Carbon Sequestration Newsletter

A Call for Papers

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April 2010

What's Inside?

Introduction

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

Highlights

***Fossil Energy Techline*, "Alabama Injection Project Aimed at Enhanced Oil Recovery, Testing Important Geologic CO_2 Storage."**

A carbon dioxide-enhanced oil recovery (CO_2-EOR) project funded through the U.S. Department of Energy's (DOE) Office of Fossil Energy (FE) and led by the University of Alabama at Birmingham is underway in the Citronelle Field of Mobile County, Alabama. The results of the 7,500-ton carbon dioxide (CO_2) injection will provide estimates of oil yields from enhanced oil recovery (EOR) and CO_2 storage capacity in depleted oil reservoirs. The primary goal of the project is to demonstrate that remaining oil can be economically produced using CO_2-EOR technology in untested areas of the United States. The Citronelle Field appears to be an ideal site for concurrent CO_2 storage and EOR because the field is composed of sandstone reservoirs in a simple structural dome and has pre-existing infrastructure. Once the oil has been recovered, the remaining storage capacity of the depleted oil reservoirs and saline formations in the Citronelle Dome is estimated in the range of 0.5 to 2 billion tons of CO_2. When the five-month injection is completed, incremental oil recovery is anticipated to be 60 percent greater than that of conventional secondary oil recovery by water flood. The Citronelle project is currently in its second phase; during the first phase, the project focused on the selection of the test site, analysis of the site geology, and study of background conditions. March 1, 2010, http://fossil.energy.gov/news/techlines/2010/10004-CO2_Injection_Begins_in_Alabama_Oi.html.

***Fossil Energy Techline*, "Secretary Chu Announces Up To $154 Million for NRG Energy's Carbon Capture and Storage Project in Texas."**

U.S. Secretary of Energy Steven Chu announced that a post-combustion carbon capture and storage (CCS) project with NRG Energy has been selected to receive up to $154 million, including funding from the American Recovery and Reinvestment Act (Recovery Act). NRG Energy will construct a 60-megawatt (MW) carbon capture demonstration facility at the company's W.A. Parish Unit 7 in Thompsons, Texas, to demonstrate advanced technology to reduce CO_2 emissions and assist with EOR efforts at a nearby oilfield. The six-year project will integrate several CCS technologies, including: (1) Fluor's advanced Econamine FG Plus(SM) carbon capture process using several different novel amine solvents; (2) Ramgen's advanced CO_2 compression system; (3) the integration of highly efficient co-generation to provide the necessary steam and electricity; and (4) CO_2-EOR in one of the Texas Gulf Coast oilfields near the Parish plant. The project will show that post-combustion carbon capture can be economically applied to existing plants when the plant has the opportunity to store CO_2 in nearby oilfields. The NRG Energy project was selected under the third round of the Clean Coal Power Initiative (CCPI), a cost-shared collaboration between the Federal government and private industry to accelerate the readiness of advanced coal technologies for commercial deployment.

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Highlights (Continued)

DOE will contribute up to $154 million in Federal funds, which will be matched by NRG Energy. For more information on DOE's Clean Coal Technology Program, click: http://www.fossil.energy.gov/programs/powersystems/cleancoal/index.html. March 9, 2010, http://www.fossil.energy.gov/news/techlines/2010/10005-NRG_Energy_Selected_to_Receive_DOE.html.

***Fossil Energy Techline*, "DOE Awards Cooperative Agreement for Post-Combustion Carbon Capture Project."**

DOE awarded a cooperative agreement to American Electric Power Service Corporation (AEP) for a project that will design, construct, and operate a system that will capture and store approximately 1.5 million tons of CO_2 per year. The "Mountaineer Commercial-Scale Carbon Capture and Storage Project" will use Alstom Power's chilled ammonia process (CAP) to capture at least 90 percent of the CO_2 from a 235-MW slipstream of the 1,300-MW Mountaineer Power Plant near New Haven, West Virginia. The captured CO_2 will then be compressed and transported by pipeline to injection sites located on AEP property near the capture facility where it will be stored in two separate saline formations located approximately 1.5 miles below the surface. Successful demonstration of the CAP system, coupled with sequestration, will show the viability of sequestration in regional saline formations and reduce CO_2 capture costs. The four-phase demonstration project will begin sequestering 1.5 million tons of CO_2 per year in 2015 and is expected to end in 2019. The $668 million project is part of the third round of DOE's CCPI and the DOE cost-share would be 50 percent ($334 million). March 12, 2010, http://www.fossil.energy.gov/news/techlines/2010/10007-DOE_Awards_Cooperative_Agreement.html.

