THE NETL CARBON SEQUESTRATION NEWSLETTER: ANNUAL INDEX

SEPTEMBER 2009 – AUGUST 2010

This is a compilation of the past year's monthly National Energy Technology Laboratory Carbon Sequestration Newsletter. The newsletter is produced by 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 from September 2009 to August 2010. 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 Information that has become outdated (e.g. conference dates, paper submittals, etc.)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 2009

***Fossil Energy Techline*, "Regional Partner Announces Plans for Carbon Storage Project Using CO_2 Captured from Coal-Fired Power Plant."** The Southeast Regional Carbon Sequestration Partnership (SECARB), one of seven members of the U.S. Department of Energy's (DOE) Regional Carbon Sequestration Partnership (RCSP) Program, and Southern Company have announced plans to store carbon dioxide (CO_2) captured from an existing coal-fired power plant located in the Citronelle Oil Field north of Mobile, Alabama. The project will capture approximately 150,000 tons of CO_2 per year from Alabama Power's Plant Barry (a total equivalent to the emissions from 25 megawatts of the plant's generating capacity) and inject the CO_2 into a deep saline reservoir 9,000 feet beneath the surface. Under the plan, the CO_2 will be transported by pipeline and injected into the saline formation, which has oil-bearing formations both above and below its location. A monitoring, verification, and accounting (MVA) program will be conducted to track the movement of the injected CO_2 and ensure that it is safely and permanently stored. The project will commence in 2011 and is expected to last up to four years. This test site was selected by SECARB because it is believed to be representative of similar saline formations that possess high potential for CO_2 storage. To learn more about DOE's RCSP Program, visit: http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html, or click: http://www.secarbon.org/ for further information about SECARB. July 20, 2009, http://www.fossil.energy.gov/news/techlines/2009/09047-SECARB_Announces_CCS_Plans.html.

***Fossil Energy Techline*, "Department of Energy Awards $20 Million for Project to Advance Industrial Carbon Capture and Storage."** DOE has awarded Ramgen Power Systems, LLC $20 million in funding from the American Recovery and Reinvestment Act (ARRA) to advance the commercial deployment of a novel CO_2 compressor, called the Rampressor, which can be used for carbon capture and storage (CCS) in industrial settings. The Rampressor uses supersonic shockwaves to compress CO_2 for capture and storage and employs a technology that reduces the cost of compressing CO_2. The device achieves supersonic compression effects in a stationary environment due to a rotating disk in the center that spins at the necessary speed. Also, compared to conventional CO_2 compressors, the Rampressor has fewer parts, a smaller footprint, and lower overall system costs. Current CO_2 compression technologies are costly; too large for many retrofits; and require substantial maintenance costs, including additional electricity needed to run the compressors. For more information on DOE's Carbon Sequestration Research Program, click: http://www.fossil.energy.gov/programs/sequestration/index.html. August 10, 2009, http://www.fossil.energy.gov/news/techlines/2009/09055-DOE_Announces_Ramgen_Power_Systems.html.

October 2009

***Fossil Energy Techline*, "First-of-a-Kind Sequestration Field Test Begins In West Virginia."** In August 2009, a U.S. Department of Energy- (DOE) sponsored project initiated the injection of carbon dioxide (CO_2) for enhanced coalbed methane (ECBM) recovery with simultaneous CO_2 sequestration in an unmineable coal seam in Marshall County, West Virginia. The goal of the project is to help mitigate potential climate change by providing an effective and economic means to permanently store CO_2 in unmineable coal seams. Prior to the injection, horizontal coalbed methane (CBM) wells were drilled approximately 1,200 to 1,800 feet underground in a five-spot pattern over a 200-acre area in the unmineable Upper Freeport coal seam. As part of this $13 million field trial, which is being conducted under the collaboration of the National Energy Technology Laboratory (NETL), West Virginia University, and CONSOL Energy, Inc., CO_2 will be injected at a pressure of up to 700 pounds per square inch (psi) and a rate of approximately 27 short tons per day over the next two years. Researchers will then monitor

the impacts of the injection on the production and composition of the CBM produced. The injection will conclude once 20,000 short tons have been injected or the CBM becomes contaminated with CO_2. Numerous site characterization and monitoring activities are planned in order to ensure the safety of the injection. The field test is funded by DOE's Office of Fossil Energy (FE) and is being managed by NETL. September 8, 2009, http://www.fossil.energy.gov/news/techlines/2009/09063-First-of-a-Kind_Sequestration_Fiel.html.

***Fossil Energy Techline*, "DOE Selects Projects to Monitor and Evaluate Geologic CO_2 Storage."** DOE selected 19 projects to enhance the capability to simulate, track, and evaluate the potential risks of CO_2 storage in geologic formations. The projects will help improve DOE's ability to monitor the movement of CO_2 into, through, and out of the targeted geologic storage area; verify the location of CO_2 that has been placed in geologic storage; account for the entire quantity of CO_2 that has been transported to geologic storage sites; mathematically simulate the placement, storage, movement, and release of CO_2 into, through, and from geologic formations; and assess the risks associated with the placement of CO_2 in geologic formations and the potential release of CO_2 from these formations. The total value of the projects, which will be managed by NETL, is approximately $35.8 million over four years, with $27.6 million of DOE funding and $8.2 million of non-Federal cost sharing. The projects cover three topic areas: monitoring, verification, and accounting (MVA); simulation; and risk assessment. To learn more about DOE's Carbon Sequestration Research Program, visit: http://www.fossil.energy.gov/programs/sequestration/index.html, or click on the following link to view the complete list of projects. August 24, 2009, http://www.fossil.energy.gov/news/techlines/2009/09059-DOE_Selects_CO2_Monitoring_Project.html.

November 2009

***Fossil Energy Techline*, "DOE Partnership Completes Successful CO_2 Injection Test in the Mount Simon Sandstone."** The Midwest Regional Carbon Sequestration Partnership (MRCSP) has successfully injected 1,000 metric tons of carbon dioxide (CO_2) into the lowest 100 feet of the Mount Simon Sandstone (3,230 to 3,530 feet below ground) at Duke Energy's East Bend Generating Station in Boone County, Kentucky. Preliminary data indicates that the formation has good CO_2 storage potential and could possibly serve as a repository for captured CO_2 emissions. The formation is covered by layers of low permeability rock and possesses several properties that are conducive to CO_2 storage, such as the appropriate depth, thickness, porosity, and permeability. Prior to drilling the test well, MRCSP conducted a seismic survey at the site and obtained necessary permits for the injection test from the U.S. Environmental Protection Agency (EPA) and the Kentucky Division of Oil and Gas. Following the permitting process, the researchers injected clean brine in order to determine formation properties like the maximum injection rate and then injected approximately 1,000 metric tons of CO_2 in two, 500-meter-ton steps. The injection rate, pressure, temperature, and quantity of CO_2 in the formation were measured throughout the test to confirm that the injection proceeded as planned. MRCSP researchers will monitor groundwater at the site for the next two years to ensure that it is unaffected by the injected CO_2. The Eau Clair Shale provides approximately 450 feet of containment above the injection zone. Led by Battelle, MRCSP is one of seven partnerships in the U.S. Department of Energy's (DOE) Regional Carbon Sequestration Partnership (RCSP) Program, which was launched by the Office of Fossil Energy (FE) in 2003 to develop and validate carbon sequestration technologies as part of a national strategy to mitigate global climate change. To learn more about DOE's RCSP program, visit: http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html. October 21, 2009, http://www.fossil.energy.gov/news/techlines/2009/09074-Partnership_Completes_CO2_Injectio.html.

December 2009

***Fossil Energy Techline*, "DOE-Sponsored Mississippi Project Hits 1-Million-Ton Milestone for Injected CO_2."** A large-scale carbon dioxide (CO_2) storage project led by the Southeast Regional Carbon

Sequestration Partnership (SECARB) has injected more than 1 million tons to date at the Cranfield site in Southwestern Mississippi, becoming the fifth project worldwide to achieve that milestone. The Cranfield project combines the use of CO_2 injection with enhanced oil recovery (EOR), followed by CO_2 injection into deeper and larger-volume saline formations. Researchers at Cranfield have been monitoring the injected CO_2 with instrumentation installed nearly two miles beneath the surface to ensure the safe and permanent storage in the Lower Tuscaloosa Formations. The Cranfield project also has been successful in the deployment of pressure-response monitoring techniques in the injection zone ("in-zone") and above the injection zone ("above zone"). Real-time data collected since July 2008 has demonstrated that these techniques are cost-effective methods for monitoring, verification, and accounting (MVA) programs across the United States. SECARB is one of seven members of the Regional Carbon Sequestration Partnership (RCSP) Program managed by the Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL). The project, sponsored by the U.S. Department of Energy's (DOE) FE, is helping to move forward on Group of Eight (G-8) recommendations for launching 20 similar international projects by 2010. For more information on SECARB, click: http://secarbon.org/. To learn more about DOE's RCSP Program, go to: http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html. November 5, 2009, http://www.fossil.energy.gov/news/techlines/2009/09076-DOE_Project_Hits_Million_Ton_Miles.html.

***Fossil Energy Techline*, "DOE Signs Cooperative Agreement for New Hydrogen Power Plant."** DOE signed a cooperative agreement with Hydrogen Energy California LLC (HECA) to build and demonstrate a hydrogen-powered, electric generating facility with carbon capture and storage (CCS) capabilities in Kern County, California. HECA also plans to construct an advanced Integrated Gasification Combined Cycle (IGCC) plant that will produce power by converting fuel into hydrogen and CO_2. Approximately 2 million tons of the CO_2 produced from the gasification process (around 90 percent) will be transported less than four miles by pipeline to the Elk Hills oilfield where it will be stored in underground geologic formations. Other benefits of the new plant include maximizing the use of non-potable water for the plant's power production, using EOR to increase oil production, and creating 1,500 construction jobs and 100 permanent operational positions. The project, which is estimated to cost approximately $2.3 billion with the Federal cost-share limited to $308 million (less than 11 percent), consists of three phases: project definition (Phase I), design and construction (Phase II), and demonstration (Phase III). The storage of 2 million tons of CO_2 per year is anticipated to begin by 2016. The project will be administered by DOE's FE and NETL and is part of the Clean Coal Power Initiative (CCPI), a cost-shared collaboration between the Federal government and private industry. November 6, 2009, http://www.fossil.energy.gov/news/techlines/2009/09077-DOE_Signs_Cooperative_Agreement.html.

***Fossil Energy Techline*, "DOE Targets Rural Indiana Geologic Formation for CO_2 Storage Field Test."** The Midwest Geological Sequestration Consortium (MGSC) has initiated the injection of 8,000 tons of CO_2 to evaluate the carbon storage potential and test the EOR potential of abandoned oil wells in the Mississippian-aged Clore Formation in Posey County, Indiana. The injection is expected to last six to eight months and the field test will assess the most promising strategies for deploying CCS in the Illinois Basin. DOE researchers believe EOR programs can improve the efficiency and economics of using the technology in a variety of geologic applications. The three member project team, which is composed of the Illinois State Geological Survey at the University of Illinois, the Indiana Geological Survey, and Gallagher Drilling Inc., is injecting CO_2 into the Mumford Hills oilfield at an approximate depth of 1,900 feet. An MVA effort is currently underway to monitor air and groundwater quality; measure the amount of produced oil, gas, and water; monitor CO_2 injection composition, volumes, and rates; and monitor injection pressure and temperature. The project is expected to support more than 120 full-time jobs over the life of the project. For more information on MGSC, visit: http://www.sequestration.org/. November 12, 2009, http://www.fossil.energy.gov/news/techlines/2009/09078-Indiana_CO2_Injection_Begins.html.

***Fossil Energy Techline*, "Worldwide Carbon Capture and Storage Projects on the Increase."** According to a new DOE online database, worldwide efforts to fund and establish CCS projects have

accelerated, indicating ongoing momentum toward achieving the G-8 goal for launching 20 CCS demonstrations by 2010. A project of FE and NETL, the CCS Database reveals 192 proposed and active CCS projects worldwide (38 capture, 46 storage, and 108 capture and storage). The database also provides information about the efforts of various industries, public groups, and governments to develop and deploy CCS technology; lists technologies being developed for capture, testing sites for CO_2 storage, and estimations of costs and anticipated project completion dates; and uses Google Earth to illustrate the location of projects and provide links for further information in a user friendly application. The database will be updated as more information becomes available. To view the NETL CCS Database, visit: http://www.netl.doe.gov/technologies/carbon_seq/database/index.html. November 13, 2009, http://www.fossil.energy.gov/news/techlines/2009/09079-DOE_Unveils_CCS_Database.html.

January 2010

***Fossil Energy Techline*, "Secretary Chu Announces $3 Billion Investment for Carbon Capture and Storage."** On Friday, December 4, 2009, the U.S. Department of Energy (DOE) announced that three new projects have been selected to accelerate the development of coal technologies with carbon capture and storage (CCS) at commercial scale. The selected projects demonstrate advanced, coal-based technologies that will capture carbon dioxide (CO_2) emissions and either sequester them or use them in a beneficial manner. The three projects will demonstrate technologies that: (1) make progress toward DOE's target CO_2 capture efficiency of 90 percent; (2) make progress toward DOE's capture and sequestration goal of less than 10 percent increase in the cost of electricity for gasification systems and less than 35 percent for combustion and oxy-combustion systems; and (3) capture and sequester, or put to beneficial use, an amount of CO_2 emissions in excess of the minimum of 300,000 tons per year required by the Clean Coal Power Initiative (CCPI). The projects, valued at $3.18 billion, will enable commercial deployment and ensure the United States has clean, reliable, and affordable electricity and power. An investment of $979 million, including funds from the American Recovery and Reinvestment Act of 2009 (ARRA), will be combined with more than $2.2 billion in private capital cost share as part of the third round of the CCPI. These are the second installment of projects awarded under CCPI Round III, which was created in 2005 to reduce the time needed for low-emission coal technologies to be prepared for commercial use. To learn more about DOE's Clean Coal Technology Program, click: http://www.fossil.energy.gov/programs/powersystems/cleancoal/index.html. December 4, 2009, http://www.fossil.energy.gov/news/techlines/2009/09081-Secretary_Chu_Announces_CCS_Invest.html.

February 2010

***Fossil Energy Techline*, "DOE Publishes Best Practices Manual for Public Outreach and Education for Carbon Storage Projects."** The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) released a new manual, titled, "Best Practices for Public Outreach and Education for Carbon Storage Projects." The publication is intended to assist project developers in understanding and applying best outreach practices for siting and operating carbon dioxide (CO_2) storage projects. The manual provides practical, experience-based guidance on designing and conducting effective public outreach activities. The primary lesson learned from the Regional Carbon Sequestration Partnerships' (RCSP) experience is that public outreach should be an integrated component of project management; conducting effective public outreach will not necessarily ensure project success, but underestimating its importance can potentially contribute to project delays, increased costs, and lack of community acceptance. In addition to the finding that public outreach should be an integral component of project management, the manual outlines an additional nine best practices. In combination, these 10 practices represent a framework for designing an outreach program that is tailored to the specific characteristics of a planned project, the project developers, and the community in which the project is planned. The recommendations are based on lessons learned by DOE's seven RCSPs during the first six years of the program. Nearly two dozen CO_2 storage field tests are in progress

or have been completed by the RCSPs to date. January 13, 2010, http://www.fossil.energy.gov/news/techlines/2010/10002-DOE_Publishes_Best_Practices_Manua.html.

March 2010

***Fossil Energy Techline*, "President Requests $760.4 Million for Fossil Energy Programs."** President Obama has requested $760.4 million for the Office of Fossil Energy (FE) in the Fiscal Year (FY) 2011 budget to support improved energy security and rapid development of climate-oriented technology. Of this total, $586.5 million would go toward Fossil Energy Research and Development (FE R&D), which is comprised of the Fuels and Power Systems Program. The Fuels and Powers Systems Program would receive $403.9 million to research, develop, and deploy technologies that use the Nation's fossil fuels more cleanly and efficiently. The core research and development (R&D) efforts of the Fuels and Power Systems Program focus on the creation of a portfolio of technologies that can capture and permanently store carbon dioxide (CO_2) from power plants and industrial processes, capture carbon from existing coal-fired power plants, improve efficiency for existing and new power generation, and improve turbines for future coal-based combined cycle plants. The U.S. Department of Energy (DOE) is requesting $143.0 million for FE's Carbon Sequestration Program to continue efforts to develop technologies that decrease the release of CO_2 into the atmosphere, complete and evaluate small- and large-scale CO_2 injection tests under the Regional Carbon Sequestration Partnership (RCSP) Program, and continue U.S. engagement and collaboration with the global community. To view a complete breakdown of the FY2011 Fossil Energy Budget, click: http://www.fossil.energy.gov/aboutus/budget/11/FY_2011_Budget.html. February 1, 2010, http://www.fossil.energy.gov/news/techlines/2010/10002-President_Requests_%24760.4_Million_.html.

April 2010

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

***Fossil Energy Techline*, "Secretary Chu Announces Up To $154 Million for NRG Energy's Carbon Capture and Storage Project in Texas."** U.S. Secretary of Energy Steven Chu announced that a post-combustion carbon capture and storage (CCS) project with NRG Energy has been selected to receive up to $154 million, including funding from the American Recovery and Reinvestment Act (Recovery Act). NRG Energy will construct a 60-megawatt (MW) carbon capture demonstration facility at the company's W.A. Parish Unit 7 in Thompsons, Texas, to demonstrate advanced technology to reduce CO_2 emissions and assist with EOR efforts at a nearby oilfield. The six-year project will integrate several CCS technologies, including: (1) Fluor's advanced Econamine FG Plus(SM) carbon capture process using several different novel amine solvents; (2) Ramgen's advanced CO_2 compression system; (3) the

integration of highly efficient co-generation to provide the necessary steam and electricity; and (4) CO_2-EOR in one of the Texas Gulf Coast oilfields near the Parish plant. The project will show that post-combustion carbon capture can be economically applied to existing plants when the plant has the opportunity to store CO_2 in nearby oilfields. The NRG Energy project was selected under the third round of the Clean Coal Power Initiative (CCPI), a cost-shared collaboration between the Federal government and private industry to accelerate the readiness of advanced coal technologies for commercial deployment. DOE will contribute up to $154 million in Federal funds, which will be matched by NRG Energy. For more information on DOE's Clean Coal Technology Program, click: http://www.fossil.energy.gov/programs/powersystems/cleancoal/index.html. March 9, 2010, http://www.fossil.energy.gov/news/techlines/2010/10005-NRG_Energy_Selected_to_Receive_DOE.html.

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

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

May 2010

***Fossil Energy Techline*, "Illinois CO_2 Injection Project Moves Another Step Forward."** The Midwest Geological Sequestration Consortium (MGSC) recently completed a 3-D seismic survey at a large-scale carbon capture and storage (CCS) test site in Decatur, Illinois. The survey, which will determine the geometry and internal structures of the deep, underground saline formation where carbon dioxide (CO_2) will be injected, is an important step toward the project's planned early 2011 startup. The project will capture CO_2 from the Archer Daniels Midland (ADM) Ethanol Production Facility and inject it into a deep saline reservoir more than one mile underground. Beginning in early 2011, up to 1 million metric tons of the captured CO_2 will be compressed into a dense, liquid-like state and injected over a three-year period.

The Mt. Simon Sandstone, which is the rock formation targeted for the injection, is the thickest and most widespread saline reservoir in the Illinois Basin, with an estimated CO_2 storage capacity as high as 110 billion metric tons. Analysis of the survey data is a key component in the comprehensive monitoring program that will be implemented to ensure the injected CO_2 is safely and permanently stored. In addition, the survey data will serve as a baseline for reservoir and fluid distribution, provide information to identify any fault networks in or above the injection zone, and be used to predict where additional geophysical surveys should be deployed as CO_2 is injected. To learn more about the U.S. Department of Energy's (DOE) Regional Carbon Sequestration Partnership (RCSP) Program, go to: http://fossil.energy.gov/programs/sequestration/partnerships/index.html. March 15, 2010, http://fossil.energy.gov/news/techlines/2010/10009-Illinois_CO2_Project_Moves_Forward.html.

***White House Press Release*, "Interagency Carbon Capture and Storage Task Force."** Following a memorandum sent by President Barack Obama to the heads of 14 Executive Departments and Federal Agencies that established an Interagency Task Force on CCS, the White House Council on Environmental Quality, DOE, and U.S. Environmental Protection Agency (EPA) announced the launch of a website for the task force. The task force will develop a comprehensive and coordinated Federal strategy to accelerate the commercial development and deployment of CCS technologies. By August 2010, the task force will propose a plan for overcoming the barriers to the widespread and cost-effective deployment of CCS within 10 years, while bringing five to 10 commercial demonstration projects online by 2016. To view the Presidential Memorandum, titled, "A Comprehensive Federal Strategy on Carbon Capture and Storage," click: http://www.whitehouse.gov/the-press-office/presidential-memorandum-a-comprehensive-federal-strategy-carbon-capture-and-storage. April 2, 2010, http://www.whitehouse.gov/administration/eop/ceq/initiatives/ccs.

June 2010

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

July 2010

***Fossil Energy Techline*, "Alabama Project Testing Potential for Combining CO_2 Storage with Enhanced Methane Recovery."** As part of the Regional Carbon Sequestration Partnership (RCSP) Initiative's Validation Phase (Phase II), the Southeast Regional Carbon Sequestration Partnership (SECARB) has started field testing the potential for combining geological carbon dioxide (CO_2) storage with enhanced methane recovery. The Black Warrior CO_2 Storage Project will inject CO_2 into a coalbed methane (CBM) well in Tuscaloosa County, Alabama, to assess the capability of mature CBM reservoirs to receive and adsorb large volumes of CO_2. Injection began at the test site on June 15; the site was selected because it is representative of the 23,000-square-mile Black Warrior Basin located in northwestern Alabama and northeastern Mississippi. It is estimated that this area has the potential to

store in the range of 1.1 to 2.3 Gigatons of CO_2, which is approximately the amount that Alabama's coal-fired power plants emit in two decades. The targeted coal seams range from 940 to 1,800 feet deep and are one to six feet thick. Approximately 240 tons of CO_2 will be injected over a 45- to 60-day period. More information on SECARB is available at: http://www.secarbon.org/. To view a map of the U.S. Department of Energy's (DOE) Validation Phase projects, click: http://www.netl.doe.gov/technologies/carbon_seq/partnerships/validation.html. June 16, 2010, http://www.fossil.energy.gov/news/techlines/2010/10019-CO2_Injection_Begins_in_Black_Warr.html.

***Fossil Energy Techline*, "Award-Winning DOE Technology Scores Success in Carbon Storage Project."** The Southwest Regional Partnership (SWP) has successfully demonstrated SEQURE™ tracer technology, which detects and tracks CO_2 movement in underground geologic storage reservoirs, at its San Juan Basin test site. Developed by scientists at the Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL), the technology uses perfluorocarbon tracers (PFTs) to provide a verifiable method to measure CO_2 movements and detect potential escape. The tracer technology improved modeling techniques vital to defining storage capacity, injection capability, flow rates, and numbers of wells associated with storage sites. Carbon dioxide concentrations as small as parts-per-quadrillion levels can be measured by the technology, and injected CO_2 can be differentiated from natural CO_2. Research demonstrating and confirming long-term CO_2 storage security is believed to be an important condition for the large-scale deployment of carbon capture and storage (CCS). SWP began injecting approximately 35,000 tons of CO_2 into the San Juan coalbed to maximize permanent storage of CO_2, while simultaneously recovering natural gas. The San Juan Basin, considered one of the top locations worldwide for CBM recovery and an ideal site for CO_2 storage, contains three CBM-producing wells and a central injection well. To visit the SWP website, go to: http://southwestcarbonpartnership.org/. To learn more about DOE's Carbon Sequestration Program, click: http://www.fossil.energy.gov/programs/sequestration/index.html. June 9, 2010, http://www.fossil.energy.gov/news/techlines/2010/10016-Tracers_Track_Subsurface_Movement_.html.

August 2010

***Fossil Energy Techline*, "DOE-Sponsored Field Test Demonstrates Viability of Simultaneous CO_2 Storage and Enhanced Oil Recovery in Carbonate Reservoirs."** The Plains CO_2 Reduction (PCOR) Partnership has conducted a field test that demonstrated using carbon dioxide (CO_2) in an enhanced oil recovery (EOR) method called "huff-and-puff" to assess the carbon storage potential of geologic formations. The PCOR Partnership collaborated with Eagle Operating, Inc. to complete the test in the Northwest McGregor Oil Field in Williams County, North Dakota. The "huff-and-puff" EOR method consists of three phases: injection, soaking, and production. During the test, 440 tons of liquid CO_2 were injected into a producing oil well in the Mission Canyon Formation, which is part of the Madison Group of Mississippian-age carbonate rocks in the western United States. The injection occurred at a depth of approximately 8,050 feet, at which CO_2 is miscible and blends with residual, in-place oil. Following two weeks of soaking, the well was placed back into operation and production more than doubled over the course of a three-month period. In addition, the test also determined that two Schlumberger technologies – a reservoir saturation tool (RST) and vertical seismic profiling (VSP) – have the potential to be effective tools for detecting and monitoring small-volume CO_2 plumes in deep carbonate reservoirs. To learn more about the PCOR Partnership, click: http://www.undeerc.org/pcor/, or visit: http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html for details on the U.S. Department of Energy's (DOE) Regional Carbon Sequestration Partnership (RCSP) Program. June 28, 2010, http://www.fossil.energy.gov/news/techlines/2010/10021-Field_Test_Demonstrates_Carbon_Sto.html.

