NETL the ENERGY lab
Office of Fossil Energy

Carbon Sequestration Newsletter

SEPTEMBER 2012

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*, "DOE-Sponsored Project Begins Demonstrating CCUS Technology in Alabama."**

A project sponsored by the U.S. Department of Energy (DOE) has begun demonstrating carbon dioxide (CO_2) injection with the goals of assessing integration of the technologies involved and laying the foundation for the future use of CO_2 for enhanced oil recovery (EOR). Conducted by the Southeast Regional Carbon Sequestration Partnership (SECARB), one of seven DOE Regional Carbon Sequestration Partnerships (RCSPs), the "Anthropogenic Test" uses CO_2 from the newly constructed post-combustion CO_2-capture facility at Alabama Power's 2,657-megawatt (MW) Barry Electric Generating Plant. Located in southwest Alabama, the project will help demonstrate the feasibility of carbon capture, utilization, and storage (CCUS) by diverting a small amount of flue gas from Plant Barry (equivalent to amount produced when generating 25 MW of electricity) and capturing it using Mitsubishi Heavy Industries' advanced amine process to produce a nearly pure stream of CO_2. The captured CO_2 is then transported approximately 12 miles to the Citronelle Dome, within the Paluxy saline formation. The CO_2 injection will span two years at a rate of up to 550 metric tons of CO_2 per day, and multiple monitoring technologies will be deployed to track the CO_2 plume, measure the pressure front, evaluate CO_2 trapping mechanisms, and ensure that the CO_2 remains in the formation. The Paluxy is an ideal site for injection because it is more than 9,000 feet underground and is overlain by multiple geologic confining units that serve as barriers to prevent CO_2 from escaping. Following three years of post-injection monitoring, the site will be closed in 2017 and the wells will either be plugged and abandoned according to state regulations, or re-permitted for CO_2-EOR and CO_2 storage operations. To learn more about DOE's RCSP Program, visit: http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html. August 22, 2012, http://www.fossil.energy.gov/news/techlines/2012/12037-CO2_Injection_Begins_in_Alabama.html.

***Fossil Energy Techline*, "Novel Sorbent Achieves 90 Percent Carbon Capture in DOE-Sponsored Test."**

The successful bench-scale test of BrightBlack™, a novel CO_2 capturing sorbent, promises to further advance the process as a possible technological option for reducing CO_2 emissions from coal-fired power plants. The new sorbent was originally developed for a different application by Advanced Technology Materials Inc. (ATMI). SRI developed a method, through partnering with the Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL), to use the ATMI sorbent to capture CO_2. In the SRI process – which is less energy-intensive than amine-based CO_2-capture processes – CO_2 is absorbed in a bed of sorbent pellets and desorbed in a separate reactor that regenerates the sorbent, cycling it back to the absorber. The observed CO_2-capture efficiency was as high as 95 percent as the test run began, with the captured CO_2 purity at 95 to 100 percent. After 7,000 absorption-regeneration cycles and 130 hours of operation,

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Highlights (Continued)

the sorbent showed little-to-no mechanical or chemical degradation. The test results will be analyzed in detail by SRI and the total system performance and estimated economic benefits will be determined. Information gathered will be used for designing a larger, pilot-scale unit of 0.5 MW or more in preparation for potential future testing at an operating pulverized-coal boiler. August 21, 2012, http://www.fossil.energy.gov/news/techlines/2012/12036-Novel_Sorbent_Meets_Goal.html.

Sequestration in the News

***CO2CRC Media Release*, "World Class Carbon Reduction Hub Opens in Victoria."**

The Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) will direct research at the newly launched Peter Cook Centre for Carbon Capture and Storage Research in Victoria, Australia. Rio Tinto will sponsor the Peter Cook Centre with $3 million in funding over three years. In addition, Rio Tinto will also provide another $3 million in funding over three years for the CO2CRC Otway Project, which is Australia's first demonstration of geologic storage. The Peter Cook Centre will incorporate extensive research already underway at the University of Melbourne, and will initially host more than 30 scientists currently working on carbon capture and storage (CCS). The center will link the researchers with the CO2CRC Otway Project Subsurface Storage Laboratory, which has been safely storing CO_2 deep underground since 2008. August 14, 2012, http://www.co2crc.com.au/dls/media/12/PeterCookCCS_Centre.pdf.

***Shell Media Release*, "Shell to Construct World's First Oil Sands Carbon Capture and Storage Project.**

Shell officials announced plans to proceed with the Quest CCS project for an oil sands operation in Canada. The project will be built on behalf of the Athabasca Oil Sands Project joint venture owners. The Athabasca Oil Sands project produces bitumen, which is piped to Shell's Scotford Upgrader near Edmonton, Alberta. In late 2015, Quest will capture and store more than 1 million tonnes a year of CO_2 produced in bitumen processing. Quest will reduce emissions from the Scotford Upgrader by up to 35 percent. The CO_2 will be injected more than two kilometers underground into a porous rock formation called the Basal Cambrian Sands (BCS), which is located beneath layers of impermeable rock. Monitoring technologies will ensure that the CO_2 is safely and permanently stored. In 2011, Quest received the world's first certificate for its storage development plan from Det Norske Veritas (DNV), an international risk management firm. The Alberta government will invest $745 million in Quest from a $2-billion fund to support CCS, while the Government of Canada will invest $120 million through its Clean Energy Fund. Shell has received the necessary federal and provincial regulatory approvals for Quest. Construction has begun and will employ an average of approximately 400 workers over roughly 30 months. September 5, 2012, http://www.shell.com/home/content/media/news_and_media_releases/2012/quest_first_oil_sands_ccs_project_05092012.html.

