THE NETL CARBON SEQUESTRATION NEWSLETTER: ANNUAL INDEX

SEPTEMBER 2007 – AUGUST 2008

This is a compilation of the past year's monthly National Energy Technology Laboratory Carbon Sequestration Newsletter. The newsletter is produced by the NETL to provide information on activities and publications related to carbon sequestration. It covers domestic, international, public sector, and private sector news. This compilation covers newsletters issued between September 2007 and August 2008. It highlights the primary news and events that have taken place in the carbon sequestration arena over the past year. Information that has become outdated (e.g. conference dates, paper submittals, etc.) was removed.

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HIGHLIGHTS

September 2007

***Fossil Energy Techline*, "Climate Technology: DOE Readies First Big U.S. Projects in CO_2 Capture and Storage."** The US Department of Energy (DOE) is currently reviewing Phase III proposals for large-scale geologic sequestration projects in support of the Regional Carbon Sequestration Partnership Program. The program, which was formed in 2003 to research the best approaches to capture and permanently store the greenhouse gas, carbon dioxide (CO_2), will enter its next phase in October with announcements of Phase III deployment projects. The new stage of the Regional Partnerships' work will follow as a logical extension of work completed to date during Phase I and Phase II, which encompassed the identification of point-source emissions and potential geologic storage formations in the United States and Canada, identifying potential projects, and performing geologic field tests to examine the various sequestration options. The Phase III proposals present scenarios using large-scale sequestration in saline formations, CO_2 capture in coal-based power generation, and CO_2sequestration for enhanced oil recovery efforts. Each of the proposed large-scale tests encompasses full project cycles to cover site characterization, injection operations and monitoring, site closure, and post-injection monitoring activities. Phase III projects are expected to continue through 2017 and will greatly enhance present international efforts for viable, large-scale demonstrations of carbon capture and storage. To learn more about DOE's Carbon Sequestration Regional Partnerships Program, visit DOE's National Energy Technology Laboratory (NETL) Carbon Sequestration Regional Partnership website at: http://www.netl.doe.gov/technologies/carbon_seq/partnerships/partnerships.html. August 3, 2007, http://www.fossil.energy.gov/news/techlines/2007/PrintVersion_1_29416_29416.html?print.

October 2007

***NETL News Release,* "Regional Partner Launches Drilling Test in DOE's Carbon Sequestration Program."** The Plains CO_2 Reduction Partnership (PCOR), one of the seven Department of Energy (DOE) Regional Carbon Sequestration Partnerships, has begun a small-scale geologic field test as part of their validation phase efforts which will focus on carbon dioxide (CO_2) storage in a lignite seam in Burke County, North Dakota. The PCOR Partnership, managed by the University of North Dakota's Energy and Environmental Research Center, will partner with Eagle Operating Inc. of Kenmare, North Dakota to conduct the two-year, two-phased test. During phase one, data about the coal seam will be collected in order to evaluate the seam's potential to produce coalbed methane. PCOR researchers will drill five test wells in order to complete a geologic characterization of the lignite coal seam. Phase two will involve the injection of CO_2 into the coal seam, as well as the potential recovery of valuable coalbed methane. PCOR's validation phase test will inject at least 400 tons of CO_2 at a depth of approximately 1,200 feet. Results from the field test will be used to conduct similar geologic sequestration and coalbed methane recovery tests in the PCOR region. August 30, 2007, http://www.netl.doe.gov/publications/press/2007/070830-Regional_Partner_Launches_Drilling.html.

November 2007

***NETL News Release,* "DOE Awards First Three Large-Scale Carbon Sequestration Projects."** On October 9, US Deputy Secretary of Energy Clay Sell announced the awards for the first of three large-scale carbon sequestration projects to be deployed as part of the Department of Energy's (DOE) Regional Carbon Sequestration Partnership Program. The ventures represent the first of several DOE large-scale sequestration projects to be awarded, each with the goal to store at least one million tons of carbon dioxide (CO_2) in deep geologic formations. The projects will kick off the third phase of work being done by the Regional Partnerships. Previous phases of work consisted of evaluating CO_2 sources and sinks in various parts of the United States and Canada and conducting a series of small-scale field tests

to validate the various geologic formations for safe and permanent storage of CO_2. The first project award, which consists of geologic sequestration projects in North Dakota and northwestern Alberta, Canada, was made to the Plains CO_2 Reduction Partnership (PCOR), led by the Energy and Environmental Research Center at the University of North Dakota. PCOR's projects will demonstrate both enhanced oil recovery and sequestration of CO_2. The Southeast Regional Carbon Sequestration Partnership (SECARB), led by the Southern States Energy Board, received the second project award, which is expected to begin in late 2008. SECARB will conduct a large-scale CO_2 injection test in two steps in the lower Tuscaloosa Formation Massive Sand Unit. The third award was made to the Southwest Regional Partnership (SWP) for Carbon Sequestration, led by the New Mexico Institute of Mining and Technology. SWP plans to inject several million tons of CO_2 into the Jurassic Entrada Formation, a deep saline formation present throughout the SWP region. Each of the Deployment Phase tests will encompass site characterization, injection operations and monitoring, and site closure and post-injection monitoring. To learn more about DOE's Regional Carbon Sequestration Partnerships, click on: http://www.netl.doe.gov/technologies/carbon_seq/partnerships/partnerships.html. October 9, 2007, http://www.doe.gov/print/5597.htm.

December 2007

***Fossil Energy Techline*, "DOE Releases Environmental Impact Statement for FutureGen Project."** The US Department of Energy (DOE) has released the Final Environmental Impact Statement (EIS) for the FutureGen Project, detailing the potential environmental effects of constructing the world's first coal-fired power plant that produces both electricity and commercial-grade hydrogen gas from coal, in addition to capturing and storing carbon dioxide (CO_2). The document evaluated four possible project sites in Mattoon, Illinois; Tuscola, Illinois; Jewett, Texas; and Odessa, Texas, and concluded each site offers an acceptable locale for funding the project, which is scheduled to begin operating in 2012. DOE will issue a Record of Decision for the Final EIS no sooner than 30 days after the Environmental Protection Agency (EPA) publishes its Notice of Availability of the Final EIS in the Federal Register. The Final EIS contains extensive evaluations of the potential environmental impacts for each site with respect to design, construction, and operation of the facility. Following the release of the Draft EIS on June 1, 2007, DOE conducted public meetings around each of the four final sites during the 45 day comment period. The FutureGen Industrial Alliance, a nonprofit consortium of coal producers and electricity generators, is responsible for making the final decision regarding the siting of the facility, which DOE anticipates to be made public before the end of the 2007. Once operational, the 275-megawatt facility will serve as the cleanest fossil fuel-fired plant in the world. To view the Final Draft of the FutureGen Environmental Impact Statement, click on: http://www.netl.doe.gov/technologies/coalpower/futuregen/EIS/FG%20Summary%20-%20FINAL.pdf. November 9, 2007, http://www.fossil.energy.gov/news/techlines/2007/PrintVersion_1_29761_29761.html?plain%20target.

January 2008

***NETL News Release*, "NETL Signs Memorandum of Understanding with Brazil."** On November 20, the US Department of Energy's (DOE) National Energy Technology Laboratory (NETL) and Brazil's Pontifical Catholic University of Rio Grande do Sul (PUC) signed a Memorandum of Understanding (MOU) to pursue collaborative work that advances the technological, environmental, and cost performance of carbon capture and storage (CCS) technologies. This follows initial discussions that began at the first Carbon Sequestration Leadership Forum (CSLF) workshop on Capacity Building for Emerging Economies in May 2007. The MOU includes the exchange of information; the exchange of scientists between NETL's Office of Research and Development and PUC's Center for Excellence on Carbon Storage Research (CEPAC); technical assistance in specific projects; and jointly funded activities between NETL and PUC. Research conducted under the MOU will primarily focus on the development of clean technologies for the use of fossil fuels, the development and assessment of sequestration options

for carbon dioxide (CO_2) and other greenhouse gases, the development and assessment of technologies to recover coalbed methane and enhanced coalbed methane with CO_2, and the development and assessment of technologies for underground coal gasification and production of syngas from high-ash coals. With Brazil's designation as the world's tenth largest energy consumer and third largest in the western hemisphere behind the United States and Canada, the MOU has the potential to help reduce the country's anthropogenic CO_2 emissions. For further information about NETL's Carbon Sequestration Program, go to: http://www.netl.doe.gov/technologies/carbon_seq/. To learn more about CSLF endorsed projects, click: http://www.cslforum.org/. November 20, 2007, http://www.netl.doe.gov/publications/press/2007/071120-NETL_Signs_Memorandum_with_Brazil.html.

February 2008

***Fossil Energy Techline*, "Energy Department Awards $66.7 Million for Large-Scale Carbon Sequestration Project."** Following three awards granted through the US Department of Energy (DOE) Regional Carbon Sequestration Partnership Program in October 2007 totaling $318 million, DOE awarded $66.7 million to the Midwest Geological Sequestration Consortium (MGSC) on December 18, 2007, to conduct DOE's fourth large-scale carbon sequestration project. Led by the Illinois State Geological Survey, the partnership will demonstrate the safe, permanent, and economic storage of more than one million tons of carbon dioxide (CO_2) in the Mount Simon Sandstone Formation, a massive geologic formation that spans Illinois, Kentucky, Indiana, and Ohio. The formation has the potential to store an estimated 100 years of CO_2 emissions from major sources in the region, which MGSC plans to test by injecting one million tons of CO_2 into the formation at a rate of 1,000 tons per day. The CO_2 will be injected for three years, after which the injection site will be closed and the effectiveness of the storage reservoir evaluated. The entire CO_2 injection process will be carried out in association with the Archer Daniels Midland (ADM) Company, whose Decatur, Illinois-based ethanol plant will serve as the primary source for the project's CO_2. ADM will share the CO_2 production costs and DOE will fund the dehydration, compression, short pipeline, and related facility costs to deliver the CO_2 to the wellhead. The grant is the fourth of seven awards to be made under the Regional Carbon Sequestration Partnerships Program's Deployment Phase. To learn more about DOE's Regional Carbon Sequestration Partnerships, click: http://www.netl.doe.gov/technologies/carbon_seq/partnerships/partnerships.html. For further information about MGSC, go to: http://www.sequestration.org/. December 18, 2007, http://www.fossil.energy.gov/news/techlines/2007/07084-Illinois_Basin_Sequestration_Proje.html.

***Reuters*, "FutureGen Picks Illinois for Coal Project,"** and ***Greenwire*, "Industry Group Picks Illinois Site for FutureGen."** On December 18, 2007, the FutureGen Alliance selected Mattoon, Illinois as the location to build FutureGen, a $1.5 billion, near-zero emissions, coal-fired power plant that will demonstrate carbon capture and sequestration technologies. After considering more than 100 site-related factors, such as land, water, and geology, the Alliance selected Mattoon over three other site finalists – Tuscola, Illinois; Jewett, Texas; and Odessa, Texas – because of the ability to pump CO_2 directly underground from the plant. FutureGen Alliance officials announced the site decision earlier than initially agreed upon with DOE. Originally, DOE was to publish the final environmental impact statements on each of the four sites, let a 30-day waiting period pass before the declaration that each of the four sites was or was not suitable for the project, and then the FutureGen Alliance would announce its final site decision. However, the FutureGen Alliance publicized its decision sooner, and consequently, the decision to build in Mattoon will remain tentative until DOE announces its Record of Decision on the site's suitability. The next challenge for the 275-megawatt plant, which is anticipated to be online in 2012, is to obtain more government funding as costs continue rise. The latest cost estimate for the project has increased to $1.76 billion, which will be funded according to a cost-sharing agreement that states the FutureGen Alliance must pay 26 percent of the cost, with DOE funding the remaining 74 percent. The 13-member FutureGen Alliance, formed in 2003, includes US companies such as American Electric Power and Peabody Energy, along with international businesses Anglo American, BHP Billiton, and China's largest coal-based power company, China Huaneng Group. To read the FutureGen Alliance's Final Site Selection Report, click: http://www.futuregenalliance.org/news/fg_final_site_selection_report.pdf.

December 18, 2007, http://www.reuters.com/article/bondsNews/idUSN18493176200712 18?sp=true and December 18, 2007, http://www.eenews.net/Greenwire/2007/12/18/1/#1.

March 2008

***Fossil Energy Techline*, "DOE Announces Restructured FutureGen Approach to Demonstrate Carbon Capture and Storage Technology at Multiple Clean Coal Plants."** On January 30, US Secretary of Energy Samuel W. Bodman announced a restructured approach to the FutureGen project, which involves the demonstration of carbon capture and storage (CCS) technology at several commercial-scale Integrated Gasification Combined Cycle (IGCC) power plants. The US Department of Energy (DOE) said that the reorganized approach caps their financing at no more than the plant's CCS component, allowing for plants to be operational as early as 2015. Under this restructured approach, DOE believes that at least twice the amount of carbon dioxide (CO_2) will be sequestered compared to the FutureGen project. The four sites evaluated in DOE's Environmental Impact Statement – Mattoon, Illinois; Tuscola, Illinois; Jewett, Texas; and Odessa, Texas – are still eligible to host a commercial-scale IGCC plant with CCS technology. DOE also issued a Request for Information (RFI) seeking industries' input by March 3, 2008 on the viability of building IGCC plants that achieve FutureGen's objectives. After the RFI period ends, DOE will issue a Funding Opportunity Announcement (FOA) to provide financing for CCS technology at IGCC plants that generate at least 300 megawatts. Announced in 2003, the FutureGen concept planned the creation of a near-zero emissions, 275-megawatt power plant that produced hydrogen and electricity from coal. Secretary Bodman also announced President Bush's budget request of $648 million, a $129 million increase from the FY2008 request, for DOE's Office of Fossil Energy's Clean Coal Technology Program for Fiscal Year (FY) 2009, including $407 million for coal research and $241 million to demonstrate technologies for cost-effective CCS. To view DOE's RFI, click: http://www.fossil.energy.gov/programs/powersystems/futuregen/final_futuregen_rfi0108.pdf. January 30, 2008, http://www.fossil.energy.gov/news/techlines/2008/08003-DOE_Announces_Restructured_FutureG.html.

***Fossil Energy Techline*, "Fossil Energy Requests $1.1 Billion for FY 2009 Budget."** DOE's FY 2009 coal budget request of $648 million is the largest for coal research in over 25 years, including $406.5 million for coal research and development (R&D), $85 million for the Clean Coal Power Initiative (CCPI), and $156 million for the restructured FutureGen approach. In regards to specific programs, the budget allocates the following: an $81.7 million funding increase from the FY 2008 FutureGen budget, increasing the total to $156 million; a $30 million increase to $149 million for carbon sequestration; a $15.5 million increase to $69 million for gasification technology; $60 million for fuel cells; and $85 million for Round 3 of President Bush's CCPI. For more detailed information about the budget, click http://www.fossil.energy.gov/aboutus/budget/09/fe_budgetfactsheet_fy09.pdf to read DOE's "Budget in Brief FY09." February 4, 2008, http://www.fossil.energy.gov/news/techlines/2008/08004-FY2009_Budget_Request.html.

April 2008

***NETL News Release*, "Carbon Sequestration Partner Initiates CO_2 Injection into Michigan Basin."** The Midwest Regional Carbon Sequestration Partnership (MRCSP), one of the US Department of Energy's (DOE) Regional Carbon Sequestration Partnerships (RCSP), has commenced a two-month field test that will inject up to 10,000 metric tons of carbon dioxide (CO_2) into a saline formation some 3,200 to 3,500 feet below the Earth's surface. The Core Energy-owned, Antrim gas field location advantageously provides the project with a DTE Energy-owned gas processing plant that supplies the CO_2; an eight-mile CO_2 pipeline previously used for enhanced oil recovery; and perhaps most importantly, the field test location at the Michigan Basin's northern rim offers a number of well documented, suitable formations ideal for the geological storage of CO_2. The 3,500-foot deep injection well is located thousands of feet below drinking water levels, which are typically no deeper than 1,000

feet in the Michigan region, moreover, the Amherstburg and Lucas formations provide 900 feet of containment above the injection zone. Led by Battelle, MRCSP received an Underground Injection Control (UIC) permit from the US Environmental Protection Agency (EPA) through Core Energy LLC in December 2007, the first such permit in the region for CO_2 sequestration; while the Michigan Department of Environmental Quality, Office of Geological Survey issued the permit to drill the test well. This Michigan Basin field test is one of three MRCSP-managed geologic tests and one of 20 or so similar projects currently underway throughout the United States. For more information about the MRCSP's activities, go to: http://www.mrcsp.org/ or for more information about DOE's RCSPs, browse: http://www.netl.doe.gov/technologies/carbon_seq/partnerships/partnerships.html. February 18, 2008, http://www.netl.doe.gov/publications/press/2008/08005-CO2_Injection_Begins_in_Michigan.html.

May 2008

***Fossil Energy Techline*, "DOE Technology Monitors CO_2 Injection in Australian Gas Field."** On April 2, Australia launched the Otway Basin Pilot Project – the first carbon sequestration project in the southern hemisphere – with the help of technology developed by United States Department of Energy (DOE) researchers. Over a span of one to two years, the $36 million project will inject up to 100,000 metric tons of carbon dioxide (CO_2) into a depleted gas field in the Waarre Formation of southeastern Australia's Otway Basin, and an international team will monitor the site's long-term storage viability. The project will use instrumentation sponsored by the DOE's National Energy Technology Laboratory (NETL) and developed at the Lawrence Berkeley National Laboratory (LBNL) that uses seismic techniques to trace the mile deep CO_2 plume before and after injection and provide data about location, migration, and permanent CO_2 storage. In addition, a well sampling technique that taps the reservoir and delivers fluid samples to the surface will be used to determine CO_2 content and to conduct geochemical analyses. The Otway Basin is thought to be an excellent test site, because it is a large source of natural CO_2 and offers plenty of depleted gas fields containing rock formations conducive to safe, long-term CO_2 storage. Several other international demonstration projects, such as CO2SINK near Berlin, Germany and the commercial-scale CO_2 storage operation at In Salah, Algeria, will benefit from the transfer of sequestration technologies by LBNL. The project is one of 19 projects endorsed by the Carbon Sequestration Leadership Forum (CSLF) and is directed by Australia's Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC). For more information about CSLF, go to: http://www.cslforum.org/, or visit http://www.co2crc.com.au/ to read more about Australia's CO2CRC. To view a video of the project, click: http://www.reuters.com/news/video?videoId=79363&newsChannel=environmentNews. April 3, 2008, http://www.fossil.energy.gov/news/techlines/2008/08009-Australian_CO2_Injection_Begins.html.

June 2008

***Fossil Energy Techline*, "DOE Awards $126.6 Million for Two More Large-Scale Carbon Sequestration Projects."** On May 6, the United States Department of Energy (DOE) announced awards totaling $126.6 million to the West Coast Regional Carbon Sequestration Partnership (WESTCARB) and the Midwest Regional Carbon Sequestration Partnership (MRCSP) to conduct large-scale tests (in California and Ohio, respectively) that demonstrate the ability of a geologic formation to store more than one million tons of carbon dioxide (CO_2). The projects are the fifth and sixth DOE grants for large-scale tests (industry partners will contribute $56.6 million in cost-shared funds) that study the three phases of geologic storage: pre-injection characterization, injection process monitoring, and post-injection monitoring. The initial 24-month stage will complete the necessary modeling, monitoring, and infrastructure improvements needed before CO_2 is injected. Led by the California Energy Commission, WESTCARB will inject one million tons of CO_2 over four years into geologic formations below the 50-megawatt Clean Energy Systems power plant in Kimberlina, California. The plant's oxyfuel system produces a relatively pure CO_2 stream that will be compressed and injected. MRCSP, headed by Battelle Memorial Laboratories, plans to inject one million tons of CO_2 from an ethanol production facility into the

Mount Simon Sandstone formation at a depth of approximately 3,000 feet. The Mount Simon formation stretches from Kentucky through Ohio and has the potential to store more than 100 years of CO_2 emissions. For more information about MRCSP, click: www.mrcsp.org, or for further details about WESTCARB, visit: http://www.westcarb.org/. May 6, 2008, http://www.fossil.energy.gov/news/techlines/2008/08012-DOE_Funds_Large-Scale_Projects.html.

***Fossil Energy Techline*, "DOE Takes Next Steps with Restructured FutureGen Approach."** DOE released a draft Funding Opportunity Announcement (FOA) to solicit public input regarding the demonstration of commercial-scale Integrated Gasification Combined Cycle (IGCC) power plants equipped with carbon capture and storage (CCS) technology as part of the restructured FutureGen approach. The FOA, which provided the public with an opportunity to review and comment through May 21, outlined the planned scope of the project, evaluation criteria, terms and conditions, and cost sharing requirements for public-private cooperation. DOE estimates the investment per project would range from $100 million to $600 million and envisions plant operation to begin as soon as the plants are commissioned by December 31, 2015. Also, the draft FOA stated that the project must produce at least 300 megawatts (MW) gross electricity output, with at least 50 percent of this output being used to produce electricity. In addition, the project must be designed to achieve approximately 90 percent capture of CO_2 (with a minimum capture rate of 81 percent). The Final FOA will be released in mid-summer 2008 and project selection is forecast for December 2008. To read the Draft FOA, click: http://e-center.doe.gov/iips/faopor.nsf/8df825feb86675de852564650046faea/37325dddc3cc2f5b8525744200579f33?OpenDocument. May 7, 2008, http://www.fossil.energy.gov/news/techlines/2008/08013-DOE_Takes_Next_Steps_With_Restruct.html.

***Carbon Sequestration Leadership Forum Press Release*, "Twenty-One Nations, European Commission, Meet in South Africa to Discuss CO_2 Sequestration."** Twenty-one Carbon Sequestration Leadership Forum (CSLF) members met in Cape Town, South Africa to discuss the development of cost-effective technologies for the separation, capture, transport, and long-term storage of CO_2. The meeting resulted in agreements on several fronts, including: (1) a CSLF declaration supporting the Group of Eight (G-8) recommendations for near-term deployment of CCS; (2) updating the CSLF strategic plan; (3) examining CSLF priorities for moving CCS forward that may be recommended to Energy Ministers; (4) appropriate initiatives and projects that would remove barriers from CCS implementation; (5) updating a CCS roadmap; (6) creating successful pathways for the transfer of technologies, knowledge, and experience about CCS; and (7) increasing the role of stakeholders in implementing the policy priorities. More information on CSLF can be obtained at: http://www.cslforum.org/index.htm, or at DOE's CSLF webpage at: http://www.fe.doe.gov/programs/sequestration/cslf/index.html. April 23, 2008, http://cslforum.org/documents/CSLFPressRelease042308.pdf.

July 2008

***Fossil Energy Techline*, "IEA Finds U.S. CO_2 Sequestration Program World's Most Ambitious."** The International Energy Agency Greenhouse Gas R&D Programme (IEA GHG), an international collaborative research program set up under the auspices of the IEA, validated the US Department of Energy's (DOE) Regional Carbon Sequestration Partnerships (RCSP) and their large-scale carbon dioxide (CO_2) tests as the world's most "ambitious" program to advance the field of carbon capture and storage (CCS). A panel of scientific experts selected by IEA GHG found that the seven RCSPs are unique in that no other country or region has initiated a similar effort. IEA GHG's report says that the projects are realistic, achievable, and should be implemented immediately; the projects serve as a major research initiative; and Phase III seeks to achieve significant results for the United States and the international community. The RCSP Program is a Federal, state, and private sector collaboration intended to determine the requisite technologies, regulations, and infrastructure needed for future CCS in different geological regions of North America. RCSPs include more than 350 state agencies, universities, and private companies within 42 states, three Indian nations, and four Canadian provinces. DOE

launched the three-phase RCSP Program in 2003 as the centerpiece of their efforts to commercialize CCS technologies. During the first phase of the program, RCSPs identified more than 3,000 billion metric tons of potential storage capacity in North American geologic formations, equivalent to more than 1,000 years of storage capacity. The second phase involved implementing some 25 small-scale geologic storage tests to evaluate whether different geologic formations have the ability to safely sequester CO_2 over the long term. RCSPs are currently engaged in Phase III, which will examine the long-term storage of more than one million tons of CO_2 in several large-scale tests. The RCSPs encompass 96 percent of the total land mass in the United States, which is home to 97 percent of coal-fired CO_2 emissions, 97 percent of industrial CO_2 emissions, and nearly all of the geologic sequestration sites available for CO_2 storage. (**See Recent Publications section for abstract and link to IEA GHG's "Expert Review of Regional Carbon Sequestration Partnerships Phase III."**) To learn more about the RCSP Program, visit: http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html, or click: http://www.ieagreen.org.uk for IEA GHG information. June 5, 2008, http://www.fossil.energy.gov/news/techlines/2008/08019-IEA_Finds_US_CCS_Plans_Ambitious.html.

***Fossil Energy Techline*, "Hawaii Joins DOE's Carbon Sequestration Regional Partnership Program."** Hawaii became the 42nd state to join DOE's RCSP Program on May 6, coinciding with funding awarded to the West Coast Carbon Sequestration Partnership (WESTCARB) for a Phase III large-scale test in California. The sequestration efforts in Hawaii will involve site characterization, or "source sink matching," of CO_2 emission point sources and the terrestrial and/or geologic sinks that could safely store CO_2. Under the leadership of the University of Hawaii, scientists will examine and update an inventory of Hawaiian GHG sources as mandated by a new state law. Hawaii joins California, Arizona, Nevada, Oregon, Washington, Alaska, and British Columbia in the California Energy Commission-managed WESTCARB, which will conduct a geologic storage project in the San Joaquin Basin in Central California as part of their Phase III efforts. To learn more about WESTCARB's activities, click: http://www.westcarb.org/. June 9, 2008, http://www.fossil.energy.gov/news/techlines/2008/08021-Hawaii_Joins_WESTCARB.html.

August 2008

***Fossil Energy Techline*, "DOE Regional Partnerships Find New Use for Unmined Coal."** The Midwest Geological Sequestration Consortium (MGSC) became the first of the seven Regional Carbon Sequestration Partnerships (RCSP) created by the US Department of Energy (DOE) to inject carbon dioxide (CO_2) into a coal seam in the United States in a field project in Wabash County, Illinois. The Phase II pilot project, headed by the National Energy Technology Laboratory (NETL) and the Illinois and Indiana State Geological Surveys, will test the viability of turning unmined coal deposits into a source of useable energy by extracting coalbed methane trapped in the coal. The Illinois State Geological Survey estimates that there is up to 3.6 billion tons of storage capacity in the Illinois Basin, with more than 10 trillion cubic feet of recoverable coalbed methane from the unmined bituminous coal seams. The Wabash County project eliminates the need for dewatering, a process where water is pumped out of the coal to extract gas; dewatering is not conducive to carbon sequestration because it creates a low pressure environment that reduces CO_2 storage capacity. To avoid this scenario, MGSC scientists pump trucked-in CO_2 through a heater and inject it as a gas, which increases the underground pressure, allowing CO_2 to absorb into the surface of the coal and displace methane. However, this method results in coal swelling, which has the potential to reduce the injection rate of CO_2 and limit the overall amount that can be injected and stored in the coal seam. MGSC scientists circumvent this challenge by injecting the CO_2 in eight to 24-hour cycles to give the CO_2 adequate time to absorb into the coal, reduce well pressure, and clear any possible congestion. Researchers anticipate up to 250 tons of CO_2 will be injected over three months while field testing the new injection approach. This project is one of six small-scale field tests being conducted by MGSC during the Validation Phase of the RCSP program; other field tests involve injecting CO_2 for enhanced oil recovery (EOR) or into saline formations a mile or more below the surface. To learn more about DOE's RCSP Program, go to: http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html, or click:

http://www.sequestration.org/ for more information about MGSC. July 17, 2008, http://www.fossil.energy.gov/news/techlines/2008/08026-Regional_Partnerships_Tap_Unmined_Coal.html

Sequestration in the News

September 2007

***Pantagraph.com,* "Blagojevich Signs FutureGen Incentive Bill,"** and ***The News-Gazette.com,* "FutureGen Bill Now a Law."** Illinois Governor Rod Blagojevich signed legislation aimed at helping to bring the $1.4 billion FutureGen plant to Illinois. FutureGen is DOE's zero-emissions coal-fired power plant initiative. If the plant is sited in Illinois, it would be located in either Mattoon or Tuscola. Illinois' best and final offer to build FutureGen will be submitted on August 1. The offer will include a $17 million state grant, $50 million in low-interest loans from the Illinois Finance Authority, several tax breaks and a package of local incentives. Since the FutureGen project includes carbon sequestration, the new state law establishes monitoring responsibility and offers liability protection from lawsuits related to the highly unlikely release of carbon dioxide. Illinois is competing against Texas which would site the plant in either Jewett or Odessa. Texas has passed a law containing similar legal protections.
July 30, 2007,
http://www.pantagraph.com/articles/2007/07/30/money/doc46ae5ce578e01817155333.prt, and July 31, 2007, http://www.news-gazette.com/news/print/2007/07/31/futuregen_bill_now_a_law/. (Subscription required.)

***KTRE, TX News Release,* "FutureGen Project,"** and ***The Dallas Morning News,* "Perry Makes Final Pitch to FutureGen Plant."** On August 1, Texas Governor Rick Perry presented his state's final proposal to become home to DOE's FutureGen project. With the final site announcement pending before the end of the year, the Texas cities of Odessa and Jewett are competing for the FutureGen Industrial Alliance's award to host the site. Perry hopes that the state's energy expertise and strong business climate will land the plant in his state. Texas is offering financial incentives that include $240 million in tax credits, $21 million in state funding, and commitments of public-private partnerships with major corporations, including Luminant, NRG Energy and Kinder Morgan. Texas is also offering to support carbon sequestration in its FutureGen offer. Texas Railroad Chairman Michael Williams, who chairs the FutureGen Texas team, said that Texas would offer liability protection for that effort. Two Illinois towns, Mattoon and Tuscola, are also being considered for the project award. August 1, 2007, http://www.ktre.com/global/story.asp?s=6873451&ClientType=Printable and August 2, 2007, http://www.dallasnews.com/sharedcontent/dws/bus/stories/080207dnbusperryfuturegen.35a82a2.html.

***PR Newswire,* "BP and Powerspan Collaborate to Demonstrate and Commercialize CO_2 Capture Technology for Power Plants."** On August 3, BP Alternative Energy and Powerspan Corporation announced their collaboration on Powerspan's CO_2 capture technology for power plants, called ECO_2. The joint project will also include sequestration of the CO_2 captured at the test site into an 8,000 foot test well for secure, long-term storage. DOE's Midwest Regional Carbon Sequestration Partnership is collaborating on the pilot scale testing at FirstEnergy Corporation's R.E. Burger plant in Shadyside, Ohio. The test is scheduled to begin in early 2008. BP and Powerspan will conduct pilot testing of the ammonia-based CO_2 capture technology, which would be the first test of its kind to demonstrate both CO_2 capture and sequestration at a conventional coal-fired power plant. The process, developed through a cooperative agreement with NETL and Powerspan, uses an ammonia-based solution to capture the CO_2 in flue gas, which can then be used for enhanced oil recovery efforts or geologic sequestration. With success of the pilot test, BP and Powerspan hope for full-scale commercial deployment of the technology. DOE estimates that the ammonia-based CO_2 capture process could be more cost effective than commercially available amine-based capture technologies, and can be retrofitted to existing coal-

fired power plants. August 8, 2007, http://www.prnewswire.com/cgi-bin/stories.pl?ACCT=104&STORY=/www/story/08-08-2007/0004641839&EDATE=.

October 2007

***ZeroGen Media Release,* "Clean Coal Project Achieves Significant Milestone,"** and ***The Age (Australia),* "Queensland ZeroGen Project Passes First Test."** A significant milestone was reached with ZeroGen, Australia's zero-emissions, clean coal power demonstration project, located in central Queensland. The Australian project combines Integrated Gasification Combined Cycle (IGCC) technology with CO_2 capture and storage in efforts to greatly reduce atmospheric CO_2 emissions. The first phase of testing, known as Drilling Program One (DP1), was completed successfully and involved drilling two test wells, both more than one kilometer deep. Results of the test have established the safe injection and storage of CO_2 into saline formations in the Northern Denison Trough. Knowledge gained about the geology of the formation will assist ZeroGen researchers in locating suitable geologic formations for long-term storage of CO_2. It will also allow them to move into the next phase of testing, Drilling Program 2 (DP2), which will involve locating a formation with sufficient storage capacity, analyzing project costs, performing risk assessment, and conducting monitoring and verification studies. More information about Australia's ZeroGen project can be found at: www.zerogen.com.au. August 30, 2007, http://www.zerogen.com.au/files/Media%20Release%2030%20August%202007%20Clean%20Coal%20project%20achieves%20significant%20milestone.pdf, and August 30, 2007, http://www.theage.com.au/news/National/Qld-ZeroGen-project-passes-first-test/2007/08/30/1188067237414.html#.

***Greenwire*, "Blue Source Will Capture Kansas CO_2, Use for Oil Recovery Elsewhere."** Blue Source LLC will partner with Coffeyville Resources Nitrogen Fertilizers LLC on a carbon sequestration project that will capture and transport CO_2 for enhanced oil recovery (EOR) efforts. Once the CO_2 is sequestered, CO_2 emission levels are expected to be reduced by 650,000 metric tons per year. The project involves capturing CO_2 from Coffeyville Resources' fertilizer plant in Kansas and transporting it via pipeline to depleted oil fields 120 miles away. Blue Source intends to market the emissions credits created by this project to fund other EOR or geologic sequestration projects. The project will cost between $50 million and $80 million. Blue Source has collaborated on many similar projects in the past and has about thirteen more in the planning stages. August 23, 2007, http://www.eenews.net/Greenwire/print/2007/08/23/14.

***The Age (Australia),* "Big Firms Set for Carbon Opportunities."** While no firm emissions targets were established at the Asia-Pacific Economic Cooperation (APEC) summit held in Sydney, many large Australian companies are recognizing investment opportunities in carbon-related business ventures, such as geosequestration and other clean coal technologies. At the same time, businesses including Chevron in Western Australia, BP Australia, Rio Tinto, Santos Limited, and Worley Parsons are reluctant and uncertain to move forward with emissions reduction investments in the absence of a clear regulatory framework and a structured carbon trading market. Carbon-related opportunities for Australian businesses include involvement of BP Australia and Rio Tinto in geosequestration, Santos' large-scale carbon sequestration project in the Cooper Basin in Victoria, and General Electric's clean coal technology development. September 11, 2007, http://www.theage.com.au/news/Business/Big-firms-set-for-carbon-opportunities/2007/09/11/1189276710149.html#

November 2007

***Odessa American Online*, "More on FutureGen."** Research conducted by Dr. Weon Shik Han of the New Mexico Institute of Mining and Technology shows that a local brine formation near the possible FutureGen site in Odessa, Texas is best suited for sequestering the plant's CO_2. By simulating the

injection history of the United States' oldest CO_2 sequestration site, located at the Scurry Area Canyon Reef Operators Committee (SACROC) field near Snyder, Texas, Han deduced that having an oil reservoir near the injection site creates a physical barrier to prevent CO_2 leakage. Han created a numerical model based on the 13 million tons of CO_2 injected into the field's northern quadrant, thus allowing him to identify the range of the trapping mechanisms. The well records showed that six million tons of CO_2 had been produced in secondary recovery operations, while the remaining seven million tons of CO_2 were successfully sequestered. Han, whose research is partly affiliated with President Bush's Global Climate Change Initiative, concluded that when CO_2 density is greater than oil density, a perfect seal is created. The Penwell site is vying against Jewett, Texas, and two Illinois towns, Mattoon and Tuscola, for the $1.5 billion, near-zero emissions, coal-fired power plant, whose final location will be announced by the FutureGen Alliance in December 2007. September 28, 2007, http://www.oaoa.com/news/co2_8216___article.html/futuregen_site.html.

***RWE News Release*, "RWE Npower to Develop First 'Carbon Dioxide Capture' Technology Pilot at a UK Coal Power Station."** By 2010, RWE npower plans to have the United Kingdom's (UK) first CO_2 capture pilot plant fully operational at the coal powered Aberthaw Power Station in South Wales. The UK's largest electricity supplier will direct an initial $17.1 million (£8.4 million) toward a 1 megawatt (MW) capture plant, then focus further investment on a CO_2 capture and storage demonstrator plant of at least 25 MW. Unlike other CO_2 capture and storage techniques, RWE will utilize post-combustion technology in both plants, a technology which is functional in already existing coal power plants. Once completed, the pilot plant will allow RWE to harness the technical and commercial issues surrounding CO_2 capture and storage technology. The larger CO_2 capture and storage demonstrator plant, currently under testing at existing plant sites in Tilbury, Essex, and Blyth, Northumberland, will form part of RWE's high efficiency, supercritical power stations. This development came on the heels of RWE npower's sister company announcing that it will team with BASF and The Linde Group to design, construct, and operate a CO_2 capture and storage system at the lignite-fired Niederaussem Power Station in Germany. October 10, 2007, http://www.rwe.com/generator.aspx/presse/language=en/id=76864?pmid=4001863.

***Blue Source LLC News Release*, "Blue Source Announces Reduction of $C0_2$ Emissions at Natural Gas Plant in Carbon Capture Project for South Central Colorado,"** and ***Reuters,* "Blue Source to Pipe Colorado CO_2 to Boost Oil Output."** Blue Source LLC, a leader in the marketing of greenhouse gas offsets in North America, announced plans to capture 20 million cubic feet of CO_2 per day from the Apple Tree natural gas processing plant in southwest Colorado and pipe it to an aging petroleum field in the Permian Basin. In order for the 20 million cubic feet of CO_2, equal to the emissions of 70,000 cars, to reach its destination, Blue Source will need an $8 million capital infusion to connect the Apple Tree vent stack to the Sheep Mountain CO_2 Pipeline located 16 miles from the site. Blue Source officials said they plan to sell the gas to energy producers or purchase market credits, known as Voluntary Emissions Reductions (VERs), which will work to finance the investment. In addition to the Apple Tree development, Blue Source previously announced plans in August to capture CO_2 from a Kansas fertilizer plant and pipe it from 70 to 120 miles for enhanced oil recovery at a cost of $50 million to $80 million. Similar Blue Source projects are in the works. October 8, 2007, http://www.ghgworks.com/5c-pr07-10-08.html and October 9, 2007, http://uk.reuters.com/article/oilRpt/idUKN09418364200710 09?pageNumber=1.

***NETL News Release*, "DOE Releases Draft Funding Opportunity Announcement for CCPI Round 3."** DOE has released the draft Funding Opportunity Announcement (FOA), Model Cooperative Agreement, and Model Payment Agreement for Round 3 of the Clean Coal Power Initiative (CCPI), which focuses on technologies that capture and sequester CO_2 emissions and put them to beneficial use. DOE established the following goals for demonstration at a commercial scale in a commercial setting: technologies that capture and sequester at least 50 percent of CO_2 emissions from the proposed facility, or put them to beneficial reuse; technologies that show significant progress toward 90 percent carbon capture; and technologies that show significant progress toward CO_2 capture and sequestration with less than 10 percent increase in electricity costs. Round 3 is structured for demonstration projects that align with ongoing sequestration field tests, which could already be operational when new projects

become available. Interested parties are encouraged to inquire about the cost-shared partnership during the public comment period, which began October 4, 2007 and ends November 9, 2007. A public workshop will be held in Pittsburgh, PA on November 1, 2007 related to the FOA. The final FOA is expected to be released by the end of November 2007 with an application due date of April 29, 2008. Serving as part of President Bush's commitment to clean coal technology, the CCPI began in 2002 as a 10-year, $2 billion program to advance coal based power generation by seeking innovative technologies on a commercial scale. To read the Draft FOA, click on: https://e-center.doe.gov/iips/faopor.nsf/UNID/381D0BFF0BCDDEFD852572E60065938E?OpenDocument. **(See the Announcements section of this newsletter for more information about the CCPI public meeting being held in response to this announcement.)** October 4, 2007, http://www.netl.doe.gov/publications/press/2007/07071-DOE_Seeks_CCPI_Comments_.html.

December 2007

***Arizona Public Service News Release,* "APS, SRP, Tucson Electric Power Join Coalition to Test Storing Carbon Dioxide Underground to Reduce Greenhouse Gases."** Three major utilities participating in the West Coast Regional Carbon Sequestration Partnership (WESTCARB) will launch a geologic sequestration pilot test near Joseph City, Arizona. The validation test, to be conducted by Arizona Public Service, Salt River Project, and Tucson Electric Power, involves injecting commercial CO_2 at a depth of approximately 4,000 feet into an underground saline formation. Although located near the APS Cholla Power Plant, the project will not capture the emissions from the coal-burning power plant for this test. The injected CO_2 will be monitored to validate the safety and long-term storage potential of this geologic formation. Local residents and community leaders gave positive feedback about the project at public hearings held in August. WESTCARB is one of the seven Regional Carbon Sequestration Partnerships formed by DOE to determine the best approaches for capturing and permanently storing CO_2. To learn more about WESTCARB, visit the partnership website at: www.westcarb.org. October 24, 2007, http://www.aps.com/general_info/newsrelease/newsreleases/NewsRelease_424.html.

***Reuters*, "NRG to Test CO_2 Capture at Coal Unit,"** and ***Greenwire*, "Companies Will Add Carbon-Capture to Texas Power Plant."** NRG Energy and Powerspan Corporation announced plans to demonstrate a CO_2 capture and storage process at the NRG-owned, coal-fired WA Parish plant in Fort Bend County, located southwest of Houston, Texas. After the CO_2 is captured from the 125-megawatt plant's flue gas, using Powerspan's electrocatalytic oxidation technology (ECO_2), companies in the region will use the CO_2 for enhanced oil recovery. The ammonia-based ECO_2 solution is designed to capture CO_2 from flue gas emitted after combustion. Powerspan expects the facility to be operational in 2012, with 90 percent of the flue gas CO_2 captured – totaling an NRG-projected one million tons of CO_2 captured and sequestered annually. Once functional, the $150 million venture will rank among the world's largest carbon sequestration projects. The announcement comes on the heels of Powerspan's teaming with BP Alternative Energy in August to commercialize the ECO_2 technology and conduct a pilot test at an Ohio coal plant in early 2008. November 2, 2007. http://www.reuters.com/articlePrint?articleId=USN0257439020071102 and November 2, 2007, http://www.eenews.net/Greenwire/print/2007/11/02/11.

***Columbus Dispatch*, "Going Underground," and *Columbus Dispatch*, "CO_2 Could Go Underground."** Researchers from the Midwest Regional Carbon Sequestration Partnership, headed by Battelle, have completed an experimental well to determine the potential of Ohio's geology to sequester the region's CO_2 emissions. As part of the Ohio Stratigraphic Borehole Project, sensing equipment was placed, and a hole was drilled to a depth of 8,695 feet. Beginning at 40 feet deep, the team collected geological cuttings every five feet until the 1,215 foot mark, where the sampling collection rate shifted to every 10 feet. Following the drilling, geologists conducted several tests, including examining core samples and lowering equipment into the shaft to measure porosity, testing for radioactivity levels; and injecting saline into prospective layers to determine how fluids move through rock. Tests revealed that the Rose Run and Clinton sandstones are potentially porous enough to sequester CO_2 in the region.

While the project took place in eastern Ohio's Tuscarawas County, geologists are also monitoring the Mount Simon sandstone in western Ohio and a layer called Copper Ridge in southern Ohio as potential CO_2 storage sites. November 6, 2007, http://www.columbusdispatch.com/live/content/science/stories/2007/11/06/sci_borehole.ART_ART_11-06-07_B4_NN8ARQL.html?print=yes&sid=101 and November 6, 2007, http://www.columbusdispatch.com/live/content/local_news/stories/2007/11/06/borehole.ART_ART_11-06-07_B1_TV8CSPE.html?print=yes&sid=101.