***Fossil Energy Techline*, "DOE Awards Cooperative Agreement for Innovative Electric Generation Facility with Pre-Combustion CO_2 Capture and Storage."**

DOE awarded a cooperative agreement to Summit Texas Clean Energy LLC (STCE) for the "Texas Clean Energy Project," which will design, build, and demonstrate an integrated gasification combined cycle (IGCC) electric generating facility, complete with co-production of high-value products and CCS. The plant will be located in Ector County, Texas, and produce power by converting subbituminous coal into hydrogen-rich synthesis gas (syngas) and CO_2. Approximately 90 percent of the CO_2 produced from the facility (up to a maximum rate of about 3 million tons per year) will be captured, compressed, and transported using existing regional pipelines to the oilfields of the West Texas Permian Basin, the largest CO_2-EOR region in the world. Other benefits of the project include: a zero-liquid-discharge approach to eliminate the release of process and cooling water to the environment, increased U.S. energy security, and the creation of approximately 1,500 jobs. Sequestration for the four-phase project is expected to begin in 2014. The $1.73 billion project is part of the third round of DOE's CCPI and the DOE cost-share would be 20 percent (~$350 million). March 12, 2010, http://www.fossil.energy.gov/news/techlines/2010/10008-DOE_Awards_Cooperative_Agreement.html.

Sequestration in the News

***Wyoming State Geological Survey News Release*, "Carbon Sequestration in Wyoming Focus of New WSGS Publication."**

According to a new report written by the Wyoming State Geological Survey (WSGS), approximately 750 million tons of CO_2 could be stored in southwestern Wyoming's Rock Springs Uplift over a 50-year period – enough to potentially allow two coal-fired power plants to meet clean coal standards. The WSGS compiled an inventory of all Wyoming stratigraphic units and geologic sites capable of sequestering commercial quantities of CO_2; the research identified the Rock Springs Uplift as the most promising geological CO_2 sequestration site in Wyoming. In collaboration with the Los Alamos National Laboratory (LANL), WSGS then performed simulations to determine the amount of CO_2 that could be injected into the Weber Sandstone on the Rock Springs Uplift. Moreover, large-scale geological CO_2 storage will require management of displaced fluids from deep, underground reservoirs. The publication states that the volume of water produced by treating these fluids at the surface represents a highly valuable commodity in southwestern Wyoming. A 25-page booklet (WSGS Challenges in Geologic Resource Development No. 8) contains the study, titled, "An integrated strategy for carbon management combining geological CO_2 sequestration, displaced fluid production, and water treatment," and is available for purchase at: http://www.wsgs.uwyo.edu/Publications/Sales. The publication summarizes two years of research. February 24, 2010, http://www.wsgs.uwyo.edu/NewsCenter/PressReleases/Feb24_2010.aspx.

***Carbon Capture Journal*, "CCS Coalition Founded in California."**

Following the publication of a study stressing the role CCS could play in helping California to meet its long-term greenhouse gas (GHG) emissions targets, a group of Californian energy companies launched the California CCS Coalition. The coalition's mission is to represent the interests of CCS stakeholders in the legislative and regulatory arena and educate organizations about CCS, including the history and safety of CCS technologies, the geologic storage process, and the importance of CCS to an emissions reduction strategy. Moreover, the coalition aims to increase awareness of CCS and inform policymakers and the general public about CCS; encourage the deployment of CCS and incentives for low-carbon power production; establish definitions for low-carbon power; and encourage low-carbon power purchases by electric utilities. The study, titled, "Meeting California's Long-Term Greenhouse Gas Reduction Goals," analyzes the next 40 years and concludes that a combination of low-carbon power generation utilizing CCS, as well as wind, solar, biomass, and nuclear power, is necessary to achieving long-term GHG reduction goals. The study is available at: http://www.ethree.com/California_2050.html. March 11, 2010, http://www.carboncapturejournal.com/displaynews.php?NewsID=531&PHPSESSID=arlrvhrnvbvebnd03p4u5lro62.

Announcements

NETL Releases Funding Opportunity Announcements.

NETL released two Funding Opportunity Announcements (FOAs): (1) "DE-FOA-0000253, CO_2 Utilization," which seeks applications that will support the Carbon Sequestration Program's efforts to develop technologies that utilize CO_2 as a reactant to produce useful products at a net cost of less than $10 per metric ton (due April 20); and (2) DE-FOA-0000250, titled, "Development of Innovative and Advanced Technologies for Geologic Sequestration," which seeks applications for research leading to innovative and advanced technologies that address CO_2 geologic storage in all reservoir types and all life cycle phases of CO_2 geologic storage operations (due April 30). For more information, visit DOE's National Energy Technology Laboratory's (NETL) Solicitation & Business Opportunities webpage at: http://www.netl.doe.gov/business/solicitations/index.html.

DOE Announces $100 Million Available for Innovative Research Projects.

U.S. Secretary of Energy Steven Chu made $100 million in Recovery Act funding available to accelerate innovation in green technology, increase America's competitiveness, and create new jobs. The Advanced Research Projects Agency – Energy's (ARPA-E) third round of funding will focus on grid-scale energy storage, electrical power technology, and building energy efficiency. To learn more about the three focus areas included in the funding opportunity, click: http://www.energy.gov/news/8696.htm. For more information about ARPA-E and previously announced awards, visit: http://arpa-e.energy.gov/About.aspx.

