Carbon Sequestration Newsletter

June 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

***Office of Fossil Energy Website*, "Public Meeting of the Interagency Task Force on Carbon Capture and Storage."**

On May 6, 2010, the U.S. Interagency Task Force on Carbon Capture and Storage (CCS) met for the first time to develop a comprehensive and coordinated Federal strategy to speed the commercial development and deployment of clean coal technologies. By August 2010, the task force will develop a proposed plan to explore incentives for the adoption of CCS, as well as address any financial, economic, technological, legal, institutional, or other barriers to deployment within the next 10 years. The task force, co-chaired by the U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA), is comprised of 14 executive departments and Federal agencies. The task force was established by a presidential memorandum on February 3, 2010. More information on the taskforce is available at: http://www.whitehouse.gov/administration/eop/ceq/initiatives/ccs. A video of the meeting can be viewed at: mms://prod-mmedia.netl.doe.gov/entire_meeting.wmv, and a transcript can be found at: http://www.whitehouse.gov/sites/default/files/microsites/ceq/20100516-public-meeting-interagency-force-carbon-capture-storage.doc. For more details, visit the Office of Fossil Energy's (FE) webpage at: http://fossil.energy.gov/programs/sequestration/ccstf/washington_meeting.html.

Sequestration in the News

***The Wetaskiwin Times*, "CO_2 Pipeline to Cut Through County."**

A planned carbon dioxide (CO_2) pipeline that will run through central Alberta will be used to transport CO_2 from Elk Island Pump Station (northeast of Edmonton) to an oilfield reservoir near Clive for enhanced oil recovery (EOR). The Alberta Carbon Trunk Line (ACTL) will have a capacity of 40,000 tonnes per day, with initial throughput ranging from 4,600 to 5,100 tonnes per day. The pipeline will be buried six to 10 feet underground and be capable of handling 2,500 pounds per square inch (psi). It is expected that injecting the CO_2 (cooled into a liquid form) into the oilfields will recover approximately 5,000 barrels of oil per day, for a total of 25 million barrels. Construction is set to begin in late 2011, with a plan to expand the pipeline to deliver CO_2 to other depleted oilfields in the future. For more information about ACTL, visit Enhance Energy's website at: http://www.enhanceenergy.com/co2_pipeline/index.html. April 14, 2010, http://www.wetaskiwintimes.com/ArticleDisplay.aspx?e=2532401.

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Sequestration in the News (Continued)

***The Independent*, "Canada Rolls Out Carbon Dioxide Capture Unit,"** and ***Natural Resources Canada*, "Unique CO_2 Technology Facility Officially Opens."**

On April 19, 2010, Canada's Natural Resources Ministry launched the CanmetENERGY CO_2 ($CanCO_2$) Research Facility, an integrated and efficient pilot-scale CO_2 capture facility that simultaneously removes emissions while purifying and compressing CO_2 for transport, storage, or other utilization. Located at the Natural Resources Canada Ottawa Research Centre in Bells Corners, Ottawa, the $CanCO_2$ is a trailer-mounted, transportable modular unit that is designed for field testing and pilot-scale demonstrations. The $CanCO_2$ Research Facility will be used by industry and research organizations to optimize, reduce costs, evaluate, and test technology options for CO_2 capture from fossil fuel-fired power plants. The data generated in field tests may be used to scale up the technology. Officials claim the facility is the first mobile CO_2 capture and compressor unit to measure and analyze power plant emissions. April 22, 2010, http://www.independent.co.uk/environment/canada-rolls-out-carbon-dioxide-capture-unit-1950887.html, and April 19, 2010, http://www.nrcan.gc.ca/media/newcom/2010/201020-eng.php?PHPSESSID=6344c93153f6feb09b2952722e8646ec.

***Reuters*, "Dutch Government Plans Subsidy for CO_2 Storage at Sea."**

The Dutch Government will provide subsidies of up to $190.5 million in the next 10 years for a CCS project involving German utility E.ON and Belgian energy company Electrabel. The project will capture CO_2 from an E.ON coal plant in Rotterdam and transport it approximately 12.4 miles by pipeline for storage in depleted gas fields under the North Sea. According to the Dutch Economy Ministry, the Dutch Government's subsidy is in addition to a contribution of up to $220 million from the European Economic Recovery Plan. The Rotterdam region produces approximately 16 percent of the Netherlands' total CO_2 emissions and officials hope similar projects will help to reduce emissions by 50 percent by 2025 compared to 1990 levels. May 12, 2010, http://www.reuters.com/article/idUSTRE64B2IN20100512?feedType=RSS.