Fossil Energy Techline*, "U.S. Partners with Canada to Renew Funding for World's Largest International CO_2 Storage Project in Depleted Oil Fields,"** and ***Natural Resources Canada

***Newsroom*, "Canada and U.S. Invest in Leading Carbon Capture and Storage Project."** DOE and Natural Resources Canada (NRCan) announced they will commit $5.2 million to bring the International Energy Agency (IEA) Greenhouse Gas Weyburn-Midale CO_2 Monitoring and Storage Project to conclusion in 2011. The funding, of which DOE is providing $3 million and the Government of Canada is providing $2.2 million, will allow the final phase of the project to focus on best practices for the safe and permanent storage of CO_2 with EOR; support research to solidify the knowledge of monitoring, verification, and accounting (MVA) in depleted oil reservoirs; and demonstrate the safe storage of CO_2. Weyburn-Midale is conducted in conjunction with $2 billion of commercial CO_2 injection operations, which to date have stored 18 million tonnes of CO_2 into the Weyburn and Midale oil fields located in Saskatchewan, Canada. Approximately 40 million tonnes of CO_2 are expected to be stored over the life of the EOR operations. July 20, 2010, http://www.fossil.energy.gov/news/techlines/2010/10026-DOE_Renews_Weyburn_Funding.html, and July 20, 2010, http://www.nrcan-rncan.gc.ca/media/newcom/2010/201053-eng.php.

Sequestration in the News

September 2009

***Denbury Resources Inc. News Release*, "Denbury Undertakes Midwest CO_2 Pipeline Feasibility Study,"** and ***Pipelines International*, "Denbury Studies Midwest Carbon Dioxide Pipelines."** Denbury Resources has begun a feasibility study of a possible CO_2 pipeline project that would connect several proposed gasification plants to existing pipeline infrastructure in the Mississippi-Louisiana region. The study will determine the most likely pipeline route(s), estimated construction costs, and regulatory requirements. Denbury's initial estimates suggest a 500- to 700-mile pipeline system with a preliminary cost estimate of approximately $1.0 billion. The potential pipeline project is projected to take four to five years to complete. The study coincides with two proposed Midwestern gasification plants, both of which have CO_2 purchase contracts with Denbury, being selected to proceed to the term sheet negotiation phase under the DOE loan guarantee program. The program also selected a third proposed gasification plant that will be built along the Gulf Coast of Mississippi and could connect to the existing Free State Pipeline. July 13, 2009, http://phx.corporate-ir.net/phoenix.zhtml?c=72374&p=irol-newsArticle&ID=1307101&highlight=, and July 28, 2009, http://pipelinesinternational.com/news/denbury_studies_midwest_carbon_dioxide_pipelines/004171/.

***University of Kentucky News Release*, "Deep Well Begins CO_2 Sequestration Test."** The Kentucky Geological Survey (KGS) began injecting CO_2 into an 8,126-foot deep well at a test site in Hancock County, Kentucky, in July. The project will store the CO_2 deep underground to demonstrate the feasibility of carbon storage in deep, western Kentucky geologic formations. KGS and industry scientists and engineers have already used brine to confirm that the Knox Dolomite section will sequester CO_2 at depths in the range of 3,800 to 7,400 feet. Funding for the project is provided from a $1.5 million allocation from a grant by the Kentucky General Assembly in 2007, as well as a total of $6.5 million in grants from the National Energy Technology Laboratory (NETL), the Western Kentucky Carbon Storage Foundation, and the Illinois Office of Coal Development and Marketing. Peabody Energy, ConocoPhillips, E.ON U.S., and the Tennessee Valley Authority created the Western Kentucky Carbon Storage Foundation to provide funding and technical assistance to the project. August 18, 2009, http://news.uky.edu/news/display_article.php?category=8&artid=4958.

***Encore Acquisition Company Press Release*, "Encore Acquisition Company Announces CO_2 Supply Agreement and Planned Tertiary Recovery Project in its Bell Creek Field."** On July 28, 2009, Encore Acquisition Company announced that it had agreed to acquire a CO_2 supply that will be used for an enhanced oil recovery (EOR) project in Encore's Bell Creek Field. Under the agreement, Encore will purchase all of the volumes available from the Lost Cabin Gas Plant located in Freemont County, Wyoming. Encore plans to build compression facilities near the plant and construct a 206-mile

pipeline to transport the compressed CO_2, which is estimated at approximately 50 million cubic feet per day, to the Bell Creek Field. The project is expected to yield an incremental 30.1 million barrels of oil. With 100 percent of the available CO_2 volumes being utilized, production is estimated to exceed 6,500 barrels of oil per day by 2015. The project will be divided into seven phases and is expected to cost approximately $425 million. July 28, 2009, http://www.encoreacq.com/releasedetail.cfm?ReleaseID=399604.

October 2009

***Fossil Energy Techline*, "Energy Department Advances Carbon Capture and Storage Research on Two Fronts."** On September 16, 2009, DOE announced $12.7 million in funding for 43 research projects to advance carbon capture and sequestration (CCS) technologies by providing graduate and undergraduate student training opportunities at universities across the United States. The projects will provide advanced research training in simulation and risk assessment; MVA; geological related analytical tools; methods to interpret geophysical models; and CO_2 capture. The three-year projects, which are funded through the 2009 American Reinvestment and Recovery Act (ARRA), will be managed by FE's NETL. Project details are available at: http://www.fossil.energy.gov/recovery/projects/geologic_sequestration_training.html. September 16, 2009, http://www.fossil.energy.gov/news/techlines/2009/09066-DOE_Advances_CCS_Training.html.

***Fossil Energy Techline*, "DOE Research Projects to Examine Promising Geologic Formations for CO_2 Storage."** On September 16, 2009, DOE announced it will contribute $75.5 million for 11 projects aimed at increasing scientific understanding about the potential of geologic formations to safely and permanently store CO_2. The projects will examine the usefulness of potential geologic storage sites and supplement existing data; in addition, project participants will participate in technical working groups on best practices for site characterization and storage site selection. Funding for the projects includes $49.75 million from ARRA to promote employment opportunities for local and regional organizations over the next three years. Project details are available at: http://www.fossil.energy.gov/recovery/projects/site_characterization.html. September 16, 2009, http://www.fossil.energy.gov/news/techlines/2009/09065-DOE_Awards_Site_Characterization_P.html.

***Fossil Energy Techline*, "Department of Energy Awards $71 Million to Accelerate Innovative Carbon Capture Project."** On September 15, 2009, DOE announced that Arizona Public Service (APS) has been awarded $70.5 million from ARRA to expand an existing industrial and innovative reuse carbon mitigation project to include testing with a coal-based gasification system. APS will scale up a concept for coproduction of electricity and substitute natural gas via coal gasification, while scaling up a technology where power plant CO_2 emissions are captured by algae and processed into liquid transportation fuels. The funding will enable APS to scale up its algae cultivation and hydrogasification concept. Researchers expect that the algae farm will reuse CO_2 at a rate of 70 metric tons per acre per year. The APS project is one of two already existing projects in the industrial carbon capture program administered by DOE's FE; the other is a Ramgen Power Systems' project to scale up a device that uses supersonic shockwaves to compress CO_2 for capture and storage. The host facility for this project is the Cholla Power Plant located in Holbrook, Arizona. September 15, 2009, http://www.fossil.energy.gov/news/techlines/2009/09064-APS_to_Scale_Up_CCS_Project.html.

***Fossil Energy Techline*, "DOE Announces More Than $8.4 Million for Regional Sequestration Technology Training Projects."** DOE Secretary Steven Chu awarded more than $8.4 million in funding to develop seven regional sequestration technology training projects. The funding, which includes $6.9 million from DOE as part of ARRA, will aid the United States in achieving their goal to develop near-zero emission technologies to reduce CO_2 emissions from power plants. The seven projects will facilitate the transfer of knowledge and technologies required for site development, operations, and monitoring of

commercial CCS projects by focusing on CCS engineering and science for site developers, geologists, engineers, and technicians. The selected projects will fund the following: an organized sponsorship development program; short courses on CCS technologies; regional training; regional/basin technology transfer services; and regional programs' planning and management. The funding will span three years and will be managed by NETL. To learn more about the selected projects, click on the following link. August 27, 2009, http://www.fossil.energy.gov/news/techlines/2009/09062-DOE_Awards_CCS_Training_Projects.html.

***Dominion News Release*, "Carbon Capture and Storage Demonstration Proposed at Dominion's Virginia City Hybrid Energy Center."** A coalition led by Virginia Tech's Virginia Center for Coal and Energy Research (VCCER) has applied for funding to finance a CCS demonstration project proposed for a power station currently under construction in Wise County, Virginia. The grant is sought to cover approximately half of the potential $580 million cost of the proposed project. Under the plan, the CO_2 would be transported by pipeline for permanent storage in unmineable coal seams and underground saline formations in the region. The carbon capture portion of the project, which would be led by Dominion Virginia Power, will be capable of removing up to 1,500 tons of CO_2 per day. The project is designed to meet DOE's goals by proving CCS on a commercial scale and achieving a minimum of 50 percent carbon capture efficiency. Subject to funding approval, as well as several company and regulatory approvals, construction for the demonstration project could be completed by April 2015, with the injection and monitoring phases of the project running through April 2021. August 25, 2009, http://dom.mediaroom.com/index.php?s=43&item=790.

***WA Today*, "Gorgon to Lead Nation's Biggest Carbon Injection Effort."** ExxonMobil will contribute multi-billion dollar contracts to supply India and China with liquefied natural gas (LNG) from the Gorgon Project at Barrow Island, off of Western Australia's Pilbara Coast. The total amount of LNG involved in those contracts will account for only 25 percent of the Chevron-led Gorgon Project's potential output, which is nearly 15 million tonnes of LNG per year. It is estimated that an average of 70,000 tonnes of CO_2 must be separated for every 1 million tonnes of gas extracted at Barrow Island. When operating at full capacity, the Chevron plant will inject 3.5 million tonnes of CO_2 per year 2.3 kilometers underground. Officials said that the project goal is to store 120 million tonnes per annum (mtpa) in a large, underground reservoir. August 20, 2009, http://www.watoday.com.au/wa-news/gorgon-to-lead-nations-biggest-carbon-injection-effort-20090820-es1j.html.

November 2009

***CH2M HILL News Release*, "CH2M HILL Awarded CO_2 Pipeline Project: Project will Reduce Carbon Emissions and Increase Domestic Energy Supplies."** Encore Acquisition Company (EAC) has awarded a contract to CH2M HILL for its recently announced Greencore Project, a 230-mile CO_2 pipeline that will transport approximately 1 million metric tons of CO_2 emissions each year from the Lost Cabin Gas Plant in Fremont County, Wyoming. The CO_2 will be used for enhanced oil recovery (EOR) in EAC's Bell Creek Field in southeastern Montana. It is estimated that the project will increase oil production from existing wells from 1,200 barrels per day to a peak response of 7,000 barrels per day. The compressed CO_2 will be transferred by a combination eight-inch and 10-inch diameter pipeline. CH2M HILL initiated the Greencore Project in August 2009. September 29, 2009, http://www.ch2m.com/corporate/news_room/news_story.asp?story_id=550.

***Carbon Capture Journal*, "Toshiba Completes CCS Pilot Plant."** Toshiba Corporation has completed the construction of a CO_2 capture pilot plant located at Mikawa Power Plant, in Omuta City, Fukuoka Prefecture, Japan. The Mikawa pilot plant, which will deploy and validate Toshiba's latest separation and capture technology, is designed to capture 10 tons of CO_2 a day. Toshiba will use the plant to verify the performance and operation of the system when applied to thermal power plants, using the data to help design systems and equipment for utility-scale power plants, which will finally be optimally integrated with other power plant equipment, such as turbines and boilers. Toshiba's goal is to establish commercial-

scale carbon capture and storage (CCS) systems for thermal power plants by 2015. The company initiated its research and development (R&D) into CCS in 2006, focusing on an amine-based chemical absorption system that consumes less energy in the CO_2 separation and capture process, and has verified, through small-scale testing, that its performance matches the leaving levels in the industry. Toshiba established a new CCS development and promotion organization in October 2008, and is seeking to further accelerate practical application and commercialization of its technology. October 9, 2009, http://www.carboncapturejournal.com/displaynews.php?NewsID=453&PHPSESSID=52erjpl5pkdkhf5oc72nen92p7.

***Energy Technologies Institute News Release*, "ETI Project to Put UK at the Leading Edge of Carbon Storage Capacity Appraisal."** The Energy Technologies Institute (ETI) initiated an approximately $5.7 million project, titled the United Kingdom CO_2 Storage Appraisal Project (UKSAP), to review potential sites that are suitable for storing CO_2 offshore and estimate CO_2 storage capacity in the United Kingdom (UK). Although the UK possesses many offshore depleted oil and gas reservoirs and saline formations, capacity estimates are widely varied. The UK government, CO_2 emitters, storage operators, and infrastructure and technology developers will use the estimates to select sites for CCS in the UK. Led by Senergy Alternative Energy Ltd., UKSAP also involves technical contributions from the British Geological Survey, the Scottish Centre for Carbon Storage, Durham University, GeoPressure Technology Ltd., Geospatial Research Ltd., Imperial College London, RPS Energy, and Element Energy Ltd. The project, which started in October 2009, will be completed by March 2011. October 9, 2009, http://www.energytechnologies.co.uk/home/news/09-10-09/ETI_project_to_put_UK_at_the_leading_edge_of_Carbon_Storage_Capacity_Appraisal.aspx.

***The Guardian*, "Britain's First Carbon Capture and Storage Plant to Be Built in Yorkshire."** After receiving a $266 million award from the European Union (EU), the UK will build its first CCS demonstration plant at Hatfield in Yorkshire. The money, which will also be matched by the UK, was awarded to Powerfuel Power for a 900-megawatt, coal-fired electricity plant that could be operating as early as 2014. Through the use of pre-combustion CCS technology, the company will remove CO_2 from the coal before it is burned and pipe it for storage in an offshore gas field 100 miles away. Money from the fund will help to finance eight other CCS demonstration plants across Germany, the Netherlands, Poland, Spain, and Italy. The EU hopes to have 12 commercial CCS projects in operation by 2015 with the funding coming from an economic recovery program that will provide an additional $1.5 billion in 2010. October 16, 2009, http://www.guardian.co.uk/environment/2009/oct/16/carbon-capture-storage-hatfield/print.

December 2009

***Reuters*, "U.S. Coal Plant Captures and Stores Carbon,"** and ***Carbon Capture Journal*, "Alstom and AEP Commission Mountaineer CCS Demonstration."** American Electric Power (AEP) and Alstom have teamed together to demonstrate technology that captures and stores CO_2 emissions at AEP's 1,300-megawatt (MW) Mountaineer Power Plant in West Virginia. The project diverts flue gas from the plant's smokestack to a structure that traps the CO_2 using a chilled ammonia solution. The CO_2 is compressed into a liquid-like state, transported approximately 1,300 feet by pipeline to two separate sites, and injected into saline formations 8,000 feet underground. The Mountaineer CCS demonstration project, which is designed to capture at least 100,000 metric tonnes of CO_2 annually and cost approximately $73 million, began capturing and storing CO_2 in September and October 2009, respectively. If successful, AEP plans to install a $670 million, 235-MW, commercial-scale CCS project at the same plant. November 17, 2009, http://www.reuters.com/article/companyNews/idUSN0926278820091118, and October 30, 2009, http://www.carboncapturejournal.com/displaynews.php?NewsID=475&PHPSESSID=1oktiartr07lsnu1m2227hvb14.

***Renewable Energy Magazine*, "GE to Power World's Largest Carbon Sequestration Plant."** According to a recent announcement, a CCS project under Barrow Island off Australia's west coast will be powered with compression equipment supplied by GE Oil & Gas. The project is part of the Gorgon Project, which involves extracting natural gas from the Gorgon natural gas field in Australia and delivering it by pipeline(s) to gas treatment and liquefaction facilities on Barrow Island. Carbon dioxide will be stripped from the natural gas before it is liquefied and the captured CO_2 will be injected into depleted natural gas wells 1,300 meters below the surface. The Gorgon Project, Australia's biggest single resource project, is projected to generate 10,000 jobs and cost approximately $39.4 billion for the first phase of development and $45.8 billion overall. Gorgon is one of the first major greenhouse gas (GHG) storage projects to be launched following the G-8's 2008 recommendation to implement 20 large-scale CCS demonstration projects by 2020. The partners of the project are proposing to capture and store more than 3.4 million metric tonnes of CO_2 per year, or 120 million tonnes over the life of the project. October 30, 2009, http://www.renewableenergymagazine.com/paginas/Contenidosecciones.asp?ID=14&Cod=4333&Tipo=&Nombre=Latest%20news.

***U.S. News & World Report*, "Dutch Government Pushes Forward on CO_2 Storage."** The Dutch Government has approved a pilot project that will inject approximately 800,000 tons of CO_2 into depleted gas fields more than one mile beneath Barendrecht, a suburb 12 miles from Rotterdam. According to estimates by the Dutch Government, there is a storage capacity of approximately 10 million tons of CO_2 in two underground depleted oil fields at this location. The project researchers will closely monitor the use of the first field before considering the use of the second field. While a number of similar projects to store CO_2 underground are currently underway across Europe, this project is the first of its kind in the Netherlands. If successful, the project will also help the European Union (EU) achieve its goal of significantly reducing GHG emissions by 2050. November 18, 2009, http://www.usnews.com/science/articles/2009/11/18/dutch-government-pushes-forward-co2-storage.html.

January 2010

***Canada.com*, "Alberta Invests in World's Biggest Carbon-Capture Pipeline,"** and ***Reuters*, "Canada Backs Alberta CO_2 Pipeline Plan."** The Canadian and Alberta governments will invest as much as $525 million in a pipeline project to carry CO_2 from an industrial region near Edmonton, Alberta, to depleted oilfields. The Alberta Carbon Trunk Line is expected to have an initial capacity of 15,000 tonnes per day, but has the potential to be expanded to 40,000 tonnes per day if secondary lines are added. At maximum pressure, the 149-mile pipeline would carry and store more than 14 million tonnes of CO_2 a year to depleted oilfields for enhanced oil recovery (EOR). The company plans to have lateral lines running off the trunkline to the oilfields, and CO_2 collection lines extending to both Fort McMurray and the coal-fired power plants near Wabamun Lake. The Canadian Government will provide approximately $59 million and Alberta will spend approximately $464 million over 15 years. Alberta and Enhance Energy signed a letter of intent that follows previous announcements for Shell's Quest project at Scotford and TransAlta's Pioneer Project at the Keephills 3 coal-fired turbine near Wabamun. Combined, the three projects will receive approximately $1.9 billion from Alberta's CCS fund. Enhance Energy will begin construction in 2011 and plans to start operations in 2012. November 24, 2009, http://www.canada.com/Alberta+invests+world+biggest+carbon+capture+pipeline/2260125/story.html, and November 24, 2009, http://www.reuters.com/article/GCA-GreenBusiness/idUSTRE5AN5AS20091124.

***Power Engineering International*, "EU Grants [$261 Million] towards Vattenfall CCS Demonstration Plant,"** and ***Vattenfall Press Release*, "Favorable Response from Brussels for CCS Development EU Commission Confirms Support for Jänschwalde Demo Project."** Vattenfall's CCS demonstration plant planned at Jänschwalde in Brandenburg of eastern Germany will receive up to $261 million in funding from the European Union (EU) Commission to develop a full-scale CCS plant at an

existing coal-fired power plant. The plant will include a lignite drying facility and plans call for the CCS plant to be connected to the grid by 2015. The electrical power capacity of the demonstration plant will be approximately 385-megawatts (MW), with a CO_2 capture rate of more than 90 percent, totaling up to 2.7 million tonnes of CO_2 per year. The funding is derived from the European Energy Programme for Recovery (EEPR), a European economic program for energy adopted in June 2009; a total of six CCS projects will be funded under EEPR. Vattenfall has been developing, testing, and demonstrating CCS technology since 2000; projects include an oxyfuel pilot plant at Schwarze Pumpe in Germany, the construction of a pre-combustion pilot plant at Buggenum in the Netherlands, and plans for the development of a large-scale CO_2 capture plant at Nuon Magnum in the Netherlands. Vattenfall also plans to explore CCS at Nordjyllandsværket in Denmark after 2020 when CCS technology is expected to be commercially viable. Vattenfall plans to demonstrate the entire CCS process chain and has undertaken seismic research to determine potential locations for the carbon captured from the demonstration facility. December 9, 2009, http://pepei.pennnet.com/display_article/371638/6/ARTCL/none/none/1/EU-grants-€180m-towards-Vattenfall-CCS-demonstration-plant/, and December 9, 2009, http://www.vattenfall.com/en/press-details-hidden.htm?newsid=6BF14C0B34BD48AD9434DAED79680429.

***ScottishPower Press Release*, "Major Breakthrough for ScottishPower Carbon Capture Prototype at Longannet,"** and ***Energy Business Review*, "ScottishPower Tests CCS Technology at Longannet Coal-Fired Station."** ScottishPower has successfully tested CCS technology at its prototype carbon capture unit at Longannet Power Station, demonstrating reduced energy requirements in the improved capture process by approximately one-third from a reference plant. The tests at Longannet have monitored the effectiveness of an amine plant that captures the CO_2 under a range of operating conditions. Testing at the coal-fired power plant will continue through February 2010, as scientists believe the technology is ready to be successfully applied at full scale. The prototype carbon capture unit is monitored 24 hours a day and has been operating successfully for more than 2,000 hours. The unit has captured approximately 90 percent of the carbon from 1,000 cubic meters an hour of exhaust gas at Longannet Power Station. November 25, 2009, http://www.scottishpower.com/PressReleases_1964.htm, and November 26, 2009, http://fossilfuel.energy-business-review.com/news/scottishpower_tests_ccs_technology_at_longannet_coalfired_station_091126/.

February 2010

***Air Products News Release*, "Air Products and DOE Sign Agreement for Carbon Capture and Storage Project in Texas."** On December 17, 2010, Air Products and DOE signed a cooperative agreement to conduct an engineering study and project plant to capture, concentrate, and purify CO_2 emitted from industrial operations for use in enhanced oil recovery (EOR). DOE will move forward on Phase I of the potential two-phase program, which proposes to design and construct a state-of-the-art system to capture CO_2 from Air Products' steam methane reformers (SMRs) located at a refinery in Port Arthur, Texas; Phase II would recover and purify the CO_2 for delivery via pipeline for EOR in Texas. Valued at $901,874, the Phase I funding will also further define the method of CO_2 delivery to the pipeline. For more information about similar American Recovery and Reinvestment Act of 2009 (ARRA) projects, click: http://www.netl.doe.gov/publications/press/2009/09072-DOE_Announces_Industrial_CCS.html. December 17, 2010, http://www.airproducts.com/PressRoom/CompanyNews/Archived/2009/17Dec2009.htm.

***IFP Press Release*, "Transporting CO_2 – Launch of the European COCATE Project Led by IFP."** A European research project called "COCATE" will examine the creation of a transportation infrastructure capable of connecting various medium-sized, CO_2-emitting industrial facilities located within a close proximity to geological storage sites. The project stems from the idea that smaller CO_2-emitting facilities must pool a CO_2 capture and transportation system in order to reduce costs (major industrial facilities can be fitted with their own CO_2 capture and transport technologies). The Le Havre region of France and the Port of Rotterdam in the Netherlands have been selected as potential test sites. The project will

examine two types of transportation infrastructure networks: (1) a local, low-pressure network that collects CO_2 emitted by various Le Havre-based industrial companies and transport it to various capture centers, and (2) a high-pressure network to transport CO_2 to the Port of Rotterdam for storage in depleted North Sea oil and gas fields. Within this construct, the project will review the technical limitations specific to each of the networks; with respect to the upstream low-pressure collection network, the flue gases will be transported as they are to the treatment unit, while the high-pressure network will focus on the effect(s) of the impurities contained in the captured CO_2. In addition, two CO_2 transportation scenarios will be investigated: (1) by pipeline (CO_2 in supercritical state above 74 bars), and (2) by boat (CO_2 transported in refrigerated liquid form [-50°C, 7 bar or -30°C, 15 bar]). This three-year project includes a risk analysis and a total budget of $6.5 million, of which nearly $4.3 million is derived from the European Commission. December 8, 2009, http://www.ifp.com/actualites/communiques-de-presse/lancement-du-projet-europeen-cocate.

***The Regina Leader-Post*, "Canadian Government Invests $[3.8] Million in Carbon Capture and Storage Research,"** and ***Western Economic Diversification Canada News Release*, "Government of Canada Supports CO_2 Assessment Centre."** On Friday, January 15, 2010, the Canadian Government announced a $3.8 million Federal investment in carbon capture and sequestration (CCS) research for the International Performance Assessment Centre for Geological Storage of CO_2 (IPAC-CO_2) at the University of Regina. The funding will allow IPAC-CO_2 to purchase analytical equipment to better understand CO_2 in the subsurface and provide improved data on storage sites. IPAC-CO_2 will also conduct modeling of carbon capture systems and work with the Canadian Standards Association (CSA) and the International Standards Organization (ISO) to develop the first international standards for geological storage. The $3.8 million Federal investment comes from the Canada-Saskatchewan Western Economic Partnership Agreement (WEPA), in which both levels of government are contributing $23.6 million each over four years. January 15, 2010, http://www.leaderpost.com/technology/Canadian+government+invests+million+carbon+capture+storage+research/2447550/story.html, and January 15, 2010, http://www.wd.gc.ca/eng/77_11804.asp.

***Carbon Capture Journal*, "EU Demonstrates CCS Projects at DNV."** In December 2009, the European Commission held its first preparatory meeting to discuss the new European network of CCS demonstration projects. The network is intended to shorten the time from policymaking to industry-scale implementation of CCS and will provide industry with a vehicle for coordination and exchanging information and experience. The network is coordinated by DNV, which will provide input to the European Commission for establishing and facilitating the collection and sharing of information within the CCS network. DNV will organize events to help focus the policies and actions that are needed in order to establish a long-term CO_2 value chain. In particular, DNV recently initiated a web-based platform in collaboration with the European Commission. In addition, DNV will launch three CCS guidelines in the near future. For more information about DNV's CCS activities, go to: http://www.dnv.com/industry/energy/segments/carbon_capture_storage/index.asp. December 21, 2010, http://www.carboncapturejournal.com/displaynews.php?NewsID=498&PHPSESSID=jk3arpcprh87o507tpqjifob74.

