NETL the ENERGY lab

Carbon Sequestration Newsletter

A Call for Abstracts

see page 3

June 2011

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*, "National Carbon Capture Center Launches Post-Combustion Test Center."**

According to the U.S. Department of Energy (DOE), the recent successful commissioning of the Post-Combustion Carbon Capture Center (PC4) at the National Carbon Capture Center (NCCC) in Alabama will speed deployment of post-combustion carbon dioxide (CO_2) capture technologies for coal-based power plants. Initial testing began at the PC4 facility, which is located at the Alabama Power Gaston Power Plant Unit 5 (an 880-megawatt [MW] supercritical pulverized coal unit), when researchers used a monoethanolamine (MEA) solvent to capture CO_2 from a slipstream of flue gas from the plant. To date, the MEA solvent has exceeded the expected 90 percent CO_2 capture; the unit is now in steady operation, capturing approximately 10 tons of CO_2 per day. NCCC, a testing and evaluation center established by DOE in 2009, is operated and managed by Southern Company and works collaboratively with technology developers worldwide to test and evaluate both pre- and post-combustion CO_2 capture technologies under realistic conditions. NCCC's goal is to accelerate development of these technologies and ensure continued use of coal for power generation. To learn more about NCCC, visit: http://www.nationalcarboncapturecenter.com/index.html. June 7, 2011, http://www.fossil.energy.gov/news/techlines/2011/11024-NCCC_Launches_Post-Combustion_Test.html.

Sequestration in the News

***Southern Company Press Release*, "World's Largest Power Plant CCS Project Is Capturing Carbon."**

Southern Company's 25-MW carbon capture and storage (CCS) facility located at Plant Barry near Mobile, Alabama, is now operating and capturing CO_2. The facility will capture approximately 150,000 tons of CO_2 annually for storage in a saline formation. The CO_2, which is being captured at the Barry facility by using Mitsubishi Heavy Industries Ltd. technology KM-CDR™, will be supplied to the Southeast Regional Carbon Sequestration Partnership (SECARB) for pipeline transport and injection 9,500 feet underground at a site within the Citronelle Oil Field, which is approximately 11 miles from the plant. The site was revealed to have excellent characteristics for safe geologic storage from a characterization well previously drilled within the field by SECARB, one of DOE's Regional Carbon Sequestration Partnerships (RCSPs). June 13, 2011, http://www.southerncompany.com/news/dyn_pressroom.aspx?s=43&item=2337.

***Transmission and Distribution World*, "Mountaineer Carbon Capture and Sequestration Project Results Announced."**

Alstom Power announced the successful operation of a chilled ammonia CCS validation project at American Electric Power's (AEP) Mountaineer Plant in New Haven, West Virginia.

National Energy
Technology Laboratory

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880

13131 Dairy Ashford Road, Suite 225
Sugar Land, TX 77478

1450 Queen Avenue SW
Albany, OR 97321-2198

2175 University Ave. South, Suite 201
Fairbanks, AK 99709

John T. Litynski
412-386-4922
john.litynski@netl.doe.gov

Dawn M. Deel
304-285-4133
dawn.deel@netl.doe.gov

Visit the NETL website at:
www.netl.doe.gov

Customer Service:
1-800-553-7681

Sequestration in the News (Continued)

The project achieved capture rates ranging from 75 percent to as high as 90 percent; CO_2 purity of greater than 99 percent; and CO_2 injection levels of approximately 7,000 tons/month. In addition, the project achieved energy penalties within a few percent of predictions from Alstom's process simulation model, and robust steady-state operation during all modes of power plant operations. These results suggest a large-scale demonstration project planned for Mountaineer would have the ability to capture up to 1.5 million metric tons of CO_2 per year. In 2009, a 20-megawatt electric (MWe) portion of AEP's 1,300-MWe coal-fired Mountaineer Plant was retrofitted with Alstom's chilled ammonia CO_2 capture technology. May 9, 2011, http://tdworld.com/business/alstom-ccs-project-results-0511/.

***Air Products News Release*, "Air Products Signs Two Agreements to Move Texas Carbon Capture and Sequestration Project Forward."**

Air Products announced the signing of two agreements to proceed with a planned CCS project in Port Arthur, Texas, where CO_2 will be captured and delivered for enhanced oil recovery (EOR) operations. As part of the agreements, Air Products will design, construct, and operate a state-of-the-art system to capture CO_2 from two steam methane reformers (SMRs) located within the Valero Refinery in Port Arthur. The CO_2 will then be delivered via a pipeline owned by Denbury Green Pipeline-Texas to Denbury Onshore, LLC, beginning in late 2012, where it will be used for EOR operations. Approximately 1 million tons of CO_2 will be recovered annually. May 26, 2011, http://www.airproducts.com/company/news-center/2011/0526-air-products-signs-two-agreements-for-texas-carbon-capture-and-sequestration-project.aspx.

ANNOUNCEMENTS

NETL Releases Updated Version of the Carbon Sequestration Website.