ANNOUNCEMENTS

Projects Selected for DOE's UCR Program.

DOE selected seven projects to participate in their University Coal Research (UCR) Program. The projects are aimed at advancing coal research and development (R&D) while providing research exposure to a new generation of scientists and engineers. For more information on the projects, visit: http://www.fossil.energy.gov/news/techlines/2010/10014-DOE_Selects_University_Projects.html.

New Online Resource for Carbon Capture and Storage.

The International Energy Agency's Greenhouse Gas R&D Program's (IEA GHG) Weyburn-Midale CO_2 Monitoring and Storage Project and Canada's CCS Network have launched an online resource for information on CCS technologies. The website contains three main areas: CCS Basics, which gives a general background to CCS; CCS Pro, which contains detailed technical information; and CCS Communities, which deals with public outreach. To view the website, click: http://www.ccs101.ca/.

Yukon Joins WCI as an Observer.

The Western Climate Initiative (WCI), a collaboration of seven U.S. states and four Canadian provinces to reduce greenhouse gas (GHG) emissions, announced the addition of the Yukon Territory as the 15th WCI observer, joining six Mexican states, six U.S. states, and two Canadian provinces. WCI participants take cooperative actions to address climate change; the 11 WCI partner jurisdictions are active participants that develop and recommend programs and policies to achieve WCI GHG reduction goals. Visit the WCI website at: http://westernclimateinitiative.org/.

Study Launched to Find CO_2 Purity Requirements for CCS.

The Integrated CO_2 Network (ICO_2N) and the Petroleum Technology Alliance of Canada (PTAC) have launched a study that will determine the purity needs for the capture, transport, and storage of CO_2. Expected to be completed in early 2011, the study will examine CO_2 purity, contaminants, temperature, and pressure, as well as determine purity requirements and cost-effectiveness as it relates to all stages of a CCS system and EOR usage. For more information, click: http://www.carboncapturejournal.com/displaynews.php?NewsID=569.

New Global Network Links Geological Storage of CO_2 Research in Eight Countries.

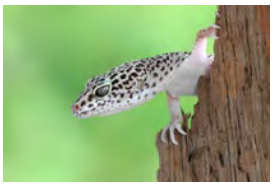
The International Performance Assessment Center for Geologic Storage of Carbon Dioxide (IPAC-CO_2) has established a global network that links organizations in eight countries that conduct geological CO_2 storage research. IPAC-CO_2, which was established at the University of Regina in 2009, will meet a public and regulatory need in the global CCS chain by providing independent performance assessments. To view the IPAC-CO_2 news release, visit: http://www.ipac-co2.com/Resources/Documents/IPAC-News%20Release-Regional%20Centres.pdf.

NETL Accomplishments Report Wins Award.

The National Energy Technology Laboratory (NETL) won a National Association of Government Communicators (NAGC) Blue Pencil and Gold Screen Award of Excellence in the Technical or Statistical Report category for their work on the 2008 NETL Accomplishments Report. This is the second award NETL has won for their annual accomplishments reports. The document is available at: http://www.netl.doe.gov/publications/others/accomp_rpt/accrpt_toc.html.

SCIENCE

***Science Daily*, "As Global Temperatures Rise, World's Lizards Are Disappearing: 20 Percent of All Lizard Species Could Be Extinct by 2080."**



Rising temperatures have driven 12 percent of Mexico's lizard populations to extinction, according to a team of international researchers who surveyed Sceloporus lizard populations in the country. Data collected from 200 different sites showed temperatures were changing too rapidly for the lizards to adapt, and that many species of lizards are already living at the "edge of their thermal limits," making them significantly more susceptible to climate-warming extinction than had previously been thought. According to the researchers' global model, which is derived from today's CO_2 emissions trends, approximately six percent of lizard species will be extinct by 2050 and approximately 20 percent by 2080. Due to CO_2 remaining in the atmosphere for decades, researchers believe the 2050 scenario is potentially unavoidable, but that continued efforts to reduce CO_2 emissions could prevent the 2080 scenario. May 13, 2010, http://www.sciencedaily.com/releases/2010/05/100513143447.htm.

***Science Daily*, "Melting Sea Ice Major Cause of Warming in Arctic, New Study Reveals."**

Warming temperatures in the Arctic Ocean have shown to be an effect of melting sea ice according to a University of Melbourne, Australia, study. Published in the journal *Nature*, the study

Science (Continued)

reveals that the rapid melting of sea ice has caused a dramatic increase in the warming levels in the region the past two decades. Scientists believe that the increased Arctic warming is a result of positive feedback between sea ice melting and atmospheric warming, which is believed to be caused by increasing amounts of anthropogenic GHGs. By using recent data from the European Centre for Medium-Range Weather Forecasting, researchers were able to uncover a pattern of warming that is consistent with the loss of sea ice. The Arctic has experienced the fastest warming of any region in the world over the past 20 years. During the same timeframe, Arctic sea ice has dramatically declined. April 28, 2010, http://www.sciencedaily.com/releases/2010/04/100428142324.htm.

