



Carbon Sequestration Newsletter

AUGUST 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, “Field Test to Advance Geological Carbon Storage While Enhancing Domestic Oil Supply.”

The Midwest Geological Sequestration Consortium (MGSC) has begun injecting carbon dioxide (CO₂) into a mature oil field in Hopkins County, Kentucky, to assess the region's CO₂ storage capacity and feasibility for enhanced oil recovery (EOR). The test is designed to inject up to 8,000 tons of CO₂ over a period of six to eight months into an existing brine-water injection well at a depth of approximately 1,900 feet; at these

depths, the CO₂ will remain in a gaseous state and partially mix with the oil it encounters. The Kentucky Geologic Survey (KGS) will monitor the CO₂ through a program that will track the rate and volume of the injection and the pressures and temperatures within the well. The results will provide an indication of how efficiently the CO₂ displaces oil within the reservoir and how it stores the CO₂. The project will span more than two years and is expected to create 13 full-time jobs. The test is part of the Regional Carbon Sequestration Partnership (RCSP) Program's Validation Phase, which consists of 22 nationwide field tests conducted in saline formations, depleted oil and gas fields, and unmineable coal seams. To visit the MGSC website, click: <http://sequestration.org/>. June 25, 2009, http://www.fossil.energy.gov/news/techlines/2009/09041-DOE_Partner_Begins_Carbon_Storage_.html.

Fossil Energy Techline, “Secretary Chu Announces Two New Projects to Reduce Emissions from Coal Plants.”

On July 1, 2009, U.S. Department of Energy (DOE) Secretary Steven Chu announced the selection of two projects for up to \$408 million in funding from the American Recovery and Reinvestment Act (ARRA). The two projects will incorporate advanced technologies to reduce CO₂ emissions. In one project, DOE will provide the Basin Electric Power Cooperative with \$100 million to demonstrate the removal of CO₂ from the flue gas from a lignite-based boiler at an existing power plant in Beulah, North Dakota. In the second project, DOE will provide Hydrogen Energy International LLC with \$308 million to design, construct, and operate an Integrated Gasification Combined Cycle (IGCC) power plant in Kern County, California, that will utilize blends of coal and petroleum coke and convert them into hydrogen and CO₂. The goal of both projects is to achieve at least 90 percent CO₂ capture efficiency. The selection of the two projects is part of the third round of the Clean Coal Power Initiative (CCPI), a cost-shared collaboration between the Federal government and private industry to increase investment in low-emission coal technology by demonstrating advanced, coal-based power generation technologies. To view the CCPI Program fact sheet, go to: <http://www.fossil.energy.gov/programs/powersystems/cleancoal/ccpi/Prog052.pdf>. July 1, 2009, <http://www.energy.gov/news2009/7559.htm>.

Fossil Energy Techline, “New Jersey Joins the Energy Department's Carbon Sequestration Regional Partnership Program.”

New Jersey has become the 43rd state to join DOE's RCSP Program, the centerpiece of U.S. efforts to deploy carbon sequestration technologies and



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HIGHLIGHTS (CONTINUED)

reduce greenhouse gas (GHG) emissions. As a member of the Midwest Regional Carbon Sequestration Partnership (MRCSP) and a participant in the MRCSP Phase II Validation Phase projects, New Jersey will focus on developing and integrating data for the potential geologic and terrestrial sequestration capacity within the state. The New Jersey Department of Environmental Protection and Rutgers University will contribute by building and refining the state's geologic and terrestrial sequestration frameworks. Also, due to the abundance of offshore storage potential in New Jersey, MRCSP will include offshore reservoirs in its potential geologic and terrestrial sequestration capacity database for the first time. To learn more about MRCSP, go to: www.mrcsp.org. For more information about DOE's RCSP Program, visit: <http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html>. June 24, 2009, http://www.fossil.energy.gov/news/techlines/2009/09040-New_Jersey_Joins_Regional_Partners.html.

SEQUESTRATION IN THE NEWS

***Business First of Louisville*, "Duke Energy Files Plans for Carbon Storage Study," and *Duke Energy News Release*, "Duke Energy Files Plans for Carbon Storage Study in Southwest Indiana."**

Duke Energy Corporation has filed plans with the Indiana Utility Regulatory Commission (IURC) for a proposed CO₂ storage project in southwest Indiana. Duke Energy will invest \$121 million to store a portion of the CO₂ emissions from a coal-gasification power plant in Edwardsport, Indiana. The CO₂ will be stored underground in deep saline aquifers and depleted oil and gas fields. If the three-year site characterization is considered a success, Duke Energy will seek permission from IURC to permanently capture and store CO₂. Duke Energy applied for a DOE CCPI Round 3 grant in January, which could offset up to 50 percent of the carbon capture and storage (CCS) costs for the project. July 6, 2009, <http://www.bizjournals.com/louisville/stories/2009/07/06/daily7.html>, and July 6, 2009, <http://www.duke-energy.com/news/releases/2009070603.asp>.