March 2010

***Carbon Capture Journal*, "Obama Announces CCS Task Force."** President Obama released a Presidential Memorandum creating an Interagency Task Force on carbon capture and sequestration (CCS) that will seek to "develop a comprehensive and coordinated Federal strategy to speed the commercial development and deployment of clean coal technologies." The memorandum, which sets a goal for five to 10 commercial demonstration projects to be running by 2016, states that the task force will be co-chaired by representatives from DOE and the U.S. Environmental Protection Agency (EPA). By August 2010, the task force will develop a proposed plan to explore incentives for the adoption of CCS, as well as address any financial, economic, technological, legal, institutional, or other barriers to deployment within the next 10 years. The task force will consider how best to coordinate existing Federal

authorities and programs and identify areas in which additional Federal authority may be necessary. Periodically, progress will be reported to President Obama through the Chair of the Council on Environmental Quality. The Presidential Memorandum, titled, "A Comprehensive Federal Strategy on Carbon Capture and Storage," was released by the White House Office of the Press Secretary on February 3, 2010, and can be viewed at: http://www.whitehouse.gov/the-press-office/presidential-memorandum-a-comprehensive-federal-strategy-carbon-capture-and-storage. February 8, 2010, http://www.carboncapturejournal.com/displaynews.php?NewsID=506&PHPSESSID=2kedq1bb5lmvjjfvnv075491c6.

***The Wall Street Journal*, "Alberta Signs CO_2 Capture, Economic Pact With Abu Dhabi,"** and ***The Government of Alberta News Release*, "Stelmach Signs Two Groundbreaking Agreements in the UAE."** The province of Alberta reached an economic and energy technology cooperation agreement with Abu Dhabi, the capital of the United Arab Emirates (UAE). The Premier of Alberta signed a Memorandum of Understanding (MOU) with the Chairman of the Abu Dhabi Department of Economic Development, setting the stage for stronger relations in areas such as energy, environmental protection, technology, and innovation. The Premier of Alberta also signed an MOU on CCS with Masdar, a company of the Government of Abu Dhabi, which commits both nations to share information on CCS technologies and policies, support projects of mutual interest, and explore opportunities for collaboration between public and private partners in both nations. January 20, 2010, http://online.wsj.com/article/BT-CO-20100120-711420.html?mod=WSJ_World_MIDDLEHeadlinesMideast (subscription may be required), and January 20, 2010, http://www.alberta.ca/acn/201001/276694C8615A0-9EDC-B9B2-DAA52CC7423B59CC.html.

***The Billings Gazette*, "Anadarko Sequesters CO_2 in Getting More Oil."** Anadarko Petroleum has sequestered 181 billion cubic feet of CO_2 during an enhanced oil recovery (EOR) project that began in 2003. According to the company, an additional 10 million barrels of oil were extracted from the Salt Creek field north of Casper, Wyoming, by the CO_2 injected into the aging oilfield. The CO_2 injection is responsible for approximately 13 million barrels of oil production per year in Wyoming; the 100-year-old Salt Creek field approaches 10,000 barrels per day. January 11, 2010, http://billingsgazette.com/news/state-and-regional/wyoming/article_be20701c-ff32-11de-9c75-001cc4c03286.html.

April 2010

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

***Carbon Capture Journal*, "CCS Coalition Founded in California."** Following the publication of a study stressing the role CCS could play in helping California to meet its long-term greenhouse gas (GHG)

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

May 2010

***University of Calgary News Release*, "Greenhouse Gas Storage Capacity Not a Problem."** According to a new University of Calgary study, it is technologically feasible to store a large amount of CO_2 deep underground in central Alberta. Coordinated by the Institute for Sustainable Energy, Environment, and Economy (ISEEE), the Wabamun Area CO_2 Sequestration Project (WASP) is one of the most comprehensive studies of large-scale CO_2 storage to have its findings made public. The WASP study was conducted over 16 months to examine the feasibility, cost, and potential risk of permanently storing 20 million tonnes of CO_2 underground annually for 50 years in a 5,500-kilometer area. The researchers believe that further investigation is required before initiating a commercial-scale operation to store the CO_2 in rock formations deep beneath the Wabamun area of Alberta, Canada. The study also found that the costs of injecting and storing the CO_2 would be about $3 per tonne; however, that cost would multiply by 10 for a full CCS project, as the CO_2 would need to be pressurized and transported. Approximately half of the targeted storage capacity (about 500 million tonnes of CO_2) can be accomplished without managing the pressure of the geologic formation. The study used existing geological, seismic, and other data to examine the Nisku geologic formation as the primary target for CO_2 storage. March 12, 2010, http://www.ucalgary.ca/wasp/PressRelease12-03.pdf.

***Carbon Capture Journal*, "DNV Releases CO_2 Storage Guideline."** DNV has developed a comprehensive guideline for safe and sustainable geological CO_2 storage. With contributions from government agencies, "The CO2QUALSTORE Guideline for Selection, Characterization, and Qualification of Sites and Projects for Geological Storage of CO_2" provides a tailored regulatory framework that covers the full lifecycle of a CO_2 storage project. While taking into account the specific characteristics of each potential site, the guidelines are provided for screening and site selection to closure and transfer of responsibility from the operator back to the national state. The goal is to hasten the implementation of CCS by providing a common, predictable, and transparent basis for decision making. In addition to benefiting the project developers, operators, and regulators, compliance with this guideline is expected to assure the general public that selected storage sites will be safely and responsibly managed. DNV plans to periodically update the CO_2 storage guideline. To view the guideline, visit: http://www.dnv.com/binaries/CO2QUALSTORE_guideline_tcm4-412142.pdf. April 7, 2010, http://www.carboncapturejournal.com/displaynews.php?NewsID=553&PHPSESSID=ajnj7576q9ignclvm4q52hio51.

***News-Leader.com*, "Drilling to Start for Carbon Sequestration Project."** City Utilities (CU) is set to initiate Phase II of a project that will drill a 2,000-foot deep well into saltwater-saturated rock to test the feasibility of injecting food-grade CO_2 for geologic storage beneath its Southwest Power Station. The project received $2.4 million in 2008 to determine the potential of the geologic formations to store CO_2.

This work followed an initial assessment by the Missouri University of Science and Technology in 2006 that concluded the Lamotte Sandstone beneath CU's Southwest Power Station holds the potential for shallow CO_2 storage. CU is partnering with several utilities and Missouri State University, Missouri University of Science and Technology, and the Missouri Department of Natural Resources. For more information, go to: http://www.cityutilities.net/renewable/carbon.htm. April 7, 2010, http://www.news-leader.com/article/20100407/NEWS01/4070447/1007/NEWS01/Drilling-to-start-for-carbon-sequestration-project.

June 2010

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

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

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

July 2010

***DOE Press Release*, "Secretary Chu Announces Nearly $1 Billion Public-Private Investment in Industrial Carbon Capture and Storage."** Three projects have been selected to receive funding from the American Recovery and Reinvestment Act (Recovery Act) to demonstrate large-scale CCS from

industrial sources by storing CO_2 in either a deep saline formation or via enhanced oil recovery (EOR). The three projects will receive up to $612 million in ARRA funding, which will be matched by $368 million in private funding, for a total investment of $980 million. Located in Texas, Illinois, and Louisiana, the projects were initially selected in October 2009 for Phase I research and development (R&D) grants. After successful completion of Phase I activities, the projects were identified as the most promising industrial CCS projects through a competitive process. The additional funding will be managed by NETL and will finance Phase II design, construction, and operation. The selected projects are expected to capture and store 6.5 million tons of CO_2 per year and increase domestic oil production by more than 10 million barrels per year by the end of the demonstration period (September 2015). June 10, 2010, http://www.energy.gov/news/9065.htm.

***Fossil Energy Techline*, "DOE Signs Cooperative Agreement for Carbon Capture Project."** DOE signed a cooperative agreement with NRG Energy Inc. (NRG) for the "Parish Post-Combustion CO_2 Capture and Sequestration Project" to design, construct, and operate a system that will capture and store approximately 400,000 tons of CO_2 per year. The NETL-managed project was selected under DOE's Clean Coal Power Initiative (CCPI) and aims to demonstrate the economic application of post-combustion carbon capture to existing power plants, as well as the viability of storage in such formations. The system will employ Fluor's Econamine FG Plus technology to capture at least 90 percent of the CO_2 from a 60-megawatt (MW) flue gas stream of the 617-MW Unit 7 at the W.A. Parish Generating Station located in Thompsons, Texas. The total project cost is $334 million; DOE's share is $167 million (50 percent of the total). Storage will begin in 2014, with project completion set for 2017. To learn more about DOE's Clean Coal Technology Program, visit: http://www.fossil.energy.gov/programs/powersystems/cleancoal/index.html. June 18, 2010, http://www.fossil.energy.gov/news/techlines/2010/10020-DOE_Signs_Cooperative_Agreement_wi.html.

***BBC News*, "Carbon Storage Plans for Moray Firth Rock Beds** Researchers from the Scottish Centre for Carbon Storage (SCCS) will examine the potential of the Captain Sandstone Field, located about one-half mile below the seabed approximately 30 miles into the North Sea, for carbon storage. The researchers believe the geology beneath the Moray Firth could possibly store decades of CO_2 output from coal-fired power plants. New geological mapping tools will be used to assess the thickness of the rocks and their storage potential, and computer modeling of CO_2 injection into the rocks will test the long-term performance of the rocks to ensure that the CO_2 remains safely and permanently stored. Under this scenario, CO_2 would displace the seawater in the porous rock; thus, SCCS researchers will also consider the challenges of storing captured CO_2 in the rock surface. In addition, a new pipeline could also be constructed to transport CO_2 from an industrial plant to the site. The results of the research are expected to be published in late-2010. June 2, 2010, http://news.bbc.co.uk/2/hi/scotland/highlands_and_islands/10214297.stm.

August 2010

***Fossil Energy Techline*, "Research Projects to Convert Captured CO_2 Emissions to Useful Products."** DOE selected six projects that will aid in the research of converting captured CO_2 emissions from power plants and industrial facilities into useful products, such as chemicals, fuels, building materials, and other commodities, to help mitigate potential climate change. The six projects have an approximate value of $5.9 million over two to three years ($4.4 million in Federal funding) and are located in North Carolina; New Jersey; Massachusetts; Rhode Island; Georgia; and Quebec, Canada. As more fossil-fuel based power plants and other CO_2-emitting industries become equipped with CO_2 emissions control technologies, it is anticipated that large volumes of captured CO_2 will become available. DOE efforts are underway to demonstrate the permanent storage of the captured CO_2 through geologic sequestration, and focus is also being placed on the potential opportunity to use the CO_2 as an inexpensive raw material and convert it to beneficial use. For more information on DOE's Carbon Sequestration Program, click: http://www.fossil.energy.gov/programs/sequestration/index.html. July 6,

2010, http://www.fossil.energy.gov/news/techlines/2010/10022-Projects_to_Convert_CO2_to_Useful_.html.

***Enbridge Media Center*, "Enbridge to join TransAlta on Project Pioneer."** Enbridge, Inc. announced it will join TransAlta Corporation in the development of Project Pioneer by offering its past experience with pipeline construction and design to the fully integrated carbon capture and storage (CCS) project. Project Pioneer will use Alstom Canada's proprietary chilled ammonia process and be designed to capture one megatonne (Mt) of CO_2 per year from Keephills 3, a coal-fired power plant west of Edmonton, Alberta, Canada, for EOR. Project Pioneer is expected to account for at least 20 percent of the Government of Alberta's target of reducing five Mt of CO_2 emissions per year by 2015. For more information about Project Pioneer, click: http://www.projectpioneer.ca/. June 28, 2010, http://www.enbridge.com/MediaCentre/News.aspx?yearTab=en2010&id=1282702.

***CSIRO Media Release*, "$10 [Million] Project to Store CO_2 Underground in China."** Australia's Commonwealth Scientific and Research Organization (CSIRO) is partnering with China United Corporation Limited (CUCBM) on a $9.01 million joint demonstration project that will store 2,000 tonnes of CO_2 underground in the Shanxi Province. This enhanced coalbed methane (ECBM) recovery project (the CO_2 injected into the coal seams displaces the methane) has received funding from the Chinese and Australian Governments as part of the Asia-Pacific Partnership on Clean Development and Climate. CSIRO is also currently collaborating with China by supporting the launch of a post-combustion capture pilot plant in Beijing and the first CO_2 capture project using post-combustion capture technology in China. July 7, 2010, http://www.csiro.au/news/Chinese-CO2-underground-storage-project.html.

Science

September 2009

***Fossil Energy Techline*, "Bees, Balloons, Pollen Used as Novel CO_2 Monitoring Approach."** Bees, helium-filled balloons, and pollen can now be used to verify that there is no CO_2 released at carbon sequestration sites, according to researchers from NETL. Researchers believe this discovery will help to determine the environmental impact without disrupting habitats surrounding sequestration sites, while ensuring the effectiveness of carbon storage. The technique involves co-injecting chemical tracers at low levels to "fingerprint" the CO_2 during storage, allowing it to be differentiated from neutral CO_2. In cooperation with bee experts at Montana State University (MSU), NETL researchers conducted several detailed tests to determine if pollen collected by bees contains measurable quantities of the tracer, or if bees bring back the tracer from direct contact with foliage. Atmospheric tracer levels were also monitored using an extensive grid of monitors and a light detection and ranging system was employed by MSU researchers to correlate field tracer levels with bee foraging locations. Apogee Scientific was contracted by NETL researchers to use a large, helium-filled balloon to elevate a carousel containing sealed sorbent tubes for sequential exposure at known times and elevations to determine if atmospheric plume monitoring of tracer would be a feasible approach. The studies were conducted at the Center for Zero Emissions Research and Technology research site at MSU. July 29, 2009, http://www.fossil.energy.gov/news/techlines/2009/09049-Bees%2C_Balloons%2C_Pollen_Monitor_CO2.html.

***Science Daily*, "Higher Carbon Dioxide May Give Pine Trees A Competitive Edge."** A team of Duke University researchers have found that pine trees grown for 12 years in air that is one-and-a-half times richer in CO_2 than today's levels can produce twice as many seeds of at least the same quality as those growing under normal conditions. It was previously found that grasses and other herbaceous plants can also produce more seeds under higher levels of CO_2, but the seeds are of inferior quality. To come to their conclusions, researchers collected, counted, and analyzed seeds produced at the Duke Free Air CO_2 Enrichment (FACE) site in Duke Forest, where growing parcels of loblolly pine trees have been

receiving elevated amounts of CO_2 since 1997 as part of a DOE-funded project designed to simulate natural growing conditions. The results showed that the high-CO_2 loblolly seeds were similar in nutrient content, germination, and growth potential to the seeds produced from trees growing under present-day CO_2 concentrations. These findings were presented during the Ecological Society of America's 2009 annual meeting in Albuquerque, New Mexico, on August 3, 2009. August 4, 2009, http://www.sciencedaily.com/releases/2009/08/090803173246.htm.

October 2009

***Science Daily*, "Sierra Nevada Birds Move In Response to Warmer, Wetter Climate."** According to a new study by biologists from the University of California, Berkeley, 48 out of 53 bird species studied over the last decade in California's Sierra Nevada mountains have adjusted to climate change by moving to sites with more favorable temperature and precipitation conditions. Researchers collected data from a survey of 82 sites in the Sierra Nevada to detail the changes in birds' geographic range over the course of a century. On average, the sites have seen a 1.4°F increase in temperature and nearly a quarter of an inch increase in rainfall during the breeding season since the early 1900s. Even though some species moved toward warmer temperatures, while others preferred cooler climates, scientists predicted the majority of their responses by using models to predict the impact of climate change. Researchers compared their findings with earlier records to eliminate the chance of calculating false absences. The findings claim that the several species that did not relocate due to climate change, such as the Anna's Hummingbird and the Western Scrub-Jay, were able to adapt more easily to urban or suburban areas. The journal article, titled, "Birds track their Grinnellian niche through a century of climate change," is available at: http://www.pnas.org/content/early/2009/09/14/0901562106.abstract. September 14, 2009, http://www.sciencedaily.com/releases/2009/09/090914151625.htm.

***BBC News*, "'Artificial Trees' to Cut Carbon,"** and ***Institute of Mechanical Engineers Press Release*, "Geo-Engineering – Cooling the Planet?"** A recent study revealed that a forest of 100,000 "artificial trees" could be deployed within 10 to 20 years to help absorb the world's carbon emissions. The findings are part of a newly published report that highlights three geo-engineering ideas that could be put into effect to address potential climate change. The trees would capture CO_2 from the air through a filter, removed, and stored. The report states a tree manufactured at a cost of $20,000 could remove as much as 10 tonnes of CO_2 per day. The prototype artificial tree is approximately the size of a shipping container and could remove thousands of times more atmospheric CO_2 than a real tree of the same size. The authors, who believe geo-engineering should be used in conjunction with efforts to reduce carbon emissions and adapt to the effect(s) of potential climate change, studied hundreds of different options before settling on the three most practical and feasible given today's technology. The full report, titled, "Geo-Engineering – Giving Us the Time to Act," is available at: http://www.imeche.org/NR/rdonlyres/448C8083-F00D-426B-B086-565AA17CB703/0/IMechEGeoengineeringReport.pdf. August 27, 2009, http://news.bbc.co.uk/2/hi/science/nature/8223528.stm, and August 27, 2009, http://www.imeche.org/media/press/GeoEngineeringReport.htm.

November 2009

***Science Daily*, "Global Warming May Spur Increased Growth In Pacific Northwest Forests."** Potential climate change could cause a significant increase in the productivity of high-elevation forests of the Pacific Northwest, according to a study conducted by researchers from the College of Forestry at Oregon State University and the Pacific Northwest Research Station. The study also claims that forests at lower elevations, which in recent years have accounted for more than 80 percent of the region's timber harvest, could face a decline in growth. Based on the predictions of computer models, the potential changes would affect the state of Washington the hardest, where high-elevation forests could see their productivity increase from 35 percent a year to as much as 500 percent, depending on which climate

scenario was used. Overall, forest productivity could see an annual increase of approximately seven percent in forests west of the Cascade Range and 20 percent in forests east of them. According to the study, most of the climate scenarios that were used showed increases in temperatures (from one to eight degrees), but precipitation projections varied widely. The productivity of forests affects a range of issues, such as potential timber harvest, habitat for wildlife, fuels that increase fire risk, and carbon sequestration. The researchers' findings were published in the journal "Forest Ecology and Management." October 19, 2009, http://www.sciencedaily.com/releases/2009/10/091019163020.htm.

***Discovery Channel News*, "Melting Arctic Could Unleash Vast CO_2 Stores."** According to a recent study of the Arctic carbon cycle, Arctic land and seas may soak up as much as a quarter of the carbon absorbed globally each year. Researchers believe that climate change threatens the potential of this carbon repository to continue its sequestering of carbon, as the warming temperatures may cause the Arctic to begin releasing its carbon stores, which in turn may lead to an increase in global temperature. On land, CO_2 is absorbed by plants through photosynthesis; when the released CO_2 is in the ocean, it dissolves directly into the water or through uptake by algae and other marine plants. These carbon sinks are tempered on land by naturally occurring events, such as plant decomposition and wildfires. In the oceans, however, when the waters warm, the dissolved CO_2 is released, increasing the rate of photosynthesis by marine organisms. The net of these processes make up approximately half of the CO_2 released worldwide being removed from the atmosphere, of which the Arctic is responsible for absorbing anywhere from zero to 25 percent. According to the study, which was published in "Ecological Monographs," as the Arctic warms, permafrost melts, allowing for faster decomposition, thus releasing the CO_2. October 21, 2009, http://dsc.discovery.com/news/2009/10/21/arctic-carbon-warming.html.

December 2009

***Canada.com*, "Global Warming a Growing Threat to Arctic Reindeer."** Climate change is affecting the reindeer population in Norway as rising temperatures hit food stocks and industry growth moves into grazing lands. As winter temperatures rise, lichen, a fungus that grows on rocks or tree trunks and serves as the main food source of reindeer in Norway, has become more difficult to find. In the past, snow has fallen on dry ground, but recently snow has fallen on previously melted snow, creating ice that covers the ground and lichen and affects the reindeers' ability to digest the food. Adding to the threat, grazing land is also disappearing as buildings, pipelines, roads, and other infrastructure are developed in the region. To alleviate the effects, reindeer herders are forced to move the animals to drier grounds. Studies show that the Arctic tends to warm three times faster than elsewhere in the Northern Hemisphere. November 15, 2009, http://www.canada.com/technology/Global+warming+growing+threat+Arctic+reindeer/2220423/story.html.

***The New York Times*, "Seas Grow Less Effective at Absorbing Emissions."** According to new research published in the journal *Nature*, the Earth's oceans have grown less efficient at absorbing CO_2 emissions. Scientists claim the oceans' intake of CO_2 from the burning of fossil fuels has declined since the 1980s, with a larger decrease since 2000. According to the research, the diminishing absorption rate results from a gradual change in the oceans' chemistry. Scientists arrived at this conclusion by creating a mathematical model using measurements of seawater, such as temperature and salinity, collected over the past 20 years. The data was then worked backward to create a formula that established the accumulation of human-generated CO_2 from the beginning of the industrial era to present day. The results showed that even as human-generated emissions of CO_2 increased, the oceans' uptake rate growth dropped by 10 percent from 2000 to 2007. November 18, 2009, http://www.nytimes.com/2009/11/19/science/earth/19oceans.html?_r=3. (Subscription required.)

***Science Daily*, "Warmer Means Windier on World's Biggest Lake."** Rising water temperatures are resulting in more powerful winds on Lake Superior, with the potential to affect currents and biological cycles. Surface water temperatures measured by lake buoys have climbed 1.2 degrees per decade since 1985, approximately 15 percent faster than the air above the lake and twice as fast as warming over

nearby land. Winds generally remain calm over cold water as a result of the wide temperature differential between water and air. However, as the water warms, the temperature gap is shrinking, causing the atmosphere to become more turbulent. Scientists and researchers used more than 20 years of temperature and wind data collected by three lake buoys and Earth-observing satellites to model Lake Superior's water and wind system in three dimensions. November 15, 2009, http://www.sciencedaily.com/releases/2009/11/091115134132.htm.

January 2010

***Science Daily*, "Predicting the Fate of Underground Carbon."** Researchers from the Massachusetts Institute of Technology (MIT) have developed a new modeling methodology for determining the capacity and assessing the risk(s) of leakage in potential underground CO_2 formations. The tool takes into account key aspects of the underlying physics to predict the shape and pattern of flow when CO_2 is injected into a deep underground formation. Before, in a numerical model, each parameter change added hours or days to the time it took to model a prediction of CO_2 behavior under various circumstances. Engineers and geologists believe that the new methodology will allow them to quickly and inexpensively determine whether CO_2 could escape from a geological formation. MIT researchers presented their findings at the 62nd Annual Meeting of the American Physical Society's (APS) Division of Fluid Dynamics at the Minneapolis Convention Center on November 23, 2009. To view the Abstract of the presentation, titled, "Post-Injection Migration of CO_2 in Saline Aquifers Subject to Groundwater Flow, Aquifer Slope, and Capillary Trapping," visit: http://meetings.aps.org/Meeting/DFD09/Event/111611. November 23, 2009, http://www.sciencedaily.com/releases/2009/11/091123132630.htm.

***United Press International*, "Global Warming Threatens Hawaiian Songbird,"** and ***Endangered Species Coalition Press Release*, "America's Hottest Species."** According to a report from the Endangered Species Coalition, the Akikiki (also known as the Kaua'i Creeper), a small honeycreeper prevalent to the Hawaiian island Kaua'i, is at risk of extinction due to potential climate change. A common threat to the Akikiki is avian malaria, which cannot develop in birds in temperatures below 55 degrees Fahrenheit. An increase in temperature of four degrees Fahrenheit would result in an 85 percent decrease in the areas where transmission of the disease is currently limited. The report, titled, "America's Hottest Species," states that there is an increasing risk of extinction for 11 U.S. species. The Intergovernmental Panel on Climate Change (IPCC) reports that 20 to 30 percent of the world's species will be at an increased risk of extinction if global temperatures increase more than three to five degrees Fahrenheit above pre-industrial levels. A climate change of that magnitude could potentially threaten species by eliminating their habitat, increasing diseases, diminishing reproduction, and reducing food supplies. To download the Endangered Species Coalition's full report, visit: http://www.stopextinction.org/cgi-bin/giga.cgi?cmd=cause_dir_custom&cause_id=1704&page=HottestSpecies. December 1, 2009, http://www.upi.com/Science_News/2009/12/01/Global-warming-threatens-Hawaiian-songbird/UPI-27961259695472/, and December 1, 2009, http://www.stopextinction.org/cgi-bin/giga.cgi?cmd=cause_dir_news_item&cause_id=1704&news_id=78688&cat_id=1012.

February 2010

***Science Daily*, "African Leaf-Eating Primates 'Likely to Be Wiped Out' by Climate Change."** New research has revealed that some monkey species have an increasing risk of extinction due to potential climate change. The study claims that populations of monkeys and apes in Africa that are largely dependent upon a diet of leaves may be wiped out by a rise of two degrees Celsius in annual temperatures. The study also states that Old World monkey populations in Africa will be most affected by a two degree Celsius increase in global mean temperature, while New World monkeys in South America will largely be unaffected. However, if temperatures rise as much as four degrees Celsius (the most extreme prediction), the South American species will be affected as suitable habitats could diminish

(small, fragmented populations are more susceptible to the risks of extinction). The study, published in the online journal *Animal Behaviour*, bases the predictions on analyses of the ecological constraints that determine how much time animals are forced to rest, which is influenced by three factors: the percentage of leaves in the animals' diet, the temperature variation, and the mean annual temperature. When the three effects mesh, vulnerable species could be unable to cope, potentially leading to the extinction of their populations. To view the study, titled, "Resting time as an ecological constraint on primate biogeography," click: http://www.sciencedirect.com/science/article/B6W9W-4XWD01N-1/2/8c3bcc941a58cb713278decb0c34b2e8.
December 21, 2009, http://www.sciencedaily.com/releases/2009/12/091220174210.htm.

