Carbon Sequestration Newsletter

July 2010

What's Inside?

Introduction

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

Highlights

***Fossil Energy Techline*, "Alabama Project Testing Potential for Combining CO_2 Storage with Enhanced Methane Recovery."**

As part of the Regional Carbon Sequestration Partnership (RCSP) Initiative's Validation Phase (Phase II), the Southeast Regional Carbon Sequestration Partnership (SECARB) has started field testing the potential for combining geological carbon dioxide (CO_2) storage enhanced methane recovery. The Black Warrior CO_2 Storage Project will inject CO_2 into a coalbed methane (CBM) well in Tuscaloosa County, Alabama, to assess the capability of mature CBM reservoirs to receive and adsorb large volumes of CO_2. Injection began at the test site on June 15; the site was selected because it is representative of the 23,000-square-mile Black Warrior Basin located in northwestern Alabama and northeastern Mississippi. It is estimated that this area has the potential to store in the range of 1.1 to 2.3 Gigatons of CO_2, which is approximately the amount that Alabama's coal-fired power plants emit in two decades. The targeted coal seams range from 940 to 1,800 feet deep and are one to six feet thick. Approximately 240 tons of CO_2 will be injected over a 45- to 60-day period. More information on SECARB is available at: http://www.secarbon.org/. To view a map of the U.S. Department of Energy's (DOE) Validation Phase projects, click: http://www.netl.doe.gov/technologies/carbon_seq/partnerships/validation.html. June 16, 2010, http://www.fossil.energy.gov/news/techlines/2010/10019-CO2_Injection_Begins_in_Black_Warr.html.

***Fossil Energy Techline*, "Award-Winning DOE Technology Scores Success in Carbon Storage Project."**

The Southwest Regional Partnership (SWP) has successfully demonstrated SEQURE™ tracer technology, which detects and tracks CO_2 movement in underground geologic storage reservoirs, at its San Juan Basin test site. Developed by scientists at the Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL), the technology uses perfluorocarbon tracers (PFTs) to provide a verifiable method to measure CO_2 movements and detect potential escape. The tracer technology improved modeling techniques vital to defining storage capacity, injection capability, flow rates, and numbers of wells associated with storage sites. Carbon dioxide concentrations as small as parts-per-quadrillion levels can be measured by the technology, and injected CO_2 can be differentiated from natural CO_2. Research demonstrating and confirming long-term CO_2 storage security is believed to be an important condition for the large-scale deployment of carbon capture and storage (CCS). SWP began injecting approximately 35,000 tons of CO_2 into the San Juan coalbed to maximize permanent storage of CO_2,

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Highlights (Continued)

while simultaneously recovering natural gas. The San Juan Basin, considered one of the top locations worldwide for CBM recovery and an ideal site for CO_2 storage, contains three CBM-producing wells and a central injection well. To visit the SWP website, go to: http://southwestcarbonpartnership.org/. To learn more about DOE's Carbon Sequestration Program, click: http://www.fossil.energy.gov/programs/sequestration/index.html. June 9, 2010, http://www.fossil.energy.gov/news/techlines/2010/10016-Tracers_Track_Subsurface_Movement_.html.

Sequestration in the News

***DOE Press Release*, "Secretary Chu Announces Nearly $1 Billion Public-Private Investment in Industrial Carbon Capture and Storage."**

Three projects have been selected to receive funding from the American Recovery and Reinvestment Act (Recovery Act) to demonstrate large-scale CCS from industrial sources by storing CO_2 in either a deep saline formation or via enhanced oil recovery (EOR). The three projects will receive up to $612 million in ARRA funding, which will be matched by $368 million in private funding, for a total investment of $980 million. Located in Texas, Illinois, and Louisiana, the projects were initially selected in October 2009 for Phase I research and development (R&D) grants. After successful completion of Phase I activities, the projects were identified as the most promising industrial CCS projects through a competitive process. The additional funding will be managed by NETL and will finance Phase II design, construction, and operation. The selected projects are expected to capture and store 6.5 million tons of CO_2 per year and increase domestic oil production by more than 10 million barrels per year by the end of the demonstration period (September 2015). June 10, 2010, http://www.energy.gov/news/9065.htm.

***Fossil Energy Techline*, "DOE Signs Cooperative Agreement for Carbon Capture Project."**

DOE signed a cooperative agreement with NRG Energy Inc. (NRG) for the "Parish Post-Combustion CO_2 Capture and Sequestration Project" to design, construct, and operate a system that will capture and store approximately 400,000 tons of CO_2 per year. The NETL-managed project was selected under DOE's Clean Coal Power Initiative (CCPI) and aims to demonstrate the economic application of post-combustion carbon capture to existing power plants, as well as the viability of storage in such formations. The system will employ Fluor's Econamine FG Plus technology to capture at least 90 percent of the CO_2 from a 60-megawatt (MW) flue gas stream of the 617-MW Unit 7 at the W.A. Parish Generating Station located in Thompsons, Texas. The total

Sequestration in the News (Continued)

project cost is $334 million; DOE's share is $167 million (50 percent of the total). Storage will begin in 2014, with project completion set for 2017. To learn more about DOE's Clean Coal Technology Program, visit: http://www.fossil.energy.gov/programs/powersystems/cleancoal/index.html. June 18, 2010, http://www.fossil.energy.gov/news/techlines/2010/10020-DOE_Signs_Cooperative_Agreement_wi.html.