***Reuters*, "Alberta to Back Three Carbon Capture Projects," and *The Calgary Herald*, "Alberta Announces Three Winning Projects for Carbon Capture Funding."**

Alberta government officials announced on June 30, 2009, that three CCS projects will be financed using a \$1.7 billion fund set aside last year. Alberta expects to provide up to \$92.5 million this year for design and engineering work on the three proposals. The three projects, which were selected after a year-long competition, include CCS at Royal Dutch Shell Plc's Scotford oil sands upgrader;



SEQUESTRATION IN THE NEWS

(CONTINUED)

a carbon capture facility at a power plant owned by EPCOR and backed by Enbridge, Inc.; and a project that takes CO₂ from an Agrium, Inc. fertilizer plant and a planned upgrader, and ships it by pipeline to oil fields, where it will be used to boost output. The first round of commercial-scale projects is expected to achieve annual CO₂ reductions by 2015. June 30, 2009, http://www.reuters.com/article/internal_ReutersNewsRoom_BehindTheScenes_MOLT/idUSTRE55T78220090630, and July 1, 2009, <http://www.calgaryherald.com/Business/Alberta+announces+three+winning+projects+carbon+capture+funding/1747893/story.html>.

International Power Press Release, “Hazelwood Carbon Capture Project Underway.”

A \$10 million CCS pilot project designed to initially capture up to 25 tonnes of CO₂ per day initiated operation in July 2009 at International Power Australia’s (IPRA) Hazelwood Plant in the Latrobe Valley in Victoria, Australia. The plant has the potential to eventually capture up to 50 tonnes a day. The CO₂ from the power plant’s flue gas is absorbed by a carbon capture technology using a solvent solution; the captured CO₂ is then used to reduce the pH of the power plant’s ash water. The CO₂ reacts with the ash water to produce calcium carbonate (CaCO₃)—a commercially usable product. Officials said that the Hazelwood project will be assessed for its potential applicability to future large-scale projects. The carbon capture plant received technology support from the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC). July 8, 2009, https://www.ipplc.com.au/_modules/Uploader/_uploaderBin/jbrinkworth/eb82e902c881129d320544a947eb8c14nrInternationalPowermrCCSlaunch080709.pdf.

ANNOUNCEMENTS

Funding Opportunity Announcement.

The National Energy Technology Laboratory (NETL) issued a Funding Opportunity Announcement (FOA) on June 29, 2009, to provide training opportunities for graduate and undergraduate students that will provide the human capital and skills required for implementing and deploying CCS technologies. The FOA will advance research in: simulation and risk assessment; monitoring, verification, and accounting (MVA); geological related analytical tools; methods to interpret geophysical models; CO₂ capture; and well completion and integrity. The FOA is available at: <http://www.fossil.energy.gov/programs/sequestration/publications/arra/DE-FOA-0000032.pdf> and applications are due August 11, 2009, at 8:00 p.m. Eastern Time.

WESTCARB Annual Meeting.

The West Coast Regional Carbon Sequestration Partnership (WESTCARB) will hold the WESTCARB 2009 Annual Business Meeting at the FireSky Resort and Spa in Scottsdale, Arizona, on Wednesday, September 16, 2009. Meeting topics include: Phase II geologic and terrestrial field projects, improved characterization of regional CO₂ storage opportunities, progress for the Phase III large-volume geologic storage test, and national and state legislative/regulatory developments. More information is available at: http://www.westcarb.org/AnnualMtg_scottsdale_announcement.html.

BSCSP Annual Meeting.

The Big Sky Carbon Sequestration Partnership (BSCSP) will hold its annual meeting at the Gallatin Gateway Inn in Bozeman, Montana, on September 23-24, 2009. Experts will discuss carbon sequestration technologies; CCS economics, costs, and opportunities; Federal and state regulatory procedures; energy policies; and carbon sequestration site development. Registration is free and open to the public until September 11, 2009; audience members will have an opportunity to ask questions following panel presentations. Registration information is available at: http://www.bigskyco2.org/annual_meeting09.

New Zealand Joins International Carbon Storage Group.

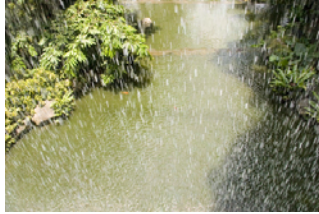
New Zealand became the 23rd member of the Carbon Sequestration Leadership Forum (CSLF) during a meeting in San Francisco, California, on June 29, 2009. To visit the CSLF website, go to: <http://www.csulf.org/>. For more information, click: http://www.fossil.energy.gov/news/techlines/2009/09042-New_Zealand_Joins_CSLF.html.

SEG CO₂ Sequestration Geophysics Workshop.

This Society of Exploration Geophysicists- (SEG) hosted workshop, scheduled for August 23-27, 2009, will focus on the geophysical aspects of CCS, such as rock and fluid physics, flow-to-seismic simulations, site characterization, CO₂ plume imaging and monitoring, quantitative CO₂ estimation and inversion, risk assessment, and novel case studies. For detailed information, visit: http://www.seg.org/SEGportalWEBproject/portals/SEG_Online.portal?_nfpb=true&_pageLabel=pg_gen_content&Doc_Url=prod/SEG-Meetings/Mtgs-Upcoming-Mtgs/SRW2009Alberta/index.htm.