Policy

***Center for Climate Strategies News Release*, "Economic Impacts of Comprehensive U.S. Climate and Energy Policy: National Climate Change Stakeholder Recommendations Would Advance Energy, Economy, and Jobs."**

The Center for Climate Strategies released findings from a study on proposed climate change policy and economics that shows the nationwide application of 23 major sector-based policy actions would reduce GHGs and household energy prices. In addition, the proposed policies developed by state stakeholders to meet climate change, energy, and economic goals would also expand jobs, income, and gross domestic product (GDP). In particular, these proposed policies would reduce U.S. GHG emissions 27 percent below 1990 levels in 2020; result in net direct economic savings of more than $5 billion by businesses and households in 2020; add an additional 2.5 million net new jobs; and expand GDP by $134.3 billion in 2020. The study combines microeconomic and macroeconomic analysis and uses policies developed in 16 states as part of state climate and energy planning. The cost-effectiveness of each proposed policy action was estimated through planning processes requiring one year or more in each state. To view the Center for Climate Strategies study, go to: http://www.nyclimatechange.us/ewebeditpro/items/O109F23079.pdf. April 23, 2010, http://www.climatestrategies.us/ewebeditpro/items/O25F23067.PDF.

"Effects of a carbon price in the U.S. on economic sectors, resource use, and emissions: An input-output approach."

The following is the Abstract of this article: "Despite differences in their implementation, most carbon policies aim to have similar outcomes: effectively raising the price of carbon-intensive products relative to non-carbon-intensive products. While it is possible to predict the simple broad-scale economic impacts of raising the price of carbon-intensive products – the demand for non-carbon-intensive products will increase – understanding the economic and environmental impacts of carbon policies throughout the life cycle of both types of products is more difficult. Using the example of a carbon tax, this study proposes a methodology that integrates short-term policy-induced consumer demand changes into the input–output framework to analyze the environmental and economic repercussions of a policy. Environmental repercussions include the direct and the indirect impacts on emissions, materials flow in the economy, and the reliance on various ecosystem goods and services. The approach combines economic data with data about physical flow of fossil fuels between sectors, consumption of natural resources and emissions from each sector. It applies several input–output modeling equations sequentially and uses various levels of aggregation/disaggregation. It is illustrated with the data for the 2002 U.S. economy and physical flows. The framework provides insight into the short-term complex interactions between carbon price and its economic and environmental effects." **Jun-Ki Choi, Bhavik R. Bakshi, and Timothy Haab**, *Energy Policy*, Available online March 4, 2010, doi:10.1016/j.enpol.2010.02.029, http://www.sciencedirect.com/science/article/B6V2W-4YHSCPV-2/2/18aef71f160464ceb577ef9f4dd359da. (Subscription may be required.)

Geology

"Geochemical Impacts to Groundwater from Geologic Carbon Sequestration: Controls on pH and Inorganic Carbon Concentrations from Reaction Path and Kinetic Modeling."

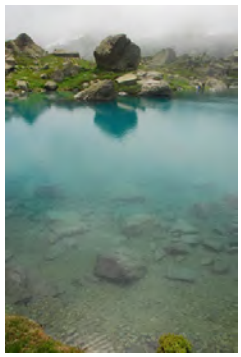
The following is the Abstract of this article: "Geologic carbon sequestration has the potential to cause long-term reductions in global emissions of [CO_2] to the atmosphere. Safe and effective application of carbon sequestration technology requires an understanding of the potential risks to the quality of underground sources of drinking water. In particular, concern is warranted regarding the potential for CO_2 leakage through geological features and abandoned wells that may result in detrimental perturbations to subsurface geochemistry. Reaction path and kinetic models indicate that geochemical shifts caused by CO_2 leakage are closely linked to mineralogical properties of the receiving aquifer. [Carbon dioxide] gas dissolution into groundwater and subsequent reaction with aquifer minerals will control the evolution of pH−bicarbonate envelopes. These parameters provide geochemical context for predicting how regulated contaminants associated with aquifer solids will respond via various mineral−water reaction processes. The distribution and abundance of carbonate, silicate, oxide, and phyllosilicate minerals are identified as key variables in controlling changes in groundwater geochemistry. Site-specific risk assessments may require characterization of aquifer geology, mineralogy, and groundwater chemistry prior to CO_2 injection. Model results also provide a frame of reference for developing indicative [monitoring, verification, and accounting (MVA)] protocols for groundwater protection." **Richard T. Wilkin and Dominic C. DiGiulio**, *Environ. Sci. Technol.*, Available online May 14, 2010, doi:10.1021/es100559j, http://pubs.acs.org/doi/abs/10.1021/es100559j. (Subscription required.)