***Lamont-Doherty Earth Observatory News Release*, "Scientists Target East Coast Rocks for CO_2 Storage."** Scientists from Columbia University's Lamont-Doherty Earth Observatory (LDEO) believe that basalt formations along the coasts of New York, New Jersey, New England, and further south could serve as reservoirs to store CO_2 emissions from power plants and other industrial point sources. Earlier research shows that CO_2 injected into basalt undergoes natural chemical reactions that will eventually turn it into a solid mineral similar to limestone. The scientists used prior research and seismic and gravity measurements to determine possible offshore basalt formations, including four areas of more than 620 square miles located offshore of northern New Jersey, Long Island, and Massachusetts. In addition, the scientists estimate that the small Sandy Hook basin near New Jersey may contain approximately 4.3 cubic miles of basalt, with the potential to store close to 1 billion tons of CO_2. According to the authors, the undersea basalt formations are beneficial because: (1) the depth would provide natural pressure to keep the CO_2 from reverting to a gas; (2) the sediments on top would form impermeable caps; and (3) the formations contain porous layers to absorb CO_2 by displacing seawater. Previous research has identified other areas of basalt throughout the Appalachians; the largest appears to extend offshore of Georgia and South Carolina. The study, titled, "Potential on-shore and off-shore reservoirs for CO_2 sequestration in Central Atlantic magmatic province basalts," is available at: http://www.pnas.org/content/early/2009/12/28/0913721107.abstract?sid=fd113be3-513d-4895-9da9-547a30621ae2. January 4, 2010, http://www.ldeo.columbia.edu/news-events/scientists-target-east-coast-rocks-co2-storage.

March 2010

***Science Daily*, "Disappearing Ducks?"** According to research published in the journal *BioScience*, millions of waterfowl that depend on the prairie pothole region of central North America for food, shelter, and a place to raise their young will be impacted by a warmer and drier climate. By developing a new wetland model to understand the impacts potential climate change could have on wetlands in the prairie pothole region, researchers discovered that the region is much more sensitive to climate change than previously thought. The new model projected major reductions in water volume, shortening of the time water remains in wetlands, and changes to wetland vegetation dynamics in the 800,000-square kilometer region of central North America. Most dabbling ducks, such as mallards and teal, require approximately 95 days of surface water for their young to grow and develop; they also need an abundance of wetlands, as breeding waterfowl often isolate themselves from the rest of their species. The model suggests that under potential climate change, the region's conditions will not be conducive to the species' needs. February 2, 2010, http://www.sciencedaily.com/releases/2010/02/100201145432.htm.

***USA Today*, "Study: Trees Are Growing Faster Because of Climate Change."** According to a new study, forests in the eastern United States are growing at a faster rate than in the past as a result of climate change. The 22-year-long study, which was published in a February issue of *Proceedings of the National Academy of Sciences*, analyzed 55 groups of mixed hardwood forest plots in Maryland that are considered representative of trees on the East Coast. Researchers found that more than 90 percent of all the trees that were analyzed grew at a rate of two to four times faster than predicted. Researchers reported in their findings that they believe the main cause for the tree's accelerated growth is climate change. Researchers also believe that the growth rate will eventually level off due to limited water

availability and soil nutrients. To view the entire study, titled, "Evidence for a recent increase in forest growth," click: http://www.pnas.org/content/early/2010/02/02/0912376107. February 2, 2010, http://content.usatoday.com/communities/greenhouse/post/2010/02/study-trees-are-growing-faster-because-of-climate-change/1.

April 2010

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

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

May 2010

***Science Daily*, "Earlier Butterfly Emergence Linked to Climate Change."** According to a University of Melbourne study, butterflies are emerging in spring more than 10 days earlier than they were 65 years ago, which scientists believe is the result of climate change. The study found that the mean emergence date for adults of the Common Brown butterfly has shifted approximately 1.6 days earlier per decade over the past 65 years. The results of the study are believed to be the first link between the increase of GHG emissions, warming temperatures, and the altered timing of a natural event. The early arrival coincides with an increase in air temperatures in the same area of approximately 0.14°C per decade, which, according to scientists, is shown to be human-induced. To arrive at their conclusions, scientists raised caterpillars in a laboratory to measure the physiological impact of temperature on the rate of development. The data was used to model the effect of historical climate trends in Melbourne on the speed of the butterfly's development. Then, to examine whether natural climate change variability or human influence was more likely to have caused the climate change, the results were combined with the global climate model outputs for the same area over the same time period. The study, titled, "Early

emergence in a butterfly casually linked to anthropogenic warming," can be found at: http://rsbl.royalsocietypublishing.org/content/early/2010/03/09/rsbl.2010.0053. March 19, 2010, http://www.sciencedaily.com/releases/2010/03/100318132510.htm.

***Science Daily*, "Warmer Summers Could Create Challenges for Nesting Arctic Seabirds."** A warmer, wetter climate in the Canadian Arctic could create problems for nesting seabirds, according to a team of Canadian scientists. The study, which was published in *Arctic*, the journal of the Arctic Institute of North America, is based on observations of six species of birds on 11 different seabird colonies in the eastern Arctic. The group of Canadian scientists spent more than 7,000 days observing the birds, combining 33 years of observations. They found that Arctic birds, which have adapted to survive in the cold, dry high Arctic summers, typically spend the winter floating in the North Atlantic Ocean, returning to the Arctic in the spring to nest. However, temperatures in the Arctic have been rising, creating stronger storm fronts, heavy fog and winds, rain, freezing rain, and wet snow. Scientists tracked the mortality rates of the Arctic seabirds and predicted that a warming climate could have serious consequences to the species' survival. March 24, 2010, http://www.sciencedaily.com/releases/2010/03/100324113538.htm

June 2010

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

***Science Daily*, "Melting Sea Ice Major Cause of Warming in Arctic, New Study Reveals."** Warming temperatures in the Arctic Ocean have shown to be an effect of melting sea ice according to a University of Melbourne, Australia, study. Published in the journal *Nature*, the study reveals that the rapid melting of sea ice has caused a dramatic increase in the warming levels in the region the past two decades. Scientists believe that the increased Arctic warming is a result of positive feedback between sea ice melting and atmospheric warming, which is believed to be caused by increasing amounts of anthropogenic GHGs. By using recent data from the European Centre for Medium-Range Weather Forecasting, researchers were able to uncover a pattern of warming that is consistent with the loss of sea ice. The Arctic has experienced the fastest warming of any region in the world over the past 20 years. During the same timeframe, Arctic sea ice has dramatically declined. April 28, 2010, http://www.sciencedaily.com/releases/2010/04/100428142324.htm.

July 2010

***Science Daily*, "Whiter Clouds Could Mean Wetter Land."** A new study by the Carnegie Institution, in collaboration with the Indian Institute of Science, suggests that whitening, more reflective clouds could reduce solar radiation absorbed by the Earth and increase monsoonal rains, causing the continents to become wetter. The whitening of clouds is derived from the reduced size of water droplets that make up clouds. The theory was tested by using a computer simulation of the global climate system in which atmospheric CO_2 concentrations were set at approximately twice that of current levels. In the model, cloud droplets over oceans reduced in size, which made the clouds more reflective. This resulted in the

reflection of more solar radiations than clouds on land, which offset the warming effect of the higher CO_2 levels. The data also showed the clouds caused the land surface to become cooler and wetter; previous similar climate simulations had reduced precipitation on land. Researchers concluded the increased precipitation over land was driven by changes in air circulation, similar to monsoonal patterns that determine rainfall in parts of Asia. June 29, 2010, http://www.sciencedaily.com/releases/2010/06/100628124609.htm.

***Science Daily*, "Warmer Ecosystems Could Absorb Less Atmospheric Carbon Dioxide."** Researchers at Queen Mary, University of London used a new model to find that a predicted rise in global temperature of 7.2°F by 2100 could lead to a 13 percent decrease in ecosystems' ability to absorb CO_2 from the atmosphere. The researchers tested their predictions against data collected from experimental ponds that were warmed to simulate climate change. The reason behind the finding is photosynthesis; if climate change raises environmental temperatures, the balance between respiration and photosynthesis could change to favor a higher degree of respiration by animals and less CO_2 absorption by plants. This study is complemented by another recent study that compared animals living in 15 similar Icelandic streams where geothermal activity heats some streams as high as 81°F, allowing researchers to examine how temperature affects Arctic ecosystems. The researchers found changes in the type and number of species in cold streams compared with the warmer ones; in particular, fish and other larger predatory animals were not found in the coldest streams. On the other hand, the scientists uncovered that predators became larger in size and number as temperatures increased from 9°F to 45°F. July 1, 2010, http://www.sciencedaily.com/releases/2010/06/100630101020.htm.

August 2010

***National Academy of Sciences News Release*, "Near-Term Emissions Decisions and Long-Term Climate Impacts: Research Council Report Released."** The National Research Council released a study that claims choices made now concerning CO_2 emissions reductions will affect potential climate change impacts over the next few decades, as well as into the coming centuries and millennia. The study, which is sponsored by the Energy Foundation and the U.S. Environmental Protection Agency (EPA), states that since CO_2 stays in the atmosphere, it can effectively lock the Earth and future generations into a range of impacts, some of which could be severe. Furthermore, the report estimates the changes in precipitation, streamflow, wildfires, crop yields, and sea level rise that can be expected with different degrees of warming per degree Celsius. For example, one degree Celsius of global warming may result in: 5 to 10 percent less total rain in southwest North America, the Mediterranean, and southern Africa; 5 to 10 percent less streamflow in some river basins, including the Arkansas and Rio Grande; and 5 to 15 percent lower yields of some crops, including U.S. and African corn and Indian wheat. July 16, 2010, http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=12877.

***Los Angeles Times*, "Oceans' Growing Carbon Dioxide Levels May Threaten Coral Reef Fish."** According to marine ecologists, rising CO_2 levels in the ocean may confuse coral reef fish and cause them to swim toward the smell of predators rather than away from them. Published in the Proceedings of the National Academy of Sciences, the study observed larval fish in water enriched with various levels of CO_2. The majority of coral reef fish can smell nearby predators, which is a key ability for their survival due to their size. However, instead of fleeing from the predators odors, the fish exposed to the highest levels of CO_2 in the experiment appeared to be attracted to the same odors that normally set off their neuronal alarms. Scientists then tested the fish in the ocean by making temporary one-fish habitats. They found that the fish that had spent time in the highest levels of CO_2 ventured farther away from their coral and acted more fearlessly than their counterparts in normal water by exploring without trying to hide and striking aggressively at food. In addition, the fish exposed to the higher levels of CO_2 were five to nine times more likely to die. July 6, 2010, http://www.latimes.com/news/science/la-sci-fish-20100707,0,399923.story.

Policy

September 2009

***Reuters*, "U.S. and China Sign Memorandum on Climate Change."** The United States and China signed a Memorandum of Understanding (MOU) on July 28, 2009, that states the nations agree to cooperate on climate change, energy, and environment issues. During the talks, U.S. and Chinese officials discussed how to reduce GHG emissions before the United Nations (U.N.) conference in Copenhagen later this year that aims to set new global goals for climate change. The MOU, which was released by the State Department, also created a new climate change policy "dialogue," which lists 10 areas of cooperation, including energy efficiency, renewable energy, cleaner use of coal, and R&D. The two countries also launched a $15 million joint project – a portion of this funding will be used to study the development of clean coal technologies. July 28, 2009, http://www.reuters.com/article/vcCandidateFeed1/idUSN28530225.

***Newsday.com*, "NY Governor Signs Order Setting Emissions Goal."** The Governor of New York signed an executive order on August 6, 2009, that sets a statewide goal of cutting GHG emissions to 80 percent below 1990 levels by mid-century. The economic impacts will be examined by a new council that represents various state agencies and a plan to reach the target levels will be prepared by September 2010. The 1990 baseline for New York's emissions is 277 million tons; currently, the state's emission levels are approximately 290 million tons. Under the order, New York's state emissions are expected to be reduced to 55 million tons by 2050. The state also has joined the Regional Greenhouse Gas Initiative (RGGI) for capping power plant emissions and auctioning carbon allowances. To view the 2009 State Energy Plan Draft, visit: http://www.scribd.com/doc/18375962/Draft-Energy-Plan-Final. August 6, 2009, http://www.newsday.com/ny-governor-signs-order-setting-emissions-goal-1.1352587.

"Policy interactions, risk and price formation in carbon markets." The following is the Abstract of this article: "Carbon pricing is an important mechanism for providing companies with incentives to invest in carbon abatement. Price formation in carbon markets involves a complex interplay between policy targets, dynamic technology costs, and market rules. Carbon pricing may under-deliver investment due to R&D externalities, requiring additional policies which themselves affect market prices. Also, abatement costs depend on the extent of technology deployment due to learning-by-doing. This paper introduces an analytical framework based on marginal abatement cost (MAC) curves with the aim of providing an intuitive understanding of the key dynamics and risk factors in carbon markets. The framework extends the usual static MAC representation of the market to incorporate policy interactions and some technology cost dynamics. The analysis indicates that supporting large-scale deployment of mature abatement technologies suppresses the marginal cost of abatement, sometimes to zero, whilst increasing total abatement costs. However, support for early stage R&D may reduce both total abatement cost and carbon price risk. An important aspect of the analysis is in elevating risk management considerations into energy policy formation, as the results of the stochastic modeling indicate wide distributions for the emergence of carbon prices and public costs around the policy expectations." **William Blyth, Derek Bunn, Janne Kettunen, and Tom Wilson,** *Energy Policy*, Available online August 18, 2009, doi:10.1016/j.enpol.2009.07.042, http://www.science-direct.com/science/article/B6V2W-4X1GG38-4/2/6a0cbc0486ce6420adedd912b40f914b. (Subscription may be required.)

October 2009

***Carbon Capture Journal*, "Australian Government Accepts Liability for Gorgon LNG."** The Australian and Western Australian Governments have agreed to accept the long-term liability associated with the storage of CO_2 in geological formations under Barrow Island as part of the Gorgon LNG project. Officials said the decision to accept a portion of the long-term CO_2 storage liability acknowledges the

scale of the Gorgon LNG project, the opportunity it provides to demonstrate CCS technology at industrial scale, and the environmental significance of Barrow Island. The Gorgon CCS operation will be a major part of the global portfolio of CCS projects supported by the Australian-led Global Carbon Capture and Storage Institute (GCSSI). The project, which will receive $60 million in funding from the Australian Government, would be the world's largest demonstration of CCS technology. The multi-billion dollar Gorgon LNG project will be the biggest single investment ever made in Australia, surpassing the $12 billion Pluto LNG project now under construction in Western Australia. The Gorgon Project is a joint venture between Chevron, ExxonMobil, and Shell. For more information about the Gorgon Project, click: http://www.gorgon.com.au/; several project fact sheets can be found at: http://www.gorgon.com.au/01gp_factsheets.html#frames(content=01gp_factsheets_body.html). August 19, 2009, http://www.carboncapturejournal.com/displaynews.php?NewsID=426&PHPSESSID=pok6e6i4hprlc4c3sf1sdh0740.

"Policy modeling on the GDP spillovers of carbon abatement policies between China and the United States." The following is the Abstract of this article: "This paper simulates the GDP spillover effects between China and U.S. caused by the implementation of different climate protection policies. It is based on a combination of several climate protection models, which are the State-contingent Model and the Demeter Model, and the GDP Spillovers Model, known as the Mundell–Fleming model. From the simulation results, it is concluded that whether the United States implements policies on increasing carbon sink or not makes very little difference on the total output in the U.S. and the GDP spillovers toward China. However, the spillover impact of American carbon abatement policies on China experiences a varying trend that rises from negative to positive. These simulation results show that the climate protection policies of one country will have positive impact on the GDP spillovers of another country in the long term. This paper is focused on two conditions while simulating the GDP for both China and the U.S. Condition A within the simulations ignores the impact of GDP spillovers of foreign countries, while condition B takes the impact of GDP spillovers of foreign countries into consideration. Furthermore, this paper presents the simulated GDP of China and the U.S. under different scenarios and analyzes the level of GDP spillovers between the two countries. This paper concludes that carbon abatement policies in the U.S. have a larger and more noticeable GDP spillover effects to China." **Zheng Wang, Hua-Qun Li, Jing Wu, Yi Gong, Huan-Bo Zhang, and Chen Zhao**, *Economic Modeling*, Available online August 21, 2009, doi:10.1016/j.econmod.2009.07.011, http://www.sciencedirect.com/science/article/B6VB1-4X24C50-2/2/6ed6f71ec9e927c06a848c5e945f2fac. (Subscription may be required.)

November 2009

***EPA News Release*, "EPA Finalizes the Nation's First Greenhouse Gas Reporting System/Monitoring to begin in 2010."** Beginning on January 1, 2010, EPA will require large GHG emitters to begin collecting data under a new GHG reporting system that will cover approximately 85 percent of the Nation's GHG emissions and apply to roughly 10,000 facilities. The new reporting system is expected to guide the development of the best possible policies and programs to reduce such emissions by providing a better understanding of where GHGs are coming from. Businesses will also use the data to track their own emissions, compare them to similar facilities, and provide assistance in identifying cost-effective methods to reduce their GHG emissions in the future. The largest emitting facilities will send their first annual reports, covering calendar year 2010, to EPA in 2011. For more information on the new reporting system and reporting requirements, visit: http://www.epa.gov/climatechange/emissions/ghgrulemaking.html. September 22, 2009, http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/194e412153fcffea8525763900530d75!OpenDocument.

***Reuters*, "Norway Plans Record 2010 Carbon Capture Spending."** The Norwegian Government announced plans to raise its investment in CO_2 capture, transport, and storage to nearly $621 million in

2010. Under the newly announced plans, the Norwegian Government would contribute funding to projects like the construction of a CO_2 capture center at Mongstad. Norway, the world's sixth highest oil exporter, would also raise investments in renewable energies. Under that plan, a fund for developing renewable energy and energy efficiency would receive approximately $874 million. The Norwegian Government is discussing the possibility of raising national cuts in GHGs to 40 percent below 1990 levels by 2020 to help a new United Nations (UN) climate pact. Norway is also planning to make the nation "carbon neutral" by 2030. Norway has been storing CO_2 offshore at the Sleipner gas field since 1986. October 13, 2009, http://www.reuters.com/article/GCA-GreenBusiness/idUSTRE59C1RC20091013.

"Moving from misinformation derived from public attitude surveys on carbon dioxide capture and storage towards realistic stakeholder involvement." The following is the Abstract of this article: "Stakeholder involvement (SI) can include many activities, from providing information on a website to one-on-one conversations with people confronting an issue in their community. For CCS, there are now quite a few surveys of public attitudes towards CCS that are being used to inform the design of SI efforts. These surveys, focused on the nascent commercial deployment of CCS technologies, have demonstrated that the general public has little knowledge about CCS – yet the surveys go on to collect what are known as 'pseudo opinions' or 'non-attitudes' of respondents who know little or nothing about CCS. Beyond establishing the lack of knowledge about CCS, the results of these surveys should not be relied upon by the larger CCS community and public and private decision makers to inform the critical task of implementing and executing SI activities. The paper discusses the issues involved in providing information as part of the survey, maintaining that such information is never unbiased and thus tends to produce pseudo opinions that reflect the pollster's or researcher's bias. Other content and methodological issues are discussed, leading to the conclusion that most of the survey results should be used neither as a gauge of public attitudes nor as an indication of public acceptance. Then the framing of SI in CCS is examined, including the assumptions that clear stakeholder acceptance is a realistic goal and that the public has a decisive say in choosing the energy technologies of the present and the future. Finally, a broader suite of SI activities is recommended as more suited to realistic and contextual goals." **Elizabeth L. Malone, James J. Dooley, and Judith A. Bradbury**, *International Journal of Greenhouse Gas Control*, Available online September 25, 2009, doi: 10.1016/j.ijggc.2009.09.004, http://www.sciencedirect.com/science/article/B83WP-4X9NCKW-2/2/d88343083fd8401d25539277947c6be5. (Subscription may be required.)

December 2009

***Internal Revenue Bulletin: 2009-44*, "Credit for Carbon Dioxide Sequestration Under Section 45Q."** On November 2, 2009, the Internal Revenue Service (IRS) issued guidance for taxpayers to claim tax credits for capturing qualified CO_2 from a qualified facility and safely storing the CO_2 in a geologic formation in the United States. Under Section 45Q, which was added to the IRS code by the Energy Improvement and Extension Act of 2008, a taxpayer who stores CO_2 under the predetermined conditions may qualify for the tax credit if: (1) the taxpayer owns an industrial facility where carbon capture equipment is in service; (2) the taxpayer captures at least 500,000 metric tons of qualified CO_2 at the industrial facility during the taxable year; and (3) the qualified CO_2 is securely stored in a geologic formation (this requirement applies only for CO_2 captured after February 17, 2009, if the CO_2 is used in an EOR project). If the qualified CO_2 is not used in an EOR project, the tax credit totals $20 per metric ton of qualified CO_2; if the qualified CO_2 is used in an EOR project, the tax credit totals $10 per metric ton of qualified CO_2. The taxpayer will be responsible for maintaining records for inspection by the IRS, including: (1) methodology, inputs, and equations used to measure the amount of CO_2 at the source of capture and verify the amount of CO_2 injected (CO_2 recycled or re-injected as part of EOR operations are not included in the credit); (2) evidence of secure geological storage, such as certificates issued by a Federal or state government; (3) methodology, inputs, and equations used to calculate the amount of CO_2; and (4) all contracts entered into by the taxpayer and any contracting party that ensure the use of the CO_2 for EOR or secure geological storage. The tax credit amount will be adjusted for inflation for any taxable year beginning in a calendar year after 2009. The complete IRS Bulletin: 2009-44, which

contains Notice 2009-83, is available at: http://www.irs.gov/pub/irs-irbs/irb09-44.pdf. November 2, 2009, http://www.irs.gov/irb/2009-44_IRB/ar11.html#d0e1860.

"Design considerations for financing a national trust to advance the deployment of geologic CO_2 storage and motivate best practices." The following is the Abstract of this article: "This paper explores how the widely held public policy view of the evolution of the risk profile associated with geologic CO_2 storage profoundly influences the public policy dialogue about how to best address the long-term risk profile for geologic storage. Evidence emerging from research and pilot scale field demonstrations of CO_2 storage demonstrates that, with proper site characterization and sound operating practices, retention of stored CO_2 will increase with time thus invalidating the premise of an ever growing risk. The authors focus on key issues of fit, interplay, and scalability associated with the ability of a trust fund funded by a hypothetical $1 per ton CO_2 tipping fee for each ton of CO_2 stored in the United States under WRE450 and WRE550 climate policies to manage such risks in an economically efficient and environmentally effective manner. The authors conclude there is no intrinsic value – in terms of risk management or risk reduction – in creating a trust fund predicated solely on collecting a universally applied tipping fee that does not take into account site-specific risk profiles. If left to grow unchecked, a trust fund that is predicated on a constant stream of payments unrelated to each contributing site's risk profile could result in the accumulation of hundreds of billions to more than a trillion dollars contributing to significant opportunity cost of capital. Further, rather than mitigating the financial consequences of long-term CCS risks, this analysis suggests a blanket $1 per ton CO_2 tipping fee, if combined with a concomitant limitation of liability may increase the probability and frequency of long-term risk by eliminating financial incentives for sound operating behavior and site selection criteria—contribute to moral hazard. At a minimum, effective use of a trust fund requires: (1) strong oversight regarding site selection and fund management, and (2) a clear process by which the fund is periodically valued and funds collected are mapped to the risk profile of the pool of covered CCS sites. Without appropriate checks and balances, there is no *a priori* reason to believe that the amount of funds held in trust will map to the actual amount of funds needed to address long-term care expenses and delimited compensatory damages. For this reason, the authors conclude that financing a trust fund or other risk management instrument should be based on a site delimited estimate of potential future expected financial consequences rather than on the random adoption of a fixed funding stream, e.g., a blanket $1 per ton, because it 'sounds' reasonable." **James J. Dooley, Chiara Trabucchi, and Lindene Patton**, *International Journal of Greenhouse Gas Control*, Available online October 15, 2009, doi: 10.1016/j.ijggc.2009.09.009, http://www.sciencedirect.com/science/article/B83WP-4XFXXB2-1/2/be52e71c0b2a3e6f61ec0e8147a0d02f. (Subscription may be required.)

"Stakeholder attitudes on Carbon Capture and Storage – An International Comparison." The following is the Abstract of this article: "This paper presents results from a survey of stakeholder attitudes towards CCS. The survey is the first to make a global comparison across three major regions: North America, Japan, and Europe. It is based on a 30-question survey which targeted individuals working at stakeholder organizations that seek to shape, and will need to respond to, policy on CCS, including electric utilities, oil and gas companies, CO_2-intensive industries and non-governmental organizations (NGOs). The paper reports results from the original survey carried out in 2006 and from a recent follow up on key CCS questions (April 2009). The results show generally small differences across the regions and between the different groups of stakeholders. All believed that the challenge of significant reductions in emissions using only current technologies was severe. There was a widespread belief that CCS as well as renewable technologies such as solar power will achieve major market entry into the electricity sector within the next 10-20 years, whereas there is more [skepticism] about the role of hydrogen and especially nuclear fusion in the next 50 years. All groups were generally positive towards renewable energy. Yet, there were some notable areas of disagreement in the responses, for example, as expected, NGOs considered the threat of climate change to be more serious than the other groups. North American respondents were more likely to downplay the threat compared to those of the other regions. The Japanese were more concerned about the burden that would be placed on industry in the coming decade as a result of emissions constraints and NGOs were more likely to believe that the

burden imposed would be light. NGO respondents also believed CCS to be far more attractive than nuclear power (fission) but much less than renewables. As expected, the risk for leakage from reservoirs was ranked number one of the risk options given. The follow-up study generally confirmed the results of the original study with a few notable differences. As expected, the results of the follow-up shows that respondents consider CCS to play an increased role in the national climate debate. In Japan, there was an increased fraction of respondents who claimed that their organization has a clear position on CCS." **Filip Johnsson, David Reiner, Kenshi Itaoka, and Howard Herzog**, *International Journal of Greenhouse Gas Control*, Available online October 16, 2009, doi: 10.1016/j.ijggc.2009.09.006, http://www.sciencedirect.com/science/article/B83WP-4XG3DJ7-1/2/54db359fb6dd0f6335fb878bb61caa4a. (Subscription may be required.)