MSNBC.com, “Study: Tropical Rain Band is Shifting North.”

Authors of a recent study state that the Earth’s most prominent rain band, which they believe bordered the equator 350 years ago during the planet’s Little Ice Age from approximately 1400 to 1850, has shifted north at an average rate of approximately one mile a year for three centuries due to climate change. The band supplies freshwater to almost 1 billion people and if the northern migration continues, the scientists asserted that some Pacific islands near the equator may no longer receive freshwater by mid-century or sooner. While the scientists noted there is no global water shortage, humans are placing additional pressure on water resources. According to the scientists, the band of tropical rainfall stems from the “intertropical convergence zone,” where winds from the northern and southern hemispheres meet and heat enters into the atmosphere from the tropical sun. To arrive at their conclusions, the authors analyzed rainfall records from annual layers of lake and lagoon sediments on four Pacific islands at or near the equator. The researchers found that areas like Washington Island, which sits at the southern edge of the intertropical convergence zone, and the island of Palau, which lies in the heart of the modern convergence zone, receive an ample supply of rainfall. Researchers also found evidence that areas located on the equator in the Eastern Pacific like the Galapagos Islands possessed a wet climate during the Little Ice Age and currently have an arid climate. The study, titled, “Southward movement of the Pacific intertropical convergence zone AD 1400-1850,” is available at: <http://www.nature.com/ngeo/journal/v2/n7/abs/ngeo554.html>. July 2, 2009, http://www.msnbc.msn.com/id/31709811/ns/us_news-environment/.



Science Daily, “Climate Change May Spell Demise of Key Salt Marsh Constituent.”

New research shows that a component of salt marshes known as pannes could be affected by climate change. Pannes, which are waterlogged, low-oxygen zones of salt marshes, are considered “plant diversity hotspots,” as at least a dozen species of plants called forbs inhabit them, including *Limonium nashii* (sea lavender), *Salicornia europaea* (pickleweed), and *Triglochin maritima*. To arrive at their conclusions, the researchers subjected plots of forb pannes to air about six degrees Fahrenheit warmer than the surrounding area; they found that plant growth initially increased, but the plants began a rapid die-off and were replaced by the salt marsh grass *Spartina patens*. In tests that spanned from 2004 to 2006, the forbs pannes cover dropped from 50 percent to less than 10 percent at two sites – Nag Creek (Prudence Island, Rhode Island) and Little River (Maine). At the third test site, Drakes Island (Maine), the forb pannes cover decreased from 50 percent to 44 percent in Summer 2007. The researchers believe the forbs disappeared due to changes in the plant-water balance, meaning the warmer air caused the forbs to take in more water, making the area less waterlogged and more welcoming for *Spartina patens*, which prefers less water-soaked environments. In the New England region, pannes span from Connecticut, where they make up less than 10 percent of a salt marsh’s area, to Maine, where they can consist of about 40 percent of the salt

marsh ecosystem. The study, titled, “Experimental warming causes rapid loss of plant diversity in New England salt marshes,” is available at: <http://www3.interscience.wiley.com/journal/122473116/abstract>. July 15, 2009, <http://www.sciencedaily.com/releases/2009/07/090713085016.htm>.

POLICY

UK Department of Energy and Climate Change, “Clean Coal to Support Up to 60,000 UK Jobs,” and UK Department of Energy and Climate Change, “Clean Coal Funding Bill Announced.”

The United Kingdom (UK) proposed a new energy bill for the upcoming Parliamentary session as part of an effort to advance clean coal technologies. The bill would enable the Secretary of State for Energy and Climate Change to fund up to four commercial-scale CCS demonstration plants; the first of these could be in operation by the middle of the next decade. The bill follows the publication of a consultation document, titled, “A Framework for the Development of Clean Coal,” (available at: http://www.decc.gov.uk/Media/viewfile.ashx?FilePath=Consultations\A framework for the development of clean coal\1_20090617164456_e_@@_cleancoalcondoc2.pdf&filetype=4) on June 17, 2009, which lays the foundation for how the UK Government proposes integrating emissions reducing technologies into future coal-fired power plants. Specifically, the proposals under consultation in the document include: providing funding for up to four commercial-scale CCS demonstrations; requiring new coal-fired power plants to demonstrate CCS; and requiring new coal-fired power plants to retrofit CCS within five years of CCS being independently judged technically and economically proven. The consultation also contains proposals for the design of the financial support mechanism introduced in the bill. June 29, 2009, <http://www.decc.gov.uk/en/content/cms/news/pn068/pn068.aspx>, and June 17, 2009, <http://www.decc.gov.uk/en/content/cms/news/pn061/pn061.aspx>.

“A survey on the public perception of CCS in France.”