Call for Papers.

The Society of Petroleum Engineers (SEP) issued a call for papers for its Eastern Regional Meeting scheduled for October 13-15, 2010, in Morgantown, West Virginia. Topics include: tight sands, shales, and coalbed methane; drilling, completions, and horizontal/multilateral wells; reservoir stimulation/production enhancement; carbon sequestration and gas storage; production operations, optimization, monitoring, and control; reservoir monitoring/formation evaluation; reservoir characterization and simulation; case histories; and economic evaluation, reserve analysis, and risk assessment. Abstracts will be accepted online through April 27, 2010; more information is available at: http://www.spe.org/events/erm/pages/general/call_for_papers.php.

Announcements (Continued)

Scotland Publishes CCS Roadmap.

The Scottish Government has released a CCS roadmap detailing the government's plans for developing CCS technology. The roadmap includes a comprehensive set of actions to promote CCS development in Scotland, such as: aiming to develop a number of demonstration projects; developing an offshore carbon licensing regime; and maximizing European Union (EU) and UK support. To learn more, visit: http://www.carboncapturejournal.com/displaynews.php?NewsID=529.

International Interdisciplinary CCS Summer School 2010.

Held from August 22-27, 2010, at Lonyearbyen, Svalbard, Norway, this course will cover the entire CCS field, aiming to present the most up-to-date results from several active research and development (R&D) fields, including: sources, capture, and transport of CO_2; underground geological storage; economic potential of CCS; and implications of CCS for GHG inventories and accounting. For more information, visit the summer school's website at: http://www.ieaghg.org/index.php?/20100113166/international-interdisciplinary-ccs-summer-school-2010.html.

CCS Workshop.

This informal workshop, titled, "CCS: Can Anything Be Learned from 35 Years Experience in Geological Disposal of Radioactive Wastes," will be held on April 27-30, 2010, in Meiringen, Switzerland. It will explore lessons that can be learned from the geological disposal of radioactive waste (GDRW). Experienced practitioners in the CCS and GDRW sectors will discuss their experiences and help identify any crossover applications. For more information, visit the workshop website at: http://www.itc-school.org/index.php/Present-Courses/Carbon-Capture-and-Storage.html.

Science

***USA Today*, "Fewer, Fiercer Tropical Cyclones Are in Our Future."**

According to a study published in the journal *Nature Geoscience*, potential climate change may result in fewer tropical cyclones, but the ones that do form will have greater intensity. The findings are based on an analysis of past storm data, as well as computer models that project future storm activity through the year 2100. The analysis concludes that the number of tropical cyclones around the world is expected to decrease six percent to 34 percent by the end of the century. On average, about 87 tropical cyclones form each year globally. However, as the overall numbers decrease, the intensity of the strongest storms is forecast to increase from two percent to 11 percent in the same timeframe. The storms that do survive would gain strength due to the potentially warmer sea-surface temperatures. To view the abstract of the study, titled, "Tropical cyclones and climate change," click: http://www.nature.com/ngeo/journal/v3/n3/abs/ngeo779.html. February 22, 2010, http://www.usatoday.com/weather/storms/hurricanes/2010-02-22-Hurricanes19_ST_N.htm.

***Science Daily*, "Drastic Musk Ox Population Decline 12,000 Years Ago Due to Climate, Not Human, Study Finds."**

According to findings published in the journal *Proceedings of the National Academy of Sciences*, the steep decline in Arctic musk ox populations that began approximately 12,000 years ago was due to a warming climate as opposed to human hunting. Once abundant in the Northern Hemisphere, the entire musk oxen population now only exists in Greenland. Researchers arrived at this conclusion by analyzing musk ox bones and other remains from animals that lived during different times and from across the species' former range. According to researchers, a reduction in genetic diversity of an animal's population can reflect a decrease in the size of the population. By estimating when the genetic diversity of musk oxen began to decline, researchers were able to test whether it was due to the arrival of humans in a particular region or to some other effect, such as climate change. The research showed that the genetic diversity of the musk oxen was much higher during the late Pleistocene Epoch than it is today, and that the genetic diversity of the species increased and decreased frequently over the past 65,000 years. When factoring in that musk oxen are sensitive to changes in the Arctic, and comparing the population decline to similar species, such as mammoths and bison, scientists believe that the habitat changes, and not the introduction of humans, are a factor in the decline of the musk oxen population. March 9, 2010, http://www.sciencedaily.com/releases/2010/03/100308171152.htm.

Policy

***Reuters*, "U.S. EPA Says to Ease Carbon Rules on Small Business."**

According to the U.S. Environmental Protection Agency (EPA), the CO_2 emission rules for small businesses will be adjusted. EPA originally planned on requiring companies that emit more than 25,000 tons of GHGs a year to obtain permits verifying they were using the best available technology to reduce GHG emissions. That threshold has now been raised to 75,000 tons of CO_2 emitted annually in 2011 and 2012, exempting sources such

Policy (Continued)

as hospitals, large buildings, and schools. However, heavy industries, such as coal-fired power plants, which emit approximately 1 million tons of CO_2 a year, would still be required to obtain a permit. To view EPA's original "Proposed Approach to Provide Assistance to Small Businesses on GHG Emissions," click: http://www.epa.gov/climateleaders/documents/small_business_approach.pdf. March 3, 2010, http://www.reuters.com/article/idUSTRE6224M520100303.