DOE's National Energy Technology Laboratory (NETL) released a new, user-friendly version of the Carbon Sequestration Program website in early May. The Carbon Sequestration Program website contains both introductory and in-depth information about sequestration fundamentals, supporting technologies, sequestration applications, environmental benefits, and the status of the latest research and development (R&D) activities. The updated website can be viewed at: http://www.netl.doe.gov/technologies/carbon_seq/index.html.

NETL Releases Worldwide CCS Database – Version 3.

NETL released Version 3 of its CCS Database, including updated information on active, proposed, canceled, and terminated CCS projects worldwide. The 254 projects in the CCS Database include 65 capture, 61 storage, and 128 capture and storage projects in more than 27 countries across 6 continents. While most of the projects are still in the planning and development stage, or have recently been proposed, 20 are actively capturing and injecting CO_2. Access to the database requires Google Earth. To view NETL's CCS Database, please visit: http://www.netl.doe.gov/technologies/carbon_seq/global/database/index.html.

NETL's 2011 Carbon Sequestration Project Portfolio Available Online.

The 2011 Carbon Sequestration Project Portfolio contains selected Carbon Sequestration Program papers and publications; NETL's Best Practices Manuals (BPMs); Infrastructure fact sheets (RCSP Validation and Development Phases); and Carbon Sequestration Core R&D fact sheets (pre-combustion capture; geologic carbon storage; monitoring, verification, and accounting [MVA]; simulation and risk assessment; and CO_2 utilization). The portfolio is available at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/project%20portfolio/2011/index.html.

Call for Abstracts.

The Carbon Management Technology Conference 2012 issued a call for abstracts on a number of CCS-related topics, including: CO_2 capture technology; transport and geologic storage; EOR and other CO_2 utilization technologies; regulatory and legal issues; economics, business models, and risk management; monitoring applications; and project case studies. The abstract submission deadline is July 18, 2011, and a brochure is available at: http://www.spe.org/events/cmtc/2012/documents/12CMTC_CFP.pdf.

Summer Course on Carbon Capture & Storage.

This Massachusetts Institute of Technology (MIT) summer course, held July 18-20, 2011, will cover the science, technology, and policy aspects of CCS. Topics to be discussed include the role of carbon storage in potential climate change mitigation, fundamentals of fluid flow and CO_2 migration in geologic formations, site selection and potential risks, technical challenges for large-scale CCS deployment, and the role of policy in establishing market and business opportunities for CCS. To learn more, visit: http://web.mit.edu/professional/short-programs/courses/carbon_capture_storage.html.

SCIENCE

***Science Daily*, "Antarctic Icebergs Help Ocean Take Up Carbon Dioxide."**

According to a study published in the journal "Deep Sea Research Part II: Topical Studies in Oceanography," icebergs in the Antarctic fertilize the Southern Ocean, which enhances the growth of carbon-storing algae. The biological effects of Antarctic icebergs were analyzed by tracking individual icebergs during three separate cruises to the Weddell Sea. The icebergs drifted to Weddell Sea as Antarctic ice shelves shrunk and split apart. According to the research, the drifting icebergs carry iron-rich sediment, which, as the icebergs melt, dissolves into the water and helps fertilize the growth of microscopic algae. Scientists measured the amount of organic carbon sinking into the deep sea beneath a free-floating iceberg and compared that with the amount of carbon sinking in the open ocean nearby. They found that approximately twice as much carbon sank into the deep sea within an 18.6-mile radius of the iceberg compared to an open-ocean area. May 12, 2011, http://www.sciencedaily.com/releases/2011/05/110511131140.htm.

***Science Daily*, "Global Warming May Increase the Capacity of Trees to Store Carbon."**

According to a study by the Marine Biological Laboratory (MBL), potential climate change may affect the ability of trees to store CO_2 by altering forest nitrogen cycling. Published in the journal "Proceedings of the National Academy of Sciences," the paper summarizes the results of a seven-year study at Harvard Forest in central Massachusetts where about one-quarter of the forest was artificially warmed by approximately 9°F above ambient to simulate a warmer climate. The results indicated that a warmer climate leads to

Science (Continued)

more rapid decomposition of the organic matter soil, which in turn leads to an increased amount of CO_2 emissions released in the atmosphere. However, the study also showed that the warmer temperatures stimulate the gain of CO_2 stored in trees, partially offsetting the soil carbon loss in the atmosphere. According to the research, the CO_2 gain in trees is due to the availability of more nitrogen to the trees with warmer soil. May 31, 2011, http://www.sciencedaily.com/releases/2011/05/110525120050.htm.

Policy

***Government of Alberta News Release*, "New Regulations Help Enable Carbon Storage."**

A new regulation, titled the "Carbon Sequestration Tenure Regulation," establishes the process for companies to seek tenure rights to evaluate potential carbon storage sites. Under the regulation, which is expected to guide how large-scale CCS projects will proceed in Alberta, companies will apply for pore space tenure following the same model that is currently in place for petroleum and natural gas rights. In addition, the regulation sets out several administrative details and processes that include establishing a five-year evaluation permit to determine storage site suitability; establishing a 15-year storage lease for longer term commercial needs; and requiring permit and lease holders to submit MVA plans, which must be approved and updated every three years. April 28, 2011, http://alberta.ca/home/NewsFrame.cfm?ReleaseID=/acn/201104/302889DAAB79F-0A5B-1418-BA33BB135909F2D8.html.