The following is the Abstract of this article: “An awareness and opinion survey on CCS was conducted on a representative sample of French residents aged 15 years and above. About [six percent] of respondents were able to provide a satisfactory definition of the technology. The key question about ‘approval of or opposition to’ the use of CCS in France was asked twice, first after presenting the technology, then after explaining its potential adverse consequences. The approval rates, which were 59 [percent] and 38 [percent], respectively, show that there is no a priori rejection of the technology. The sample was split in two to test for a semantic effect: half of the questionnaires used ‘stockage’ (English: storage), the other half ‘Sequestration.’ Manipulating the vocabulary had no statistically significant effect on approval rates. Stockage is more meaningful, but does not convey the idea of permanent monitoring.” **Minh Ha-Duong, Alain Nadaï, and Ana Sofia Campos, *International Journal of Greenhouse Gas Control*, Available online June 23, 2009, doi:10.1016/j.ijggc.2009.05.003, <http://www.sciencedirect.com/science/article/B83WP-4WKJ5MD-3/2/bc6a8c7e9e404ca4ea4498a5ca1e1037>. (Subscription may be required.)**

“Optimizing geologic CO₂ sequestration by injection in deep saline formations below oil reservoirs.”

The following is the Abstract of this article: “The purpose of this research is to present a best-case paradigm for geologic CO₂ storage: CO₂ injection and sequestration in saline formations below oil reservoirs. This includes the saline-only section below the oil-water contact (OWC) in oil reservoirs, a storage target neglected in many current storage capacity assessments. This also includes saline aquifers (high porosity and permeability formations) immediately below oil-bearing formations. While this is a very specific injection target, [the authors] contend that most, if not all, oil-bearing basins in the [United States] contain a great volume of such strata, and represent a rather large CO₂ storage capacity option. [The authors] hypothesize that these are the best storage targets in those basins. The purpose of this research is to evaluate this hypothesis. [The authors] quantitatively compared CO₂ behavior in oil reservoirs and brine formations by examining the thermophysical properties of CO₂, CO₂-brine, and CO₂-oil in various pressure, temperature, and salinity conditions. In addition, [the authors] compared the distribution of gravity number (N), which characterizes a tendency towards buoyancy-driven CO₂ migration, and mobility ratio (M), which characterizes the impeded CO₂ migration, in oil reservoirs and brine formations. [The authors] research suggests competing advantages and disadvantages of CO₂ injection in oil reservoirs vs. brine formations: (1) CO₂ solubility in oil is significantly greater than in brine (over 30 times); (2) the tendency of buoyancy-driven CO₂ migration is smaller in oil reservoirs because density contrast between oil and CO₂ is smaller than it between brine and oil (the approximate density contrast between CO₂ and crude oil is ~100 kg/m³ and between CO₂ and brine is ~350 kg/m³); (3) the increased density of oil and brine due to the CO₂ dissolution is not significant (about 7–15 kg/m³); (4) the viscosity reduction of oil due to CO₂ dissolution is significant (from 5790 to 98 mPa s). [The authors] compared these competing properties and processes by performing numerical simulations. Results suggest that deep saline CO₂ injection immediately below oil formations reduces buoyancy-driven CO₂ migration and, at the same time, minimizes the amount of mobile CO₂ compared to conventional deep saline CO₂ injection (i.e., CO₂ injection into brine formations not below oil-bearing strata). Finally, to investigate practical aspects and field applications of this injection paradigm, [the authors] characterized oil-bearing formations and their thickness (capacity) as a component of the Southwest Regional Partnership on Carbon Sequestration (SWP) field deployments. The field-testing program includes specific sites in Utah, New Mexico, Wyoming, and western Texas of the United States.” **Weon Shik Han and Brian J. McPherson**, *Energy Conversion and Management*, Available online July 12, 2009, <http://dx.doi.org/10.1016/j.enconman.2009.06.008>, <http://www.sciencedirect.com/science/article/B6V2P-4WRKF58-3/2/b40c9bdede3002b3ec95edd7e93fdb45>. (Subscription may be required.)

“Oil Recovery and Sequestration Potential of Naturally Fractured Reservoirs During CO₂ Injection.”

The following is the Abstract of this article: “With urgent need of [GHG] sequestration and booming oil prices, underground oil/gas reservoirs seem the only value-added choice. A great portion of current CO₂ injection projects in the world is in naturally fractured reservoirs.