January 2008

***Salt Lake Tribune*, "Project Plans to Bury CO_2,"** and ***Salt Lake Tribune*, "Putting a Lid on Global Warming."** A 10-year, $88 million carbon sequestration research project, funded primarily by a $67 million grant from DOE's NETL, is targeting the long term CO_2 injection and storage capabilities of mile-deep, saltwater-filled sandstone formations located 130 miles southeast of Salt Lake City in Wellington, Utah. The project, managed by the Southwest Regional Partnership (SWP), plans to capture naturally occurring CO_2 from the Pure Energy-owned site and pipe CO_2 from a coalbed methane site; compress the CO_2 at 2,200 pounds per square inch (psi); and inject some three million tons of CO_2 over the next four years into a 200 to 300 feet thick sandstone formation covered by an impervious layer of shale. The new, Wellington-based project phase is focused on an area called Farnham Dome, a storage site located 5,000 feet below the desert surface that has naturally stored CO_2 for some 10 to 50 million years. In fact, businesses collected CO_2 from the naturally occurring CO_2 pool until 1979 for use during the production of dry ice and soft drinks. For further information about SWP projects, partners, and events, go to: http://www.southwestcarbonpartnership.org/. November 16, 2007, http://www.sltrib.com/ci_7488186 and November 16, 2007, http://www.sltrib.com/ci_7478872 (Subscription required).

***Tulsa World*, "Capturing Carbon: AEP-PSO Program to Route CO_2 to State Oil Fields."** After signing a Memorandum of Understanding (MOU) with SemGreen in October, American Electric Power-Public Service Company of Oklahoma (AEP-PSO) announced plans to capture and pipe about half of the CO_2 produced from one of its 450-megawatt units located at the Northeastern Station in Oologah, Oklahoma to mature oil fields. Under the agreement, SemGreen, a subsidiary of Tulsa-based SemGroup LP, will receive 1.5 million tons of CO_2 per year that will be used by SemGreen or sold to other companies for enhanced oil recovery. AEP expects the project, which is billed as the largest of its kind in the nation, to be installed and operational by 2012, helping to reduce the emissions from the world's seventh largest CO_2 producing company. In addition, AEP selected Oklahoma as a viable location for the technology due to the state's active energy industry and the prospect that the recovered CO_2 could be used for developing declining oil resources. Although Oklahoma's oil production has recently dipped, industry hopes CO_2 injection can increase oil production at more than 74,000 wells that are responsible for producing about 85 percent of the state's total oil output. November 17, 2007, http://www.tulsaworld.com/business/article.aspx?articleID=071117_238_E1_hAEPP48341.

***Penn West Energy Trust News Release*, "Penn West Announces Update on South Swan Hills CO_2 Pilot Project."** Penn West Energy Trust announced a partnership with the Government of Alberta to initiate a CO_2 enhanced oil recovery pilot test at the South Swan Hills Unit, which includes the permanent sequestration of large volumes of CO_2 in a portion of the reservoir that has not yet been effectively tapped by prior hydrocarbon injection. By using the CO_2 flooding process, Penn West hopes to safely store CO_2 underground that would otherwise be emitted into the air and develop infrastructure necessary for an industry wide movement toward commercial scale CO_2 enhanced oil recovery projects within the basin. Penn West officials believe the project is the first key step in evaluating and confirming the economic viability of recovering additional oil from the Swan Hills area using CO_2 enhanced oil recovery techniques. The project is expected to begin during the first quarter of 2008, with Penn West and Alberta Energy investing approximately $20 million and $6.5 million, respectively, to bring the project to life. As part of Alberta Energy's Innovative Energy Technologies Program (IETP), the project is one of several

that benefits from a five-year, $200 million commitment to pilot projects that demonstrate new technologies that increase and encourage responsible development of oil and natural gas reserves. December 11, 2007, http://www.pennwest.com/documents/SSHUPressRelease.pdf.

February 2008

***Business Week*, "FutureGen Developers Propose Cost Change."** Less than one month after the designatation of Mattoon, Illinois as the future location of FutureGen, DOE threatened to delay or rescope the project into several research sites across the country in light of ever increasing construction costs. Government projections show the plant's projected cost has risen from $950 million to $1.8 billion, boosting DOE's obligation to around $1.3 billion – significantly up from the $800 million originally projected in 2003. Consequently, DOE has offered to lower the government's contribution to the same level as when the project was announced, leaving the FutureGen Alliance to cover the remaining cost and assume any further cost increases, more than likely funded through a combination of bank financing and repayments from plant-generated revenue. In response, FutureGen Alliance officials have been receptive to dialogue and offered to increase their contribution, because adding sites would delay the project by another two to five years due to further environmental reviews and other testing to prove site suitability. DOE has yet to issue its Record of Decision for the Mattoon site – a requirement before the department can spend taxpayer money on the project. January 11, 2008, http://www.businessweek.com/ap/financialnews/D8U419PG0.htm.

***Houston Business Journal*, "Proposed Freeport Plant Will Capture, Re-use Waste,"** and ***Dow Chemical Company News Release*, "Dow Signs MOU for Gasification Facility."** Houston-based Hunton Energy and Michigan-based Dow Chemical Company announced the signing of a 15-year Memorandum of Understanding (MOU) that will result in the construction of a capture-ready synthetic natural gas plant in Freeport, Texas. Under the terms of the MOU, the plant will manufacture syngas by mixing oxygen with petroleum coke and biomass and then convert it to methane, liquid sulfur, and slag – in addition to capturing 100 percent of CO_2 emissions. Hunton Energy would own, build, and operate the plant, which would be located on Dow's Oyster Creek property, and once the gasification plant is completed, Dow would purchase synthetic natural gas and steam from Hunton for transport to its large Texas Operations manufacturing site, located in Freeport as well. Over the course of the project, Hunton plans to use steam turbines to produce additional power, sell CO_2 for enhanced oil recovery use, and sell byproduct sulfur and slag to fertilizer and concrete manufacturers, respectively. Groundbreaking for the plant is expected to take place in late 2008, giving Dow seven years to fulfill their company initiative to reduce greenhouse gas emissions by 20 percent by 2015. December 17, 2007, http://www.bizjournals.com/houston/stories/2007/12/17/daily8.html and December 13, 2007, http://news.dow.com/dow_news/corporate/2007/20071213c.htm.

***Total Press Release*, "Total and Indonesia Sign a Memorandum of Understanding on CO_2 Capture and Storage,"** and ***Energy Business Review*, "Total and Indonesia Sign Carbon Capture and Storage Deal."** On December 17, Total announced the signing of a Memorandum of Understanding (MOU) by Total E&P Indonesia and the Indonesian Ministry of Energy and Mineral Resources, allowing for Indonesia's Agency of Research and Development for Energy and Mineral Resources to access Total's data from a CO_2 pilot project taking place near Lacq in southwest France. The project, dubbed as one of the first in the world to encompass the complete sequence from fuel combustion to geological storage, is anticipated to prove the viability of an integrated carbon capture and storage methodology. The agreement provides Indonesia with the opportunity to evolve its economical and technical knowledge of geologic CO_2 storage mechanisms and assist the Indonesian Government in the establishment of proper regulatory framework for comparable projects. Total, Indonesia's leading gas producer, supplies a portion of the domestic market and foreign markets in Japan, Korea, and Taiwan. December 17, 2007, http://www.total.com/en/press/press_releases/pr_2007/071217-indonesia-co2-capture-storage_14383.htm and December 17, 2007, http://www.energy-business-review.com/article_news.asp?guid=E1C793B2-00F3-446F-9040-F7C888F8F0FC.

March 2008

***Wall Street Journal Online*, "China Works To Trap, Use Carbon Output."** On January 30, Hong Kong-based Enviro Energy International Holding Ltd. and Canada-based Petromin Resources Ltd. signed an agreement with China United Coalbed Methane Corp. to initiate a five-year, multi-well CO_2 injection-based enhanced coal bed methane pilot project. The $1.39 million (10 million yuan) project, partially funded by the Chinese Ministry of Science and Technology, includes drilling wells in an unminable coal bed located about 3,000 feet below the surface. China is interested in using methane to power turbines in power plants because of the country's 90-gigawatt rise in electricity capacity over the past two years – a figure equivalent to the combined generating capacity of the United Kingdom and France in 2006-07. A $9 million (64.6 million yuan) pilot test conducted near the South Qinshui Basin in Shanxi Province revealed that methane rates double when CO_2 was injected into the coal bed. January 30, 2008, http://online.wsj.com/article/SB120166910098728185.html.

***The Canadian Press*, "Enbridge to Lead Group of 19 Energy Companies in Carbon Capture Project."** Enbridge Inc., a Canadian pipeline company, is leading the Alberta Saline Aquifer Project (ASAP), an initiative that intends to inject CO_2 emissions into underground saltwater pools. The project, conducted by a group of 19 energy industry members, is currently in its first phase, which includes a study to find ideal locations to commence the project at a cost of $750,000. Officials said a small-scale pilot project capable of injecting 1,000 tonnes of CO_2 per day would cost $20 million to $30 million and the price of commercializing the technology would exceed $200 million – a figure significantly lower than a $2 billion fee estimated by a Canadian government taskforce on CO_2 capture and storage. A similar Canadian initiative, the Integrated CO_2 Network (ICO_2N), seeks to create a nationwide system to capture emissions from a number of industrial sites and move them by pipeline to depleted oil and gas fields, unmineable coal formations, or deep saline aquifers. February 4, 2008, http://canadianpress.google.com/article/ALeqM5jkXSSwenMdSK8TW3j7Jwrlrn4krA.

***Norway Post*, "Aker to Invest in Pioneering Carbon Capture Facility,"** and ***Aker ASA Press Release*, "Invests Close to a Billion Kroner in Pioneering Carbon Capture Facility."** Aker Clean Carbon announced plans to build a CO_2 capture and storage facility near the natural gas-fired power plant and gas processing facilities at Kårstø in Rogoland, Norway, capable of capturing 100,000 tons of CO_2 annually from exhaust gases – a project billed as the world's first and largest CO_2 capture facility of its kind. The facility, expected to be operational in 2009, is connected to both CO_2 point sources to allow for continuous CO_2 removal. In addition, the new CO_2 capture plant is projected to cost $160 million (NOK 875 million), with operating costs of $27 million (NOK 150 million) over a three-year period. Aker said that their recent efforts have focused on mitigating the cost of carbon sequestration, so that building facilities for CO_2 capture and storage becomes a more economically friendly option than polluting. January 24, 2008, http://www.norwaypost.no/cgi-bin/norwaypost/imaker?id=127340 and January 24, 2008, http://www.akercleancarbon.com/publish_files/080124_Aker_Clean_Carbon_PME_1100.pdf.

***Reuters UK*, "UAE Carbon Storage to Cost $2-$3 Billion - SNC Lavalin."** The Canadian engineering and construction company SNC-Lavalin revealed that a plan to build CO_2 capture and storage network would reduce the United Arab Emirates' (UAE) CO_2 emissions by around 10 percent, boost oil output, and cost from $2 billion to $3 billion. Based on an estimated 76 million tonnes of CO_2 emissions per year, a study proposed that four to six projects, costing approximately $500 million each, could be quickly built to reduce CO_2 emissions from six million to eight million tonnes per year. The aim of the project, which would be the largest single integrated CO_2 capture and storage project in the world, is to inject CO_2 into oilfields to maintain oil pressure and enhance output. UAE, the world's fifth-largest oil exporter, will benefit from the close proximity of emissions sites to oilfields and the abundance of large reservoirs that can be used for CO_2 storage. January 22, 2008, http://uk.reuters.com/article/UK_SMALLCAPSRPT/idUKL2265559420080122.

***Kyodo News*, "Power Firm Succeeds in Injecting Large Amount of CO_2 into Coal Beds."** General Environmental Technos Corporation, a subsidiary of Kansai Electric Power Corp. (KEPCO), announced the successful, large scale injection of CO_2 into deep coal beds through the use of nitrogen – a first in the world. The nitrogen technology enabled 6.6 tons of CO_2 to be injected per day, equivalent to the amount of CO_2 absorbed by 900,000 cedar trees each day. In addition to enhancing the recovery of coal bed methane, the use of nitrogen prevents the coal bed from swelling, which would reduce the space available for greenhouse gas (GHG) storage. The nitrogen-based technology has undergone testing since 2004 in Yubari, Hokkaido under a project promoted by the Japanese Ministry of Economy, Trade and Industry. January 28, 2008, http://home.kyodo.co.jp/modules/fstStory/index.php?storyid=360105. (Subscription required.)

April 2008

***Urbana/Champaign News-Gazette*, "States Join Illinois' Call for Original FutureGen Plan,"** and ***LiveMint.com*, "India May Pull Out of FutureGen as US Mulls Project Scaleback."** On March 5, representatives from Illinois, Indiana, Ohio, Kentucky, Wisconsin, and West Virginia sent a letter to President George W. Bush emphasizing the need to keep the FutureGen project in Mattoon, Illinois and the importance of developing clean coal technology and maintaining commitments to foreign countries financially contributing to the project. Although the restructured approach allows DOE to partially fund multiple projects, the letter presented concerns about the project failing to sequester as much CO_2 as the original FutureGen plan and questioned the expenses of those who originally applied. Dozens of proposals were received by DOE regarding the restructured approach, which will help shape bids for the project and approximate cost and project feasibility. DOE expects to begin taking industry bids sometime this spring. Meanwhile, India is considering withdrawing from the FutureGen initiative despite having already invested $10 million, but Indian officials have maintained open lines of communication with US officials about the project. As India generates a significant portion of its electricity from coal, the FutureGen project's advanced technologies interested the Indian government, but now Indian officials describe their interest for the project as "extremely low." The restructured FutureGen approach would invest in only the carbon capture and storage (CCS) portion of the project and not an entire plant's construction, which would allow for multiple plants to be commercially working by 2015 with viable CCS technologies. For further information about FutureGen, visit: http://www.fossil.energy.gov/programs/powersystems/futuregen/. March 6, 2008, http://www.news-gazette.com/news/local/2008/03/06/states_join_illinois_call_for_original, and March 7, 2008, http://www.livemint.com/2008/03/06231204/India-may-pull-out-of-FutureGe.html. (Subscription required.)

***Bloomberg.com*, "Canada Requires New Oil-Sands Projects to Capture, Store Carbon," and *Google News*, "Canada Unveils Carbon Capture Plan, Ban on Dirty Coal."** New environmental regulations announced by the Canadian government state that oil sands projects beginning operation in 2012 or later will be required to capture and store their CO_2 emissions and the construction of new coal-fired power plants will be restricted, aiding Canada in its goal to reduce greenhouse gas (GHG) levels by 20 percent by 2020. Alberta's oil sands are the second largest oil reserve in the world, but the estimated 173 billion barrels had gone largely untouched until 2000 due to high extraction costs (oil sands must be mined and bitumen separated from the sand and water, then upgraded and refined). However, Canadian officials believe the GHG emissions of oil sands projects, which extract oil from tar deposits, may double by 2015 if oil sand output triples over the next decade as projected. Some officials believe the new carbon regulations will deter future investment in such projects, although Enbridge Inc. announced in February that it will head a group of 19 energy firms studying the feasibility of injecting and storing CO_2 in saline formations 8,000 feet deep. March 10, 2008, http://www.bloomberg.com/apps/news?pid=20601082&sid=aQ3QdGGEE8H4&refer=canada, and March 10, 2008, http://afp.google.com/article/ALeqM5i2qa6dmy7kOB4_yvmPNZRUsxCxaw.

***Oil Voice*, "State and RWE Dea Launch CO_2 Storage Project to Aid Climate Protection."** Following $39 million (25 million euros) in research grants to the University of Kiel and Leibniz Institute of Marine Sciences IFM-GEOMAR last year, the German Federal state of Schleswig-Holstein and RWE Dea AG are initiating a CO_2 storage project that will explore three regions in Germany's northern, lowland plains – North Frisia, East Holstein, and the North Sea. RWE Dea has already applied for permission from the German State Department for Mining, Energy and Geology to examine the CO_2 storage potential in these regions and hopes that once approval is received, seismic survey results could be available by the end of 2009. Should these seismic results align with projections, an exploratory well could be drilled early in the summer of 2010, which could lead to the construction of a CO_2 storage facility in Schleswig-Holstein. Current RWE Dea projections estimate that a $93.2 million (60 million euros) investment would be necessary for the construction of a plant that would have an annual $6.2 million (4 million euros) operating cost. March 12, 2008, http://www.oilvoice.com/n/State_and_RWE_Dea_Launch_CO2_Storage_Project_to_Aid_Climate_Protection/aa2df854.aspx.

***Saskatoon Star Phoenix*, "Gov't Proceeding with $1.4B Clean Coal-Carbon Capture Project,"** and ***SaskPower News Release*, "New Federal Funding Opens Door to Major Carbon Capture Demonstration Project in Saskatchewan."** Saskatchewan's provincial government announced plans to commence a seven-year project that will reconstruct and repower SaskPower's coal-fired power generation unit at the Boundary Dam Power Station. The announcement came one day after the Canadian Federal budget allotted $240 million to Saskatchewan to demonstrate a clean-coal project; SaskPower's share of the total $1.4 billion cost will be approximately $758 million. The proposed project would produce 100 megawatts of baseload power, reduce SaskPower's GHG emissions by about one million tonnes per year, and use the captured CO_2 for enhanced oil recovery. SaskPower's announcement follows their cancelled initiative to construct a 300-megawatt, near-zero emission, pulverized coal plant, which failed to progress because SaskPower needed the Federal government to up their financial support for an initial $3.8 billion plant near Estevan. The project will contribute to the Saskatchewan Party government's goal to cut GHG emissions by 32 percent by 2020. February 27, 2008, http://www.canada.com/saskatoonstarphoenix/news/story.html?id=98b0cc5b-943b-48ef-89bd-99eddfb95925&k=88812, and February 27, 2008, http://www.saskpower.com/aboutus/news/?p=368#more-368.

***Google News,* "Utility Proposes First US Coal-Fired Plant to Capture CO_2,"** and ***Tenaska News Release*, "Tenaska Proposes Nation's First New Conventional Coal-Fueled Power Plant to Capture Carbon Dioxide."** US energy company Tenaska announced a proposal for a new 600-megawatt, coal-fired power plant in Texas that would capture 90 percent of its CO_2 emissions to sell for enhanced oil recovery in the Permian Basin. If the plant is built it will be located near Sweetwater, Texas and operate as the first commercial-scale coal-fired plant to capture and provide storage for CO_2. Tenaska has already requested a state air permit through the Texas Commission on Environmental Quality for the three billion dollar plant, but withheld any future plans, saying the final decision will come in 2009 based on government incentives, construction costs, and the price of electricity and CO_2. In addition to transporting the CO_2 via pipeline for geological storage, the plant, which could be operational in 2014 if construction begins in late 2009, will power some 600,000 homes and contribute more than one billion dollars in oil production to Texas' economy. February 19, 2008, http://afp.google.com/article/ALeqM5hpAuRq-wbtc5esL6s6_sm6ML7K9w, and February 19, 2008, http://www.tenaska.com/newsItem.aspx?id=30.

May 2008

***Environment & Energy Daily*, "DOE May Lower FutureGen Requirement for Capturing CO_2,"** and ***House Committee on Science and Technology Press Release*, "Subcommittee Reviews DOE's Plans for FutureGen."** On April 8, the Senate Commerce, Science and Transportation Committee held

a hearing to discuss the restructured FutureGen project and it was recommended that DOE reduce the 90 percent capture requirement for restructured FutureGen project proposals, because it is uneconomical to increase a gasifier's CO_2 capture rate. Other topics discussed included: the possibility of a "dual track" program combining the original and restructured FutureGen approach, which would cost nearly $3 billion; a regulatory framework that encourages technological development; economic incentives; carbon pricing; a cost-sharing plan for the first adopters of the technology; and a plan to address liability issues. Another hearing held on April 16 by the House Science and Technology Committee's Energy and Environment Subcommittee reviewed DOE's decision to restructure FutureGen and questioned individuals about DOE's decision making process and whether this approach is the best method to exhibit carbon capture and storage (CCS) technologies. Some committee members also expressed concern that the restructured FutureGen program will delay the development, demonstration, and advancement of CCS technologies after being told they must head in a new direction following five years of thinking FutureGen would solve one of the United States' critical environmental challenges. April 10, 2008, http://www.eenews.net/EEDaily/2008/04/10/2/, and April 15, 2008, http://science.house.gov/press/PRArticle.aspx?NewsID=2157.

***Business Wire*, "Southern California Edison Launches the Nation's First Full Commercial Scale Assessment of Advanced Coal Generation Technologies."** Following plan approval by the California Public Utilities Commission (CPUC) on April 10, the United States' first advanced coal technology feasibility study will be conducted by Southern California Edison (SCE) at a commercial-scale, 600-megawatt facility. The two-year, $50 million project will test the following elements for the first time: capturing as much as 90 percent of CO_2 and sequestering the CO_2 in a deep saline or depleted oil formation for enhanced oil recovery (EOR). On October 9, 2007, SCE received a share of a $65 million DOE grant, a portion of which also was awarded to the Southwest Regional Partnership (SWP) of DOE's Regional Carbon Sequestration Partnership (RCSP) Program. SWP plans to inject one million tons of CO_2 in the Western United States' Entrada Sandstone Formation as part of SCE's Clean Hydrogen Power Generation program. For more information about the SWP, click: http://www.southwestcarbonpartnership.org/. April 10, 2008, http://www.businesswire.com/portal/site/google/?ndmViewId=news_view&newsId=20080410006160&newsLang=en.

***ZeroGen Media Release*, "Reconfigured ZeroGen Project to Deliver Large Scale Clean Coal Power Plant by 2017,"** and ***ZeroGen Media Release*, "Coal Industry Funds Revamped ZeroGen Queensland Clean Coal Project."** On March 20, ZeroGen Pty Ltd announced that Queensland, Australia's ZeroGen project is being reconfigured into two stages that will minimize the technological risk associated with building the world's first coal gasification power plant. Under this modified plan, Stage One would entail building an 80-megawatt demonstration plant by 2012 capable of capturing 75 percent of emissions with the state-of-the-art 6-flow turbine. The CO_2 emissions will be transported approximately 137 miles by truck from the plant's Rockhampton location in Central Queensland to reservoirs in the Northern Denison Trough for injection and safe storage. Stage Two involves building the world's first large-scale, 330-megawatt plant by 2017 that would be capable of capturing up to 90 percent of CO_2 emissions. A feasibility study to determine the location of the plant will run concurrently to Stage One, with hopes research can be completed by the end of 2009. The Australian Coal Association (ACA) supports the reconfigured project and said it would provide up to $26 million through the COAL21 Fund to finance the Stage One study. To view the ZeroGen website, click: http://www.zerogen.com.au/home. March 20, 2008, http://www.zerogen.com.au/files/ReconfiguredZeroGenproject_0.pdf, and March 20, 2008, http://www.zerogen.com.au/files/Australian%20Coal%20Association%20media%20release.pdf.

***Environment & Energy Daily*, "Miners Seek $1 Billion per Year Sequestration Fund."** In a letter submitted to John Dingell, the House Energy and Commerce Chairman, the presidents of the United Mine Workers of America (UMWA) and National Mining Association (NMA) asked Congress to fund a new $1 billion per year sequestration fund that would finance the development of coal-fired power plants fitted with CCS technology. The suggested fund would not be included in Congress's annual

appropriations, but rather the letter offered that fossil fuel energy users be charged a fee to finance the fund. The joint letter arose from a US Environmental Protection Agency (EPA) sponsored report conducted by the Advanced Coal Technology Work Group that advocated funding five to 10 commercial-scale power plants capable of capturing and storing greenhouse gases (GHG). The working group, composed of industry officials, academics, scientists, and environmentalists, also expressed the need to establish a carbon "market driver" and expand EPA outreach efforts regarding health risks and benefits. Representatives Dingell and Rich Boucher, the Energy and Air Quality Subcommittee chairman, have previously communicated their desire to increase incentives for carbon technologies and draft a broader global warming bill as early as this spring. To read the EPA-sponsored report, go to: http://www.eenews.net/features/documents/2008/04/01/document_daily_03.pdf. To view the UMWA-NWA letter, click: http://www.eenews.net/features/documents/2008/04/01/document_daily_01.pdf. April 1, 2008, http://www.eenews.net/EEDaily/2008/04/01/3/.

***Jamestown Post-Journal*, "Budget Includes $400K for Carbon Capture Testing."** A New York state budget bill passed on April 4 includes $400,000 to fund an in-depth geological study in western New York that will investigate equipping a proposed 43-megawatt coal-fired power plant in Jamestown with CCS technology. With the state matching an earlier $400,000 grant from the New York State Energy Research and Development Authority (NYSERSA), the study is entirely government funded and will likely be completed within an 18-month period. Battelle Labs, which is already responsible for conducting DOE's Midwest Regional Carbon Sequestration Partnership (MRCSP) project in Columbus, Ohio, will drill the test wells for the study and examine rock structures located at least 3,000 feet beneath the Earth's surface. The project, backed by President George W. Bush's administration, is also supported by the Democrat-controlled Assembly, the Republican-controlled state Senate, and New York Governor David Paterson. For more information about New York's state-funded, carbon sequestration research projects, click: http://www.nyserda.org/Press_Releases/2008/PressRelease20081401_3.asp. April 8, 2008, http://post-journal.com/articles.asp?articleID=26523.

June 2008

***Montana State University News Service*, "Montana Carbon Sequestration Study Receives State Funding."** The Montana Board of Research and Commercialization awarded the Big Sky Carbon Sequestration Partnership a $157,000 grant to help fund a study investigating the geological storage potential at Kevin Dome in northern Montana. Led by Montana State University geologists David Bowen and David Lageson, the study will use existing well logs, core samples, and seismic surveys to determine the porosity, permeability, thickness, areal extent, and structural features of the underground, dome-shaped rock formation. As part of the DOE-funded Regional Carbon Sequestration Program's (RCSP) Validation Phase, the project will commence this summer, under the premise that the Kevin Dome study will shed light on the storage characteristics of similar formations in the region. Additional details about DOE's Validation Phase are available at: http://www.netl.doe.gov/technologies/carbon_seq/partnerships/validation-phase.html, or visit: http://www.netl.doe.gov/technologies/carbon_seq/partnerships/validation.html to view a field test map. For more information about the Big Sky Carbon Sequestration Partnership, click: http://www.bigskyco2.org/. April 28, 2008, http://www.montana.edu/cpa/news/nwview.php?article=5868.

***Premier of Victoria Media Release*, "$127.4 Million to Secure Victoria's Clean Coal Future."** An April 30th announcement by the Victoria Premier established a $102 million ($110 million Australian) fund to launch new commercial-scale CCS demonstration projects in the Latrobe Valley and an $11.4 million ($12.2 million Australian) fund to establish an organization designed for maximizing Victoria's coal resources, called Clean Coal Victoria. Another $4.9 million ($5.2 million Australian) will finance research and modeling that investigates the storage potential of the Gippsland Basin in southeastern Australia. The investment is part of the Energy Technology Innovation Strategy's (ETIS) second phase. The first phase involved the development of the Latrobe Valley Post Combustion Project at Loy Yang Power

Station outside of Traralgon. The Latrobe Valley project initiated on April 30 and will capture up to 1,000 tonnes of CO_2 per year. Officials hope their additional investment will enhance the project's ability to demonstrate CCS technologies at a commercial-scale. Since 2002, the Australian government has invested some $244 million in clean coal technology. April 30, 2008, http://www.premier.vic.gov.au/newsroom/$127.4-million-to-secure-victorias-clean-coal-future.html.

***Business Wire*, "ExxonMobil to Build Commercial Demonstration Plant to Remove Carbon Dioxide from Natural Gas."** ExxonMobil announced it will commit some $100 million toward building a commercial-scale demonstration plant near LaBarge, Wyoming that will develop and test a natural gas treatment technology that could reduce the cost of CCS technology and significantly reduce GHGs. The technology, called Controlled Freeze Zone (CFZ), is a single-step cryogenic separation process that freezes out and then melts the CO_2 and removes other components. Using the CFZ process, CO_2 and the other components are discharged as a high-pressure liquid stream conducive to CO_2 injection for underground storage or improving the enhanced oil recovery (EOR) process. The demonstration plant will be located at ExxonMobil's Shute Creek Treating Facility and will process about 14 million cubic feet of gas per day. Construction is set to commence this summer and plant startup expected in late 2009. http://www.businesswire.com/portal/site/exxonmobil/index.jsp?ndmViewId=news_view&ndmConfigId=1001106&newsId=20080505006145&newsLang=en.

***Fort Saskatchewan Record*, "Carbon Capture Project Planned for Heartland."** Led by the Alberta Research Council and ARC Energy Trust, the Heartland Area Redwater Project will evaluate the ability to store as much as 1,000 megatonnes (1,102 megatons) of CO_2 in the Redwater Leduc Reef located near the industrial region north of Fort Saskatchewan, Canada. The 373-square-mile geological reef is capable of storing approximately 20 years worth of CO_2 emissions, because the reef's porous texture allows for CO_2 to mix with brine located about 1,000 meters below the reef. The project will be implemented in three phases: during the initial $1.8 million phase, which is expected to be completed by Spring 2009, the Redwater reef's size and suitability for storing CO_2 will be determined; during the second phase, a test well will be drilled to collect more detailed data; and efforts during the third phase will demonstrate CO_2 injection and storage. Officials also hope the sequestration project will aide EOR projects in the region and attract investors to build a CO_2 pipeline for future projects. April 18, 2008, http://cgi.bowesonline.com/pedro.php?id=10&x=story&xid=393714.

July 2008

***Springfield News-Leader*, "City Utilities to Test Plan for Clean Coal."** After receiving a $2.46 million Federal grant and $98,000 from each of five utility partners, City Utilities (CU) of Springfield, Missouri, is preparing to inject food-grade CO_2 from its Southwest Power Station into a 2,000-foot deep saline formation. CU will work with Missouri State University, Missouri University of Science and Technology, and the Missouri Department of Natural Resources over the next three years to determine whether the geological storage of CO_2 is an economic and safe method for reducing GHG emissions. CU's Southwest Power Station generates 3,562 tons of CO_2 per day and their 300-megawatt Southwest 2 power plant will generate 6,052 tons of CO_2 per day once it comes online in 2010. CU officials hope that successful testing will free the utility from the cost of building pipelines to transport CO_2 to injection sites in northern states. A presentation outlining the particulars of the "Missouri Carbon Sequestration Project" is available at: http://www.cityutilities.net/community/missouricarbonproject.pdf, or click http://www.cityutilities.net/community/missourcarbonproject-hi.wmv for a project video. May 21, 2008, http://www.news-leader.com/apps/pbcs.dll/article?AID=2008805280465.

***Reuters*, "Spectra Eyes Big Carbon Capture Project in Canada,"** and ***Vancouver Sun*, "Study Examines Underground Carbon Dioxide Storage in B.C."** Spectra Energy Corporation plans to examine the viability of building a large-scale carbon sequestration facility at its natural gas plant in northeastern British Columbia that would store CO_2 in a depleted natural gas reservoir 1.3 miles (two kilometers) underground. The reservoir could potentially store one million tons of CO_2 annually – a figure

equivalent to the plant's CO_2 production over the next 20 to 50 years. Spectra has previously captured and stored 200,000 tonnes of CO_2 in depleted natural gas reservoirs. The provincial government provided $3.4 million ($3.5 million Canadian) toward the project's $11.8 million (12.1 million Canadian) budget as part of their effort to reduce GHG emissions by 33 percent by 2020. May 26, 2008, http://www.reuters.com/article/marketsNews/idUSN2629605920080526, and May 26, 2008, http://www.canada.com/vancouversun/news/business/story.html?id=28b15589-844e-46f4-9d26-c265c15b5c15.

***The Chronicle-Herald*, "Search for Places to Store CO_2 Emissions Set to Begin."** A CCS project led by the Carbon Storage Research Consortium of Dalhousie University, Nova Scotia Power, and Nova Scotia's Energy Department will be initiated this summer by searching for potential CO_2 storage sites in Cape Breton and northern Nova Scotia. The four-phase project, which recently received $4.87 million ($5 million Canadian) in Federal research funds, will also examine the regulatory issues and economic impacts facing CO_2 storage, in addition to assessing the geology of northern Nova Scotia's oil reservoirs and deep coalbeds. Officials said that only certain locales are deemed feasible for geologic storage in Canada – mainly Alberta, southern Saskatchewan, and Nova Scotia. Nova Scotia emits about 20 million tonnes of GHGs annually, with coal-fired power plants serving as the largest point source of GHGs at about 10 million tonnes annually. If the project succeeds, it is believed that Nova Scotia could be storing up to 10,000 tonnes of CO_2 per day by 2018 to 2020. June 5, 2008, http://thechronicleherald.ca/Business/1060298.html.

***Reuters*, "Vattenfall to Build Carbon Capture Test Plant,"** and ***Vattenfall Press Release*, "Vattenfall Will Build CCS Demonstration Plant in Jänschwalde."** Vattenfall plans to build a demonstration plant equipped with CCS technology at one of their 500-megawatt blocks at the Jänschwalde facility in the State of Brandenburg, Germany. Following an investment estimated at around $1.57 billion (1 billion euros), the Swedish-owned utility said it expects full-scale operation no later than 2015. The CCS-equipped block will house two boilers: a newly built boiler with Oxyfuel technology and a boiler retrofitted with post-combustion technology. Gaz de France Production and Exploration GmbH will collaborate with Vattenfall to test technology for storing the captured CO_2 in a depleted natural gas field in Altmark, Germany. Vattenfall will open the world's first pilot-scale plant – a $108.2 million (70 million euro), 30-megawatt effort – for CO_2 separation at Schwarze Pumpe power station in the State of Brandenburg this summer. May 23, 2008, http://www.reuters.com/article/environmentNews/idUSL2385285020080523, and May 23, 2008, http://www.vattenfall.com/www/vf_com/vf_com/370103press/558539press/index.jsp?pmid=91724.

August 2008

***Kentucky Post,* "Ky. Partners To Research CO_2 Storage,"** and ***Courier-Journal.com,* "Kentucky Carbon Storage Test Partnership Formed."** The Western Kentucky Carbon Storage Foundation has teamed up with the Kentucky Geological Survey to improve the long-term CO_2 storage opportunities within the state. The $7.8 million research project will drill more than 8,000 feet deep into the Knox and Mount Simon geological formations in Hancock County to test their ability to store CO_2. While the Kentucky Geological Survey will lead the project research with other state agencies, the Western Kentucky Carbon Storage Foundation will provide technical assistance as well as most of the funding. Drilling will begin in late 2008 and CO_2 injection is expected to occur in early 2009. The non-profit Western Kentucky Carbon Storage Foundation was formed by three private partners – Peabody Energy, ConocoPhillips, and E.ON U.S. – as a result of a mandate by the Kentucky legislature. To read the Governor's official press release, go to: http://governor.ky.gov/pressrelease.htm?PostingGUID=%7B5B8EE408-5CD8-46B1-96F9-83920FC3BE8A%7D. July 1, 2008, http://www.kypost.com/content/news/commonwealth/story.aspx?content_id=fc2102ee-f8c3-4618-b275-607e1c10c85e, and June 30, 2008, http://www.courier-journal.com/apps/pbcs.dll/article?AID=/20080630/BUSINESS/80630034.

***Boston.com,* "ND Utility to Unveil Plans to Capture CO_2,"** and ***Greenwire,* "N.D. Utility Plans to Capture CO_2 at Power Plant."** Basin Electric Power Cooperative and Powerspan Corporation plan to capture 1 million tons of CO_2 annually from one of the two units at the 900-megawatt Antelope Valley Station in central North Dakota. Powerspan's post-combustion technology consists of an ammonia-based solution that captures CO_2 from a power plant's flue gas and releases it in a form that is ready for compression, safe transportation, and geological storage. Basin Electric's goal is to use the technology to capture and remove the amount of CO_2 equivalent to that emitted by a 120-megawatt power plant. The CO_2 will then be piped to Canada where it will be used for EOR. The project is expected to begin in late 2009 and end in 2012. To read the official press release, go to: http://www.basinelectric.com/News_Center/News_Releases/Basin_Electric%2C_Powerspan_brin.html. June 17, 2008, http://www.boston.com/news/local/new_hampshire/articles/2008/06/17/nd_utility_to_unveil_plans_to_capture_c02/?page=full, and June 18, 2008, http://www.eenews.net/Greenwire/2008/06/18/13/.

***Reuters*, "Enhance Plans Alberta Carbon Dioxide Pipeline,"** and ***globeandmail.com*, "Shell Launches Carbon-Capture Project."** The Government of Alberta will invest $1.98 billion ($2 billion Canadian) over the next five years to launch several large-scale, industry run carbon capture and storage (CCS) projects. Royal Dutch Shell PLC, in one of the first initiatives under the new plan, will begin testing for ways to capture and store CO_2 at its Scotford Upgrader near Fort Saskatchewan, Alberta. Shell's project, Quest, would reduce emissions from their oil sands operations by 1 million tonnes a year beginning in 2015. The Scotford mine and upgrader currently produces more than 1.75 million tonnes of emissions annually. Enhance Energy Incorporated plans to build Alberta's first major CO_2 pipeline system in central Alberta that will capture GHGs from a planned oil sand upgrader and nitrogen plant and transport them 149 miles (240 kilometers) to oilfields for EOR. Enhance's $300 million CO_2 pipeline will initially have a capacity of 5,000 tonnes per day and increase to 25,000 tonnes per day over time. Regulatory applications are planned for the spring of 2009 and project start-up is expected in 2011. A video of Alberta Premier Ed Stelmach's announcement is available at: http://www.premier.alberta.ca/media/mediaPage.cfm. July 10, 2008, http://www.reuters.com/article/environmentNews/idUSN1020839120080710, and July 9, 2008, http://www.theglobeandmail.com/servlet/story/LAC.20080709.RSHELL09/TPStory/Business. (Subscription required).

***Bloomberg*, "Australia Agency Captures Carbon from Power Plant Gas,"** and ***ClimateWire*, "Australia Successfully Tests Gas-Trapping Method."** Australia's national science agency, the Commonwealth Scientific and Industrial Research Organization (CSIRO), successfully captured CO_2 at the coal-fired Loy Yang power plant in Victoria. According to CSIRO, the trial technology could capture as much as 1,000 metric tons of CO_2 per year, which is more than 85 percent of total emissions. This marks the first time post-combustion capture technology has been successfully applied in the Southern Hemisphere. The project is a joint collaboration between the Australian Government, Loy Yang Power, and International Power PLC. Australia generates more than 80 percent of its energy from coal. To learn more about CSIRO's research, visit: http://www.csiro.au/science/ps3m.html. July 9, 2008, http://www.bloomberg.com/apps/news?pid=20601081&sid=azRqQQ4pghr0#, and July 10, 2008, http://www.eenews.net/climatewire/print/2008/07/10/8.

Science

September 2007

***Science Daily,* "Global Warming: Carbon Dioxide 'Tree Banking' May Help, Provided Trees Have Optimal Water and Nutrient Levels."** Results of a ten-year study, known as Free Air Carbon Enrichment (FACE), indicate that the introduction of extra CO_2 may result in trees growing more tissue,

but there is a limit to the amount of CO_2 that a tree can store over time. During the experiment, the researchers pumped one and half times more CO_2 to the test pines than the trees would normally receive. Scientists were then able to formulate results about the carbon accumulations in the trees. The experimental data suggest that only those pines receiving greater amounts of both water and fertilizers are able to have an effect on the atmospheric concentrations of CO_2. Trees that received less water at the same time that CO_2 levels were increased showed no net gain in carbon sequestration. Increased levels of CO_2 also had no effect on "self thinning" of the forests, a process by which smaller trees die off as the most successful grow bigger. Furthermore, trees that grow more foliage due to increased CO_2 levels do not result in increased carbon storage, because foliage does not store carbon over time as effectively as carbon stored in wood. August 7, 2007, http://www.sciencedaily.com/releases/2007/08/070807084202.htm.

Reuters, "Floods, Heat Hit Europe, but Is It Global Warming?," Climate scientist Myles Allen, of Oxford University, leads a research project which uses computer modeling to determine if single weather events can be linked to global warming. The research involves "borrowing" the computing time of over 6,000 members of the general public to model run thousands of simulations of an individual British flood that happened in 2000, the wettest autumn recorded in 230 years. The individual computers run one climate simulation with or without manmade greenhouse gas emissions, to identify the contribution of global warming to the flood. The results will be published later this year. To read more about the World Wildlife Federation's Climateprediction.net project or to join the Climateprediction.net experiment go to http://www.climateprediction.net/. July 27, 2007, http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=43316.

October 2007

***SciDev.Net (London),* "Soil Degradation Issues 'Swept Aside', Say Experts."** Scientists in attendance at the International Forum of Soils, Society and Global Change, held in Selfoss, Ireland, claim that the connection between soil and land degradation and climate change is significant. Global emissions from deforestation and degradation of lands are contributing as much as 25 percent of the excess CO_2 in the atmosphere. Without the cover of vegetation, land becomes more reflective and heats the air above it, causing temperatures to increase. Attendees at the forum are calling for the Intergovernmental Panel on Climate Change to draft a special report on this subject. They are also demanding more attention be given to the potential for carbon sequestration in soils, noting that land and forest restoration have the capacity to replace one to two billion tons of carbon by restoring degraded ecosystems. September 7, 2007, http://www.scidev.net/News/index.cfm?fuseaction=readNews&itemid=3879&language=1.

***Reuters,* "Islands Emerge as Arctic Ice Shrinks to Record Low."** Significant decreases in ice and snow amounts are occurring on the Norwegian archipelago of Svalbard, and unmapped islands are appearing out of the water. Data from the US National Snow and Ice Data Center show that the 2007 level of Arctic sea ice is currently below the all-time recorded low, which was registered back in 2005. Norwegian Environment Minister Helen Bjoernoy spoke to scientists and politicians at a seminar in Ny Alesund, a settlement and base for Arctic research that is located 750 miles from the North Pole. Bjoernoy and others believe that the acceleration of melting ice may be occurring at a faster rate than that predicted by the United Nation's Intergovernmental Panel on Climate Change. The reduction of snow and ice is already having adverse effects on polar bears, seals, and other species. August 21, 2007, http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=43813.

November 2007

***CNN.com*, "Gore Shares Nobel Peace Prize with U.N. Panel,"** and ***Chicago Tribune*, "Local Nobel 'Winners' Were Just Glad to Help."** In recognition of their work to raise awareness about global

warming, former Vice President Al Gore and the UN Intergovernmental Panel on Climate Change (IPCC) received the 2007 Nobel Peace Prize. The Nobel committee commended both recipients on their efforts to expand knowledge and research about man-made climate change and formulate policies necessary to bringing about change. The committee also dubbed Gore, who plans to donate his share of the $1.5 million prize to the Alliance for Climate Protection, as "one of the world's leading environmental politicians." The Nobel Prize is the most recent of several awards bestowed to Gore, who collected two Oscars for his film "An Inconvenient Truth" and an Emmy for a television show he co-created called "Current TV." Rajendra Pachauri, chairman of the IPCC, praised the 2,000 scientists that contribute to the IPCC and encouraged them to do even more in the future. Many of the panel members conducted their work pro bono, mostly reading journal articles and editing reports for several years. The award draws attention to work that otherwise goes overlooked by many. Former President Bill Clinton praised Gore's foresight of the dangers accompanying climate change and President Bush offered his congratulations through a spokesman. The award ceremony will take place December 10, 2007 in Oslo, Norway. To view the Nobel Committee press release, click: http://nobelprize.org/nobel_prizes/peace/laureates/2007/press.html. October 12, 2007, http://www.cnn.com/2007/POLITICS/10/12/nobel.gore/index.html and October 13, 2007, Link unavailable.