"Carbon Capture and Sequestration: The U.S. Department of Energy's R&D Efforts to Characterize Opportunities for Deep Geologic Storage of Carbon Dioxide in Offshore Resources."

The following is the Abstract of this article: "DOE is the lead Federal agency for the research, development, demonstration, and deployment (RDD&D) of carbon sequestration technologies. This effort is being implemented through several activities, including applied R&D, demonstration projects, and technical support to loan guarantee and tax incentives programs. The sequestration program started in 1997 and has grown significantly. In Fiscal Year 2010, $145 million in Federal funding was received to support CCS-related R&D. The Sequestration Program also received $80 million in funding from the 2009 American Recovery and Reinvestment Act (ARRA) to support the development of resources for geologic storage of CO_2. The goal of the program is to develop a suite of technologies that can support the implementation of commercial CCS projects by 2020. Part of the program funding is being used to assess the potential for storing CO_2 in offshore geologic formations. This paper presents an overview of projects awarded to assess the potential for geologic storage in state and Federal waters in the Gulf of Mexico (GOM), the Atlantic and Pacific Oceans, and in Texas and California state territorial waters, as well as research efforts DOE is supporting world-wide. These efforts are aimed at capacity assessments; monitoring and modeling of sub-seabed storage projects; characterization of projects that are drilling wells and conducting seismic surveys; and assessment of regulatory gaps relative to storing CO_2 inoffshore formations. The results are expected to provide a summary of basin-scale suitability and will identify and prioritize potential offshore CO_2 geological storage opportunities." **J.T. Litynski, B.M. Brown, D.M. Vikara, R.D. Srivastava**. Presented at the Offshore Technology Conference, held May 2-5, 2011, in Houston, Texas, http://www.onepetro.org/mslib/app/Preview.do?paperNumber=OTC-21987-MS&societyCode=OTC. (Subscription may be required.)

Geology

"A review of physical [modeling] and numerical simulation of long-term geological storage of CO_2."

The following is the Abstract of this article: "Numerical simulations are essential to the understanding of the long-term geological storage of CO_2. Physical [modeling] of geological storage of CO_2 has been based on Darcy's law, together with the equations of conservation of mass and energy. [Modeling] and simulations can be used to predict where CO_2 is likely to flow, to interpret the volume and spatial distribution of CO_2 under storage conditions, and to [optimize] injection operations. The state of the art of physical [modeling] and numerical simulation of CO_2 dispersion is briefly reviewed in this paper, which calls for more accurate and more efficient [modeling] approaches. A systematic evaluation of the numerical methods used and a comparison between the streamline based methods and the grid based methods would be valuable. Multi-scale [modeling] may prove to be of great value in predicting the long-term geological storage of CO_2, while highly accurate numerical methods such as high-order schemes may be employed in numerical simulations of CO_2 dispersion for local transport calculations." **Xi Jiang**, *Applied Energy*, Available online May 31, 2011, doi:10.1016/j.apenergy.2011.05.004, http://www.sciencedirect.com/science/article/pii/S0306261911002959. (Subscription may be required.)

"Permeability evolution in fractured coal: The roles of fracture geometry and water-content."

The following is the Abstract of this article: "[The authors] report laboratory experiments that investigate the permeability evolution of an anthracite coal as a function of applied stress and pore pressure at room temperature as an analog to other coal types. Experiments are conducted on 2.5 cm diameter, 2.5-5 cm long cylindrical samples at confining stresses of 6 to 12 MPa. Permeability and sorption characteristics are measured by pulse transient methods, together with axial and volumetric strains for both inert (helium [He]) and strongly adsorbing (methane [CH_4] and CO_2) gases. To explore the interaction of swelling and fracture geometry [the authors]measure the evolution of mechanical and transport characteristics for three separate geometries — sample A containing multiple small embedded fractures, sample B containing a single longitudinal through-going fracture and sample C containing a single radial through-going fracture. Experiments are conducted at constant total stress and with varied pore pressure — increases in pore pressure represent concomitant (but not necessarily equivalent) decreases in

Geology (Continued)

effective stress. For the samples with embedded fractures (A and C) the permeability first decreases with an increase in pressure (due to swelling and fracture constraint) and then increases near-linearly (due to the over-riding influence of effective stresses). Conversely, this turnaround in permeability from decreasing to increasing with increasing pore pressure is absent in the discretely fractured sample (B) — the influence of the constraint of the connecting fracture bridges in limiting fracture deformation is importantly absent as supported by theoretical considerations. Under water saturated conditions, the initial permeabilities to all gases are nearly two orders of magnitude lower than for dry coal and permeabilities increase with increasing pore pressure for all samples and at all gas pressures. [The authors] also find that the sorption capacities and swelling strains are significantly reduced for water saturated samples — maybe identifying the lack of swelling as the primary reason for the lack of permeability decrease. Finally, [the authors] report the weakening effects of gas sorption on the strength of coal samples by loading the cores to failure. Results surprisingly show that the strength of the intact coal (sample A) is smaller than that of the axially fractured coal (sample B) due to the extended duration of exposure to CH_4 and CO_2. Average post-failure particle size for the weakest intact sample (A) is found to be three times larger than that of the sample B, based on the sieve analyses from the samples after failure. [The authors] observe that fracture network geometry and saturation state exert important influences on the permeability evolution and strength of coal under in situ conditions." **Shugang Wang, Derek Elsworth, and Jishan Liu**, *International Journal of Coal Geology*, Available online May 1, 2011, doi:10.1016/j.coal.2011.04.009, http://www.sciencedirect.com/science/article/pii/S0166516211000851. (Subscription may be required.)