The matrix part of these reservoirs constitutes the major oil storage unit and this oil is targeted during CO₂ injection. It is [the authors’] intention to show that this media could also be used as permanent CO₂ storage unit while recovering oil from it. These reservoirs, however, are complex in nature and the physics of the matrix–fracture interaction process during CO₂ injection is still not known to a great extent. To ease the complex nature of the problems, experiments were performed on fractured sandstone cores (single fracture) saturated with n-decane and carbonate cores saturated with dead crude oil. CO₂ was injected at constant rates into the fracture while maintaining the high pressure into the core and the system. Injection and production data were monitored and collected using continuous data logging system. After continuous injection, diffusion of CO₂ was allowed to occur by shutting down the system for a specific period of time and followed by a blowdown period to recover oil that diffused from matrix to fracture. At different pressure steps, produced liquid was analyzed using gas chromatography while the produced gas was measured using a flow meter. The CO₂ storage capacity of the rock with change in the pressure and the amount of oil recovered during blow down period were analyzed. The results of the continuous injection experiments were used to obtain diffusion coefficients by matching the simulation results. Using dimensionless analysis and matrix–fracture diffusion groups, [the authors] obtained a critical number for optimal recovery/sequestration. The pressure decay behavior during the shutdown was analyzed in conjunction with the gas chromatograph analysis of produced oil sample collected during blowdown after the quasiequilibrium reached during pressure decay. This led to insights into the governing mechanism of extraction/condensation and miscibility for recovering lighter to heavier hydrocarbons during pressure depletion from fractured reservoirs.” **J. J. Trivedi and T. Babadagli**, *Energy Fuels*, Available online July 8, 2009, DOI:10.1021/ef900361n, <http://pubs.acs.org/doi/abs/10.1021/ef900361n>. (Subscription may be required.)

“Coal energy conversion with carbon sequestration via combustion in supercritical saline aquifer water.”

The following is the Abstract of this article: “The standard idea for deep saline aquifer sequestration is to separate [CO₂] from a process stream, compress it, and inject it underground. However, since [CO₂] is less dense than water, even at the high pressures found in aquifers, it is buoyant and will move towards the surface unless trapped by an impermeable seal. Also, significant energy expenditure is required to separate and compress [CO₂], even though neat [CO₂] is not a desired product. These issues may be addressed by combining the idea of fast dissolution at the surface with supercritical water oxidation (SCWO). By burning coal at high pressure in supercritical water drawn from an aquifer, and then sequestering the entire pre-equilibrated effluent, all carbon from the fuel is captured, as well as all non-mineral coal combustion products including sulfur and metals. A possible block diagram of an SCWO-based electric power plant is proposed, including processes to handle salts from the aquifer brine and minerals from coal. The plant is thermodynamically modeled, using an indirectly fired combined cycle to convert energy from hot combustion products to work. This model estimates the overall thermal efficiency that can be achieved, and reveals unanticipated interactions within the plant that have significant effects on efficiency. The assumptions and results of the model highlight design challenges for an actual system.” **J.R. Heberle and C.F. Edwards**, *International*

GEOLOGY (CONTINUED)

Journal of Greenhouse Gas Control, Available online June 23, 2009, doi:10.1016/j.ijggc.2009.05.001, <http://www.sciencedirect.com/science/article/B83WP-4WKJ5MD-1/2/6ae9153b19566cbbfbb6944546432a5c>. (Subscription may be required.)

TECHNOLOGY

“Screening and selection of sites for CO₂ sequestration based on pressure buildup.”

The following is the Abstract of this article: “This paper presents a simple methodology for estimating pressure buildup due to the injection of supercritical CO₂ into a saline formation, and the limiting pressure at which the formation starts to fracture. Pressure buildup is calculated using the approximate solution of Mathias et al., which accounts for two-phase Forchheimer flow (of supercritical CO₂ and brine) in a compressible porous medium. Compressibility of the rock formation and both fluid phases are also accounted for. Injection pressure is assumed to be limited by the pressure required to fracture the rock formation. Fracture development is assumed to occur when pore pressures exceed the minimum principal stress, which in turn is related to the Poisson’s ratio of the rock formation. Detailed guidance is also offered concerning the estimation of viscosity, density, and compressibility for the brine and CO₂. Example calculations are presented in the context of data from the Plains CO₂ Reduction (PCOR) Partnership. Such a methodology will be useful for screening analysis of potential CO₂ injection sites to identify which are worthy of further investigation.” **Simon A. Mathias, Paul E. Hardisty, Mark R. Trudell, and Robert W. Zimmerman**, *International Journal of Greenhouse Gas Control*, Available online June 23, 2009, doi:10.1016/j.ijggc.2009.05.002, <http://www.sciencedirect.com/science/article/B83WP-4WKJ5MD-2/2/b556fae8e190d1512aa0c9aeb46979f7>. (Subscription may be required.)

data from a Mojave Desert landscape, and (3) apply the model to understanding soil inorganic carbon response to elevated atmospheric CO₂ concentrations. Two parameters are introduced in this study to account for surface water redistribution on the landscape: the precipitation threshold (Ω) and the topographic index threshold (Λ). These parameters account for runoff-generating rainfall events (Ω) and the potential to shed or collect water at a location (Λ). A one-dimensional compartmentalized thermodynamic model is used to simulate calcite precipitation and dissolution. Geomorphic delineation, sediment collected from dust traps, and detailed soil descriptions including percent sand and clay, and bulk density from 16 soil pits of the southern Fry Mountain piedmont served as inputs into the model. Precipitation and temperature inputs were simulated using stochastic models. Time steps for the sample sites used to calibrate the model were determined from optically-stimulated luminescence dates. Incorporation of precipitation and topographic index thresholds into the model allowed more information to be extracted from carbonate depth distributions than previous pedogenic calcite models. The model predicts a net loss of inorganic carbon from the upper 10 cm soil depth under elevated atmospheric CO₂ and a consequent gain in the 10-20 cm depth. The leaching of calcite from shallow depths to below 10 cm is evident in all landforms including those most susceptible to wind erosion. This leads to the conclusion that increased atmospheric CO₂ levels may result in a concentration of inorganic carbon at a depth that is protected from wind erosion creating a more geomorphically stable pool of carbon.” **Daniel R. Hirmas, Christopher Amrhein, and Robert C. Graham**, *Geoderma*, Available online July 8, 2009, doi:10.1016/j.geoderma.2009.05.005, <http://www.sciencedirect.com/science/article/B6V67-4WPS9N5-1/2/5165685689b2af372428e397b861fdff>. (Subscription may be required.)