Sequestration in the News (Continued)

***DNV Press Release*, "New Experimental Data to Support CCS Safety."**

The DNV-led CO2PIPETRANS joint industry project (JIP) launched the 2nd release of data along with supporting material. The free experimental data will assist dense phase CO_2 computer model development and validation and further support global CCS implementation. The material released by the CO2PIPETRANS JIP in May was gathered by BP in 2006 as part of their Peterhead/Miller CO_2 capture and EOR project. The 2nd release (collected by Shell in 2010) provides datasets covering different initial conditions and a greater number of measurements. According to DNV officials, the combined material now released by the JIP provides a reference source for those involved with CCS, CO_2-EOR, or CO_2-rich hydrocarbon extraction. The material covers a number of experiments undertaken to investigate the behavior of releasing dense phase CO_2 up to 150 bar (2,175 pounds per square inch [psi]) and 150°C (300°F) through orifices up to 25 mm (1 inch) in diameter at constant or decaying inventory pressure. The data has been critically reviewed prior to being made available and the review reports are also being provided with the datasets to help interpretation. The data can be downloaded, along with the 1st datasets released, from DNV's website, at: www.dnv.com/ccs. September 6, 2012, http://www.dnv.com/press_area/press_releases/2012/new_experimental_data_to_support_ccs_safety.asp.

***Fossil Energy Techline*, "Energy Department Announces Awards to Projects Advancing Innovative Clean Coal Technology."**

DOE has selected eight projects to advance the development of transformational oxy-combustion technologies capable of high-efficiency, low-cost CO_2 capture from coal-fired power plants. The selections are part of a two-phase effort to evaluate and develop advanced oxy-combustion projects that yield cost-competitive options for CCUS. The selected projects, each lasting one year, will aim to achieve at least 90 percent CO_2 removal while delivering CO_2 at a capture cost of less than $25 per ton. DOE will invest $7 million to support the development and deployment of CCUS by focusing on further improving the efficiency and reducing the costs associated with carbon capture. The projects will be managed by NETL. July 26, 2012, http://www.fossil.energy.gov/news/techlines/2012/12033-DOE_Announces_Oxycombustion_Projec.html.

Announcements

Carbon Storage R&D Project Review Meeting Presentations Available.

NETL has released the conference proceedings from the Carbon Storage R&D Project Review Meeting held on August 21-23, 2012, in Pittsburgh, Pennsylvania. All presentations from the plenary and parallel sessions can be downloaded from: http://www.netl.doe.gov/publications/proceedings/12/carbon_storage/index.html.

NETL Releases Accomplishments Document.

DOE/NETL has released a new document, titled, "Carbon Storage Program 2010-2011 Accomplishments," which highlights the accomplishments of the Carbon Storage Program during the 2010 and 2011 calendar years. The new publication shows that the program has achieved numerous accomplishments through the growth, expansion, and introduction of new concepts and opportunities as a result of an adapting effort that incorporates novel activities to resolve issues uncovered by research and development (R&D) activities and social demands. The document is available on the NETL website at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/CS-Program-2010-2011-Accomplishments.pdf.

United States, Canada Announce Next Phase of U.S.-Canada Clean Energy Dialogue.

On June 21, 2012, DOE and Environment Canada released the U.S.-Canada Clean Energy Dialogue (CED) Action Plan II, renewing their commitment to collaborate on CCS technologies, build more efficient electrical grids, and advance clean energy R&D. The CED was established in 2009 to encourage the development of clean energy technologies to reduce greenhouse gases (GHGs) and address potential climate change. To view Action Plan II, click: http://energy.gov/articles/united-states-canada-announce-next-phase-us-canada-clean-energy-dialogue.

CarbonKids Resources.

The Commonwealth Scientific and Industrial Research Organization (CSIRO) has developed an educational program called "CarbonKids," which combines the latest in climate science with education in sustainability. CarbonKids aims to provide primary and secondary schools with resources to encourage their community to address potential climate change. The materials are available at: http://www.csiro.au/CarbonKids and http://www.csiro.au/en/Portals/Education/Teachers/Classroom-activities/CarbonKids/Carbon-Kids/Resources.aspx.

Short Educational Videos on CCS Technology.

Victoria's (Australia) Department of Primary Industries has developed a short film to provide an introduction to CCS technology for educational purposes. Transcripts of each segment are also available for download. The videos (full version and segments) and transcripts are available at: http://www.dpi.vic.gov.au/earth-resources/community-information/carbon-capture-and-storage-videos.