Geology (Continued)

"Effects of reduction in porosity and permeability with depth on storage capacity and injectivity in deep saline aquifers: A case study from the Mount Simon Sandstone aquifer."

The following is the Abstract of this article: "The Upper Cambrian Mount Simon Sandstone is recognized as a deep saline reservoir that has significant potential for geological sequestration in the Midwestern region of the United States. Porosity and permeability values collected from core analyses in rocks from this formation and its lateral equivalents in Indiana, Kentucky, Michigan, and Ohio indicate a predictable relationship with depth owing to a reduction in the pore structure due to the effects of compaction and/or cementation, primarily as quartz overgrowths. The regional trend of decreasing porosity with depth is described by the equation: $(d) = 16.36 \times e^{-0.00039*d}$, where is the porosity and d is the depth in m. The decrease of porosity with depth generally holds true on a basin-wide scale. Bearing in mind local variations in lithologic and petrophysical character within the Mount Simon Sandstone, the source data that were used to predict porosity were utilized to estimate the pore volume available within the reservoir that could potentially serve as storage space for injected CO_2. The potential storage capacity estimated for the Mount Simon Sandstone in the study area, using efficiency factors of [one percent, five percent, 10 percent, and 15 percent], is 23,680, 118,418, 236,832, and 355,242 million metric tons of CO_2, respectively." **Cristian R. Medina, John A. Rupp, and David A. Barnes**, *International Journal of Greenhouse Gas Control*, Available online April 9, 2010, doi:10.1016/j.ijggc.2010.03.001, http://www.sciencedirect.com/science/article/B83WP-4YTD7PB-1/2/8724f5284aff363fb6a5ecffed6c48d6. (Subscription may be required.)

"Geomechanical issues of anthropogenic CO_2 sequestration in exploited gas fields."



The following is the Abstract of this article: "Anthropogenic CO_2 sequestration in deep geological formations may represent a viable option to fulfill the requirements of the 1997 Kyoto Protocol on the reduction of [GHG] emissions. Scenarios of CO_2 sequestration through three injection wells in an exploited gas field located in the Po sedimentary basin (Italy) are simulated with the final target to understand the geomechanical consequences of the injection of CO_2. Investigated scenarios include, as a hypothetical case, the long-term injection of CO_2 until the initial reservoir pressure is exceeded by as much as 40 [percent] over a period of about 100 years. The process is analyzed from the geomechanical point of view using a finite element–interface element (FE–IE) model with the following main issues addressed: (1) prediction of the possible land vertical uplift and corresponding impact on the ground infrastructures; (2) evaluation of the stress state induced in the reservoir formation with the possible generation of fractures; and (3) a risk analysis for the activation of existing faults. The geomechanical constitutive law of the Northern Adriatic basin relying on the radioactive marker interpretation is implemented into the FE model, while an elasto-plastic relationship based on the Mohr-Coulomb criterion is used for the IE reproducing the fault behavior. The in situ stress prior to the gas field exploitation is compressive with the principal horizontal stress in the direction perpendicular to the major faults equal to the vertical stress. The results show that the ground surface rebound due to the overpressure generated by the CO_2 sequestration partially mitigates the land subsidence experienced by the area because of the previous gas field depletion with differential displacements that are confined within the safety bounds suggested in the literature for the surface infrastructures. Activation of a few faults lying close to the northern reservoir boundary points to a slip of a couple of centimeters only and occurs before the CO_2 plume reaches the activated faults, so there is little chance for a CO_2 escape. The caprock is also proven to maintain its full integrity during the injection process. Finally the shear stress appears to approach the limiting state prone to the rock shear failure exclusively within the reservoir on a quite local scale and can hardly jeopardize the overall effectiveness of the CO_2 sequestration." **Massimiliano Ferronato, Giuseppe Gambolati, Carlo Janna, and Pietro Teatini**, *Energy Conversion and Management*, Available online March 21, 2010, doi:10.1016/j.enconman.2010.02.024, http://www.sciencedirect.com/science/article/B6V2P-4YNBRKS-5/2/3de517bfbd5c2024fc713f39d3907ae0. (Subscription may be required.)