Carbon Market Update, July 24, 2009

CCX-CFI 2009 (\$/tCO₂)
\$0.50 (Vintage 2009)

EU ETS-EUA DEC 2009
(\$/tCO₂) \$20.44

(Converted from € to US\$)

TERRESTRIAL

“Spatial and process-based modeling of soil inorganic carbon storage in an arid piedmont.”

The following is the Abstract of this document: “Inorganic carbon comprises approximately a third of the total carbon pool in soils worldwide, largely in the form of pedogenic calcite. Pedogenic calcite occurs in semi-arid and arid regions in the form of calcareous, calcic, and petrocalcic horizons. Understanding the processes governing the storage and flux of this inorganic carbon pool is crucial to the development of accurate regional and global carbon budgets. Objectives of this study were to: (1) develop a process-based pedogenic calcite model that accounts for landscape hydrology and geomorphic position, (2) calibrate model parameters with field

TRADING

RGGI News Release, “Fourth RGGI Auction Yields \$104.2 Million for Investment in the Green Economy.” On June 17, 2009, the 10 states participating in the Regional Greenhouse Gas Initiative (RGGI) conducted their fourth regional carbon allowance auction, raising a total of \$104.2 million from selling all of the 30,887,620 available allowances for the 2009 vintage at a price of \$3.23. Potomac Economics, the RGGI independent market monitor, found that 54 separate entities submitted bids to purchase 2.6 times the available supply of 2009 allowances; compliance entities and their affiliates purchased 85 percent of the 2009 allowances offered. In a parallel offering, the RGGI states also auctioned all of the



TRADING (CONTINUED)

2,172,540 allowances for the 2012 vintage at a price of \$2.06 for the second three-year control period beginning January 1, 2012. Thirteen entities submitted bids to purchase 1.5 times the available supply of 2012 allowances; compliance entities and their affiliates purchased

81 percent of the 2012 allowances offered. Since the first auction in September 2008, RGGI members have auctioned more than 110 million allowances for a total of \$366.5 million to invest in energy efficiency, renewable energy, and other programs. Potomac Economics' Marketing Monitoring Report for Auction 4 is available at the following link. June 19, 2009, http://www.rggi.org/docs/Auction_4_News_Release_MM_Report.pdf.

RECENT PUBLICATIONS

“A Performance Standards Approach to Reducing CO₂ Emissions from Electric Power Plants.”

The following is the Abstract of this document: “The premise of this paper is that significant reductions in the CO₂ emissions from fossil fuel power plants are urgently needed as part of a national effort to address global climate change. This paper describes one of several policy approaches for reducing CO₂ emissions from U.S. electric power plants, namely, the application of performance standards limiting CO₂ emissions from electric power generators. In contrast to a cap-and-trade policy that limits the total annual mass emissions of CO₂ from a collection of sources, a performance standard may apply to individual generating units or to a collection of plants. It typically specifies a maximum allowable rate of emissions per unit of product (e.g., pounds of CO₂ per megawatt-hour of electricity generated or sold), or a required percentage reduction in potential emissions. For new fossil fuel power plants that begin construction after a specified date, a New Source Performance Standard (NSPS) could restrict CO₂ emissions to levels achievable only with CCS. For existing power plants, emissions could be restricted in any of several ways, including: age-based performance standards for individual units; fleet-wide performance standards that vary over time (with flexibility for emissions trading); or performance standards applied to electricity sales from either coal plants or all plant types (also varying over time). Several types of CO₂ performance standards are evaluated and compared to a cap-and-trade policy based on nine criteria established under the Pew Center Coal Initiative. Maintaining a significant role for coal in the U.S. generating mix emerges as an especially important criterion in evaluating alternative policy options.” To read the complete document, click: <http://www.pewclimate.org/docUploads/Coal-Initiative-Series-Rubin.pdf>.

“Realistic Costs of Carbon Capture.”