***Associated Press*, "Lacking Sea Ice, Walruses Head for Shore."** Likely due to record low Arctic sea ice and warming temperatures, thousands of walruses currently line Alaska's northwest shore, spanning from Barrow, America's northernmost point, to Cape Lisburne, located about 300 miles southwest on the Chukchi Sea. The arrival of the walruses in late July, occurring a month earlier than usual, has fueled concerns among individuals affiliated with the US Fish and Wildlife Service in Anchorage, Alaska. These fears include walruses stampeding into the water due to avoidable human contact, losing energy from having to travel farther to hunt food, and leaving orphan calves to fend for themselves. Also, some worry about the walruses' anxiety and stress levels and sometimes thin appearance. During the 2007 melt season, the National Snow and Ice Data Center (NSIDC) reported that Arctic sea ice dropped to its lowest levels since measurements started in 1979. This further hampers the walruses' ability to hunt for food, forcing them to dive to the sea bottom in waters that exceed their maximum diving depth of about 630 feet. At 1.65 million square miles, this September's average sea ice extent is the lowest September on record, passing the previous record set in 2005 by 23 percent. The walruses are expected to remain along the Alaskan shore until November, when they will move south as the Chukchi Sea freezes. To read the complete NSIDC press release, which includes statistical data, video analysis, and high-resolution photos, go to: http://www.nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease.html. October 5, 2007, http://www.msnbc.msn.com/id/21148381/.

December 2007

***University of East Anglia News Release*, "North Atlantic Slows on the Uptake of CO_2."** Results of a decade long study, conducted by Dr. Ute Schuster and Professor Andrew Watson of the University of East Anglia's School of Environmental Sciences, show that the North Atlantic Ocean's CO_2 uptake slowed considerably between the mid-1990s and early 2000s. The paper, titled "Large variations in anthropogenic carbon accumulation in the North Atlantic subtropics," surmises that the North Atlantic served as the most intense sink for atmospheric CO_2 since the industrial revolution, consequently slowing climate change. However, after collecting data from merchant ships equipped with automatic instruments for measuring CO_2 levels in the water, Schuster and Watson found a sudden proportional decrease in the North Atlantic's CO_2 uptake and inferred a slowdown in Southern Atlantic's uptake. The majority of the data came from a container ship making a round-trip from the West Indies to the United Kingdom once a month, generating more than 90,000 CO_2 measurements over the course of the study. Specifically, the data reveal that uptake decreased 50 percent from the mid-1990s to 2002-05. To view a PDF of the study, click: http://lgmacweb.env.uea.ac.uk/ajw/Reprints/brown_et_al_submitted.pdf. October 22, 2007, http://comm.uea.ac.uk/press/release.asp?id=796.

Greenwire, **"Warming Tied to Mass Extinctions -- Study,"** and ***University of York Press Release*****, "Fossil Record Supports Evidence of Impending Mass Extinction."** According to research conducted by Dr. Peter Mayhew of the University of York and University of Leeds Professor Tim Benton, the gradual rises in temperature and sea level throughout Earth's history have been precursors for mass extinctions. The two population ecologists predict that if future, real world conditions align with their projections, a new mass extinction event could occur, affecting some 50 percent of the animal and plant species on Earth. Through the analysis of fossil records, the scientists compared the number of species and overall marine and terrestrial biodiversity to sea temperatures and divided their data into 10 million-year-periods. They concluded that biodiversity is lower during warmer "greenhouse" phases and extinction rates relatively high, with the opposite holding true in "icehouse" periods. As a result of their findings, they believe that four of the past five mass extinctions over the last 520 million years are attributable to warmer tropical seas and thus, a warmer Earth. The two believe the last mass extinction occurred 251 million years ago, when 95 percent of animal and plant species died. Also, the study shows the Earth goes through 60-million-year climate cycles, oscillating between warmer "greenhouse" periods and cooler "icehouse" phases. To see a full text version of the study, go to: http://www.journals.royalsoc.ac.uk/content/3x081w5n5358qj01/fulltext.pdf. October 24, 2007, http://www.eenews.net/Greenwire/print/2007/10/24/13 and October 24, 2007, http://www.eurekalert.org/pub_releases/2007-10/uoy-frs102207.php#.

January 2008

Science Daily**, "Delay in Autumn Color Caused By Increased Carbon Dioxide Not Global Warming."** A study conducted by University of Southampton researchers suggests that the delay in autumnal leaf coloration and leaf fall is caused by increasing levels of CO_2 in the atmosphere and not by rising global temperatures. The process of plant aging where leaves discolor and fall, known as autumnal senescence, has been delayed by 1.3 to 1.8 days each decade over the last 30 years across Europe, which has been explained by rising global temperatures causing prolonged growing seasons. However, while a strong correlation exists between increased global temperatures and earlier spring "re-greening" in some 14 European countries, the association between autumn leaf color change and fall and temperature trends is weak. The researchers found that atmospheric CO_2 has risen by 13.5 percent over the 30 years autumnal senescence has been monitored. In addition, experimental tests show that increased atmospheric CO_2 impacts plant physiology and function. By simulating atmospheric CO_2 concentrations in the year 2050, researchers were able to measure changes in the tree canopy through the use of remote sensing. The measurements revealed that trees exposed to elevated CO_2 levels retained their leaves longer and possessed a smaller decline in end of the season chlorophyll content, consequently resulting in a greener autumn hue relative those trees exposed to ambient CO_2 levels. To read the study, titled, "Future atmospheric CO_2 leads to delayed autumnal senescence," click: http://www.blackwell-synergy.com/doi/pdf/10.1111/j.1365-2486.2007.01473.x (Subscription required). November 19, 2007, http://www.sciencedaily.com/releases/2007/11/071117104404.htm.

The Independent**, "Expanding Tropics 'A Threat to Millions'."** A recent study warns the Earth's tropical belt is expanding north and south at an unprecedented rate, posing a threat to large regions of the world where the climate figures to become more arid or stormier depending on the location. Compared to 1980, the study reveals that during the past 25 years the region around the equator classified as "tropical" has expanded toward the poles by about 172 miles, meaning that an additional 8.5 million square miles are now thought of as having tropical climate. In other words, the Earth's tropical region has moved farther north and south by about 2.5 degrees of latitude, which is greater than the Intergovernmental Panel on Climate Change's (IPCC) "extreme scenario" prediction of a 2 degree shift by 2100. Specifically, scientists warn the millions of people living in dry, subtropical regions are at risk for a more arid climate due to possible changes in rainfall patterns and wind directions; those living in the Mediterranean, southwest US, northern Mexico, southern Australia, southern Africa, and parts of South America face agricultural problems due to shrinking water supplies; and all humans are threatened with irreversible climate damage, as water vapor, an important greenhouse gas, is pumped naturally into the

atmosphere at an increasing rate. Scientists believe Australia would be the most affected country, because westerly winds that deliver much needed rainfall to the continent's southern coast would be pushed further south by the shifting tropics, meaning rain would fall over the ocean rather than land. December 3, 2007, http://environment.independent.co.uk/climate_change/article3218026.ece.

February 2008

***Science Daily*, "Penguins In Peril As Climate Warms."** According to a World Wildlife Fund (WWF) report, the four penguin populations that breed on the Antarctic continent – the Adélie, Emperor, Chinstrap and Gentoo – are facing increasing pressure to survive as global warming shrinks both their food supply and the ground where their young are raised. Data show that the Antarctic Peninsula is warming five times faster than the average rate of global warming. The vast Southern Ocean has warmed to a depth of 3,000 meters, which has significantly reduced the area's krill population. In regards to the West Antarctic Peninsula, sea ice covers 40 percent less area than it did 26 years ago, which has decreased the Chinstrap penguin population by as much as 30 percent to 66 percent in some colonies. Moreover, the Emperor penguin has seen some of its colonies decrease 50 percent over the past half century, as warmer winter temperatures and stronger winds cause sea ice to prematurely break off, sending many eggs and chicks away before they can survive on their own. The Antarctic Peninsula's northwestern coast has been affected most by warming, causing Adélie penguin population to drop by 65 percent over the past 25 years. To view the report, titled "Antarctic Penguins and Climate Change," click: http://assets.panda.org/downloads/folleto_penguins.pdf. December 15, 2007, http://www.sciencedaily.com/releases/2007/12/071213203604.htm.

***Reuters*, "2008 to be in Top 10 Warmest Years Say Forecasters."** Projections by experts at the Met Office and the University of East Anglia show 2008 will be slightly cooler than recent years, but still rank among the top 10 warmest years on record since 1850. The forecasters said global average temperatures would be 0.37 of a degree Celsius above the long term 1961 to 1990 average of 14 degrees – the coolest since 2000. In comparison, from 2001 to 2007 the rate of warming averaged 0.44 degrees Celsius above the 1961 to 1990 average and 0.21 degrees Celsius warmer than corresponding values for 1991 to 2000. The projections take into account the annual Pacific Ocean La Nina weather phenomenon, which is expected to be strong this year and consequently limit the warming trend, and rising atmospheric concentrations of greenhouse gases, solar variations, and natural changes in the ocean currents. Due to the current La Nina reducing the sea surface temperature by around 0.5 degrees Celsius, the global surface temperature response to the cooling effect is expected to be slightly greater in 2008 than it was in 2007. In December 2007, the World Meteorological Organization (WMO) said that the 10 years from 1998 to 2007 were the hottest decade on record. The Met Office Hadley Centre added that the top 11 warmest years have all occurred over the past 13 years. January 3, 2008, http://uk.reuters.com/article/environmentNews/idUKL0314515220080103?sp=true.

March 2008

***MSNBC.COM*, "Study on Hurricanes, Warming Creates Storm."** Researchers at the National Oceanic and Atmospheric Administration's (NOAA) Miami Lab and the University of Miami believe that global warming could reduce the number of hurricanes that make landfall in the United States. In the study, warming waters in the Indian and Pacific Oceans are linked to increased wind shear – referring to a change in wind speed or direction – in the Atlantic Ocean to show that global warming makes it more difficult for hurricanes to form, strengthen, and subsist. The study also suggests that wind shear within the 10 degree to 20 degree North latitude belt that stretches from West Africa to Central America is crucial to determining future Atlantic hurricane activity. Specifically, Chunzai Wang, the study's author, believes that wind shear increases up to 10 miles per hour for every degree Celsius that the oceans warm, consequently weakening a storm's ability to form. Data analyzed from 1854 to 2006 show sea surface temperatures increasing across the globe, although at a higher rate in the tropical regions of the

Pacific, Atlantic, and Indian Oceans – producing increased vertical wind shear in the area where Atlantic hurricanes typically form. Thus, the warming of the Pacific and Indian Oceans increases vertical wind shear, which curbs Atlantic hurricane activity. Wang said that while wind shear is the most important factor, atmospheric humidity, sea level pressure, and sea surface temperature also affect hurricane strength. To read an abstract of the study, titled "Global warming and United States landfalling hurricanes," click: http://www.agu.org/pubs/crossref/2008/2007GL032396.shtml. January 23, 2008, http://www.msnbc.msn.com/id/22790698/.

***Science Daily*, "Tipping Elements in Earth's Climate System."** According to a climate research report published by the Potsdam Institute, several elements of the Earth's climate system could exceed a critical threshold, dubbed the "tipping element," this century. However, the authors stress that even small changes in human activities can have positive, long-term consequences for the Earth's climate system. The study presents nine tipping elements and a forecast for when these events may occur: melting of Arctic sea ice (approximately 10 years); decay of the Greenland ice sheet (more than 300 years); collapse of the West Antarctic ice sheet (more than 300 years); collapse of the Atlantic thermohaline circulation (approximately 100 years); increase in the El Nino Southern Oscillation (approximately 100 years); collapse of the Indian summer monsoon (approximately 1 year); greening of the Sahara/Sahel and disruption of the West African monsoon (approximately 10 years); dieback of the Amazon rainforest (approximately 50 years); and dieback of the Boreal Forest (approximately 50 years). The study says the most sensitive tipping elements with the smallest uncertainty, due to global warming, are the Arctic sea-ice and Greenland ice sheet scenarios. The scenarios with the largest uncertainty are the West Antarctic ice sheet, Amazon rainforest and Boreal forests, the El Niño phenomenon, and the West African monsoon scenarios. February 4, 2008, http://www.sciencedaily.com/releases/2008/02/080204172224.htm.

April 2008

***Discovery News,* "Pythons Could Slither North as Climate Warms."** A US Geological Survey (USGS) climate model for the year 2100 shows that 20-foot pythons could move into a number of US states due to global warming replicating their native Pakistani and Indonesian climates in North America. Regions where the pythons could appear include the northernmost parts of Texas and Arkansas, the southeast half of Kansas, the southern half of Missouri, and parts of southern Illinois and Indiana; while states like Tennessee, Kentucky, Maryland, Delaware, New Jersey, California, Arizona, Nevada, New Mexico, Washington, and Oregon may prove climatically hospitable to python populations in the future. Gordon Rodda, the USGS' invasive snake expert, conducted the model and admitted that factors like food and habitat were not taken into account, but he still expects the pythons could spread north wherever and whenever possible. The pythons, which can weigh over 250 pounds in some cases, are thought to be the offspring of a released pet and were first found in 2003 in the Florida Everglades. The largest snake in North America is either the bull snake or indigo snake, which are both shorter than nine feet long – a stark contrast to a python capable of killing deer, alligators, and even adult humans. USGS researchers are currently investigating the possibility of nine similar snakes, including the boa constrictor and yellow anacondas, invading North America. February 22, 2008, http://dsc.discovery.com/news/2008/02/22/python-climate-change.html.

***Washington Post*, "Carbon Output Must Near Zero to Avert Danger, New Studies Say."** Two recent, separately conducted studies claim that both developing and industrial nations must reduce their GHG emissions as soon as 2050 to prevent global warming scenarios that could result in changing precipitation patterns and water sources drying up across the globe. Through the utilization of advanced computer models, the studies conclude CO_2 emissions must be reduced to near zero levels as soon as possible, although worldwide CO_2 output totals some 10 billion tons per year and continues to steadily rise. In fact, the scientists believe the situation has worsened to the point where it is no longer logical to set a GHG emissions threshold and instead, they favor setting a temperature threshold, because the

Earth has already warmed by 1.4 degrees Fahrenheit above pre-industrial levels. The consensus among scientists is that an increase of 3.6 degrees Fahrenheit could have disastrous consequences; one of the studies suggests if the status quo holds the Earth will warm by 7.2 degrees Fahrenheit by 2100 and more than 15 degrees Fahrenheit by 2300. Moreover, the scientists cautioned that even after the world's emissions reach zero, warming will still take place, as CO_2 can trigger deep sea warming despite natural cycles removing roughly half of anthropogenic CO_2 emissions from the atmosphere over the next 100 years. A report published by the United Nations Intergovernmental Panel on Climate Change (IPCC) said that industrialized nations would have to cut emissions 80 to 95 percent by 2050 to reduce GHG emissions to the 450 parts per million (ppm) goal. The global warming studies are available at http://www.agu.org/pubs/crossref/2008/2007GB002953.shtml and http://www.agu.org/pubs/crossref/2008/2007GL032388.shtml. March 10, 2008, http://www.washingtonpost.com/wpdyn/content/article/2008/03/09/AR2008030901867.html.

May 2008

***Science Daily*, "Satellite Makes First Ever Observation of Regionally Elevated Carbon Dioxide from Manmade Emissions,"** and ***Science Daily*, "'Revolutionary' Carbon Dioxide Maps Zoom In On Greenhouse Gas Sources."** Through the use of the SCIAMACHY instrument on the European Space Agency's (ESA) Envisat environmental satellite, scientists have detected regionally elevated levels of atmospheric CO_2 caused by manmade emissions for the first time. Data analyzed from 2003 to 2005 shows a large plume over Europe's most heavily populated region, which stretches from Amsterdam in the Netherlands to Frankfurt, Germany. The scientists acknowledged that detecting regional manmade CO_2 emissions can be difficult due to natural CO_2 fluxes, but they hope a better understanding of the Earth's carbon cycle will aid scientists in their efforts to project future climate change. Another CO_2 mapping project, called Vulcan, revealed the southeastern United States is responsible for a much larger portion of GHGs than previously estimated. The three-year, DOE and National Aeronautics and Space Administration (NASA) funded project is able to depict CO_2 emissions at more than 100 times more detail than was previously available, because the Vulcan model examines CO_2 emissions at local levels on an hourly basis. In particular, Vulcan tracks CO_2 emissions from coal-fired power plants, factories, roadways, neighborhoods, and commercial districts and merges this data with geographic information systems (GIS) data to attribute CO_2 emissions to specific roads and regions. To view the satellite images, click: http://www.esa.int/esaCP/SEM1DUQ08ZE_Protecting_0.html. The Vulcan data is available for download at: http://www.eas.purdue.edu/carbon/vulcan. March 20, 2008, http://www.sciencedaily.com/releases/2008/03/080318110330.htm, and April 8, 2008, http://www.sciencedaily.com/releases/2008/04/080407172656.htm.

***Science Daily*, "Carbon Dioxide Removed From Smokestacks Could Be Useful In DVD And CD-ROM Manufacture."** Two chemists presented separate reports at an American Chemical Society (ACS) meeting on April 8 about how removing CO_2 from smokestack emissions could be useful in making polycarbonate plastics for consumer products in a less expensive, safer, and greener fashion than is currently used. One paper researched at the Catalytic Center (CAT) stressed the fact that CO_2 is readily available and a cheap starting material capable of replacing more expensive starting materials and becoming an economic driving force in the process. In addition, it was pointed out that millions of tons of polycarbonates are sold every year and consumer products, such as eyeglass lenses, automotive headlamp lenses, DVDs and CDs, and beverage bottles, possess great potential as CO_2 sinks. Another presentation, given by Japan's National Institute of Advanced Industrial Science and Technology (AIST), suggested using CO_2 as an alternative feedstock to convert carbonates and urethanes into plastics and battery components. The scientists believe it is only a matter of years before CO_2-derived polymers are available to the public. To learn more about CAT, visit: http://www.catalyticcenter.rwth-aachen.de/, or for further information about AIST, click: http://www.aist.go.jp/index_en.html. April 9, 2008, http://www.sciencedaily.com/releases/2008/04/080408144824.htm.

June 2008

***The Independent*, "Insects 'Will be Climate Change's First Victims.'"** A recent study found that tropical insects may be among the first species to face extinction as a result of climate change. New research shows that although the polar regions may experience the largest change in average temperature this century, a smaller shift in the average tropical temperature could have a more widespread impact on nature. With many insects thought to be living at the threshold of their temperature range, scientists believe an average tropical temperature rise of one or two degrees Celsius could unravel the interconnectedness of the tropical ecosystem. For example, the tropics depend on insects for breaking down organic matter, pollinating flowers to produce fruits and nuts, and providing food for animals higher up the food chain. After analyzing daily and monthly global temperatures from 1950 to 2000 and comparing the data with a series of factors like population growth rates and physical performance, the scientists arrived at their conclusion, adding that shade would provide little relief and tropical insects have no way to adapt or other locations to move to. Finally, the scientists said changing rainfall patterns resulting from climate change could impact food crops in tropical regions. The study is available at: http://beta.pnas.org/content/105/18/6668.abstract?sid=3eefb478-100c-47c3-8d3d-d2091fedf2eb. (Subscription may be required.) May 6, 2008, http://www.independent.co.uk/news/science/insects-will-be-climate-changes-first-victims-821616.html.

***Science Daily*, "Hot Climate Could Shut Down Plate Tectonics."** A new finding that links climate and the Earth's geophysics may explain the evolutionary difference between Earth and similar planets: prolonged atmospheric heating can shut down plate tectonics and lock a planet's crust into place. For instance, while Earth and Venus are similar in size and geological composition, Venus possesses a CO_2-rich atmosphere that is 100 times denser than Earth's, causing Venus to have a surface temperature hotter than the closest planet to the sun, Mercury. The researchers found that the process where Earth's crust (segments of which are called tectonic plates) returns to the Earth's interior by sliding beneath other plates can become unstable if the Earth's surface temperature would rise by 100 degrees Fahrenheit or more over the course of a few million years. Specifically, as rising atmospheric temperatures heat the crust of a planet, the deep inside of a planet can heat to the point where tectonic plate movement ceases. For the Earth, the mantle (the flowing layer of rock that extends from the planet's outer core located about 1,800 miles below the surface to within about 30 miles of the surface) becomes less active if it heats up. The scientists said their most noteworthy finding is that the atmospheric heating needed to disrupt plate tectonics is noticeably less than the temperature that would cause free water on the Earth's surface to evaporate. The study, titled, "A climate change induced transition in the tectonic style of a terrestrial planet," is available at: http://www.sciencedirect.com/science/article/B6V61-4S6P23T-2/1/2ac76bfc6a7976a6b353da2567aa2f33. (Subscription may be required.) May 13, 2008, http://www.sciencedaily.com/releases/2008/05/080512135102.htm.

July 2008

***Baltimore Sun, "*Outlook is Bleak for State Shoreline."** A recent report by the National Wildlife Federation (NWF) says rising sea levels caused by global warming could destroy more than half the beaches on Maryland's Eastern Shore. The study states that recent developments along the shoreline have prevented beaches from shifting inward as water levels rise. According to the study's authors, the cause of the rising water levels is due to GHGs melting glaciers and causing bodies of water to expand. NWF's analysis predicts that 415 square miles of open water will replace beaches and coastal land. The report also says that 161,000 acres of marsh will be destroyed over the next century, disrupting the breeding of fish and birds. Higher water temperatures also could result in low-oxygen dead zones in the Chesapeake Bay, leading to less aquatic vegetation. The report is based on calculations from the Intergovernmental Panel on Climate Change (IPCC) that predicted global sea levels will rise up to 27 inches by 2100. Specifically, an NWF consultant employed a computerized model based on these

predictions to calculate what the data could mean for marshes and shorelines around the Chesapeake Bay. The report concluded that by 2100, 69 percent of the beach acreage and 58 percent of oceanfront beaches in the area could be washed out. To view NWF's technical report, titled, "Sea-Level Rise and Coastal Habitats of the Chesapeake Bay," go to: http://www.nwf.org/sealevelrise/pdfs/SeaLevelRiseandCoastalHabitats_ChesapeakeRegion.pdf, or visit: http://www.nwf.org/sealevelrise/chesapeake.cfm for more information. May 23, 2008, http://www.baltimoresun.com/sports/outdoors/bal-md.shore23may23,0,1010861.story.

***The Independent,* "Warmer Seas Blamed for Rapid Decline of Scottish Puffin Colony,"** and ***MSNBC.com,* "Decline of Scottish Puffins Seen as Climate Sign."** Researchers on the Island of May, home to the largest Atlantic puffin colony in the North Sea, revealed new data that shows after 40 years of steady increase, the resident population of puffins has plummeted by nearly one-third in the past five years. The last time researchers surveyed the birds, in 2003, there were 69,300 breeding pairs and the population was growing at 10 percent a year; today, however, there are only 41,000 pairs. Researchers have not been able to determine the exact cause of the decline, but the emeritus professor for Britain's Center of Ecology and Hydrology (CEH) believes climate change could possibly be at fault. According to CEH, as the sea temperature rises, the number of fish available for the puffin to eat drops. Research shows that many of the pairs that survived the winter were under their typical weight. Sand eels, puffins' staple food source, have also seen a population decline. Since the puffin sits near the top of the Atlantic Ocean's food chain, researchers believe they are excellent bio-indicators for the health of the environment and this decline could signal a national trend. The Scottish island has been the focal point of the United Kingdom's research for three decades. To view more of CEH's research, go to: http://www.ceh.ac.uk/news/news_archive/2008_news_item_16.html. June 4, 2008, http://www.independent.co.uk/environment/nature/warmer-seas-blamed-for-rapid-decline-of-scottish-puffin-colony-839600.html, and June 5, 2008, http://www.msnbc.msn.com/id/24986904/.

August 2008

***Science Daily,* "Whales Set To Chase Shrinking Feed Zones,"** and ***Reuters*, "Retreating Antarctic Sea Ice Threatens Southern Whales."** Research conducted by the World Wildlife Fund (WWF) found that endangered migratory whales may be faced with shrinking Antarctic foraging zones that will contain less food and will be further away. WWF's research, which was summarized in the report titled, "Ice breaker: Pushing the boundaries for whales," says that predicted global warming levels over the next 40 years could lead to a 30 percent decline of winter sea ice coverage in key areas of the Southern Ocean. The result may force migratory whale species to travel 144 to 360 miles (200 to 500 kilometers) further south to find "frontal" zones that contain their sea ice-dependent, primary food source – krill. As the amount of sea ice drops, the abundance of krill is expected to as well, reducing the quantity of food for whales in feeding areas. Also, due to the distance of the migration paths, the duration of the feeding season could be reduced. Migratory whale species, including blue whales, Earth's largest living creatures, and humpback whales, which were recently near-extinction due to commercial whaling, have the potential to be affected. WWF's research is based on the assumption that average temperatures will rise by two degrees Celsius (3.6 [degrees Fahrenheit]) by 2042. To view WWF's report, go to: http://assets.panda.org/downloads/english_final_proof_final.pdf. July 1, 2008, http://www.sciencedaily.com/releases/2008/06/080629143936.htm, and June 19, 2008, http://uk.reuters.com/article/environmentNews/idUKL1943431320080619.

***Rocky Mountain News*, "North Pole Soon May Be Ice-Free,"** and ***National Geographic*, "North Pole May Be Ice-Free for First Time This Summer."** Scientists at the National Snow and Ice Data Center (NSIDC) at the University of Colorado in Boulder believe the ice at the North Pole could be completely melted by September 2008, before refreezing during the Arctic winter. NSIDC believes GHGs have helped elevate temperatures two to seven degrees Fahrenheit across the Arctic. Last September, the part of the Arctic Ocean that was ice-free opened up a new area of water the size of California and Texas combined. The melting has accelerated at such levels in recent years that scientists predict the *entire*

Arctic Ocean could be ice-free for at least one day by 2020 – 50 years sooner than originally predicted. Satellite images show that the area around the North Pole is mostly made up of first-year ice – thin, new ice that forms each year and is more susceptible to melting during warmer months than multiyear ice, which is thicker and denser. According to researchers, sea ice is crucial to the global climate system, as without it the Earth loses its capacity to regulate temperature via the ocean currents. Scientists have been tracking the recession of sea ice in the Arctic Sea for 29 years using satellite data. The North Pole has never been ice-free in its recorded history. To view NSIDC's website, which offers daily Arctic sea ice data, visit: http://www.nsidc.org/arcticseaicenews/. June 28, 2008, http://www.rockymountainnews.com/news/2008/jun/27/north-pole-may-be-ice-free-september/, and June 20, 2008, http://news.nationalgeographic.com/news/2008/06/080620-north-pole.html.

Policy

September 2007

***Reuters,* "UN Climate Change Meeting Aims at Rich Countries,"** and ***Reuters,* "UN Climate Chief Skeptical about Global Carbon Tax."** The first full-scale United Nations session dedicated to climate change was held on August 30 and 31 in New York. The meeting called for rich countries to take on the economic burden of global climate change. Assisting poorer countries to finance their efforts to cut greenhouse gas emissions was an option suggested to wealthy nations. The United States continues to support voluntary emissions cuts and President Bush has agreed with other Group of Eight industrialized nations to negotiate a new climate pact to extend the Kyoto Protocol beyond its expiration in 2012. Yvo de Boar, head of the U.N. Framework Convention on Climate Change, expressed skepticism about a global carbon tax, but stated that national taxes were possible. Moreover, he favors cap-and-trade laws, which offer financial incentive for emission reductions by assigning a cost to pollution. Another U.N. meeting on climate change is scheduled for September 24. August 2, 2007, http://www.planetark.org/avantgo/dailynewsstory.cfm?newsid=43427, and August 2, 2007, http://in.reuters.com/article/worldNews/idINIndia-28774420070801.

"Science-based permitting of geological sequestration of CO_2 in brine reservoirs in the U.S." [The authors] present a science-based approach to the regulation and permitting of CO_2 sequestration activities. Any such regulatory scheme should address both operational (or short-term) issues and the long-term goals of geological sequestration of CO_2. In the United States many of the key operational issues, such as permitting injection wells and CO_2 pipelines, are reasonably well addressed in current Federal- and State-based rules and legislation. The long-term, overarching goal of sequestration projects of decreasing the rate of increase in atmospheric concentrations of CO_2 is not addressed by current regulations. [The authors] propose a hierarchical approach, in which the State/Federal government is responsible for developing regional assessments that result in broad regions of brine reservoirs being rated as "sequestration ready" (and designated in this paper as general permits). The burden faced by an applicant in permitting an injection site should be considerably less if the general area of the chosen site has been ranked favorably. Such a phased, hierarchical permitting process would be helpful in addressing public and stakeholder concerns related to the impact and safety of geological sequestration operations. It will also build in coordination between neighboring injection sites, where interferences are likely because of the large amount of CO_2 to be injected. **Jean-Philippe Nicot and Ian J. Duncan,** *Environmental Science and Policy,* Published online June 25, 2007, doi:10.1016/j.envsci.2007.05.003, http://www.sciencedirect.com/science/article/B6VP6-4P248H6-1/2/7a7dfaf6624caa2e9f41ced822b1b8d1. (Subscription may be required.)

October 2007

***Greenwire,* "Asia-Pacific Business Leaders Want Carbon Pricing."** During the Asia Pacific Economic Cooperation (APEC) summit in Australia, business leaders pledged that they will make urgent appeals to

their governments to implement CO_2 emissions trading schemes. Attendees also requested that their leaders provide incentives to invest in energy saving technologies to control greenhouse gas emissions. Australia has placed significant importance on climate change at the summit. The government has expressed interest in a new treaty after the 2012 expiration of the Kyoto Protocol that would require more effort on the part of developing nations to reduce emissions. While the United States backs Australia's sentiments, developing nations such as India and China do not support agreements that duplicate or replace the United Nations framework on climate change. Other APEC leaders have expressed their exclusive support to the United Nations emissions framework. According to research conducted in Australia, the country's failure to ratify the Kyoto Protocol is costing the country billions of dollars in lost investment opportunities by hindering investment in low-emissions technologies that could be funded through carbon credits. September 5, 2007, http://www.eenews.net/Greenwire/print/2007/09/05/13. (Subscription may be required.)

"Research for Deployment: Incorporating Risk, Regulation, and Liability for Carbon Capture and Sequestration." Carbon capture and sequestration (CCS) has the potential to enable deep reductions in global carbon dioxide (CO_2) emissions, however this promise can only be fulfilled with large-scale deployment. For this to happen, CCS must be successfully embedded into a larger legal and regulatory context, and any potential risks must be effectively managed. [The authors] developed a list of outstanding research and technical questions driven by the demands of the regulatory and legal systems for the geologic sequestration (GS) component of CCS. [The authors] then looked at case studies that bound uncertainty within two of the research themes that emerge. These case studies, on surface leakage from abandoned wells and groundwater quality impacts from metals mobilization, illustrate how research can inform decision makers on issues of policy, regulatory need, and legal considerations. A central challenge is to ensure that the research program supports development of general regulatory and legal frameworks, and also the development of geological, geophysical, geochemical, and modeling methods necessary for effective GS site monitoring and verification (M&V) protocols, as well as mitigation and remediation plans. If large-scale deployment of GS is to occur in a manner that adequately protects human and ecological health and does not discourage private investment, strengthening the scientific underpinnings of regulatory and legal decision-making is crucial.
Elizabeth J. Wilson, S. Julio Friedmann, and Melisa F. Pollak, *Environmental Science Technology,* Published online July 25, 2007, DOI: 10.1021/es062272t, http://pubs.acs.org/cgi-bin/abstract.cgi/esthag/2007/41/i17/abs/es062272t.html. (Subscription required.)

November 2007

***Reuters*, "UN Chief Sees Major Commitment to Climate Change."** On September 24, U.N. Secretary-General Ban Ki-moon convened a one day event titled "The Future in our Hands: Addressing the Leadership Challenge of Climate Change" with hopes to build momentum in advance of the U.N. Climate Change Conference in December. Ban believes the conference served as a turning point in the battle against global warming and said he was pleased with the political commitment. Some 80 heads of state or government attended, including Brazilian President Luiz Ignacio Lula da Silva, Greenpeace China leader Lo Sze Ping, and US Secretary of State Condoleezza Rice, who represented President George Bush. Speaking to the attendees, Rice acknowledged that climate change is a generational and global challenge because of the issue's complex nature and stressed that the US is committed to the U.N. Framework Convention on Climate Change. Also, Rice encouraged a technological revolution based on clean energy technology, such as hydrogen technologies; carbon sequestration; and advanced nuclear energy, which would lessen humans' dependence on fossil fuels. With President Bush contending the Kyoto Protocol burdens rich countries and the European Commission insisting success is possible only with US involvement, talks to replace the soon expiring agreement could prove to be challenging. The U.N. Climate Change Conference is scheduled to be held December 3-14 in Bali, Indonesia. To view the complete text of Secretary Rice's "Remarks at the U.N. General Assembly High-Level Event on Climate Technology Session," click: http://www.state.gov/secretary/rm/2007/09/92662.htm. September 24, 2007, http://www.reuters.com/article/homepageCrisis/idUSN24278607._CH_.2400.

"Investment risks under certain climate change policy." This paper describes results from a model of decision-making under uncertainty using a real options methodology, developed by the International Energy Agency (IEA). The model represents investment decisions in power generation from the perspective of a private company. The investments are subject to uncertain future climate policy, which is treated as an external risk factor over which the company has no control. The aims of this paper are to (i) quantify these regulatory risks in order to improve understanding of how policy uncertainty may affect investment behavior by private companies and (ii) illustrate the effectiveness of the real options approach as a policy analysis tool. The study analyzed firms' investment options of coal- and gas-fired power plants and carbon capture and storage (CCS) technologies. Policy uncertainty is represented as an exogenous event that creates uncertainty in the carbon price. [The authors'] findings indicate that climate policy uncertainty creates a risk premium for power generation investments. In the case of gas- and coal-fired power generation, the risk premium would lead to an increase in electricity prices of 5–10 [percent] in order to stimulate investment. In the case of CCS, the risk premium would increase the carbon price required to stimulate investment by 16–37 [percent] compared to a situation of perfect certainty. The option to retrofit CCS acts as a hedge against high future carbon prices, and could accelerate investment in coal plant. This paper concludes that to minimize investment risks in low carbon technologies, policy-makers should aim to provide some long-term regulatory certainty. **William Blyth, Richard Bradley, Derek Bunn, Charlie Clarke, Tom Wilson and Ming Yang,** *Energy Policy,* Volume 31, Issue 11, November 2007, Pages 5766-5773. Available online August 17, 2007, doi:10.1016/j.enpol.2007.05.030 , http://www.sciencedirect.com/science/article/B6V2W-4PFDPNY-1/2/69e44caf1745e2e072cc26fda459d35d. (Subscription may be required.)

December 2007

***Wall Street Journal Online*, "Energy (A Special Report) -- Regulators; Cutting Edge: Is Canada's Approach to Reducing Greenhouse-Gas Emissions a Breakthrough – or a PR Gimmick?"** In 2010, Canada will become the first country to implement a different approach to the Kyoto Protocol. Rather than limiting the total amount of emissions, oil, gas, power, iron, steel, chemical, cement, and other material producers can increase production so long as the ratio of their emissions to the basic unit of production in their industry declines. Critics argue the policy will not result in emissions cuts because, for example, a power generator's ratio is based on kilowatt-hours and an oil producer's ratio is based on barrels of oil, leading some to believe that the ratios support political interests, instead of aiding the environment. The proposed policy is based on the thinking that cutting emissions to percentages below the Kyoto mandated 1990 levels would devastate the Canadian economy. In addition, this past September, Canada agreed to the Sydney Declaration, vowing to reduce energy intensity, or the amount of energy needed to produce a dollar of gross domestic product, by 25 percent by 2030. While no deductions in overall emissions totals are mandated, large industrial companies are required to reduce their emission ratios by 18 percent below 2006 levels in 2010 and by two percent each following year through 2020. The government's hope is that once this policy is meshed with energy efficiency measures and renewable fuel drives, Canada's greenhouse-gas emissions will fall one fifth by 2020. The options for those failing to reduce their emission-ratio targets include pursuing renewable energy projects, trading CO_2 credits on the international or Canadian market after it launches later this year, or paying a $15.35 ($15 Canadian) fine per metric ton of CO_2 above their target ratio into a technology development fund. For many, the most intriguing technology is carbon sequestration, because Alberta possesses many oil and gas wells capable of storing CO_2.
November 12, 2007, http://online.wsj.com/article/SB119463318508988186.html. (Subscription required.)

"The energy-climate challenge: Recent trends in CO_2 emissions from fuel combustion." Fossil fuel combustion is the single largest human influence on climate, accounting for 80 [percent] of anthropogenic greenhouse gas emissions. This paper presents trends in world carbon dioxide (CO_2) emissions from fossil fuel combustion worldwide, based on the estimates of the International Energy Agency (IEA) [IEA, 2006a. CO_2 Emissions from Fuel Combustion 1971–2004. International Energy

Agency, Paris, France]. Analyzing the drivers of CO_2 emissions, the paper considers regions, types of fuel, sectors, and socio-economic indicators. The paper then examines the growing body of climate change mitigation policies and measures, both multinational and federal. Policies discussed include the Kyoto Protocol, the European Union Emissions Trading Scheme, and the potential measures to be implemented in 2012 and beyond. CO_2 emissions of recent years have grown at the highest rates ever recorded, an observed trend incompatible with stabilizing atmospheric concentrations of greenhouse gases and avoiding long-term climate change. Within this aggregate upward trend, a comparison of emissions sources proves dynamic: while industrialized countries have so far dominated historical emissions, rapid growth in energy demand of developing economies, led by China, may soon spur their absolute emissions beyond those of industrialized countries. **Roberta Quadrelli and Sierra Peterson**, *Energy Policy*, Available online: September 4, 2007, doi: 10.1016/j.enpol.2007.07.001, http://www.sciencedirect.com/science/article/B6V2W-4PK8G4S-1/2/c4379d67d5511f07a27cfc91d4cdb9bd. (Subscription may be required.)

January 2008

***Reuters*, "Australia's New Government Ratifies Kyoto Pact."** Almost immediately after taking his oath of office on December 3, Australia's newly elected Prime Minister Kevin Rudd signed the Kyoto Protocol, ending nearly a decade of Australian opposition to the global pact and isolating the US as the only developed nation not to ratify the agreement. In the past, Australia contended that ratifying Kyoto would harm its heavily coal dependant energy sector and export driven economy, because developing neighbors China and India are not bound by such targets. However, a new report from the Climate Institute found that Australian economic growth would fall by only 0.1 percent of gross domestic product (GDP) annually if Australia cut emissions levels by 20 percent by 2020 and strived to be carbon neutral by 2050, which the study's authors believe Australia could cope with. Australia will not be a full member of Kyoto for 90 days, when full ratification will take place following the UN's acceptance of Australia's formal Instrument of Ratification. Despite their reluctance to sign to global treaty, previous Australian officials allege that Australia would have met 2012 Kyoto targets, despite information suggesting their target of curbing greenhouse emissions growth to 108 percent of 1990 levels would not be met. Although Rudd has yet to determine an interim target for emissions cuts by 2020, Rudd set a long-term goal of cutting carbon emissions by 60 percent of 2000 levels by 2050. December 3, 2007, http://news.yahoo.com/s/nm/20071203/wl_nm/australia_politics_dc_2.

***Reuters*, "U.N. Climate Talks Under Pressure to Drop 2020 Goals,"** and ***Associated Press*, "China Says West Should Deal With Warming."** As of December 10, US representatives stood steadfast on their insistence U.N. officials and other nations' representatives opt to remove a 2020 emissions reduction target from a draft text developed at the Bali talks, stating rich nations must cut greenhouse gases 25 to 40 percent below 1990 levels. The draft's purpose is to lay out the guidelines for future negotiations, but also mentions ranges for long term emissions cuts, which the US refuses to adhere to, and scientific evidence stating the world must reduce emissions 50 percent below 2000 levels by 2050 to avert serious global warming troubles. While the US insists developing nations such as China and India be held to similar standards, China rejected mandatory emission cuts for developing nations, because their officials believe the US and other wealthy nations are responsible for global warming and should amend their environmental practices accordingly. Furthermore, some now think China is the world's top emitter of CO_2, but a top Chinese climate expert argued that America's emissions per person are six times higher than China's despite having a significantly lower population. U.N. officials hope the December 3-14 talks in Bali lead to negotiations on a new global climate treaty that can be adopted at the 2009 UN conference in Copenhagen, Denmark. December 10, 2007, http://www.reuters.com/article/environmentNews/idUSL1064001320071210, and December 8, 2007, http://ap.google.com/article/ALeqM5gBTCrOwOrOXV9BkLBDRmtO3XWbHQD8TCPUE80.

February 2008

***Reuters*, "Bali Breakthrough Launches Climate Talks,"** and ***Reuters*, "U.S. Drops Opposition to U.N. Climate Deal."** Following pleas from other nations, the United States dropped its opposition to a global warming plan and will participate in future talks regarding a new United Nations climate treaty that would replace the Kyoto Protocol, which is set to expire in 2012. The agreement signals a shift in the United States' climate policy stance after six years of disagreement with major allies caused by President George W. Bush withdrawal from the Kyoto Protocol. The Bali meeting creates a "roadmap" for two years of talks, which will ideally lead to the adoption of a new treaty at a global meeting in Copenhagen in late 2009. The deal came when the United States dropped opposition to a proposal presented by the Group of 77 (G77) – the United Nations' main developing nation bloc – that called for rich nations to do more to help the developing world fight rising greenhouse emissions. As the world's leading greenhouse gas emitter, the United States maintained its uncertainty over future talks despite dropping their opposition. If a global climate agreement can be reached by 2009, governments would have sufficient time to ratify the pact and assure confidence in markets and investors wanting to switch to cleaner energies. Under the Kyoto Protocol, all industrial nations besides the United States are required to cut emissions between 2008 and 2012. A new climate deal would seek to include developing nations that are currently exempt from emissions standards.
December 15, 2007, http://www.reuters.com/article/environmentNews/idUSL1412327320071215 and December 15, 2007, http://www.reuters.com/article/environmentNews/idUSL1513238120071215.

"Analysis of the impacts of combining carbon taxation and emission trading on different industry sectors." Application of price mechanisms has been the important instrument for carbon reduction, among which the carbon tax has been frequently advocated as a cost-effective economic tool. However, blanket taxes applied to all industries in a country might not always be fair or successful. It should therefore be implemented together with other economic tools, such as emission trading, for CO_2 reduction. This study aims to analyze the impacts of combining a carbon tax and emission trading on different industry sectors. Results indicate that the "grandfathering rule (RCE2000)" is the more feasible approach in allocating the emission permit to each industry sector. Results also find that the accumulated GDP loss of the petrochemical industry by the carbon tax during the period 2011–2020 is 5.7 [percent]. However, the accumulated value of GDP will drop by only 4.7 [percent] if carbon taxation is implemented together with emission trading. Besides, among petrochemical-related industry sectors, up-stream sectors earn profit from emission trading, while down-stream sectors have to purchase additional emission permits due to failure to achieve their emission targets. **Cheng F. Lee, Sue J. Lin and Charles Lewis**, *Energy Policy*, Available online December 3, 2007, doi:10.1016/j.enpol.2007.10.025, http://www.sciencedirect.com/science/article/B6V2W-4R8M9HG-2/2/5b143cec4352e8d62001ac30dd65c5bb. (Subscription may be required.)

March 2008

***Reuters*, "EU Agrees Goal for Climate Deal by April 2009,"** and ***Reuters*, "Factbox-The EU's Energy and Climate Plan."** On January 24, European Union (EU) chair, Slovenia, reached an agreement with the three countries that will succeed its rule to strive toward enacting extensive climate change and energy laws by April 2009. Slovenian Environment Minister Janez Podobnik said that the EU's 27 member states have agreed to quickly reach an accord on the proposal's first reading, so that Europe is able to take a primary role in the global climate change negotiations set for December 2009 in Copenhagen. The European Commission proposed several goals: to cut GHG emissions by 20 percent from 1990 levels, including a stipulation to increase the reduction figure to 30 percent if an international climate change deal is in place; increase renewable energy such as solar, wind, wave, hydro, and biomass by 20 percent by 2020; and use 10 percent of biofuels for transport by 2020. These initiatives will cost an estimated 0.5 percent of gross domestic product (GDP), or $86.53 billion (60 billion euros) per year, and raise electricity prices 10 percent to 15 percent per year. However, the changes will reduce energy imports totaling $74 billion (50 billion euros) per year and save $16.3 billion (11 billion euros) a year by 2020 on air pollution control. For information about proposed changes to the European Union

Emissions Trading Scheme (EU ETS), see the "Trading" section below. January 24, 2008, http://www.reuters.com/article/environmentNews/idUSL242321720080124 and January 23, 2008, http://www.reuters.com/article/environmentNews/idUSL2347327520080123.