***BBC News*, "Carbon Storage Plans for Moray Firth Rock Beds**

Researchers from the Scottish Centre for Carbon Storage (SCCS) will examine the potential of the Captain Sandstone Field, located about one-half mile below the seabed approximately 30 miles into the North Sea, for.

carbon storage. The researchers believe the geology beneath the Moray Firth could possibly store decades of CO_2 output from coal-fired power plants New geological mapping tools will be used to assess the thickness of the rocks and their storage potential, and computer modeling of CO_2 injection into the rocks will test the long-term performance of the rocks to ensure that the CO_2 remains safely and permanently stored. Under this scenario, CO_2 would displace the seawater in the porous rock; thus, SCCS researchers will also consider the challenges of storing captured CO_2 in the rock surface. In addition, a new pipeline could also be constructed to transport CO_2 from an industrial plant to the site. The results of the research are expected to be published in late-2010. June 2, 2010, http://news.bbc.co.uk/2/hi/scotland/highlands_and_islands/10214297.stm.

Announcements

CSLF Releases CCS Papers.

The Carbon Sequestration Leadership Forum (CSLF) has released a series of papers that present solutions to common issues surrounding CCS. The inFocus series of issue papers covers topics such as: safety and practicality of geological storage; CO_2 capture; and CO_2 transportation. The papers are available at: www.cslforum.org. To learn more about DOE's role in the CSLF, visit: http://www.fossil.energy.gov/programs/sequestration/cslf/index.html.

RGGI Offset Handbook Now Available.

The Regional Greenhouse Gas Initiative (RGGI) has made their Offset Handbook for the RGGI Model Rule and Model Offset Applications and Monitoring and Verification (M&V) Reports available online. The purpose of the Offset Handbook is to explain RGGI Model Rule provisions for offset projects, and to explain the documentation required in model templates to offset project Consistency Applications and M&V Reports. The RGGI Offset Handbook is available at: http://www.rggi.org/offsets/process/offset_handbook.

NMED Releases Draft Rule for GHG Cap-and-Trade Program.

The New Mexico Environment Department (NMED) released a preliminary draft rule for a cap-and-trade program to reduce statewide greenhouse gas (GHG) emissions that would initially apply to sources that emit at least 25,000 metric tons of CO_2 per year. The draft rule defines conditions that would allow New Mexico to implement the program as part of the Western Climate Initiative (WCI) regional program. For additional information, as well as a link to the draft rules, visit: http://www.nmenv.state.nm.us/cc/.

New South Wales Atlas for CCS Launched.

The Cooperative Research Centre for Greenhouse Gas Technologies (CO_2CRC) launched a new Atlas that outlines statewide opportunities for the application of CCS in New South Wales. The Atlas works through the geology of New South Wales, as well as other considerations required for CCS projects, to provide a template for regional assessments that can be used by other states and countries. For more information, click: http://www.co2crc.com.au/dls/media/10/NSW_Atlas.pdf.

CMU Releases Model Legislation.

Anchored by the Department of Engineering and Public Policy at Carnegie Mellon University (CMU), the CCS Regulatory (CCSReg) Project has released recommended statutory and regulatory actions that could enable large-scale CCS. To read the document, entitled, "Model Legislation: The Carbon Capture and Sequestration Regulatory Act of 2010," visit: http://www.ccsreg.org/pdf/CCS_Draft_Leg_05192010.pdf.

Science

***Science Daily*, "Whiter Clouds Could Mean Wetter Land."**

A new study by the Carnegie Institution, in collaboration with the Indian Institute of Science, suggests that whitening, more reflective clouds could reduce solar radiation absorbed by the Earth and and increase monsoonal rains, causing the continents to become wetter. The whitening of clouds is derived from the reduced size of water droplets that make up clouds. The theory was tested by using a computer simulation of the global climate system in which atmospheric CO_2 concentrations were set at approximately twice that of current levels. In the model, cloud droplets over oceans reduced in size, which made the clouds more reflective. This resulted in the reflection of more solar radiations than clouds on land, which offset the warming effect of the higher CO_2 levels. The data also showed the clouds caused the land surface to become cooler and wetter; previous similar climate simulations had reduced precipitation on land. Researchers concluded the increased precipitation over land was driven by changes in air circulation, similar to monsoonal patterns that determine rainfall in parts of Asia. June 29, 2010, http://www.sciencedaily.com/releases/2010/06/100628124609.htm.