"Water Challenges for Geologic [CCS]."

The following is the Abstract of this article: "CCS has been proposed as a means to dramatically reduce [GHG] emissions with the continued use of fossil fuels. For geologic sequestration, the [CO_2] is captured from large point sources (e.g., power plants or other industrial sources), transported to the injection site and injected into deep geological formations for storage. This will produce new water challenges, such as the amount of water used in energy resource development and utilization and the 'capture penalty' for water use. At depth, brine displacement within formations, storage reservoir pressure increases resulting from injection, and leakage are potential concerns. Potential impacts range from increasing water demand for capture to contamination of groundwater through leakage or brine displacement. Understanding these potential impacts and the conditions under which they arise informs the design and implementation of appropriate monitoring and controls, important both for assurance of environmental safety and for accounting purposes. Potential benefits also exist, such as co-production and treatment of water to both offset reservoir pressure increase and to provide local water for beneficial use." **Robin L. Newmark, Samuel J. Friedmann, and Susan A. Carroll**, *Environmental Management*, Available online February 3, 2010, doi:10.1007/s00267-010-943-1, http://www.springerlink.com/content/k4304515k5733194/?p=3c5c743728ef4e6399e57e439e1e7d78&pi=22. (Subscription may be required.)

Geology

"Characteristics of CO_2 sequestration in saline aquifers."

The following is the Abstract of this article: "Storage of CO_2 in saline aquifers is a viable option for reducing the amount of CO_2 released to the atmosphere. This paper provides an overall review of CO_2 sequestration in saline aquifers. First, the principles of CO_2 sequestration are presented, including CO_2 phase behavior, CO_2-water-rock interaction, and CO_2 trapping mechanisms. Then storage capacity and CO_2 injectivity are discussed as the main determinants of the storage potential of saline aquifers. [A site selection] process is addressed considering basin characteristics, reservoir characteristics, and economic and social concerns. Three main procedures are then presented to investigate the suitability of a site for CO_2 sequestration, including site screening, detailed site characterization, and pilot field-scale test. The methods for these procedures are also presented, such as traditional site characterization methods, laboratory experiments, and numerical simulation. Finally, some operational aspects of sequestration are discussed, including well type, injection rate, CO_2 purity, and injection strategy." **Fang Yang, Baojun Bai, Dazhen Tang, Dunn-Norman Shari, and Wronkiewicz David**, *Petroleum Science*, Available online February 3, 2010, doi:10.1007/s12182-010-0010-3, http://www.springerlink.com/content/y40t761146488p11/?p=434239c48fa9469a9f5e82039a30e8b0&pi=16. (Subscription may be required.)

"Mineral sequestration of [CO_2] in basalt: A pre-injection overview of the CarbFix project."

The following is the Abstract of this article: "In this paper [the authors] describe the thermodynamic and kinetic basis for mineral storage of [CO_2] in basaltic rock, and how this storage can be optimized. Mineral storage is facilitated by the dissolution of CO_2 into the aqueous phase. The amount of water required for this dissolution decreases with decreased temperature, decreased salinity, and increased pressure. Experimental and field evidence suggest that the factor limiting the rate of mineral fixation of carbon in silicate rocks is the release rate of divalent cations from silicate minerals and glasses. Ultramafic rocks and basalts, in glassy state, are the most promising rock types for the mineral sequestration of CO_2 because of their relatively fast dissolution rate, high concentration of divalent cations, and abundance at the Earth's surface. Admixture of flue gases, such as [sulfur dioxide (SO_2)] and [hydrogen fluoride (HF)], will enhance the dissolution rates of silicate minerals and glasses. Elevated temperature increases dissolution rates but porosity of reactive rock formations decreases rapidly with increasing temperature. Reduced conditions enhance mineral carbonation as reduced iron can precipitate in carbonate minerals. Elevated CO_2 partial pressure increases the relative amount of carbonate minerals over other secondary minerals formed. The feasibility to fix CO_2 by carbonation in basaltic rocks will be tested in the CarbFix project by: (1) injection of CO_2 charged waters into basaltic rocks in SW Iceland, (2) laboratory experiments, (3) studies of natural analogues, and (4) geochemical modeling." **Sigurdur Reynir Gislason, Domenik Wolff-Boenisch, Andri Stefansson, Eric H. Oelkers, Einar Gunnlaugsson, Hólmfridur Sigurdardottir, Bergur Sigfusson, Wallace S. Broecker, Juerg M. Matter, Martin Stute, Gudni Axelsson, and Thrainn Fridriksson**, *International Journal of Greenhouse Gas Control*, Available online January 22, 2010, doi:10.1016/j.ijggc.2009.11.013, http://www.sciencedirect.com/science/article/B83WP-4Y71D6B-1/2/8713f44d0f0028ad7701093d5eede306. (Subscription may be required.)