***Reuters*, "Alberta Targets Emission Cuts with Carbon Capture."** Alberta Premier Ed Stelmach revealed on January 24 that a new climate change strategy will reduce CO_2 emissions 14 percent below 2005 levels by 2050 through the implementation of CCS programs. As Canada's top oil producing province, Alberta plans to let GHG emissions rise until around 2020, due to more than $100 billion worth of planned oil sands projects that will triple current oil output. Stelmach said that he will allow GHGs to rise for the next decade because the province is a large oil provider to the United States and he did not want to risk harming Alberta's $73 billion in annual exports to the United States. Under Stelmach's climate change initiative, 12 percent of the emissions reductions will result from energy efficiency and conservation efforts, while some 70 percent of the targeted 200 megatonne emissions cut over the next 42 years will come from CO_2 capture and storage. In addition, Stelmach has been fining industrial emitters $15 per tonne of CO_2 emissions above a designated limit and contributing the money into a $503 million CCS R&D fund. Part of this fund would finance a study to explore the costs of developing a pipeline to transport CO_2 emissions to old oilfields for use in enhanced oil recovery. January 24, 2008, http://www.reuters.com/article/latestCrisis/idUSN24260627.

April 2008

***Reuters*, "EU Wants Developing Nations to do More on Climate."** Despite being the leading purchaser of carbon offsets from developing nations, the European Union (EU) wants developing nations to stop relying on carbon offset schemes and instead begin taking a proactive role in cutting their GHG emissions. European Commission officials believe that the current process, which allows rich countries to meet binding targets on GHG emissions by funding cuts in developing nations, will not lead to targeted emissions levels. United Nations officials do not support the EU's stance, as they conversely desire to expand the carbon offset process under the Kyoto Protocol's Clean Development Mechanism (CDM). In addition, this stance poses a significant threat to the multibillion dollar carbon market. Ideally, the EU would prefer a cap-and-trade scheme to set a limit on GHG emissions and allow counties to trade carbon credits below the cap; however, developing nations refuse to be restricted by such limits, saying their primary focus is ending poverty and rich nations should resolve climate issues. The EU statement comes on the heels of their January proposal to freeze the use of carbon offsets by the energy-intensive industry from 2013 to 2020 – a move currently worrying carbon market investors. The CDM market tripled to a value of $18.57 billion (12 billion euros) in 2007 and may find new life if developing nations agreed to sell offsets for clean energy technologies. March 11, 2008, http://www.reuters.com/article/environmentNews/idUSL1119071820080311?sp=true.

"CO_2 Embodied in International Trade with Implications for Global Climate Policy." The flow of pollution through international trade flows has the ability to undermine environmental policies, particularly for global pollutants. In this article [the authors] determine the CO_2 emissions embodied in international trade among 87 countries for the year 2001. [The authors] find that globally there are over 5.3 [gigatons] of CO_2 embodied in trade and that Annex B countries are net importers of CO_2 emissions. Depending on country characteristics—such as size variables and geographic location—there are considerable variations in the embodied emissions. [The authors] argue that emissions embodied in trade may have a significant impact on participation in and effectiveness of global climate policies such as the Kyoto Protocol. [The authors] discuss several policy options to reduce the impact of trade in global climate policy. If countries take binding commitments as a part of a coalition, instead of as individual countries, then the impacts of trade can be substantially reduced. Adjusting emission inventories for trade gives a more consistent description of a country's environmental pressures and circumvents many trade related issues. It also gives opportunities to exploit trade as a means of mitigating emissions. Not least, a better understanding of the role that trade plays in a country's economic and environmental development will

help design more effective and participatory climate policy post-Kyoto. **Glen P. Peters and Edgar G. Hertwich**, *Environmental Science & Technology*, Available online January 30, 2008, doi: 10.1021/es072023k, http://pubs.acs.org/cgi-bin/abstract.cgi/esthag/2008/42/i05/abs/es072023k.html. (Subscription required.)

May 2008

***Reuters*, "U.N. Approves Thousandth Kyoto Clean Energy Project,"** and **UNFCCC Press Release, "Kyoto Protocol Clean Development Mechanism Passes 1000th Registered Project Milestone."** On April 14, the United Nations (UN) approved the 1,000th project initiated under the Kyoto Protocol's Clean Development Mechanism (CDM). The project is an energy efficiency program in Andhra Pradesh, India that is expected to reduce CO_2 emissions by some 34,000 tonnes; as a whole, the 1,000 CDM-registered projects will likely result in an annual reduction of 200 million tonnes in 49 countries. Thus far, CDM projects have produced over 135 million certified emission reductions (CERs) – a figure that is expected to increase to 2.7 billion CERs in the Kyoto Protocol's first commitment period. The CDM, which is supervised by the UN Framework Convention on Climate Change (UNFCCC), allows rich nations to meet their GHG targets under the Kyoto Protocol by purchasing carbon offsets issued to clean energy projects in developing nations. Nearly half of all CDM projects take place in India and China. For CDM-related project activity, click: http://cdm.unfccc.int/Projects/index.html. April 14, 2008, http://www.reuters.com/article/environmentNews/idUSL1426496820080414, and April 14, 2008, http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/pressrel_080414_1000.pdf.

"Implications of carbon cap-and-trade for US voluntary renewable energy markets." Many consumers today are purchasing renewable energy in large part for the greenhouse gas (GHG) emissions benefits that they provide. Emerging carbon regulation in the US has the potential to affect existing markets for renewable energy. Carbon cap-and-trade programs are now under development in the Northeast under the Regional Greenhouse Gas Initiative (RGGI) and in early stages of development in the West and Midwest. There is increasing discussion about carbon regulation at the national level as well. While renewable energy will likely benefit from carbon cap-and-trade programs because compliance with the cap will increase the costs of fossil fuel generation, cap-and-trade programs can also impact the ability of renewable energy generation to affect overall CO_2 emissions levels and obtain value for those emissions benefits. This paper summarizes key issues for renewable energy markets that are emerging with carbon regulation, such as the implications for emissions benefits claims and voluntary market demand and the use of renewable energy certificates (RECs) in multiple markets. It also explores policy options under consideration for designing carbon policies to enable carbon markets and renewable energy markets to work together. **Lori A. Bird, Edward Holt and Ghita Levenstein Carroll**, *Energy Policy*, Available online April 8, 2008, doi:10.1016/j.enpol.2008.02.009, http://www.sciencedirect.com/science/article/B6V2W-4S7HSFM-1/2/3037809ff849d75329630e58723267e8. (Subscription may be required.)

June 2008

***British Columbia Ministry of Finance Media Release*, "Carbon Tax Guarantees Tax Cuts for British Columbians."** British Columbia's Minister of Finance announced that British Columbia is the first Canadian province to implement a revenue-neutral carbon tax to reduce personal, corporate, and business income tax rates. The carbon tax, based on a $10 per tonne of CO_2 price that will increase $5 each year until reaching $30 in 2012, is expected to generate $1,849 million in revenue over its first three years. Among its several tax cuts, the revenue will reduce the bottom two personal income tax rates by two percent in 2008, with plans to increase the rate by five percent in 2009 on the first $70,000 in earnings ($784 million in tax cuts). It will also reduce the general corporate tax rate from 12 percent to 11 percent, with plans to lower the rate to 10 percent by 2011 ($415 million in tax cuts) and reduce the small

business tax rate to 3.5 percent from 4.5 percent, with plans to lower the rate to 2.5 percent by 2011 ($255 million in tax cuts). Finally, the revenue will finance a new Climate Action Credit fund that will provide lower income British Columbians with a payment of $100 per adult and $30 per child per year, with plans to increase these amounts by five percent in 2009 ($395 million). The carbon tax will go into effect on July 1, 2008, and apply to all fossil fuels, including gasoline, diesel, natural gas, coal, propane, and home heating fuel. A breakdown of the budget is available at: http://www.bcbudget.gov.bc.ca/2008/backgrounders/backgrounder_tax_impacts.htm. For more information about British Columbia's "Climate Smart Programs," click: http://www.smartchoicesbc.ca/EN/bc's_climate_smart_programs/. April 28, 2008, http://www2.news.gov.bc.ca/news_releases_2005-2009/2008FIN0009-000645.htm.

"An indicator framework for assessing US state carbon emissions reduction efforts (with baseline trends from 1990 to 2001)." States are at the forefront of climate-related energy policy in the US, developing innovative policy and regional institutions for reducing carbon dioxide and other greenhouse gases. States matter because the larger ones use more energy and produce more carbon emissions than most nations and because their policies, though heterogeneous and until recently quite limited in scope, are shaping the context for national climate action. Despite this significance, little is known about trends in state carbon emissions or the effectiveness of state policies in reducing emissions. This paper describes a framework for analyzing and comparing state carbon emissions performance using sectoral indicators of emissions, energy consumption and carbon intensity linked to key policy domains. The paper also describes the range of state experience across indicators during the period 1990–2001, establishing a baseline of leading, lagging and average experience against which future state and regional change can be assessed. The conceptual framework and the empirical analysis of emission trends are intended to provide a better understanding of, and means for monitoring, state contributions toward achieving energy system sustainability. **Scott Jiusto**, *Energy Policy*, Available online April 21, 2008, doi:10.1016/j.enpol.2008.02.034, http://www.sciencedirect.com/science/article/B6V2W-4SB9F1H-1/1/5ecc1650feff93f2fb3835e3eb961809. (Subscription may be required.)

July 2008

***Reuters*, "IEA Urges $45 Trln 'Energy Revolution' To Halve CO_2,"** and ***Energy Current*, "G8 Aims for 20 Carbon Capture Projects by 2010."** In a new report, titled, "Energy Technology Perspectives 2008," IEA recommended a $45 trillion "energy technology revolution" to raise the cost of producing CO_2. According to the IEA report commissioned three years ago by the Group of Eight (G-8), failure to do so by 2050 could result in a surge in GHG emissions. IEA claims that without a multilateral government policy, emissions would rise by 130 percent and oil demand would increase by 70 percent. The report calls for a 15-year research and development (R&D) plan that would cost anywhere from $10 billion to $100 billion per year. Under this scenario, the power sector would need to build 32 new nuclear power plants and install CCS technology at 35 coal-fired and 25 gas-fired power plants per year from 2010 to 2050. In addition, nations not participating in the IEA program would need to conserve energy to achieve the target. At a meeting held June 6-7 in Aomori, Japan, G-8 members agreed to launch 20 large CCS demonstration projects by 2010. DOE pledged to provide funding for the addition of CCS technology at several commercial-scale Integrated Gasification Combined Cycle (IGCC) plants. To read a fact sheet highlighting the two future sustainable energy scenarios, click: http://www.iea.org/Textbase/techno/etp/fact_sheet_ETP2008.pdf. June 6, 2008, http://www.reuters.com/article/environmentNews/idUSSP11179420080606?pageNumber=1&virtualBrandChannel=0, and June 9, 2008, http://www.energycurrent.com/index.php?id=3&storyid=11052.

"Effective EU and Member State policies for stimulating CCS." Although CO_2 capture and storage (CCS) is widely recognized as an option to mitigate climate change, consistent and effective EU policies to advance CCS are still absent. This paper discusses policy instruments for advancing large-scale

deployment of CCS in the European Union, and evaluates them in a multi-criteria analysis. The EU Emissions Trading Scheme (EU-ETS) is a cost-effective instrument for limiting greenhouse gas emissions, but it is questionable whether its currently limited time horizon and short-trading periods will lead to substantial CCS [operations] Complementary policies at the EU and the Member State level may repair this and provide sufficient incentives for CCS. Potential policies include financial instruments such as investment subsidies, a feed-in scheme, or a CO_2 price guarantee, as well as a CCS mandate or a low-carbon portfolio. These policy options differ with respect to their environmental effectiveness, possible interaction with the EU-ETS, costs and financial risk involved, and their competition with other mitigation options. Interactions between Member State policies and the EU-ETS are smaller in scope than those of EU-wide policies, but they are more likely to lead to displacement of financial resources from other low-carbon technologies. In addition, national policies may pose a significant part of the financial risk of CCS operations with Member States, reducing the operator's incentive to innovate. Overall, structural policies at the EU level, such as a mandate or a low-carbon portfolio standard would be more conducive for realizing large-scale deployment of CCS across the EU as well as more acceptable to environmental organizations. **Heleen Groenenberg and Heleen de Coninck**, *International Journal of Greenhouse Gas Control*, Available online June 2, 2008, doi:10.1016/j.ijggc.2008.04.003**,** http://www.sciencedirect.com/science/article/B83WP-4SN92PX-1/1/af4f908886178f3a6b03573c04afbdce. (Subscription may be required.)

August 2008

***EPA News Release*, "EPA Lays Groundwork for Promising Technologies to Help Mitigate Climate Change," and *Oil and Gas Journal*, "EPA Proposes Rules for Carbon Dioxide Storage."** The US Environmental Protection Agency (EPA) has proposed regulations for the long-term, underground storage of CO_2. The proposed regulations would establish a new class of injection wells under EPA's existing Underground Injection Control (UIC) program and would update the Safe Drinking Water Act (SDWA). Under the proposed rules, a new category of injection well, Class VI, would be established to monitor the long-term, geologic storage of CO_2. The proposed regulation will build on the existing UIC program by including requirements to ensure wells are properly located, constructed, tested, monitored, and closed with proper funding. EPA is requesting public comments on the proposed rule for 120 days following its release, and a final rule is anticipated in late 2010 or early 2011. EPA is working with DOE on carbon sequestration research and development and monitors the progress of sequestration projects throughout the United States, including those initiated by DOE's RCSPs. The proposed rule results from EPA's coordination with DOE to monitor the progress of pilot-scale geologic storage projects and seven workshops held since 2005 to discuss various technical issues associated with geologic storage. To view the proposed rule, go to: http://www.epa.gov/safewater/uic/pdfs/prefr_uic_co2rule.pdf. To listen to a sound bite from EPA Administrator Stephen L. Johnson, click: http://www.epa.gov/adminweb/multimedia/newscontent/2008-07-15-oa/audio/071508.mp3. July 15, 2008, http://yosemite.epa.gov/opa/admpress.nsf/bd4379a92ceceeac8525735900400c27/d35b72dfe481043b85257487005e47cd!OpenDocument, and July 15, 2008, http://www.ogj.com/display_article/334413/7/ONART/none/GenIn/1/EPA-proposes-rules-for-carbon-dioxide-storage/.

"Environmental bonds and the challenge of long-term carbon sequestration." The potential to capture carbon from industrial sources and dispose of it for the long-term, known as carbon capture and storage (CCS), is widely recognized as an important option to reduce atmospheric carbon dioxide emissions. Specifically, CCS has the potential to provide emissions cuts sufficient to stabilize greenhouse gas levels, while still allowing for the continued use of fossil fuels. In addition, CCS is both technologically feasible and commercially viable compared to alternatives with the same emissions profile. Although the concept appears to be solid from a technical perspective, initial public perceptions of the technology are uncertain. Moreover, little attention has been paid to developing an understanding of

the social and political institutional infrastructure necessary to implement CCS projects. In this paper [the authors] explore a particularly dicey issue—how to ensure adequate long-term monitoring and maintenance of the carbon sequestration sites. Bonding mechanisms have been suggested as a potential mechanism to reduce these problems (where *bonding* refers to financial instruments used to ensure regulatory or contractual commitments). Such mechanisms have been successfully applied in a number of settings (e.g., to ensure court appearances, completion of construction projects, and payment of taxes). The paper examines the use of bonding to address environmental problems and looks at its possible application to nascent CCS projects. [The authors] also present evidence on the use of bonding for other projects involving deep underground injection of materials for the purpose of long-term storage or disposal. **David Gerard and Elizabeth J. Wilson**, *Journal of Environmental Management*, Available online July 10, 2008, doi:10.1016/j.jenvman.2008.04.005, http://www.sciencedirect.com/science/article/B6WJ7-4SYDB0K-1/1/6a8552ff2a455bb734c35f53553dbef0. (Subscription may be required.)

Geology

September 2007

"Time-lapse crosswell seismic and VSP monitoring of injected CO_2 in a brine aquifer." Seismic surveys successfully imaged a small scale CO_2 injection (1,600 ton) conducted in a brine aquifer of the Frio Formation near Houston, Texas. These time-lapse borehole seismic surveys, crosswell and vertical seismic profile (VSP), were acquired to monitor the CO_2 distribution using two boreholes (the new injection well and a pre-existing well used for monitoring) which are 30 m [meters] apart at a depth of 1,500 m. The crosswell survey provided a high-resolution image of the CO_2 distribution between the wells via tomographic imaging of the P-wave velocity decrease (up to 500 m/s [meters per second]). The simultaneously acquired S-wave tomography showed little change in S-wave velocity, as expected for fluid substitution. A rock physics model was used to estimate CO_2 saturations of 10–20 [percent] from the P-wave velocity change. The VSP survey resolved a large (~70 [percent]) change in reflection amplitude for the Frio horizon. This CO_2 induced reflection amplitude change allowed estimation of the CO_2 extent beyond the monitor well and on three azimuths. The VSP result is compared with numerical modeling of CO_2 saturations and is seismically modeled using the velocity change estimated in the crosswell survey. **Thomas M. Daley, Larry R. Myer, J. E. Peterson, E. L. Majer, and G. M. Hoversten,** *Environmental Geology,* Published online July 25, 2007, DOI: 10.1007/s00254-007-0943-z, http://www.springerlink.com/content/x80826132064h837/?p=5748bcb387064315a157aad1b539584c&pi=0. (Subscription required.)

"Geologic factors controlling CO_2 storage capacity and permanence: case studies based on experience with heterogeneity in oil and gas reservoirs applied to CO_2 storage." A variety of structural and stratigraphic factors control geological heterogeneity, inferred to influence both sequestration capacity and effectiveness, as well as seal capacity. Structural heterogeneity factors include faults, folds, and fracture intensity. Stratigraphic heterogeneity is primarily controlled by the geometry of depositional facies and sandbody continuity, which controls permeability structure. The permeability structure, in turn, has implications for CO_2 injectivity and near-term migration pathways, whereas the long-term sequestration capacity can be inferred from the production history. Examples of Gulf Coast oil and gas reservoirs with differing styles of stratigraphic heterogeneity demonstrate the impact of facies variability on fluid flow and CO_2 sequestration potential. Beach and barrier-island deposits in West Ranch field in southeast Texas are homogeneous and continuous. In contrast, Seeligson and Stratton fields in south Texas, examples of major heterogeneity in fluvial systems, are composed of discontinuous, channel-fill sandstones confined to narrow, sinuous belts. These heterogeneous deposits contain limited compartments for potential CO_2 storage, although CO_2 sequestration effectiveness may be enhanced by the high number of intraformational shale beds. These

field examples demonstrate that areas for CO_2 storage can be optimized by assessing sites for enhanced oil and gas recovery in mature hydrocarbon provinces. **W. A. Ambrose, S. Lakshminarasimhan, M. Holtz, V. Núñez-López, S. Hovorka, I. Duncan,** *Environmental Geology,* Published online July 27, 2007, DOI: 10.1007/s00254-007-0940-2, http://www.springerlink.com/content/n502k12606481724/?p=9028d37ebb904e5fb5635008c6be1c4d&pi=0. (Subscription required.)

October 2007

"Effects of in-situ conditions on relative permeability characteristics of CO_2-brine systems." Carbon dioxide capture and geological storage (CCGS) is an emerging technology that is increasingly being considered for reducing greenhouse gas emissions to the atmosphere. Deep saline aquifers provide a very large capacity for CO_2 storage and, unlike hydrocarbon reservoirs and coal beds, are immediately accessible and are found in all sedimentary basins. Proper understanding of the displacement character of CO_2-brine systems at in-situ conditions is essential in ascertaining CO_2 injectivity, migration and trapping in the pore space as a residual gas or supercritical fluid, and in assessing the suitability and safety of prospective CO_2 storage sites. Because of lack of published data, the authors conducted a program of measuring the relative permeability and other displacement characteristics of CO_2-brine systems for sandstone, carbonate and shale formations in central Alberta in western Canada. The tested formations are representative of the in-situ characteristics of deep saline aquifers in compacted on-shore North American sedimentary basins. The results show that the capillary pressure, interfacial tension, relative permeability and other displacements characteristics of CO_2-brine systems depend on the in-situ conditions of pressure, temperature and water salinity, and on the pore size distribution of the sedimentary rock. This paper presents a synthesis and interpretation of the results. **Stefan Bachu and Brant Bennion,** *Environmental Geology,* Published online July 24, 2007, DOI: 10.1007/s00254-007-0946-9, http://springerlink.metapress.com/content/k05245331h864771/?p=70070aac2be64638acdb2f7b3cce2f51&pi=0. (Subscription required.)

"Site characterization of a basin-scale CO_2 geological storage system: Gippsland Basin, southeast Australia." Geological storage of CO_2 in the offshore Gippsland Basin, Australia, is being investigated by the Cooperative Research Centre for Greenhouse Gas Technologies (CO_2CRC) as a possible method for storing the very large volumes of CO_2 emissions from the nearby Latrobe Valley area. A storage capacity of about 50 million tonnes of CO_2 per annum for a 40-year injection period is required, which will necessitate several individual storage sites to be used both sequentially and simultaneously, but timed such that existing hydrocarbon assets will not be compromised. Detailed characterization focused on the Kingfish Field area as the first site to be potentially used, in the anticipation that this oil field will be depleted within the period 2015–2025. The potential injection targets are the interbedded sandstones of the Paleocene-Eocene upper Latrobe Group, regionally sealed by the Lakes Entrance Formation. The research identified several features to the offshore Gippsland Basin that make it particularly favorable for CO_2 storage. These include: a complex stratigraphic architecture that provides baffles which slow vertical migration and increase residual gas trapping and dissolution; non-reactive reservoir units that have high injectivity; a thin, suitably reactive, lower permeability marginal reservoir just below the regional seal providing mineral trapping; several depleted oil fields that provide storage capacity coupled with a transient production-induced flow regime that enhances containment; and long migration pathways beneath a competent regional seal. This study has shown that the Gippsland Basin has sufficient capacity to store very large volumes of CO_2. It may provide a solution to the problem of substantially reducing greenhouse gas emissions from future coal developments in the Latrobe Valley. **C. M. Gibson-Poole, L. Svendsen, J. Underschultz, M. N. Watson, J. Ennis-King, P. J. van Ruth, E. J. Nelson, R. F. Daniel and Y. Cinar,** *Environmental Geology,* Published online August 3, 2007, DOI: 10.1007/s00254-007-0941-1, http://www.springerlink.com/content/0r4v8l4j846t5308. (Subscription required.)

November 2007

"Coalbed methane reservoir data and simulator parameter uncertainty modelling for CO_2 storage performance assessment." Laboratory studies and a number of field pilots have demonstrated that CO_2 injection into coal seams has the potential to enhance coalbed methane (CBM) recovery with the added advantage that most of the injected CO_2 can be stored permanently in coal. The concept of storing CO_2 in geologic formations as a safe and effective greenhouse gas mitigation option requires public and regulatory acceptance. In this context it is important to develop a good understanding of the reservoir performance, uncertainties and the risks that are associated with geological storage. The paper presented refers to the sources of uncertainty involved in CO_2 storage performance assessment in coalbed methane reservoirs and demonstrates their significance using extensive digital well log data representing the Manville coals in Alberta, Canada. The spatial variability of the reservoir properties was captured through geostatistical analysis, and sequential Gaussian simulations of these provided multiple realizations for the reservoir simulator inputs. A number of CO_2 injection scenarios with variable matrix swelling coefficients were evaluated using a 2D reservoir model and spatially distributed realizations of total net thickness and permeability. **Anna Korre, Ji Quan Shi, Claire Imrie, Carlos Grattoni and Sevket Durucan,** *International Journal of Greenhouse Gas Control,* Volume 1, Issue 4, October 2007, Pages 492-501, Available online August 28, 2007, doi:10.1016/S1750-5836(07)00093-X, http://www.sciencedirect.com/science/article/B83WP-4PHSFSB-1/2/f17f8ebfcb3f1335d5535c46dc4f14ee. (Subscription may be required.)

"Effects of matrix shrinkage and swelling on the economics of enhanced-coalbed-methane production and CO_2 sequestration in coal." Increases in carbon dioxide (CO_2) levels in the atmosphere and their contributions to global climate change are a major concern. [Carbon] sequestration in unmineable coals may be a very attractive option, for economic as well as environmental reasons, if a combination of enhanced-coalbed-methane (ECBM) production and tax incentives becomes sufficiently favorable compared to the costs of capture, transport, and injection of CO_2. Darcy flow through cleats is an important transport mechanism in coal. Cleat compression and permeability changes caused by gas sorption/desorption, changes of effective stress, and matrix swelling and shrinkage introduce a high level of complexity into the feasibility of a coal sequestration project. The economic effects of CO_2-induced swelling on permeabilities and injectivities has received little (if any) detailed attention. [Carbon dioxide] and methane (CH_4) have different swelling effects on coal. In this work, the Palmer-Mansoori model for coal shrinkage and permeability increases during primary methane production was rewritten to also account for coal swelling caused by CO_2 sorption. The generalized model was added to a compositional, dual-porosity coalbed-methane reservoir simulator for primary (CBM) and ECBM production. A standard five-spot of vertical wells and representative coal properties for Appalachian coals was used (Rogers 1994). Simulations and sensitivity analyses were performed with the modified simulator for nine different parameters, including coal seam and operational parameters and economic criteria. The coal properties and operating parameters that were varied included Young's modulus, Poisson's ratio, cleat porosity, and injection pressure. The economic variables included CH_4 price, CO_2 cost, CO_2 credit, water disposal cost, and interest rate. Net-present-value (NPV) analyses of the simulation results included profits resulting from CH_4 production and potential incentives for sequestered CO_2. This work shows that for some coal seams, the combination of compressibility, cleat porosity, and shrinkage/swelling of the coal may have a significant impact on project economics.
F. Burcu Gorucu, Sinisha A. Jikich, Grant S. Bromhal, W. Neal Sams, Turgay Ertekin and Duane H. Smith, *SPE Reservoir Evaluation & Engineering,* Volume 10, Issue 4, August 2007, Pages 382-392. DOI: 10.2118/97963PA. (Link Unavailable.)

December 2007

"The Atmospheric Background of Perfluorocarbon Compounds Used as Tracers." There are seven cyclic perfluoroalkane compounds, which can be detected in extremely low concentrations, that

are used to track mass movement and transfer in a variety of research and practical applications. They are used in leak detection in underground storage and pipelines and in atmospheric transport and diffusion research on local, regional, and continental scales. They are likely to be a used globally for monitoring carbon sequestration in geological formations. The atmospheric background levels of these compounds must be accurately known, and trends in their concentrations determined for these compounds to be effective in monitoring CO_2 reservoirs and because there are environmental concerns about their release. Results of measurements of perfluorocarbon background concentrations from two recent field programs are presented, and trends in these values examined using data collected over the last 25 years. The current atmospheric concentrations of these compounds are in the low parts per quadrillion levels, and their annual atmospheric growth rate is less than 1 part per quadrillion per year. The environmental effects of these compounds are examined and found to be negligible at current release rates. **Thomas B. Watson, Richard Wilke, Russell N. Dietz, John Heiser, and Paul Kalb**, *Environmental Science Technology,* Available online: September 15, 2007, DOI: 10.1021/es070940k, http://pubs.acs.org/cgi-bin/abstract.cgi/esthag/2007/41/i20/abs/es070940k.html. (Subscription required.)

January 2008

"CO_2 storage in geological media: Role, means, status and barriers to deployment." Carbon dioxide capture and geological storage is an enabling technology that will allow the continued use well into this century of fossil fuels, mainly coal, for power generation and combustion in industrial processes because they are relatively abundant, cheap, available and globally distributed, thus enhancing the security and stability of energy systems. Geological media suitable for CO_2 storage through various physical and chemical trapping mechanisms must have the necessary capacity and injectivity, and must confine the CO_2 and impede its lateral migration and/or vertical leakage to other strata, shallow potable groundwater, soils and/or atmosphere. Such geological media are mainly oil and gas reservoirs and deep saline aquifers that are found in sedimentary basins. Storage of gases, including CO_2, in these media has been demonstrated on a commercial scale by enhanced oil recovery operations, natural gas storage and acid gas disposal. Some of the risks associated with CO_2 capture and geological storage are similar to, and comparable with, any other industrial activity for which extensive safety and regulatory frameworks are in place. Specific risks associated with CO_2 storage relate to the operational (injection) phase and to the post-operational phase, of which the risks of most concern are those posed by the potential for acute or chronic CO_2 leakage from the storage site. Notwithstanding the global climate effect of CO_2 returning to the atmosphere, the local risks to health and safety, environment and equity need to be properly assessed and managed. Currently there are very few operations in the world where CO_2 is injected and stored in the ground, mostly if not exclusively as a by-product of an operation driven by other considerations than climate change, such as oil production or regulatory requirements regarding H_2S. These operations show that there are no major technological barriers to CO_2 geological storage, and that challenges and barriers lie elsewhere. A major challenge in the implementation of CO_2 geological storage is the high cost of CO_2 capture, particularly for dilute streams like those from power plants and industrial combustion processes. There are concerns that public opinion and public's acceptance or rejection of this technology will likely affect the large-scale implementation of CO_2 geological storage. The current paucity of policy, legislation and a proper regulatory framework in most jurisdictions is presently the most significant barrier. The resolution of these challenges will affect the economics and financial risk of CO_2 geological storage and will accelerate or delay the deployment of this technology for reducing anthropogenic CO_2 emissions into the atmosphere. **Stefan Bachu**, *Progress in Energy and Combustion Science*, Available online: November 7, 2007, doi:10.1016/j.pecs.2007.10.001, http://www.sciencedirect.com/science/article/B6V3W-4R2Y44R-1/2/3f50590576a52cfdd97d1d82454b2967.

February 2008

"Heat optimization of a staged gas–solid mineral carbonation process for long-term CO_2 storage." Carbonation of magnesium silicates offers an interesting option for CO_2 emission mitigation in Finland, a country with large resources of serpentine-type minerals. Wet processes using aqueous solutions show reasonable chemical kinetics combined with poor energy economy. A dry, gas–solid process with slower chemical kinetics (demonstrated previously), but better energy economy could be an alternative. This paper addresses the energy economy of a two- or three-stage gas–solid process for magnesium silicate carbonation. It involves production of reactive magnesium as magnesium oxide or hydroxide in an atmospheric pressure step, followed by carbonation at elevated pressures that allow for reasonable carbonation reaction kinetics under conditions where magnesium carbonate is thermodynamically stable. For a feasible large-scale process the kinetics in the individual reactors must be fast enough, while the heat produced in the carbonation step must be sufficient to compensate for energy inputs to the preceding step(s). Results give reactor temperature combinations that allow for operation at a negative or zero energy input, for given carbonation reactor pressure and degree of carbonation conversion, and other process energy requirements. Softwares used were HSC and Aspen Plus. Also, some results from gas–solid kinetics studies with magnesium oxide-based materials at the pressures considered are included. **Ron Zevenhoven, Sebastian Teir and Sanni Eloneva**, *Energy*, Available online December 21, 2007, doi:10.1016/j.energy.2007.11.005, http://www.sciencedirect.com/science/article/B6V2S-4RDB8T4-1/2/bc2dec6bca60068666fb0839b0f2abf8. (Subscription may be required.)

"Experimental evaluation of interactions in supercritical CO_2/water/rock minerals system under geologic CO_2." The hydrothermal autoclave experiments were conducted to simulate the interactions in the [Supercritical] CO_2/water/rock minerals (quartz, biotite and granite) reaction systems using a Hastelloy [carbon] reaction cell at 100 [degrees Celsius]. The dissolution characteristics of rock minerals and their surface texture alternation after hydrothermal treatment were examined by ICP-AES and SEM/EDX investigation, respectively. The results suggested that the hydrolysis of plagioclase phase should be mainly responsible for the elements dissolved from the Iidate granite samples. The dissolution was encouraged by the introduction of CO_2 in the water/granite system, and generated an unknown aluminosilicate. No distinct chemical alternations occurred in the water-free $scCO_2$/granite system, which indicated that rock minerals should be chemically stable in the water-free $scCO_2$ fluids under the current mild experimental conditions. Both the highest concentration of Ca existing in the $scCO_2$/vapor/granite system and the SEM observation results of calcite deposit, suggested that a meaningful CO_2 minerals trapping process should be potential in the CO_2-rich field during a short physicochemical interaction period. **Hongfei Lin, Takashi Fujii, Reisuke Takisawa, Toru Takahashi and Toshiyuki Hashida**, *Journal of Materials Science*, Available online December 22, 2007, DOI: 10.1007/s10853-007-2029-4, http://www.springerlink.com/content/116857412745p8l3/?p=bc1e6c1e9a1f478a80629085f14f242d&pi=1. (Subscription required.)

March 2008

"Effect of coal properties on CO_2 sorption capacity under supercritical conditions." Relationships between coal properties and CO_2 sorption capacity have been investigated for 30 coals from various sources in Australia and elsewhere, selected to cover a wide range of rank and maceral composition. Samples were characterized by their CO_2 sorption capacity, porosity, density and chemical and petrographic composition. Carbon dioxide adsorption isotherms were measured on dry coal at 53 [degrees Celsius] and at pressures up 16 MPa using a gravimetric apparatus. Isotherms were fitted to a modified Dubinin–Radushkevich (DR) model using gas density rather than pressure to enable the model to be applied to supercritical conditions. A term related to Henry's Law to account for gas absorbed by the coal is also included in the model. This model provided excellent fits to the experimental data; in most cases the difference between the predicted and measured value was less than 1 [percent] of the sorption capacity over the entire pressure range. Sorption capacities of the coals investigated were found to vary by over a factor of 2, even when comparing on a dry-ash-free basis. Carbon dioxide sorption capacity tended to reduce with rank to reach a minimum that corresponded to a vitrinite

reflectance of about 1.2 [percent] after which it began to increase. Increasing hydrogen content tended to result in a decrease in sorption capacity. Two of the coals showed significantly higher sorption capacity than any of the other samples examined. In both of these cases, the coals had been naturally weathered and exhibited high porosity relative to the other samples. In general, however, the correlations observed were quite weak with considerable scatter in the data. This implies that CO_2 sorption capacity, required for assessing sequestration potential, cannot be reliably inferred from the coal properties investigated here. **Stuart Day, Greg Duffy, Richard Sakurovs and Steve Weir,** *International Journal of Greenhouse Gas Control*, Available online December 4, 2007, doi:10.1016/S1750-5836(07)00120-X, http://www.sciencedirect.com/science/article/B83WP-4R8PNX1-1/2/fed79a15dc708c2775daf2337d18f734. (Subscription may be required.)

April 2008

"Competitive adsorption equilibria of CO_2 and CH_4 on a dry coal." Gases like CO_2 and [methane (CH_4)] are able to adsorb on the coal surface, but also to dissolve into its structure causing the coal to swell. In this work, the binary adsorption of CO_2 and CH_4 on a dry coal (Sulcis Coal Province, Italy) and its swelling behavior are investigated. The competitive adsorption measurements are performed at 45 Â [degrees Celsius] and up to 190 bar for pure CO_2, CH_4 and four mixtures of molar feed compositions of 20.0, 40.0, 60.0 and 80.0 [percent] CO_2 using a gravimetric-chromatographic technique. The results show that [CO_2] adsorbs more favorably than methane leading to an enrichment of the fluid phase in CH_4. Coal swelling is determined using a high-pressure view cell, by exposing a coal disc to CO_2, CH_4 and He at 45 and 60 Â [degrees Celsius] and up to 140 bar. For CO_2 and CH_4 a maximum swelling of about 4 and 2 [percent] is found, whereas He shows negligible swelling. The presented adsorption and swelling data are then discussed in terms of fundamental, thermodynamic aspects of adsorption and properties which are crucial for an ECBM operation, i.e. the CO_2 storage capacity and the dynamics of the replacement of CH_4 by CO_2. **Stefan Ottiger, Ronny Pini, Giuseppe Storti, and Marco Mazzotti**, *Adsorption*, Available online March 5, 2008, DOI: 10.1007/s10450-008-9114-0, http://www.springerlink.com/content/1676n04035452u21/?p=0a38ca0344ec4e27bccf38189bd5f7c1&pi.

May 2008

"A method for quick assessment of CO_2 storage capacity in closed and semi-closed saline formations." Saline aquifers of high permeability bounded by overlying/underlying seals may be surrounded laterally by low-permeability zones, possibly caused by natural heterogeneity and/or faulting. Carbon dioxide (CO_2) injection into and storage in such "closed" systems with impervious seals, or "semi-closed" systems with non-ideal (low permeability) seals, is different from that in "open" systems, from which the displaced brine can easily escape laterally. In closed or semi-closed systems, the pressure buildup caused by continuous industrial-scale CO_2 injection may have a limiting effect on CO_2 storage capacity, because geomechanical damage caused by overpressure needs to be avoided. In this research, a simple analytical method was developed for the quick assessment of the CO_2 storage capacity in such closed and semi-closed systems. This quick-assessment method is based on the fact that native brine (of an equivalent volume) displaced by the cumulative injected CO_2 occupies additional pore volume within the storage formation and the seals, provided by pore and brine compressibility in response to pressure buildup. With non-ideal seals, brine may also leak through the seals into overlying/underlying formations. The quick-assessment method calculates these brine displacement contributions in response to an estimated average pressure buildup in the storage reservoir. The CO_2 storage capacity and the transient domain-averaged pressure buildup estimated through the quick-assessment method were compared with the "true" values obtained using detailed numerical simulations of CO_2 and brine transport in a two-dimensional radial system. The good agreement indicates that the proposed method can produce reasonable approximations for storage–formation–seal systems of various geometric and hydrogeological properties. **Quanlin Zhou, Jens T. Birkholzer, Chin-Fu Tsang and Jonny Rutqvist**, *International Journal of Greenhouse Gas Control*, Available online March 21, 2008,

doi:10.1016/j.ijggc.2008.02.004, http://www.sciencedirect.com/science/article/B83WP-4S3P8H1-1/2/fc763c66646cd0191604c6ca29933710. (Subscription may be required.)

June 2008

"Carbon dioxide storage potential of shales." Options for the geologic storage of carbon dioxide vary from saline aquifers and depleted oil and gas reservoirs to unminable coal seams and abandoned coal mines. Important aspects include the sealing integrity of the cap rock and potential changes in this integrity, owing to the interaction with CO_2. In this study, diffusive transport and gas sorption experiments on one well characterized shale sample (Muderong Shale, Australia) and on different clay minerals were performed to obtain information on the sealing integrity and the CO_2 storage potential of these materials. All measurements were performed under reservoir conditions relevant for CO_2 storage (T = 45–50 [degrees Celsius]; p < 20 MPa). Repeat diffusion experiments on one shale plug yielded increased effective diffusion coefficients and a decrease in the concentration of the bulk CO_2 volume in the sample. The latter is believed to be dissolved in formation water, sorbed to mineral surfaces or involved with geochemical reactions. For the Muderong Shale, bulk volume CO_2 concentrations are greater within the experimental time frame (222–389 mol/m^3), when compared to coal and cemented sandstone (3–4 and 8–10 mol/ m^3), respectively. This high CO_2 storage potential could not fully be explained by CO_2 dissolution in water alone. Thus, gas sorption experiments were performed on crushed shale and various clay minerals. High CO_2 sorption capacities (e.g. up to 1 mmol/g for the Muderong Shale) show that the high CO_2 concentration is related to a combination of CO_2 dissolution in water and gas sorption on clay minerals. Additionally, changes in specific surface areas before and after the sorption experiments and variations in the CO_2 sorption and diffusion behavior due to repetitive experiments on the identical sample were observed, possibly related to geochemical alteration of the Muderong Shale and the clay minerals. These could not be quantified however and seemed to occur only at high pressures. Results obtained in this study provide a more positive view on the sealing integrity of intact cap rock formations. Carbon dioxide that migrates from a storage reservoir into the cap rock through the pore network will be immobilized to a certain extent, hence minimizing (slow, diffusion-driven) leakage and providing additional CO_2 storage potential. **Andreas Busch, Sascha Alles, Yves Gensterblum, Dirk Prinz, David N. Dewhurst, Mark D. Raven, Helge Stanjek and Bernhard M. Krooss**, *International Journal of Greenhouse Gas Control*, Available online April 24, 2008, doi:10.1016/j.ijggc.2008.03.003, http://www.sciencedirect.com/science/article/B83WP-4SBYYNJ-1/1/b13d83473d16bd1d994795f097bb3f56. (Subscription may be required.)

"Sequestration of Dissolved CO_2 in the Oriskany Formation." Experiments were conducted to determine the solubility of CO_2 in a natural brine solution of the Oriskany formation under elevated temperature and pressure conditions. These data were collected at temperatures of 22 and 75 [degrees Celsius] and pressures between 100 and 450 bar. Experimentally determined data were compared with CO_2 solubility predictions using a model developed by Duan and Sun (*Chem. Geol.* 2003, *193*, 257−271). Model results compare well with Oriskany brine CO_2 solubility data collected experimentally, suggesting that the Duan and Sun model is a reliable tool for estimating solution CO_2 capacity in high salinity aquifers in the temperature and pressure range evaluated. The capacity for the Oriskany formation to sequester dissolved CO_2 was calculated using results of the solubility models, estimation of the density of CO_2 saturated brine, and available geographic information system (GIS) information on the formation depth and thickness. Results indicate that the Oriskany formation can hold approximately 0.36 gigatonnes of dissolved CO_2 if the full basin is considered. When only the region where supercritical CO_2 can exist (temperatures greater than 31 [degrees Celsius] and pressures greater than 74 bar) is considered, the capacity of the Oriskany formation to sequester dissolved CO_2 is 0.31 gigatonnes. The capacity estimate considering the potential to sequester free-phase supercritical CO_2 if brine were displaced from formation pore space is 8.8 gigatonnes in the Oriskany formation. **Robert M. Dilmore, Douglas E. Allen, J. Richard McCarthy Jones, Sheila W. Hedges, and Yee Soong**, *Environmental Science & Technology*, Available online February 9, 2008, doi:10.1021/es702229f, http://pubs.acs.org/cgi-bin/abstract.cgi/esthag/2008/42/i08/abs/es702229f.html. (Subscription required.)

July 2008

"Intermediate storage of carbon dioxide in geological formations: A technical perspective." The following is the abstract of this article: "Enhanced oil recovery (EOR) through CO_2 flooding has been practiced on a commercial basis for the last 35 years and continues today at several sites, currently injecting in total over 30 million tons of CO_2 annually. This practice is currently exclusively for economic gain, but can potentially contribute to the reduction of emissions of greenhouse gases provided it is implemented on a large scale. Optimal operations in distributing CO_2 to CO_2-EOR or enhanced gas recovery (EGR) projects (referred to here collectively as CO_2-EHR) on a large scale and long time span imply that intermediate storage of CO_2 in geological formations may be a key component. Intermediate storage is defined as the storage of CO_2 in geological media for a limited time span such that the CO_2 can be sufficiently reproduced for later use in CO_2-EHR. This paper investigates the technical aspects, key individual parameters and possibilities of intermediate storage of CO_2 in geological formations aiming at large scale implementation of carbon dioxide capture and storage (CCS) for deep emission reduction. The main parameters are thus the depth of injection and density, CO_2 flow and transport processes, storage mechanisms, reservoir heterogeneity, the presence of impurities, the type of the reservoirs and the duration of intermediate storage. Structural traps with no flow of formation water combined with proper injection planning such as gas-phase injection favor intermediate storage in deep saline aquifers. In depleted oil and gas fields, high permeability, homogeneous reservoirs with structural traps (e.g. anticlinal structures) are good candidates for intermediate CO_2 storage. Intuitively, depleted natural gas reservoirs can be potential candidates for intermediate storage of carbon dioxide due to similarity in storage characteristics." **Semere Solomon, Michael Carpenter and Todd Allyn Flach**, *International Journal of Greenhouse Gas Control*, Available online May 20, 2008, doi:10.1016/j.ijggc.2008.04.004, http://www.sciencedirect.com/science/article/B83WP-4SJGWYJ-2/1/5fbe2f7b28fe54d48c43ec6825849e03. (Subscription may be required.)