***Science Daily*, "Warmer Ecosystems Could Absorb Less Atmospheric Carbon Dioxide."**

Researchers at Queen Mary, University of London used a new model to find that a predicted rise in global temperature of 7.2°F by 2100 could lead to a 13 percent decrease in ecosystems' ability to absorb CO_2 from the atmosphere. The researchers tested their predictions against data collected from experimental ponds that were warmed to simulate climate change. The reason behind the finding is photosynthesis; if climate change raises environmental temperatures, the balance between respiration and photosynthesis could change to favor a higher degree of respiration by animals and less CO_2 absorption by plants. This study is complemented by another recent study that compared animals living in 15 similar Icelandic streams where geothermal activity heats some streams as high as 81°F, allowing researchers to examine how temperature affects Arctic ecosystems. The researchers found changes in the type and number of species in cold streams compared with the warmer ones; in particular, fish and other larger predatory animals were not found in the coldest streams. On the other hand, the scientists uncovered that predators became larger in size and number as temperatures increased from 9°F to 45°F. July 1, 2010, http://www.sciencedaily.com/releases/2010/06/100630101020.htm

Policy

***IPAC-CO_2 News Release*, "World's First Standards for Deep-Earth Storage of Industrial Carbon Emissions to be Developed by CSA Standards and IPAC-CO_2 Research,"** and ***Regina Leader-Post*, "Agreement Reached to Develop Standard."**

CSA Standards and the International Performance Assessment Centre for Geologic Storage of Carbon Dioxide (IPAC-CO_2) have agreed to develop Canada's first CCS standard for the geologic storage of industrial emissions. Once completed, and if approved by the Standards Council of Canada, it will be the world's first formally recognized CCS standard. The new standard, which will provide guidelines for regulators, industry, and others around the world involved with scientific and commercial CCS projects, will then be used for the promotion of international standards through the International Standards Organization (ISO). The new standard will focus primarily on the long-term geologic storage of CO_2 deep underground. June 16, 2010, http://www.ipac-co2.com/Resources/Documents/CSA%20IPAC%20CO2%20Standard%20Release%20Final.pdf, and June 16, 2010, http://www.leaderpost.com/technology/Agreement+reached+develop+standard/3159841/story.html.

"A contribution to risk analysis for leakage through abandoned wells in geological CO_2 storage."

The following is the Abstract of this article: "The selection and the subsequent design of a subsurface CO_2 storage system are subject to considerable uncertainty. It is therefore important to assess the potential risks for health, safety and environment. This study contributes to the development of methods for quantitative risk assessment of CO_2 leakage from subsurface reservoirs. The amounts of leaking CO_2 are estimated by evaluating the extent of CO_2 plumes after numerically simulating a large number of reservoir realizations with a radially symmetric, homogeneous model. To conduct the computationally expensive simulations, the 'CO_2 Community Grid' was used, which allows the execution of many parallel simulations simultaneously. The individual realizations are set up by randomly choosing reservoir properties from statistical distributions. The statistical characteristics of these distributions have been calculated from a large reservoir database, holding data from over 1,200 reservoirs. An analytical risk equation is given, allowing the calculation of average risk due to multiple leaky wells with varying distance in the surrounding of the injection well. The reservoir parameters most affecting risk are identified. Using these results, the placement of an injection well can be optimized with respect to risk and uncertainty of leakage. The risk and uncertainty assessment can be used to determine whether a site, compared to others, should be considered for further investigations or rejected for CO_2 storage." **Andreas Kopp, P.J. Binning, K. Johannsen, R. Helmig, and H. Class**, *Advances in Water Resources*, Available online May 15, 2010, doi:10.1016/j.advwatres.2010.05.001, http://www.sciencedirect.com/science/article/B6VCF-5033Y11-1/2/cd60e420c516c54a6a72cc06d31a0e2a. (Subscription may be required.)

Geology

"Microbially Enhanced Carbon Capture and Storage by Mineral-Trapping and Solubility-Trapping."