Technology

"Seismic detection of CO_2 leakage along monitoring wellbores."

The following is the Abstract of this article: "A pilot CO_2 sequestration experiment was carried out in the Michigan Basin in which 10,000 tonnes of supercritical CO_2 was injected into the Bass Island Dolomite (BILD) at 1050 m depth. A passive seismic monitoring (PSM) network was operated before, during and after the 17-day injection period. The seismic monitoring network consisted of

Technology (Continued)

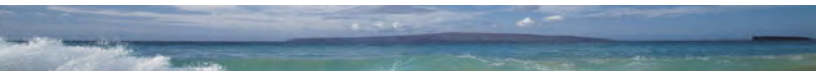
two arrays of eight, three-component sensors, deployed in two monitoring wells at only a few hundred meters from the injection point. [Two-hundred and twenty-five] microseismic events were detected by the arrays. Of these, only one event was clearly an injection-induced microearthquake. It occurred during injection, approximately 100 m above the BILD formation. No events, down to the magnitude −3 detection limit, occurred within the BILD formation during the injection. The observed seismic waveforms associated with the other 224 events were quite unusual in that they appear to contain dominantly compressional (P) but no (or extremely weak) shear (S) waves, indicating that they are not associated with shear slip on faults. The microseismic events were unusual in two other ways. First, almost all of the events occurred prior to the start of injection into the BILD formation. Second, hypocenters of the 94 locatable events cluster around the wells where the sensor arrays were deployed, not the injection well. While the temporal evolution of these events shows no correlation with the BILD injection, they do correlate with CO_2 injection for EOR into the 1670 m deep Coral Reef formation that had been going on for 2.5 years prior to the pilot injection experiment into the BILD formation. [The authors] conclude that the unusual microseismic events reflect degassing processes associated with leakage up and around the monitoring wells from the EOR-related CO_2 injection into the Coral Reef formation, 700 m below the depth of the monitoring arrays. This conclusion is also supported by the observation that as soon as injection into the Coral Reef formation resumed at the conclusion of the BILD demonstration experiment, seismic events (essentially identical to the events associated with the Coral Reef injection prior to the BILD experiment) again started to occur close to a monitoring arrays. Taken together, these observations point to vertical migration around the casings of the monitoring wellbores. Detection of these unusual microseismic events was somewhat fortuitous in that the arrays were deployed at the depth where the CO_2 undergoes a strong volume increase during transition from a supercritical state to a gas. Given the large number of pre-existing wellbores that exist in depleted oil and gas reservoirs that might be considered for CO_2 sequestration projects, passive seismic monitoring systems could be deployed at appropriate depths to systematically detect and monitor leakage along them." **M. Bohnhoff, M.D. Zoback, L. Chiaramonte, J.L. Gerst, and N. Gupta**, *International Journal of Greenhouse Gas Control*, Available online February 26, 2010, doi:10.1016/j.ijggc.2010.01.009, http://www.sciencedirect.com/science/article/B83WP-4YGHKKY-1/2/b0cb00e5b28ff4ec1aca428fb492508c. (Subscription may be required.)

"Coda-wave interferometry analysis of time-lapse VSP data for monitoring geological carbon sequestration."

The following is the Abstract of this article: "Injection and movement/saturation of CO_2 in a geological formation will cause changes in seismic velocities. [The authors] investigate the capability of coda-wave interferometry technique for estimating CO_2-induced seismic velocity changes using time-lapse synthetic vertical seismic profiling (VSP) data and the field VSP datasets acquired for monitoring injected CO_2 in a brine aquifer in Texas, USA. Synthetic VSP data are calculated using a finite-difference elastic-wave equation scheme and a layered model based on the elastic Marmousi model. A possible leakage scenario is simulated by introducing seismic velocity changes in a layer above the CO_2 injection layer. [The authors] find that the leakage can be detected by the detection of a difference in seismograms recorded after the injection compared to those recorded before the injection at an earlier time in the seismogram than would be expected if there was no leakage. The absolute values of estimated mean velocity changes, from both synthetic and field VSP data, increase significantly for receiver positions approaching the top of a CO_2 reservoir. [The authors'] results from field data suggest that the velocity changes caused by CO_2 injection could be more than 10 [percent] and are consistent with results from a crosswell tomogram study. This study demonstrates that time-lapse VSP with coda-wave interferometry analysis can reliably and effectively monitor geological carbon sequestration." **Rongmao Zhou, Lianjie Huang, James T. Rutledge, Michael Fehler, Thomas M. Daley, and Ernest L. Majer**, *International Journal of Greenhouse Gas Control*, Available online February 26, 2010, doi:10.1016/j.ijggc.2010.01.010, http://www.sciencedirect.com/science/article/B83WP-4YGHKKY-2/2/f000221ae44c2df8f06c71dcfa1f2c71. (Subscription may be required.)