Technology

"U.S. DOE methodology for the development of geologic storage potential for carbon dioxide at the national and regional scale."

The following is the Abstract of this article: "A detailed description of the U.S.-DOE methodology for estimating CO_2 storage potential for oil and gas reservoirs, saline formations, and unmineable coal seams is provided. The oil and gas reservoirs are assessed at the field level, while saline formations and unmineable coal seams are assessed at the basin level. The U.S.-DOE methodology is intended for external users such as RCSPs, future project developers, and governmental entities to produce high-level CO_2 resource assessments of potential CO_2 storage reservoirs in the United States and Canada at the regional and national scale; however, this methodology is general enough that it could be applied globally. The purpose of the U.S.-DOE CO_2 storage methodology, definitions of storage terms, and a CO_2 storage classification are provided. Methodology for CO_2 storage resource estimate calculation is outlined. The Log Odds Method when applied with Monte Carlo Sampling is presented in detail for estimation of CO_2 storage efficiency needed for CO_2 storage resource estimates at the regional and national scale. [Carbon dioxide] storage potential reported in the U.S.-DOE's assessment are intended to be distributed online by a geographic information system in [National Carbon Sequestration Database and Geographic Information System (NATCARB)] and made available as hard-copy in the Carbon Sequestration Atlas of the United States and Canada. U.S.-DOE's methodology will be continuously refined, incorporating results of the Development Phase projects conducted by the RCSPs from 2008 to 2018. Estimates will be formally updated every two years in subsequent versions of the Carbon Sequestration Atlas of the United States and Canada." **Angela Goodman, Alexandra Hakala, Grant Bromhal, Dawn Deel, Traci Rodosta, Scott Frailey, Mitchell Small, Doug Allen, Vyacheslav Romanov, Jim Fazio, Nicolas Huerta, Dustin McIntyre, Barbara Kutchko, and George Guthrie**, *International Journal of Greenhouse Gas Control*, Available online April 19, 2011, doi:10.1016/j.ijggc.2011.03.010, http://www.sciencedirect.com/science/article/pii/S1750583611000405. (Subscription may be required.)

"Combining power plant water needs and carbon dioxide storage using saline formations: Implications for carbon dioxide and water management policies."

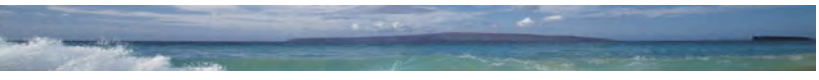
The following is the Abstract of this article: "Research involving management of [CO_2] has increased markedly over the last decade as it relates to concerns over climate change. Capturing and storing CO_2 in geological formations is one of many proposed methods to manage, and likely reduce, CO_2 emissions from burning fossil fuels in the electricity sector. Saline formations represent a vast storage resource, and the waters they contain could be managed for beneficial use. To address this issue, a methodology was developed to test the feasibility of linking coal-fired power plants, deep saline formations for CO_2 storage, and extracting and treating saline waters for use as power plant cooling water. An illustrative hypothetical case study examines a representative power plant and saline formation in the southwestern United States. A regional assessment methodology includes analysis of injection-induced changes in subsurface groundwater chemistry and fate and transport of supercritical CO_2. Initial water-CO_2-formation reactions include dissolution of carbonate minerals as expected, and suggest that very little CO_2 will be stored in mineral form within the first few centuries. Reservoir simulations provide direct input into a systems-level economic model, and demonstrate how water extraction can help manage injection-induced overpressure. Options for treatment of extracted water vary depending upon site specific chemistry. A high efficiency reverse osmosis system (HERO™) shows promise for economical desalination at the volumes of recovered water under consideration. Results indicate a coupled use CO_2 storage and water extraction and treatment system may be feasible for tens to hundreds of years." **Peter H. Kobos, Malynda A. Cappelle, Jim L. Krumhansl, Thomas A. Dewers, Andrea McNemar, and David J. Borns**, *International Journal of Greenhouse Gas Control*, Available online May 2, 1011, doi:10.1016/j.ijggc.2011.03.015, http://www.sciencedirect.com/science/article/pii/S1750583611000466. (Subscription may be required.)

"A new triaxial apparatus to study the mechanical and fluid flow aspects of carbon dioxide sequestration in geological formations."