The following is the Abstract of this article: "The potential of microorganisms for enhancing CCS via mineral-trapping (where dissolved CO_2 is precipitated in carbonate minerals) and solubility trapping (as dissolved carbonate species in solution) was investigated. The bacterial hydrolysis of urea (ureolysis) was investigated in microcosms including synthetic brine (SB) mimicking a prospective deep subsurface CCS site with variable headspace pressures [$p(CO_2)$] of $^{13}C{-}CO_2$. Dissolved Ca^{2+} in the SB was completely precipitated as calcite during microbially induced hydrolysis of 5–20 g L^{-1} urea. The incorporation of carbonate ions from $^{13}C{-}CO_2$ ($^{13}C{-}CO_3^{2-}$) into calcite increased with increasing $p(^{13}CO_2)$ and increasing urea concentrations: from 8.3 [percent] of total carbon in $CaCO_3$ at 1 g L^{-1} to 31 [percent] at 5 g L^{-1}, and 37 [percent] at 20 g L^{-1}. This demonstrated that ureolysis was effective at precipitating initially gaseous [CO_2(g)] originating from the headspace over the brine. Modeling the change in brine chemistry and carbonate precipitation after equilibration with the initial $p(CO_2)$ demonstrated that no net precipitation of CO_2(g) via mineral-trapping occurred, since urea hydrolysis results in the production of dissolved inorganic carbon. However, the pH increase induced by bacterial ureolysis generated a net flux of CO_2(g) into the brine. This reduced the headspace concentration of CO_2 by up to 32 mM per 100 mM urea hydrolyzed because the capacity of the brine for carbonate ions was increased, thus enhancing the solubility-trapping capacity of the brine. Together with the previously demonstrated permeability reduction of rock cores at high pressure by microbial biofilms and resilience of biofilms to supercritical CO_2, this suggests that engineered biomineralizing biofilms may enhance CCS via solubility-trapping, mineral formation, and CO_2(g) leakage reduction." **Andrew C. Mitchell, Knud Dideriksen, Lee H. Spangler, Alfred B. Cunningham, and Robin Gerlach**, *Environ. Sci. Technol.*, Available online June 14, 2010, doi:10.1021/es903270w, http://pubs.acs.org/doi/abs/10.1021/es903270w. (Subscription may be required.)

"Investigation of the pH effect of a typical host rock and buffer solution on CO_2 sequestration in synthetic brines."

The following is the Abstract of this article: "Carbon dioxide [storage] in deep saline aquifers is a critical component of long-term storage options. It is suggested that the precipitation of mineral carbonates is mostly dependent on brine pH and is favored above a basic pH of 9.0. However, brine pH will drop to acidic values once CO_2 is injected into the brine. Therefore, there is a need to raise brine pH and maintain it stable. Synthetic brines were used here instead of natural brines because of the difficulty in obtaining and storing natural brines. Therefore, experiments were conducted to prepare a series of synthetic brines and to compare their suitability to natural brines for carbon [storage] firstly. A typical host rock (Oriskany rock) and a buffer solution [sodium chloride/sodium bicarbonate ($NaCl/NaHCO_3$)] were selected to buffer brine pH. In a subsequent step, studies were conducted to correlate how brine samples respond in the presence of the host rock or the buffer solution at realistic reservoir temperatures (40 and 100°C) and pressures (1160 and 1500 psi) for CO_2 storage. The results show that synthetic brines prepared can be used as analogues as natural brines for carbon [storage] studies in terms of chemical composition and pH response. Both XRD and SEM/EDS analyses confirmed the presence of mineral carbonates in the CO_2–rock–brine and the CO_2–buffer–brine experiments. However, the amount of carbonates precipitated from the CO_2–buffer–brine reactions is nearly 18 times larger than that formed from the CO_2–rock–brine experiments. ICP-MS studies also verified that there was only [four percent] reduction in Ca concentration in solution after the CO_2–rock–brine studies, while the concentrations of Ca and Sr decreased by 90 [percent] during the CO_2–buffer–brine experiments." **Qi Liu and M. Mercedes Maroto-Valer**, *Fuel Processing Technology*, Available online June 2, 2010, doi:10.1016/j.fuproc.2010.05.002, http://www.sciencedirect.com/science/article/B6TG3-506YWYT-2/2/9f3abe38e2e391c26ead74960df1cb69. (Subscription may be required.)

"A simple model for the prediction of CO_2 solubility in H_2O–NaCl system at geological sequestration conditions."

The following is the Abstract of this article: "Carbon dioxide released in the atmosphere is the principal cause of the so-called global warming or greenhouse phenomenon. One procedure for the mitigation of CO_2 consists of the capture, transport and geological storage of the gas in deep saline aquifers. In this work, a model for predicting CO_2 solubility in H_2O–NaCl system covering conditions typically encountered in geological [storage] (e.g., 300–500 K, 50–2000 bar, and 1–4 mol salt/kg) has been developed and validated by comparison with available experimental and theoretical data. The model is a simple one with four adjustable parameters that is based on an extension of the well-known Setschenov model [$K_{gs} / K_{g0} = (P / P0)^{f(T_r,m)}$ with $f(T_r,m) = (0.461 + 0.078\ m)(-1 + T_r / (1.0 + 0.1267\ m))$]. The model is developed by exploiting interesting features in the behavior of solubility data of CO_2 in saline water over the above-mentioned ranges of conditions. The model is capable of predicting CO_2 solubility in saline water with accuracy comparable to that made by multi-parameter models (having 20 parameters or more). It is also in very good agreement with the available experimental data with root-mean-squared-error (RMSE) in the range of 0.03–0.225 mol CO_2/kg H_2O. The extrapolative power of the model is acceptable at both ends of its range of applicability." **N.A. Darwish and N. Hilal**, *Desalination*, Available online May 31, 2010, doi:10.1016/j.desal.2010.04.056, http://www.sciencedirect.com/science/article/B6TFX-506H0N0-3/2/2ae05bf39e34bdf63cc97b359e7cc753. (Subscription may be required.)