"Predictive tool for an accurate estimation of [CO_2] transport properties."

The following is the Abstract of this article: "In the present work, simple-to-use predictive tool, which is simpler than current available models and involves a fewer number of parameters, requiring less complicated and shorter computations, is formulated to arrive at an appropriate estimation of the transport properties (namely viscosity and thermal conductivity) of CO_2 as a function of pressure and temperature. The correlation developed accurately works for temperatures ranging from 260 to 450 K as well as pressures ranging from 10 to 70 MPa, which is the range of pressure that is widely considered in CO_2 sequestration. Results have been compared with the reported data and excellent agreement has been obtained between the predicted results and observed values. The average absolute deviations were found to be 1.1 and 1.3 [percent] for viscosity and thermal conductivity of CO_2, respectively. [The proposed simple predictive tool can be used for the verification of the transport properties (namely viscosity and thermal conductivity) of CO_2 at various temperatures and pressures without performing any experimental measurements.] In particular, personnel dealing with regulatory bodies of GHG control and process industries would find the proposed approach to be user friendly involving transparent calculations with no complex expressions." **Alireza Bahadori and Hari B. Vuthaluru**, *International Journal of Greenhouse Gas Control*, Available online January 18, 2010, doi:10.1016/j.ijggc.2009.12.007, http://www.sciencedirect.com/science/article/B83WP-4Y648N5-1/2/4a164df441fb916bae1405485aeda9a1. (Subscription may be required.)



Terrestrial

"Modeling interannual variability of global soil respiration from climate and soil properties."

The following is the Abstract of this article: "To develop a model describing the dependence of annual soil respiration on climate and soil properties, [the authors] compiled 657 published annual soil respiration (R_S) measurements that were assembled from 147 sites globally, representing croplands, grasslands, forests and tundra ecosystems. Each of these annual soil respiration data was then aggregated with the appropriate mean air temperature (T) and annual precipitation (P) data derived from geographically referenced datasets and with soil properties gathered from the original literature. Partial correlation analyses showed that global annual R_S significantly related to annual mean temperature, annual precipitation, and topsoil (0-20 cm) organic carbon (SOC) storage, while topsoil total nitrogen (SN) and pH did not show a direct and clear relationship with R_S across ecosystems. While [the authors] employed the T&P-model that used temperature and annual precipitation to globally predict annual soil respiration, it was able to explain 41 [percent], 57 [percent], and 31 [percent] of the variability of soil respiration for croplands, grasslands and forests, respectively. However, the residuals were significantly related to SOC for croplands and grasslands. Thus, [the authors] developed a T&P&C-model that includes SOC as an additional predictor of annual R_S. This extended but still simple model performed better than the T&P-model and explained 69 [percent], 89 [percent], and 47 [percent] of the interannual and intersite variability of R_S with a mean absolute error of 0.11, 0.18, and 0.28 kg C m^{-2} yr^{-1} for croplands, grasslands and forests, respectively. Overall, the modeling efficiency of the T&P&C-model was nearly 60 [percent] across ecosystems. Globally, the mean turnover time of topsoil carbon (SOC/R_S) was highly comparable among croplands, grasslands and forests, equivalent to 6.1-6.3 years. Therefore, better estimates of global annual soil respiration would be obtained with the new model driven by climate and soil properties together. [The authors] expect significant improvements of global annual soil respiration predictions given that measurements of soil respiration coupling with soil properties and site productivities are widely taken across ecosystems over the world." **Shutao Chen, Yao Huang, Jianwen Zou, Qirong Shen, Zhenghua Hu, Yanmei Qin, Haishan Chen, and Genxing Pan**, *Agricultural and Forest Meteorology*, Available online March 1, 2010, doi:10.1016/j.agrformet.2010.02.004, http://www.sciencedirect.com/science/article/B6V8W-4YH4PPX-1/2/a7aaf504e5c1509a375158cbf460eac9. (Subscription may be required.)

Trading

Carbon Market Update, March 10, 2010	
CCX-CFI 2010 ($/tCO$_2$)	EU ETS-EUA DEC 2010
$0.10 (Vintage 2010)	($/tCO$_2$) $18.10
	(Converted from € to US$)

***RGGI News Release*, "RGGI CO_2 Auctions Yield Millions for Investment in Clean Energy, Job Creation."**

On March 10, the 10 Northeast and Mid-Atlantic states participating in the Regional Greenhouse Gas Initiative (RGGI) held the first quarterly auction of CO_2 allowances in 2010. All of the 40,612,408 CO_2 allowances for the first three-year control period (2009-2011) offered in the auction sold at a price of $2.07; in a parallel offering, 2,091,000 of the 2,137,992 CO_2 allowances for the second control period sold at a price of $1.86. In total, Auction 7 yielded $87,956,944.56 for investment in the clean energy economy. Proceeds from all of the auctions held to date now total more than $582.3 million; states invest the proceeds to improve energy efficiency, accelerate the deployment of renewable energy technologies, and invest in job training. To learn more about how each state invests RGGI auction proceeds, visit: http://www.rggi.org/states/program_investments. For more information about RGGI Auction 7, click: http://www.rggi.org/co2-auctions/market_monitor. March 12, 2010, http://www.rggi.org/docs/Auction_7_Release_MM_Report_2010_03_12.pdf.