August 2008

"The role of optimality in characterizing CO_2 seepage from geologic carbon sequestration sites." Storage of large amounts of carbon dioxide (CO_2) in deep geologic formations for greenhouse-gas mitigation is gaining momentum and moving from its conceptual and testing stages toward widespread application. In this work [the authors] explore various optimization strategies for characterizing surface leakage (seepage) using near-surface measurement approaches such as accumulation chambers and eddy covariance towers. Seepage characterization objectives and limitations need to be defined carefully from the outset especially in light of large natural background variations that can mask seepage. The cost and sensitivity of seepage detection are related to four critical length scales pertaining to the size of the: (1) region that needs to be monitored; (2) footprint of the measurement approach, (3) main seepage zone; [and] (4) region in which concentrations or fluxes are influenced by seepage. Seepage characterization objectives may include one or all of the tasks of detecting, locating, and quantifying seepage. Each of these tasks has its own optimal strategy. Detecting and locating seepage in a region in which there is no expected or preferred location for seepage nor existing evidence for seepage requires monitoring on a fixed grid, e.g., using eddy covariance towers. The fixed-grid approaches needed to detect seepage are expected to require large numbers of eddy covariance towers for large-scale geologic CO_2 storage. Once seepage has been detected and roughly located, seepage zones and features can be optimally pinpointed through a dynamic search strategy, e.g., employing accumulation chambers and/or soil-gas monitoring. Quantification of seepage rates can be done through measurements on a localized fixed grid once the seepage is pinpointed. Background measurements are essential for seepage detection in natural ecosystems. Artificial neural networks are considered as regression models useful for distinguishing natural system behavior from anomalous behavior suggestive of CO_2 seepage without need for detailed understanding of natural system processes. Because of the local extrema in CO_2 fluxes and concentrations in natural systems, simple steepest-descent algorithms are not effective and evolutionary computation algorithms are proposed as a paradigm for dynamic monitoring networks to pinpoint CO_2 seepage areas. **Andrea Cortis, Curtis M. Oldenburg and Sally M.**

Benson, *International Journal of Greenhouse Gas Control*, Available online June 9, 2008, doi:10.1016/j.ijggc.2008.04.008, http://www.sciencedirect.com/science/article/B83WP-4SPSPRR-1/1/7bb902e2fa88083c81e3249fe1d63517. (Subscription may be required.)

"Assessing geochemical carbon management." The challenge of reversing rising atmospheric CO_2 concentrations is growing with the continued expansion of CO_2-emitting energy infrastructure throughout the world and with the lack of coordinated, effective measures to manage and reduce emissions. Given this situation, it is prudent for society to explore all potential carbon management options, including those with seemingly low probability for success. Recent initiatives for advancing and enhancing carbon storage options have focused primarily on the physical trapping of CO_2 in underground geologic formations and on the biological uptake of CO_2; less attention has been given to approaches that rely primarily on geochemical reactions that enhance transformation of CO_2 gas into dissolved or solid phase carbon by liberating cations to neutralize carbonic acid. This paper provides a structured review of the technical status of these geochemical approaches, and also presents a simple framework for assessing the potential and limitations of various proposed geochemical approaches to assist prioritizing future research in this area. Despite major limitations, geochemical approaches have unique potential to contribute to CO_2 reductions in ways that neither physical nor biological carbon storage can by allowing for the direct removal of CO_2 from the atmosphere with minimal requirements for integrating with existing infrastructure. Recognizing the severity and urgency of the need for carbon management options, [the authors] argue for an increase in research activity related to geochemical approaches to carbon management. **Jennie C. Stephens and David W. Keith**, *Climatic Change*, Available online June 24, 2008, DOI:10.1007/s10584-008-9440-y, http://www.springerlink.com/content/85838m000280xl77/?p=79160e5a36774749841cb0ee51c24be1&pi=5. (Subscription required.)

Technology

September 2007

"CO_2 capture by adsorption with nitrogen enriched carbons." The success of CO_2 capture with solid sorbents is dependent on the development of a low cost sorbent with high CO_2 selectivity and adsorption capacity. Immobilized amines are expected to offer the benefits of liquid amines in the typical absorption process, with the added advantages that solids are easy to handle and that they do not give rise to corrosion problems. In this work, different alkylamines were evaluated as a potential source of basic sites for CO_2 capture, and a commercial activated carbon was used as a preliminary support in order to study the effect of the impregnation. The amine coating increased the basicity and nitrogen content of the carbon. However, it drastically reduced the microporous volume of the activated carbon, which is chiefly responsible for CO_2 physisorption, thus decreasing the capacity of raw carbon at room temperature. **M.G. Plaza, C. Pevida, A. Arenillas, F. Rubiera and J.J. Pis,** *Fuel,* Published online July 2, 2007, doi:10.1016/j.fuel.2007.06.001, http://www.sciencedirect.com/science/article/B6V3B-4P3KYKW-1/2/8ae9e8eecebc889199c179357f27b505. (Subscription may be required.)

October 2007

"Performance of immobilized tertiary amine solid sorbents for the capture of carbon dioxide." The capture of carbon dioxide (CO_2) from a simulated flue gas stream was achieved by utilizing immobilized tertiary amine solid sorbents. The tertiary amine immobilized in these solid substrates was 1, 8 Diazabicyclo-[5.4.0]-undec-7-ene (DBU) and it has the stoichiometric capability of capturing carbon dioxide at a 1:1 R-NH_2:CO_2 molar ratio. This is a unique feature compared to other primary and secondary amines which capture CO_2 at a 2:1 molar ratio, thus making the immobilized DBU solid sorbents competitive with existing commercially available sorbents and liquid amine-based capture

systems. The immobilized DBU solid sorbents prepared in this study exhibit acceptable CO_2 capture capacities of 3.0 mol CO_2/kg sorbent at 25 [degrees Celsius]; however, at the critical operational temperature of 65 [degrees Celsius], the capacity was reduced to 2.3 mol/kg sorbent. The DBU sorbents did exhibit acceptable stability over the adsorption/desorption temperature range of 25–90 [degrees Celsius] based on XPS [X-ray photoelectron spectroscopy] and TGA [Thermogravimetric analysis] analyses. **M.L. Gray, K.J. Champagne, D. Fauth, J.P. Baltrus and Henry Pennline,** International *Journal of Greenhouse Gas Control,* Available online August 22, 2007, doi:10.1016/S1750-5836(07)00088-6, http://www.sciencedirect.com/science/article/B83WP-4PGH839-1/2/fcbae8bbe7648c2ef8f54b433dd903ec. (Subscription may be required.)

"A model for the CO_2 capture potential." Global warming is a result of increasing anthropogenic CO_2 emissions, and the consequences will be dramatic climate changes if no action is taken. One of the main global challenges in the years to come is therefore to reduce the CO_2 emissions. Increasing energy efficiency and a transition to renewable energy as the major energy source can reduce CO_2 emissions, but such measures can only lead to significant emission reductions in the long-term. Carbon capture and storage (CCS) is a promising technological option for reducing CO_2 emissions on a shorter time scale. A model to calculate the CO_2 capture potential has been developed, and it is estimated that 25 billion tonnes CO_2 can be captured and stored within the EU by 2050. Globally, 236 billion tonnes CO_2 can be captured and stored by 2050. The calculations indicate that wide implementation of CCS can reduce CO_2 emissions by 54 [percent] in the EU and 33 [percent] globally in 2050 compared to emission levels today. Such a reduction in emissions is not sufficient to stabilize the climate. Therefore, the strategy to achieve the necessary CO_2 emissions reductions must be a combination of (1) increasing energy efficiency, (2) switching from fossil fuel to renewable energy sources, and (3) wide implementation of CCS. **Aage Stangeland,** *International Journal of Greenhouse Gas Control,* Available online August 9, 2007, doi:10.1016/S1750-5836(07)00087-4 , http://www.sciencedirect.com/science/article/B83WP-4PCR1YB-1/2/d9089a5c4fce446272a34780a6426660#sec8. (Subscription may be required.)

November 2007

"Advances in CO_2 capture technology—The U.S. Department of Energy's Carbon Sequestration Program." There is growing concern that anthropogenic carbon dioxide (CO_2) emissions are contributing to global climate change. Therefore, it is critical to develop technologies to mitigate this problem. One very promising approach to reducing CO_2 emissions is CO_2 capture at a power plant, transport to an injection site, and sequestration for long-term storage in any of a variety of suitable geologic formations. However, if the promise of this approach is to come to fruition, capture costs will have to be reduced. The Department of Energy's Carbon Sequestration Program is actively pursuing this goal. CO_2 capture from coal-derived power generation can be achieved by various approaches: post-combustion capture, pre-combustion capture, and oxy-combustion. All three of these pathways are under investigation, some at an early stage of development. A wide variety of separation techniques is being pursued, including gas phase separation, absorption into a liquid, and adsorption on a solid, as well as hybrid processes, such as adsorption/membrane systems. Current efforts cover not only improvements to state-of-the-art technologies but also development of several innovative concepts, such as metal organic frameworks, ionic liquids, and enzyme-based systems. This paper discusses the current status of the development of CO_2 capture technology. **José D. Figueroa, Timothy Fout, Sean Plasynski, Howard McIlvried and Rameshwar D. Srivastava,** *International Journal of Greenhouse Gas Control,* Available online September 17, 2007, doi:10.1016/S1750-5836(07)00094-1, http://www.sciencedirect.com/science/article/B83WP-4PP201T-1/2/ea6e3a43ec03a55cc371a4d1a9ece690. (Subscription may be required.)

December 2007

"Should a Coal-Fired Power Plant be Replaced or Retrofitted?" In a cap-and-trade system, a power plant operator can choose to operate while paying for the necessary emissions allowances, retrofit emissions controls to the plant, or replace the unit with a new plant. Allowance prices are uncertain, as are the timing and stringency of requirements for control of mercury and carbon emissions. [The authors] model the evolution of allowance prices for SO_2, NO_x, Hg, and CO_2 using geometric Brownian motion with drift, volatility, and jumps, and use an options-based analysis to find the value of the alternatives. In the absence of a carbon price, only if the owners have a planning horizon longer than 30 years would they replace a conventional coal-fired plant with a high-performance unit such as a supercritical plant; otherwise, they would install SO_2 and NO_x controls on the existing unit. An expectation that the CO_2 price will reach $50/t in 2020 makes the installation of an IGCC with carbon capture and sequestration attractive today, even for planning horizons as short as 20 years. A carbon price below $40/t is unlikely to produce investments in carbon capture for electric power. **Dalia Patiño-Echeverri, Benoit Morel, Jay Apt, and Chao Chen**, *Environmental Science Technology,* Available online: October 17, 2007, DOI: 10.1021/es0711009, http://pubs.acs.org/cgi-bin/abstract.cgi/esthag/asap/abs/es0711009.html. (Subscription required.)

January 2008

"Electric Swing Adsorption for CO_2 removal from flue gases." One of the most important sources of CO_2 emissions are the fossil-fuel fired plants for production of electricity. Removal of CO_2 from flue gas streams for further sequestration has been proposed by the International Panel on Climate Change experts as one of the most reliable solutions to mitigate anthropogenic greenhouse emissions. When natural gas is employed as fuel, the molar fraction of CO_2 in the flue gas is lower than 5 [percent] causing serious problems for capture. The purpose of this work is to present experimental validation of an Electric Swing Adsorption (ESA) technology that may be employed for carbon capture for low molar fractions of CO_2 in the flue gas streams. To improve energy utilization, an activated carbon honeycomb monolith with low electrical resistivity was employed as selective adsorbent. A mathematical model for this honeycomb is proposed as well as different ESA cycles for CO_2 capture. **Carlos A. Grande and Alírio E. Rodrigues**, *International Journal of Greenhouse Gas Control*, Available online: November 5, 2007, doi:10.1016/S1750-5836(07)00116-8, http://www.sciencedirect.com/science/article/B83WP-4R2H23Y-1/2/ba3405c358651be811400f5ecd01b877.

"An engineering-economic model of pipeline transport of CO_2 with application to carbon capture and storage." Carbon dioxide capture and storage (CCS) involves the capture of CO_2 at a large industrial facility, such as a power plant, and its transport to a geological (or other) storage site where CO_2 is sequestered. Previous work has identified pipeline transport of liquid CO_2 as the most economical method of transport for large volumes of CO_2. However, there is little published work on the economics of CO_2 pipeline transport. The objective of this paper is to estimate total cost and the cost per tonne of transporting varying amounts of CO_2 over a range of distances for different regions of the continental United States. An engineering-economic model of pipeline CO_2 transport is developed for this purpose. The model incorporates a probabilistic analysis capability that can be used to quantify the sensitivity of transport cost to variability and uncertainty in the model input parameters. The results of a case study show a pipeline cost of US$ 1.16 per tonne of CO_2 transported for a 100 km pipeline constructed in the Midwest handling 5 million tonnes of CO_2 per year (the approximate output of an 800 MW coal-fired power plant with carbon capture). For the same set of assumptions, the cost of transport is US$ 0.39 per tonne lower in the Central US and US$ 0.20 per tonne higher in the Northeast US. Costs are sensitive to the design capacity of the pipeline and the pipeline length. For example, decreasing the design capacity of the Midwest US pipeline to 2 million tonnes per year increases the cost to US$ 2.23 per tonne of CO_2 for a 100 km pipeline, and US$ 4.06 per tonne CO_2 for a 200 km pipeline. An illustrative probabilistic analysis assigns uncertainty distributions to the pipeline capacity factor, pipeline inlet pressure, capital recovery factor, annual O&M cost, and escalation factors for capital cost components. The result indicates a 90 [percent] probability that the cost per tonne of CO_2 is between US$ 1.03 and US$ 2.63 per tonne of CO_2 transported in the Midwest US. In this case, the transport cost is shown to be most

sensitive to the pipeline capacity factor and the capital recovery factor. The analytical model elaborated in this paper can be used to estimate pipeline costs for a broad range of potential CCS projects. It can also be used in conjunction with models producing more detailed estimates for specific projects, which requires substantially more information on site-specific factors affecting pipeline routing. **Sean T. McCoy and Edward S. Rubin**, *International Journal of Greenhouse Gas Control*, Available online: November 19, 2007, doi:10.1016/S1750-5836(07)00119-3, http://www.sciencedirect.com/science/article/B83WP-4R5G8M6-4/2/9979191aebc06d41927bf47ee5ff743e.

February 2008

"Fast CO_2 sequestration by aerogel composites." The increasingly evident impact of anthropogenic CO_2 emissions on climate change and associated environmental effects is stimulating the search for viable methods to remove this gas. One of the most promising strategies is the long-term storage of CO_2 in inert, insoluble and thermodynamically-stable materials. This strategy mimics the natural reactions that transform silicates into carbonates regulating the cycle of CO_2 on the surface of the Earth, operating on a geological time-scale. Consequently, the aim is to accelerate these reactions to be applicable on the timescale of human lives. [The authors] present the various technologies developed or proposed to date, based on this particular approach. The principal limiting factor is that high pressures and temperatures are required to produce appropriate materials capable of CO_2 sequestration and storage. Nevertheless, the synthetic materials known as aerogels can be modified in shape, size and chemical functionality so as to catalyze the process of CO_2 elimination through silicates (of Ca or Mg), considerably reducing the reaction time and working at atmospheric pressure and temperature. **Alberto Santos, Mohamed Ajbary, Abdelhak Kherbeche, Manuel Piñero, N. De la Rosa-Fox and Luis Esquivias**, *Journal of Sol-Gel Science and Technology*, Available online December 25, 2007, DOI:10.1007/s10971-007-1672-1, http://www.springerlink.com/content/w23315054r0422v6/?p=fdce916b125f45e1b45bdaf04e1882ae&pi=1. (Subscription required.)

"Cycle Development and Design for CO_2 Capture from Flue Gas by Vacuum Swing Adsorption." CO_2 capture and storage is an important component in the development of clean power generation processes. One CO_2 capture technology is gas-phase adsorption, specifically pressure (or vacuum) swing adsorption. The complexity of these processes makes evaluation and assessment of new adsorbents difficult and time-consuming. In this study, [the authors] have developed a simple model specifically targeted at CO_2 capture by pressure swing adsorption and validated our model by comparison with data from a fully instrumented pilot-scale pressure swing adsorption process. The model captures non-isothermal effects as well as nonlinear adsorption and nitrogen coadsorption. Using the model and our apparatus, [the authors] have designed and studied a large number of cycles for CO_2 capture. [The authors] demonstrate that by careful management of adsorption fronts and assembly of cycles based on understanding of the roles of individual steps, [the authors] are able to quickly assess the effect of adsorbents and process parameters on capture performance and identify optimal operating regimes and cycles. [The authors] recommend this approach in contrast to exhaustive parametric studies which tend to depend on specifics of the chosen cycle and adsorbent. [The authors] show that appropriate combinations of process steps can yield excellent process performance and demonstrate how the pressure drop, and heat loss, etc. affect process performance through their effect on adsorption fronts and profiles. Finally, cyclic temperature profiles along the adsorption column can be readily used to infer concentration profiles − this has proved to be a very useful tool in cyclic function definition. [The authors'] research reveals excellent promise for the application of pressure/vacuum swing adsorption technology in the arena of CO_2 capture from flue gases. **Jun Zhang and Paul A. Webley**, *Environmental Science & Technology,* Available online December 7, 2007, DOI:10.1021/es0706854, http://pubs.acs.org/cgi-bin/abstract.cgi/esthag/2008/42/i02/abs/es0706854.html. (Subscription required.)

March 2008

"Capture of CO_2 from high humidity flue gas by vacuum swing adsorption with zeolite 13X." Capture of CO_2 from flue gas streams using adsorption processes must deal with the prospect of high humidity streams containing bulk CO_2 as well as other impurities such as SOx, NOx, etc. Most studies to date have ignored this aspect of CO_2 capture. In this study, we have experimentally examined the capture of CO_2 from a 12 [percent] synthetic flue gas stream at a relative humidity of 95 [percent] at 30 [degrees Celsius]. A 13X adsorbent was used and the migration of the water and its subsequent impact on capture performance was evaluated. Binary breakthrough of CO_2/water vapor was performed and indicated a significant effect of water on CO_2 adsorption capacity, as expected. Cyclic experiments indicate that the water zone migrates a quarter of the way into the column and stabilizes its position so that CO_2 capture is still possible although decreased. The formation of a water zone creates a "cold spot" which has implications for the system performance. The recovery of CO_2 dropped from 78.5 [percent] to 60 [percent] when moving from dry to wet flue gas while the productivity dropped by 22 [percent]. Although the concentration of water leaving the bed under vacuum was 27 [percent] (vol), the low vacuum pressure prevented condensation of water in this stream. However, the vacuum pump acted as a condenser and separator to remove bulk water. An important consequence of the presence of a water zone was to elevate the vacuum level thereby reducing CO_2 working capacity. Thus although there is a detrimental effect of water on CO_2 capture, long term recovery of CO_2 is still possible in a single VSA process. Pre-drying of the flue gas steam is not required. However, careful consideration of the impact of water and accommodation thereof must be made particularly when the feed stream temperature increases resulting in higher feed water concentration. **Gang Li, Penny Xiao, Paul Webley, Jun Zhang, Ranjeet Singh and Marc Marshall**, *Adsorption*, Available online January 16, 2008, DOI: 10.1007/s10450-007-9100-y, http://www.springerlink.com/content/343150385122754x/?p=07dbd91f560f4dd597c93aa7542cc9b1&pi=2. (Subscription required.)

"Infrared monitoring of underground CO_2 storage using chalcogenide glass fibers." An optical-fiber-based system suitable for monitoring the presence of carbon dioxide, so-called "greenhouse gas", is investigated. Since each pollutant gas shows a characteristic optical absorption spectrum in the mid-infrared (mid-IR), it is possible to detect selectively and quantitatively the presence of gases in a given environment by analyzing mid-IR spectra. The main infrared signature of carbon dioxide gas is a double absorption peak located at 4.2 μm. Chalcogenide optical fibers, which can transmit light in the 1–6 μm range, are well-adapted for CO_2 analysis. In this wavelength range, they show attenuation losses that compare favorably with other types of fiber such as silver halide fibers. In this paper, the detection limit of CO_2 is established as a function of optical path length. The dynamic parameters of the sensors, such as reversibility, response time and recovery time, are also studied. It is concluded that optical fibers based on chalcogenide glasses could be used to transport infrared light from a black body source to a remote CO_2 geological storage zone in order to monitor, in real time, CO_2 gas leakage. **Frédéric Charpentier, Bruno Bureau, Johann Troles, Catherine Boussard-Plédel, Karine Michel-Le Pierrès, Frédéric Smektala and Jean-Luc Adam,** *Optical Materials*, Available online January 30, 2008, doi:10.1016/j.optmat.2007.10.014, http://www.sciencedirect.com/science/article/B6TXP-4RPVJ1T-3/2/dd503718e8de6c01fbc829496d947048. (Subscription may be required.)

April 2008

"Atmospheric monitoring and verification technologies for CO_2 geosequestration." The paper describes various techniques for measuring emissions to the atmosphere from geologically stored carbon dioxide, from point, line and area sources at scales of meters to several kilometers. Flux chambers are suitable for measuring small leakage rates from sources at known locations but many samples are required because of large spatial heterogeneity in the fluxes. Micrometeorological eddy covariance, relaxed eddy accumulation and flux-gradient techniques are suitable for measuring leakage from large area sources, while integrated horizontal mass balance, tracer methods and plume dispersion

approaches are applicable for line and point sources. Distinguishing between leakage signals and natural fluctuations in CO_2 concentrations due to biogenic sources pose significant challenges and the use of naturally occurring tracers such as CO_2 isotopologues or introduced tracers such as SF_6 added to the sequestered CO_2 will assist with this problem. Forward Lagrangian dispersion calculations showed that CO_2 concentrations 0–80 m downwind of a point source would be readily detectable above all natural variations for point sources >0.3 g CO_2 s^{-1} (about 10 tonnes of CO_2 per year). The inverse problem involves solving for the unknown emission rate from measured wind fields and down wind concentration perturbations. An optimum monitoring strategy for inverse analysis will require continuous measurements of CO_2 and tracer compounds upwind and downwind of the possible leak location, coupled with transport modeling to determine leakage fluxes, and to differentiate them from other sources. Computations using The air pollution model (TAPM) showed that expected perturbations in CO_2 concentrations at distances of several hundred meters from a leak of 32 g CO_2 s^{-1} (about 1000 tonnes CO_2 per year, or about 0.01 [percent] per year of a typical amount to be stored) will be detectable, but this anomaly will be very small compared to natural variations, thereby complicating the inverse analysis. While the techniques canvassed here have proven successful for measuring fluxes in other applications, none has yet been demonstrated for geosequestration. The next step is to test [these techniques] in the field. **Ray Leuning, David Etheridge, Ashok Luhar and Bronwyn Dunse**, *International Journal of Greenhouse Gas Control*, Available online March 6, 2008, doi:10.1016/j.ijggc.2008.01.002, http://www.sciencedirect.com/science/article/B83WP-4S0HC8N-1/2/8df18b802f791960685c42a32311f29b. (Subscription may be required.)

"Sorbents for CO_2 capture from high carbon fly ashes." Fly ashes with high-unburned-carbon content, referred to as fly ash carbons, are an increasing problem for the utility industry, since they cannot be marketed as a cement extender and, therefore, have to be disposed. Previous work has explored the potential development of amine-enriched fly ash carbons for CO_2 capture. However, their performance was lower than that of commercially available sorbents, probably because the samples investigated were not activated prior to impregnation and, therefore, had a very low surface area. Accordingly, the work described here focuses on the development of activated fly ash derived sorbents for CO_2 capture. The samples were steam activated at 850 [degrees Celsius], resulting in a significant increase of the surface area (1075 m^2/g). The activated samples were impregnated with different amine compounds, and the resultant samples were tested for CO_2 capture at different temperatures. The CO_2 adsorption of the parent and activated samples is typical of a physical adsorption process. The impregnation process results in a decrease of the surface areas, indicating a blocking of the porosity. The highest adsorption capacity at 30 and 70 [degrees Celsius] for the amine impregnated activated carbons was probably due to a combination of physical adsorption inherent from the parent sample and chemical adsorption of the loaded amine groups. The CO_2 adsorption capacities for the activated amine impregnated samples are higher than those previously published for fly ash carbons without activation (68.6 vs. 45 mg CO_2/g sorbent). **M. Mercedes Maroto-Valer, Zhe Lu, Yinzhi Zhang, and Zhong Tang**, *Waste Management*, Available online February 21, 2008, doi:10.1016/j.wasman.2007.10.012, http://www.sciencedirect.com/science/article/B6VFR-4RWHX8W-2/2/8f4752c4d3950d952e354f7afc31ff00. (Subscription may be required.)

May 2008

"Pipeline design for a least-cost router application for CO_2 transport in the CO_2 sequestration cycle." CO_2 capture and geological storage (CCS) is considered as a viable option to mitigate greenhouse gas emissions during the transition phase towards the use of clean and renewable energy. This paper concentrates on the transport of CO_2 between source (CO_2 capture at plants) and sink (geological storage reservoirs). In the cost estimation of CO_2 transport, the pipeline diameter plays an important role. In this respect, the paper reviews equations that were used in several reports on CO_2 pipeline transport. As some parameters are not taken into account in these equations, alternative formulas are proposed which calculate the proper inner diameter size based on flow rate, pressure drop

per unit length, CO_2 density, CO_2 viscosity, pipeline material roughness and topographic height differences (the Darcy–Weisbach solution) and, in addition, on the amount and type of bends (the Manning solution). Comparison between calculated diameters using the reviewed and the proposed equations demonstrate the important influence of elevation difference (which is not considered in the reviewed equations) and pipeline material roughness-related factor on the calculated diameter. Concerning the latter, it is suggested that a Darcy–Weisbach roughness height of 0.045 mm better corresponds to a Manning factor of 0.009 than higher Manning values previously proposed in literature. Comparison with the actual diameter of the Weyburn pipeline confirms the accuracy of the proposed equations. Comparison with other existing CO_2 pipelines (without pressure information) indicate that the pipelines are designed for lower pressure gradients than 25 Pa/m or for (future) higher flow rates. The proposed Manning equation is implemented in an economic least-cost route planner in order to obtain the best economic solution for pipeline trajectory and corresponding diameter. **V. Vandeginste and K. Piessens**, *International Journal of Greenhouse Gas Control*, Available online March 17, 2008, doi:10.1016/j.ijggc.2008.02.001, http://www.sciencedirect.com/science/article/B83WP-4S2VG6V-1/2/d001a8db2783a44c86b12251d19be3ad. (Subscription may be required.)

"Implications of generator siting for CO_2 pipeline infrastructure." The location of a new electric power generation system with carbon capture and sequestration (CCS) affects the profitability of the facility and determines the amount of infrastructure required to connect the plant to the larger world. Using a probabilistic analysis, [the authors] examine where a profit-maximizing power producer would locate a new generator with carbon capture in relation to a fuel source, electric load, and CO_2 sequestration site. Based on models of costs for transmission lines, CO_2 pipelines, and fuel transportation, [the authors] find that it is always preferable to locate a CCS power facility nearest the electric load, reducing the losses and costs of bulk electricity transmission. This result suggests that a power system with significant amounts of CCS requires a very large CO_2 pipeline infrastructure. **Adam Newcomer and Jay Apt**, *Energy Policy*, Available online March 14, 2008, doi:10.1016/j.enpol.2008.01.038, http://www.sciencedirect.com/science/article/B6V2W-4S26K5P5/2/2168a29dc95f0e05ceb33b20ee3479fe. (Subscription may be required.)

June 2008

"Monitoring of CO_2 plumes during storage in geological formations using temperature signals: Numerical investigation." Carbon dioxide (CO_2) injection into a storage formation is accompanied by non-isothermal effects. These are caused by a CO_2 injection temperature that does not correspond to the formation temperature, cooling of the carbon dioxide due to expansion (Joule–Thomson cooling) and heat of dissolution of CO_2 in brine. During flow in the subsurface, the carbon dioxide transports energy (advective heat transport) and undergoes an equilibrating process between temperature differences (heat conduction). These non-isothermal processes can be used for the purpose of monitoring the CO_2 plume propagation in the subsurface. Temperature sensors at monitoring wells at a certain distance from the injection well can detect temperature changes and give information about the CO_2 flow in the storage site. In this study, a numerical multi-phase simulation program is used to investigate the non-isothermal effects during CO_2 injection into a storage formation. The feasibility of using temperature measurements for the observation of the carbon dioxide plume in the reservoir is addressed. Various thermal processes and their dependency on the geological characterization of the reservoir are discussed in detail. **Andreas Bielinski, Andreas Kopp, Hartmut Schütt and Holger Class**, *International Journal of Greenhouse Gas Control*, Available online April 18, 2008, doi:10.1016/j.ijggc.2008.02.008, http://www.sciencedirect.com/science/article/B83WP-4S9R231-1/1/370898aa9af83be639fb8b86661bdd64. (Subscription may be required.)

July 2008

"Modeling of carbon sequestration in coal-beds: A variable saturated simulation." Storage of carbon dioxide in deep coal seams is a profitable method to reduce the concentration of green house gases in the atmosphere while the methane as a byproduct can be extracted during carbon dioxide injection into the coal seam. In this procedure, the key element is to keep carbon dioxide in the coal seam without escaping for a long term. It is depended on many factors such as properties of coal basin, fracture state, phase equilibrium, etc., especially the porosity, permeability and saturation of the coal seam. In this paper, a variable saturation model was developed to predict the capacity of carbon dioxide sequestration and coal-bed methane recovery. This variable saturation model can be used to track the saturation variability with the partial pressures change caused by carbon dioxide injection. Saturation variability is a key factor to predict the capacity of carbon dioxide storage and methane recovery. Based on this variable saturation model, a set of related variables including capillary pressure, relative permeability, porosity, coupled adsorption model, concentration and temperature equations were solved. From results of the simulation, historical data agree with the variable saturation model as well as the adsorption model constructed by Langmuir equations. The Appalachian basin, as an example, modeled the carbon dioxide sequestration in this paper. The results of the study and the developed models can provide the projections for the CO_2 sequestration and methane recovery in coal-beds within different regional specifics. **Guoxiang Liu and Andrei V. Smirnov**, *Energy Conversion and Management*, Available online April 28, 2008, doi:10.1016/j.enconman.2008.03.007, http://www.sciencedirect.com/science/article/B6V2P-4SCTVNW-4/1/f1e78915263fa188483ea4b3963fe4a6. (Subscription may be required.)

"Techno-economic study of CO_2 capture and storage in coal fired oxygen fed entrained flow IGCC power plants." The attractiveness of fossil fuel as a feedstock for power generation depends on the development of energy conversion systems that are efficient, clean and economical. Coal fired power plants are generally considered to be "dirty" since they have high CO_2 emissions, with the exception of those coal fired power plants that employ CO_2 capture technology. Among the coal fired options, Integrated Gasification Combined Cycle (IGCC) systems have the best environmental performance and are potentially suitable candidates. The objective of this work is to provide an assessment and analysis of the potential for reduction of the output of greenhouse gas from the oxygen fed entrained flow gasifier systems, including the cost and cost-effectiveness of each likely conceptual scheme. The ECLIPSE process simulator was used successfully to perform technical, environmental and economic assessment studies for a wide range of IGCC power generation systems. Two IGCC power generation designs were selected, the Shell dry feed and GE (previously called Texaco) wet feed entrained flow gasifiers. As a reference fuel input, the American Federal coal was also used in IGCC systems. The performance of two IGCC systems was optimized within the constraint of being based on one particular advanced gas turbine and using a subcritical steam system. In this work, several IGCC plant attributes such as the fuel consumption, utility usages, plant performance as well as the specific CO_2 generation and capture rates were simulated and weighed against each other. Factors affecting the IGCC plant performance, specifically net power output, process efficiency, power consumption coming from the Air Separation Unit (ASU) and CO_2 removal and overall emissions were also evaluated and discussed. Finally, an economic evaluation of the system was conducted and the costs of CO_2 capture plus transport are illustrated. This case study shows that the option of using IGCC for capturing CO_2 could be technically feasible and cost-effective. **Y. Huanga, S. Rezvania, D. McIlveen-Wrighta, A. Minchenerb and N. Hewitta,** *Fuel Processing Technology*, Available online May 2, 2008, doi:10.1016/j.fuproc.2008.03.002, http://www.sciencedirect.com/science/article/B6TG3-4SDNK8G-1/1/26d5579ee4cd205d95a127776530de08. (Subscription may be required.)

August 2008

"Impurity impacts on the purification process in oxy-fuel combustion based CO_2 capture and storage system." Based on the requirements of CO_2 transportation and storage, non-condensable gases, such as [oxygen (O_2)], [nitrogen dioxide (N_2)] and [Argon (Ar)] should be removed from the CO_2-stream captured from an oxy-fuel combustion process. For a purification process, impurities have great

impacts on the design, operation and optimization through their impacts on the thermodynamic properties of CO_2-streams. [Study results show that the increments of impurities will increase the energy consumption of purification; and decrease the CO_2 purity of the separation product and CO_2 recovery rate.] In addition, under the same operating conditions, energy consumptions have different sensitivities to the variation of the impurity mole fraction of feed fluids. The isothermal compression is more sensitive to the variation of [sulfur dioxide (SO_2)]; while the isentropic compression is more sensitive to the variation of [Argon]. In the flash system, the energy consumption of condensation is more sensitive to the variation of [Argon]; but in the distillation system, the energy consumption of condensation is more sensitive to the variation of SO_2, and CO_2 purity of separation is more sensitive to the variation of SO_2. **H. Li, J. Yan, J. Yan and M. Anheden**, *Applied Energy*, Available online July 7, 2008, doi:10.1016/j.apenergy.2008.05.006, http://www.sciencedirect.com/science/article/B6V1T-4SXRYH3-1/1/ad9be262beb4584b3310675be6eae250. (Subscription may be required.)

"Geochemical effects of CO_2 sequestration in sandstones under simulated in-situ conditions of deep saline aquifers." The geochemical effects of brine and supercritical CO_2 ($SCCO_2$) on reservoir rocks from deep (1500 to 2000 [meters]) saline aquifers were examined via experimental simulation at in-situ conditions. Dry sandstone samples were mounted in a triaxial cell and autoclave system, evacuated, and saturated with 1 M [sodium chloride (NaCl)] solution. The brine-rock system was allowed to react at 30 [millipascals (MPa)] confining pressure, 15 MPa pore fluid pressure, and 60 [degrees Celsius] while $SCCO_2$ was injected at a pressure gradient of 1-2 MPa. The experiment was conducted for a period of 1496 [hours], during which fluids were periodically sampled and analyzed. The pH measured in partially degassed fluid sample at 25 [degrees Celsius] decreased from a starting value of 7.0 to 4.3 (9 days) and finally 5.1 after saturation with $SCCO_2$. Fluid analyses indicate that most of the major [(e.g. calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn)] and trace elements [(e.g. strontium (Sr), barium (Ba), lead (Pb)] of the sandstone increase in concentration during the reaction with brine and $SCCO_2$. These results are supported by scanning electron microscopy which indicated dissolution of dolomite cement, [potassium] feldspar, and albite. In addition to dissolution reactions the formation of montmorillonite was observed. By adjusting surface area and reaction rates of dissolution and precipitation, geochemical modeling of the experiments could reproduce long-term trends in solution chemistry and indicated limited rates of dissolution as the system remained strongly undersaturated with most minerals, including carbonates. The geochemical models could not account for decreases in concentration of some elements, changes in solution composition resulting from changes in imposed pressure gradient, and the observed Ca/Mg and [silicon/aluminum (Si/Al)] ratios in solution. **M. Wigand, J.W. Carey, H. Schütt, E. Spangenberg and J. Erzinger**, *Applied Geochemistry*, Available online June 25, 2008, doi:10.1016/j.apgeochem.2008.06.006, http://www.sciencedirect.com/science/article/B6VDG-4SV5V50-1/1/a245ece039ba1a57db9662ffbe1a1dd4. (Subscription may be required.)

Terrestrial/Ocean

September 2007

"Evaluation of carbon stock variation in Northern Italian soils over the last 70 years." Carbon (C) sequestration in soils is gaining increasing acceptance as a means of reducing net carbon dioxide (CO_2) emissions to the atmosphere. Numerous studies on the global carbon budget suggest that terrestrial ecosystems in the mid-latitudes of the Northern Hemisphere act as a large carbon sink of atmospheric CO_2. However, most of the soils of North America, Australia, New Zealand, South Africa and Eastern Europe lost a great part of their organic carbon pool on conversion from natural to agricultural ecosystems during the explosion of pioneer agriculture, and in Western Europe the adoption of modern agriculture after the Second World War led to a drastic reduction in soil organic carbon content. The depletion of organic matter is often indicated as one of the main effects on soil, and the storage of organic carbon in the soil is a means of improving the quality of soils and mitigating the effects of

greenhouse gas emission. The soil organic carbon in an area of Northern Italy over the last 70 years has been assessed in this study. The variation of top soil organic carbon (SOC) ranged from −60.3 to +6.7 [percent]; the average reduction of SOC, caused by agriculture intensification, was 39.3 [percent]. This process was not uniform, but related to trends in land use and agriculture change. For the area studied (1,394 [square kilometers]) there was an estimated release of 5 [Teragrams] CO_2-C to the atmosphere from the upper 30 [centimeters] of soil in the period 1935–1990. **Ciro Gardi and Francesca Sconosciuto,** *Sustainability Science,* Published online July 27, 2007, DOI: 10.1007/s11625-007-0034-9, http://www.springerlink.com/content/r283173208j10uw4/?p=cbf5cfb9fd2846a3ad78969edb73d498&pi=0. (Subscription required.)

"Promotion of ecosystem carbon sequestration by invasive predators." Despite recent interest in understanding the effects of human-induced global change on carbon (C) storage in terrestrial ecosystems, most studies have overlooked the influence of a major element of global change, namely biological invasions. [The authors] quantified ecosystem C storage, both above- and below-ground, on each of 18 islands off the coast of New Zealand. Some islands support high densities of nesting seabirds, while others have been invaded by predatory rats and host few seabirds. Our results show that, by preying upon seabirds, rats have indirectly enhanced C sequestration in live plant biomass by 104 [percent], reduced C sequestration in non-living pools by 26 [percent] and increased total ecosystem C storage by 37 [percent]. Given the current worldwide distribution of rats and other invasive predatory mammals, and the consequent disappearance of seabird colonies, these predators may be important determinants of ecosystem C sequestration. **David A. Wardle, Peter J. Bellingham, Tadashi Fukami and Christa P.H. Mulder,** *Biology Letters,* Published online July 24, 2007, DOI: 10.1098/rsbl.2007.0163, http://www.journals.royalsoc.ac.uk/content/?k=%e2%80%9cPromotion+of+ecosystem+carbon+sequestration+by+invasive+predators.%e2%80%9d++. (Subscription required.)

October 2007

"Projected increase in continental runoff due to plant responses to increasing carbon dioxide." In addition to influencing climatic conditions directly through radiative forcing, increasing carbon dioxide concentration influences the climate system through its effects on plant physiology. Plant stomata generally open less widely under increased [CO_2] concentration, which reduces transpiration and thus leaves more water at the land surface. This driver of change in the climate system, which [the authors] term 'physiological forcing', has been detected in observational records of increasing average continental runoff over the twentieth century. Here [the authors] use an ensemble of experiments with a global climate model that includes a vegetation component to assess the contribution of physiological forcing to future changes in continental runoff, in the context of uncertainties in future precipitation. [The authors] find that the physiological effect of doubled [CO_2]concentrations on plant transpiration increases simulated global mean runoff by 6 percent relative to pre-industrial levels; an increase that is comparable to that simulated in response to radiatively forced climate change (11 ± 6 percent). Assessments of the effect of increasing [CO_2] concentrations on the hydrological cycle that only consider radiative forcing will therefore tend to underestimate future increases in runoff and overestimate decreases. This suggests that freshwater resources may be less limited than previously assumed under scenarios of future global warming, although there is still an increased risk of drought. Moreover, [the authors'] results highlight that the practice of assessing the climate-forcing potential of all greenhouse gases in terms of their radiative forcing potential relative to [CO_2] does not accurately reflect the relative effects of different greenhouse gases on freshwater resources. **Richard A. Betts, Olivier Boucher, Matthew Collins, Peter M. Cox, Peter D. Falloon, Nicola Gedney, Deborah L. Hemming, Chris Huntingford, Chris D. Jones, David M. H. Sexton & Mark J. Webb.** *Nature*, Volume 448, Pages 1037-1041, DOI: 10.1038/nature06045, Published online August 30, 2007, http://www.nature.com/nature/journal/v448/n7157/abs/nature06045.html. (Subscription required.)

November 2007

"Strengthening the soil organic carbon pool by increasing contributions from recalcitrant aliphatic bio(macro)molecules." Photosynthetically fixed CO_2 is converted into terrestrial bio(macro)molecules and sequestered as soil organic matter (SOM) by (bio)chemical and physical stabilization processes. SOM is generally divided in arbitrary pools for modeling SOM dynamics. Biochemically recalcitrant SOM fractions are enriched with alkyl carbon (C) structures and resist decomposition due to intrinsic molecular properties. The proportion of alkyl C and the mean age of SOM increase with increase in soil depth. Precursors of these recalcitrant bio(macro)molecules such as glycerides, waxes, and terpenoids occur in plants, microorganisms and animals. The intrinsic biochemical stability of naturally occurring recalcitrant aliphatic biomacromolecules may enhance the terrestrial storage of atmospheric CO_2. Also, aliphatic macromolecules may be formed in soils upon non-enzymatic polymerization of low-molecular-weight lipids. In this review [the authors] propose that increasing the soil organic carbon (SOC) pool by land-use and management practices should also include strategies to increase the proportion of aliphatic compounds in the belowground biomass. Thus, collaborative research is needed to study the fate of plant-, microbial- and animal-derived aliphatic C as precursors for stabilized aliphatic SOC fractions, in particular in deeper soil horizons. **Klaus Lorenz, Rattan Lal, Caroline M. Preston and Klaas G.J. Nierop.** *Geoderma,* Available online September 5, 2007, doi:10.1016/j.geoderma.2007.07.013, http://www.sciencedirect.com/science/article/B6V67-4PKG610-2/2/49cab6c07fef7e4e82bf795e804cf15f#secx12. (Subscription may be required.)

December 2007

"Induced effects of hedgerow networks on soil organic carbon storage within an agricultural landscape." Hedgerow network landscapes or "*bocages*" are present throughout a large part of Western Europe [Baudry, J., Bunce, R.G.H. et al., 2000. Hedgerows: an international perspective on their origin, function and management. Journal of Environmental Management 60 (1), 7–22.]. These manmade landscapes are typically comprised of fields separated by boundaries, often marked by perennial vegetation (hedges or shelterbelts), yet little is known about the effect of these field margins on soil organic carbon (SOC) stocks and their dynamics, which offer large carbon sequestration potential [Walter, C., Mérot, P., Layer, B., Dutin, G., 2003. The effect of hedgerows on soil organic carbon storage in hill slopes. Soil Use and Management 19, 201–207.; Falloon, P., Powlson, D., Smith, P., 2004. Managing field margins for biodiversity and carbon sequestration: a Great Britain case study. Soil Use and Management 20, 240–247.]. In hedged landscapes, hedges induce a modification to the soil A-horizon geometry at the slope scale, as attributed to an anti-erosive effect, along with a local modification of the associated SOC stocks. Most studies undertaken within this context have been performed in two dimensions and under favorable conditions for soil accumulation with the hedges lying perpendicular to the steepest slope direction. Consequently, an extrapolation of these findings to the entire landscape can lead to overestimating SOC stocks at the landscape scale. The aims of this paper were to: quantify SOC stocks, describe their spatial variability in three dimensions, and identify the main determinants behind this variability within an agricultural hedgerow network landscape. To achieve these aims, [the authors] conducted a detailed field survey that took into account all three dimensions of the soil cover and anthropogenic structures. [The authors] then analyzed the spatial distribution of SOC contents and stocks with respect to pedological and landscape parameters. **Stéphane Follain, Christian Walter, Arnaud Legout, Blandine Lemercier and Gilles Dutin**, *Geoderma*, Available online: September 4, 2007, doi: 10.1016/j.geoderma.2007.08.002, http://www.sciencedirect.com/science/article/B6V67-4PK8MRG-1/2/00b73c4c173020ba6108a0c487f64a88. (Subscription may be required.)