Science

***UPI.com*, "Australia's Fish React to Climate Change,"** and ***ABC News*, "Climate Change Sees Tropical Fish Arrive in Tasmania."**

According to a new report by CSIRO, some of Australia's fish species are moving southward due to warmer waters. More than 80 Australian marine scientists from 34 universities and research organizations contributed to the report, titled, "2012 Marine Climate Change in Australia Report Card," which also found that potential climate change is possibly causing a decline in some temperate fish stocks and that ocean acidification is beginning to affect shellfish. While some species found in tropical and temperate waters are relocating, researchers also discovered that some tropical fish species are better able to adjust to rising water temperatures than previously thought. To view the CSIRO report, click: http://www.oceanclimatechange.org.au/content/images/uploads/Marine_Report_Card_Australia_2012.pdf. August 17, 2012, http://www.upi.com/Business_News/Energy-Resources/2012/08/17/Australias-fish-react-to-climate-change/UPI-43531345225788/, and August 17, 2012, http://www.abc.net.au/news/2012-08-17/climate-change-sees-tropical-fish-head-south/4203830?section=tas.

***Science Daily*, "How Sea Otters Can Reduce CO_2 in the Atmosphere: Appetite for Sea Urchins Allows Kelp to Thrive."**

A new study by UC Santa Cruz researchers suggests that a thriving sea otter population that feeds on sea urchins will allow kelp forests to flourish. Through photosynthesis, the kelp can absorb as much as 12 times the amount of CO_2 from the atmosphere than if it were subject to sea urchins, the study finds. The paper, published in "Frontiers in Ecology and the Environment," combines 40 years of data on otters and kelp bloom from Vancouver Island to the western edge of Alaska's Aleutian Islands, resulting in the conclusion that otters affect the cycle of CO_2 storage. The research found that when otters are around, sea urchins hide in crevices and eat kelp; with no otters around, sea urchins graze on living kelp. The authors state that the restoration and protection of otters is an example of how managing animal populations can affect ecosystems abilities to store carbon. September 7, 2012, http://www.sciencedaily.com/releases/2012/09/120907161437.htm.

Policy

***National Geographic News Watch*, "Singapore Issues National Climate Change Strategy."**

Singapore has published its national climate change strategy, reflecting its efforts to prepare for potential climate change and support the transition to a lower emission economy. Singapore, the newest addition to the global C40 Cities Climate Leadership Group, is focused on adapting to impacts of potential climate change through integrated land use planning, water management, and investment in research and infrastructure. Singapore is also studying the reduction of its emissions by building on current efforts, as well as the long-term stabilization of its emissions. The report, titled, "Climate Change & Singapore: Challenges. Opportunities. Partnerships.," indicates that these efforts have delivered results, with Singapore ranking 123rd out of 137 countries in emissions per gross domestic product (GDP). To read Singapore's full climate change strategy, visit: http://app.nccs.gov.sg/data/resources/docs/Documents/NCCS-2012.pdf. August 16, 2012, http://newswatch.nationalgeographic.com/2012/08/16/singapore-issues-national-climate-change-strategy/.

"Long-Term Energy and Climate Implications of Carbon Capture and Storage Deployment Strategies in the [U.S.] Coal-Fired Electricity Fleet."

The following is the Abstract of this article: "To understand the long-term energy and climate implications of different implementation strategies for CCS in the [U.S.] coal-fired electricity fleet, [the authors] integrate three analytical elements: scenario projection of energy supply systems, temporally explicit life cycle modeling, and time-dependent calculation of radiative forcing. Assuming continued large-scale use of coal for electricity generation, [the authors] find that aggressive implementation of CCS could reduce cumulative [GHG] emissions (CO_2, [methane (CH_4)], and [nitrous oxide (N_2O)]) from the [U.S.] coal-fired power fleet through 2100 by 37–58 [percent]. Cumulative radiative forcing through 2100 would be reduced by only 24–46 [percent], due to the front-loaded time profile of the emissions and the long atmospheric residence time of CO_2. The efficiency of energy conversion and carbon capture technologies strongly affects the amount of primary energy used but has little effect on [GHG] emissions or radiative forcing. Delaying implementation of CCS deployment significantly increases long-term radiative forcing. This study highlights the time-dynamic nature of potential climate benefits and energy costs of different CCS deployment pathways and identifies opportunities and constraints of successful CCS implementation." **Roger Sathre and Eric Masanet**, *Environ. Sci. Technol.*, Available online August 2, 2012, doi:10.1021/es3006332, http://pubs.acs.org/doi/abs/10.1021/es3006332. (Subscription required).

"The Canadian oil sands industry under carbon constraints."

The following is the Abstract of this article: "[The authors] investigate the impact of climate policies on Canada's oil sands industry, the largest of its kind in the world. Deriving petroleum products such as gasoline and diesel from oils sands involves significant amounts of energy, and that contributes to a high level of CO_2 emissions. [The authors] apply the MIT Emissions Prediction and Policy Analysis (EPPA) model, a computable general equilibrium model of the world economy, augmented to include detail on the oil sands production processes, including the possibility of CCS. [The authors] find: (1) without climate policy, annual Canadian bitumen production increases almost [four]-fold from 2010 to 2050; (2) with climate policies implemented in developed countries, Canadian bitumen production drops by 32 [percent] to 68 [percent] from the reference [four]-fold increase, depending on the viability of large-scale CCS implementation, and bitumen upgrading capacity moves to the developing countries; (3) with climate policies implemented worldwide, the Canadian bitumen production is significantly reduced even with CCS technology, which lowers CO_2 emissions at an added cost. This is mainly because upgrading bitumen abroad is no longer economic with the global climate policies." **Gabriel Chan, John M. Reilly, Sergey Paltsev, Y.-H. Henry Chen**, *Energy Policy*, Available online August 17, 2012, doi:10.1016/j.enpol.2012.07.056, http://www.sciencedirect.com/science/article/pii/S0301421512006507. (Subscription may be required.)