"The analysis of country-to-country CDM permit trading using the gravity model in international trade."

The following is the Abstract of this article: "The fairness and effectiveness of the Clean Development Mechanism (CDM) in reducing [GHG] emissions and promoting economic development is a matter of substantial concern for the international community as it works towards another GHG reduction agreement in Copenhagen. Among other reasons, the CDM has been criticized as favoring some countries and disfavoring others, resulting in an imbalance in the distribution of development projects, thus undermining one of the original purposes of this institutional arrangement. In this paper, CDM projects were evaluated using econometric models based on international trade theory. Although the CDM suffers from imbalances as have been noted elsewhere, the primary determinant of CDM projects is the total GHG emissions from host and credit countries. GHG emissions in each were positively and consistently related to the CDM projects. Project size and the extent of a host country's infrastructure (such as road, rail lines, airports, electricity supply, telephone and internet connections) were each important determinants. Finally, results are discussed in the context of policy-based action that might limit or otherwise affect CDM implementation after the Copenhagen meeting." **Haifeng Wang and Jeremy Firestone**, *Energy for Sustainable Development*, Available online January 27, 2010, doi:10.1016/j.esd.2009.12.003, http://www.sciencedirect.com/science/article/B94T4-4Y835C4-1/2/43a3d8561317eb308424cf429a31574b. (Subscription may be required.)

Recent Publications

U.S. Oil Production Potential From Accelerated Deployment of Carbon Capture and Storage.

The following is from the Background of this White Paper: "Implementation of the American Clean Energy and Security Act (ACES), or H.R. 2454, which was passed by the U.S. House of Representatives in 2009 (the 'Waxman-Markey' bill), or similar legislation, would result in rapid deployment of CCS by new power generation and industrial facilities through the bill's extensive incentives for the technology. As of the publication of this report, additional incentives are being considered by the U.S. Senate to further encourage CCS from both power generation facilities (including gas-fired facilities) and other industrial sources. It has been alleged that requiring CCS for new power generation capacity would impose severe economic hardships on consumers and the Nation's economy. In fact, this report demonstrates that CCS can provide both significant environmental and economic benefits; especially if value-added opportunities for productively using captured CO_2 are encouraged and pursued. In addition, large-scale CCS deployment could lead to significant increases in energy security. The captured CO_2, if stored in depleted oil fields with CO_2-EOR technologies, could result in significant increases in domestic oil production, with commensurate reductions in oil imports. Specifically, combining CO_2 storage with CO_2-EOR can help produce more oil from mature, already-developed oil fields in the United States, while sequestering large quantities of CO_2, rather than emitting this GHG to the atmosphere." The complete White Paper is available at: http://www.adv-res.com/pdf/ARI%20CCS-CO2-EOR%20whitepaper%20FINAL%203-10-10.pdf.

An Investigation to Explore the Potential for Geologic Sequestration of Carbon Dioxide Produced by Wisconsin's Electricity Generation Fleet.

The following is from the Executive Summary of this draft document: "Based on recommendations contained in the Interim Report of the Governor's Task Force on Global Warming (February 2008), the Public Service Commission of Wisconsin and the Wisconsin Department of Natural Resources formed a Study Group to explore the potential for geologic sequestration of CO_2 produced by Wisconsin's electricity generation fleet. This technical report is the final work product of the Study Group. Wisconsin currently relies on coal for roughly 38 [percent] of the state's installed electric generating capacity and 66 [percent] of actual generation. Coal has historically been an abundant and inexpensive fuel for electric generation, but it also emits more CO_2 per unit of electricity than any other fuel in common use. New regulations limiting GHG emissions appear to be inevitable, and these regulations could radically change the economics of coal-fired electric generation unless the associated CO_2 emissions are reduced…The Study Group found that several promising technologies are being developed and tested for capturing CO_2 emissions from power plants. Carbon dioxide can be captured either pre- or post-combustion – depending on the type of power plant – and compressed for transport and disposal. The technology that is closest to commercial deployment is pre-combustion capture from an [IGCC] power plant. Post-combustion capture coal-fired plants or natural gas combined cycle (NGCC) power plants has moved from laboratory testing to field testing, but the first full-scale commercial applications are not expected for several years. The Study Group also found that long-distance transport of CO_2 is a proven, viable option with over 3,000 miles of pipeline already in use for this purpose nationwide." To view the draft document, click: http://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=127780.