The following is from the Abstract of this article: "Climate scientists are practically unanimous in the belief that anthropogenic [greenhouse

Technology (Continued)

gas (GHG)] contributions have added to the thickness and thus the effectiveness of the [GHG] layer, leading to a warming of the planet. Engineers and scientists around the globe are researching and developing measures to reduce [GHG] emissions. These measures have included proposals to sequester CO_2 in deep geological formations. For CO_2 sequestration in deep geological reservoirs to become a feasible strategy to reduce [GHG] emissions, a sound understanding of the manner by which mechanical properties and permeability changes with the introduction of CO_2 to the geological reservoir will influence the stability of that reservoir is required. Thus there is a need to develop laboratory equipment capable of simulating the CO_2 injection and storage process for deep geological CO_2 sequestration under the expected in situ pressure (confinement and fluid) and temperature conditions. Triaxial experiment has been identified as the best method for this purpose. Therefore, [the authors] present a new high-pressure triaxial apparatus which can provide the high confining and fluid injection pressures and elevated temperatures expected for deep geological CO_2 sequestration. The new setup can be used to conduct mechanical and permeability testing on intact or fractured natural rock samples or synthetic rock samples subjected to high-pressure injection of up to three fluid phases (gas and/or liquid) at high pressures and temperatures corresponding to field conditions. The equipment is capable of delivering fluids to the sample at injection pressures of up to 50 MPa, confining pressures of up to 70 MPa and temperature up to 50°C and will continuously record fluid injection and confining pressures, axial load and displacement, radial displacement and independent outflow rates for liquid and gas fluid phases (under drained conditions). Leakage tests have confirmed the effectiveness of the device at pressures up to its maximum capacities. Additionally the temperature-pressure relationship for the hydraulic oil used to apply confining pressure to the sample has been calibrated to account for the influence of changes in temperature on confining pressure. Several permeability tests (using [nitrogen (N_2)] and CO_2 as the injection fluid and 10 MPa confining pressure) and one strength test are reported for black coal samples from the Sydney Basin, New South Wales. According to the results of the permeability tests, coal mass permeability decreases with increasing effective stress for both gases. However, the permeability for N_2 gas is much higher than CO_2. Moreover, test results are consistent with matrix swelling due to the adsorption of CO_2 in coal. The strength testing results are in agreement with the results of testing carried on similar black coal samples from literature, certifying the ability for the new device to accurately measure strength and deformation properties of rock under deep ground conditions." **P.G. Ranjith and M.S.A. Perera**, *Fuel*, Available online April 16, 2011, doi:10.1016/j.fuel.2011.04.004, http://www.sciencedirect.com/science/article/pii/S0016236111001967. (Subscription may be required.)



Terrestrial

"Long-term management impacts on carbon storage in Lake States forests."

The following is the Abstract of this article: "[The authors] examined carbon storage following 50+ years of forest management in two long-term silvicultural studies in red pine and northern hardwood ecosystems of North America's Great Lakes region. The studies contrasted various thinning intensities (red pine) or selection cuttings, shelterwoods, and diameter-limit cuttings (northern hardwoods) to unmanaged controls of similar ages, providing a unique opportunity to evaluate long-term management impacts on carbon pools in two major North American forest types. Management resulted in total ecosystem carbon pools of 130–137 Mg ha^{-1} in thinned red pine and 96–177 Mg ha^{-1} in managed northern hardwoods compared to 195 Mg ha^{-1} in unmanaged red pine and 224 Mg ha^{-1} in unmanaged northern hardwoods. Managed stands had smaller tree and deadwood pools than unmanaged stands in both ecosystems, but management had limited impacts on understory, forest floor, and soil carbon pools. Total carbon storage and storage in individual pools varied little across thinning intensities in red pine. In northern hardwoods, selection cuttings stored more carbon than the diameter-limit treatment, and selection cuttings generally had larger tree carbon pools than the shelterwood or diameter-limit treatments. The proportion of total ecosystem carbon stored in mineral soil tended to increase with increasing treatment intensity in both ecosystems, while the proportion of total ecosystem carbon stored in the tree layer typically decreased with increasing treatment intensity. When carbon storage in harvested wood products was added to total ecosystem carbon, selection cuttings and unmanaged stands stored similar levels of carbon in northern hardwoods, but carbon storage in unmanaged stands was higher than that of thinned stands for red pine even after adding harvested wood product carbon to total ecosystem carbon. [The authors'] results indicate long-term management decreased on-site carbon storage in red pine and northern hardwood ecosystems, but thinning intensity had little impact on carbon storage in red pine while increasing management intensity greatly reduced carbon storage in northern hardwoods. These findings suggest thinning to produce different stand structures would have limited impacts on carbon storage in red pine, but selection cuttings likely offer the best carbon management options in northern hardwoods." **Matthew Powers, Randall Kolka, Brian Palik, Rachel McDonald, and Martin Jurgensen**, *Forest Ecology and Management*, Available online May 7, 2011, doi:10.1016/j.foreco.2011.04.008, http://www.sciencedirect.com/science/article/pii/S0378112711002234. (Subscription may be required.)

"Phytolith occluded carbon and silica variability in wheat cultivars."

