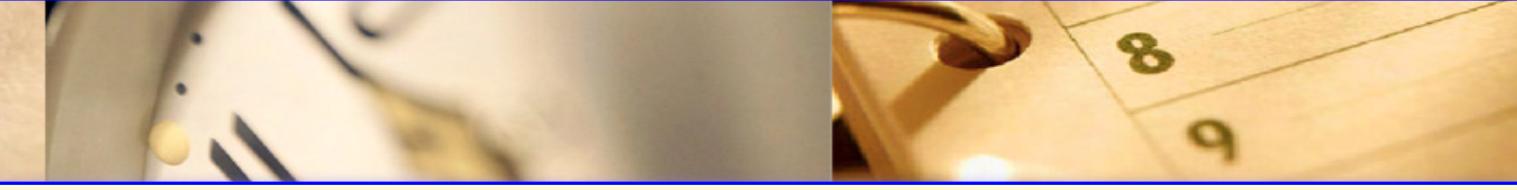
March 17-19, 2009, **Carbon Market Insights 2009**, *Bella Center in Copenhagen, Denmark*. This event will examine the impact(s) that the global economy is having on carbon markets and the effect(s) international policy will have on reaching a new climate agreement. All market aspects – from carbon trading to the voluntary carbon trading market – will be covered. For more information, go to: <http://www.pointcarbon.com/events/conferences/cmi09/1.986082/>.

March 19-21, 2009, **ENVIROENERGY 2009: International Conference on Energy and Environment**, *Taj Chandigarh, Chandigarh, India*. This international conference aims to address the challenges related to energy and environment. The conference agenda will focus on environmental policies, identification of green technologies, and their subsequent implementation for sustainable development. To learn more about ENVIROENERGY 2009, click: <http://www.enviroenergy2009.org/>.

March 22-24, 2009, **First International Greenhouse Gas Measurement Symposium**, *Hyatt Regency San Francisco Airport, Burlingame, California, USA*. This symposium will provide a forum for participants to define and discuss GHG measurements and monitoring, as well as the technical need for accurate local, regional, national, and international monitoring systems. To view the conference website, go to: [http://www.awma.org/events/view\\_event.html?typeid=1&id=115](http://www.awma.org/events/view_event.html?typeid=1&id=115).

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>.

May 4-7, 2009, **8<sup>th</sup> 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>.



## EVENTS (CONTINUED)

May 27-29, 2009, **International Conference on Deep Saline Aquifers for Geological Storage of CO<sub>2</sub> 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<sub>2</sub> storage in saline aquifers, including processes induced by CO<sub>2</sub> 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>.

## FOR SUBSCRIPTION DETAILS...

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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).