Technology

"Monitoring CO_2 response on surface seismic data; a rock physics and seismic modeling feasibility study at the CO_2 sequestration site, Ketzin, Germany."

The following is the Abstract of this article: "An important component of any CO_2 [storage] project is seismic monitoring for tracking changes in subsurface physical properties such as velocity and density. Reservoir conditions and CO_2 injection quantities govern whether such changes may be observable as a function of time. Here we investigate surface seismic response to CO_2 injection at the Ketzin site, the first European onshore CO_2 [storage] pilot study dealing with research on geological storage of CO_2. First, a rock physics model was built

Technology (Continued)

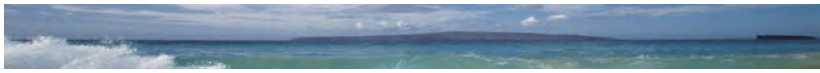
to evaluate the effect of injected CO_2 on the seismic velocity. On the basis of this model, the seismic response for different CO_2 injection geometries and saturation was studied using 1D elastic modeling and 2D acoustic finite difference modeling. Rock-physics models show that CO_2 injected in a gaseous state, rather than in a supercritical state, will have a more pronounced effect on seismic velocity, resulting in a stronger CO_2 response. However, reservoir heterogeneity and seismic resolution, as well as random and coherent seismic noise, are negative factors that need to be considered in a seismic monitoring program. In spite of these potential difficulties, our seismic modeling results indicate that the CO_2 seismic response should be strong enough to allow tracking on surface seismic data. Amplitude-related attributes (i.e., acoustic impedance versus Poisson's ratio cross-plots) and time-shift measurements are shown to be suitable methods for CO_2 monitoring." **Sayed Hesammoddin Kazemeini, Christopher Juhlin, and Sergey Fomel**, *Journal of Applied Geophysics*, Available online June 12, 2010, doi:10.1016/j.jappgeo.2010.05.004, http://www.sciencedirect.com/science/article/B6VFC-5093N3M-1/2/4712629cedf4458b6c1129fdb80375d3. (Subscription may be required.)

"Mathematical modeling and simulation of gasification processes with Carbon Capture and Storage (CCS) for energy vectors poly-generation."

The following is the Abstract of this article: "Gasification of solid fuels is a partial oxidation process which converse the solid feedstock into syngas which can be used in a large number of applications e.g. power generation, manufacture of various chemicals and fuels (hydrogen, methanol, ammonia, fertilizers etc.). Not all of the gasification systems are suitable for energy vectors polygeneration with [CCS]. This paper is proposing to evaluate various gasification technologies by mathematical modeling and simulation methods (especially for entrained flow types as these gasifiers are more suitable for implementing carbon capture technologies). In this paper a particular accent will be put on the selection of the most promising gasifier, as not all are appropriate for a carbon capture Integrated Gasification Combined Cycle (IGCC) applied for energy vectors poly-generation (with a particular focus on hydrogen and electricity co-production case) with [CCS]. For the selection of the most appropriate gasifier technologies the process were mathematical modeled and simulated with process flow modeling software (e.g. ChemCAD, Aspen). In the evaluation of various gasification technologies (e.g. Shell, Siemens, GE-Texaco, Conoco-Phillips etc.) a multi-criteria analysis was performed." **Victoria Maxim, Calin-Cristian Cormos, Ana-Maria Cormos, and Serban Agachi**, *Computer Aided Chemical Engineering*, Available online May 28, 2010, doi:10.1016/S1570-7946(10)28117-8, http://www.sciencedirect.com/science/article/B8G5G-505XT0T-48/2/01e3df41fe01b2df2d0bd33d71d19229. (Subscription may be required.)

"Predictions of the impurities in the CO_2 stream of an oxy-coal combustion plant."

The following is from the Abstract of this article: "Whilst all three main carbon capture technologies (post-combustion, pre-combustion and oxy-fuel combustion) can produce a CO_2 dominant stream, other impurities are expected to be present in the CO_2 stream. The impurities in the CO_2 stream can adversely affect other processes of the CCS chain including the purification, compression, transportation and storage of the CO_2 stream. Both the nature and the concentrations of potential impurities expected to be present in the CO_2 stream of a CCS-integrated power plant depend on not only the type of the power plant but also the carbon capture method used. The present paper focuses on the predictions of impurities expected to be present in the CO_2 stream of an oxy-coal combustion plant…" **Hao Liu and Yingjuan Shao**, *Applied Energy*, Available online May 26, 2010, doi:10:1016/j.apenergy.2010.04.014, http://www.sciencedirect.com/science/article/B6V1T-505FHWV-2/2/7af47f626ee4323d07447fa10f34732d. (Subscription may be required.)