Legislative Activity

***Business Week*, "Ky. House Passes Eminent Domain for CO_2 Pipelines."**

The Kentucky House approved legislation that would extend eminent domain rights to pipeline companies transporting CO_2. The measure, which will now go to the Senate for consideration, would allow private companies to obtain easements across private property. Kentucky already allows the use of eminent domain for natural gas, oil, and similar pipelines; this measure is expected to help the state if Federal regulators impose additional restrictions on CO_2 emissions. February 19, 2010, http://www.businessweek.com/ap/financialnews/D9DVBAS00.htm.

***Deseret News*, "Utah Legislature: Carbon Credit Bill Clears Committee Hurdle."**

On March 2, 2010, a Utah committee approved a bill that allows Utah communities to sell carbon credits. According to the bill's sponsor, Senate Bill (S.B.) 128, "City and County Carbon Credits for Sequestration of Waste Stream Materials," will clarify current law regarding carbon credits. Several landfills in Utah are using methane gas to produce electricity, and then selling the resulting carbon credits on national exchanges, generating revenue for the communities. To view S.B. 128, click: http://le.state.ut.us/~2010/htmdoc/sbillhtm/SB0128S01.htm. March 2, 2010, http://www.deseretnews.com/article/700013514/Utah-Legislature-Carbon-credit-bill-clears-committee-hurdle.html.

EVENTS

April 14-16, 2010, **Navigating the American Carbon World**, *San Francisco Marriott Marquis, San Francisco, California, USA*. Conference attendees will discuss the future of carbon reduction and environmental change under the current U.S. Administration. The four topics to be covered are: innovative solutions and reductions, carbon market updates, California and western initiatives, and national and international policies. To view a detailed program, visit the conference website at: http://www.nacw2010.org/.

April 15-16, 2010, **IGCC Outlook China 2010**, *Ramada Plaza Pudong Shanghai, China*. This conference will focus on the development of integrated gasification combined cycle (IGCC) technologies in China, including the integration of IGCC with CCS and international cooperation in terms of equipment and solutions. To learn more, visit the conference website at: http://www.igvision.com/igcc/.

April 19-22, 2010, **European Conference on CCS Research, Development, and Demonstration**, *Hilton Rotterdam Hotel, Rotterdam, Netherlands*. This conference will examine topics such as: the large-scale application of CCS in Rotterdam; technical priorities for industrial-scale geological storage; monitoring, verification, and accounting (MVA) techniques; and CO_2 transportation. For more details, visit: http://www.ccs-conference.eu/programme/.

April 20-21, 2010, **Coal Power Plant Fundamentals**, *Hyatt Regency Chicago, Chicago, Illinois, USA*. This event provides its attendees with basic engineering concepts needed to better understand the workings of a coal-fired power plant. A general overview of a power plant layout will be presented, as will the operating principles. To download a brochure, visit the conference website at: http://www.euci.com/conferences/0410-coal-power/index.php?ci=957.

May 10-13, 2010, **9th Annual Conference on Carbon Capture & Sequestration**, *Hilton Pittsburgh, Pittsburgh, Pennsylvania, USA*. Following in the footsteps of the previous eight events, this annual conference will focus on the potential of present and future CCS technologies deployed in the United States and North America. Members from the U.S. and international scientific and engineering communities will be present to share experiences on such technologies and systems. For more information, visit the conference website at: http://www.carbonsq.com/.

May 13-14, 2010, **CO_2 Shipping Conference 2010**, *Millennium Gloucester Hotel and Conference Centre London, London, England*. This conference was developed as a forum to discuss the future potential of CO_2 transportation and its significance as a new market opportunity for gas carrier operators. Attendees will discuss the challenges that face CO_2 transport and the progress that has been made to date. To learn more, visit the conference website at: http://www.rivieramm.com/events/CO2-Shipping-Conference-24/Event-Home-257.

May 23-28, 2010, **Energy, Water, and Global Climate Change as a Regional Agenda of the Americas**, *San Diego, California, USA*. The focus of this Pan-American Advanced Studies Institute (PASI) conference is to discuss the current state of research linking energy, water, and global climate change in the Americas. Topics to be covered during this conference include: climate and energy; climate and water; and climate and sustainability. For more information, visit the conference website at: http://www-rohan.sdsu.edu/~energy/pasi/index.htm.

June 8-9, 2010, **4th Annual Climate Change Summit**, *Regent's Park Marriott Hotel, London, United Kingdom*. This summit focuses on post-Copenhagen topics, such as: forthcoming carbon legislation; key steps to improving energy efficiency; life cycle analysis; and achieving a balance between adaption and mitigation. To download the event brochure, click: http://www.ethicalcorp.com/climate/index.asp.

EVENTS (CONTINUED)

June 22-23, 2010, **Carbon Capture and Storage World Australia 2010**, *Crown Conference Center, Melbourne, Australia*. Australia's only CCS-dedicated event, this two-day conference will focus on CCS commercialization and its application to primary industries. In addition, the event will cover other topics such as storage site exploration and management, government funding, and carbon pricing mechanisms. Visit the conference website, which includes a downloadable brochure, at: http://www.terrapinn.com/2010/ccs/index.stm.

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

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