"Evaluation of geologic storage options of CO_2: Applicability, cost, storage capacity and safety."

The following is the Abstract of this article: "[Carbon dioxide] emissions in the atmosphere are increasing continually, which are mainly originated from burning of fossil fuels. The fossil fuels are expected to remain a major component of the world's energy supply in the near future, because of their inherent advantages. Therefore, various measures have to be considered to reduce anthropogenic CO_2 emissions. Increasing the efficiency of energy usage and/or developing lower carbon or non-carbon energies to replace high carbon fuels may bring the result of the reduction of the accumulation of CO_2 in the atmosphere. The other alternative to reduce CO_2 concentrations in atmosphere include gaseous storage in various deep geological formations, liquid storage in the ocean, and solid storage by reaction of CO_2 with metal oxides to produce stable carbonates. In this article, the geological storage options of CO_2 are examined. They are discussed in terms of applicability, cost, storage capacity and safety." **Gokhan Aydin, Izzet Karakurt, and Kerim Aydiner**, *Energy Policy*, Available online March 7, 2010, doi:10.1016/j.enpol.2010.04.035, http://www.sciencedirect.com/science/article/B83WP-4YTD7PB-1/2/8724f5284aff363fb6a5ecffed6c48d6. (Subscription may be required.)

Technology

"A review of studies on CO_2 sequestration and caprock integrity."

The following is the Abstract of this article: "This review presents a comprehensive overview of the technologies and science of CCS, including a brief description of the key aspects of CO_2 transport and subsequent trapping. It focuses on the various methods that have been employed for the sequestration of CO_2 in geological media and the different carbon mitigation processes that occur after injection of the CO_2. For a geosequestration

Technology (Continued)

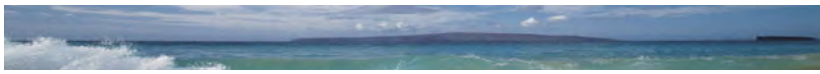
project, high degree leak-proof, large storage capacity with effective sealing and non-faulting stratum are ideal characteristics of the target reservoir and caprock. The geophysical and geochemical aspects of caprock–CO_2–pore fluid interaction, stability of the caprock during and after injection of CO_2, and the impact of pre-existing fractures and probabilities of fault reopening on seal integrity are discussed. Also in geosequestration, the injection pressure in conjunction with the upward pressure exerted by the injected CO_2 (due to buoyant forces) leads to perturbation of the stress field in the reservoir. The change in stress, and chemical and physical alteration of the reservoir formation rock and caprock caused by the carbonic acid which is formed when CO_2 dissolves in the groundwater, can lead to strength reduction and failure of the caprock. The review has identified major research gaps and a need for further study on caprock integrity under the combined effects of high pressure and high temperature. The changes in pressure and stress field caused by CO_2 injection, and interaction of supercritical CO_2 with the brine in the reservoir formations are also needed to be investigated experimentally." **Richa Shuklaa, Pathegama Ranjitha, Asadul Haquea, and Xavier Choib**, *Fuel*, Available online May 22, 2010, doi:10.1016/j.fuel.2010.05.012, http://www.sciencedirect.com/science/article/B6V3B-504JYMP-2/2/ca090d0c36c433589e458f3f4617e213. (Subscription may be required.)

"CO_2 capture and separation technologies for end-of-pipe applications – A review."

The following is the Abstract of this article: "Carbon capture from point source emissions has been recognized as one of several strategies necessary for mitigating unfettered release of GHGs into the atmosphere. To keep GHGs at manageable levels, large decreases in CO_2 emissions through capturing and separation will be required. This article reviews the possible CO_2 capture and separation technologies for end-of-pipe applications. The three main CO_2 capture technologies discussed include post-combustion, pre-combustion and oxyfuel combustion techniques. Various separation techniques, such as chemical absorption, physical absorption, physical adsorption, cryogenics, membrane technology, membranes in conjunction with chemical absorption and chemical-looping combustion (CLC) are also thoroughly discussed. Future directions are suggested for application by oil and gas industry. Sequestration methods, such as geological, mineral carbonation techniques, and ocean dump are not covered in this review." **Abass A. Olajire**, *Energy*, Available online April 8, 2010, doi:10.1016/j.energy.2010.02.030, http://www.sciencedirect.com/science/article/B6V2S-4YT6N6B-2/2/d0075ef55d2355925d7a46c3a784010a. (Subscription may be required.)

"A futuristic least-cost optimization model of CO_2 transportation and storage in the UK/UK Continental Shelf."