Terrestrial

"Carbon contents and respiration rates of aggregate size fractions under no-till and conventional tillage."

The following is the Abstract of this article: "The purpose of the present study was to evaluate the long-term (14 [years]) effect of no-till (NT) compared with conventional tillage (CT) on the distribution of dry sieved aggregate size fractions, their carbon (C) and nitrogen (N) contents and respiration activity. Soil samples were taken from a long-term (14 years) tillage experiment with a rotation of [six] cash crops, [four] years pasture and another [six] cash crops in the sandy plains region of semiarid central Argentina, on an Entic Haplustoll. Sampling was carried out at 0.06 m intervals to 0.18 m depth, with [four] replicates per tillage treatment. Bulk density (BD), C and N were determined on air dried samples. Dry aggregate size distribution (fractions: >4, 1–4, and <1 mm) and C and N contents of these size fractions were determined. Samples of fractions and of undisturbed soil were incubated and respiration was measured by trapping evolved CO_2 in NaOH. The NT soil had 25 [percent] more macroaggregates in surface 0.06 m samples than CT, while at 0.06-0.12 and 0.12-0.18 m, these increased by 38 and 17 [percent] respectively. This indicated that the effect of NT on aggregate size distribution extended towards deeper soil regions. The intermediate aggregate fraction of surface soil under NT had 8.2 g $kg^{-}1$ more C than under CT, while for >4 and <1 mm aggregates the differences between tillage systems were smaller (6.8 and 7.6 g kg^{-1} respectively). The data confirmed [the] hypothesis with respect to higher C accretion in intermediate aggregates under NT, approaching values of a permanent pasture soil. Large aggregates did not sequester more C than small aggregates, as would be expected according to the conceptual model of aggregate hierarchy. At 0.06-0.12 m depth these differences in C concentrations were less pronounced. Thus, although the effect of tillage on aggregate size distribution extended below the upper 0.06 m, C [storage] occurred mainly in this depth interval. While intermediate aggregates represented 12 and 15 [percent] of total C under NT and CT respectively, their contribution to soil respiration was19 and 21 [percent] for the same treatments. This would indicate that C losses from soil through mineralization are mostly associated with

intermediate aggregate size." **Romina Fernández, Alberto Quiroga, Carlos Zorati, and Elke Noellemeyer**, *Soil and Tillage Research*, Available online June 8, 2010, doi:10.1016/j.still.2010.05.002, http://www.sciencedirect.com/science/article/B6TC6-50867FX-2/2/a499ef6fbc8acec0ea1ee5b34ce939d4. (Subscription may be required.)

Trading

Carbon Market Update, June 17, 2010	
CCX-CFI 2010 ($/tCO$_2$)	EU ETS-EUA DEC 2010
$0.10 (Vintage 2010)	($/tCO$_2$) $19.33
	(Converted from € to US$)

***RGGI News Release*, "Release of Joint Offset Quality White Paper."**

The three North American regional climate initiatives – the Northeast and Mid-Atlantic RGGI, the Midwestern GHG Reduction Accord, and WCI – are releasing a joint white paper, entitled, "Ensuring Offset Quality: Design and Implementation Criteria for a High-Quality Offset Program," to promote the consistency and integrity of offsets throughout North America. The three regional programs have joined a cooperative effort to share experiences in the design and implementation of regional cap-and-trade programs, inform Federal decision making on climate change policy, and explore the potential for additional future collaboration. The offset quality white paper outlines the key design and implementation criteria necessary to establish a high-quality offset program. All three regional programs incorporate an offset component in order to reduce compliance costs and increase compliance flexibility for sources covered by the programs. Together, the three regional programs account for approximately 50 percent of the U.S. population, more than 33 percent of U.S. GHG emissions, more than 75 percent of the Canadian population, and 50 percent of Canadian GHG emissions. To view the white paper, visit: http://www.rggi.org/docs/Three_Regions_Offsets_Whitepaper_05_17_10.pdf. May 19, 2010, http://www.rggi.org/docs/3_Regions_Offsets_Announcement_05_17_10.pdf.

***RGGI News Release*, "RGGI CO_2 Auction Fuels Clean Energy Economy with $80.4 Million in Proceeds."**

The 10 Northeast and Mid-Atlantic states participating in RGGI, the Nation's first mandatory, market-based program to reduce GHGs, announced the results of the second quarterly auction of CO_2 allowances in 2010. The auction yielded a total of $80,465,566.78 for states to invest in the clean energy initiatives. The 40,685,585 CO_2 allowances offered for the first three-year control period (2009-2011) sold at a price of $1.88; the 2,137,993 CO_2 allowances for the second control period sold at a price of $1.86. Proceeds from all the RGGI auctions now total more than $662.8 million. States are investing the . proceeds to improve energy efficiency; accelerate the deployment of renewable energy technologies; and fund consumer benefit programs that further reduce emissions, save consumers money, and create jobs. States are beginning to document both the direct consumer benefits and the broad economic gains resulting from RGGI proceeds in the region. To learn more about how each state is investing RGGI auction proceeds, click: http://www.rggi.org/states/program_investments. June 11, 2010, http://www.rggi.org/docs/Auction_8_NewsRelease_MMReport.pdf.