January 2008

"Land-use conversion effects on CO_2 emissions: from agricultural to hybrid poplar plantation." Land-use changes such as deforestation have been considered one of the main contributors to

increased greenhouse gas emissions, while verifiable [carbon] sequestration through afforestation projects is eligible to receive [carbon] credits under the Kyoto Protocol. [The authors] studied the short-term effects on CO_2 emissions of converting agricultural land-use (planted to barley) to a hybrid poplar (*Populus deltoids* Ã—*Populus* Ã— *petrowskyana* var. Walker) plantation in the Parkland region in northern Alberta, where large areas are being planted to hybrid poplars. CO_2 emissions were measured using a static gas chamber method. No differences were found in soil temperature, volumetric moisture content, or soil respiration rates between the barley and Walker plots. The mean soil respiration rate in 2005 was 1.83 Â± 0.19 (mean Â± 1 SE) and 1.89 Â± 0.13 µmol CO_2 m^{-2} s^{-1} in the barley and Walker plots, respectively. However, biomass production was higher in the barley plots, indicating that the agricultural land-use system had a greater ability to fix atmospheric CO_2. The [carbon] balance in the land-use systems were estimated to be a small net gain (before considering straw and grain removal through harvesting) of 0.03 Â± 0.187 Mg [carbon] ha^{-1} $year^{-1}$ in the barley plots and a net loss of 3.35 Â± 0.080 Mg [carbon] ha^{-1} $year^{-1}$ from the Walker poplar plots. Over the long-term, [the authors] expect the hybrid poplar plantation to become a net [carbon] sink as the trees grow bigger and net primary productivity increases. **D. D. Saurette, S. X. Chang and B. R. Thomas**, *Ecological Research*, Available online: September 21, 2007, DOI: 10.1007/s11284-007-0420-x, http://www.springerlink.com/content/bm6015n8161k65p4.

February 2008

“Microbial activity and soil C sequestration for reduced and conventional tillage cotton.” Crop management practices, such as tillage and diversified crop rotations, impact microbial activity, organic matter turnover, and ultimately soil [carbon] and [nitrogen] sequestration. The objectives of this study were to determine the impacts of tillage on soil microbial biomass, mineralized C and N, and soil organic C (SOC) and N (SON) contents for different cotton (*Gossypium hirsutum* L.) cropping systems in a south-central Texas silt loam soil. Tillage influenced SOC and SON, but most effects were observed at 0–5 cm rather than 5–15 cm. Reduced tillage (RT) in a continuous cotton monoculture increased SOC by 24 [percent] and SON by 27 [percent] compared to conventional tillage (CT) at 0–5 cm, but tillage had no effect at 5–15 cm. Crop rotation increased soil C and N contents compared to continuous cotton, as a cotton-corn (*Zea mays* L.) rotation under CT increased SOC by 28 [percent] and SON by 26 [percent] at 0–5 cm compared to CT continuous cotton. Soil organic C and SON were both 18 [percent] greater for cotton-corn than continuous cotton at 5–15 cm. For the 0–15 cm depth interval, the CT cotton-corn rotation increased SOC by an average of 518 kg C [per hectare per year] and SON by 57 kg N [per hectare per year] compared to CT continuous cotton. Cotton under RT sequestered 254 kg C [per hectare per year] and 33 kg N [per hectare per year] more than cotton under CT. Reduced tillage increased soil microbial biomass C (MBC) by an average of 11 and 18 [percent] compared to CT continuous cotton and the cotton-corn rotation, respectively, while microbial biomass N (MBN) for RT was 62 [percent] greater than for CT. Tillage decreased mineralized C and N at both depth intervals, while cotton-corn showed higher mineralized C than continuous cotton. Soils for cropping systems that sequestered the most C and N also had the highest microbial biomass and mineralized C and N, indicating close relationships between microbial activity and soil C and N sequestration. Beneficial effects of RT and intensive cropping were enhanced soil C and N sequestration rates and potentially lower N fertilizer requirements for crops. **Alan L. Wright, Frank M. Hons, Robert G. Lemon, Mark L. McFarland and Robert L. Nichols**. *Applied Soil Ecology*, Available online December 3, 2007, doi:10.1016/j.apsoil.2007.10.006, http://www.sciencedirect.com/science/article/B6T4B-4R8KT1N-1/2/0b2f0233272db32ed47626f66e88b50c. (Subscription may be required.)

March 2008

“The effect of the tillage system on soil organic carbon content under moist, cold-temperate conditions.” Soil tillage and its interaction with climate change are widely discussed as a measure fostering carbon sequestration. To determine possible carbon sinks in agriculture, it is necessary to study

carbon sequestration potentials in relation to agricultural management. The aim of this paper is to evaluate the soil carbon sequestration potential of a site in northeastern Switzerland under different tillage systems. The study was performed as a long-term (19-year) trial on an Orthic Luvisol (sandy loam) with a mean annual air temperature of 8.4 [degrees Celsius] and a long-term precipitation mean of 1183 mm. The soil organic carbon (SOC) concentration was determined five times during the study period, with the paper focusing mainly on the year 2006. The main objective was to quantify the influence of moldboard plowing (PL), shallow tillage (ST), no-tillage (NT) practices, and grassland (GL) on soil organic carbon content, the latter's different fractions (labile, intermediate, and stable), and its distribution by depth. In calculating the SOC content of the whole soil profile, we included a correction factor accounting for variations in bulk density (equivalent soil mass). The total SOC stock at a depth of 0–40 cm was 65 Mg [carbon] [per hectare], and although higher under GL, did not differ significantly between PL, ST, and NT. SOC concentrations per soil layer were significantly greater for NT and ST (0–10 cm) than for PL, which had greater SOC concentrations than NT and ST at 20–30 cm depth. Both SOC concentrations and stocks (0–20 cm) were largest under GL. In all treatments, most of the carbon was found in the intermediate carbon fraction. There was no significant difference in any of the three SOC fractions between NT and ST, although there was between ST and PL. A sharp decrease in [carbon]-concentrations was observed in the first 7 years after the transition from grassland to arable land, with a new equilibrium of the carbon concentration in the 0–40 cm layer being reached 12 years later, with no significant difference between the tillage treatments. Overall, the results indicate that effects of tillage on soil carbon are small in moist, cold-temperate soils, challenging conversion into no-till as a measure for sequestering [carbon]. **Sandra Hermle, Thomas Anken, Jens Leifeld and Peter Weisskopf**, *Soil and Tillage Research*, Available online January 16, 2008, doi:10.1016/j.still.2007.10.010, http://www.sciencedirect.com/science/article/B6TC6-4RKVHJ9-1/2/f14d7b5e1f8f9906b17ef6f1f91d4d71. (Subscription may be required.)

April 2008

"Carbon Sequestration in Native Prairie, Perennial Grass, No-Till, and Cultivated Palouse Silt Loam." Comparative assessments for evaluating soil organic C (SOC) and its characteristics were made at different soil (Palouse silt loam) depths (0–5, 5–10, 10–20, and 0–20 cm) among sites with seven contrasting management histories: conventional inversion tillage (CT) followed by no-till (NT) for 4 (NT4) and 28 (NT28) yr; bluegrass (*Poa pratensis* L.) seed production for 9 yr followed by NT for 4 yr (BGNT4); a sequence of 10 yr NT, 3 yr CT, and 1 yr NT (NTR); CT followed by 11 yr perennial grass under the Conservation Reserve Program (CRP); long-term >100 yr CT; and native prairie (NP). Overall ranking of SOC, particulate organic C (POC), and microbial biomass C (MBC) at 0 to 20 cm was NP > NTR > NT4 = NT28 > CRP > BGNT4 = CT. Greater SOC, POC, and MBC in NTR than NT28 indicated that tillage rotation could result in more soil C sequestration, primarily by increasing C stocks in 5- to 20-cm depths. The POC was labile in nature as it highly correlated with C_{min} (r = 0.69, P < 0.01) and MBC (r = 0.86, P < 0.01) as well as SOC (r = 0.89, P < 0.01). [The authors] concluded that: (i) neither NT nor conversion to perennial vegetation would attain the SOC found in NP over 10 to 30 yr; and (ii) medium duration of NT (10 yr) combined with short intervals of CT (3 yr) followed by NT might increase SOC compared with continuous long-term NT under annual cropping. **T. J. Purakayastha, D. R. Huggins and J. L. Smith**, *Soil Science Society of America Journal*, Available online February 28, 2008, DOI: 10.2136/sssaj2005.0369, http://soil.scijournals.org/cgi/content/abstract/soilsci;72/2/534. (Subscription required.)

May 2008

***New Scientist*, "Greenhouse Double Whammy for Some Crops…While Others Lock Carbon Away for Years."** A report in New Scientist suggests that one method for cutting GHG levels may be to grow grasses like wheat and sorghum, which are capable of capturing large amounts of CO_2 in their phytoliths, or "plantstones." Phytoliths are microscopic balls of silica that form around a plant's cells as they absorb

minerals from the soil and trap scraps of plant material. As a result, scientists believe that the practically indestructible phytoliths have the potential to sequester CO_2 for thousands of years. Two scientists from Southern Cross University found that soil buried longer contained a higher proportion of CO_2 than the rest of the soil and that sugar cane is the best carbon capturer at 0.66 tonnes of CO_2 equivalents per hectare per year. Scientists now plan to examine how such CO_2 capturing plants fare in terms of crop yield and quality. January 7, 2008, http://environment.newscientist.com/channel/earth/mg19726374.800-plantstones-could-help-lock-away-carbon.html. (Subscription required.)

"Tillage and wind effects on soil CO_2 concentrations in muck soils." Rising atmospheric carbon dioxide (CO_2) concentrations from agricultural activities prompted the need to quantify greenhouse gas emissions to better understand carbon (C) cycling and its role in environmental quality. The specific objective of this work was to determine the effect of no-tillage, deep plowing and wind speeds on the soil CO_2 concentration in muck (organic) soils of the Florida Everglades. Miniature infrared gas analyzers were installed at 30 cm and recorded every 15 min in muck soil plowed with the Harrell Switch Plow (HSP) to 41 cm and in soil Not Tilled (NT), i.e., not plowed in last 9 months. The soil CO_2 concentration exhibited temporal dynamics independent of barometric pressure fluctuations. Loosening the soil resulted in a very rapid decline in CO_2 concentration as a result of "wind-induced" gas exchange from the soil surface. Higher wind speeds during mid-day resulted in a more rapid loss of CO_2 from the HSP than from the NT plots. The subtle trend in the NT plots was similar, but lower in magnitude. Tillage-induced change in soil air porosity enabled wind speed to affect the gas exchange and soil CO_2 concentration at 30 cm, literally drawing the CO_2 out of the soil resulting in a rapid decline in the CO_2 concentration, indicating more rapid soil carbon loss with tillage. At the end of the study, CO_2 concentrations in the NT plots averaged about 3.3 [percent] while that in the plowed plots was about 1.4 [percent]. Wind and associated aerodynamic pressure fluctuations affect gas exchange from soils, especially tilled muck soils with low bulk densities and high soil air porosity following tillage. **D.C. Reicosky, R.W. Gesch, S.W. Wagner, R.A. Gilbert, C.D. Wente and D.R. Morris**, *Soil and Tillage Research*, Available online March 26, 2008, doi:10.1016/j.still.2008.02.006, http://www.sciencedirect.com/science/article/B6TC6-4S4S5GT-1/2/93d474e24ccdff36edf8a448b86bcc22. (Subscription may be required.)

June 2008

"No-Tillage and Soil-Profile Carbon Sequestration: An On-Farm Assessment." No-tillage (NT) farming is superior to intensive tillage for conserving soil and water, yet its potential for sequestering soil organic carbon (SOC) in all environments as well as its impacts on soil profile SOC distribution are not well understood. Thus, [the authors] assessed the impacts of long-term NT-based cropping systems on SOC sequestration for the whole soil profile (0–60-cm soil depth) across 11 Major Land Resource Areas (MLRAs: 121, 122, and 125 in Kentucky; 99, 124, 139A in Ohio; and 139B, 139C, 140, 147, and 148 in Pennsylvania) in the eastern United States. Soil was sampled in paired NT and plow tillage (PT) based cropping systems and an adjacent woodlot (WL). No-tillage farming impacts on SOC and [nitrogen (N)] were soil specific. The SOC and N concentrations in NT soils were greater than those in PT soils in 5 out of 11 MLRAs (121, 122, 124, 139A, and 148), but only within the 0- to 10-cm depth. Below 10 cm, NT soils had lower SOC than PT soils in MLRA 124. The total SOC with NT for the whole soil profile (0–60 cm) did not differ from that with PT ($P > 0.10$) in accord with several previous studies. In fact, total soil profile SOC in PT soils was 50 [percent] higher in MLRA 125, 21 [percent] in MLRA 99, and 41 [percent] in MLRA 124 compared with that in NT soils. Overall, this study shows that NT farming increases SOC concentrations in the upper layers of some soils, but it does not store SOC more than PT soils for the whole soil profile. **Humberto Blanco-Canqui and R. Lal**, *Soil Science Society of America Journal*, Available online April 8, 2008, DOI: 10.2136/sssaj2007.0233, http://soil.scijournals.org/cgi/content/abstract/72/3/693. (Subscription may be required.)

July 2008

"Combining remote sensing data with process modeling to monitor boreal conifer forest carbon balances." Approaches combining satellite-based remote sensing data with ecosystem modeling offer potential for the accurate assessment of changes in forest carbon balances, for example, in support of emission credits under the Kyoto Protocol. [The authors] investigate the feasibility of two alternative methods of using satellite-derived data to constrain the behavior of a dynamic ecosystem model, in order to improve the model's predictions of the net primary production (NPP) of conifer forests in northern Europe (4–30 [degrees] E, 55–70 [degrees] N). The ecosystem model incorporates a detailed description of forest stand structure and biogeochemical processes. The satellite product comprises multi-spectral reflectance data from the VEGETATION sensor. The first method combines satellite-based estimates of FPAR, the fraction of incoming photosynthetically active radiation absorbed by vegetation, with the model's predictions of the efficiency with which trees use the incoming radiation to fix carbon. Results obtained using this method averaged 0.22 kg [carbon] m^{-2} yr^{-1} for the NPP of conifer and mixed forests across the study area, and compared well with forest-inventory-based estimates for Sweden. The second method uses forest stand descriptions derived by application of an inverse radiation transfer scheme to VEGETATION data to prescribe stand structure in the ecosystem model simulations. Predictions obtained by this method averaged 0.31 kg [carbon] m^{-2} yr^{-1}, somewhat high compared to forest inventory data for central and northern Sweden. Simulations by the ecosystem model when driven only by climate, CO_2 and soils data, but unconstrained by satellite information, yielded an average NPP of 0.41 kg [carbon] m^{-2} yr^{-1}, which is likely to be an overestimate. Summed over the study area, the NPP estimates amounted to 0.16–0.23 Gt [carbon] yr^{-1}, around 6–9 [percent] of the NPP of all boreal forest globally or 0.3–0.4 [percent] of terrestrial NPP globally. The investigated methods of combining process modeling and products derived from remote sensing data offer promise as a step towards the development of operational tools for monitoring forest carbon balances at large scales. **Benjamin Smith, Wolfgang Knorr, Jean-Luc Widlowski, Bernard Pinty and Nadine Gobron,** *Forest Ecology and Management*, Available online May 21, 2008, doi:10.1016/j.foreco.2008.03.056, http://www.sciencedirect.com/science/article/B6T6X-4SJR2DV-4/1/e4b1cab97c473d9e9fc4a4b828805f1c. (Subscription may be required.)

August 2008

"Impacts of long-term and recently imposed tillage practices on the vertical distribution of soil organic carbon." Although many studies suggest that no-tillage (NT) increases soil organic carbon (SOC) within the soil profile relative to mouldboard ploughing, other studies indicate that no net change occurs. The latter studies suggest that NT only stratifies the SOC, where a near-surface increase in SOC is offset by a concomitant decrease in the subsurface. [The authors] examined the SOC distribution and stocks in a cool, humid Brookston clay (Typic Argiaquoll) soil under four soil management systems with a corn–soybean rotation. The objectives of this study were to compare the profile distribution and total amount of SOC under long-term (21 years) NT and mouldboard plough (MP) tillage with the changes that occur over 8 years when 13-years continuous NT is converted to MP, and when 13-years continuous MP is converted to NT. In the top 5 cm of soil, the long-term NT management accumulated greater SOC compared with the long-term MP treatment. However, this near-surface increase was offset by lower SOC concentrations in the 10–20 cm depth, resulting in similar total amounts of SOC stored in 0–20 cm for both long-term NT and MP. The SOC stratification that existed after 13 years of NT management was eliminated with one mouldboard ploughing operation, however the total SOC content in the plough layer of the new-MP treatment remained relatively constant over the subsequent 8 years. Soil organic carbon stratification was evident in the new no-tillage treatment 3 years after the cessation of tillage. The continuous build-up of SOC in the surface of new-NT soils was associated with no change in the total amount of SOC in the plough layer relative to long-term NT. This implies that the diminution of SOC in the 10–20 cm depth was at the same rate as the accumulation of SOC in the 0–5 cm depth. Although there was no net effect of tillage on total carbon stocks in this fine-textured soil, SOC stratification required several years to build-up after adoption of NT, but only a single year to destroy under MP. **X.M. Yang, C.F. Drury, W.D. Reynolds and C.S. Tan**, *Soil and Tillage Research*, Available online July 1,

2008, doi:10.1016/j.still.2008.05.003, http://www.sciencedirect.com/science/article/B6TC6-4SWG0BG-1/1/1d80d2e3bb077aaa96ec5a66b6ccf7ff. (Subscription may be required.)

Trading

September 2007

***Greenwire,* "Forest Service to Sell Carbon Credits to Fund Reforestation."** The US Forest Service and National Forest Foundation are teaming up to start a voluntary carbon offset program aimed to fund reforestation projects in US forests. The plan will allow consumers to make donations to fund tree planting and other work in national forests by calculating their carbon footprint and then donating money to the program, known as the Carbon Capital Fund. For $6 an individual can offset one metric ton of CO_2 and the money will go to forests damaged by wildfires, tornadoes, and other catastrophic events. It is estimated that US forests offset about 10 percent of CO_2 emissions in the US and that terrestrial sequestration could greatly increase that percentage. Other benefits include clean watershed and improved species habitat. The Forest Service has identified two projects to kick off the new program, including a 500-acre reforestation project in Custer National Forest in Montana and 1400 acres in Payette National Forest in Idaho. The Forest Service has been under scrutiny for allowing an estimated backlog of one million acres of land requiring reforestation. To learn more about the Carbon Capital Fund and to calculate your own carbon footprint, go to: http://www.carboncapitalfund.org/. July 26, 2007, http://www.eenews.net/Greenwire/print/2007/07/26/11. (Subscription may be required.)

***Bank of America Press Release,* "Bank of America Joins Chicago Climate Exchange, Makes Strategic Investment in Climate Exchange PLC."** Bank of America, one of the world's largest financial institutions, announced that it will become a member of the Chicago Climate Exchange (CCX). The company will also join the Chicago Climate Futures Exchange (CCFE), a wholly-owned subsidiary of the CCX, and the European Climate Exchange (ECX), the largest exchange for allowances traded under the European Union's mandatory cap-and-trade scheme for CO_2 emissions. As part of a joint venture, Bank of America will acquire .5 percent of the current issued share capital of CLE. Bank of America recently announced a climate exchange initiative, a ten-year effort aimed at developing environmentally sustainable business practices through lending, investing, philanthropy, and the creation of new products and services. July 25, 2007, http://newsroom.bankofamerica.com/index.php?s=press_releases&item=7841.

October 2007

***Chicago Climate Exchange Press Release,* "Chicago Climate Futures Exchange to Launch Certified Emission Reduction (CER) Futures Contracts on August 24."** On August 23, the Chicago Climate Futures Exchange (CCFE) announced that it will begin the CCFE Certified Emission Reduction (CERs) futures contracts on August 24, 2007. CERs, which are considered the global currency in carbon trading, are issued under the United Nations Clean Development Mechanism, an arrangement under the Kyoto Protocol that allows national and corporate GHG reduction goals to be met through the use of CERs. The arrangement allows industrialized countries to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries. This CCFE CER futures contracts will be the first time that hedging tools for CERs are offered on a North American exchange. The CCFE is a wholly-owned subsidiary of the Chicago Climate Exchange. To learn more about the CCFE, visit: www.ccfe.com. August 23, 2007, http://www.chicagoclimateexchange.com/news/press/release_20070823_CER.pdf.

***Reuters,* "U.S., Canadian West Set Joint Carbon-Cutting Target,"** and ***All American Patriots,* "Western Climate Initiative Members Set Regional Target to Reduce Greenhouse Gas Emissions."**

On August 22, the six western states and two Canadian provinces that make up the Western Climate Initiative (WCI) announced a regional goal to reduce greenhouse gas (GHG) emissions to 15 percent below 2005 levels by 2020. As part of the agreement, state officials have until August 2008 to design a multi-sector market-based policy to meet emissions targets, which will most likely be a load-based cap-and-trade program. Each participating state and Canadian province will also participate in a multi-state GHG emissions registry. The WCI pact, along with the eastern US equivalent, the Regional Greenhouse Gas Initiative pact, may add pressure on Congress to pass legislation that will regulate GHG emissions at the federal level. The WCI was formed in February 2007 by the governors of Arizona, New Mexico, Oregon, Washington, and California. The state of Utah and the Canadian provinces of British Columbia and Manitoba subsequently joined the group, which is led by California Governor Arnold Schwarzenegger. Other states and provinces are participating as observers to the WCI. Details about the recently announced regional goal can be found at: www.westernclimateinitiative.org. August 22, 2007, http://www.reuters.com/article/environmentNews/idUSN2244930020070822?sp=true, and August 23, 2007, http://www.allamericanpatriots.com/48729669_new_mexico_western_climate_initiative_members_set_regional_target_reduce_greenhouse_gas_emi.

November 2007

***Chicago Climate Exchange,* "Chicago Climate Exchange Announces Landmark Growth in Binding Greenhouse Gas Reduction Commitments, Membership and New International Activities at Clinton Global Initiative."** On October 1, the Chicago Climate Exchange (CCX) announced that emission reduction commitments by its members have reached over a million metric tons of CO_2. These reductions represent the only reductions being achieved in North America by a legally binding compliance regime. Additional announcements regarding the CCX's recent growth were made at the Third Clinton Global Initiative meeting in New York City, a conference for global leaders to devise and implement innovative solutions to some of the world's most pressing challenges, including energy and climate change. The Governor of the State of Santa Catarina, Brazil announced the country's membership to the CCX, making it the first state outside of the United States to join the exchange. Also announced were commitments from various companies in India that will join the US-based exchange as offset aggregators and verifiers for CCX offset projects. October 1, 2007, http://www.chicagoclimateexchange.com/news.jsf?story=1881.

December 2007

***Reuters*, "World Carbon Market Seen Doubling this Year: IETA," and *Reuters*, "U.S. Exchanges Explore Carbon Trading Market."** After growing from $11 billion in 2005 to $30 billion in 2006, International Emissions Trading Association (IETA) representatives believe the carbon emissions trading market will double to at least $60 billion this year as investors and businesses seek to profit from reducing greenhouse gases. They added that the European Union's Emissions Trading Scheme (EU ETS) is still the main source of market value, but emissions trading markets across the globe are evolving quickly. In the United States, several carbon trading market developments are beginning to take shape as exchanges monitor the global market's growth and domestic government policy: New York Stock Exchange operator NYSE Euronext announced a partnership with French bank Caisse des Depots to initiate a carbon trading market in 2008; CME Group Incorporated recently hinted at plans to develop carbon trading products after its 10 percent acquisition of the Brazilian Mercantile and Futures Exchange (BM&F); and Nymex Holdings Incorporated's, owner of the New York Mercantile Exchange (NYMEX), statement that it will begin offering carbon trading contracts in the first quarter of 2008. Unlike the European Union, the US has not established a nationwide cap on greenhouse gases, but several large corporations voluntarily trade carbon allowances. November 5, 2007, http://www.reuters.com/articlePrint?articleId=USSP20658520071105 and November 6, 2007, http://www.reuters.com/articlePrint?articleId=USN0640911720071106.

January 2008

***Reuters*, "EU Eyes CO_2 Capture in Trade Scheme-Draft."** A European Commission draft document proposes that companies electing to capture and store CO_2 will receive credit under the European Union (EU) trading scheme for not releasing emissions. In addition to requiring permits for exploring storage sites and the storage process itself, the proposal lays forth a foundation for governing CO_2 capture, transportation, and injection underground; rules mandating proper inspections and monitoring requirements; and penalties for those failing to comply with the designated standards. The document also permits EU governments the right to take over CO_2 geological storage projects under certain circumstances. Also, power companies would not be forced to engage in CCS practices. However, large combustion plants would be required to possess adequate space for renovations to equip the facility with carbon capture and storage technology. With the EU trading scheme serving as the 27-member coalition's strongest tool for fighting climate change, officials believe the integration of carbon capture into the market will provide companies with another means for reaching emissions targets and possibly escalate the deployment of CCS in a more cost effective manner. This draft document is part of a larger climate change legislation package that the European Commission plans to release in January 2008. November 28, 2007, http://www.reuters.com/article/idUSL2888608820071128.

February 2008

***Reuters*, "Tokyo Seen Eyeing China's Carbon Credits."** According to the Japanese newspaper Yomiuri Shimbun, Japanese and Chinese officials have agreed to a deal where Japan would purchase carbon credits yielded by its investments in emissions-cutting projects in China. The agreement will be formally signed when Chinese President Hu Jintao visits Japan in late March and selects specific emissions-cutting projects. Although the price of the credits was not revealed, government sources project that six projects could generate emissions reductions equivalent to 10 million tons to 15 million tons of CO_2 over the next five years. Japan is the only Asian country obligated under the Kyoto Protocol to cut its greenhouse gas levels and has been lagging behind its commitment to a 6 percent cut from 1990 levels during the 2008 to 2012 period. Late last year, Japanese officials finalized a list of measures to cut roughly 35 to 36 million tons of CO_2 through voluntary industrial agreements and energy conservation programs. In addition to purchasing credits from China under Kyoto's Clean Development Mechanism, which allows rich polluters to buy developing nations' emissions reductions to put toward their domestic quotas, Japan agreed to buy credits from Hungary in December and is also engaged in talks with Poland, the Czech Republic, and Ukraine about similar deals. January 3, 2008, http://uk.reuters.com/article/oilRpt/idUKT22551420080103.

***Times Online*, "Tighter European Limits Set to Push Up Price of Carbon Emissions,"** and ***Times Online*, "EU Cracks Down on Carbon Emissions Trading."** According to Andrei Marcu, president of the International Emissions Trading Association (IETA), the value of the global carbon trading emissions market could reach $100 billion this year, which would exceed the estimated $60 billion to $70 billion figure in 2007. The bulk of the estimated total would come from the European Union Emissions Trading Scheme (EU ETS), whose second phase went into effect on January 2, 2008 and lasts until 2012. The second phase is expected to prosper much more than the first phase, because there will be a 5 percent to 10 percent reduction in the number of emissions permits granted. Launched in 2005, the first phase was widely dismissed as a failure, because too many permits were granted by member states to individual polluters, causing market prices to plunge as low as $1.46 (€1) per tonne. Deutsche Bank and UBS expect forward prices to rise from the present level of about $33.77 (€23) a tonne to $51.39 (€35) and $44.05 (€30) a tonne, respectively. Critics believe EU ETS needs to auction off a much larger portion of the permits, so that big polluters are not tempted to sell any excess permits that they originally received for free. January 3, 2007,

http://business.timesonline.co.uk/tol/business/markets/europe/article3123564.ece and January 2, 2007, http://business.timesonline.co.uk/tol/business/industry_sectors/utilities/article3121968.ece.

March 2008

***Greenwire*, "Northeast States Prep for Inaugural Carbon Auction."** Following a 2005 agreement to reduce GHGs 10 percent by 2020, several participants in the 10-member Regional Greenhouse Gas Initiative (RGGI) are preparing for a June 2, 2008 auction of emissions credits in advance of the scheme's January 2009 start date. Under the agreement, members elected to cap GHG emissions at 188 million short tons per year from 2009 through 2014, followed by a cap reduction of 2.5 percent a year through 2018 to achieve the overall 10 percent emission reduction goal. Not all RGGI members plan to participate in the auction, which will provide the first U.S. opportunity to gauge GHG prices, but individual utilities and power generators can participate even if their home states do not. While the states still must determine exactly how many emissions credits to put up for auction and how many free credits should be distributed to offset RGGI compliance costs, the 2007 RGGI Model Rule regulates the number of credits allocated per state, permitted offsets for power generators, and how the auction proceeds will be invested. Participants have agreed that auction proceeds will be spent on renewable energy programs and at least 25 percent of the permits will be auctioned. To view the RGGI Model Rule, click: http://www.rggi.org/docs/model_rule_corrected_1_5_07.pdf. January 22, 2008, http://www.eenews.net/Greenwire/2008/01/22/1/.

***Carbon Positive*, "Europe Reveals Tight ETS Phase III Plan,"** and ***Reuters UK*, "Factbox-EU Plans Carbon Trading Overhaul."** A plan released by the European Commission reveals that the European Union Emissions Trading Scheme's (EU ETS) Third Phase will cut emission allowances by 21 percent. From 2013 through 2020, industries covered under the EU ETS will have their emission allowances annually reduced, so that emissions drop 21 percent below 2005 levels by 2020; this would result in emissions dropping to 1.72 billion tonnes of CO_2, compared to the current 2 billion tonnes of CO_2. Under the proposal, the proportion of total EU emissions covered in the ETS will increase from about 40 percent to 50 percent and the emissions reduction target would be raised from 20 percent to 30 percent by 2020 if foreign emitters agree to emission caps. In addition, national allocations plans, which regulate the emissions cap for each country, sector, and individual installation until 2012, would be eliminated and replaced by a single EU emissions allocation; owners of unused allowances issued in 2008 to 2012 would be allowed to use these credits until 2020; and around 60 percent of allowances would be auctioned off in 2013, up from 10 percent currently. The European Commission plan, which would include a 10 percent to 15 percent increase in electricity prices, must be approved by the 27-member states and the EU Parliament before becoming a law. January 24, 2008, http://www.carbonpositive.net/viewarticle.aspx?articleID=968 and January 23, 2008, http://uk.reuters.com/article/oilRpt/idUKL2359672920080123?sp=true.

April 2008

***Reuters UK*, "Japan Considers Emissions Cap-and-Trade System,"** and ***Reuters India*, "Japan Wants Cap-and-Trade Plan Soon."** As the world's fifth largest emitter of GHG, Japan is considering mandating a cap on GHG emissions and implementing a domestic trading scheme in order to meet its post-Kyoto Protocol commitments. Currently, Japanese companies are free to set their own emissions targets and individually monitor their compliance practices, although this policy may change in light of an informal study requested by the Ministry of Economy, Trade and Industry (METI) that will investigate initiatives that would further cut emissions. Following the study's expected completion in June, METI officials will meet with industry officials to lay the groundwork for a climate action plan that would take effect in 2013; in addition, Japan will host a Group of Eight (G-8) meeting in July, where 2020 emission targets will be discussed. Japanese industry officials believe voluntary emission cuts and household energy conservation initiatives would satisfy Japan's Kyoto obligations. The METI actions arise from

Japan falling behind on its Kyoto commitment to cut GHG emissions by six percent a year on average from 1990 levels over the 2008 to 2012 timeframe and the tougher emissions cuts expected to follow Kyoto's expiration in 2013, fueled by the EU's plan to cut emissions by 20 percent in 2020 from 1990 levels. February 20, 2008, http://uk.reuters.com/article/oilRpt/idUKT36546720080220, and March 11, 2008, http://in.reuters.com/article/worldNews/idINIndia-32416820080311.

May 2008

***Boston Globe*, "States' Inaugural CO_2 Allowance Auction Set for Sept. 10,"** and ***Carbon Control News*, "RGGI Announces Rules, Date for First CO_2 Allowance Auction."** The 10 states participating in the Regional Greenhouse Gas Initiative (RGGI) – Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont –announced plans to hold their CO_2 allowance auction on September 10, 2008, less than four months before the cap-and-trade program officially takes effect on January 1, 2009. Although some states' pending legislation has prevented the finalization of several design elements, the participants have agreed that all market participants will be eligible to participate in the initial auction; participants will be limited to purchasing 25 percent of the allowances offered in any single auction; an initial price of $1.86 per allowance (equivalent to one ton of CO_2) will be set for the first auction; any unsold allowances will be available for sale in future auctions; and a decision will be made regarding the retirement of any unsold allowances in 2012. Under the RGGI program, states have established an initial emissions cap of about 188 millions tons – the expected amount of CO_2 power plants will emit in 2009 – and plan to annually reduce the cap 2.5 percent starting in 2015. The cap-and-trade program will ultimately result in a 16 percent decrease in emissions and allow for excess allowances to be sold on the secondary market. For more details about RGGI's design elements, go to: http://www.rggi.org/docs/20080317auction_design.pdf. March 17, 2008, http://www.boston.com/news/local/vermont/articles/2008/03/17/states_inaugural_co2_allowance_auction_set_for_sept_10/, and March 17, 2008, http://carboncontrolnews.com/index.php/ccn/show/rggi_announces_rules_date_for_first_co2_allowance_auction/. (Subscription required.)

June 2008

***ClimateWire*, "First U.S. Carbon Futures Contract Born."** The New York Mercantile Exchange (NYMEX) announced that it plans to introduce carbon allowance futures contracts under the upcoming Regional Greenhouse Gas Initiative (RGGI) through its Green Exchange. These contracts are expected to be the United States' first tradable exchange contract needed for compliance with a government cap-and-trade program, although the launch date for the new contracts has yet to be determined and regulatory review remains pending. The Green Exchange previously only offered CO_2 allowances from the European Union's Emission Trading Scheme (EU ETS), certified emissions reductions (CERs) from the Kyoto Protocol's Clean Development Mechanism (CDM), and some seasonal and annual sulfur dioxide (SO_2) and nitrogen oxide (NO_x) allowances regulated by the United States Environmental Protection Agency (EPA). The Green Exchange, which hosted 1.59 million metric tons in carbon credit trades following its launch on March 17, 2008, is also waiting for responses from the Commodities Futures Trading Commission (CFTC) regarding a move into the voluntary carbon market, increasing the trading platform's market share in Europe, and a plan to become independent of NYMEX systems. To visit the Green Exchange website, click: http://www.greenfutures.com/, or click: http://www.rggi.org/ for information related to RGGI. May 8, 2008, http://www.eenews.net/climatewire/2008/05/08/6/.

July 2008

***The Montreal Gazette*, "Montreal Climate Exchange is Launched,"** and ***CTV,* "Montreal Exchange for Emission Trading Opens."** The Montreal Exchange (MX), in collaboration with the Chicago Climate Exchange, launched the Montreal Climate Exchange (MCeX) to initiate trading in future contracts based

on GHG emissions. Experts predict that MCeX is the first of what could soon be many environmental markets throughout Canada as more legislation is passed for regulating CO_2 emissions. The exchange allows industries that lack the technology needed to cut GHG emissions to comply with government-mandated standards by buying CO_2 credits from other industries that are able to meet emissions targets. The MCeX will initiate with three market makers posting prices and participants joining as prices begin to set. Beginning in 2010, Canadian industry will have to start reducing their GHG emissions by 20 percent over the following decade. To visit the MX website, go to: http://www.m-x.ca/accueil_en.php. May 31, 2008, http://www.canada.com/montrealgazette/news/business/story.html?id=8b776d55-a2b2-4679-85ce-5d43af3d6f33, and May 30, 2008, http://www.ctv.ca/servlet/ArticleNews/story/CTVNews/20080530/carbon_trading_080530/20080530?hub=TopStories.

August 2008

"Impacts of long-term and recently imposed tillage practices on the vertical distribution of soil organic carbon." Although many studies suggest that no-tillage (NT) increases soil organic carbon (SOC) within the soil profile relative to mouldboard ploughing, other studies indicate that no net change occurs. The latter studies suggest that NT only stratifies the SOC, where a near-surface increase in SOC is offset by a concomitant decrease in the subsurface. [The authors] examined the SOC distribution and stocks in a cool, humid Brookston clay (Typic Argiaquoll) soil under four soil management systems with a corn–soybean rotation. The objectives of this study were to compare the profile distribution and total amount of SOC under long-term (21 years) NT and mouldboard plough (MP) tillage with the changes that occur over 8 years when 13-years continuous NT is converted to MP, and when 13-years continuous MP is converted to NT. In the top 5 cm of soil, the long-term NT management accumulated greater SOC compared with the long-term MP treatment. However, this near-surface increase was offset by lower SOC concentrations in the 10–20 cm depth, resulting in similar total amounts of SOC stored in 0–20 cm for both long-term NT and MP. The SOC stratification that existed after 13 years of NT management was eliminated with one mouldboard ploughing operation, however the total SOC content in the plough layer of the new-MP treatment remained relatively constant over the subsequent 8 years. Soil organic carbon stratification was evident in the new no-tillage treatment 3 years after the cessation of tillage. The continuous build-up of SOC in the surface of new-NT soils was associated with no change in the total amount of SOC in the plough layer relative to long-term NT. This implies that the diminution of SOC in the 10–20 cm depth was at the same rate as the accumulation of SOC in the 0–5 cm depth. Although there was no net effect of tillage on total carbon stocks in this fine-textured soil, SOC stratification required several years to build-up after adoption of NT, but only a single year to destroy under MP. **X.M. Yang, C.F. Drury, W.D. Reynolds and C.S. Tan**, *Soil and Tillage Research*, Available online July 1, 2008, doi:10.1016/j.still.2008.05.003, http://www.sciencedirect.com/science/article/B6TC6-4SWG0BG-1/1/1d80d2e3bb077aaa96ec5a66b6ccf7ff. (Subscription may be required.)

Recent Publications

September 2007

Carbon Sequestration Leadership Forum (CSLF) Strategic Plan Implementation Report (SPIR). This quarterly report provides an overview of recent activities of CSLF task forces, stakeholders and the CSLF Secretariat. An improved element of this SPIR includes short status reports from CSLF projects, including the two new projects that were recognized by the CSLF at the Paris meeting: the Otway Basin Pilot Project (nominated by Australia and the United States), and the Zama Acid Gas EOR, CO_2 Sequestration, and Monitoring Project (nominated by Canada and the United States). To read an introductory letter to the report written by Thomas D. Shope, Acting Assistant Secretary for Fossil Energy

and CSLF Policy Group Chair, see: http://www.cslforum.org/documents/ShopeSPIRChairmansLetter0707.pdf. To read the full July 2007 CSLF Strategic Plan Implementation Report, go to: http://www.cslforum.org/documents/SPIR0707.pdf.

"Energy Market and Economic Impacts of S. 280, the Climate Stewardship and Innovation Act of 2007." This report responds to a request from Senators Joseph Lieberman and John McCain for an estimate of the economic impacts of S. 280, the Climate Stewardship and Innovation Act of 2007. S. 280 would establish a series of caps on greenhouse gas emissions starting in 2012 followed by increasingly stringent caps beginning in 2020, 2030 and 2050. It provides estimates of the effects of S. 280 on energy markets and the economy through 2030, the current time horizon of projections in the Energy Information Administration's (EIA) *Annual Energy Outlook (AEO2007)*. The gases regulated under S. 280 are carbon dioxide, methane, nitrous oxide, and three classes of fluorinated gases—hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Covered entities include those in the commercial, industrial, and electric power sectors with annual emissions at any single facility in excess of 10,000 metric tons carbon dioxide equivalent; refiners and importers of petroleum products sold for transportation; and producers and importers of fluorinated gases. EIA estimates that about 78 percent of the total greenhouse gas emissions in 2005 would be covered under the allowance program. The specific S. 280 allowance caps for each time period are: 2012 to 2019 – 2004 emissions level; 2020 to 2029 – 1990 emissions level; 2030 to 2049 – 22 percent below 1990 emissions level; 2050 and beyond – 60 percent below 1990 emissions level. Under S. 280, covered entities would be required to report their greenhouse gas emissions annually and submit a matching number of government-issued allowances. Some tradable allowances would be distributed for free and the remainder would be auctioned to raise funds for supporting programs. These include programs to encourage innovative emissions reduction technologies and to mitigate adverse economic impacts on consumers and communities. Allowances in excess of compliance needs can be banked for future use. Entities would also be able to meet up to 30 percent of their allowance obligation with offsets for emissions reductions from non-covered entities and foreign sources. To read the entire Energy Information Administration report, go to: http://www.eenews.net/features/documents/2007/08/06/document_pm_02.pdf.

October 2007

"The Power to Reduce CO_2 Emissions, The Full Portfolio." The large-scale CO_2 reductions envisioned to stabilize, and ultimately reverse, global atmospheric CO_2 concentrations present major technical, economic, regulatory and policy challenges. Reconciling these challenges with the continued growth in energy demand highlights the need for a diverse, economy-wide approach. This Discussion Paper provides stakeholders with a *framework* for developing a research, development, and demonstration (RD&D) Action Plan that will enable sustainable and substantial electricity sector CO_2 emissions reductions over the coming decades. The technology development pathways and specific research activities discussed in this paper provide a basis for a detailed Action Plan to be published later this year incorporating input from participants in the 2007 EPRI [Electric Power Research Institute] Summer Seminar. The analyses summarized in this paper address the technical feasibility for the sector to achieve large-scale CO_2 emissions reductions, the technology development pathways and associated RD&D funding needed to achieve this potential, and the economic impact of realizing emissions reduction targets. Given the 20- to 30-year lead-time needed to fully research, develop, and commercially deploy technologies, it is critical for the industry to define priorities and initiate RD&D activities. The assessment involves three related EPRI studies: [1] The *PRISM analysis*, which determined the US electricity sector's potential for reducing CO_2 emissions from a purely technical perspective, based on deployment of a portfolio of advanced technologies; [2] *A technology development pathways analysis*, which identified the sequence of research, development, and demonstration (RD&D) steps needed to achieve the necessary technology performance and deployment levels, and developed preliminary estimates of the RD&D investment required; [3] The *MERGE analysis*, which assessed the economic value of deploying the full technology portfolio analyzed in the PRISM analysis, and projected the least-cost combination of technologies needed to meet a specified CO_2 emission reduction

requirement. To download the complete EPRI discussion paper prepared for the EPRI 2007 Summer Seminar, go to: http://epri-reports.org/DiscussionPaper2007.pdf.