Geology

"CO_2/Brine Transport into Shallow [Formations] along Fault Zones."

The following is the Abstract of this article: "Unintended release of CO_2 from carbon [storage] reservoirs poses a well-recognized risk to groundwater quality. Research has largely focused on in situ CO_2-induced pH depression and subsequent trace metal mobilization. In this paper [the authors] focus on a second mechanism: upward intrusion of displaced brine or brackish-water into a shallow [formation] as a result of CO_2 injection. Studies of two natural analog sites provide insights into physical and chemical mechanisms controlling both brackish water and CO_2 intrusion into shallow [formations] along fault zones. At the Chimayó, New Mexico site, shallow groundwater near the fault is enriched in CO_2 and, in some places, salinity is significantly elevated. In contrast, at the Springerville, Arizona site CO_2 is [releasing] upward through brine [formations] but does not appear to be increasing salinity in the shallow [formation]. Using multiphase transport simulations [the authors] show conditions under which significant CO_2 can be transported through deep brine [formations] into shallow layers. Only a subset of these conditions favor entrainment of salinity into the shallow [formation]: high aspect-ratio [release] pathways and viscous coupling between the fluid phases. Recognition of the conditions under which salinity is favored to be cotransported with CO_2 into shallow [formations] will be important in environmental risk assessments." **Elizabeth H. Keating, Dennis L. Newell, Hari Viswanathan, J.W. Carey, G. Zyvoloski, and Rajesh Pawar**, *Environ. Sci. Technol*., Available online July 16, 2012, doi:10.1021/es301495x, http://pubs.acs.org/doi/abs/10.1021/es301495x. (Subscription required.)

"Supercritical CO_2 and Ionic Strength Effects on Wettability of Silica Surfaces: Equilibrium Contact Angle Measurements."

The following is the Abstract of this article: "Wettability of reservoir mineral surfaces is a critical factor controlling CO_2 mobility, trapping, and safe-storage in geological carbon [storage]. Although recent studies have begun to show that wettability of some minerals can change in the presence of supercritical CO_2 ($scCO_2$), different laboratories have reported significantly different wetting behavior. [The authors] studied wettability alteration of silica in CO2–brine systems through measuring equilibrium water contact angles under wide ranges of pressures (0.1 to 25 MPa) and ionic strengths (0 to 5.0 M NaCl), at 45°C. Using two independent approaches for each of the experiments, [the authors] found the following: (1) Equilibrium water contact angles on silica increased up to 17.6° ± 2.0° as a result of reactions with $scCO_2$. This increase occurred primarily within the pressure range 7–10 MPa, and the contact angles remain nearly constant at pressure greater than 10 MPa. (2) The contact angle increased with ionic strength nearly linearly, with a net increase of 19.6° ± 2.1° at 5.0 M NaCl. These changes in contact angle induced by changes in $scCO_2$ pressure and aqueous solution ionic strength are approximately additive over the range of tested conditions. These findings can be used to estimate the wetting behavior of silica surfaces in reservoirs containing supercritical CO_2." **Jong-Won Jung and Jiamin Wan**, *Energy Fuels*, Available online July 27, 2012, doi:10.1021/ef300913t, http://pubs.acs.org/doi/abs/10.1021/ef300913t. (Subscription required.)

Technology

"Uncertainty Quantification in CO_2 [Storage] Using Surrogate Models from Polynomial Chaos Expansion."

The following is the Abstract of this article: "In this paper, surrogate models are built iteratively using polynomial chaos expansion (PCE) and detailed numerical simulations of a carbon [storage] system. Output variables from a numerical simulator are approximated as polynomial functions of uncertain parameters. Once generated, PCE representations can be used in place of the numerical simulator and often decrease simulation times by several orders of magnitude. However, PCE models are expensive to derive unless the number of terms in the expansion is moderate, which requires a relatively small number of uncertain variables and a low degree of expansion. To cope with this limitation, instead of using a classical full expansion at each step of an iterative PCE construction method, [the authors] introduce a mixed-integer programming (MIP) formulation to identify the best subset of basis terms in the expansion. This approach makes it possible to keep the number of terms small in the expansion. Monte Carlo (MC) simulation is then performed by substituting the values of the uncertain parameters into the closed-form polynomial functions. On the basis of the results of MC simulation, the uncertainties of injecting CO_2 underground are quantified for a saline [formation]. Moreover, based on the PCE model, [the authors] formulate an optimization problem to determine the optimal CO_2 injection rate so as to maximize the gas saturation (residual trapping) during injection, and thereby minimize the chance of [release]." **Yan Zhang and Nikolaos V. Sahinidis**, *Ind. Eng. Chem. Res*., Available online June 6, 2012, doi:10.1021/ie300856p, http://pubs.acs.org/doi/abs/10.1021/ie300856p. (Subscription required.)