January 2010

***EPA News Release*, "EPA: Greenhouse Gases Threaten Public Health and the Environment."** EPA announced on December 7, 2009, that GHGs are threatening to the public health and welfare of the American people. EPA's endangerment findings, which claim that GHGs such as CO_2 can potentially lead to hotter, longer heat waves, are a response to a U.S. Supreme Court decision in 2007 that GHGs fit within the Clean Air Act (CAA) definition of air pollutants. EPA research shows that as a result of human activities, GHG concentrations in the atmosphere are at record high levels and that the Earth has been warming over the past 100 years and at an increased rate in recent decades. The findings lay the groundwork for EPA to develop rules under the CAA that limit GHG emission from vehicles and stationary CO_2 point sources like power plants and other industrial facilities. For more information on EPA's findings, click: http://www.epa.gov/climatechange/endangerment.html. December 7, 2009, http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/08d11a451131bca585257685005bf252%21OpenDocument.

"Evaluating the development of carbon capture and storage technologies in the United States." The following is the Abstract of this article: "CCS is seen as an important solution to solve the twin challenge of reducing GHG emissions, while utilizing fossil fuel reserves to meet future energy requirements. In this study an innovation systems perspective is applied to review the development of CCS technologies in the [United States] between 2000 and 2009 and to come up with policy recommendations for technology managers that wish to accelerate the deployment of CCS. The analysis describes the successful build-up of an innovation system around CCS and pinpoints the key determinants for this achievement. However, the evaluation of the system's performance also indicates that America's leading role in the development of CCS should not be taken for granted. It shows that the large CCS [research and development (R&D)] networks, as well as the extensive CCS knowledge base, which have been accumulated over the past decade, have not yet been valorized by entrepreneurs to explore the market for integrated CCS concepts linked to power generation. Therefore, it is argued that the build-up of the innovation system has entered a critical phase that is decisive for a further thriving development of CCS technologies in the [United States]. This study provides a clear understanding of the current barriers to the technology's future deployment and outlines a policy strategy that (1) stimulates technological learning; (2) facilitates collaboration and coordination in CCS actor networks; (3) creates financial and market incentives for the technology; and (4) provides supportive regulation and sound communication on CCS." **Klaas van Alphen, Paul M. Noothout, Marko P. Hekkert, and Wim C. Turkenburg**, *Renewable and Sustainable Energy Reviews*, Available online November 18, 2009, doi: 10.1016/j.rser.2009.10.028, http://www.sciencedirect.com/science/article/B6VMY-4XR4GV8-1/2/019d09178bbd1377e4b2dd8998a7c2de. (Subscription may be required.)

February 2010

***Taiwan Today*, "Government Sets Carbon Emission Reduction Goals,"** and ***Commodity Online*, "Taiwan Sets Goal to Cut CO_2 Emission Levels."** The Executive Yuan (Executive Branch) of Taiwan

announced that it has set short-, medium-, and long-term goals to reduce CO_2 emissions by 87 million metric tons by 2020. The short-term range is from now until 2020, at which point CO_2 emission levels will be approximately 257 million metric tons, the same as they were in 2005; the medium-term range lasts until 2025, at which point carbon levels should be reduced to 2000 levels; and the long-term range is through 2050, at which point emission levels should be reduced to half of 2000 levels. The newly set goals are expected to accelerate the Taiwanese Government's efforts to reduce CO_2 emissions while benefitting businesses, and to speed up the development of Taiwan's green energy sector. The largest source for CO_2 reduction is expected to be through the use of clean energy, which could potentially reduce emissions by 41 million metric tons. Another 26.7 million metric tons of CO_2 emissions can be reduced by the purchase of CO_2 credits. January 19, 2010, http://taiwantoday.tw/ct.asp?xItem=92315&CtNode=413, and January 19, 2010, http://www.commodityonline.com/news/Taiwan-sets-goal-to-cut-Co2-emission-levels-24882-3-1.html.

"Assessing innovation in emerging energy technologies: Socio-technical dynamics of carbon capture and storage (CCS) and enhanced geothermal systems (EGS) in the USA." The following is the Abstract of this article: "This study applies a socio-technical systems perspective to explore innovation dynamics of two emerging energy technologies with potential to reduce [GHG] emissions from electrical power generation in the United States: CCS and enhanced geothermal systems (EGS). The goal of the study is to inform sustainability science theory and energy policy deliberations by examining how social and political dynamics are shaping the struggle for resources by these two emerging, not-yet-widely commercializable socio-technical systems. This characterization of socio-technical dynamics of CCS and EGS innovation includes examining the perceived technical, environmental, and financial risks and benefits of each system, as well as the discourses and actor networks through which the competition for resources – particularly public resources – is being waged. CCS and EGS were selected for the study because they vary considerably with respect to their social, technical, and environmental implications and risks, are unproven at scale and uncertain with respect to cost, feasibility, and life-cycle environmental impacts. By assessing the two technologies in parallel, the study highlights important social and political dimensions of energy technology innovation in order to inform theory and suggest new approaches to policy analysis." **Jennie C. Stephens and Scott Jiusto**, *Energy Policy*, Available online December 29, 2009, doi: 10.1016/j.enpol.2009.12.003, http://www.sciencedirect.com/science/article/B6V2W-4Y1W8RX-2/2/847cf28a312ee71c15a8fa0e462e0c48. (Subscription may be required.)

March 2010

***The White House Press Release*, "President Obama Sets Greenhouse Gas Emissions Reduction Target for Federal Operations."** President Obama announced that the Federal Government will reduce its GHG emissions by 28 percent by 2020. This Executive Order is expected to spur clean energy investments that can create new private-sector jobs, drive long-term savings, build local market capacity, and foster innovation and entrepreneurship in clean energy industries. The Federal Government is the largest energy consumer in the U.S. economy, having spent more than $24.5 billion on electricity and fuel in 2008. By reaching the Federal GHG emission target, Federal energy use will be reduced by the equivalent of 646 trillion British thermal units (Btu), which is also equivalent to a cumulative total of $8 billion to $11 billion in avoided energy costs through 2020. Federal Departments and Agencies will achieve their GHG reduction targets by measuring their current energy and fuel use; becoming more energy efficient; and shifting to clean energy sources, such as solar, wind, and geothermal. Each agency's sustainability plan will be validated and scored by the Office of Management and Budget (OMB); annual progress will also be measured and made public. Examples of agency actions that are currently underway can be found on the White House Council on Environmental Quality website at: http://www.whitehouse.gov/administration/eop/ceq. January 29, 2010, http://www.whitehouse.gov/the-press-office/president-obama-sets-greenhouse-gas-emissions-reduction-target-federal-operations.

***New York Times*, "California Sets Up Statewide Network to Monitor Global-Warming Gases."** California plans to install a system of monitoring devices on towers throughout the state that will detect GHG emissions. Unlike preexisting monitoring networks used across the globe, which are deliberately placed in remote locations and measure the average global concentrations of GHGs, this network is intended to help California find specific sources of emissions, while verifying the state's overall compliance with its adopted plan to limit GHGs. Seven portable analyzers have been purchased by the California Air Resources Board (CARB) and will be deployed on towers in the San Joaquin and Sacramento Valleys. One analyzer is capable of covering as much as several hundred miles, according to scientists. CARB currently uses computer modeling to estimate state GHG emissions; the first task of the new network will be to see if actual concentrations of GHGs match those estimates. California's climate change law requires that GHG emissions be cut to 1990 levels by 2020. February 2, 2010, http://www.nytimes.com/2010/02/03/business/energy-environment/03emit.html?ref=earth.

"Geological storage of CO_2 in saline aquifers – A review of the experience from existing storage operations." The following is the Abstract of this article: "The experience from CO_2 injection at pilot projects (Frio, Ketzin, Nagaoka, [RCSPs]) and existing commercial operations (Sleipner, Snøhvit, In Salah, acid-gas injection) demonstrates that CO_2 geological storage in saline aquifers is technologically feasible. Monitoring and verification technologies have been tested and demonstrated to detect and track the CO_2 plume in different subsurface geological environments. By the end of 2008, approximately 20 Mt of CO_2 had been successfully injected into saline aquifers by existing operations. Currently, the highest injection rate and total storage volume for a single storage operation are approximately 1 Mt CO_2/year and 25 Mt, respectively. If CCS is to be an effective option for decreasing [GHG] emissions, commercial-scale storage operations will require orders of magnitude larger storage capacity than accessed by the existing sites. As a result, new demonstration projects will need to develop and test injection strategies that consider multiple injection wells and the optimization of the usage of storage space. To accelerate large-scale CCS deployment, demonstration projects should be selected that can be readily employed for commercial use; i.e. projects that fully integrate the capture, transport and storage processes at an industrial emissions source." **K. Michael, A. Golab, V. Shulakova, J. Ennis-King, G. Allinson, S. Sharma, and T. Aiken**, *International Journal of Greenhouse Gas Control*, Available online January 25, 2010, doi:10.1016/j.ijggc.2009.12.011, http://www.sciencedirect.com/science/article/B83WP-4Y7MN79-1/2/2f5b9abab49358cd40a7e841b6c92077. (Subscription may be required.)

April 2010

***Reuters*, "U.S. EPA Says to Ease Carbon Rules on Small Business."** According to the U.S. Environmental Protection Agency (EPA), the CO_2 emission rules for small businesses will be adjusted. EPA originally planned on requiring companies that emit more than 25,000 tons of GHGs a year to obtain permits verifying they were using the best available technology to reduce GHG emissions. That threshold has now been raised to 75,000 tons of CO_2 emitted annually in 2011 and 2012, exempting sources such as hospitals, large buildings, and schools. However, heavy industries, such as coal-fired power plants, which emit approximately 1 million tons of CO_2 a year, would still be required to obtain a permit. To view EPA's original "Proposed Approach to Provide Assistance to Small Businesses on GHG Emissions," click: http://www.epa.gov/climateleaders/documents/small_business_approach.pdf. March 3, 2010, http://www.reuters.com/article/idUSTRE6224M520100303.

"Water Challenges for Geologic [CCS]." The following is the Abstract of this article: "CCS has been proposed as a means to dramatically reduce [GHG] emissions with the continued use of fossil fuels. For geologic sequestration, the [CO_2] is captured from large point sources (e.g., power plants or other industrial sources), transported to the injection site and injected into deep geological formations for storage. This will produce new water challenges, such as the amount of water used in energy resource development and utilization and the 'capture penalty' for water use. At depth, brine displacement within formations, storage reservoir pressure increases resulting from injection, and leakage are potential concerns. Potential impacts range from increasing water demand for capture to contamination of

groundwater through leakage or brine displacement. Understanding these potential impacts and the conditions under which they arise informs the design and implementation of appropriate monitoring and controls, important both for assurance of environmental safety and for accounting purposes. Potential benefits also exist, such as co-production and treatment of water to both offset reservoir pressure increase and to provide local water for beneficial use." **Robin L. Newmark, Samuel J. Friedmann, and Susan A. Carroll**, *Environmental Management*, Available online February 3, 2010, doi:10.1007/s00267-010-943-1, http://www.springerlink.com/content/k4304515k5733194/?p=3c5c743728ef4e6399e57e439e1e7d78&pi=22. (Subscription may be required.)

May 2010

***U.S. Environmental Protection Agency News Release*, "EPA Proposes to Add Sources to Greenhouse Gas Reporting System/Requirements Target Potent and Persistent Greenhouse Gases."** EPA is proposing to include emissions data from the oil and natural gas sector and from facilities that inject and store CO_2 underground for the purposes of geologic storage or enhanced oil and gas recovery (EOR/EGR) in its first-ever national mandatory GHG reporting system. The rule currently requires 31 industry sectors, covering 85 percent of total GHG emissions in the United States, to track and report their emissions. The data collected from facilities that inject CO_2 underground would enable EPA to track the amount of CO_2 that is injected and allow businesses to track their own emissions, compare them to similar facilities, and identify cost-effective methods to reduce future emissions. Under these proposals, newly covered sources would begin collecting emissions data on January 1, 2011, with the first annual reports submitted to EPA on March 31, 2012. EPA finalized the first-ever mandatory GHG reporting requirement in October 2009. March 23, 2010, http://yosemite.epa.gov/opa/admpress.nsf/e77fdd4f5afd88a3852576b3005a604f/8d717a8525394687852576ef00595ffc!OpenDocument.

***Carbon Capture Journal*, "UK Launches CCS Industrial Strategy."** The United Kingdom (UK) Government recently published their CCS Industrial Strategy, which outlines plans to set up a CCS industry worth up to $8.8 billion by 2030. An Office of Carbon Capture and Storage (OCCS) within the Department of Energy and Climate Change (DECC) has also been set up for the facilitation of CCS activities in the UK. One of the first activities of OCCS will be the development of a CCS Roadmap. In addition, the report addresses how to provide an opportunity for project developers to propose co-located capture projects and develop experience with CO_2 pipelines and CO_2 storage practices. March 17, 2010, http://www.carboncapturejournal.com/displaynews.php?NewsID=543&PHPSESSID=63e82fcv36ldqinmrm7jua0kn4.

"Lay perceptions of carbon capture and storage technology." The following is the Abstract of this article: "The extent of social acceptance of CCS is likely to significantly influence the sustainable development of CO_2 storage projects. Acceptance of CCS by the key stakeholders (policymakers, the general public, the media and the local community), linked to specific projects, as well as how the technology is communicated about and perceived by the public, have become matters of interest for the social sciences. This article reports on an investigation of the public perception of CCS technology in Spain. Individuals' views on CCS are analyzed through focus groups with lay citizens using 'stimulus materials.' As the analysis shows, lay views of CCS differ significantly from the views of decision makers and experts. Public concerns and reactions to CCS technology and potential projects, as well as the degree of consensus on its acceptance or rejection are detailed. Implications for the future use of CCS are discussed." **C. Oltra, R. Sala, R. Solà, M. Di Masso, and G. Rowe**, *International Journal of Greenhouse Gas Control*, Available online March 11, 2010, doi:10.1016/j.ijggc.2010.02.001, http://www.sciencedirect.com/science/article/B83WP-4YK8MMV-1/2/c57bdeeb60b5edeb8f62f807f79f743c. (Subscription may be required.

June 2010

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

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

July 2010

***IPAC-CO2 News Release*, "World's First Standards for Deep-Earth Storage of Industrial Carbon Emissions to be Developed by CSA Standards and IPAC-CO2 Research,"** and ***Regina Leader-Post*, "Agreement Reached to Develop Standard."** CSA Standards and the International Performance Assessment Centre for Geologic Storage of Carbon Dioxide (IPAC-CO2) have agreed to develop Canada's first CCS standard for the geologic storage of industrial emissions. Once completed, and if approved by the Standards Council of Canada, it will be the world's first formally recognized CCS standard. The new standard, which will provide guidelines for regulators, industry, and others around the world involved with scientific and commercial CCS projects, will then be used for the promotion of international standards through the International Standards Organization (ISO). The new standard will focus primarily on the long-term geologic storage of CO_2 deep underground. June 16, 2010, http://www.ipac-co2.com/Resources/Documents/CSA%20IPAC%20CO2%20Standard%20Release%20Final.pdf, and

June 16, 2010,
http://www.leaderpost.com/technology/Agreement+reached+develop+standard/3159841/story.html.

"A contribution to risk analysis for leakage through abandoned wells in geological CO_2 storage." The following is the Abstract of this article: "The selection and the subsequent design of a subsurface CO_2 storage system are subject to considerable uncertainty. It is therefore important to assess the potential risks for health, safety and environment. This study contributes to the development of methods for quantitative risk assessment of CO_2 leakage from subsurface reservoirs. The amounts of leaking CO_2 are estimated by evaluating the extent of CO_2 plumes after numerically simulating a large number of reservoir realizations with a radially symmetric, homogeneous model. To conduct the computationally expensive simulations, the 'CO_2 Community Grid' was used, which allows the execution of many parallel simulations simultaneously. The individual realizations are set up by randomly choosing reservoir properties from statistical distributions. The statistical characteristics of these distributions have been calculated from a large reservoir database, holding data from over 1,200 reservoirs. An analytical risk equation is given, allowing the calculation of average risk due to multiple leaky wells with varying distance in the surrounding of the injection well. The reservoir parameters most affecting risk are identified. Using these results, the placement of an injection well can be optimized with respect to risk and uncertainty of leakage. The risk and uncertainty assessment can be used to determine whether a site, compared to others, should be considered for further investigations or rejected for CO_2 storage." **Andreas Kopp, P.J. Binning, K. Johannsen, R. Helmig, and H. Class**, *Advances in Water Resources*, Available online May 15, 2010, doi:10.1016/j.advwatres.2010.05.001, http://www.sciencedirect.com/science/article/B6VCF-5033Y11-1/2/cd60e420c516c54a6a72cc06d31a0e2a. (Subscription may be required.)

August 2010

***E&E News PM*, "White House Issues Draft Guidance on Agency Emissions."** Following the issuing of Executive Order 13514 last year, the White House released draft guidance on July 15 that informs Federal agencies how to proceed with plans to achieve a target of reducing GHG emissions 28 percent over the next decade. The executive order requires agencies to establish an inventory of GHG emissions for the current fiscal year and submit it to the White House by January 31, 2010. The agencies will then work to reduce their total GHG emissions and cut the government's energy bills in the range of $8 billion to $11 billion. The draft guidance from the Council on Environmental Quality (CEQ) informs agencies how to measure emissions by focusing on land use, carbon offsets, and the burning of biomass. The draft guidance, which currently exempts biomass and biofuels from reduction targets, is available for public comment on the Federal Register along with a technical support document. The "Draft Federal Greenhouse Gas Accounting and Reporting Guidance" is available at: http://www.whitehouse.gov/sites/default/files/microsites/ceq/Draft-GHG-Accounting-and-Reporting-Guidance-6-30-10.pdf, and the draft technical support document can be viewed at: http://www.whitehouse.gov/sites/default/files/microsites/ceq/Draft-GHG-Technical-Support-Document.pdf. July 15, 2010, http://www.eenews.net/eenewspm/2010/07/15/archive/3.

***German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety Press Release*, "CCS Act an Important Step for a Future Technology."** Germany's Federal Economics Minister and Federal Environment Minister presented a joint draft act that uses a gradual approach to set a legal framework for the demonstration and application of CCS technologies. The draft act permits testing and demonstration of storages, which will result in an evaluation of CCS technologies by 2017. In addition, the draft act sets requirements for site characterization, operator liability, protection of stakeholders, and MVA. A new provision in draft act states that storage facilities may only be licensed if the application is filed by the end of 2015, the annual storage volume per facility does not exceed 3 million tonnes, and the overall volume nationwide does not exceed 8 million tonnes of CO_2 per year. Other provisions state that precautionary measures must be taken, funds must be set aside for long-term monitoring, landowners' rights protected, and municipalities where projects take place will receive

compensation. The German government will evaluate the act in 2017 by preparing a report that will determine whether CCS may be used on a larger scale. The draft act will now be reviewed and voted upon within the German government. July 14, 2010, http://www.bmu.de/english/current_press_releases/pm/46238.php.

"Determinants of the costs of carbon capture and sequestration for expanding electricity generation capacity." The following is from the Abstract of this article: "This study models the costs of electricity generation with CCS, from generation at the power plant to carbon injection at the reservoir, examining the economic factors that affect technology choice and CCS costs at the individual plant level. The results suggest that natural gas and coal prices have profound impacts on the carbon price needed to induce CCS. To extend previous analyses [the authors] develop a 'cost region' graph that models technology choice as a function of carbon and fuel prices. Generally, the least-cost technology at low carbon prices is pulverized coal, while intermediate carbon prices favor natural gas technologies and high carbon prices favor coal gasification with capture. However, the specific carbon prices at which these transitions occur is largely determined by the price of natural gas. For instance, the CCS-justifying carbon price ranges from \$27/t CO_2 at high natural gas prices to \$54/t CO_2 at low natural gas prices. This result has important implications for potential climate change legislation. The capital costs of the generation and CO_2 capture plant are also highly important, while pipeline distance and criteria pollutant control are less significant." **Emily Giovanni and Kenneth R. Richards**, *Energy Policy*, Available online July 9, 2010, doi:10.1016/j.enpol.2010.05.058, http://www.sciencedirect.com/science/article/B6V2W-50GTRFY-2/2/46fa41016613b258413a2654196adde2. (Subscription may be required.)

"Real options analysis of investment in carbon capture and sequestration technology." The following is from the Abstract of this article: "Among a comprehensive scope of mitigation measures for climate change, CCS plays a potentially significant role in [industrialized] countries. In this paper, [the authors] develop an analytical real options model that values the choice between two emissions-reduction technologies available to a coal-fired power plant. Specifically, the plant owner may decide to invest in either full CCS (FCCS) or partial CCS (PCCS) retrofits given uncertain electricity, CO_2, and coal prices. [The authors] first assess the opportunity to upgrade to each technology independently by determining the option value of installing a CCS unit as a function of CO_2 and fuel prices. Next, [the authors] value the option of investing in either FCCS or PCCS technology. If the volatilities of the prices are low enough, then the investment region is dichotomous, which implies that for a given fuel price, retrofitting to the FCCS (PCCS) technology is optimal if the CO_2 price increases (decreases) sufficiently. The numerical examples provided in this paper using current market data suggest that neither retrofit is optimal immediately. Finally, [the authors] observe that the optimal stopping boundaries are highly sensitive to CO_2 price volatility." **Somayeh Heydari, Nick Ovenden, and Afzal Siddiqui**, *Computational Management Science*, Available online June 16, 2010, doi:10.1007/s10287-010-0124-5, http://www.springerlink.com/content/r2hx264343864724/?p=b1325ea06ce84a3cbb841c0d1ee6ad2d&pi=8. (Subscription required.)

Geology

September 2009

"Greenhouse gas mitigation in a carbon constrained world: The role of carbon capture and storage." The following is the Abstract of this article: "CCS promises to allow for low-emissions fossil-fuel-based power generation. The technology is under development; a number of technological, economic, environmental and safety issues remain to be solved. CCS may prolong the prevailing coal-to-electricity regime and countervail efforts in other mitigation categories. Given the need to continue using fossil-fuels for some time, however, it may also serve as a bridging technology towards a renewable energy future. In this paper, [the authors] analyze the structural characteristics of the CCS innovation system and perform an energy-environment-economic analysis of the potential contribution of CCS,

using a general equilibrium model for Germany. [The authors] show that a given climate target can be achieved at lower marginal costs when the option of CCS is included into the mix of mitigation options. [The authors] conclude that, given an appropriate legal and policy framework, CCS, energy efficiency and some other mitigation efforts are complementary measures and should form part of a broad mix of measures required for a successful CO_2 mitigation strategy." **Barbara Praetorius and Katja Schumacher**, *Energy Policy*, Available online August 8, 2009, doi: 10.1016/j.enpol.2009.07.01, http://www.sciencedirect.com/science/article/B6V2W-4WYCT88-2/2/2069a4623c20490a71b2ca55b5abf1c3. (Subscription may be required.)

"New Trapping Mechanism in Carbon Sequestration." The following is the Abstract of this article: "The modes of geologic storage of CO_2 are usually categorized as structural, dissolution, residual, and mineral trapping. Here [the authors] argue that the heterogeneity intrinsic to sedimentary rocks gives rise to a fifth category of storage, which we call local capillary trapping. Local capillary trapping occurs during buoyancy-driven migration of bulk phase CO_2 within a saline aquifer. When the rising CO_2 plume encounters a region (10−2 to 10+1m) where capillary entry pressure is locally larger than average, CO_2 accumulates beneath the region. This form of storage differs from structural trapping in that much of the accumulated saturation will not escape, should the integrity of the seal overlying the aquifer be compromised. Local capillary trapping differs from residual trapping in that the accumulated saturation can be much larger than the residual saturation for the rock. [The authors] examine local capillary trapping in a series of numerical simulations. The essential feature is that the drainage curves (capillary pressure versus saturation for CO_2 displacing brine) are required to be consistent with permeabilities in a heterogeneous domain. In this work, [the authors] accomplish this with the Leverett J-function, so that each grid block has its own drainage curve, scaled from a reference curve to the permeability and porosity in that block. [The authors] find that capillary heterogeneity controls the path taken by rising CO_2. The displacement front is much more ramified than in a homogeneous domain, or in a heterogeneous domain with a single drainage curve. Consequently, residual trapping is overestimated in simulations that ignore capillary heterogeneity. In the cases studied here, the reduction in residual trapping is compensated by local capillary trapping, which yields larger saturations held in a smaller volume of pore space. Moreover, the amount of CO_2 phase remaining mobile after a leak develops in the caprock is smaller. Therefore, the extent of immobilization in a heterogeneous formation exceeds that reported in previous studies of buoyancy-driven plume movement." **Eshan Saadatpoor, Steven L. Bryant, and Kamy Sepehrnoori**, *Transport in Porous Media*, Available online August 4, 2009, doi: 10.1007/s11242-009-9446-6, http://www.springerlink.com/content/r0703xn633632u15/?p=97d3dd493d0f4afc88a0d87441ba7f26&pi=3. (Subscription may be required.)

"Basin-scale hydrogeologic impacts of CO_2 storage: Capacity and regulatory implications." The following is the Abstract of this article: "Industrial-scale injection of CO_2 into saline formations in sedimentary basins will cause large-scale fluid pressurization and migration of native brines, which may affect valuable groundwater resources overlying the deep sequestration aquifers. In this paper, we discuss how such basin-scale hydrogeologic impacts (1) may reduce current storage capacity estimates, and (2) can affect regulation of CO_2 storage projects. Our assessment arises from a hypothetical future carbon sequestration scenario in the Illinois Basin, which involves twenty individual CO_2 storage projects (sites) in a core injection area most suitable for long-term storage. Each project is assumed to inject five million tonnes of CO_2 per year for 50 years. A regional-scale three-dimensional simulation model was developed for the Illinois Basin that captures both the local-scale CO_2–brine flow processes and the large-scale groundwater flow patterns in response to CO_2 storage. The far-field pressure buildup predicted for this selected sequestration scenario support recent studies in that environmental concerns related to near- and far-field pressure buildup may be a limiting factor on CO_2 storage capacity. In other words, estimates of storage capacity, if solely based on the effective pore volume available for safe trapping of CO_2, may have to be revised based on assessments of pressure perturbations and their potential impacts on caprock integrity and groundwater resources. Our results suggest that (1) the area that needs to be characterized in a permitting process may comprise a very large region within the basin

if reservoir pressurization is considered, and (2) permits cannot be granted on a single-site basis alone because the near- and far-field hydrogeologic response may be affected by interference between individual storage sites. We also discuss some of the challenges in making reliable predictions of large-scale hydrogeologic impacts related to CO_2 sequestration projects." **Jens T. Birkholzer and Quanlin Zhou**, *International Journal of Greenhouse Gas Control*, Available online August 8, 2009, doi:10.1016/j.ijggc.2009.07.002, http://www.sciencedirect.com/science/article/B83WP-4WYCTC4-1/2/9119c6c4c48060cc95cbc729f959cced. (Subscription may be required.)