The following is the Abstract of this article: "The owners of [eight] power plants in the UK have announced interest in capturing and sequestering CO_2. Using various criteria from the literature twenty fields in the UK Continental Shelf were selected as possible sinks for the captured CO_2. Using a linear programming model, the study determined the least-cost transportation network under various constraints on the volumes of CO_2 captured from the sources and the injection rates at the sinks. Four scenarios were developed to gauge the sensitivity of the results to these and to the availability of fields for EOR and Permanent Storage. Depending on the scenario, the optimal transportation CAPEX was found to range [from ~$4.3 to ~$6.4 billion] in real terms. With higher minimum injection rates at the fields, accelerating CO_2-EOR investments was found to reduce unit transportation CAPEX compared to waiting for their cessation of production dates. On the other hand a combination of the later availability of the CO_2-EOR fields plus a lower minimum injection rate yielded the minimum transportation network CAPEX. The modeling also unveiled the problem of CO_2 supply overflows in the longer term. The modeling approach has wide applicability beyond the UK." **Alexander G. Kemp and A. Sola Kasim**, *Energy Policy*, Available online April 8, 2010, doi:10.1016/j.enpol.2010.02.042, http://www.sciencedirect.com/science/article/B6V2S-4YT6N6B-2/2/d0075ef55d2355925d7a46c3a784010a. (Subscription may be required.)



Terrestrial

"Carbon pools and fluxes in small temperate forest landscapes: Variability and implications for sampling design."

The following is the Abstract of this article: "Assessing forest carbon storage and cycling over large areas is a growing challenge that is complicated by the inherent heterogeneity of forest systems. Field measurements must be conducted and analyzed appropriately to generate precise estimates at scales large enough for mapping or comparison with remote sensing data. In this study [the authors] examined spatial variability in three small temperate forest landscapes. [The authors'] objectives were (1) to quantify the magnitude and scale of variability in stand structure, carbon pools, and carbon fluxes and (2) to assess how this variability influences both optimal sampling strategy and required sampling intensity. Stand structure was consistently less variable than carbon pools or fluxes, suggesting that measuring carbon dynamics may require more intense sampling than traditional forestry inventories. Likewise, the magnitude of variability differed substantially among response variables, implying that sampling efficiency can be enhanced by adopting a flexible sampling strategy that is optimized for each carbon pool. [The authors'] results indicate that plots dispersed across the study area are generally more effective than clustered plots for characterizing carbon dynamics." **John B. Bradford, Peter Weishampel, Marie-Louise Smith, Randall Kolka, Richard A. Birdsey, Scott V. Ollinger, and Michael G. Ryan**, *Forest Ecology and Management*, Available online March 20, 2010, doi:10.1016/j.foreco.2009.04.009, http://www.sciencedirect.com/science/article/B6T6X-4W80C8C-2/2/0da2b818ac9b7e2494557489d127c234. (Subscription may be required.)

TRADING

Carbon Market Update, May 14, 2010	
CCX-CFI 2010 ($/tCO$_2$)	EU ETS-EUA DEC 2010
$0.10 (Vintage 2010)	($/tCO$_2$) $19.99
	(Converted from € to US$)

***Reuters*, "EU Approves Bulgaria's Delayed [2008-2012] CO_2 Plan,"** and ***France24*, "EU Approves Bulgaria's Long-Delayed CO_2 Emissions Plan."**

The European Commission has approved Bulgaria's CO_2 plan, which will allow companies to join the European Union's (EU) carbon trading scheme. Under the plan, Bulgaria will be able to distribute 42.4 million tonnes of CO_2 permits a year to 132 industrial installations; utilities and industrial companies will receive 40.3 million tonnes for 2009 and 34.7 million tonnes for 2010. Bulgaria had been the only EU member state without an approved plan. According to the Ministry of Environment, industrial companies' EU allowances for 2008 were approximately the same as their emissions. However, industry had more than 6 million excessive credits to trade in 2009. Bulgaria has agreed to cut its CO_2 emissions by eight percent compared to their 1988 level, while emitting no more than 130 million tonnes of CO_2 a year. April 22, 2010, http://uk.reuters.com/article/idUKLDE62313W20100422, and April 24, 2010, http://www.france24.com/en/20100424-eu-approves-bulgarias-long-delayed-co2-emissions-plan.