"Public acceptability of personal carbon trading and carbon tax."

The following is the Abstract of this article: "Climate change is one of the greatest challenges confronting the international community requiring action to achieve deep cuts in carbon emissions. The implementation of potentially uncomfortable but necessary policy measures is, though, critically dependent upon public acceptability. This paper reports a novel application of stated preference techniques to explore the influence of key design attributes on the acceptability of a personal carbon trading scheme in isolation and when compared to a carbon tax. Illustrative forecasts from the models developed indicate the importance of design attributes, especially the basis of the initial permit allocation for personal carbon trading and the use to which revenues are put for carbon tax. Results indicate that the 'best' scheme designs could be acceptable to a majority of respondents." **Abigail L. Bristow, Mark Wardman, Alberto M. Zanni, and Phani K. Chintakayala**, *Ecological Economics*, Available online May 23, 2010, doi:10.1016/j.ecolecon.2010.04.021, http://www.sciencedirect.com/science/article/B6VDY-504YBRW-1/2/9fce0bbb1bc93c2468d613c788a2790f. (Subscription may be required.)

Recent Publications

"Carbon Capture and Storage: Progress and Next Steps."

The following is from the Background of this document: "Since 2008, significant progress has been made to address the high-level recommendations on CCS made by the [Group of Eight (G-8)] Leaders. CCS has advanced towards commercialization, notably through the commissioning of CCS pilot plants, continued learning from plants already in operation and the development of legal and regulatory frameworks. Several governments have committed to provide over $26 billion in funding support for demonstration projects. International collaborative and public outreach activities have increased substantially. The mapping of suitable storage sites is underway in various countries and a guide for CCS-ready plant has been developed. Critical to the deployment of CCS, however, is the experience to be gained from from the operation of large-scale demonstration projects. While much progress has been achieved, the recommendation made by the G-8 Leaders at the 2008 Hokkaido Toyako Summit that 20 large-scale CCS demonstration projects should be launched by 2010 remains a

Recent Publications (Continued)

challenge and will require that governments and industry work in concert. To measure progress against the goal of launching 20 large-scale CCS projects by 2010, the International Energy Agency (IEA), CSLF and the Global CCS Institute reviewed government initiatives and developed a set of assessment criteria against which to review progress by industry. Over the past two years, governments have made significant commitments that will facilitate the launch of 19 to 43 large-scale CCS integrated demonstration projects by 2020. This is promising, as government support is vital to helping projects under development overcome the final hurdles. A study commissioned by the Global CCS Institute (2010) identified 80 large-scale integrated projects at various stages of development around the world. Notable efforts from both government and industry can be found in the United States, the European Union, particularly the United Kingdom, Canada and Australia. Five large-scale CCS projects are in operation, all commissioned prior to the 2008 G-8 Summit. From the pool of 80 projects, one new project, the Australian Gorgon project, has been launched and is proceeding to construction." The complete IEA document is available at: http://www.iea.org/papers/2010/ccs_G-8.pdf.

Final Complementary Policies White Paper.

The following is from the Background of this WCI document: "The WCI Partners have recommended a comprehensive regional effort to reduce emissions of global warming pollution, combining a broad cap-and-trade program with complementary policies to achieve the WCI 2020 regional emissions goal. Complementary policies can address market barriers that would otherwise limit the use of low-cost GHG emission-reduction options and reduce emissions from sources excluded from the cap-and-trade program. Thus, complementary policies can lower the overall cost of reducing GHG emissions. This view is supported by the 2008 economic analysis of WCI's cap-and-trade design, which incorporated complementary policies related to energy efficiency and tailpipe emission standards. The analysis found that the WCI 2020 reduction goals can be achieved with small overall net savings due to reduced energy expenditures exceeding the direct costs of greenhouse gas emission reductions. As part of the WCI 2009-2010 Workplan, the WCI Partner jurisdictions formed the Complementary Policies Committee. The charge of the Committee is to recommend to the WCI Partner jurisdictions those policies which, if harmonized across multiple states and provinces both within and outside the WCI Partner jurisdictions, would help achieve the regional emissions reduction goals and assist with the transition to a low-carbon economy. By harmonizing complementary policies, the WCI Partner jurisdictions intend to foster increased market certainty, encourage trade among participating jurisdictions, reduce administrative costs and streamline regulatory procedures." To view the final white paper, click: http://www.westernclimateinitiative.org/component/remository/func-startdown/255/.