"Monitoring CO_2 Intrusion and Associated Geochemical Transformations in a Shallow Groundwater System Using Complex Electrical Methods."

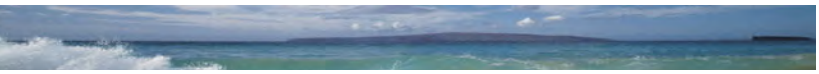
The following is the Abstract of this article: "The risk of CO_2 [release] from a properly permitted deep geologic storage facility is expected to be very low. However, if [release] occurs it could potentially impact potable groundwater quality. Dissolved CO_2 in groundwater decreases pH, which can mobilize naturally occurring trace metals commonly contained in [formation] sediments. Observing such processes requires adequate monitoring strategies. Here, [the authors] use laboratory and field experiments to explore the sensitivity of time-lapse complex resistivity responses for remotely monitoring dissolved CO_2 distribution and geochemical transformations that may impact groundwater quality. Results show that electrical resistivity and phase responses correlate well with dissolved CO_2 injection processes. Specifically, resistivity initially decreases due to increase of bicarbonate and dissolved species. As pH continues to decrease, the resistivity rebounds toward initial conditions due to the transition of bicarbonate into nondissociated carbonic acid, which reduces the total concentration of dissociated species and thus the water conductivity. An electrical phase decrease is also observed, which is interpreted to be driven by the decrease of surface charge density as well as potential mineral dissolution and ion exchange. Both laboratory and field experiments demonstrate the potential of field complex resistivity method for remotely monitoring changes in groundwater quality due to CO_2 [release]." **Baptiste Dafflon,**

Technology (Continued)

Yuxin Wu, Susan S. Hubbard, Jens T. Birkholzer, Thomas M. Daley, John D. Pugh, John E. Peterson, and Robert C. Trautz, *Environ. Sci. Technol.*, Available online June 7, 2012, doi:10.1021/es301260e, http://pubs.acs.org/doi/abs/10.1021/es301260e. (Subscription required.)

"Molecular Simulation Studies of CO_2 Adsorption by Carbon Model Compounds for Carbon Capture and [Storage] Applications."

The following is the Abstract of this article: "Effects of oxygen-containing surface functionalities on the adsorption of mixtures including CO_2/CH_4, CO_2/[nitrogen (N_2)], and CO_2/H_2O have been investigated in the current work. Together with Bader charge analysis, electronic structure calculations have provided the initial framework comprising both the geometry and corresponding charge information required to carry out statistical-based molecular simulations. The adsorption isotherms and selectivity of CO_2 from CO_2/N_2, CO_2/CH_4, and CO_2/H_2O gas mixtures were determined by grand canonical Monte Carlo simulations at temperature/pressure conditions relevant to [CCS] applications. The interactions between the surfaces with induced polarity and nonpolar/polar molecules have been investigated. It has been observed that, due to the induced polarity of the surface functionalization, the selectivity of CO_2 over CH_4 increases from approximately 2 to higher than 5, and the selectivity of CO_2 over N_2 increases from approximately 5 to 20, especially in the low-pressure regime. However, water vapor will always preferentially adsorb over CO_2 in carbon-based systems containing oxygen functionalized surfaces at conditions relevant to carbon capture application. Molecular simulation results indicate that the surface chemistry in micropores is tunable thereby influencing the selectivity for enhanced uptake of CO_2." **Yangyang Liu and Jennifer Wilcox**, *Environ. Sci. Technol.*, Available online July 2, 2012, doi:10.1021/es3012029, http://pubs.acs.org/doi/abs/10.1021/es3012029. (Subscription required.)



Terrestrial

"Early Public Impressions of Terrestrial Carbon Capture and Storage in a Coal-Intensive State."

The following is the Abstract of this article: "While CCS is considered to be critical to achieving long-term climate-protection goals, public concerns about the CCS practice could pose significant obstacles to its deployment. This study reports findings from the first state-wide survey of public perceptions of CCS in a coal-intensive state, with an analysis of which factors predict early attitudes toward CCS. Nearly three-quarters of an Indiana sample (N = 1001) agree that storing carbon underground is a good approach to protecting the environment, despite 80 [percent] of the sample being unaware of CCS prior to participation in the two-wave survey. The majority of respondents do not hold strong opinions about CCS technology. Multivariate analyses indicate that support for CCS is predicted by a belief that humankind contributes to climate change, a preference for increased use of renewable energy, and egalitarian and individualistic worldviews, while opposition to CCS is predicted by self-identified political conservatism and by selective attitudes regarding energy and climate change. Knowledge about early impressions of CCS can help inform near-term technology decisions at state regulatory agencies, utilities, and pipeline companies, but follow-up surveys are necessary to assess how public sentiments evolve in response to image-building efforts with different positions on coal and CCS." **Sanya R. Carley, Rachel M. Krause, David C. Warren, John A. Rupp, and John D. Graham**, *Environ. Sci. Technol.*, Available online Jun 7, 2012, doi:10.1021/es300698n, http://pubs.acs.org/doi/abs/10.1021/es300698n. (Subscription required.)