"State of the Voluntary Carbon Markets 2007: Picking Up Steam." In the course of 2006 and 2007, interest in climate change, carbon offsets and the voluntary carbon markets accelerated dramatically. And yet despite this interest, and the fact that voluntary carbon markets have effectively been operating since 1989, quantitative data surrounding this market has been sorely lacking. Because of this situation, Ecosystem Marketplace and New Carbon Finance teamed up to undertake the most comprehensive analysis to date of the voluntary carbon market. The research has involved a wide ranging survey with responses from over 70 organizations and involved all stages of the supply chain including developers, aggregators, brokers and retailers, covering five continents. The results show that, like the early stages of the regulated carbon markets of the European Union's Emissions Trading Scheme (EU ETS) and the Kyoto Protocol, the voluntary markets are evolving rapidly. They also show that 2006 was a year of significant growth with many new retailers, brokers, and other actors entering the market. Since 2002 the number of organizations supplying carbon credits into the market has grown by 200 [percent], with online retailers being the fastest growing sector of the marketplace. Between 2005 and 2006, the Over the Counter (OTC) voluntary offset market also grew 200 [percent]. In 2006, 23.7 million tonnes of carbon dioxide equivalent ($MtCO_2e$) were transacted in the voluntary carbon markets. Of this, 10.3 $MtCO_2e$ were transacted on the Chicago Climate Exchange (CCX), and [the authors'] survey revealed that some 13.4$MtCO_2e$ were transacted in the OTC market. Because it is impossible to capture all OTC transactions in a survey such as this, the actual volume traded may be considerably larger than this amount. While these numbers are small relative to volumes of transacted in the regulated carbon markets like the EU ETS, the combined voluntary markets (CCX+OTC) are larger in volume than both the Kyoto Protocol's Joint Implementation mechanism and the New South Wales Greenhouse Gas Abatement Scheme. Just as importantly, the voluntary markets are significant in that they represent an active demand by businesses and individuals for some form of action on climate change in the absence of direct regulation. To read this comprehensive report on the state of the voluntary carbon markets in its entirety, go to:
http://ecosystemmarketplace.com/documents/acrobat/StateoftheVoluntaryCarbonMarket18July_Final.pdf.

"Stepping Up: Accelerating the Deployment of Low Emission Technology in Australia."
Addressing the serious consequences of climate change is arguably the biggest challenge facing current and future generations globally. Effective management of climate change requires an integrated, national response to both mitigation and adaptation challenges. The Australian Business & Climate Group strongly supports the adoption of an integrated National Climate Change Response. It will be essential to integrate the component elements of the response as they are intrinsically interlinked. It is also critical that [Australians] seek solutions on a national basis, rather than state by state. A National Climate Change Response will also benefit by linking with international efforts to maximize learning, share costs and expertise while minimizing unnecessary duplication of effort. Transforming the way Australia produces and uses energy must be a cornerstone of a national response aimed at significantly reducing greenhouse gas emissions. While bipartisan acceptance for the establishment of an emissions trading scheme is now established, Australia must also explore complementary policies to accelerate the uptake of breakthrough low emission technologies. The rate of technology improvement and subsequent adoption must be faster than the usual commercial timeframes if these technologies are to be available at scale, performance and at an acceptable cost when required to meet challenging emission trajectories. The Australian Business & Climate Group believes that a National Low Emission Technology Strategy is an essential element of a National Climate Change Response. The challenge is complex and the response must be comprehensive. Business is ready to play its part in delivering the solutions and has prepared this paper as a catalyst for discussion between all stakeholders. To read the complete report, which includes consideration of carbon capture and storage, go to:
http://www.businessandclimate.com/downloads/ABCG_Report_2007.pdf.

November 2007

"Climate Change Legislation Design White Paper, Scope of a Cap-and-Trade Program." The Committee on Energy and Commerce and its Subcommittee on Energy and Air Quality are issuing a series of Climate Change Legislation Design White Papers as the next step in the legislative process leading to enactment of a mandatory, economy-wide climate change program. While the hearings earlier in the year were designed to give the Committee an understanding of the status and projected path of climate change and potential ways to address it, these White Papers and the hearings on them will focus the Committee's attention on crafting mandatory, economy-wide climate change legislation. The White Papers will lay out the basic design and key principles of a program, and also identify issues about which further information and discussion is needed. This White Paper addresses the scope and coverage of the climate change program. It discusses what sectors and activities are directly emitting greenhouse gases, and how those emissions could be included in a cap-and-trade program. Other White Papers will address a number of other cap-and-trade design elements and additional topics, including: cap levels and timetables, measures for containing costs in a cap-and-trade program, carbon sequestration, offsets and credits, developing countries, distribution of allowances, and additional measures to complement the cap-and-trade program. To read the complete White Paper prepared by the US House of Representatives Committee on Energy and Commerce staff, go to: http://energycommerce.house.gov/Climate_Change/White_Paper.100307.pdf.

"The Future of Coal Under a Carbon Cap and Trade Regime." Global climate change is the greatest environmental challenge we face. We have at most a few decades to make the necessary investments to prevent the most serious impacts of climate change. Future generations will judge us based on the investments we are considering now. In its February 2007 report, the Intergovernmental Panel on Climate Change (IPCC) warns that global emissions must peak no later than 2015 if we are to hold average global temperature increases to 2.4 degrees Celsius (4.3 [degrees Fahrenheit]) or less. Moving to an emissions pathway that will hold temperature increases and other impacts to a minimum will require a colossal effort. There is no time to lose given the long lag in research and development cycles, and energy-intensive infrastructure and product turnover. Fundamentally altering the world's energy system is unlikely to occur within this timeframe. It is thus imperative to find means to reduce the footprint of the existing system – most particularly, of coal, which is the most greenhouse gas intensive of the fossil fuels driving climate change. It is in this context that carbon dioxide capture and sequestration (CCS) becomes one of the most critical technologies in the menu of choices we have to cut greenhouse gas emissions. It is the only option that provides a potentially near-term solution to rapidly expanding coal use here, in China and around the world. CCS must play the critical role of curbing growth in emissions from coal until other alternatives are ready. To download the complete paper prepared for the US House of Representatives Select Committee on Energy Independence and Global Warming, go to: http://pdf.wri.org/20070914_submission_houseeigw.pdf.

December 2007

"Final Environmental Impact Statement of FutureGen Project." This Environmental Impact Statement (EIS) provides an analysis of the potential environmental impacts of the proposed FutureGen Project. The project would include the planning, design, construction, and operation of the proposed FutureGen facility, a prototype electric power and hydrogen (H_2) generating plant that would employ coal gasification technology integrated with combined-cycle electricity generation and sequester carbon dioxide (CO_2) emissions. The project would also include an ongoing research program, which would be the principal feature of the prototype plant. The FutureGen Initiative, announced by President George W. Bush on February 27, 2003, is based on recommendations in the National Energy Policy (NEP), issued in May 2001 (NEP, 2001). The NEP cites, in broad terms, the need to promote diverse and secure sources of energy and the expected need for coal to play a significant role in providing that energy. The NEP specifically states, "In the long term, the goal of the [clean coal technology] program is to develop

low cost, zero-emission power plants with efficiencies close to double that of today's fleet." Action is needed to support the President's announcement emphasizing the need for the FutureGen Initiative and to support other federal initiatives including the National Climate Change Technology Initiative (June 11, 2001) and the Hydrogen Fuel Initiative (January 28, 2003). These initiatives aim to reduce the Nation's output of greenhouse gas (GHG) emissions from coal-fueled energy production, to improve the global environment, and to provide advanced technologies to meet the world's energy needs. **(See article in this month's Highlights section, "DOE Releases Environmental Impact Statement for FutureGen Project," which references the release of the document.)** To download the complete FutureGen Final EIS, click on: http://www.netl.doe.gov/technologies/coalpower/futuregen/EIS/FG%20Summary%20-%20FINAL.pdf.

"A Program to Accelerate the Deployment of CO_2 Capture and Storage (CCS): Rationale, Objectives, and Cost." This White Paper analyzes one strategy for accelerating the deployment of carbon capture and storage (CCS) by the coal-fueled electricity-generation industry. This strategy involves providing reimbursement for the incremental costs of installing and operating CCS systems, with reimbursement provided for: (1.) Retrofitting some existing commercial-scale (500+ MW net capacity, before installation of CCS) coal-fueled electric generation plants with CCS and operating these for five years; (2.) Incorporating CCS into some new, commercial-scale (400+ MW net capacity, after installation of CCS) coal-fueled electric generation plants and operating these for five years; and (3.) Launching large-scale (1 to 3 million metric tons per year) demonstrations of geologic storage of carbon dioxide (CO_2) primarily in saline formations and operating these for five years, using CO_2 from non-utility industrial sources. The paper sets forth two alternative sets of objectives and outcomes for such a cost reimbursement program, based on program size. The objectives of the Smaller-Scale Program (10 commercial-scale demonstrations of CCS at coal-fueled electric power plants, plus five CCS demonstrations using CO_2 from other industrial sources) would be to establish reliable CCS cost and performance data, and to build experience with CCS. The objectives of the Larger-Scale Program (30 commercial-scale demonstrations of CCS at coal-fueled power plants plus 10 demonstrations of CCS using CO_2 from other industries sources) would be much more ambitious. Here the objectives are to achieve significant reductions in CO_2 capture costs and energy penalties, build broad public acceptance of CO_2 storage, and promote the timely development of CCS regulatory systems, in addition to establishing reliable cost and performance data and experience with CCS. To download the first of six white papers prepared for the Pew Center on Global Climate Change as part of the Coal Initiative Series, go to: http://www.pewclimate.org/docUploads/CCS%20Deployment.pdf.

"Coal Meeting the Climate Challenge: Technology to Reduce Greenhouse Emissions." A sustainable energy future is one where society's energy needs are met using resources available to us over the short, medium and long term. At the same time, it means producing and utilizing all these energy sources in a way that minimizes adverse impacts on the environment and maximizes economic and social benefits. This is a significant challenge – particularly because of surging energy demand, concerns about energy security, and the environmental impacts of energy production and consumption. [Humankind has] to take steps to reconcile economic and social objectives with environmental imperatives – specifically those posed by climate change. Over the last ten years, world primary energy demand has risen by over 20 [percent] and this upward trend is set to continue. Fossil fuels will continue to dominate energy consumption; still meeting around 80 [percent] of energy needs in 2030. Coal will meet over 25 [percent] of global energy demand. Coal is abundantly available, affordable, reliable, geographically well-distributed and easy and safe to transport. Coal markets are well-functioning and responsive to changes in supply and demand. The major challenges facing coal are concerned with its environmental impacts. Viable, highly effective technologies have been developed to tackle the release of pollutants – such as oxides of sulfur (SOx) and nitrogen (NOx) – and particulate and trace elements, such as mercury. More recently, greenhouse gas (GHG) emissions, including carbon dioxide (CO_2) and methane (CH_4) have become a concern because of their link to climate change. To read the entire report from the World Coal Institute, go to:
http://www.worldcoal.org/assets_cm/files/PDF/coal_meeting_the_climate_challenge.pdf.

"Storage of Carbon Dioxide in Geologic Structures: A Legal and Regulatory Guide for States and Provinces." This report is the product of the Interstate Oil and Gas Compact Commission (IOGCC) Task Force on Carbon Capture and Geologic Storage. It is the culmination of a two-phase, five-year effort. This Phase II report takes the form of a Guidance Document for U.S. states and Canadian provinces. Its purpose is to provide to a state or province contemplating adoption of a legal and regulatory framework for the storage of carbon dioxide (CO_2) in geologic media the resources needed to draft a framework that meets the unique requirements of that particular state or province. It is anticipated that a state adopting a regulatory framework for CO_2 storage will make changes to the model framework as necessary to conform to state law. The Task Force therefore envisions that what will result will be a substantially consistent system for the geologic storage of CO_2 regulated at the state and provincial level in conformance with national and international law and protocol. To read the complete regulatory guide, go to: http://www.iogcc.state.ok.us/docs/MeetingDocs/Master-Document-September-252007-FINAL-(2).pdf.

January 2008

"Intergovernmental Panel on Climate Change Fourth Assessment Report: Climate Change 2007." This Synthesis Report is based on the assessment carried out by the three Working Groups of the Intergovernmental Panel on Climate Change (IPCC). It provides an integrated view of climate change as the final part of the IPCC's Fourth Assessment Report (AR4). Topic 1 summarizes observed changes in climate and their effects on natural and human systems, regardless of their causes, while topic 2 assesses the causes of the observed changes. Topic 3 presents projections of future climate change and related impacts under different scenarios. Topic 4 discusses adaptation and mitigation options over the next few decades and their interactions with sustainable development. Topic 5 assesses the relationship between adaptation and mitigation on a more conceptual basis and takes a longer-term perspective. Topic 6 summarizes the major robust findings and remaining key uncertainties in this assessment. A schematic framework representing anthropogenic drivers, impacts of, and responses to climate change and their linkages, is shown in Figure I.1. At the time of the Third Assessment Report (TAR) in 2001, information was mainly available to describe the linkages clockwise, i.e. to derive climatic changes and impacts from socio-economic information and emissions. With increased understanding of these linkages, it is now possible to assess the linkages also counterclockwise, i.e. to evaluate possible development pathways and global emissions constraints that would reduce the risk of future impacts that society may wish to avoid. To read the IPCC's Fourth Assessment Report, go to: http://www.ipcc.ch/ipccreports/ar4-syr.htm or click: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf to view the Summary for Policymakers. To watch a webcast of the press conference, go to: http://ipcc.cac.es/.

"Carbon Capture and Storage in the CDM." Carbon dioxide capture and storage (CCS) in geological formations is a potentially important climate change mitigation measure in the coming decades, as geological formations can store large amounts of CO_2 (as well as other gases or liquids) for thousands of years. However, CCS has not been widely used to date. The largest CO_2 storage project to date (at the Sleipner field in the North Sea) has been injecting approximately 1 million tonnes of CO_2 per year since 1996 into a saline formation. The possible inclusion of CCS projects under the Clean Development Mechanism (CDM) raises a number of issues, including how to deal with potential leaks of CO_2 and associated permanence and liability issues, what an appropriate project boundary is, how to deal with CDM "leakage" (i.e. emissions resulting from the project activity beyond its boundaries) and what the possible impact of including CCS would be on the broad CDM portfolio. The paper assesses these issues. While the bulk of long-term potential CO_2 emission reductions from CCS is associated with the capture and storage of CO_2 from combustion of fossil fuels, the short-term CCS potential is in different areas. These include enhanced oil recovery (EOR) projects and capture-ready streams of CO_2 from natural gas processing and industrial processes such as refineries, ammonia and hydrogen plants. The maximum short-term (i.e. in 2012) theoretical potential of CCS CDM projects is estimated at 584 Mt CO_2/year - larger than under the current CDM portfolio. However, this potential is unlikely to be reached

given the long lead-time of projects. Hence, the risk that CCS technology could "crowd out" other technologies in the CDM portfolio seems unfounded. To read the entire International Energy Agency paper, go to: http://www.iea.org/textbase/papers/2007/CCS_in_CDM.pdf.

"Building Public Acceptability for Carbon Capture and Sequestration." Carbon dioxide capture and sequestration (CCS) could prove an essential component of the effort to address the climate change challenge. While demonstration projects across the globe can show that CCS risks are low, public perception of such risks will be critical in influencing how policy and regulatory frameworks develop around the technology. This brief outlines the risks associated with CCS, describes how the public views the technology, and explains what can be done to develop long-term public support. [The authors] conclude that the best way to build public acceptance for CCS is by developing large, well-managed demonstration projects; promoting robust regulations and industry standards; and creating more interactive public outreach and education programs. To read the complete brief from the World Resources Institute, click: http://pdf.wri.org/building-public-acceptability-for-ccs.pdf.

"Key Elements of a Post-2012 Agreement on Climate Change." Affordable, secure and reliable energy supply enables economic development which is absolutely essential to the achievement of the global objectives of the United Nations Universal Declaration of Human Rights. Fossil fuels currently dominate primary energy supply – they meet 80 [percent] of global energy needs and will likely supply 81 [percent] of energy in 2030. Coal is the most abundant, affordable and geographically dispersed fossil fuel. Against a background of global rising demand for energy, coal provides a level of energy security not matched by any other fuel. Coal will continue to play an important role in underpinning global economic development, improving standards of living, and alleviating poverty for the foreseeable future. Reducing greenhouse gas (GHG) emissions will require a transformation in the way we produce and use energy. A portfolio of new and existing near-zero and low emission energy technologies, including carbon capture and storage (CCS) is required to deliver that transformation. To read the second in a series of several World Coal Institute policy papers, go to: http://www.worldcoal.org/assets_cm/files/PDF/wci_post_2012_report.pdf.

February 2008

"Near-Term Opportunities for Carbon Dioxide Capture and Storage." Today, fossil fuels provide about 80 [percent] of global energy demand and the outlook is that they will remain the dominant source of energy for decades to come. Consequently global energy-related CO_2 emissions increase 55 [percent] between 2004 and 2030 in a business-as-usual outlook. It is increasingly clear that this development path is not sustainable. Carbon dioxide capture and storage (CCS) is a critical technology to significantly reduce CO_2 emissions. In a global CO_2 emissions stabilization scenario, CCS in power generation, industry and fuel transformation could account for 20 [percent] of CO_2 savings (6.5 Gt of CO_2 captured and stored annually in 2050). Accelerating investment in R&D and demonstration projects will be needed if CCS is to make a significant contribution. CCS along with other mitigation measures could significantly reduce the costs of stabilizing greenhouse gas concentrations and increase the flexibility to achieve that goal. To read the complete International Energy Agency (IEA) summary report on near-term carbon dioxide capture and storage (CCS) opportunities, click: http://www.iea.org/textbase/work/2007/oslo/summary_report.pdf.

"Liability and Financial Responsibility Frameworks for Carbon Capture and Sequestration." This issue brief examines existing federal and state liability and financial responsibility frameworks that may be applicable for carbon dioxide capture and geological sequestration (CCS). Many of the potential risks involved with CCS have been successfully managed under existing state and federal regimes. However, the long time scales associated with CCS projects present unique risks that must be addressed before CCS technology can be widely deployed. Establishment of reliable risk profiles will help to create the appropriate financial responsibility framework to minimize and manage such risks. Significant

jurisdictional differences in the existing state liability frameworks will likely influence the siting, construction and operation of CCS projects. Options to address these differences include establishing minimum standards for financial responsibility and/or an indemnity program. To view the World Resource Institute issue brief, click: http://pdf.wri.org/liability-and-financial-responsibility.pdf.

"Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?" The United States could reduce greenhouse gas emissions in 2030 by 3.0 to 4.5 CO_2e using tested approaches and high potential emerging technologies. These reductions would involve pursuing a wide array of abatement options available at marginal costs less than $50 per ton, with the average net cost to the economy being far lower if the nation can capture sizable gains from energy efficiency. Achieving these reductions at the lowest cost to the economy, however, will require strong, coordinated, economy-wide action that begins in the near future. Although our research suggests the net cost of achieving these levels of GHG abatement could be quite low on a societal basis, issues of timing and allocation would likely lead various stakeholders to perceive the costs very differently – particularly during the transition to a lower carbon economy. Costs will tend to concentrate more in some sectors than others, and involve "real" up-front outlays that would be offset by "avoided" future outlays. Given the timing of investments relative to savings, the economy might well encounter periods of significant visible costs, with the costs and benefits shared unequally among stakeholders. Nonetheless, a concerted, nationwide effort to reduce GHG emissions would almost certainly stimulate economic forces and create business opportunities that we cannot foresee today and that may accelerate the rate of abatement the nation can achieve, thereby reducing the overall cost. To read the complete executive report from the US Greenhouse Gas Abatement Mapping Initiative, go to:
http://www.mckinsey.com/clientservice/ccsi/pdf/US_ghg_final_report.pdf.

March 2008

"The Future of Carbon Capture and Storage." A global consensus has formed on the need for government intervention to reduce GHGs, particularly carbon dioxide (CO_2), in order to fight the potentially disastrous impacts of climate change. This will have a huge impact on the energy industry, one of the leading sources of GHG emissions. While there is some potential for switching to carbon-free methods of generation, it is likely that coal and natural gas will be a part of the generation mix for a long time. This means that methods of reducing the CO_2 produced by power generation must be developed. CCS is one way in which carbon emissions can be reduced and there is a need for members of the industry to understand the technology of CCS, the role it can play in helping generators succeed in a carbon constrained environment, and the impact that its implementation will have on generation costs. The report aims to provide the reader with a thorough understanding of CCS and how it serves as a GHG mitigation option. It also aims to provide a look at the options that exist to implement CCS and the current programs underway to develop and implement CCS technology. The report focuses specifically on the needs of the electric power industry as they relate to CCS, providing the information necessary for industry participants to start moving forward with participation in CCS opportunities. This report will be of interest to the utility industry, power plant developers, and generation technology vendors. It will also be of interest to energy industry vendors, academics, consultants, and analysts. To order the 3rd Edition of Research Reports International's "The Future of Carbon Capture and Storage report," go to:
http://www.researchandmarkets.com/reports/c80081. (Subscription required.)

"Pipelines for Carbon Dioxide (CO_2) Control: Network Needs and Cost Uncertainties." Congress is considering policies promoting the capture and sequestration of carbon dioxide (CO_2) from sources such as electric power plants. Carbon capture and sequestration (CCS) is a process involving a CO_2 source facility, a long-term CO_2 sequestration site, and CO_2 pipelines. There is an increasing perception in Congress that a national CCS program could require the construction of a substantial network of interstate CO_2 pipelines. However, divergent views on CO_2 pipeline requirements introduce significant uncertainty into overall CCS cost estimates and may complicate the federal role, if any, in CO_2 pipeline development. S. 2144 and S. 2191 would require the Secretary of Energy to study the feasibility of

constructing and operating such a network of pipelines. S. 2323 would require carbon sequestration projects to evaluate the most cost-efficient ways to integrate CO_2 sequestration, capture, and transportation. P.L. 110-140, signed by President Bush on December 19, 2007, requires the Secretary of the Interior to recommend legislation to clarify the issuance of CO_2 pipeline rights-of-way on public land. To read the complete CRS Report for Congress, click: http://assets.opencrs.com/rpts/RL34316_20080110.pdf.

"Geologic Storage of Carbon Dioxide - Staying Safely Underground." Geologic storage of carbon dioxide (CO_2) is the underground disposal of CO_2 from large industrial sources such as power plants. Carbon Capture and Storage (CCS), also known as Carbon Capture and Sequestration, includes geologic storage as one of its components. CCS is a powerful tool – along with energy efficiency, fuel switching and renewable energy sources – essential to reducing atmospheric CO_2 levels. Many studies show that the most effective and least-costly way to reduce CO_2 levels to avoid climate change is to use all CO_2 reduction tools, including CCS. CO_2 is a natural substance in the air that is essential to life. As part of the natural carbon cycle, people and animals inhale oxygen from the air and exhale CO_2. Meanwhile, green plants absorb CO_2 for photosynthesis and emit oxygen back into the atmosphere. CO_2 is also widely used for many purposes such as carbonating drinks and filling fire extinguishers. As a greenhouse gas, its presence in the atmosphere traps heat from the sun. Normally, this keeps the climate warm enough for life to continue. However, the burning of fossil fuels is increasing CO_2 levels in the atmosphere above naturally-occurring levels, contributing to global climate change. To view the complete booklet, published by the IEA Working Party on Fossil Fuels and the IEA Greenhouse Gas R&D Programme, click: http://www.cslforum.org/documents/geostoragesafe.pdf.

April 2008

"Policy Options for Reducing CO_2 Emissions." There is a growing scientific consensus that rising concentrations of carbon dioxide (CO_2) and other [GHGs], which result from the burning of fossil fuels, are gradually warming the Earth's climate. The amount of damage associated with that warming remains uncertain, but there is some risk that it could be large and perhaps even catastrophic. Reducing that risk would require restraining the growth of CO_2 emissions—and ultimately limiting those emissions to a level that would stabilize atmospheric concentrations—which would involve costs that are also uncertain but could be substantial. The most efficient approaches to reducing emissions of CO_2 involve giving businesses and households an economic incentive for such reductions. Such an incentive could be provided in various ways, including a tax on emissions, a cap on the total annual level of emissions combined with a system of tradable emission allowances, or a modified cap-and-trade program that includes features to constrain the cost of emission reductions that would be undertaken in an effort to meet the cap. This Congressional Budget Office (CBO) study—prepared at the request of the Chairman of the Senate Committee on Energy and Natural Resources—compares those policy options on the basis of three key criteria: their potential to reduce emissions efficiently, to be implemented with relatively low administrative costs, and to create incentives for emission reductions that are consistent with incentives in other countries. In keeping with CBO's mandate to provide objective, impartial analysis, the report contains no recommendations. To read the complete Congressional Budget Office study, click: http://www.cbo.gov/ftpdocs/89xx/doc8934/02-12-Carbon.pdf.

"Climate Change Legislation Design: Appropriate Roles for Different Levels of Government." Sorting out the appropriate roles of each level of government in addressing climate change is far more complicated than the specific question of whether State climate change programs should be preempted. This Paper raises more comprehensive and complex questions that the Committee must consider: what roles are best played by each level of government as we marshal our country's resources to address climate change and how should these roles be reflected in Federal legislation. Many State and local governments have begun to address climate change, as the Subcommittee heard last year in testimony from State and local witnesses. Activity by State and local governments has helped reduce [GHG]

emissions, has helped build a consensus that we need to address climate change nationally, and is helping to develop and test different policies. To read the first in a series of white papers from the House Committee on Energy and Commerce and its Subcommittee on Energy and Air Quality, go to: http://energycommerce.house.gov/Climate_Change/white%20paper%20st-lcl%20roles%20final%202-22.pdf.

"Managing the Transition to a Secure, Low-Carbon Energy Future." Over the coming decades, the world faces a daunting challenge in meeting the energy needs of a growing and developing world population while mitigating the impacts of global climate change. There is now broad-based scientific and political agreement that climate change is occurring and that the increase in atmospheric [GHG] concentrations is the single biggest factor in global temperature rise. Stabilizing GHG concentrations at levels that will not dangerously interfere with the climate system requires an urgent and fundamental change in the way we produce and use energy. At the same time, concern over energy security grows deeper as global energy demand increases, prices continue to rise, and the ability to bring new supplies to market is called into question. Although the world is not running out of energy resources overall, significant geopolitical, economic, environmental, and technical challenges lie in accessing, producing, converting, and delivering those resources to the people who need them. The entire World Resources Institute Issue Brief is available at: http://pdf.wri.org/managing_transition_to_low-carbon_energy_future.pdf.

"Designing a Greenhouse Gas Emissions Registry." With the federal government now debating the best way to reduce [GHG] emissions on a national scale, policymakers must also address the need to collect the emissions data necessary to ensure the success of U.S. climate change policies. The first step in reducing emissions is to measure them. Without accurate and complete data on the sources of emissions and the amount they emit, the success of U.S. climate policies may be compromised. In December 2007, Congress passed and President Bush signed into law the *Consolidated Appropriations Act, 2008*. The law includes a provision directing the U.S. Environmental Protection Agency to require mandatory reporting of [GHG] emissions from appropriate sources in all sectors of the U.S. economy. This policy brief explains the critical need for such a mandatory [GHG] emissions registry and reporting program and outlines key design elements to include in such a registry. To view the World Resources Institute policy brief, click: http://pdf.wri.org/designing_a_us_ghg_emissions_registry.pdf.

May 2008

"Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006." An emissions inventory that identifies and quantifies a country's primary anthropogenic sources and sinks of greenhouse gases is essential for addressing climate change. This inventory adheres to both 1) a comprehensive and detailed set of methodologies for estimating sources and sinks of anthropogenic greenhouse gases, and 2) a common and consistent mechanism that enables Parties to the United Nations Framework Convention on Climate Change (UNFCCC) to compare the relative contribution of different emission sources and greenhouse gases to climate change. In 1992, the United States signed and ratified the UNFCCC. As stated in Article 2 of the UNFCCC, "The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." To download the complete version of EPA's annual national GHG inventory, click: http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf.

"Clean Coal Technologies - Accelerating Commercial and Policy Drivers for Deployment." Coal is and will remain the world's most abundant and widely distributed fossil fuel. Burning coal, however, can pollute and it produces carbon dioxide. Clean coal technologies address this problem. The widespread

deployment of pollution-control equipment to reduce sulphur dioxide, [nitrogen oxide (NOx)] and dust emissions from industry is just one example which has brought cleaner air to many countries. Since the 1970s, various policy and regulatory measures have created a growing commercial market for these clean coal technologies, with the result that costs have fallen and performance has improved. More recently, the need to tackle rising CO_2 emissions to address climate change means that clean coal technologies now extend to include those for CO_2 capture and storage (CCS). To read the complete International Energy Agency (IEA) publication, click: http://www.iea.org/textbase/papers/2008/Clean_Coal_CIAB_2008.pdf.

"Analysis of the Lieberman-Warner Climate Security Act (S. 2191) Using the National Energy Modeling System (NEMS/ACCF/NAM)." The American Council for Capital Formation (ACCF) and the National Association of Manufacturers (NAM) believe it important to fully and realistically examine the potential costs that enactment of Lieberman-Warner Climate Security Act (S. 2191) would impose on the U.S. economy. It is becoming increasingly recognized that the cost to U.S. consumers and employers of implementing greenhouse gas (GHG) emission reductions is highly dependent on the market penetration achieved by key technologies and the availability of carbon offsets by 2030. Understanding the potential economic impacts at the national, state and individual household levels can help guide choices on climate change policy to minimize the impacts on economic growth and maximize the benefits to the environment. Greenhouse gas reduction policies need to include consideration of impacts on energy security, economic growth, and U.S. competitiveness. To view the report, written by Science Applications International Corporation (SAIC), go to: http://www.accf.org/pdf/NAM/fullstudy031208.pdf.

"Measuring Forest Carbon: Strengths and Weaknesses of Available Tools." Policy makers at every level recognize the importance of forests in the global carbon cycle, and there is a growing consensus that protecting forestland and enhancing its carbon stores will be an important component of any attempt to mitigate climate change. Whether it's Congress considering a national cap-and-trade system, the Regional Greenhouse Gas Initiative (scheduled for the northeastern U.S. in 2009), or the California Climate Action Registry Forest Project Protocol, forests will play an important role in carbon storage and mitigating climate change. As these efforts unfold, it's important to develop accurate measures of the carbon stored in forests and the changes in those stores over time. To read the complete policy brief, compiled by The Wilderness Society, click: http://wilderness.org/Library/Documents/upload/FR7-28carbonbrief.pdf.

June 2008

"Energy Market and Economic Impacts of S.2191, the Lieberman-Warner Climate Security Act of 2007." This report responds to a request from Senators Lieberman and Warner for an analysis of S. 2191, the Lieberman-Warner Climate Security Act of 2007 and a subsequent analysis request from Senators Barasso, Inhofe, and Voinovich. S. 2191 is a complex bill regulating emissions of greenhouse gases (GHG) through market-based mechanisms, energy efficiency programs, and economic incentives. Title I of S. 2191 establishes a cap on emissions of greenhouse gases beginning in 2012 through an emission allowance program. The Title I allowance program covers energy-related carbon dioxide (CO_2), methane, nitrous oxide, perfluorocarbons, sulfur hexafluoride, and hydrofluorocarbons (HFCs) emitted from production of hydrochlorofluorocarbons (HCFCs). Sources that are exempt from the Title I cap, but which have other emission reduction incentives under the bill, include most non-CO_2 agricultural emission sources, emissions from coal mines and landfills, and the other HFCs. The emissions covered under Title I represented approximately 87 percent of total GHG emissions in 2006 as reported by the Energy Information Administration (EIA) in its inventory. To read the EIA report, which responds to a request from Senators Lieberman and Warner for an analysis of S.2191, click: http://www.eia.doe.gov/oiaf/servicerpt/s2191/pdf/sroiaf(2008)01.pdf.

"The European Union's Emissions Trading System in Perspective." The performance of the European Union's Emissions Trading System (EU ETS) to date cannot be evaluated without recognizing

that the first three years from 2005 through 2007 constituted a "trial" period and understanding what this trial period was supposed to accomplish. Its primary goal was to develop the infrastructure and to provide the experience that would enable the successful use of a cap-and-trade system to limit European GHG emissions during a second trading period, 2008-12, corresponding to the first commitment period of the Kyoto Protocol. The trial period was a rehearsal for the later more serious engagement and it was never intended to achieve significant reductions in CO_2 emissions in only three years. In light of the speed with which the program was developed, the many sovereign countries involved, the need to develop the necessary data, information dissemination, compliance and market institutions, and the lack of extensive experience with emissions trading in Europe, [the authors] think that the system has performed surprisingly well. The document is available at: http://www.pewclimate.org/docUploads/EU-ETS-In-Perspective-Report.pdf.

"What Will It Cost to Protect Ourselves From Global Warming?" Important parts of the world are acting to reduce greenhouse gases that cause global warming, and the United States is not debating whether to join that process. This paper examines the potential impact of a cap on greenhouse gases on the U.S. economy as a whole and on American families. What will it cost to protect ourselves against the potentially catastrophic consequences of global warming? Advocates of action anticipate minimal costs. Those who want to do nothing sometimes assert that carbon cuts will "bankrupt the economy." Who is right? This paper conducts the broadest assessment to date of the impacts on the U.S. economy of capping greenhouse gases. This report synthesizes the findings of several state-of-the-art economic models, and arrives at a strong conclusion: The United States can enjoy robust economic growth over the next several decades while making ambitious reductions in greenhouse gas emissions. If [the United States] put a cap-and-trade policy in place soon, [Americans] can achieve substantial cuts in greenhouse gas emissions without significant adverse consequences to the economy. And in the long run, the coming low-carbon economy can provide the foundation for sustained American economic growth and prosperity. To read the entire economic policy report produced by the Environmental Defense Fund (EDF), click: http://www.edf.org/documents/7815_climate_economy.pdf.

"Adapting to Climate Change: A Business Approach." The business community has for some time been aware of the risks and opportunities associated with greenhouse gas mitigation and current and future climate change policies. Many businesses have taken steps to reduce greenhouse gas emissions voluntarily. Many are taking into account some of the impacts of climate change—potential state and federal regulations, shareholder perceptions, and changes in consumer and supplier markets, for example—on the cost of doing business now and in the future. Fewer businesses, however, are incorporating the risks and opportunities associated with the physical effects of climate change in their business planning. As trends in climate become clearer and the uncertainty surrounding future changes is reduced, more businesses will want to consider whether to adapt to projected changes by taking action now. This, in turn, involves reacting to and managing risks as well as taking advantage of opportunities. To read the complete report, which outlines a sensible business approach to analyzing and adapting to the physical risks of climate change, click: http://www.pewclimate.org/docUploads/Business-Adaptation.pdf.

"General Reporting Protocol." The Climate Registry (the Registry) sets best practice standards for voluntary North American greenhouse gas (GHG) emissions calculation, reporting and verification. It is a non-profit organization governed by its member U.S. States, Canadian Provinces, Mexican States and Native American Tribes. As of March 2008, the Registry's membership includes: thirty-nine U.S. states and the District of Columbia, seven Canadian provinces, six Mexican states, and three Native American Tribes. Emissions Reporters are environmental leaders in the private and public sectors. The Registry also supports the collection of high-quality GHG emissions data for mandatory emissions reporting programs. To read the complete General Report Protocol, go to: http://www.theclimateregistry.org/downloads/GRP.pdf.

July 2008

"Expert Review of Regional Carbon Sequestration Partnerships Phase III." The Regional Carbon Sequestration Partnerships Program (Partnerships Program) is a multi-million dollar research program which is underway in the USA. The Partnerships Program is being carried out in three phases: (1) Phase I – Characterization (2003-2005); (2) Phase II – Validation (2005-2009); and (3) Phase III – Deployment (2008-2017). The USDOE requires that an independent technical review of the Phase III program should be undertaken at the outset of the program. The USDOE approached the IEA Greenhouse Gas R&D Programme (IEA GHG) to undertake the Phase III technical review. IEA GHG has extensive experience of CO_2 injection projects worldwide and has organized a number of independent technical reviews on behalf of member organizations such as USDOE. To review the Partnerships Program and the Phase III activities IEA GHG appointed an independent international panel of experts. The experts were drawn from on-shore CO_2 injection projects underway in Canada, Europe and Australia, many of the experts were involved in the IPCC Special Report on CO_2 Capture and Storage or the IPCC 2006 Inventories Guidelines report. The complete expert review is available at: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/Expert_Review_of_DOE_Regional_Patrnerships_Phase_III_-_ExecS.pdf.

"Getting the Most Greenhouse Gas Reductions for Our Money." One of the [House Committee on Energy and Commerce and its Subcommittee on Energy and Air Quality's] goals in designing a comprehensive climate change program is to achieve the necessary greenhouse gas reductions for the least cost and with the least economic disruption. Reducing greenhouse gas emission will be an expensive proposition, but scientists tell us that *not* reducing emissions will leave future generations with serious problems that will cost even more to address. This White Paper discusses ways to keep costs as low as feasible while still achieving out environmental goals. The most important way to keep costs down is to establish a system that will achieve lowest-cost reductions. The climate change debate often focuses on the need for expensive measures. If the program is structured properly, however, significant reductions can be achieved by economically beneficial measures (i.e. measures with savings that exceed costs). In large part, these measures are improvements in energy efficiency and productivity. The decision to have a cap-and-trade regulatory program as the cornerstone of a mandatory climate change program is driven in large part by the ability of such a program to reduce greenhouse gas emissions to a specified level at the lowest possible overall cost to society and to lower the cost for regulated entities. As compared to more traditional forms of regulation, a well-designed cap-and-trade program generally should achieve the same environmental results at a lower cost because it provides flexibility to emitters, creates incentives for sources to use low-cost compliance strategies, and provides incentives for technological advances. To read the complete White Paper, issued by the House Committee on Energy and Commerce and its Subcommittee on Energy and Air Quality, go to: http://energycommerce.house.gov/Climate_Change/Climate%20Change%20White%20Paper-Cost%20Containment.052708.pdf.

"Capturing King Coal." Coal is a key fuel source for current and future electric power generation. Coal becomes even more critical when cost of electricity and security of supply issues are viewed in light of other fuel sources such as gas or uranium. Yet coal combustion produces about 1.9 billion tons of CO_2 per year in the U.S., roughly equivalent to all CO_2 emissions from U.S. transport per annum. The burning of coal, with more CO_2 emissions per unit of energy produced than any other fossil fuel, has significant adverse climate change impacts. One way to reduce carbon emissions from coal-fired power plants is to capture and store it permanently underground, a process called carbon capture and storage (CCS), also called carbon sequestration. CCS has captured the attention of policymakers, power generators, and environmentalists because of its potential as a bridging technology that will permit the continued use of coal as a fuel source while not contributing to a further destabilization of the climate. A great deal of work is underway to develop and improve the technologies, legal frameworks, and policies required for wide-scale deployment of CCS systems. To view the full report about deploying CCS systems in the United States, click: http://pdf.wri.org/capturing_king_coal.pdf.

August 2008

"Returns to Scale in Carbon Capture and Storage Infrastructure and Deployment." The degree to which carbon capture and storage (CCS) is deployed will be partly determined by the returns to scale of the technological system that captures, transports, and stores carbon dioxide (CO_2). This technological system spatially connects the organization of CO_2 point sources with the organization of geologic CO_2 storage reservoirs. These point sources and storage reservoirs are heterogeneous in the amount of CO_2 that they produce or store and in the costs of capturing or storing CO_2, and the associated cost structures interact to determine the returns to scale for the entire coupled system. The SimCCS cost-minimizing geospatial deployment model is used to deploy CCS for a variety of combinations of CO_2 sources and injection reservoirs and determine the returns to scale for CCS deployment and unravel the determinants thereof. SimCCS minimizes the total costs of the entire capture, transport, and storage system by simultaneously determining how much CO_2 is captured from each source, how much CO_2 is stored in each storage reservoir, and assigning CO_2 flows through pipeline networks that include trunk distribution lines that are routed to minimize the influence of the social and physical topography. The returns to scale for the entire CCS system involves the interaction of the cost structures for each link in the CCS chain - capture at the source, transport through the network, and storage at the reservoir - each of which is modeled with cost structures that allow for increasing returns to scale. While it is possible that these cost structures can reinforce each other, the variability of source and reservoir costs and capacities interact with the spatial organization of sources and reservoirs to limit and ultimately reverse the returns to scale for CCS as the scale of the system expands. The complete discussion paper is available at: http://belfercenter.ksg.harvard.edu/files/Bielicki_CCSReturnsToScale.pdf.

"Carbon Capture and Storage: A Solution to the Problem of Carbon Emissions." Carbon capture and storage (CCS) is a technically feasible solution for mitigating global warming. It does so by capturing carbon dioxide from large single-point sources and storing it underground rather than allowing it to be released into the atmosphere. In September 2007, The Boston Consulting Group analyzed global sources of carbon dioxide and determined that if the CCS were implemented at the 250 largest stationary emitters worldwide, carbon dioxide emissions would be reduced by 4 Gton per year – 25 percent of the total from all stationary sources worldwide. Implementing CCS at the 1,000 largest stationary sources would reduce emissions by 8 Gton per year – a 50 percent reduction. Over time, the benefits of CCS would grow. By 2030, its use at the 1,000 largest stationary sources would reduce emissions by 15 Gton per year. That would represent a reduction of more than one-third of the 42 Gton of global emissions from all sources estimated for 2030 – a significant contribution to solving the global warming problem. The BGG analysis also looked at how to pay for CCS. [The authors] concluded that by 2030, assuming a stable global market price of [$47.09 (€30)] per ton, carbon trading would offset the likely cost of capturing, transporting, and storing the carbon dioxide emitted by stationary fossil-fuel-burning sources in Europe and North America. Today, however, it would cost a minimum of about [$70.64 (€45)] per ton to implement CCS at these facilities. [The authors'] estimates indicate that financing the technological advancements that will lower the cost of CCS to the threshold of [$47.09 (€30)] per ton will require approximately [$793 billion (€500 billion)] in government subsidies and company investments through 2030, most of which could be recovered through the trading of carbon certificates. Although the required government share of subsidies is difficult to predict, [the authors] expect it to be no more than about [$158.6 billion (€100 billion)], or one-fifth of the total estimated cost. To read the complete publication, go to: http://www.bcg.com/impact_expertise/publications/files/Carbon_Capture_and_Storage_Jun_2008.pdf.

"Six Thousand Feet Under: Burying the Carbon Problem." The challenge of reducing emissions to tackle climate change is one of the toughest faced by modern economies. The political consensus is that carbon emissions [need to be reduced by 60 to 80 percent] by 2050 and yet, instead of falling, they continue to rise. Worldwide emissions from fossil fuels are expected to rise 62 [percent] by 2030, with two thirds of that in India and China. Carbon Capture and Storage (CCS) is a term for a set of technologies which could tackle part of this problem by capturing up to 95 [percent] of the carbon dioxide (CO_2) released by coal and gas fired power stations. The CO_2 is captured from the station emissions,

liquefied for transport by ship or pipeline before being finally stored underground in depleted oil and gas fields, coal seams or deep saline aquifers. [The authors'] report finds that: (1) fitting CCS equipment to coal and gas power stations could slash global emissions by between 28-50 [percent] by 2050; (2) fitting CCS to UK plants could cut emissions by 20 [percent] by 2020; and (3) these emission reductions could be extremely affordable. If all large gas and coal fuelled electricity plants in the UK were fitted with commercially viable CCS, the additional cost of electricity would be around $118.77 (£60) per household per year. To view the complete report, visit: http://www.policyexchange.org.uk/images/libimages/390.pdf.

Legislative

September 2007

***E&E Daily,* "CO_2 Sequestration May Have Reached 'Adolescence'."** On August 1, the Senate Energy and Natural Resources Committee held a hearing to discuss recent advancements in clean coal technology, including large-scale sequestration of CO_2 emissions. The hearing was the third full committee hearing of its kind held this year. Challenges facing the coal industry, including long-term liability issues related to permanent storage of CO_2 and public acceptance of sequestration technology were reported as testimony at the hearing. A National Coal Council representative presented a report that states that new CO_2 capture and storage technologies could be commercially available within the next 15 years. Carl Bauer, director of DOE's National Energy Technology Laboratory, also provided testimony and affirmed that DOE would announce a third round of solicitations for the Clean Coal Power Initiative. **(See the Announcements section of this newsletter for a link to Carl Bauer and other witnesses' testimony at the Senate oversight hearing.)** August 2, 2007, http://www.ens-newswire.com/ens/aug2007/2007-08-06-10.asp.