October 2009

"Short-Range Atmospheric Dispersion of Carbon Dioxide." The following is the Abstract of this article: "[The authors] present a numerical study aimed at quantifying the effects of concentration-dependent density on the spread of a seeping plume of CO_2 into the atmosphere such as could arise from a leaking geologic carbon sequestration site. Results of numerical models can be used to supplement field monitoring estimates of CO_2 seepage flux by modeling transport and dispersion between the source emission and concentration-measurement points. [The authors] focus on modeling CO_2 seepage dispersion over relatively short distances where density effects are likely to be important. [The authors] model dense gas dispersion using the steady-state Reynolds-averaged Navier-Stokes equations with density dependence in the gravity term. Results for a two-dimensional system show that a density dependence emerges at higher fluxes than prior estimates. A universal scaling relation is derived that allows estimation of the flux from concentrations measured downwind and vice versa." **Andrea Cortis and Curtis M. Oldenburg**, *Boundary-Layer Meteorology*, Available online August 20, 2009, doi: 10.1007/s10546-009-9418-y, http://www.springerlink.com/content/725h341984k04585/?p=1d42a0507fd548f1b9f0802e886580e7&pi=1. (Subscription may be required.)

"On Mobilization of Lead and Arsenic in Groundwater in Response to CO_2 Leakage from Deep Geological Storage." The following is the Abstract of this article: "If [CO_2] stored in deep saline aquifers were to leak into an overlying aquifer containing potable groundwater, the intruding CO_2 would change the geochemical conditions and cause secondary effects mainly induced by changes in pH. In particular, hazardous trace elements such as lead and arsenic, which are present in the aquifer host rock, could be mobilized. In an effort to evaluate the potential risks to potable water quality, reactive transport simulations were conducted to evaluate to what extent and mechanisms through which lead and arsenic might be mobilized by intrusion of CO_2. An earlier geochemical evaluation of more than 38,000 groundwater quality analyses from aquifers throughout the United States and an associated literature review provided the basis for setting up a reactive transport model and examining its sensitivity to model variation. The evaluation included identification of potential mineral hosts containing hazardous trace elements, characterization of the modal bulk mineralogy for an arenaceous aquifer, and augmentation of the required thermodynamic data. The reactive transport simulations suggest that CO_2 ingress into a shallow aquifer can mobilize significant lead and arsenic, contaminating the groundwater near the location of intrusion and further downstream. Although substantial increases in aqueous concentrations are predicted compared to the background values, the maximum permitted concentration for arsenic in drinking water was exceeded in only a few cases, whereas that for lead was never exceeded." **Liange Zheng, John A. Apps, Yingqi Zhang, Tianfu Xu, and Jens T. Birkholzer**, *Chemical Geology*, Available online September 14, 2009, doi: 10.1016/j.chemgeo.2009.09.007, http://www.sciencedirect.com/science/article/B6V5Y-4X77HKX-1/2/01d02efee1c243b35262087c5a3aa0df. (Subscription may be required.)

November 2009

"Life Cycle Inventory of CO_2 in an Enhanced Oil Recovery System." The following is the Abstract of this article: "EOR has been identified as a method of sequestering CO_2 recovered from power plants. In

CO_2-flood EOR, CO_2 is injected into an oil reservoir to reduce oil viscosity, reduce interfacial tension, and cause oil swelling which improves oil recovery. Previous studies suggest that substantial amounts of CO_2 from power plants could be sequestered in EOR projects, thus reducing the amount of CO_2 emitted into the atmosphere. This claim, however, ignores the fact that oil, a carbon rich fuel, is produced and 93 percent of the carbon in petroleum is refined into combustible products ultimately emitted into the atmosphere. In this study [the authors] analyze the net life cycle CO_2 emissions in an EOR system. This study assesses the overall life cycle emissions associated with sequestration via CO_2-flood EOR under a number of different scenarios and explores the impact of various methods for allocating CO_2 system emissions and the benefits of sequestration." **Paulina Jaramillo, W. Michael Griffin, and Sean T. McCoy**, *Environmental Science and Technology*, Available online September 30, 3009, doi: 10.1021/es902006h, http://pubs.acs.org/doi/abs/10.1021/es902006h. (Subscription may be required.)

"Carbonation of wellbore cement by CO_2 diffusion from caprock." The following is the Abstract of this article: "To evaluate the risk of corrosion of cement by geosequestered CO_2, samples are being retrieved from wells placed in natural CO_2 deposits. If the cement passing through the cap rock is carbonated, it may indicate that annular gaps or cracks have allowed carbonic acid to come into contact with the cement. However, it must be recognized that the pore water in the cap rock has become saturated with CO_2 over geological time. After the well is placed, the CO_2 will diffuse toward the cement and react with it. A simple analysis of the diffusion kinetics demonstrates that carbonation depths of millimeters to centimeters can be expected from this reaction within the lifetime of a well, in the absence of any cracks or gaps. Therefore, the occurrence of carbonation in cement sealing natural CO_2 deposits must be interpreted with caution." **George W. Scherer and Bruno Huet**, *International Journal of Greenhouse Gas Control*, Available online September 24, 2009, doi:10.1016/j.ijggc.2009.08.002, http://www.sciencedirect.com/science/article/B83WP-4X9DB94-1/2/2d5c1e0673c00dc05737a2b82a7c5223. (Subscription may be required.)

December 2009

"Changes in reservoir properties from injection of supercritical CO_2 into coal seams – A laboratory study." The following is the Abstract of this article: "Two Australian Permian coals of similar rank but different texture, one predominantly dull and the other predominantly bright, were investigated in laboratory experiments to assess changes in reservoir properties following exposure to supercritical CO_2 ($SCCO_2$) and water. Both powdered coal (0.180-0.220 mm) and small cubes (15 mm to a side) were tested in a high-pressure (HP) batch reactor for up to 120 hrs. Two reaction fluids were used, each on separate sister coal samples: de-ionized water (DH_2O) only, and a $SCCO_2$ and DH_2O mixture. Properties were measured before and after treatment with: high-pressure CO_2 adsorption isotherms (storage capacity); helium pycnometry, mercury porosimetry and low-pressure (LP) CO_2 adsorption (density, porosity and PSD effects); leachate chemical analysis for dissolved mineral matter; and water and CO_2 permeabilities at in situ conditions during core flood experiments on an 80 mm cube. Micro and meso porosities for both coals showed significant increases after reactions with the $SCCO_2$ and DH_2O mixture. The macro porosity decreased significantly for the dull coal, but increased marginally for the bright coal. Total accessible porosity for dull coal showed virtually no change (0.5 [percent]); the bright coal exhibited 3.4 [percent] increase from a pretreatment total porosity of 11.0 [percent]. On powdered samples reacted with the mixture, 80 [percent]+ increases in internal surface areas, measured using LP CO_2 sorption at 0°C, were noted for both coals. The HP CO_2 excess adsorption isotherms on both coals increased after treatment, varying with pressure level, coal type and coal texture. The core flood tests indicated the permeability to CO_2, after a waterflood stage, increased significantly. The second stage waterflood exhibited an over 600 [percent] increase on the pre-CO_2 first stage waterflood permeability. These combined results indicate that mineral matter in Permian coals is dissolved and mobilized by the carbonic acid formed during CO_2 dissolution in water, leading to increased porosity, permeability and HP CO_2 excess adsorption." **P. Massarotto, S.D. Golding, J.-S. Bae, R. Iyer, and V. Rudolph**, *International Journal of Coal Geology*, Available online November 11, 2009, doi:

10.1016/j.coal.2009.11.002, http://www.sciencedirect.com/science/article/B6V8C-4XNN5B9-1/2/f315ed125c98cec799200670306288fc. (Subscription may be required.)

"Role and impact of CO_2-rock interactions during CO_2 storage in sedimentary rocks." The following is the Abstract of this article: "Before implementing CO_2 storage on a large scale its viability regarding injectivity, containment and long-term safety for both humans and environment is crucial. Assessing CO_2-rock interactions is an important part of that as these potentially affect physical properties through highly coupled processes. Increased understanding of the physical impact of injected CO_2 during recent years including buoyancy driven two-phase flow and convective mixing elucidated potential CO_2 pathways and indicated where and when CO_2-rock interactions are potentially occurring. Several areas of interactions can be defined: (1) interactions during the injection phase and in the near well environment, (2) long-term reservoir and caprock interactions, (3) CO_2-rock interactions along leakage pathways (well, caprock and fault), (4) CO_2-rock interactions causing potable aquifer contamination as a consequence of leakage, (5) water-rock interactions caused by aquifer contamination through the CO_2 induced displacement of brines and finally engineered CO_2-rock interactions (6). The driving processes of CO_2-rock interactions are discussed as well as their potential impact in terms of changing physical parameters. This includes dissolution of CO_2 in brines, acid induced reactions, reactions due to brine concentration, clay desiccation, pure CO_2-rock interactions and reactions induced by other gases than CO_2. Based on each interaction environment the main aspects that are possibly affecting the safety and/or feasibility of the CO_2 storage scheme are reviewed and identified. Then the methodologies for assessing CO_2-rock interactions are discussed. High priority research topics include the impact of other gaseous compounds in the CO_2 stream on rock and cement materials, the reactivity of dry CO_2 in the absence of water, how CO_2 induced precipitation reactions affect the pore space evolution and thus the physical properties and the need for the development of coupled flow, geochemical and geomechanical models." **Irina Gaus**, *International Journal of Greenhouse Gas Control*, Available online November 2, 2009, doi: 10.1016/j.ijggc.2009.09.015, http://www.sciencedirect.com/science/article/B83WP-4XKSY3T-1/2/1607d6daddb03048627d59695f95f2e5. (Subscription may be required.)

January 2010

"Sequestering carbon dioxide in a closed underground volume." The following is the Abstract of this article: "The capture and subsequent geologic sequestration of CO_2 has been central to plans for managing CO_2 produced by the combustion of fossil fuels. The magnitude of the task is overwhelming in both physical needs and cost, and it entails several components including capture, gathering and injection. The rate of injection per well and the cumulative volume of injection in a particular geologic formation are critical elements of the process. Published reports on the potential for sequestration fail to address the necessity of storing CO_2 in a closed system. [The authors'] calculations suggest that the volume of liquid or supercritical CO_2 to be disposed cannot exceed more than about [one percent] of pore space. This will require from [five] to 20 times more underground reservoir volume than has been envisioned by many, and it renders geologic sequestration of CO_2 a profoundly non-feasible option for the management of CO_2 emissions. Material balance modeling shows that CO_2 injection in the liquid stage (larger mass) obeys an analog of the single-phase, liquid material balance, long-established in the petroleum industry for forecasting undersaturated oil recovery. The total volume that can be stored is a function of the initial reservoir pressure, the fracturing pressure of the formation or an adjoining layer, and CO_2 and water compressibility and mobility values. Further, published injection rates, based on displacement mechanisms assuming open [formation] conditions are totally erroneous because they fail to reconcile the fundamental difference between steady state, where the injection rate is constant, and pseudo-steady state where the injection rate will undergo exponential decline if the injection pressure exceeds an allowable value. A limited [formation] indicates a far larger number of required injection wells for a given mass of CO_2 to be sequestered and/or a far larger reservoir volume than the former." **Michael J. Economides and Christine Ehlig-Economides**, *Journal of Petroleum Science and Engineering*, Available online November 20, 2009, doi: 10.1016/j.petrol.2009.11.002,

http://www.sciencedirect.com/science/article/B6VDW-4XRJX7V-1/2/5ad2e833c9ea78891ed0a96a8e7f5472. (Subscription may be required.)

"Laboratory characterization of coal reservoir permeability for primary and enhanced coalbed methane recovery." The following is the Abstract of this article: "Coal permeability is highly sensitive to the stress. Meanwhile, coal swells with gas adsorption, and shrinks with gas desorption. Under reservoir conditions these strain changes affect the cleat porosity and thus permeability. Coal permeability models, such as the Palmer and Mansoori and Shi and Durucan models, relate the stress and swelling/shrinkage effect to permeability using an approximate geomechanical approach. Thus, in order to apply these models, stress-permeability behavior, swelling/shrinkage behavior and the geomechanical properties of the coal must be estimated. This paper presents a methodology for the laboratory characterization of the Palmer and Mansoori and Shi and Durucan permeability models for reservoir simulation of [enhanced coalbed methane (ECBM)] and CO_2 sequestration in coal. In this work a triaxial cell was used to measure gas permeability, adsorption, swelling and geomechanical properties of coal cores at a series of pore pressures and for [methane (CH_4)], CO_2, and helium with pore pressures up to 13 MPa and confining pressures up to 20 MPa. Properties for the permeability models such as cleat compressibility, Young's modulus, Poisson's ratio and adsorption-induced swelling are calculated from the experimental measurements. Measurements on an Australian coal are presented. The results show that permeability decreases significantly with confining pressure and pore pressure. The permeability decline with pore pressure is a direct result of adsorption-induced coal swelling. Coal geomechanical properties show some variation with gas pressure and gas species, but there is no direct evidence of coal softening at high CO_2 pressures for the coal sample studied. The experimental results also show that cleat compressibility changes with gas species and pressure. Then the measured properties were applied in the Shi and Durucan model to investigate the permeability behavior during CO_2 sequestration in coal." **Zhejun Pan, Luke D. Connell, and Michael Camilleri**, *International Journal of Coal Geology*, Available online November 10, 2009, doi: 10.1016/j.coal.2009.10.019, http://www.sciencedirect.com/science/article/B6V8C-4XNF6BB-1/2/385b16f78cdaeb9e2c2f27fa5bb2c083. (Subscription may be required.)

"Role and impact of CO_2-rock interactions during CO_2 storage in sedimentary rocks." The following is the Abstract of this article: "Before implementing CO_2 storage on a large scale its viability regarding injectivity, containment and long-term safety for both humans and environment is crucial. Assessing CO_2-rock interactions is an important part of that as these potentially affect physical properties through highly coupled processes. Increased understanding of the physical impact of injected CO_2 during recent years including buoyancy driven two-phase flow and convective mixing elucidated potential CO_2 pathways and indicated where and when CO_2-rock interactions are potentially occurring. Several areas of interactions can be defined: (1) interactions during the injection phase and in the near well environment, (2) long-term reservoir and caprock interactions, (3) CO_2-rock interactions along leakage pathways (well, caprock, and fault), (4) CO_2-rock interactions causing potable [formation] contamination as a consequence of leakage, (5) water-rock interactions caused by [formation] contamination through the CO_2 induced displacement of brines and finally engineered CO_2-rock interactions (6). The driving processes of CO_2-rock interactions are discussed as well as their potential impact in terms of changing physical parameters. This includes dissolution of CO_2 in brines, acid induced reactions, reactions due to brine concentration, clay desiccation, pure CO_2-rock interactions and reactions induced by other gases than CO_2. Based on each interaction environment the main aspects that are possibly affecting the safety and/or feasibility of the CO_2 storage scheme are reviewed and identified. Then the methodologies for assessing CO_2-rock interactions are discussed. High priority research topics include the impact of other gaseous compounds in the CO_2 stream on rock and cement materials, the reactivity of dry CO_2 in the absence of water, how CO_2 induced precipitation reactions affect the pore space evolution and thus the physical properties and the need for the development of coupled flow, geochemical and geomechanical models." **Irina Gaus**, *International Journal of Greenhouse Gas Control*, Available online November 2, 2009, doi: 10.1016/j.ijggc.2009.09.015, http://www.sciencedirect.com/science/article/B83WP-4XKSY3T-1/2/1607d6daddb03048627d59695f95f2e5. (Subscription may be required.)

February 2010

"Buoyant dispersal of CO_2 during geological storage." The following is the Abstract of this article: "[CCS] is currently the only technology that may allow significant reductions in CO_2 emissions from large point sources. Seismic images of geological CO_2 storage show the rise of CO_2 is influenced by horizontal shales. The buoyant CO_2 spreads beneath impermeable barriers until a gap allows its upward migration. The large number and small scale of these barriers makes the prediction of the CO_2 migration path and hence the magnitude of CO_2 trapping very challenging. [The authors] show that steady buoyancy dominated flows in complex geometries can be modeled as a cascade of flux partitioning events. This approach allows the analysis of two-dimensional plume dispersal from a horizontal injection well. [The authors] show that the plume spreads laterally with height y above the source according to $(y/h)^{1/2} L$, where L is the width of the shales and h is their vertical separation. The fluid volume below successive shale layers, and therefore the magnitude of trapped CO_2, increase as $(y/h)^{5/4}$ above the source, so that every additional layer of barriers traps more CO_2 than the one below. Upscaling small-scale flow barriers by reducing the vertical permeability, common in numerical simulations of CO_2 storage, does not capture the dispersion and trapping of the CO_2 plume by the flow barriers." **M.A. Hesse and A.W. Woods**, *Geophysical Research Letters*, Available online January 9, 2010, doi: 10.1029/2009GL041128, http://www.agu.org/pubs/crossref/2010/2009GL041128.shtml. (Subscription may be required.)

"Pore-Scale Investigation of the Matrix−Fracture Interaction During CO_2 Injection in Naturally Fractured Oil Reservoirs." The following is the Abstract of this article: "Sequestration of CO_2 into oil and gas reservoirs gains respect as an economically and environmentally convenient way of reducing emissions of [GHG] and increasing hydrocarbon production at the same time. Because the naturally fractured reservoirs (NFRs) constitute a great portion of current and potential CO_2 injection applications, it is essential to understand the matrix-fracture interaction during such applications to maximize the efficiency of the process, maximizing incremental oil production with maximum CO_2 storage. Visualization of the phase behavior and flow patterns to/from the fracture and from/to the matrix is critical in understating the process and discovering ways to co-optimize the oil production-[GHG] gas storage process. Hence, pore-scale behavior of the CO_2-oil interaction was investigated experimentally using homo- and heterogeneous fractured micromodels. Glass-etched microfluidic models were employed to investigate the pore-scale interaction between the matrix and fracture. Models were prepared by etching homo- and heterogeneous microscale pore patterns with a fracture in the middle of the model on glass sheets bonded together and then saturated with colored n-decane as the oleic phase. CO_2 was injected at miscible and immiscible conditions. The focus of the study was on visual pore-scale analysis of miscibility, breakthrough of CO_2, and oil/CO_2 transfer between the matrix and fracture under different miscibility conditions. More specifically, the CO_2-oil interaction near the fracture region inside the matrix was visualized, and its impacts on the further transport of CO_2 inside the matrix by diffusion, transfer of oil from the matrix to the fracture and its flow in the fracture, and CO_2 storage inside the matrix during these processes were analyzed visually." **Vahapcan Er, Tayfun Babadagli, and Zhenghe Xu**, *Energy Fuels*, Available online December 8, 2009, doi: 10.1021/ef901038v, http://pubs.acs.org/doi/abs/10.1021/ef901038v. (Subscription may be required.)

"Analytical solution for estimating storage efficiency of geologic sequestration of CO_2." The following is the Abstract of this article: "During injection of CO_2 into deep saline aquifers, the available pore volume of the aquifer may be used inefficiently, thereby decreasing the effective capacity of the repository for CO_2 storage. Storage efficiency is the fraction of the available pore space that is utilized for CO_2 storage, or, in other words, it is the ratio between the volume of stored CO_2 and the maximum available pore volume. In this note, [the authors] derive and present simple analytical expressions for estimating CO_2 storage efficiency under the scenario of a constant-rate injection of CO_2 into a confined, homogeneous, isotropic, saline aquifer. The expressions for storage efficiency are derived from models developed previously by other researchers describing the shape of the CO_2-brine interface. The storage efficiency of CO_2 is found to depend on three dimensionless groups, namely: (1) the residual saturation

of brine after displacement by CO_2; (2) the ratio of CO_2 mobility to brine mobility; (3) a dimensionless group (which [the authors] call a 'gravity factor') that quantifies the importance of CO_2 buoyancy relative to CO_2 injection rate. In the particular case of negligible residual brine saturation and negligible buoyancy effects, the storage efficiency is approximately equal to the ratio of the CO_2 viscosity to the brine viscosity. Storage efficiency decreases as the gravity factor increases, because the buoyancy of the CO_2 causes it to occupy a thin layer at the top of the confined formation, while leaving the lower part of the aquifer under-utilized. Estimates of storage efficiency from our simple analytical expressions are in reasonable agreement with values calculated from simulations performed with more complicated multi-phase-flow simulation software. Therefore, [the authors] suggest that the analytical expressions presented herein could be used as a simple and rapid tool to screen the technical or economic feasibility of a proposed CO_2 injection scenario." **Roland T. Okwen, Mark T. Stewart, and Jeffrey A. Cunningham**, *International Journal of Greenhouse Gas Control*, Available online December 8, 2009, doi: 10.1016/j.ijggc.2009.11.002, http://www.sciencedirect.com/science/article/B83WP-4XWD05C-3/2/aafaa64550f6ed0bff1107cd771de75f. (Subscription may be required.)

March 2010

"Potential for [enhanced coalbed methane (ECBM)] and CO_2 storage in mixed gas Australian coals." The following is the Abstract of this article: "Coal seams in Australia often contain large volumes of gas and in many cases mixed gas conditions prevail where coal seam gas (CSG) consists of a mixture of CO_2 and methane (CH_4). While in most coalfields of the world CH_4 is the dominant gas, in Australian coalfields either of the two gases can be the dominant gas. The occurrence of large volumes of CO_2 in Australian coal seams provides valuable insights into the mechanism of long term storage of CO_2 in coal seams. Australia is also a major producer of CSG, otherwise known as coalbed methane (CBM). Some of the CSG fields in Australia are among the most productive fields in the world and some coal seams have been drained for more than a decade. For coal seams where the gas content is approaching the residual content, the remaining gas may be released if the production is stimulated by injecting CO_2. In this paper the results from observations of mixed gas conditions in coal seams and laboratory measurements of gas storage and diffusion properties of coals from Sydney Basin coalfields in Australia are reported. While the gas content data show that CH_4 and CO_2 have similar upper limits, the adsorption data show higher storage capacities for CO_2 than for CH_4. Therefore, the CO_2 undersaturation in coal is more pronounced compared to CH_4 and this seems to be a common aspect of CSG in coal, at least for the coalfields studied. The reasons for CO_2 undersaturation in Australian coals and its effect on potential for CO_2 storage are assessed and discussed in this paper." **A. Saghafi**, *International Journal of Coal Geology*, Available online January 11, 2010, doi:10.1016/j.coal.2010.01.002, http://www.sciencedirect.com/science/article/B6V8C-4Y4R2XP-1/2/78edb31a2f7a7f685a934d5f78675348. (Subscription may be required.)

"A response surface methodology to address uncertainties in cap rock failure assessment for CO_2 geological storage in deep aquifers." The following is the Abstract of this article: "Cap rock failure assessment, either tensile fracturing or shear slip reactivation of pre-existing fault, is a key issue for preventing CO_2 leakage from deep aquifer reservoirs up to the surface. For an appropriate use in risk management, the uncertainties associated with such studies should be investigated. Nevertheless, uncertainty analysis requires multiple simulations and a direct use of conventional numerical approaches might be too computer time consuming. An alternative is to use conventional analytical models, but their assumptions appear to be too conservative. An intermediate approach is then proposed based on the response surface methodology, consisting in estimating the effective stress state after CO_2 injection as a linear combination of the most influential site properties based on a limited number of numerical simulations. The decision maker is provided with three levels of information: (1) the identification of the most important site properties; (2) an analytical model for a quick assessment of the maximal sustainable overpressure; and (3) a simplified model to be used in a computationally intensive uncertainty analysis framework. This generic methodology is illustrated with the Paris Basin case using a large-scale hydromechanical model to assess cap rock failure in the injector zone." **Jeremy Rohmer and Olivier**

Bouc, *International Journal of Greenhouse Gas Control*, Available online January 4, 2010, doi:10.1016/j.ijggc.2009.12.001, http://www.sciencedirect.com/science/article/B83WP-4Y34G8F-1/2/8e4e32307a99810435703d75d1e86f71. (Subscription may be required.)

"Monitoring Phase Behavior of Sub- and Supercritical CO_2 Confined in Porous Fractal Silica with 85 [Percent] Porosity." The following is the Abstract of this article: "Phase behavior of CO_2 confined in porous fractal silica with volume fraction of SiO_2 $\varphi_s = 0.15$ was investigated using small-angle neutron scattering (SANS) and ultrasmall-angle neutron scattering (USANS) techniques. The range of fluid densities ($0 < (\rho_{CO2})_{bulk} < 0.977$ g/cm^3) and temperatures (T = 22°C, 35 and 60°C) corresponded to gaseous, liquid, near critical and supercritical conditions of the bulk fluid. The results revealed formation of a dense adsorbed phase in small pores with sizes $D < 40$ Å at all temperatures. At low pressure ($P <$ 55 bar, $(\rho_{CO2})_{bulk} < 0.2$ g/cm^3) the average fluid density in pores may exceed the density of bulk fluid by a factor up to 6.5 at T = 22°C. This 'enrichment factor' gradually decreases with temperature, however significant fluid densification in small pores still exists at temperature T = 60°C, i.e., far above the liquid−gas critical temperature of bulk CO_2 (T_C = 31.1°C). Larger pores are only partially filled with liquid-like adsorbed layer which coexists with unadsorbed fluid in the pore core. With increasing pressure, all pores become uniformly filled with the fluid, showing no measurable enrichment or depletion of the porous matrix with CO_2." **Yuri B. Melnichenko, H. Mayama, G. Cheng, and T. Blach**, *Langmuir,* Available online December 31, 2009, doi:10.1021/la904032p, http://pubs.acs.org/doi/abs/10.1021/la904032p. (Subscription may be required.)