The following is the Abstract of this article: "Phytolith Occluded Carbon (PhytOC) has recently been demonstrated to be an important long-term terrestrial carbon fraction. The aim of this study was to examine the rates of silica accumulation and carbon bio-sequestered within the silica phytoliths of the leaf and stem material of wheat (Triticum sp.) cultivars. The phytolith content of 53 wheat cultivars sourced from 25 countries around the world and grown on a single trial site was first isolated and the PhytOC content then determined. The data shows that the phytolith occluded carbon content of the wheat cultivars ranged from 0.06 [percent] to 0.60 [percent] of dry leaf and stem biomass: a range of 1,000 [percent]. The data also demonstrates that it is the efficiency by which carbon is encapsulated within silica rather than the quantity of silica accumulated by the plant that is the most important factor in determining the relative

Terrestrial (Continued)

PhytOC yields. The potential phytolith carbon bio-sequestration rates in the leaf and stem components of these wheat cultivars ranged up to 0.246 t-e-CO_2 $ha^{-1}y^{-1}$. These phytolith carbon bio-sequestration rates indicate a substantial potential (~50 million t-e-CO_2 y^{-1}) exists for increasing the rate of secure carbon bio-sequestration in wheat crops using existing cultivars." **Jeffrey F. Parr and Leigh A. Sullivan**, *Plant and Soil*, doi: 10.1007/s11104-010-0680-z, http://www.springerlink.com/content/y9846747n88h6h36/. (Subscription required.)

"Carbon bio-sequestration within the phytoliths of economic bamboo species."

The following is the Abstract of this article: "The rates of carbon bio-sequestration within silica phytoliths of the leaf litter of 10 economically important bamboo species indicates that (a) there is considerable variation in the content of carbon occluded within the phytoliths (PhytOC) of the leaves between different bamboo species, (b) this variation does not appear to be directly related to the quantity of silica in the plant but rather the efficiency of carbon encapsulation by the silica. The PhytOC content of the species under the experimental conditions ranged from 1.6 [percent] to 4 [percent] of the leaf silica weight. The potential phytolith carbon bio-sequestration rates in the leaf-litter component for the bamboos ranged up to 0.7 tonnes of CO_2 equivalents (t-e-CO_2) ha^{-1} yr^{-1} for these species. Assuming a median phytolith carbon bio-sequestration yield of 0.36 t-e-CO_2 ha^{-1} yr^{-1}, the global potential for bio-sequestration via phytolith carbon (from bamboo and/or other similar grass crops) is estimated to be ~1.5 billion t-e-CO_2 yr^{-1}, equivalent to 11 [percent] of the current increase in atmospheric CO_2. The data indicate that the management of vegetation such as bamboo forests to maximize the production of PhytOC has thepotential to result in considerable quantities of securely bio-sequestered carbon." **Jeffrey Parr, Leigh Sullivan, Bihua Chen, Gongfu Ye, and Weipeng Zheng**, *Global Change Biology*, doi: 10.1111/j.1365-2486.2009.02118.x, http://dx.doi.org/10.1111/j.1365-2486.2009.02118.x. (Subscription may be required.)

Trading

***RGGI News Release*, "Regional Clean Energy Economy Boosted with $25.5 Million in RGGI Auction Proceeds."**

The states participating in the Regional Greenhouse Gas Initiative (RGGI) announced the results of their 12th quarterly auction of CO_2 allowances and published a report prepared by the independent market monitor Potomac Economics containing auction data and a list of the qualified participants. Of the 42,034,184 CO_2 allowances offered for sale for the current control period (2009-2011), 12,537,000 were sold (approximately 30 percent); the 25 winning bids ranged from $1.89 (the auction clearing price) to $7.40. Of the 1,864,952 CO_2 allowances offered for the future control period (2012-2014), 943,000 were sold (approximately 51 percent); the five winning bids ranged from $1.89 to $2.07. Electric generators and their corporate affiliates purchased 91 percent of the current control period allowances sold and 100 percent of the future control period allowances sold. To date, more than $886.4 million has been generated from the auctions, with a vast majority of the proceeds invested to promote clean energy sources and lower energy costs for consumers across the region. June 10, 2011, http://www.rggi.org/docs/Auction_12_Release_Report.pdf.

"Optimal pricing instruments for emission reduction certificates."

The following is the Abstract of this article: "The clean development mechanism (CDM), launched under the Kyoto Protocol is intended to internalize environmental externalities and to help developing countries achieve their developmental objectives employing cleaner, albeit possibly more expensive, technologies, inter alia creating markets for trading of emission reduction certificates (certified emission reduction [CER]). Statistical analyses reveal trends in pricing of Euro denominated CERs, which is interpreted as market inefficiency. Since the exporting countries are required to 'liquidate,' 'package' and 'export' a natural asset, and in real terms, surrender the option to employ certain technologies or to undertake certain initiatives, they should be recompensed through an asset of comparable quality, and more importantly, one on whose valuation the sellers have sufficient control. A currency-basket consisting of major CER exporting country currencies is considered. A specially constructed synthetic currency named the CERO, a weighted average of the CER exporting countries' import partners' currencies is proposed as a second alternative. It is strongly recommended that policy makers negotiating a successor to the Kyoto Protocol actively consider the basket approach to valuation proposed herein." **Srinivasan Sunderasan**, *Environmental Science & Policy*, Available online April 17, 2011, doi:10.1016/j.envsci.2011.03.013, http://www.sciencedirect.com/science/article/pii/S1462901111000475. (Subscription may be required.)