"Improving regional soil carbon inventories: Combining the IPCC carbon inventory method with regression kriging."

The following is the Abstract of this article: "Regional assessments of change in soil organic carbon (SOC) stocks due to land-use change are essential for supporting policy and management decisions related to [GHG] emissions and mitigation through carbon [storage] in soils. [The authors] have developed an improved approach by integrating geostatistical techniques with the Intergovernmental Panel on Climate Change (IPCC) carbon inventory approach to assess the impact of no-till management and crop-residue retention on SOC changes at a regional scale. Specifically, the improved approach utilizes regression kriging (RK) to estimate reference carbon stocks for the IPCC method. In [the authors'] case study, [they] compared the results from the RK method with a simple averaging (SA) method to derive the reference stocks as implemented in the Tier 2 IPCC approach, for a seven state area of the Midwestern United States. Using this improved method, [the authors] predict that eliminating tillage and retaining crop residues on all croplands of the study area would result in 11,735 Gg C yr^{-1} [storage] for 20 years in the top 30 cm of the soil profile. Most cropland area would [store] 0.2–0.75 Mg C ha^{-1} yr^{-1}. However, at a few places, the predicted rate of [storage] was more than 0.75 Mg C ha^{-1} yr^{-1}, with an upper limit of 1.1 Mg C ha^{-1} yr^{-1}. The highest rates of carbon accumulation were associated with favorable environmental conditions, such as lower slope positions and cold, temperate, moist climates. Validating predicted SOC change at 18 sites with varying soil types and environmental conditions showed that the RK approach to estimate reference carbon stocks decreased global prediction errors by 45 [percent] relative to the default reference values. The increase in prediction accuracy was due to using spatially varying SOC stocks rather than simple data averaging to derive reference SOC values. The uncertainty analysis demonstrated that there was more precision in the results from the RK approach in comparison to the results from the SA approach. These results suggest that improved geostatistical approach is a promising technique for improving soil carbon inventories that utilize the IPCC method, and will provide more precise results for informing public policy and management decisions while retaining ease of application." **Umakant Mishra, Margaret S. Torn, Eric Masanet, and Stephen M. Ogle,** *Geoderma*, Available online August 18, 2012, doi:10.1016/j.geoderma.2012.06.022, http://www.sciencedirect.com/science/article/pii/S0016706112002571. (Subscription may be required.)

Trading

***RGGI News Release*, "RGGI Auction Sells 24.5 Million CO_2 Allowances."**

The states participating in the Regional Greenhouse Gas Initiative (RGGI) announced that 24,589,000 CO_2 allowances were sold in their 17th auction, held Wednesday, September 5. The auction generated $47.4 million for reinvestment by the RGGI states in energy efficiency, clean and renewable energy, direct bill assistance, and other consumer benefit programs across the region. Bids for the CO_2 allowances ranged from $1.93 to $6.51 per allowance, with a clearing price of $1.93, the minimum reserve price for the auction. Allowances sold represent 65 percent of the 37,949,558 allowances offered for sale. The RGGI states are conducting a comprehensive program review to ensure RGGI's continued success. The next RGGI auction is scheduled for December 5, 2012. September 7, 2012, http://www.rggi.org/docs/Auctions/17/PR090712_Auction17.pdf.

***UPI.com*, "Australia and EU to Link Emissions Trading."**

The Australian government announced that Australia's carbon pricing scheme will link with the European Union's (EU) emissions trading plan. In the EU's plan, businesses emitting 25,000 tons of CO_2 (or the equivalent in other GHGs) are charged $24 per ton. In 2015, Australia's plan was to convert to an emissions trading scheme with a floating price starting at a floor of $15; the floor price will now be eliminated and the plan will be linked with the EU's, whose emissions trading scheme stands at approximately $10 per ton. The link will initially be "one way," allowing Australian businesses to buy permits from the EU scheme; "two-way" trade will begin in 2018. August 28, 2012, http://www.upi.com/Business_News/Energy-Resources/2012/08/28/Australia-and-EU-to-link-emissions-trading/UPI-20871346165904/?spt=hs&or=er.

***China Daily*, "Carbon Emission Rights Trading Scheme Launched."**

Shanghai has launched a pilot carbon emission rights trading scheme to encourage carbon emission reductions among the approximately 200 local emitters participating, the city government announced. Each of the carbon market participants, which include industrial companies whose annual CO_2 emissions approach 20,000 metric tons and non-industrial enterprises whose annual emissions total 10,000 metric tons, will get a free quota for a certain base carbon emission. Those companies who fail to meet their emission cut targets will need to buy quota from the companies whose emission cuts exceed their targets. China has pledged to reduce CO_2 emissions per unit of GDP by 40 to 45 percent compared to 2005 levels by 2020. August 17, 2012, http://www.chinadaily.com.cn/china/2012-08/17/content_15682368.htm.