April 2010

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

"Mineral sequestration of [CO_2] in basalt: A pre-injection overview of the CarbFix project." The following is the Abstract of this article: "In this paper [the authors] describe the thermodynamic and kinetic basis for mineral storage of [CO_2] in basaltic rock, and how this storage can be optimized. Mineral storage is facilitated by the dissolution of CO_2 into the aqueous phase. The amount of water required for this dissolution decreases with decreased temperature, decreased salinity, and increased pressure. Experimental and field evidence suggest that the factor limiting the rate of mineral fixation of carbon in silicate rocks is the release rate of divalent cations from silicate minerals and glasses. Ultramafic rocks and basalts, in glassy state, are the most promising rock types for the mineral sequestration of CO_2 because of their relatively fast dissolution rate, high concentration of divalent cations, and abundance at the Earth's surface. Admixture of flue gases, such as [sulfur dioxide (SO_2)] and [hydrogen fluoride (HF)], will enhance the dissolution rates of silicate minerals and glasses. Elevated temperature increases dissolution rates but porosity of reactive rock formations decreases rapidly with increasing temperature. Reduced conditions enhance mineral carbonation as reduced iron can precipitate in carbonate minerals.

Elevated CO_2 partial pressure increases the relative amount of carbonate minerals over other secondary minerals formed. The feasibility to fix CO_2 by carbonation in basaltic rocks will be tested in the CarbFix project by: (1) injection of CO_2 charged waters into basaltic rocks in SW Iceland, (2) laboratory experiments, (3) studies of natural analogues, and (4) geochemical modeling." **Sigurdur Reynir Gislason, Domenik Wolff-Boenisch, Andri Stefansson, Eric H. Oelkers, Einar Gunnlaugsson, Hólmfridur Sigurdardottir, Bergur Sigfusson, Wallace S. Broecker, Juerg M. Matter, Martin Stute, Gudni Axelsson, and Thrainn Fridriksson**, *International Journal of Greenhouse Gas Control*, Available online January 22, 2010, doi:10.1016/j.ijggc.2009.11.013, http://www.sciencedirect.com/science/article/B83WP-4Y71D6B-1/2/8713f44d0f0028ad7701093d5eede306. (Subscription may be required.)

May 2010

"**Swelling of Coals by Supercritical Gases and Its Relationship to Sorption."** The following is the Abstract of this article: "If CO_2 can be sequestered in coal seams while simultaneously displacing coalbed methane (enhanced coalbed methane [ECBM]), some of the sequestration costs can be recovered through the production of CH_4. One potential difficulty with ECBM is that CO_2 is known to swell coal, which may reduce its permeability. Coals also swell in other gases, although not to the same extent. Here, [the authors] report on the swelling of subbituminous and bituminous coals in CO_2, CH_4, nitrogen (N_2), tetrafluoromethane (CF_4), ethane, and various noble gases. Helium and neon (Ne) induced negligible swelling; all other gases swelled the coals to varying degrees. The maximum swelling was proportional to the critical temperature of the gas, except for CF_4, which is attributed to its greater size, preventing it from penetrating the coal as completely as the other gases. This indicates that swelling of these coals by all of these gases has a similar basic mechanism; CO_2 is only different in the extent to which it swells coal. All coals swelled more in the direction perpendicular to the bedding plane than parallel to it, with the ratio of the swelling in each direction independent of pressure or gas type. Gas sorption and swelling in coal were found to be related according to a simple quadratic polynomial expression. The same relationship held for all of the coals and all gases investigated here. This means that swelling can be accurately predicted from the condensed volume of the gas adsorbed, regardless of the type of coal or gas." **Stuart Day, Robyn Fry, Richard Sakurovs, and Steve Weir**, *Energy & Fuels*, Available online March 16, 2010, doi:10.1021/ef901588h, http://pubs.acs.org/doi/abs/10.1021/ef901588h. (Subscription may be required.)

"Geologic assessment and injection design for a pilot CO_2-enhanced oil recovery and sequestration demonstration in a heterogeneous oil reservoir: Citronelle Field, Alabama, USA." The following is the Abstract of this article: "CO_2 pilot injection studies, with site-specific geologic assessment and engineering reservoir design, can be instrumental for demonstrating both incremental [EOR] and permanent geologic storage of GHGs. The purpose of this paper is to present the geologic and reservoir analyses in support of a field pilot test that will evaluate the technical and economic feasibility of commercial-scale CO_2-[EOR] to increase oil recovery and extend the productive life of the Citronelle Oil Field, the largest conventional oil field in Alabama (SE USA). Screening of reservoir depth, oil gravity, reservoir pressure, reservoir temperature, and oil composition indicates that the Cretaceous-age Donovan sand, which has produced more than 169×106 bbl in Citronelle Oil Field, is amenable to miscible CO_2 flooding. The project team has selected an 81 ha (200 ac) [five]-spot test site with one central gas injector, two producers, and two initially temporarily abandoned production wells that are now in production. Injection is planned in two separate phases, each consisting of 6,804 t (7,500 short tons) of food-grade CO_2. The Citronelle Unit B-19-10 #2 well (Permit No. 3232) is the CO_2 injector for the first injection test. The 14-1 and 16-2 sands of the upper Donovan are the target zones. These sandstone units consist of fine to medium-grained sandstone that is enveloped by variegated mudstone. Both of these sandstone units were selected based on the distribution of perforated zones in the test pattern, production history, and the ability to correlate individual sandstone units in geophysical well logs. The pilot injections will evaluate the applicability of tertiary oil recovery to Citronelle Field and will provide a

large volume of information on the pressure response of the reservoirs, the mobility of fluids, time to breakthrough, and CO_2 sweep efficiency. The results of the pilot injections will aid in the formulation of commercial-scale reservoir management strategies that can be applied to Citronelle Field and other geologically heterogeneous oil fields and the design of similar pilot injection projects."
Richard A. Esposito, Jack C. Pashin, Denise J. Hills, and Peter M. Walsh, *Environmental Earth Sciences*, Available online March 10, 2010, doi:10.1007/s12665-010-0495-5, http://www.springerlink.com/content/726183q6h7341351/?p=893829d7de6548a2a7848d48fe10121b&pi=5. (Subscription may be required.)

"Navajo Sandstone-brine-CO_2 interaction: implications for geological carbon sequestration." The following is the Abstract of this article: "The injection of CO_2 into deep saline [formations] is being considered as an option for GHG mitigation. However, the response of [a formation] to the injected CO_2 is largely unknown. Experiments involving the reaction of Navajo Sandstone with acidic brine were conducted at 200°C and 25 or 30 MPa to evaluate the extent of fluid-rock interactions. The first experiment examined sandstone interaction with CO_2-impregnated brine; the second experiment examined sandstone dissolution in CO_2-free acidic brine; the third one is carried out in a mixed-flow reactor and designed to measure sandstone dissolution rates based on time-series [silicon (Si)] concentrations. The solution chemistry data indicate that the [silicon dioxide (SiO_2)(aq)] increases gradually and pH increases slowly with reaction progress. Silicate minerals in the sandstone display textures (dissolution features, secondary mineralization), indicating that these phases are reacting strongly with the fluid. Dissolution of feldspars and conversion of smectite to illite are likely to be the two reactions that contribute to the release of SiO_2(aq). The product minerals present at the end of the experiments are illite, illite/smectite, allophane, and carbonate minerals (for the CO_2-charged system). Dissolved CO_2 is likely to acidify the brine and to provide a source of carbon for the precipitation of carbonate minerals. Mineral trapping through the precipitation of carbonate minerals is favored thermodynamically and was observed in the experiments. The chemical reactions likely increase the bulk porosity of the sandstone due to dissolution of silicate minerals. However, allophane and illite/smectite fill voids in sandstone grains. There is no evidence for the removal of clay coatings due to chemical reactions. It is uncertain whether the mechanical forces near an injection well would mobilize the smectite and allophane and clog pore throats. Trace amounts of metals, including [copper (Cu), zinc (Zn), and barium (Ba)], were mobilized." **Peng Lu, Qi Fu, William E. Seyfried Jr, Anne Hereford, and Chen Zhu**, *Environmental Earth Sciences*, Available online March 2, 2010, doi:10.1007/s12665-010-0501-y, http://www.springerlink.com/content/4716615w9361k231/?p=893829d7de6548a2a7848d48fe10121b&pi=9. (Subscription may be required.)

June 2010

"Geochemical Impacts to Groundwater from Geologic Carbon Sequestration: Controls on pH and Inorganic Carbon Concentrations from Reaction Path and Kinetic Modeling." The following is the Abstract of this article: "Geologic carbon sequestration has the potential to cause long-term reductions in global emissions of [CO_2] to the atmosphere. Safe and effective application of carbon sequestration technology requires an understanding of the potential risks to the quality of underground sources of drinking water. In particular, concern is warranted regarding the potential for CO_2 leakage through geological features and abandoned wells that may result in detrimental perturbations to subsurface geochemistry. Reaction path and kinetic models indicate that geochemical shifts caused by CO_2 leakage are closely linked to mineralogical properties of the receiving aquifer. [Carbon dioxide] gas dissolution into groundwater and subsequent reaction with aquifer minerals will control the evolution of pH−bicarbonate envelopes. These parameters provide geochemical context for predicting how regulated contaminants associated with aquifer solids will respond via various mineral−water reaction processes. The distribution and abundance of carbonate, silicate, oxide, and phyllosilicate minerals are identified as key variables in controlling changes in groundwater geochemistry. Site-specific risk assessments may require characterization of aquifer geology, mineralogy, and groundwater chemistry prior to CO_2

injection. Model results also provide a frame of reference for developing indicative [monitoring, verification, and accounting (MVA)] protocols for groundwater protection." **Richard T. Wilkin and Dominic C. DiGiulio**, *Environ. Sci. Technol.*, Available online May 14, 2010, doi:10.1021/es100559j**,** http://pubs.acs.org/doi/abs/10.1021/es100559j. (Subscription required.)

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

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

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

July 2010

"Microbially Enhanced Carbon Capture and Storage by Mineral-Trapping and Solubility-Trapping." The following is the Abstract of this article: "The potential of microorganisms for enhancing CCS via mineral-trapping (where dissolved CO_2 is precipitated in carbonate minerals) and solubility trapping (as dissolved carbonate species in solution) was investigated. The bacterial hydrolysis of urea (ureolysis) was investigated in microcosms including synthetic brine (SB) mimicking a prospective deep subsurface CCS site with variable headspace pressures [$p(CO_2)$] of $^{13}C{-}CO_2$. Dissolved Ca^{2+} in the SB was completely precipitated as calcite during microbially induced hydrolysis of 5−20 g L^{-1} urea. The incorporation of carbonate ions from $^{13}C{-}CO_2$ ($^{13}C{-}CO_3^{2-}$) into calcite increased with increasing $p(^{13}CO_2)$ and increasing urea concentrations: from 8.3 [percent] of total carbon in $CaCO_3$ at 1 g L^{-1} to 31 [percent] at 5 g L^{-1}, and 37 [percent] at 20 g L^{-1}. This demonstrated that ureolysis was effective at precipitating initially gaseous [CO_2(g)] originating from the headspace over the brine. Modeling the change in brine chemistry and carbonate precipitation after equilibration with the initial $p(CO_2)$ demonstrated that no net precipitation of CO_2(g) via mineral-trapping occurred, since urea hydrolysis results in the production of dissolved inorganic carbon. However, the pH increase induced by bacterial ureolysis generated a net flux of CO_2(g) into the brine. This reduced the headspace concentration of CO_2 by up to 32 mM per 100 mM urea hydrolyzed because the capacity of the brine for carbonate ions was increased, thus enhancing the solubility-trapping capacity of the brine. Together with the previously demonstrated permeability reduction of rock cores at high pressure by microbial biofilms and resilience of biofilms to supercritical CO_2, this suggests that engineered biomineralizing biofilms may enhance CCS via solubility-trapping, mineral formation, and CO_2(g) leakage reduction." **Andrew C. Mitchell, Knud Dideriksen, Lee H. Spangler, Alfred B. Cunningham, and Robin Gerlach**, *Environ. Sci. Technol.*, Available online June 14, 2010, doi:10.1021/es903270w, http://pubs.acs.org/doi/abs/10.1021/es903270w. (Subscription may be required.)

"Investigation of the pH effect of a typical host rock and buffer solution on CO_2 sequestration in synthetic brines." The following is the Abstract of this article: "Carbon dioxide [storage] in deep saline aquifers is a critical component of long-term storage options. It is suggested that the precipitation of mineral carbonates is mostly dependent on brine pH and is favored above a basic pH of 9.0. However, brine pH will drop to acidic values once CO_2 is injected into the brine. Therefore, there is a need to raise brine pH and maintain it stable. Synthetic brines were used here instead of natural brines because of the difficulty in obtaining and storing natural brines. Therefore, experiments were conducted to prepare a series of synthetic brines and to compare their suitability to natural brines for carbon [storage] firstly. A typical host rock (Oriskany rock) and a buffer solution [sodium chloride/sodium bicarbonate ($NaCl/NaHCO_3$)] were selected to buffer brine pH. In a subsequent step, studies were conducted to

correlate how brine samples respond in the presence of the host rock or the buffer solution at realistic reservoir temperatures (40 and 100°C) and pressures (1160 and 1500 psi) for CO_2 storage. The results show that synthetic brines prepared can be used as analogues as natural brines for carbon [storage] studies in terms of chemical composition and pH response. Both XRD and SEM/EDS analyses confirmed the presence of mineral carbonates in the CO_2–rock–brine and the CO_2–buffer–brine experiments. However, the amount of carbonates precipitated from the CO_2–buffer–brine reactions is nearly 18 times larger than that formed from the CO_2–rock–brine experiments. ICP-MS studies also verified that there was only [four percent] reduction in Ca concentration in solution after the CO_2–rock–brine studies, while the concentrations of Ca and Sr decreased by 90 [percent] during the CO_2–buffer–brine experiments." **Qi Liu and M. Mercedes Maroto-Valer**, *Fuel Processing Technology*, Available online June 2, 2010, doi:10.1016/j.fuproc.2010.05.002, http://www.sciencedirect.com/science/article/B6TG3-506YWYT-2/2/9f3abe38e2e391c26ead74960df1cb69. (Subscription may be required.)

"A simple model for the prediction of CO_2 solubility in H_2O–NaCl system at geological sequestration conditions." The following is the Abstract of this article: "Carbon dioxide released in the atmosphere is the principal cause of the so-called global warming or greenhouse phenomenon. One procedure for the mitigation of CO_2 consists of the capture, transport and geological storage of the gas in deep saline aquifers. In this work, a model for predicting CO_2 solubility in H_2O–NaCl system covering conditions typically encountered in geological [storage] (e.g., 300–500 K, 50–2000 bar, and 1–4 mol salt/kg) has been developed and validated by comparison with available experimental and theoretical data. The model is a simple one with four adjustable parameters that is based on an extension of the well-known Setschenov model [$K_{gs} / K_{g0} = (P / P_0)^{f(T_r,m)}$ with $f(T_r,m) = (0.461 + 0.078\ m)(-1 + T_r / (1.0 + 0.1267\ m)]$. The model is developed by exploiting interesting features in the behavior of solubility data of CO_2 in saline water over the above-mentioned ranges of conditions. The model is capable of predicting CO_2 solubility in saline water with accuracy comparable to that made by multi-parameter models (having 20 parameters or more). It is also in very good agreement with the available experimental data with root-mean-squared-error (RMSE) in the range of 0.03–0.225 mol CO_2/kg H_2O. The extrapolative power of the model is acceptable at both ends of its range of applicability." **N.A. Darwish and N. Hilal**, *Desalination*, Available online May 31, 2010, doi:10.1016/j.desal.2010.04.056, http://www.sciencedirect.com/science/article/B6TFX-506H0N0-3/2/2ae05bf39e34bdf63cc97b359e7cc753. (Subscription may be required.)

August 2010

"Coupled hydromechanical modeling of CO_2 sequestration in deep saline aquifers." The following is from the Abstract of this article: "Sequestration of CO_2 in deep saline aquifers has emerged as an option for reducing [GHG] emissions to the atmosphere. The large amounts of supercritical CO_2 that need to be injected into deep saline aquifers may cause large fluid pressure increases. The resulting overpressure may promote reactivation of sealed fractures or the creation of new ones in the caprock seal. This could lead to escape routes for CO_2. In order to assess the probability of such an event, [the authors] model an axisymmetric horizontal aquifer–caprock system, including hydromechanical coupling. [The authors] study the failure mechanisms, using a viscoplastic approach. Simulations illustrate that, depending on boundary conditions, the least favorable moment takes place at the beginning of injection. Initially, fluid pressure rises sharply because of a reduction in permeability due to desaturation. Once CO_2 fills the pores in the vicinity of the injection well and a capillary fringe is fully developed, the less viscous CO_2 displaces the brine and the capillary fringe laterally. The overpressure caused by the permeability reduction within the capillary fringe due to desaturation decreases with distance from the injection well. This results in a drop in fluid pressure buildup with time, which leads to a safer situation. Nevertheless, in the presence of low-permeability boundaries, fluid pressure continues to rise in the whole aquifer. This occurs when the radius of influence of the injection reaches the outer boundary. Thus, caprock integrity might be compromised in the long term." **Victor Vilarrasa, Diogo Bolster, Sebastia Olivella, and Jesus Carrera**, *International Journal of Greenhouse Gas Control*, Available

online July 10, 2010, doi:10.1016/j.ijggc.2010.06.006, http://www.sciencedirect.com/science/article/B83WP-50H1HPS-1/2/2b2913fa2d68f61e5fab81ff1e57361d. (Subscription may be required.)

"Sensitivities of injection rates for single well CO_2 injection into saline aquifers." The following is from the Abstract of this article: "This paper investigates methods to predict potential injection rates of CO_2 into a saline aquifer and analyses the sensitivities of the input parameters. Geological parameters are based on conditions at the European CO_2 Onshore Research Storage and Verification Project in Ketzin, Germany, and varied within an acceptable range. Two injection regimes for CO_2 are [analyzed]: pressure controlled injection and power plant controlled injection, where the CO_2 flux depends on the load curve of a 600 MW_{net} lignite power plant. The results are determined with a numerical model and compared to an analytical solution with constant pressure injection. The injection rates depend mainly on the geological setting and only slightly on technical parameters. Aquifer permeability and thickness show approximately linear sensitivity and have a dominant impact. Depth is also of high importance, but the impact is more complex and is based on geothermal temperature and hydrostatic gradient, which affect viscosity, compressibility and caprock stability. Vertical anisotropy is insensitive. The difference in the mean rate between constant pressure injection and power plant controlled injection is [eight percent]. Peak injection rates are 29 [percent] above mean injection rates, which shows that the reservoir can effectively dampen rate variations. The analytical solution predicts the highest injection rates, the lowest temporal variability and decreasing rates with injection duration. The numerical solution predicts a stronger temporal variability and the rates increase with duration. In the initial phase the differences between the methods add up to a factor of 1.45." **Bernd Wiese, Michael Nimtz, Matthias Klatt, and Michael Kühn**, *Chemie der Erde – Geochemistry*, Available online July 1, 2010, doi:10.1016/j.chemer.2010.05.009, http://www.sciencedirect.com/science/article/B7CW6-50F4622-1/2/a00b8fca747203e03e0d53f5bc58d739. (Subscription may be required.)

"Dissolution and Precipitation of Clay Minerals under Geologic CO_2 Sequestration Conditions: CO_2−Brine−Phlogopite Interactions." The following is from the Abstract of this Article: "To ensure efficiency and sustainability of geologic CO_2 sequestration (GCS), a better understanding of the geochemical reactions at CO_2-water-rock interfaces is needed. In this work, both fluid/solid chemistry analysis and interfacial topographic studies were conducted to investigate the dissolution/precipitation on phlogopite ($KMg_3Si_3AlO_{10}(F,OH)_2$) surfaces under GCS conditions (368 K, 102 atm) in 1 M [sodium chloride (NaCl)]. Phlogopite served as a model for clay minerals in potential GCS sites. During the reaction, dissolution of phlogopite was the predominant process. Although the bulk solution was not supersaturated with respect to potential secondary mineral phases, interestingly, nanoscale precipitates formed. Atomic force microcopy (AFM) was utilized to record the evolution of the size, shape, and location of the nanoparticles. Nanoparticles first appeared on the edges of dissolution pits and then relocated to other areas as particles aggregated. Amorphous silica and kaolinite were identified as the secondary mineral phases, and qualitative and quantitative analysis of morphological changes due to phlogopite dissolution and secondary mineral precipitation are presented. The results provide new information on the evolution of morphological changes at CO_2-water-clay mineral interfaces and offer implications for understanding alterations in porosity, permeability, and wettability of pre-existing rocks in GCS sites." **Hongbo Shao, Jessica R. Ray, and Young-Shin Jun**, *Environ. Sci. Technol.*, Available online June 29, 2010, doi:10.1021/es1010169, http://pubs.acs.org/doi/abs/10.1021/es1010169. (Subscription required.)

Technology

September 2009

"A Phase-Partitioning Model for CO_2-Brine Mixtures at Elevated Temperatures and Pressures: Application to CO_2-Enhanced Geothermal Systems" The following is the Abstract of this article:

“Correlations are presented to compute the mutual solubilities of CO_2 and chloride brines at temperatures 12-300Â°C, pressures 1-600 bar (0.1-60 MPa), and salinities 0-6 m [sodium chloride (NaCl)]. The formulation is computationally efficient and primarily intended for numerical simulations of CO_2-water flow in carbon sequestration and geothermal studies. The phase-partitioning model relies on experimental data from literature for phase partitioning between CO_2 and NaCl brines, and extends the previously published correlations to higher temperatures. The model relies on activity coefficients for the [water (H_2O)]-rich (aqueous) phase and fugacity coefficients for the CO_2-rich phase. Activity coefficients are treated using a Margules expression for CO_2 in pure water, and a Pitzer expression for salting-out effects. Fugacity coefficients are computed using a modified Redlich-Kwong equation of state and mixing rules that incorporate asymmetric binary interaction parameters. Parameters for the calculation of activity and fugacity coefficients were fitted to published solubility data over the P-T range of interest. In doing so, mutual solubilities and gas-phase volumetric data are typically reproduced within the scatter of the available data. An example of multiphase flow simulation implementing the mutual solubility model is presented for the case of a hypothetical, enhanced geothermal system where CO_2 is used as the heat extraction fluid. In this simulation, dry supercritical CO_2 at 20Â°C is injected into a 200Â°C hot-water reservoir. Results show that the injected CO_2 displaces the formation water relatively quickly, but that the produced CO_2 contains significant water for long periods of time. The amount of water in the CO_2 could have implications for reactivity with reservoir rocks and engineered materials.” **Nicolas Spycher and Karsten Pruess**, *Transport in Porous Media*, Available online July 17, 2009, doi: 10.1007/s11242-009-9425-y, http://www.springerlink.com/content/t1h0744x531x4105/?p=f92985ffed6f4ef3abfe1f855b86ff7c&pi=15. (Subscription may be required.)

“CO_2 capture and sequestration source-sink match optimization in Jing-Jin-Ji region of China.” The following is the Abstract of this article: “CCS is considered to be an important option for climate change mitigation. A key problem for the implementation of CCS technology is the source-sink match design and optimization when considering both economic and environmental requirement. This paper presents a generic-optimization-based model for the strategic planning and design of future CCS source-sink matching. The features and capabilities of the model are illustrated through a detailed case study for the Jing-Jin-Ji (Beijing, Tianjin, and Hebei Province) region in China. It shows how the model helps make a compromise in arriving at a strategic decision for CCS source-sink matching by providing the tradeoff frontiers between economic and environmental performance, and the features of match solutions with the best economic performance or with the best environmental performance.” **Zhong Zheng, Dan Gao, Linwei Ma, Zheng Li, and Weidou Ni**, *Frontiers of Energy and Power Engineering in China*, Available online July 21, 2009, doi: 10.1007/s11708-009-0053-6, http://www.springerlink.com/content/m677h0p704722132/?p=97d3dd493d0f4afc88a0d87441ba7f26&pi=9. (Subscription may be required.)

October 2009

“Near-surface monitoring for the ZERT shallow CO_2 injection project.” The following is the Abstract of this article: “As part of a collaborative effort operated by the Zero Emission Research and Technology Center (ZERT), a series of two shallow releases of CO_2 was performed at a test site in Bozeman, MT. The purpose of the experiment was to simulate possible leakage scenarios from a [CCS] operation in order to further develop and verify monitoring technologies used to characterize and quantify the release of CO_2. The project included collaboration with several research groups and organizations. Presented here are the results of soil-gas monitoring conducted by researchers from [NETL], including CO_2 flux measurement, soil-gas analysis, perfluorocarbon tracer monitoring, and soil resistivity measurements. Together, these methods proved to be effective in detecting and characterizing leakage in the near-surface.” **Brian R. Strazisar, Arthur W. Wells, J. Rodney Diehl, Richard W. Hammack, and Garret A. Veloski**, *International Journal of Greenhouse Gas Control*, Available online September 10, 2009, doi:10.1016/j.ijggc.2009.07.005, http://www.sciencedirect.com/science/article/B83WP-4X6DBSP-1/2/81951c72053928267b24d24b6cf545c4. (Subscription may be required.)

"The influence of membrane CO_2 separation on the efficiency of a coal-fired power plant." The following is the Abstract of this article: "In this paper, the influence of membrane separation of CO_2 from flue gases and the impacts of the whole CCS process (CO_2 separation and compression) on the performance of a coal-fired power plant are studied. First, the effects of the characteristics of the membrane (selectivity and permeability) and the parameters of the process (feed and permeate pressure) on two indices, CO_2 recovery rate and CO_2 purity are analyzed. Next, a method for determining the minimum power loss and efficiency loss of the power plant as a function of these calculated indices is described. Then, the power requirements and efficiency loss (up to 15.4 percentage points) because of the CCS installation are calculated. A method for reducing these losses through the integration of the CCS installation with the power plant is also proposed. The main aims of the integration are heat exchange between media and a decrease in the CO_2 temperature before compression. Implementing this process can result in a significant reduction of the efficiency loss by [eight] percentage points." **Janusz Kotowicz, Tadeusz Chmielniak, and Katarzyna Janusz-Szymańska**, *Energy*, Available online September 2, 2009, doi: 10.1016/j.energy.2009.08.008, http://www.sciencedirect.com/science/article/B6V2S-4X4RCH0-2/2/e5e1acc1f5ba738477c4a6bce23da781. (Subscription may be required.)