***AFP*, "Romania to Launch Carbon Trading Scheme."**

The Romanian government approved a carbon trading scheme to reduce GHGs, which is expected to earn the country up to $3.3 billion through 2012. The funding will be spent on environmental projects and investments in renewable energy production. The carbon trading scheme was adopted under the Kyoto Protocol, which sets GHG emissions-reducing targets for 37 industrialized countries and the European community. The emissions reduction is expected to be approximately five percent more than the five-year period 2008 to 2012 compared to the level in 1990. April 28, 2010, http://www.google.com/hostednews/afp/article/ALeqM5g8djuLTxmGY1EdZ7EN3dr2nhWdow.

"Carbon Trading Thickness and Market Efficiency."

The following is the Abstract of this article: "This note tests for the efficient market hypothesis (EMH) in the market for CO_2 emission allowances in Phase I and Phase II of the European Union Emissions Trading Scheme (EU ETS). As usually is the case in emerging and non-competitive markets such as the EU ETS, trading often not occurs on a frequent basis. This has adverse implications for both the gains from permit trade as well as biases the EMH tests. Variance ratio tests are employed to adjust for the thin trading effect. The results indicate that Phase I –the trial and learning period– was inefficient, whereas the first period under Phase II shows signs of restoring market efficiency." **Alberto Montagnoli and Frans P. de Vries**, *Energy Economics*, Available online April 16, 2010, doi:10.1016/j.eneco.2010.04.001, http://www.sciencedirect.com/science/article/B6V7G-4YVY76D-1/2/d11a8d72d881ff69abb091782d5f6937. (Subscription may be required.)

RECENT PUBLICATIONS

Viability of a Large-Scale Carbon Capture and Sequestration Network in Pennsylvania.

The following is from the Executive Summary of this document: "The objective of this report is to assess the technical and economic viability of an integrated 'early mover' CCS network within Pennsylvania. The deployment of this integrated network could potentially lower the costs for individual power plants of deploying [CCS] through the use of shared infrastructure, the reduction of regulatory uncertainty and the provision of public incentives. Once scale is achieved, new generation assets, enabled for carbon capture, can be phased in and linked to the network over time, at lower cost and involving less public subsidy." The Pennsylvania Department of Conservation and Natural Resources (DCNR) report is available at: http://www.dcnr.state.pa.us/info/carbon/viabilitylargescale-ccs.pdf.

Assessment of Risk, Legal Issues, and Insurance for Geologic Carbon Sequestration in Pennsylvania.

The following is from the Executive Summary of this document: "The Pennsylvania DCNR report, 'Geologic Carbon Sequestration Opportunities in Pennsylvania,' issued earlier in 2009, assessed the suitability of geologic formations for the location of a state CO_2 sequestration network. This report extends the initial evaluation of the geologic setting with more detailed analysis of the potential for geological storage. A risk assessment is performed to evaluate the potential human-health, safety and environmental risks associated with CCS. Legal and insurance issues associated with future statewide geologic sequestration of CO_2 in Pennsylvania are also evaluated." The Pennsylvania DCNR report is available at: http://www.dcnr.state.pa.us/info/carbon/assessmentrisk-ccs.pdf.

Climate Change Indicators in the United States.

The following is the Introduction of this document: "Over the last several decades, evidence of human influences on climate change has become increas-ingly clear and compelling. There is indisputable evidence that human activities such as electricity pro-duction and transportation are adding to the concentrations of [GHGs] that are already naturally present in the atmosphere. These heat-trapping gases

Recent Publications (Continued)

are now at record-high levels in the atmosphere compared with the recent and distant past. Warming of the climate system is well documented, evident from increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. The buildup of [GHGs] in the atmosphere is likely the cause of most of the recent observed increase in average temperatures, and contributes to other climate changes. Collecting and interpreting environmental indicators has played a critical role in [the United States'] increased understanding of climate change and its causes. An indicator represents the state of certain environmental conditions over a given area and a specified period of time. Scientists, analysts, decision-makers, and others use environmental indicators, including those related to climate, to help track trends over time in the state of the environment, key factors that influ¬ence the environment, and effects on ecosystems and society." The U.S. Environmental Protection Agency (EPA) report is available at: http://www.epa.gov/climatechange/indicators.html.

U.S. Carbon Dioxide Emissions and Intensities Over Time: A Detailed Accounting of Industries, Government and Households. The following is from the Executive Summary of this document: "[GHG] emissions have increased markedly since the pre-industrial era and are increasing at such a rate that their concentration in the atmosphere is producing a warming influence on the global climate. In order to make well-informed decisions on ways to reduce [GHG] emissions, it is important to understand how the different economic sectors contribute to the production of [GHGs], which sectors are relatively CO_2 intensive, and how these patterns have evolved over time. To that end, this report analyzes energy-related CO_2 emissions and intensities for 349 industries, Government (Federal, state, and local), and Households for the 1998 to 2006 period. The 349 industries cover the entire economy, providing information on detailed subsectors within the aggregate sectors of Agriculture, Forestry and Fisheries, Mining, Construction, Manufacturing, Transportation Services, and All Other Services. [Carbon dioxide] intensities for industries and Government refer to the emissions produced per billion dollars of output. [Carbon dioxide] intensities for Households are measured by emissions per thousand households." The U.S. Commerce Department's Economics and Statistics Administration's report is available at http://www.esa.doc.gov/co2/.