Recent Publications

"Understanding how individuals perceive carbon dioxide: Implications for acceptance of carbon dioxide capture and storage."
The following is the Executive Summary of this document: "CCS presents one potential technological solution for mitigating the atmospheric emission of CO_2. However, CCS is a relatively new technology with associated uncertainties and perceived risks. For this reason, a growing body of research now focuses on public perceptions and potential for societal acceptance of CCS technology. Almost all explanations of CCS technology make reference to [CO_2], with an assumption that the general public understands CO_2. It has become apparent that the general public's knowledge and understanding of CO_2's properties influences how they engage with CO_2 emitting industries and CCS technologies. However, surprisingly little research has investigated public perceptions, knowledge, and understanding of CO_2. This investigation attempts to fill that gap. This report describes an investigation of how citizens of three countries – Japan, Australia, and the Netherlands – perceive CO_2. Furthermore, it attempts to relate individual perceptions of CO_2 to perceptions of CCS, and to determine how information provision about the underlying properties and characteristics of CO_2 influences individual attitudes towards low carbon energy options, particularly CCS. In brief, the research had four ultimate aims. It aimed to: [1] Explore the public's knowledge and understanding of the properties of CO_2; [2]•Examine the influence of that knowledge on their perceptions of CO_2 and CCS; [3] Investigate how information provision about the underlying properties and characteristics of CO_2 influences individual attitudes towards CCS; and [4] Identify if any differences between countries exist in relation to values and beliefs, knowledge of CO_2's properties, and CCS perceptions. The research employed both qualitative and quantitative methods designed to complement each other. The qualitative component consisted of interviews and focus groups aimed at exploring public knowledge of CO_2 across each of the countries. They also provided an opportunity to explore how participants reacted when provided with information about CO_2 and CCS. Using a grounded theory approach, common themes and attributes identified in the qualitative component informed the development of a large scale survey, which was piloted and then rolled out in each country." The full CSIRO report is available at: http://cdn.globalccsinstitute.com/sites/default/files/publications/42501/perceptionsofco2reportfinalversion200612.pdf.

"Global Industrial CCS Technology Roadmap: Sectoral Assessment: Source-to-Sink Matching Final Report."
The following is from the Executive Summary of this document: "The aim of this study was to perform a 'source-to-sink' matching exercise on five selected industrial sectors in non-[Organization for Economic Cooperation and Development (OECD)] countries, in order to determine the potential for industrial CCS deployment. This assessment was completed within the greater context of the [United Nations Industrial Development Organization (UNIDO)] 'Global Technology Roadmap for CCS in Industry' assessment. As such, this study serves as a basis for identifying some key tasks that will need to be undertaken if

Recent Publications (Continued)

industrial CCS deployment is to advance to a level that is necessary for achieving global GHG emission reduction targets by 2050. The analysis performed here, which uses a qualitative source-to-sink matching approach to pair industrial CO_2 sources with geological formations seen as potentially holding sufficient CO_2 storage capacity, focuses on [11] non-OECD regions throughout the world. In terms of emission source inventory, this study is based on the emission source information available from the [International Energy Agency Greenhouse Gas R&D Program (IEAGHG)] CO_2 database, which is currently the most comprehensive, publicly available database and which also provides the geographical location data needed for this study." To download the report, go to: http://www.globalccsinstitute.com/publications/global-industrial-ccs-technology-roadmap-sectoral-assessment-source-sink-matching-final.

"Integrity of wellbore cement in CO_2 storage wells: State of the art review."

The following is from the Executive Summary of this document: "Wells are the key technology for both storing CO_2 and monitoring its reservoir migration. However new and existing wells could also represent a risk to storage assurance by potentially providing [release] pathways. Well construction involves the use of cement for two main functions; to cement well casing in place and to plug wells that are abandoned. CO_2 could [release] from abandoned wells by flowing through a degraded, damaged or incomplete plug or outside the casing, between the casing and the formation. While one outcome is that CO_2 could migrate directly to surface via the well there is also the potential for CO_2 to migrate to other formations which may not have appropriate geology to prevent subsequent [release] or may contain other resources. There are three main pathways for CO_2 [release] between the casing and the formation; the interface between the cement and the formation, within the cement itself or the interface between the cement and well casing. While poor cementing practices during well completion may represent an important opportunity for the creation of migration pathways, there is also potential that cement degradation over long time periods could create pathways in otherwise soundly cemented wells. The focus of the current report is on the previous work related to the potential for cement to degrade to the extent that storage assurance is compromised rather than on completion practices." The full document is available at: http://www.globalccsinstitute.com/publications/integrity-wellbore-cement-co2-storage-wells-state-art-review.