The following is the Abstract of this document: “There is a growing interest in CCS as a means of reducing CO₂ emissions. However, there are substantial uncertainties about the costs of CCS. Costs for pre-combustion capture with compression (i.e. excluding costs of transport and storage and any revenue from EOR associated with storage) are examined here for First-of-a-Kind (FOAK) plant and for more mature technologies (Nth-of-a-Kind plant [NOAK]). For FOAK plant using solid fuels the levelized cost of electricity on a 2008 basis is approximately 10¢/kWh higher with capture than for conventional plants (with a range of 8-12 ¢/kWh). Costs of abatement are found typically to be approximately \$150/tCO₂ avoided (with a range of \$120-180/tCO₂ avoided). For NOAK plants, the additional cost of electricity with capture is approximately 2-5¢/kWh, with costs of the range of \$35-70/tCO₂ avoided. Costs of abatement with carbon capture for other fuels and technologies are also estimated for NOAK plants. The costs of abatement are calculated with reference to conventional supercritical pulverized coal (SCPC) plant for both emissions and costs of electricity. Estimates for both FOAK and NOAK are mainly based on cost data from 2008, which was at the end of a period of sustained escalation in the costs of power generation plant and other large capital projects. There are now indications of costs falling from these levels. This may reduce the costs of abatement so costs presented here may be ‘peak of the market’ estimates.” This document is available at: <http://e360.yale.edu/images/digest/2009-ccs-report-harvard.pdf>.

“CCSReg Project Policy Brief Summaries.”

The following is a summary of the policy brief series: “The Carbon Capture and Sequestration Regulatory Project (CCSReg) is developing recommendations for regulation of deep geological sequestration of [CO₂] in the United States. The project is funded by a grant from the Doris Duke Charitable Foundation and anchored at Carnegie Mellon University with collaborators at the University of Minnesota, Vermont Law School, and the law firm of Van Ness Feldman. In January of 2009, the project released an interim report titled ‘Carbon Capture and Sequestration: Framing the Issues for Regulation.’ The interim report identifies a number of regulatory and legal barriers to the large-scale deployment of CCS technology and various options to remove them. The next stage of [the authors’] work is to prepare policy briefs that recommend specific options to address these issues.” The summary policy brief is available at: http://www.ccsreg.org/pdf/Brief%20Summaries_07212009.pdf. The collection of policy briefs, including “Comprehensive Regulation of Geologic Sequestration,” “Regulating Carbon Dioxide Pipelines for the Purpose of Transporting Carbon Dioxide to Geologic Sequestration Sites,” “Governing Access to and Use of Pore Space for Deep Geologic Sequestration,” and “Compensation, Liability and Long-Term Stewardship for CCS,” is available at: http://www.ccsreg.org/policy_briefs.html.

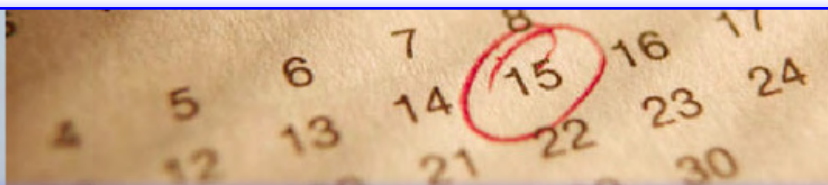
LEGISLATIVE ACTIVITY

Senator Robert P. Casey, Jr. News Release, “Casey, Enzi Introduce Bill to Encourage Private Investment in Carbon Capture and Storage.”

On July 22, 2009, U.S. Senators Bob Casey (Pennsylvania) and Mike Enzi (Wyoming) introduced the Carbon Storage Stewardship Trust Fund Act of 2009 (S. 1502) to create a program for managing the liability of the long-term CO₂ storage. The program would provide the private sector with a framework for the legal and financial responsibilities of commercial carbon storage operations, create a carbon storage liability trust fund, and share liability between the private sector and the Federal government. Specifically, S. 1502 would: (1) require private liability insurance for geological storage facility construction and for CO₂ transport, injection, well plugging, post-closure monitoring; (2) establish a Federal trust fund from fees paid for by commercial CO₂ storage facility operators; (3) establish a Federal program to certify closure of commercial facilities and transfer of liability to the Federal government; (4) transfer post-closure liability to the Federal government or state upon closure; and (5) provide for prompt compensation for damages from the transport, injection, or storage of CO₂ in geological storage units. The Carbon Storage Stewardship Trust Fund Act of 2009 is available at: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:s1502is.txt.pdf. July 22, 2009, <http://casey.senate.gov/newsroom/press/release/?id=1dcc1f91-d977-4818-b6f4-9a5226a52b62>.

Senator Dianne Feinstein Press Release, “Senators Feinstein and Snowe Introduce Measure to Establish Federal Oversight for New Carbon Markets.”