Legislative Activity

***The Washington Post*, "Sens. Kerry and Lieberman Introduce Compromise Climate Bill,"** and ***Reuters*, "Details of New Senate Climate Bill."**

On May 12, 2010, U.S. Senators John Kerry and Joseph Lieberman introduced comprehensive energy and climate change legislation that seeks to create jobs, strengthen America's energy independence, safeguard national security, and restore global economic leadership. The bill, titled, "The American Power Act," would fund investments in clean energy R&D and provide annual incentives of $2 billion per year for R&D of CCS technologies. The bill will cut CO_2 emissions by 17 percent from 2005 levels by 2020, and by more than 80 percent by 2050. Carbon prices would rise at a fixed rate over inflation, with an annual floor increase of three percent and a ceiling of five percent. In addition, incentives would be offered for the commercial deployment of 72 GW of CCS. For more information on The American Power Act, click: http://kerry.senate.gov/americanpoweract/intro.cfm. May 13, 2010, http://www.washingtonpost.com/wp-dyn/content/article/2010/05/12/AR2010051202913.html?hpid=moreheadlines (Subscription may be required), and May 11, 2010, http://www.reuters.com/article/idUSTRE64B00220100512.

***Forbes.com*, "Wyoming Senator's Clean Coal Bill Passes Panel."**

The U.S. Senate Committee on Energy and Natural Resources passed a bill on Thursday, May 6, 2010, that seeks to encourage innovation and investment in CCS development. Sponsored by U.S. Senator John Barrasso, the Carbon Dioxide Capture Technology Act (S. 2744) would establish an advisory board comprised of climate scientists, physicists, chemists, engineers, business managers, and economists. The bill would also create an award system for scientists and researchers who develop CCS technologies. Once the technology is developed, the United States would share the intellectual property rights with the inventor. To view S. 2744, go to: http://www.govtrack.us/congress/billtext.xpd?bill=s111-2744. To read Senator Barrasso's Press Release, visit: http://barrasso.senate.gov/public/index.cfm?FuseAction=PressOffice.PressReleases&ContentRecord_id=6f4e22a5-a906-c157-784d-eead63f062fe&Region_id=&Issue_id. May 6, 2010, http://www.forbes.com/feeds/ap/2010/05/07/business-financial-impact-us-barrasso-clean-coal_7585579.html?boxes=Homepagebusinessnews.

EVENTS

June 1-2, 2010, **Coal Tech 2010**, *Brisbane Marriott Hotel, Brisbane, Queensland, Australia*. The latest project advances and R&D developments in coal technology will be addressed at this networking forum. Specific analysis will focus on topics such as CCS advances, post-combustion capture, and underground coal gasification. To view the full agenda, visit the conference website at: http://www.iir.com.au/conferences/mining-resources/metals-minerals/coal-tech-2010-E1012.

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.

June 16-17, 2010, **Climate Change: Impacts and Opportunities**, *British Geological Survey, Keyworth, Nottingham, United Kingdom*. This conference will focus on the potential impacts of climate change, strategies for adaption, and challenges and opportunities in the energy sector. Other key topics include opportunities for regional development in CCS and the transition to a low-carbon economy. For more information, visit the conference website at: http://www.bgs.ac.uk/climateconference/home.html.

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.

June 24, 2010, **The UK Energy Summit**, *The Dorchester, London, United Kingdom*. This summit will provide strategic opportunities to discuss energy challenges facing the UK. Topics to be covered include energy security, investing in renewable energy, and energy-related technologies. For more information, including a detailed program, visit the conference website at: http://www.economistconferences.co.uk/event/uk-energy-summit/1366.

July 8-10, 2010, **Second International Conference on Climate Change: Impacts and Responses**, *University of Queensland, Brisbane, Australia*. This conference will address technological, social, ethical, and political responses to climate change. It will examine the natural and human causes of climate change, as well as its impact on ecosystems and human life. For more information, including details of four different "streams" conference attendees can follow, go to: http://on-climate.com/conference-2010/.

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

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

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

Events (Continued)

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

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