Recent Publications

"CCS Demonstration in Developing Countries: Priorities for a Financing Mechanism for Carbon Dioxide Capture and Storage."

The following is from the Executive Summary of this document: "Despite often-aggressive programs to promote energy efficiency and deploy nuclear, renewable, and other low-carbon energy sources, many developing countries will still rely heavily on fossil fuel energy to power their development for decades to come. There is therefore a need for developing countries to create strategies that address fossil fuel emissions in a way that minimizes the costs of doing so, and consequently minimizes impacts to their national development goals. CCS is currently the only near-commercial technology proven to directly disassociate CO_2 emissions from fossil fuel use at scale. Its

Recent Publications (Continued)

CCS is currently the only near-commercial technology proven to directly disassociate CO_2 emissions from fossil fuel use at scale. Its deployment could potentially allow developing countries to gradually shift away from fossil fuels for energy and industrial needs with relatively little disruption to their long-term development strategies. If deployed as an interim measure, it could allow time for other alternative low-carbon technologies to be developed and deployed, permitting fossil fuels to be gradually phased out. This strategy could assist developing countries to transition to a low-carbon economy in the next 15 [to] 50 years. While CCS is potentially attractive to some developing countries, there has been limited development of demonstration projects in Africa, Asia, or Latin America due mainly to their high cost in the absence of expected profits or significant carbon financing. The International Energy Agency (IEA) CCS Roadmap proposes 50 CCS projects in developing countries in the next 10 to 20 years. As well as reducing the developing world's [GHG] emissions, accelerating CCS demonstration efforts in non-OECD countries can likely also improve technologies, increase efficiency, reduce uncertainty and risk, and initiate learning-by-doing at a lower cost than would be possible in OECD countries. The captured benefits from doing so will be more significant the sooner acceleration in CCS development in developing countries begins." The full World Resources Institute (WRI) Working Paper is available at: http://pdf.wri.org/working_papers/ccs_demonstration_in_developing_countries.pdf.

"Carbon Capture and Storage Legal and Regulatory Review – Edition 2."

The following is a summary of this document: "The IEA considers CCS a crucial part of worldwide efforts to limit [climate change] by reducing GHGs. The IEA has estimated that the broad deployment of low-carbon energy technologies could reduce projected 2050 emissions to half 2005 levels – and that CCS could contribute about one-fifth of those reductions in a least-cost emissions reduction portfolio. Reaching that goal, however, would require around 100 CCS projects to be implemented by 2020 and over 3 000 by 2050. Such rapid expansion raises many regulatory issues, so in 2008 the IEA established the IEA International CCS Regulatory Network (Network). This publication, the IEA Carbon Capture and Storage Legal and Regulatory Review (CCS Review), was launched in October 2010 in response to a suggestion made at the Network's second meeting (Paris, January 2010) that the IEA produce a regular review of CCS regulatory progress worldwide. The CCS Review aims to help countries develop their own CCS regulatory frameworks by providing a forum for sharing knowledge on CCS legal and regulatory issues. It also identifies steps taken towards the legal and regulatory goals in the 2009 IEA Technology Roadmap: Carbon capture and storage. The CCS Review is produced every six months, to provide an up-to-date snapshot of CCS regulatory developments in contributing jurisdictions…The theme for this second edition of the CCS Review is long-term liability for stored CO_2. This is discussed in the second part of each contribution. Where a jurisdiction or [organization] has limited potential to discuss long-term liability, broader challenges to CCS regulatory development are addressed. For this edition, contributions were received from 28 governments and 9 international CCS [organizations]." The full publication is available for download at: http://www.iea.org/publications/free_new_Desc.asp?PUBS_ID=2407.

"Climate and Electricity Annual 2011: Data and Analyses."

The following is the Summary of this document: "Electricity use is growing worldwide, providing a range of energy services: lighting, heating and cooling, specific industrial uses, entertainment, information technologies, and mobility. Because its generation remains largely based on fossil fuels, electricity is also the largest and the fastest-growing source of energy-related CO_2 emissions, the primary cause of human-induced climate change. Forecasts from the IEA and others show that 'decarbonizing' electricity and enhancing end-use efficiency can make major contributions to the fight against climate change…The IEA Climate and Electricity Annual 2011 provides an authoritative resource on progress to date in this area, with statistics related to CO_2 and the electricity sector across ten regions of the world. It also presents topical analyses on meeting the challenge of rapidly curbing CO_2 emissions from electricity, from both a policy and technology perspective." To view the rest of the IEA report, visit: http://www.iea.org/w/bookshop/add.aspx?id=410. (Purchase required.)

Legislative Activity

***U.S. Senator John Barrasso News Release*, "Barrasso CCS Bills Ensure Long-Term Future for Coal."**

The U.S. Senate Energy and Natural Resources Committee held a hearing on two measures in May 2011. The committee discussed S.699, which would establish a program within DOE that would help the development of 10 commercial-scale CCS projects. The bill would also create an MVA system for the CO_2 stored at the project sites and provide a $10 million annual grant to educate state regulators. The second bill, S.757, would incentivize the development and implementation of new carbon capture technologies. S.699 is available at: http://www.gpo.gov/fdsys/pkg/BILLS-112s699is/pdf/BILLS-112s699is.pdf. S.757 is available at: http://www.gpo.gov/fdsys/pkg/BILLS-112s757is/pdf/BILLS-112s757is.pdf. A webcast and testimony from the hearing can be viewed at: http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Hearing&Hearing_ID=bc9e9485-df04-5fb0-8621-ac3afa2b26a6. May 12, 2011, http://barrasso.senate.gov/public/index.cfm?FuseAction=PressOffice.PressReleases&ContentRecord_id=e649575b-0a36-1cd0-9674-17f6c74ace58&Region_id=&Issue_id.