***Washington Post,* "Two Senators to Unveil Climate Bill,"** and ***Associated Press,* "Senators Line Up Behind Economy-Wide Approach to Slow Global Warming."** On August 2, Senator Joe Lieberman (I-Conn.) and ranking Republican, John Warner of Virginia outlined a bipartisan measure addressing climate change. The bill calls for three elements: a "Federal Reserve-style" board whose goal would be to regulate the cost of carbon; a 70 percent cut in greenhouse gas emissions below today's level by 2050; and initiation of a Climate Change Credit Corporation that would auction pollution credits among electric utilities, transportation, and other industries and use the revenue to promote new technologies, including carbon capture and sequestration. The Senators hope to have the bill to the Senate floor by late fall. Speaker of the House, Nancy Pelosi (D-Calif.) is preparing to offer a climate change bill in the House this fall which also favors a cap-and-trade program to reduce CO_2 emissions. August 2, 2007, http://www.washingtonpost.com/wp-dyn/content/article/2007/08/01/AR2007080102321_pf.html, and August 3, 2007, http://climate.weather.com/articles/senators080307.html.

October 2007

***E&E Daily,* "International Carbon Traders Pick Apart Lieberman-Warner Proposal."** Participants in the European carbon market are voicing their concern over Senators Joe Lieberman (I-Conn.) and John Warner's (R-Va.) draft climate bill, and specifically their approach on how to manage a US cap-and-trade program. In a letter to the senators, International Emissions Trading Association (IETA) president and CEO, Andrei Marcu, praised them for taking a market-based approach to climate change with the establishment of a cap-and-trade based system, but offered detailed suggestions on certain issues of concern contained within it. The Lieberman-Warner bill proposes the formation of a Carbon Market Efficiency Board, whose responsibility it would be to monitor the pricing of the carbon market. The IETA, however, discouraged this type of intervention. Other areas of concern to the IETA include the provision in the senators' proposal to set up a 15 percent limit on the use of carbon sequestration, forestry,

methane capture, and other projects. An initial auction of up to 42 percent of the allowances in the cap-and-trade program was also opposed by Marcu and other IETA members. The Lieberman-Warner plan is expected to be formally introduced in the Senate by the end of September. To read the IETA's letter to the senators, go to: http://www.eenews.net/features/documents/2007/09/10/document_pm_05.pdf. September 11, 2007, http://www.eenews.net/EEDaily/print/2007/09/11/1.

***E&E Daily,* "Global Warming Panel Takes on CO_2-Capture for Coal."** On September 6, the House Select Committee on Global Warming will hear testimony from industry and government representatives on ways to reduce CO_2 emissions in the US, including the option of carbon capture and storage. With emissions expected to increase at an average rate of 1.2 percent per year through 2030, the prospect of adopting legislation aimed at reducing the country's carbon footprint is being considered. NETL Director Carl Bauer provided testimony at the hearing, along with American Electric Power CEO, Michael Morris and Natural Resources Defense Council Climate Center Director, David Hawkins. The hearing follows a study released by Latham and Watkins partner Bob Sussman, which recommends mandatory carbon capture and storage for new coal-fired power plants by 2016. To read Carl Bauer's testimony "Future of Coal: Carbon Capture and Storage," go to: http://www.netl.doe.gov/newsroom/testimony/September%206_NETL_Bauer.pdf. September 4, 2007, http://www.eenews.net/EEDaily/print/2007/09/04/9.

November 2007

***PressMediaWire,* "EPA to Develop Regulations for Geologic Sequestration of Carbon Dioxide,"** and ***USA Today,* "EPA Studies Emissions Storage."** On October 11, The US Environmental Protection Agency (EPA) announced plans to develop geologic CO_2 sequestration regulations. Once in place, the regulations will ensure a consistent and effective permitting system under the Safe Drinking Water Act for commercial-scale projects aimed at mitigating CO_2, a greenhouse gas that contributes to global climate change. The same federal law established the Underground Injection Control (UIC) program which works with state and local governments to oversee underground injection of waste in order to prevent contamination of drinking water resources. The EPA said in a statement that it will propose regulations by the summer of 2008. For further information about the UIC program as related to the geologic sequestration of CO_2, see: http://www.epa.gov/safewater/uic/index.html. October 12, 2007, http://pressmediawire.com/printFriendly.cfm?articleID=2759, and October 14, 2007, http://www.usatoday.com/money/industries/energy/environment/2007-10-14-epa-carbon-dioxide_N.htm.

***E&E Daily*, "Senate Bill Seeks Study on CO_2 Pipeline Expansion."** Ten United States senators introduced legislation on October 14, calling for DOE to study the safety, cost, and overall potential of transporting large amounts of CO_2 by pipeline to its eventual underground location. Cosponsored by several members of the Senate Energy and Natural Resource Committee, the bill states the DOE would partner with the Commerce and Interior departments, Federal Energy Regulatory Commission, and the Environmental Protection Agency to study the unknowns related to expanding the nearly 1,500 miles of US pipeline that ships both natural and man-made CO_2, mostly to western Texas oilfields. The bill's main objective is to examine issues such as compression rates for CO_2, potential for leakage, inspection policies, injection methods, and whether CO_2 fits the classification of a commodity or pollutant, an important difference for regulation. While engineers and lawmakers someday hope to have a sound CO_2 infrastructure, many hurdles still exist, such as rights-of-way, the absence of detailed CO_2 rules, and incentives for private lenders and developers. To view a copy of the draft legislation, "Carbon Dioxide Pipeline Study Act of 2007," click on: http://www.eenews.net/features/documents/2007/10/05/document_pm_01.pdf. October 5, 2007, http://www.eenews.net/eenewspm/print/2007/10/05/2. (Subscription may be required.)

***Biopact,* "Towards Carbon-Negative Bioenergy: U.S. Senator Introduces Biochar Legislation."** Legislation focused on carbon-negative bioenergy production was recently introduced in the Senate.

S.1884, entitled “The Salazar Harvesting Energy Act of 2007” relates to the concept of producing carbon-negative fuels and energy. The legislation includes the creation of a joint US Department of Agriculture/DOE research program that involves a quantification and verification of the carbon sequestration benefits of various bioenergy and agricultural crops and practices. Unlike “carbon-neutral” technologies which factor out the CO_2 emissions with the growth of new energy crops, carbon-negative bioenergy effectively removes more CO_2 from the atmosphere than is released. Proponents of the biochar technology boast of its low cost and long-term benefits. The technology involves heating green waste or other biomass without oxygen to generate renewable energy through a process called pyrolysis. Because of the absence of oxygen in this process, no CO_2 is emitted. The byproduct of this process is agrichar, a black carbon substance which is added to agricultural soils where it can be stored safely for hundreds or even thousands of years. Benefits of agrichar use in soils are numerous. It reduces fertilizer requirements, increases crop yields, and reduces the impact of croplands on the climate and environment. Also, the low-cost technique can be applied world-wide on agricultural soils in developing countries. To read S.1884, “The Salazar Harvesting Energy Act of 2007,” click on: http://www.biochar-international.org/images/S.1884_Salazar_Harvesting_Energy_Act_of_2007.pdf. October 7, 2007, http://biopact.com/2007/10/towards-carbon-negative-bioenergy-us.html.

December 2007

***Wall Street Journal Online*, “Senate Panel Backs Cap-and-Trade for Limiting GHG.”** On November 1, 2007, a US Senate Environment and Public Works subcommittee voted 4-3 to approve legislation that would institute a cap-and-trade system to limit greenhouse gases. Should the bill come to fruition, companies would receive allowances beginning in 2012 to release a predetermined amount of CO_2 and other greenhouse gases, with the amount of emissions permitted decreasing 70 percent by 2050. The responsibly for allocating credits would fall into the hands of the EPA, while a newly created “Climate Change Credit Corporation” would auction off 18 percent of the credits at the program’s onset; by 2036 that figure would rise to 73 percent. Over the first five years of the program, electrical power companies would receive 19 percent of the allowances and industrial companies would receive 20 percent, with the free, tradable allowances completely phased out by 2036. About 55 percent of the auction proceeds would fund energy technology deployment, such as developing new automobiles. The bill arises from a United Nations panel estimate that greenhouse gas emissions must be reduced 50 to 85 percent below 2000 levels by 2050 to avert significant damage to the environment. To browse the Senate Committee web site, see: http://epw.senate.gov/public/index.cfm?FuseAction=Hearings.Hearing&Hearing_ID=ec1a7a4f-802a-23ad-4773-1e922d374f71. To view the legislation, go to: http://epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=85a349e8-0579-4b3b-a642-70219ab09f41. November 1, 2007, http://online.wsj.com/article/SB119393294388879212.html?mod=googlenews_wsj. (Subscription may be required.)

***Reuters*, “Kerry Floats GHG Sequestration Proposal.”** Massachusetts Senator John Kerry introduced a bill titled “Carbon Capture and Storage Technology Act of 2007,” on November 8, 2007, calling for billions of dollars to be spent boosting carbon sequestration research and development funds and assembling a nationwide assessment of CO_2 storage capacity. The bill would authorize DOE to create a competitive grant program for the construction of three to five coal-fired power plants capable of capturing CO_2 and an equal number of sequestration projects able to exhibit the storage of one million tons of CO_2 per year. The power plants would receive $2.4 billion per year thru 2015, while the sequestration projects would receive $1.6 billion per year, with half of the power plants and 20-50 percent of the sequestration projects costs covered by non-federal sources. The bill requires at least two of the sequestration projects inject CO_2 into deep saline aquifers, instead of unminable coal seams or depleted oil or gas reservoirs. In addition, a task force composed of EPA, DOE, and US Geological Survey officials would develop regulations regarding safe transportation and storage of CO_2, possible liability issues, and storage site certifications. DOE would also be responsible for researching and

developing several capture techniques, including oxygen-fueled pulverized coal combustion, separation of oxygen and air, and coal gasification. To view a copy of the proposed legislation, click on: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:s2323is.txt.pdf November 8, 2007, http://www.eenews.net/EEDaily/print/2007/11/08/6.

January 2008

***Reuters*, "Climate Change Bill Heads for Full Senate,"** and ***E&E Daily*, "Focus Shifts to Senate Floor as Lieberman-Warner Clears Committee."** On December 5, the Senate Environment and Public Works (EPW) Committee approved S. 2192, America's Climate Security Act of 2007, with an 11-8 committee vote, clearing the path for the global warming legislation to be considered by the full Senate in 2008. If the bill reaches fruition, a federal program to reduce greenhouse gas emissions from power, industry, and transportation sectors by 70 percent by 2050 would be created, with special care taken to protect the economy and citizens from hardships. During the nine-and-a-half hour markup, Senators addressed many issues arising from the broad climate bill. In particular, the EPW committee added an amendment setting a new low-carbon fuel standard for the nation's motor vehicles and several state related amendments regarding emission allowances and financial incentives for new technology. However, Senators failed to pass amendments concerning the following issues: exemptions for major industries undertaking projects to reduce greenhouse gas levels, increasing the bill's emissions reduction target for 2050 from 70 percent to 80 percent, auctioning of the climate program's emission credits, expanding nuclear power, endorsing a 10 percent production tax credit for new nuclear power plants, and the conditions that would negate the new US climate program. EPW Committee head, Barbara Boxer, promised to discuss unaddressed issues on the Senate floor. To view the S. 2192 bill, titled, "America's Climate Security Act of 2007," click: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:s2191is.txt.pdf. December 6, 2007, http://www.reuters.com/article/environmentNews/idUSN058916420071206 and December 6, 2007, http://www.eenews.net/EEDaily/2007/12/06/1/#1.

***E&E Daily*, "Feinstein Looks Ahead to Carbon Market Oversight."** California Senator Dianne Feinstein introduced a carbon market bill on December 6 that would designate the EPA as regulators of the estimated $300 billion carbon market created by the Senate bound Climate Security Act of 2007. Feinstein chose the EPA to oversee the new carbon markets because the Agency currently regulates under the Clean Air Act of 1990 that created cap-and-trade programs for sulfur dioxide and nitrogen oxide emissions. The bill, designed to prevent Enron like fraud from entering into carbon markets, would require EPA to publish market price data to increase market transparency, monitor trading for manipulation and fraud, and enforce position limits, referring to the total number of emission credits a company can hold at one time. Furthermore, the bill would prevent carbon market participants from false reporting, engaging in manipulation or deception as defined in the Securities Exchange Act, and cheating or defrauding another market participant. Violators of the aforementioned offenses would be subject to EPA sanctioned $1 million fines and 10 year jail sentences per each offense. In addition, the Feinstein Bill gives the Commodity Futures Trading Commission (CFTC) exclusive jurisdiction over CO_2 futures markets. December 7, 2007, http://www.eenews.net/EEDaily/2007/12/07/3/#3.

February 2008

***New York Times Online*, "Bush Signs Broad Energy Bill."** On December 19, President George W. Bush signed the Energy Independence and Security Act of 2007, which will increase fuel economy standards for the first time in 32 years, phase out incandescent light bulbs within 10 years, and require the production of 36 billion gallons of renewable fuels by 2022. The landmark legislation passed in the House on a bipartisan vote of 314 to 100, but critics contend the potential exists for farmland to be used for ethanol feedstock and raise the cost of food due to increased competition for corn and grain. Proponents say that the legislation has the potential to significantly reduce dependence on foreign oil

imports and greenhouse gas emissions. In regards to carbon sequestration, the legislation provides up to $30 million for a national assessment of capacity for CO_2, up to $200 million per year for the demonstration of technologies exhibiting the large-scale capture of CO_2 from industrial sources, and up to $240 million per year for research and development (R&D). To view the Energy Bill's Title VII, highlighting carbon capture and sequestration plans, click: http://www.govtrack.us/data/us/bills.text/110/h/h6.pdf and view pages 213-225. December 19, 2007, http://www.nytimes.com/2007/12/19/washington/19cnd-energy.html?ex=1355720400&en=8b630cb48ce08ed5&ei=5088&partner=rssnyt&emc=rss.

***Gillette News Record*, "Legislator: Greenhouse Gases Must Be Managed."** Wyoming State Representative Tom Lubnau announced that three separate carbon sequestration bills, supported by House Speaker Roy Cohee and Governor Dave Freudenthal, will go before the Wyoming Legislature in February 2008. The legislation would create a legal framework for pumping CO_2 underground by addressing ownership, regulation, and "condemnation" issues – although Lubnau admitted sequestration projects could cause up to a 40 percent increase in consumers' electric bills. The draft bill contains the following: pore space would be owned by the surface owners, while the gas would be owned by whoever injects it; Wyoming's Department of Environmental Quality and Oil and Gas Conservation Commission would both play a role in regulating the gas; and condemnation issues, such as how to manage CO_2 that moves from under one person's property to another or into a neighboring state, because underground chambers can stretch for hundreds of miles. At the Federal level, Wyoming Senator John Barrasso said that he recently voted against the Lieberman-Warner (S. 2191) bill that would cap greenhouse gases, but would consider each greenhouse gas bill that comes before him. January 9, 2008, http://www.gillettenewsrecord.com/articles/2008/01/09/news/recent_articles/news07.txt.

March 2008

***E&E Daily,* "States Should Keep Control for Pipeline Siting, Officials Say."** Following testimony before the Senate's Energy and Natural Resource Committee, witnesses said it was argued that states should play a prominent role in the regulation of CO_2 pipelines, which currently span around 3,900 miles and would need to be significantly expanded for effective CCS. In particular, Federal Energy Regulatory Commission (FERC) Chairman Joseph Kelliher, who believes states should maintain their regulatory authority, supported a proposal sponsored by Senator Norm Coleman (R-Minnesota) that called for a DOE led study of the regulatory factors impacting the expansion of the nation's CO_2 pipeline network. The alternatives to the states maintaining regulatory authority include FERC establishing a set CO_2 transportation rate or granting FERC both siting and rate jurisdiction. It was also urged that the Interstate Oil and Gas Compact Commission (IOGCC) be consulted because of the commission's experience in CO_2 regulation. Currently, states and pipeline operators are free to establish their own rates, with the US Department of Transportation's (DOT) Surface Transportation Board settling rate disputes and US DOT's Office of Pipeline Safety providing oversight. February 1, 2008, http://www.eenews.net/EEDaily/2008/02/01/2/.

***Environmental News Service*, "States Seek Fraud Protection for Carbon Offset Market."** With the US market for carbon offset credits expected to reach $100 million annually within the next four years, California Attorney General Edmund G. Brown, Jr. teamed with attorneys from nine other states to advocate that the Federal Trade Commission (FTC) hone carbon credits guidelines to prevent fraud. The letter recommended that the FTC conduct research on consumers' understanding of carbon offsets, guarantee that offset projects do not double sell credits or claim credits for practices that are already required by law, and ensure that consumers understand carbon offsets and the potential for fraud. The states also called for a more concrete definition of what constitutes a carbon offset. Finally, the states said that the FTC, responsible for ensuring that carbon offsets are honestly marketed to consumers, offer consumer tips on its website and describe details about offsets on all marketing material. The letter came in response to an FTC request for comments on marketing carbon offsets. January 25, 2008, http://www.ens-newswire.com/ens/jan2008/2008-01-25-091.asp.

April 2008

***Casper Star Tribune,* "Gov Signs Carbon Bills."** On March 4, Wyoming Governor Dave Freudenthal signed two bills that establish ownership and regulation principles for the state's effort to develop CCS technologies for coal-fired power plants. The laws, which go into effect July 1, 2008, state the following: Wyoming Bill 89 designates that owners of the land surface retain underground storage rights, while Wyoming Bill 90 creates a state regulatory framework for carbon sequestration projects. However, several legal questions still remain unresolved, such as what happens when the right to develop minerals on a piece of land interferes with the landowner's right to store carbon underneath and what happens if stored carbon migrates under neighboring land parcels. The storage ownership bill was written by Representative Tom Lubnau, who specified Wyoming does not plan to force power plants to institute CCS technologies. As the nation's largest coal-producing state, Wyoming hopes to market their electrical power as a "value-added" product to states like California. Lubnau said the legislature will continue their work to resolve unsettled issues. To read Wyoming Bill 89, click: http://legisweb.state.wy.us/2008/Enroll/HB0089.pdf or for Wyoming Bill 90, click: http://legisweb.state.wy.us/2008/Enroll/HB0090.pdf. March 5, 2008, http://www.casperstartribune.net/articles/2008/03/05/news/wyoming/41d80ae8b86188e48725740300021c5f.txt.

***Carbon Control News*, "Washington State CO_2 Storage Rules May Set Baseline Ahead of EPA."** The state of Washington is working to become the first state to establish regulations for CO_2 injection and sequestration projects, which officials plan to have completed by the end of June. The state rules fall under the EPA's UIC Permitting Program of the Safe Drinking Water Act (SDWA) and may offer EPA officials a roadmap for creating nationwide rules for CCS. The proposed regulations would require CO_2 injection projects to acquire a UIC Class 5 permit for experimental wells, although the permit requirements nearly replicate the prerequisites necessary to obtain a UIC Class 1 permit. The intent of the regulations is to protect underground sources of drinking water (USDWs) and public health and safety; but most importantly, the legislation places full liability on project developers to ensure the safe, long-term geological storage of CO_2. EPA is due to release its own draft proposal regarding CO_2 injection projects in July and it remains to be seen if such projects will be permitted as Class 1 wells – or possibly under a new Class 6 well designation specifically for sequestration – which may dictate amending of Washington's regulations. To view Washington's CO_2 injection and sequestration proposal, click: http://carboncontrolnews.com/ccndocs/mar08/ccn03102008_washington.pdf. March 10, 2008, http://carboncontrolnews.com/index.php/ccn/show/washington_state_co2_storage_rules_may_set_baseline_ahead_of_epa/. (Subscription required.)

May 2008

***Environment & Energy Daily*, "Quick Fix Makes Lieberman-Warner Bill Deficit Neutral – CBO."** Following an earlier Congressional Budget Office (CBO) report that Senate bill S. 2191, "America's Climate Security Act," would add $15 billion over 10 years to the Federal government's record budget deficit, Senators Barbara Boxer, Joe Lieberman, and John Warner drafted an amendment rearranging the way that money raised from auctioning off GHG emission credits can be spent. The amendment created the "Climate Change Deficit Reduction Fund," which would set aside about six percent of the cap-and-trade program's annual revenue in 2012 and increase to 16 percent by 2031, resulting in some $78 billion over 10 years that would go toward the US Treasury. The April 10, 2008, CBO report states that S. 2191 would increase government revenue by $1.21 trillion from 2009 to 2018, when direct government spending is expected to total $1.13 trillion. CBO officials contend the projected deficit figure is derived from their option to count the free distribution of the bill's emission credits as the government giving away money as part of a new $100 billion market. To read the new CBO report, click: http://www.eenews.net/features/documents/2008/04/11/document_daily_03.pdf, or click

http://www.eenews.net/features/documents/2008/04/11/document_daily_04.pdf for the original CBO report, dated December 5, 2007. The Boxer-Lieberman-Warner amendment is available at: http://www.eenews.net/features/documents/2008/04/11/document_daily_02.pdf. April 11, 2008, http://www.eenews.net/EEDaily/most_read/2008/04/11/2/.

***Reuters*, "Bush Urges Halt of CO_2 Emission Growth by 2025."** On April 16, President George W. Bush called for the United States to stop the growth of GHG emissions by 2025 and said coal-fired power plants need to develop new methods for reducing GHGs. Some view the 2025 timeframe as an essential first step in the United States' efforts to reduce GHG emissions, although some feel that his position falls significantly short of scientific recommendations. While President Bush's approach does not go to the extent of European emissions goals or domestic lawmakers' proposals, his speech was aimed to influence the upcoming mandatory CO_2 rules debate in June and global climate change talks that took place April 16-18 in Paris, France. President Bush added that he does not believe measures like new taxes, abandoning nuclear power, or adopting trade barriers would resolve the GHG issue; instead, he favors strong new laws, appropriate incentives, and adherence to the principles he discussed. In the past, President Bush has opposed setting mandatory emissions caps, because of the possible threat to the US economy and lack of action from developing nations like China and India. For a video of the speech, click: http://www.reuters.com/news/video?videoId=80478&newsChannel=environmentNews, or click http://www.eenews.net/features/documents/2008/04/16/document_pm_02.pdf for a transcript of President Bush's speech. April 16, 2008, http://www.reuters.com/article/environmentNews/idUSN1518272120080416.

June 2008

***Carbon Control News*, "Senate Budget Chairman Eyes New Incentives for Carbon Storage Projects."** According to Senate Budget Committee Chairman Kent Conrad's staff, Senator Conrad is planning to introduce or co-sponsor legislation that provides tax incentives for CCS technologies. The legislation, called "The Clean Technology Bridge Act of 2008," was discussed at a National Rural Electric Cooperative Association (NRECA) conference and is said to include a production tax credit for biomass facilities that co-fire with coal, an investment tax credit for CCS technology, and a credit for storing carbon underground. An NRECA outline of the plan (available at: http://carboncontrolnews.com/ccndocs/may08/ccn05062008_nreca.pdf) contains two incentives: (1) a 10 to 30 percent tax credit for new clean-coal power plants that capture CO_2 and (2) a 30 percent tax credit for CCS equipment installed on new or existing coal-fired power plants. The outline also states the legislation would provide a $30 per ton credit for CO_2 stored in a geologic formation, $20 per ton if transferred to the Federal government, and $10 per ton if used for EOR. Finally, the outline contains details about regulations, such as making the owner or operator of the facility that captures, transports, or injects CO_2 liable for up to $100 million in the event of an accident, transferring full liability for stored CO_2 to the Federal government after the storage project is decommissioned, and establishing the right of eminent domain for the construction of CO_2 pipelines. May 6, 2008, http://carboncontrolnews.com/index.php/ccn/show/senate_budget_chairman_eyes_new_incentives_for_carbon_storage_projects/. (Subscription required.)

July 2008

***ClimateWire*, "Landmark Local Emissions Fee Passed in N. Calif.,"** and ***MSNBC.com*, "It's a First: Bay Area Businesses to Pay CO_2 Fee."** The Bay Area Air Quality Management District (BAAQMD) imposed the first carbon fee in the United States, approving a 4.4 cent charge per metric ton of CO_2 equivalent on businesses within the nine-county region in northern California. BAAQMD worked with California's Air Resources Board to integrate the local fee with already existing state laws and regulations, such as the "California Global Warming Solutions Act of 2006" (AB 32). According to data compiled by the air district, of the 2,500 stationary sources that are subject to the fee, seven of the

sources would have to pay more than $50,000 to comply, with most of the regulated emitters paying less than one dollar. The new rule will go into effect on July 1 and the money raised in fiscal year 2009, which BAAQMD predicts will total around $1.1 million, will finance the district's climate protection program. California passed AB 32 on August 31, 2006, to cost-effectively reduce GHGs. A fact sheet for AB 32 is available at: http://www.ef.org/documents/AB-32-fact-sheet.pdf. To browse the BAAQMD website, click: http://www.baaqmd.gov/. May 22, 2008, http://www.eenews.net/climatewire/2008/05/22/2/, and May 21, 2008, http://www.msnbc.msn.com/id/24762980/.

***Greenwire*, "Markey Unveils Bill for Slashing Emissions 85 Percent."** On June 4, Massachusetts Representative Edward J. Markey introduced legislation, called the "Investing in Climate Action and Protection Act (iCAP), H.R. 6186," which proposes cutting CO_2 and other GHG emissions by 85 percent through a cap-and-trade system that would go into effect in 2012. Under the proposed bill, 94 percent of the billions of dollars in emissions credits would be auctioned off, with the proceeds used for energy technology research, tax cuts, and energy efficiency programs. United States manufacturers most vulnerable to trade competition would receive the remaining six percent. The cap-and-trade program transition would result in 100 percent of emissions credits being auctioned by 2020; countries that do not implement similar policies by that time would need to purchase emission allowances to import CO_2-intensive goods into the United States. If the proposed bill reaches its fruition, all coal-fired power plants built after January 2009 would need to capture and store 85 percent of their GHG emissions. To read the executive summary of iCAP, click: http://markey.house.gov/docs/icap_exec_sum.pdf, or browse http://markey.house.gov/ for complete information. May 28, 2008, http://www.eenews.net/Greenwire/2008/05/28/1/.

***Greenwire*, "Bipartisan House Bill would Create Carbon Sequestration Fund."** Legislation was introduced on June 12 by a US House of Representatives coalition to create a multibillion-dollar fund aimed at speeding up the deployment of CCS technologies. The bill, backed by the House Energy and Air Quality Subcommittee, would set up a $1 billion annual fund paid for by power companies that use coal, natural gas, and oil. Under the legislation, a newly created Carbon Storage Research Corporation would manage the fund as an affiliate of the Electric Power Research Institute (EPRI) and distribute grants and contracts to various private, academic, and governmental bodies to help commercialize technologies that capture and store CO_2. Electric utilities believe the bill will help them survive under a future US regulatory system that places a limit on GHG emissions. According to the bill's sponsors, the legislation will add around $10 to $12 to residential customers' annual rates. To read the bill, go to: http://www.eenews.net/features/documents/2008/06/12/document_gw_01.pdf. June 12, 2008, http://www.eenews.net/Greenwire/2008/06/12/2/.

August 2008

***ClimateWire*, "Wash. Sets CO_2 Emissions for New Power Plants…,"** and ***Washington Department of Ecology News Release*, "Adopting New Rules, Washington Continues Leadership in Limiting Climate Change."** The state of Washington set standards for emissions performance on all new electrical generation, as well as adopted guidelines for CCS. The emission standards, which immediately went into effect for power plants generating less than 350 megawatts, restrict facilities to the average emissions of combined-cycle natural gas turbine plants, or 1,100 pounds of CO_2 per megawatt-hour; the standard for larger power plants went into effect July 25, 2008. Both emission standards only apply to long-term power contracts of five or more years and impose a $1.60 charge per metric ton of CO_2, with discounts for co-generation and CO_2 sequestration. Emissions that are permanently sequestered are not counted when determining if a generating facility meets the emissions performance standard. The CCS guidelines address safety, public hearings, and post-closure monitoring issues. However, the guidelines do not cover long-term liability or how to settle property rights issues, nor do they estimate the state's storage capacity for CO_2. The legislation is available at: http://www.ecy.wa.gov/laws-

rules/wac173407_218/x0711a.pdf. July 8, 2008, http://www.eenews.net/climatewire/rss/2008/07/08/4, and June 30, 2008, http://www.ecy.wa.gov/news/2008news/2008-180.html.

***Sun Advocate,* "Utah, North Dakota Senators Introduce Federal Clean Coal Technology Legislation."** On June 26, Senators Orrin Hatch of Utah and Kent Conrad of North Dakota unveiled Federal legislation to expand the use of clean coal technology in the United States. The Carbon Reduction Technology Bridge Act of 2008, if passed by Congress, would promote private research into clean coal technology by creating tax incentives. Included in the bill are the following incentives: a tax credit for installing CCS equipment equivalent to 30 percent of the qualified investment for a taxable year; tax credits of $30 per metric ton of CO_2 injected and stored by the taxpayer; tax credits of $20 per metric ton of CO_2 compressed and transferred for storage; and tax credits of $15 per metric ton of CO_2 injected for EOR by the taxpayer. The senators believe these incentives are necessary to achieve energy independence because coal is used to generate roughly half of all electricity produced in the United States. The legislation is available at: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:s3208is.txt.pdf. To read the official press release, go to: http://hatch.senate.gov/public/index.cfm?FuseAction=PressReleases.View&PressRelease_id=c6f88aae-1b78-be3e-e089-3a5fa28d5a33. July 3, 2008, http://www.sunadvocate.com/index.php?tier=1&article_id=13492.

Announcements

September 2007

Carbon Sequestration Testimony Given. A Senate Energy and Natural Resources Oversight Hearing was held August 1 to receive testimony on recent advances in clean coal technology, with participation by Carl Bauer, Director of DOE's National Energy Technology Laboratory. To read Carl Bauer's testimony, which includes testimony regarding the laboratory's work in Carbon Sequestration, go to: http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Hearing&Hearing_ID=1645.

Georgia Governor Announces Carbon Sequestration Registry. On August 3, Georgia became the first southern state to implement a public registry for landowners who use approved forest management practices on their land. The Carbon Sequestration Registry, managed by the Georgia Forestry Commission, can be found at www.gacarbon.org.

Listen to Podcast, "Climate Change USA." SciPod is an international science podcast produced by New Scientist Magazine. This special edition podcast explores American attitudes toward climate change and other global warming issues. A link to this podcast can be found at: http://media.newscientist.com/data/av/podcast/newsci-20070702-climate-change-usa.mp3.

The Carbon Sequestration Newsletter Annual Index. Access the Annual Index covering September 2006-August 2007 issues of the Carbon Sequestration Newsletters at: http://www.netl.doe.gov/publications/carbon_seq/subscribe.html.

October 2007

DOE's National Energy Technology Laboratory (NETL) Launches New Carbon Capture and Sequestration FAQ Portal. A profusion of information about carbon capture and storage (CCS) can be found at the recently launched NETL web portal. The website provides answers to a wide range of questions about the technology, the status of ongoing projects, and potential safety concerns, among other CCS topics. The website is useful to experts in the field of CCS and to those wanting to learn

about the topic for the first time. To visit the website, click on: http://www.netl.doe.gov/technologies/carbon_seq/faqs.html.

Carbon Sequestration Technology Roadmap and Program Plan 2006 Wins Award for Excellence. DOE's National Energy Technology Laboratory has been awarded a 2007 APEX Award for the 2006 Carbon Sequestration Technology Roadmap and Program Plan. The "Roadmap" was recognized for its superior quality in graphic design, editorial content, and the ability to achieve overall communications excellence. The 2006 roadmap described the status of CO_2 capture and sequestration technology, identified research pathways, and described DOE efforts to pursue priority pathways. The 2007 Carbon Sequestration Roadmap and Program Plan can be downloaded at: http://www.netl.doe.gov/publications/carbon_seq/project%20portfolio/2007/2007Roadmap.pdf.

Video Interview with National Resource Defense Council on Cost Implications of Cap-and-Trade Policy. This video interview with Dan Lashof, Deputy Director and Science Director of the National Resource Defense Council's Climate Center, analyzes the economic implication of key legislative proposals and why he favors a cap-and-trade policy over a carbon tax. To watch the video, click on: http://www.eenews.net/tv/video_guide/655.

Listen to a Podcast, "Carbon Storage: How It Works, What It Means." Earth & Sky's Lindsay Patterson spoke with two experts on the subject in order to understand how carbon capture and storage works and what it means. This 5-minute Earth and Sky Podcast is available for download at: http://www.earthsky.org/clear-voices/51562/lynn-orr-and-elizabeth-wilson.

November 2007

Interactive Multimedia, "Vital Signs of a Warming World: The science, impacts, and scenarios of climate shifts." MSNBC investigates the impact of temperature changes across the globe through the use of pictures, videos, and full length stories to examine issues such as melting ice in the Polar Regions, potential animal extinctions, landscape alterations, and the detrimental effects on low lying coastal areas. A link to this website is available at: http://www.msnbc.msn.com/id/19463513/.

December 2007

CSLF Launches Discussion Board. The Carbon Sequestration Leadership Forum (CSLF) announced the creation of a public meeting place (PuMP) for policy makers, financial institutions, technology experts, project sponsors, and the public to post comments and questions about carbon capture and storage. Visit http://www.cslforum.org or access the forum directly at: http://www.cslforum.org/cslfpump/forums/list.page.

UCL Launches Carbon Capture and Storage Legal Initiative. University College London (UCL) launched the Carbon Capture Legal Programme (CCLP) website; making carbon capture program information readily available to governments, companies, lawyers, and non-governmental organizations. The website will include links to legislation dealing with climate change, emissions trading regimes, and carbon capture and storage. To view the website, go to: http://www.ucl.ac.uk/cclp/.

Video Interview with World Resources Institute Associate. World Resources Institute (WRI) representative, John Venezia, discusses a series of policy briefs on carbon capture and storage that are being released by WRI. The interview probes the obstacles facing carbon capture and storage technology and the opportunities that could arise from carbon capture and storage implementation. The video is available at: http://www.eenews.net/tv/video_guide/693.

January 2008

Coal Power Plant Database Now Available From DOE. DOE's NETL has released its 2007 Coal Power Plant Database. This database provides information about 191 fields, 1,700 boilers and associated units, emissions, power generation, location, and firing data for all US coal-power plants. To browse the database, which also includes carbon sequestration resources, visit: http://www.netl.doe.gov/energy-analyses/technology.html.

Kyoto Protocol's Electronic Emissions Trading System Log Launched. The UN Climate Change Secretariat announced the launching of the International Transaction Log (ITL), a computer-based system that ensures Kyoto sanctioned emissions trading complies with established rules. For further information about the UN Framework Convention on Climate Change (UNFCCC) ITL, visit: http://unfccc.int/kyoto_protocol/registry_systems/itl/items/4065.php.

Database Revealing Highest CO_2 Emitting Power Sources Created. Carbon Monitoring for Action (CARMA) offers users the opportunity to search a power plant database by country, state, province, county, metro area, city, power company, power plant, or zip code to learn the carbon emissions of more than 50,000 power plants and 4,000 power companies located in every country on Earth. To browse the CARMA web site, click: http://carma.org/.

Chicago Climate Futures Exchange Improves Trading Platform. Trading Technologies International, Inc. (TT) connected the Chicago Climate Futures Exchange to its X_TRADER 7 order-entry software, providing customers with direct, online access to Carbon Financial Instrument futures and Certified Emission Reduction futures. For more information, go to: http://www.ccfe.com/ or http://tradingtechnologies.com/news/071127_CCFE.pdf.

February 2008

Chicago Climate Futures Exchange Announces New Records in 2007. The Chicago Climate Futures Exchange (CCFE) announced that 283,756 contracts were traded in 2007, compared to 28,924 contracts in 2006 – a record-setting 881 percent increase. In addition, open interest on CCFE rose 719 percent, growing from 3,822 contracts at the start of 2007 to 31,290 contracts at year's end. For further details, click: http://www.chicagoclimateexchange.com/news/press/release_20080110_CCFE_endyearrecord.pdf or visit: http://www.chicagoclimateexchange.com/.

Carbon Management Council Formed. A group of eight companies formed the Carbon Management Council (CMC) on December 17 to help organizations develop solutions for managing their carbon emissions. CMC offers decision makers information for creating a carbon management program and discovering market opportunities created by reducing their carbon footprint. Members include representatives from Fortune 1000 companies, public utilities, and venture capital firms. To view the website, go to: http://www.carboncouncil.org/.

March 2008

Leading Wall Street Banks Establish "The Carbon Principles." Citi, JPMorgan Chase, and Morgan Stanley announced the formation of climate change guidelines for power company advisors and lenders in the United States. The Carbon Principles were created to assess the risk associated with power companies and global climate change legislation. For more information about the principles – energy efficiency, renewable and low carbon technologies, and conventional and advanced generation – click: http://www.citigroup.com/citigroup/press/2008/080204a.htm.

North America's First Online Carbon Emissions Auction. World Energy Solutions, Inc., the operator of several online exchanges for energy commodities, announced on January 23 that the company

oversaw North America's first online carbon emissions auction. Verdant Energy, a leading Canadian power supplier, made history by auctioning 80,000 tonnes of carbon offsets using the World Green Exchange recently established under the Alberta Offset System. For further information, go to: http://biz.yahoo.com/cnw/080123/world_energy_auction.html?.v=1.

April 2008

Chinese Begin Accounting for CO_2 Emissions. Chinese cement producers have taken the first steps toward measuring and managing CO_2 emissions across the country's cement sector. This represents a significant step forward by the Chinese government in its clean development and climate change strategies, because cement production accounts for five percent of global CO_2 emissions, of which China contributes some 45 percent. The Chinese government plans to institute a three-phase strategy to collect data, beginning with multinational companies and followed by medium and small companies. For details, click: http://www.wri.org/stories/2008/02/chinese-cement-companies-account-co2-emissions.

CCX Sets Trading Volume Record. On March 4, the Chicago Climate Exchange, Inc. (CCX) announced it had achieved a new monthly record in trading volume during February 2008, when 100,496 Carbon Financial Instrument (CFI) contracts were traded. This volume nearly trumps the 102,724 contracts sold in all of 2006 and brings the year-to-date volume to more than half of 2007's volume of 229,375 contracts. For more information about CCX prices and volume information, go to: http://www.theccx.com/market/data/summary.jsf.

International Greenhouse Gas Registry Launched. The Gold Standard Foundation and APX, Inc. announced the creation of the Gold Standard Voluntary Emissions Reductions (VER) Registry on March 11, providing individuals with the opportunity to use APX's Environmental Market Depository technology to track and trade Gold Standard VERs throughout the world. Also, the registry tracks the certification of Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs) that are part of Gold Standard's Clean Development Mechanism (CDM) and Joint Implementation (JI) project database. Go to http://goldstandard.apx.com/ to browse the Gold Standard VER Registry website.

Climate Change and the Western United States' Power Sector. A study conducted by DOE's Argonne National Laboratory (ANL) used results from regional climate models to study the impacts of projected changes in temperature and precipitation on the development and operations of the Western United States' power system. The study will be presented at the IAEE Conference in Ankara, Turkey in June 2008. To read the study, go to: http://www.dis.anl.gov/news/WECC_ClimateChange.html.

May 2008

Office of Fossil Energy Develops Educational Materials. Climate change and fossil energy study guides, online lessons, and classroom activities that target elementary, middle, and high school students are now available courtesy of DOE. The materials offer lessons about where coal, petroleum, and natural gas come from, how these fossil fuels are utilized, and how research will lead to more environmentally friendly fossil fuel usage. The educational materials are available at: http://www.fossil.energy.gov/news/techlines/2008/08011-FE_Develops_Educational_Materials.html.

IEA GHG CCS Summer School. Following the success of last year's inaugural session, IEA Greenhouse Gas R&D Programme is offering another week long session for young scientists (i.e. PhD students or Post Docs) about CCS. Students will be divided into teams to research the issues surrounding CCS technology development and implementation and give a presentation to their peers at the end of the week. For more information about IEA's International Interdisciplinary Summer School program, visit: http://www.co2captureandstorage.info/SummerSchool/SummerSchoolIndex.html.

California Registry Launches Website. The nonprofit California Climate Action Registry launched the "Climate Action Reserve," a system designed to provide the public and CO_2 emitters with an open venue to track, list, register, and retire carbon offsets. The California Registry is as a voluntary GHG registry that has several internationally proven elements to protect and promote actions that reduce emissions. To view the Climate Action Reserve, click: http://www.climateregistry.org/offsets.html.

Video Interview on the Challenges Facing Carbon Capture. Hank Courtright, vice president of the Electric Power Research Institute (EPRI), talked about the challenges facing the electric power sector relating to CCS technology, public acceptance issues, public education, safety and security concerns, and the economics of CCS projects in an interview with E&E TV. The interview concludes with a discussion about new EPRI research that is testing the viability of using chilled ammonia to capture CO_2. To watch the video, visit: http://www.eenews.net/tv/video_guide/763.

June 2008

Principles for Global Warming Legislation Released. Representatives Henry A. Waxman, Ed Markey, and Jay Inslee released the "Principles for Global Warming Legislation" in order to provide a framework for legislation that will: (1) reduce emissions, (2) transition America to a clean energy economy, (3) recognize and minimize any economic impacts from global warming legislation, and (4) aid communities and ecosystems susceptible to harm from global warming. To browse the Select Committee on Energy Independence and Global Warming website, visit: http://globalwarming.house.gov/.

Port Authority Creates Website to Offset Emissions. The Port Authority of New York and New Jersey announced plans to become the first tolling agency in the United States to create a website where travelers using the Port Authority's bridges, tunnels, and/or airports can buy credits to offset their CO_2 emissions. For further details, click: http://www.nytimes.com/2008/04/21/nyregion/21carbon.html.

CPUC Establishes Institute for Climate Solutions. The California Public Utilities Commission (CPUC) created the California Institute for Climate Solutions (CICS) in order to (1) facilitate research that results in technological solutions and the development of policies that work to reduce GHG emissions and (2) accelerate the transfer, deployment, and commercialization of GHG technologies. More information is available at: http://www.cpuc.ca.gov/puc/.

Alberta Launches Carbon Council. Following a commitment to reduce projected emissions by 200 megatonnes (220.5 megatons) by 2050 (CCS would account for 139 megatonnes [153.2 megatons]), Alberta launched a carbon council composed of several government and industry officials that will create a roadmap outlining CCS implementation and respond to recommendations made by the Canadian Federal government in January. Details concerning Alberta's climate change action plan are accessible at: http://www.environment.alberta.ca/1319.html.

CantorCO2e Announces the Launch of the "Social Carbon Company." The Social Carbon Company will provide carbon management services to project developers in the Verified Emission Reduction (VER) market. The company uses a methodology that enhances carbon credits by quantifying a project's contribution to sustainable development in developing countries. An explanation of the methodology is available at: http://www.socialcarbon.com/en/?page=Social_Carbon_In_Action.

July 2008

Energy Analysis Firm Debuts GHG Reduction Database. Point Carbon unveiled its online database, "Carbon Project Manager North America," in an attempt to organize information on GHG reduction projects. The online database provides figures on more than 500 projects in North America that reduce

GHG emissions through renewable energy and sequestration methods. For more information, go to: http://www.eenews.net/climatewire/2008/05/19/6/.

CCS Network Launched. IEA launched the International CCS Regulators' Network at IEA Headquarters in Paris, France, to discuss the importance of CCS in mitigating climate change. The network will meet regularly to aide the development of a legal and regulatory framework for CCS. To learn more about the launch of the regulators' network, visit: http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=361.

August 2008

NETL Releases Annual Accomplishments Report. NETL released its annual Accomplishments Report showcasing its successes in research and technology during the past fiscal year. Also included are sections about technology transfer and awards received in the course of achieving NETL's primary goal – the successful commercialization of advanced technologies to benefit the United States. The complete accomplishment report is available at: http://www.netl.doe.gov/publications/others/accomp_rpt/accomp_fy07.pdf.

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For more information on the Carbon Sequestration Program please visit our web site:
NETL Carbon Sequestration Page at:
http://www.netl.doe.gov/technologies/carbon_seq/index.html.