Legislative Activity

***Washington Business Journal*, "Montgomery County Council Supports Carbon, Energy Tax."**

The United States' first locally based carbon tax was passed by Montgomery County Council (Maryland) members on May 19, 2010. The measure would charge $5 per ton for any entity that emits more than 1 million tons of CO_2 in a calendar year. The money raised from this tax, expected to be approximately $15 million, would finance programs such as the Home Energy Loan Program, which helps finance energy-efficiency projects. May 19, 2010, http://washington.bizjournals.com/washington/stories/2010/05/17/daily32.html.

Events

July 26-28, 2010, **Carbon Capture and Storage: Science, Technology, and Policy**, *MIT, Cambridge, Massachusetts, USA*. This energy short course covers the science, technology, and policy aspects of CCS, focusing on the role of CCS in the climate change mitigation portfolio; the technical approaches to CO_2 capture; the science behind geological storage, site selection, and risk evaluation; and the role of policy in establishing a market and business opportunities for CCS. For more information, visit the course website at: http://web.mit.edu/professional/short-programs/courses/carbon_capture_storage.html.

EVENTS (CONTINUED)

August 10-12, 2010, **6th Australian-New Zealand Climate Change and Business Conference**, *Sydney Convention and Exhibition Centre, New South Wales, Australia*. This conference focuses on how businesses respond to potential climate change in the face of policy uncertainty. Other topics to be discussed include: the potential for reduced emissions from key sectors, low-emissions technology, international policy, and the science behind climate change. To visit the conference website, which includes a downloadable program, visit: http://www.climateandbusiness.com/index.cfm.

August 10-12, 2010, **Carbon Capture and Sequestration: New Developments and Applications, Case Studies, Lessons Learned**, *The Green Center, Colorado School of Mines, Golden, Colorado, USA*. This American Association of Petroleum Geologists (AAPG) workshop has a special focus on new approaches and case studies in the geological storage and capture of CO_2. Presentations will be given representing real-life scenarios and situations concerning geosciences technology. For more information, click: http://www.aapg.org/gtw/CarbonCapture_Sequestration/index.cfm.

August 10-12, 2010, **Coal Gen 2010**, *David L. Lawrence Convention Center, Pittsburgh, Pennsylvania, USA*. This three-day event covers the latest topics affecting the design, development, upgrading, operation, and maintenance of coal-fired power plants, as well as how to address challenges associated with them. For more information, visit this conference website at: http://www.coal-gen.com/index.html.

September 13-17, 2010, **2010 CO_2 Capture Technology R&D Meeting**, *Sheraton Station Square Hotel, Pittsburgh, Pennsylvania, USA*. This meeting provides a public forum to present CO_2 capture technology development status and accomplishments. Topics to be covered include post-, oxy-, and pre-combustion carbon capture technologies – including post-combustion solvent, sorbent, and membrane technologies – and CO_2 compression technologies. For registration information, visit the conference website at: http://www.netl.doe.gov/events/10conferences/co2capture/#mtg.

September 15-17, 2010, **10th International Conference on Clean Energy**, *Salamis Bay Conti Hotel, Famagusta, North Cyprus*. This conference provides a platform to discuss two topics: the depletion of fossil fuels and the resulting potential environmental problems. Other topics to be discussed include climate change, renewable energy sources, environmental impacts, and risk analysis and economics. To learn more, visit the conference website at: http://icce2010.emu.edu.tr/proceedings.html.

September 19-23, 2010, **10th International Conference on Greenhouse Gas Control Technologies**, *RAI, Amsterdam, The Netherlands*. Attendees of this conference, which is held every two years, will contribute to discussions on overcoming the barriers to implementing GHG mitigation technologies, as well as technological and policy-related developments. For more information, visit the conference website at: http://www.ghgt.info/GHGT10.html.

September 29-30, 2010, **Carbon Capture and Storage Summit**, *Capital Hilton, Washington, DC*. The 4th Annual CCS Summit will provide a forum to discuss the continuing development of commercialized CCS technologies. Topics to be discussed include: the impact of legislation on CCS; legal, regulatory, and liability issues surrounding CCS; CO_2-EOR; and the acceleration of CO_2 transport infrastructure. For a full list of topics, visit the conference website at: http://www.carboncapturesummit.com/index.html.

October 12-14, 2010, **2010 SPE Eastern Regional Meeting**, *Morgantown, West Virginia, USA*. The technical sessions at this meeting will cover topics such as CCS and gas storage; production operations, optimization, monitoring, and control; formation evaluation; and the drilling of wells. More information can be found by visiting the conference website at: http://www.spe.org/events/erm/2010/.

October 19-20, 2010, **Carbon Capture and Storage Symposium 2010**, *Chifley at Lennons, Brisbane, Queensland, Australia*. The Carbon Capture and Storage Symposium 2010 features cases studies of local and global initiatives and projects related to CCS, including policy and regulatory frameworks, business models and strategies in a low carbon economy, technical presentations on low emissions technologies, site selection, and expert-led panel discussions. Detailed information can be obtained at: http://www.carbon-capture.com.au/Event.aspx?id=329858.

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