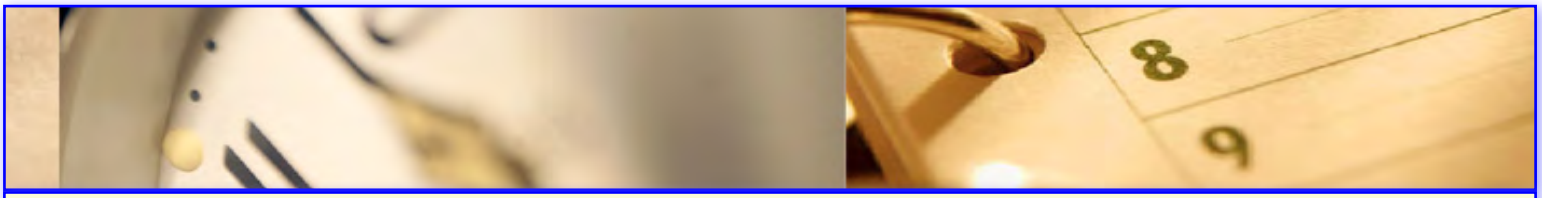
Legislative Activity

***DNV Press Release*, "New Certification Framework for CO_2 Storage."**

DNV's new framework builds on preceding guidelines for CO_2 storage and is organized as two documents. The first document, "Recommended Practice (RP) J203," is for the selection, qualification, and management of geological storage sites. This document is available at: http://exchange.dnv.com/publishing/Codes/download.asp?url=2012-04/rp-j203.pdf. RP J203 outlines generic workflows reflective of a site-specific and risk-based approach that should contribute to enhanced traceability and efficiency across projects. The second document, "DNV Service Specification (DSS) 402," defines the following statements and certificates that may be issued in project development: Statement of Feasibility, Statement of Endorsement, Certificate of Fitness for Storage, and Certificate of Fitness for Closure. This document is available at: http://exchange.dnv.com/publishing/Codes/download.asp?url=2012-06/dss-402.pdf. RP-J203 is consistent with the ISO31000 international standard for risk management. According to officials, the new framework fills a gap by providing a common international method for CO_2 storage site selection, risk assessment, monitoring, and verification. August 29, 2012, http://www.dnv.com/news_events/news/2012/newcertificationframeworkforco2storage.asp.

Events

October 15-16, 2012, **Climate Change: Security, Resilience and Diplomacy**, *Chatham House, London, UK*. The 16th Annual Chatham House Conference on Climate Change will assess the actions that need to be taken to manage climate security challenges in the 21st century. The conference is made up of six separate sessions, including one focused on climate change policy and the effect of carbon trading on reducing global carbon emissions. More information is available at: http://www.chathamhouse.org/climatechange2012.



Events (Continued)

October 15-18, 2012, **29th Annual Pittsburgh Coal Conference**, *David L. Lawrence Convention Center, Pittsburgh, Pennsylvania, USA*. This conference will focus on environmental emissions issues and technologies surrounding the continued use of coal, as well as the development of future coal-based energy plants. Among the topics to be discussed in the sessions are combustion, gasification, sustainability, carbon management, coal-derived products, coal science, clean coal demonstration and commercial projects, and coal mining and coal gas. For more information, visit the conference website at: http://www.engineering.pitt.edu/Coal_Conference/2012_Conference.aspx.

October 17-18, 2012, **ImechE Carbon Capture and Storage – Ready, Steady, Go!**, *Institution of Mechanical Engineers, London, UK*. The Institution of Mechanical Engineers' (ImechE) 6th international conference aims to prepare companies for commercial-scale CCS technologies by covering, among other topics, the latest in European Union (EU) and UK government CCS decisions, funding for CCS research and project development, CCS business development and investment opportunities, and legal and regulatory issues surrounding the development market. To download the brochure, visit the seminar's website at: http://events.imeche.org/EventView.aspx?EventID=1442.

October 21-23, 2012, **National CCS Conference**, *Burswood Entertainment Complex, Perth, Australia*. The theme of this conference, which is the major event of National CCS Week, a biennial Australian-based event focusing on CCS as an essential part of the global GHG mitigation portfolio, is "Advancing CCS: Progress and Achievements." The aim of the conference will be to facilitate knowledge sharing and networking opportunities between CCS stakeholders and to raise awareness of CCS among the community. To learn more about the conference and Australia's National CCS Week, visit: http://www.nationalccs.com.au/information/?IntCatId=43.

November 5-6, 2012, **1st International Conference on Urban Sustainability and Resilience**, *University College London, London, UK*. Experts from engineering, science, and social science disciplines will come together at this international conference to discuss the current state of knowledge in the field of urban sustainability and resilience. Among the central themes of the conference will be the development of a low-carbon urban environment. To learn more, go to: http://www.usar-conference-2012.org/.

November 5-9, 2012, **CLIMATE 2012**. This online climate conference will focus on the latest scientific findings on the social, economic, and political aspects of potential climate change. New projects and innovative initiatives in both industrialized and developing countries by universities, scientific institutions, government bodies, non-governmental organizations (NGOs), and other stakeholders will be covered. For more information, visit the conference website at: http://www.climate2012.de/.

November 18-22, 2012, **International Conference on Greenhouse Gas Technologies 11 (GHGT-11)**, *Kyoto International Conference Center, Japan*. This will be the second visit to Kyoto by the GHGT conference series, with more than 1,600 delegates expected to attend. The call for papers has expired. Visit: http://www.ghgt.info/index.php/Content-GHGT11/ghgt-11-overview.html for more details.

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To learn more about DOE's Carbon Sequestration Program, please contact John Litynski at john.litynski@netl.doe.gov, or Dawn Deel at dawn.deel@netl.doe.gov.