U.S. Senators Dianne Feinstein (California) and Olympia Snowe (Maine) introduced the Carbon Market Oversight Act of 2009 (S.1399), which would establish a framework to regulate the trading of carbon allowances and standardized carbon derivatives. The legislation would also grant full oversight authority for all carbon market trading to the Commodity Futures Trading Commission (CFTC). The legislation is derived from the three following principles: carbon market trading should be transparent and electronically monitored; manipulation, fraud, and speculation should be prohibited and violations should be punished; and professional standards for all registered carbon market traders, dealers, and brokers should be established. In terms of transparency, the legislation would require all carbon allowance trading and standardized allowance derivatives to occur through “registered carbon trading facilities” and be cleared by CFTC. With respect to manipulation, fraud, and speculation, “registered carbon trading facilities” would be required to monitor for manipulation using electronic tools; establish and enforce fair trading rules; and enforce aggregate position limits. Finally, traders cannot be felons; may not have been stripped of a financial license; submit to a background check; complete at least 20 hours of pre-registration education on trading ethics, rules, and laws; and must pass a test approved by CFTC. The Carbon Market Oversight Act of 2009 is available at: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:s1399is.txt.pdf. July 7, 2009, http://feinstein.senate.gov/public/index.cfm?FuseAction=NewsRoom.PressReleases&ContentRecord_id=56882a2e-5056-8059-7641-d899a09efeac.



EVENTS

August 16-19, 2009, **Geological Carbon Sequestration: Prediction and Verification**, *Vancouver, British Columbia, Canada*. This research conference will bring together experts from government, industry, and academia to discuss geological CO₂ sequestration and improve the ability to predict and verify the fate of injected CO₂ in the subsurface. Topics include site selection and characterization, large-scale simulations, and MVA. For more information, visit the conference website at: <http://www.aapg.org/education/hedberg/vancouver/index.cfm>.

August 19-21, 2009, **COAL-GEN 2009**, *Charlotte Convention Center, Charlotte, North Carolina, USA*. This three-day event covers the current state of the coal industry and offers attendees the opportunity to learn how to capitalize on the challenges facing coal-fired power plants. Also included are technical tours of Duke Energy’s Cliffside and Allen Steam Stations. For more information, visit: <http://www.coal-gen.com/index/exhibition.html>.

September 1-4, 2009, **COAL-GEN Europe**, *Expo Silesia, Katowice, Poland*. COAL-GEN Europe offers attendees two parallel conference tracks to examine the latest clean coal technology developments and discuss the issues facing the European coal-fired power generation sector. To view the conference topics, registration information, and the two-track agenda, go to: <http://cge09.events.pennnet.com/fl/content.cfm?NavId=8523&Language=Engl>.



EVENTS (CONTINUED)

September 13-19, 2009, **8th International Carbon Dioxide Conference**, *Friedrich-Schiller-University, Jena, Germany*. This conference provides a multidisciplinary forum for all aspects of modern carbon cycle research relevant to understanding the natural and anthropogenic controls of atmospheric CO₂ and its interactions in the global ecosystem. For registration information, visit the conference website at: <http://www.conventus.de/icdc8/>.

September 14-15, 2009, **Carbon Capture and Sequestration Summit**, *Omni Shoreham Hotel, Washington, DC, USA*. The goal of this summit is to develop a greater understanding of current and future needs for the commercialization of CCS. Topics to be discussed include: current Federal and state legal and regulatory environments; CCS economics and business models; and the challenges facing CO₂ transportation and storage. To learn more, click: <http://www.americanconference.com/energy/Energy.htm?PageMode=Search>.

September 14-15, 2009, **Platts 2nd Annual Carbon Capture & Sequestration**, *Westin Grand Hotel in Washington, DC, USA*. This two-day conference has three main focuses: new policy directions and economic challenges for large-scale deployment; jurisdiction and regulatory framework; and CCS economics. To view the full agenda, visit the conference website by clicking: <http://www.environmental-expert.com/resultEachEvent.aspx?cid=20884&codi=8025&lr=1>.

September 22-24, 2009, **Carbon Capture and Storage World Summit**, *Hotel Palomar Arlington, Arlington, Virginia, USA*. This summit will provide a comprehensive look at CCS by examining the most up-to-date information on CCS policy and funding, as well as technology and industry updates. For more information, visit the summit website at: <http://www.carboncaptureandstorageconference.com/>.

September 29-30, 2009, **South African Carbon Capture & Storage Conference**, *The Sandton Sun, Johannesburg, South Africa*. This conference provides an entry level introduction to CCS that aims to develop a basic understanding of the various technical, economic, policy, and regulatory aspects of capturing and storing CO₂. To view a detailed program, visit the conference website at: <http://www.ccsconference.co.za/index.html>.

September 30-October 2, 2009, **5th Conference on Carbon Credit Market and Carbon Capture and Storage**, *Rome Fair Centre, Rome, Italy*. The only Italian event specializing in GHG emissions and the technology used for GHG reductions, this conference will take place in conjunction with CCS EXPO, the first event for the Mediterranean area focused on CCS. To learn more information, click: http://www.zeroemissionrome.eu/en/index_co2.asp.

November 5-6, 2009, **3rd International Symposium: Capture and Geological Storage of CO₂ - Accelerating Deployment**, *Paris, France*. This symposium takes a global and cross-disciplinary approach that focuses on the industrial deployment of CCS. Included in the agenda is a discussion on DOE's RCSPs. For more information, including a detailed program, visit the conference website at: <http://www.ccsconference.co.za/index.html>.

FOR SUBSCRIPTION DETAILS...

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

To view an archive with past issues of the newsletter, see: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/subscribe.html.

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.