EVENTS

July 11-14, 2011, **Global Conference on Global Warming 2011**, *Calouste Gulbenkian Congress Center, Lisbon, Portugal*. This international conference discusses potential solutions to climate change issues and provides a forum for the exchange of the latest developments and technical information. To view a complete list of conference-related topics, click: http://www.gcgw.org/gcgw11/documents/poster_GCGW11.pdf.

July 18-20, 2011, **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 geologic 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.

July 19-21, 2011, **Society of Petroleum Engineers (SPE) Enhanced Oil Recovery Conference**, *InterContinental Kuala Lumpur, Kuala Lumpur, Malaysia*. This conference brings together global experts to share successes and lessons learned in evaluating and implementing the full range of EOR techniques. More information on the Technical Program is available at: http://www.spe.org/events/eorc/pages/schedule/tues_technical_programme.php.

July 21-22, 2011, **Third International Conference on Climate Change**, *JW Marriot, Rio De Janeiro, Brazil*. This conference will examine, among other topics, natural and human-generated causes of potential climate change, as well as CCS technological responses and carbon and taxes offsets. In addition, the conference will explore other social, ethical, and political responses to potential climate change. To learn more, visit: http://on-climate.com/conference-2011/.

July 25-26. 2011, **Social Media for Utilities: Strategy Development and Legal Issues**, *Denver, Colorado, USA*. This course teaches utility representatives how to build a comprehensive social media strategy through case studies and hands-on interactive exercises. Attendees will discuss the use of social media outlets to build interactive relationships with customers through engagement and responsiveness. More information is available at: https://www.euci.com/events/?ci=1353&t=O.

August 17-19, 2011, **COAL-GEN**, *Greater Columbus Convention Center, Columbus, Ohio, USA*. Covering the latest topics affecting the design, development, upgrading, operation, and maintenance of coal-fired power plants, COAL-GEN is the industry's largest event focused on the present and future of coal-fired generation. Visit the conference website at: http://www.coal-gen.com/index.html.

August 22-26, 2011, **NETL CO_2 Capture Technology Meeting**, *Sheraton Station Square Hotel, Pittsburgh, Pennsylvania, USA*. This DOE-hosted conference will present CO_2 capture technology development status and accomplishments made under NETL's Innovations for Existing Plants (IEP), Carbon Sequestration, and Demonstration Programs. Topics to be discussed include post-, oxy-, and pre-combustion carbon capture, as well as chemical looping and CO_2 compression technologies. For more information, click: http://www.netl.doe.gov/events/11conferences/co2capture/.

October 9-11, 2011, **Reservoir Characterization and Simulation Conference and Exhibition**, *Beach Rotana Hotel, Abu Dhabi, UAE*. The Society of Petroleum Engineers (SPE) is hosting the third edition of the Reservoir Characterization and Simulation Conference and Exhibition (RCSC). The conference focuses on reservoir applications and different technologies for characterizing, modeling, and simulating reservoir characteristics. To learn more, visit: http://www.spe.org/events/rcsc/2011/.

October 9-14, 2011, **CO_2 Storage: Will we be ready in time?**, *The Algarve, Portugal*. This forum, designed for professionals in the oil and gas, power, and alternative energy industries who focus on CCS schemes, will address the opportunities and challenges related to the development of CO_2 geologic storage activities that would be several orders of magnitude larger than current demonstration projects. For more information, visit: http://www.spe.org/events/11fse3/pages/about/index.php.

Events (Continued)

October 19-20, 2011, **Carbon Capture and Storage – The Leading Edge**, *London, United Kingdom*. This Institution of Mechanical Engineers seminar will discuss carbon capture technology and the implications across the regulatory, financial, and process technology fields. The following areas will also be covered: properties of CO_2, European Union competition, and front-end engineering design (FEED) case studies. Seminar details are located at: http://events.imeche.org/EventLocation.aspx?EventID=1204.

November 15-16, 2011, **Low-Carbon Energy Technologies: Innovations in Efficiency and Greenhouse Gas Reduction Science and Technology Seminar**, *Southwest Research Institute, San Antonio, Texas, USA*. This seminar will focus on alternative energy technologies, carbon reduction through improvements in efficiency, and carbon conversion and storage. Topics include: efficiency improvements to reduce carbon footprint, alternative power (wind, solar, and energy storage), low-carbon emission power plant cycles, CO_2 compression and storage, and CO_2 conversion and utilization. For more information, go to: http://www.swri.org/mailer/Div18/2011/IndLectureFlyr-4.pdf.

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 John Litynski at john.litynski@netl.doe.gov, or Dawn Deel at dawn.deel@netl.doe.gov.