November 2009

"Feasibility of storing CO_2 in the Utsira formation as part of a long term Dutch CCS strategy: An evaluation based on a GIS/MARKAL toolbox." The following is the Abstract of this article: "This study provides insight into the feasibility of a CO_2 trunk line from the Netherlands to the Utsira formation in the Norwegian part of the North Sea, which is a large geological storage reservoir for CO_2. The feasibility is investigated in competition with CO_2 storage in onshore and near-offshore sinks in the Netherlands. Least-cost modeling with a MARKAL model in combination with ArcGIS was used to assess the cost-effectiveness of the trunk line as part of a Dutch GHG emission reduction strategy for the Dutch electricity sector and CO_2 intensive industry. The results show that under the condition that a CO_2 permit price increases from \$37 per tCO_2 in 2010 to \$89 per tCO_2 in 2030, and remains at this level up to 2050, CO_2 emissions in the Netherlands could reduce with 67 [percent] in 2050 compared to 1990, and investment in the Utsira trunk line may be cost-effective from 2020–2030 provided that Belgian and German CO_2 is transported and stored via the Netherlands as well. In this case, by 2050 more than 2.1 $GtCO_2$ would have been transported from the Netherlands to the Utsira formation. However, if the Utsira trunk line is not used for transportation of CO_2 from Belgium and Germany, it may become cost-effective 10 years later, and less than 1.3 $GtCO_2$ from the Netherlands would have been stored in the Utsira formation by 2050. On the short term, CO_2 storage in Dutch fields appears more cost-effective than in the Utsira formation, but as yet there are major uncertainties related to the timing and effective exploitation of the Dutch offshore storage opportunities." **Machteld van den Broek, Andrea Ramírez, Heleen Groenenberg, Filip Neele, Peter Viebahn, Wim Turkenburg, and André Faaij**, *International Journal of Greenhouse Gas Control*, Available online September 26, 2009, doi:10.1016/j.ijggc.2009.09.002, http://www.sciencedirect.com/science/article/B83WP-4X9V345-1/2/13e67d72f667b7fc5f082159e897a470. (Subscription may be required.)

"CCS scenarios optimization by spatial multi-criteria analysis: Application to multiple source sink matching in Hebei province." The following is the Abstract of this article: "A method, based on spatial analysis of the different criteria to be taken into consideration for building scenarios of CCS, has been developed and applied to real case studies in the Hebei province. Totally 88 point sources (42 from power sector, [nine] from iron and steel, 18 from cement, 16 from ammonia, and [three] from oil refinery) are estimated and their total emission amounts to 231.7 $MtCO_2$/year with power, iron and steel, cement, ammonia and oil refinery sharing 59.13 [percent], 25.03 [percent], 11.44 [percent], 3.5 [percent], and 0.91 [percent], respectively. Storage opportunities can be found in Hebei province, characterized by a strong tectonic subsidence during the Tertiary, with several kilometers of accumulated clastic sediments. Carbon storage potential for 25 hydrocarbon fields selected from the Huabei complex is estimated as

215 $MtCO_2$ with optimistic assumption that all recovered hydrocarbon could be replaced by an equivalent volume of CO_2 at reservoir conditions. Storage potential for aquifers in the Miocene Guantao formation is estimated as 747 $MtCO_2$ if closed aquifer assumed or 371 $MtCO_2$ if open aquifer and single highly permeable horizon assumed. Due to poor knowledge on deep hydrogeology and to pressure increase in aquifer, injecting very high rates requested by the major CO_2 sources (>10 $MtCO_2$/year) is the main challenge, therefore piezometry and discharge must be carefully controlled. A source sink matching model using ArcGIS software is designed to find the least-cost pathway and to estimate transport route and cost accounting for the additional costs of pipeline construction due to landform and land use. Source-sink matching results show that only 15–25 [percent] of the emissions estimated for the 88 sources can be sequestrated into the hydrocarbon fields and the aquifers if assuming sinks should be able to accommodate at least 15 years of the emissions of a given source." **Wenying Chen, Yves-Michel Le Nindre, Ruina Xu, Delphine Allier, Fei Teng, Kim Domptail, Xing Xiang, Laura Guillon, Jiyong Chen, Lingyan Huang, and Rongshu Zeng**, *International Journal of Greenhouse Gas Control*, Available online September 25, 2009, doi:10.1016/j.ijggc.2009.09.001, http://www.sciencedirect.com/science/article/B83WP-4X9NCKW-1/2/31a6884596948594c5f4d805cf52507f. (Subscription may be required.)

"The potential for increased atmospheric CO_2 emissions and accelerated consumption of deep geologic CO_2 storage resources resulting from the large-scale deployment of a CCS-enabled unconventional fossil fuels industry in the U.S." The following is the Abstract of this article: "Desires to enhance the energy security of the United States have spurred renewed interest in the development of abundant domestic heavy hydrocarbon resources including oil shale and coal to produce unconventional liquid fuels to supplement conventional oil supplies. However, the production processes for these unconventional fossil fuels create large quantities of CO_2 and this remains one of the key arguments against such development. Carbon dioxide capture and CCS technologies could reduce these emissions and preliminary analysis of regional CO_2 storage capacity in locations where such facilities might be sited within the U.S. indicates that there appears to be sufficient storage capacity, primarily in deep saline formations, to accommodate the CO_2 from these industries. Nevertheless, even assuming wide-scale availability of cost-effective CO_2 capture and geologic storage resources, the emergence of a domestic U.S. oil shale or coal-to-liquids (CTL) industry would be responsible for significant increases in CO_2 emissions to the atmosphere. The authors present modeling results of two future hypothetical climate policy scenarios that indicate that the oil shale production facilities required to produce 3 MMB/d from the Eocene Green River Formation of the western U.S. using an in situ retorting process would result in net emissions to the atmosphere of between 3000 and 7000 $MtCO_2$, in addition to storing potentially 900–5000 $MtCO_2$ in regional deep geologic formations via CCS in the period up to 2050. A similarly sized, but geographically more dispersed domestic CTL industry could result in 4000–5000 $MtCO_2$ emitted to the atmosphere in addition to potentially 21,000–22,000 $MtCO_2$ stored in regional deep geologic formations over the same period. While this analysis shows that there is likely adequate CO_2 storage capacity in the regions where these technologies are likely to deploy, the reliance by these industries on large-scale CCS could result in an accelerated rate of utilization of the nation's CO_2 storage resource, leaving less high-quality storage capacity for other carbon-producing industries including electric power generation." **James J. Dooley, Robert T. Dahowski, and Casie L. Davidson**, *International Journal of Greenhouse Gas Control*, Available online September 21, 2009, doi:10.1016/j.ijggc.2009.08.004, http://www.sciencedirect.com/science/article/B83WP-4X8V5CK-1/2/aa08e5cd96d550fcb1a15ef586837173. (Subscription may be required.)

December 2009

"Making carbon dioxide sequestration feasible: Toward federal regulation on CO_2 sequestration pipelines." The following is the Abstract of this article: "As the United States moves closer to a national climate change policy, it will have to focus on a variety of factors affecting the manner in which the country moves toward a future with a substantially lower carbon footprint. In addition to encouraging renewable energy, smart grid, clean fuels and other technologies, the United States will need to make

substantial infrastructure investments in a variety of industries. Among the significant contributors to the current carbon footprint in the United States is the use of coal as a major fuel for the generation of electricity. One of the most important technologies that the United States can employ to reduce its carbon footprint is to sequester the CO_2 from coal-fired power plants. This article focuses on the legal and policy issues surrounding a critical piece of the necessary sequestration infrastructure: CO_2 pipelines that will carry CO_2 from where it is removed from fuel or waste gas streams to where it will be sequestered. Ultimately, this article recommends developing a federally regulated CO_2 pipeline program to foster the implementation of carbon sequestration technology." **Joel Mack and Buck Endemann**, *Energy Policy*, Available online October 28, 2009, doi: 10.1016/j.enpol.2009.10.018, http://www.sciencedirect.com/science/article/B6V2W-4XJN4X4-4/2/b23168f0c51c94939fdbdc34b1f5fe79. (Subscription may be required.)

"CO_2 sequestration from coal fired power plants." The following is the Abstract of this article: "The paper takes into consideration a new approach for CO_2 capture and transport, based on the formation of solid CO_2 hydrates. Carbon dioxide sequestration from power plants can take advantage of the properties of gas hydrates. The formation and decomposition of hydrates from various N_2-CO_2 mixtures has been studied experimentally in a 2 l reactor, to determine the CO_2 separation in terms of hydrate composition and residual CO_2 content in the reacted gas. Carbon dioxide acts as a co-former for the production of hydrates containing nitrogen, besides CO_2. The mixed hydrates that are obtained are less stable than simple CO_2 hydrates. When CO_2 content in the flue gas is higher than 30 [percent] by volume, the hydrates formed at 5 MPa are sufficiently concentrated (about 70 [percent] CO_2) and [CO_2] reduction in the reacted gas is acceptable. The application of a process based on hydrate formation could be especially interesting (for CO_2 capture and transport) when connected to an oxy-coal combustion process; in this case the CO_2 content in the flue gas is very high and the hydrate formation is greatly facilitated." **Carlo Giavarini, Filippo Maccioni, and Maria Laura Santarelli**, *Fuel*, Available online October 14, 2009, doi: 10.1016/j.fuel.2009.09.035, http://www.sciencedirect.com/science/article/B6V3B-4XFN8DC-3/2/b1a8fb38a632d453b57432adaa457790. (Subscription may be required.)

January 2010

"Quantitative risk assessment of CO_2 transport by pipelines – a review of uncertainties and their impacts." The following is the Abstract of this article: "A systematic assessment, based on an extensive literature review, of the impact of gaps and uncertainties on the results of quantitative risk assessments (QRA) for CO_2 pipelines is presented. Sources of uncertainties that have been assessed are: failure rates, pipeline pressure, -temperature, -section length, -diameter, orifice size, type and direction of release, meteorological conditions, jet diameter, vapour mass fraction in the release and the dose-effect relationship for CO_2. A sensitivity analysis with these parameters is performed using release, dispersion and impact models. The results show that the knowledge gaps and uncertainties have a large effect on the accuracy of the assessed risks of CO_2 pipelines. In this study it is found that the individual risk contour can vary from [zero] to 124 m from the pipeline depending on assumptions made. In existing studies this range is found to be between <1 m and 7.2 km. Mitigating the relevant risks is part of current practice, making them controllable. It is concluded that QRA for CO_2 pipelines can be improved by validation of release and dispersion models for high pressure CO_2 releases, definition and adoption of a universal dose-effect relationship and development of a good practice guide for QRAs for CO_2 pipelines." **Joris Koornneef, Mark Spruijt, Menso Molag, Andrea Ramírez, Wim Turkenburg, and André Faaij**, *Journal of Hazardous Materials*, Available online November 18, 2009, doi: 10.1016/j.jhazmat.2009.11.068, http://www.sciencedirect.com/science/article/B6TGF-4XR5N97-2/2/fe68a2a9dfa1ae5d884f3ca9ed2a8cd6. (Subscription may be required.)

"Accelerating the deployment of carbon capture and storage technologies by strengthening the innovation system." The following is the Abstract of this article: "In order to take up the twin challenge of reducing CO_2 emissions, while meeting a growing energy demand, the potential deployment of CCS

technologies is attracting a growing interest of policy makers around the world. In this study [the authors] evaluate and compare national approaches towards the development of CCS in the United States, Canada, Norway, the Netherlands, and Australia. The analysis is done by applying the functions of innovation systems approach. This approach posits that new technology is developed, demonstrated and deployed in the context of a technological innovation system. The performance assessment of the CCS innovation system shows that the extensive knowledge base and knowledge networks, which have been accumulated over the past years, have not yet been utilized by entrepreneurs to explore the market for integrated CCS concepts linked to power generation. This indicates that the build-up of the innovation system has entered a critical phase that is decisive for a further thriving development of CCS. In order to move the CCS innovation system through this present difficult episode and deploy more advanced CCS concepts at a larger scale it is necessary to direct policy initiatives at the identified weak system functions, i.e. entrepreneurial activity, market creation and the mobilization of resources. Moreover, in some specific countries it is needed to provide more regulatory guidance and improve the legitimacy for the technology. [The authors] discuss how policy makers and technology managers can use these insights to develop a coherent policy strategy that would accelerate the deployment of CCS." **Klaas van Alphen, Marko P. Hekkert, and Wim C. Turkenburg**, *International Journal of Greenhouse Gas Control*, Available online November 3, 2009, doi: 10.1016/j.ijggc.2009.09.019, http://www.sciencedirect.com/science/article/B83WP-4XKXRW7-1/2/d96755887e1846e49f59e18b7a723637. (Subscription may be required.)

"The role of carbon capture technologies in greenhouse gas emissions-reduction models: A parametric study for the U.S. power sector." The following is the Abstract of this article: "This paper analyzes the potential contribution of CCS technologies to [GHG] emissions reductions in the U.S. electricity sector. Focusing on capture systems for coal-fired power plants until 2030, a sensitivity analysis of key CCS parameters is performed to gain insight into the role that CCS can play in future mitigation scenarios and to explore implications of large-scale CCS deployment. By integrating important parameters for CCS technologies into a carbon-abatement model similar to the EPRI Prism analysis, this study concludes that the start time and rate of technology diffusion are important in determining emissions reductions and fuel consumption for CCS technologies. Comparisons with legislative emissions targets illustrate that CCS alone is very unlikely to meet reduction targets for the electric-power sector, even under aggressive deployment scenarios. A portfolio of supply and demand-side strategies is needed to reach emissions objectives, especially in the near term. Furthermore, model results show that the breakdown of capture technologies does not have a significant influence on potential emissions reductions. However, the level of CCS retrofits at existing plants and the eligibility of CCS for new subcritical plants have large effects on the extent of [GHG] emissions reductions." **John E. Bistline and Varun Rai**, *Energy Policy*, Available online November 27, 2009, doi:10.1016/j.enpol.2009.11.008, http://www.sciencedirect.com/science/article/B6V2W-4XT2CT3-2/2/f8b2b8098d7b1deb7ff0278c18db235e. (Subscription may be required.)

February 2010

"Near-surface soil carbon detection for monitoring CO_2 seepage from a geological reservoir." The following is the Abstract of this article: "The promise of the Brookhaven National Laboratory (BNL) Inelastic Neutron Scattering (INS) System was evaluated for use as a long-term, in-field monitor to detect cumulative changes in belowground carbon resulting from the leakage of CO_2 stored in deep geological reservoirs. This system underwent tests at a facility constructed specifically for testing, under controlled conditions, various detection systems for monitoring near-surface transport and accumulations of CO_2 fluxes emanating from a shallow buried, slotted horizontal well. The INS System was assessed by comparing the results from placing it above the horizontal well at a spot with a known high CO_2 leak identified and quantified the previous years, with those obtained from background readings adjacent to the well. At two different 'Hot Spots', a suppression of about 14 [percent] in 2008 and about [seven percent] in 2009 in carbon content above the well in comparison to the background signal was observed. An overview of these results is presented." **Lucian Wielopolski and Sudeep Mitra**, *Environmental Earth*

Sciences, Available online December 9, 2009, doi: 10.1007/s12665-009-0397-6, http://www.springerlink.com/content/a01601q6044u7448/?p=dc01a3c69f88414596b4a8254398d113&pi=10. (Subscription may be required.)

"Sharp Front Capturing Method for Carbon Dioxide Plume Propagation during Injection into a Deep Confined Aquifer." The following is the Abstract of this article: "An in-depth understanding of patterns and evolutional characteristics of [CO_2] plume has significant implications to optimize operational strategies and manage [CO_2] during and after injection into saline aquifers for long-term geological storage. A sharp-interface mathematical model that describes the displacement process and its interfacial dynamics of [CO_2]-brine flow in a deep confined saline aquifer was proposed for predicting the propagation of the [CO_2] plume. On the basis of a conservative level set method (LSM), the governing equation of interfacial dynamics for capturing time-dependent fronts of the [CO_2] plume was established. It features a unified relationship between the properties of fluids and the saturations in both the single-phase fluid regions, and the interfacial region in the computational domain was derived by the approximation of linear fraction functions. The model equations numerically solved under different operational conditions after the effects of two adjustable parameters in the interfacial dynamics equation that determine stable and convergent interfaces in the simulations were illustrated and analyzed. A comprehensive comparison to the similarity solutions to a benchmark problem was made to illustrate the reliability and accuracy of the proposed approach. The simulation results show that the maximum migration distances predicted by the proposed approach are shorter than those of the similarity solutions, and the patterns and evolutional characteristics of [CO_2] plume are intensively dependent upon both injection durations and injection rates at the injection well. The results also show the importance of the effect of vertical mass flux in modeling the migrations of [CO_2] plume in saline aquifers regardless of injection rates. Moreover, the influences of the underlying assumptions on the interfacial dynamics of the migration of [CO_2] were analyzed and discussed in detail. The proposed approach and the simulation results will provide insights into the determination of optimal operational strategies and rapid identification of the consequences of [CO_2] injection into deep confined saline aquifers." **Yongzhong Liu, Le Wang, and Bo Yu**, *Energy Fuels*, Available online January 5, 2010, doi: 10.1021/ef9010498, http://pubs.acs.org/doi/abs/10.1021/ef9010498. (Subscription may be required.)

"Integration of post-combustion capture and storage into a pulverized coal-fired power plant." The following is the Abstract of this article: "Post-combustion CCS presents a promising strategy to capture, compress, transport and store CO_2 from a high volume–low pressure flue gas stream emitted from a fossil fuel-fired power plant. This work undertakes the simulation of CO_2 capture and compression integration into an 800-MWe, supercritical, coal-fired power plant using chemical process simulators. The focus is not only on the simulation of full load of flue gas stream into the CO_2 capture and compression, but also, on the impact of a partial load. The result reveals that the energy penalty of a low capture efficiency, for example, at 50 [percent] capture efficiency with 10 [percent] flue gas load is higher than for 90 [percent] flue gas load at the equivalent capture efficiency by about 440 kWhe/tonne CO_2. The study also addresses the effect of CO_2 capture performance by different coal ranks. It is found that lignite pulverized coal (PC)-fired power plant has a higher energy requirement than subbituminous and bituminous PC-fired power plants by 40.1 and 98.6 MWe, respectively. In addition to the investigation of energy requirement, other significant parameters including energy penalty, plant efficiency, amine flow rate and extracted steam flow rate, are also presented. The study reveals that operating at partial load, for example at half load with 90 [percent] CO_2 capture efficiency, as compared with full load, reduces the energy penalty, plant efficiency drop, amine flow rate and extracted steam flow rate by 9.9 [percent], 24.4 [percent], 50.0 [percent] and 49.9 [percent], respectively. In addition, the effect of steam extracted from different locations from a series of steam turbine with the objective to achieve the lowest possible energy penalty is evaluated. The simulation shows that a low extracted steam pressure from a series of steam turbines, for example at 300 kPa, minimizes the energy penalty by up to 25.3 [percent]." **Teerawat Sanpasertparnich, Raphael Idem, Irene Bolea, David deMontigny, and Paitoon Tontiwachwuthikul**, *International Journal of Greenhouse Gas Control*, Available online January 6, 2010, doi:

10.1016/j.ijggc.2009.12.005, http://www.sciencedirect.com/science/article/B83WP-4Y3K1B8-1/2/c13d269971cc909d9dac16c236c223de. (Subscription may be required.)

March 2010

"CO_2-ECBM field tests in the Ishikari Coal Basin of Japan." The following is the Abstract of this article: "The feasibility of extracting gas from coal seam while storing CO_2 underground was evaluated in Japan. A CO_2-ECBM project had begun near the town of Yubari on the island of Hokkaido in northern Japan. The primary coal seam of interest was 5-6 m thick Yubari coal seam located at the depth of 900 m. A micro-pilot test with a single well and multi-well CO_2 injection tests, involving an injection and production wells, were carried out in the period from May 2004 to October 2007. There were a variety of tests conducted in the injection well, including an initial water-injection falloff test and a series of CO_2 injection and falloff tests. Although gas production rate was obviously enhanced by CO_2 injection, water production rate was not clearly affected by CO_2 injection. Several injection tests suggested that injectivity of CO_2 into the virgin coal seam saturated with water was eventually increased as the water saturation near the injector was decreased by the injected CO_2. It was estimated that low injectivity of CO_2 was caused by the reduction in permeability induced by coal swelling. [Nitrogen (N_2)] flooding test was performed in 2006 to evaluate the effectiveness of N_2 injection on improving well injectivity. The N_2 flooding test showed that daily CO_2 injection rate was boosted, but only temporarily. Moreover, the permeability did not return to the initial value after CO_2 and N_2 were repeatedly injected. It was also indicated that the coal matrix swelling might create a high stress zone near to the injection well." **Masaji Fujioka, Shinji Yamaguchi, and Masao Nako**, *International Journal of Coal Geology*, Available online January 25, 2010, doi:10.1016/j.coal.2010.01.004, http://www.sciencedirect.com/science/article/B6V8C-4Y7P6PT-1/2/5efc9b84a43102b801fde98fa805f0ab. (Subscription may be required.)

"Retrieving surface deformation by PSInSAR™ technology: A powerful tool in reservoir monitoring." The following is the Abstract of this article: "Reservoir monitoring improves understanding of reservoir behavior and helps achieve more effective reservoir management and prediction of future performance with obvious economic benefits. It relies on an integrated approach involving both surveillance (well or surface based; seismic, electrical, leakage, flow and deformation measurements, etc.) and modeling. Surface deformation monitoring can provide valuable constraints on the dynamic behavior of a reservoir enabling the evaluation of volumetric changes in the reservoir through time. Leveling campaigns, tiltmeters, GPS permanent stations and Permanent Scatterer SAR Interferometry (PSInSAR™) are the techniques most widely used to determine surface displacements. Whatever the surveying technique, the detection of millimeter-level surface deformation is required to monitor small surface displacement rates that could impact risk evaluation and land use planning. Depending on depth and reservoir/overburden rheology, volumetric changes in reservoirs due to fluid extraction and injection can induce either subsidence or uplift that could trigger fault reactivation and threaten well integrity; deformation may also be detectable at the surface. Mapping surface effects accurately requires hundreds of observation points per km^2 which cannot be delivered by traditional monitoring methods without unacceptably large expenditure. PSInSAR™ is one of the most promising and cost-effective techniques capable of providing high precision and high areal density displacement measurements over long periods of time. Moreover, the availability of PS data for both ascending and descending orbits enables the estimation of both vertical and E–W horizontal displacement fields. Two case histories will be presented to illustrate the advantages of PSInSAR™ technology for the detection of surface deformation induced by reservoir exploitation and monitoring of its evolution though time." **A. Tamburini, M. Bianchi, C. Giannico, and F. Novali**, *International Journal of Greenhouse Gas Control*, Available online January 22, 2010, doi:10.1016/j.ijggc.2009.12.009, http://www.sciencedirect.com/science/article/B83WP-4Y71D6B-2/2/fb4a76cf64da734c00707e45ae4c1d4a. (Subscription may be required.)

"Reactive Transport Modeling to Study Changes in Water Chemistry Induced by CO_2 Injection at the Frio-I Brine Pilot." The following is the Abstract of this article: "To demonstrate the potential for geologic storage of CO_2 in saline aquifers, the Frio-I Brine Pilot was conducted, during which 1600 tons

of CO_2 were injected into a high-permeability sandstone and the resulting subsurface plume of CO_2 was monitored using a variety of hydrogeological, geophysical, and geochemical techniques. Fluid samples were obtained before CO_2 injection for baseline geochemical characterization, during the CO_2 injection to track its breakthrough at a nearby observation well, and after injection to investigate changes in fluid composition and potential leakage into an overlying zone. Following CO_2 breakthrough at the observation well, brine samples showed sharp drops in pH, pronounced increases in HCO_3^- and aqueous [iron (Fe)], and significant shifts in the isotopic compositions of [water (H_2O)] and dissolved inorganic carbon. Based on a calibrated 1-D radial flow model, reactive transport modeling was performed for the Frio-I Brine Pilot. A simple kinetic model of Fe release from the solid to aqueous phase was developed, which can reproduce the observed increases in aqueous Fe concentration. Brine samples collected after half a year had lower Fe concentrations due to carbonate precipitation, and this trend can be also captured by the modeling. The paper provides a method for estimating potential mobile Fe inventory, and its bounding concentration in the storage formation from limited observation data. Long-term simulations show that the CO_2 plume gradually spreads outward due to capillary forces, and the gas saturation gradually decreases due to its dissolution and precipitation of carbonates. The gas phase is predicted to disappear after 500 years. Elevated aqueous CO_2 concentrations remain for a longer time, but eventually decrease due to carbonate precipitation. For the Frio-I Brine Pilot, all injected CO_2 could ultimately be sequestered as carbonate minerals." **Tianfu Xu, Yousif K. Kharaka, Christine Doughty, Barry M. Freifeld, and Thomas M. Daley**, *Chemical Geology*, Available online January 18, 2010, doi:10.1016/j.chemgeo.2010.01.006, http://www.sciencedirect.com/science/article/B6V5Y-4Y65SG8-1/2/9e4348c1a102c85b485d8e071c82c52b. (Subscription may be required.)

April 2010

"Seismic detection of CO_2 leakage along monitoring wellbores." The following is the Abstract of this article: "A pilot CO_2 sequestration experiment was carried out in the Michigan Basin in which 10,000 tonnes of supercritical CO_2 was injected into the Bass Island Dolomite (BILD) at 1050 m depth. A passive seismic monitoring (PSM) network was operated before, during and after the 17-day injection period. The seismic monitoring network consisted of two arrays of eight, three-component sensors, deployed in two monitoring wells at only a few hundred meters from the injection point. [Two-hundred and twenty-five] microseismic events were detected by the arrays. Of these, only one event was clearly an injection-induced microearthquake. It occurred during injection, approximately 100 m above the BILD formation. No events, down to the magnitude −3 detection limit, occurred within the BILD formation during the injection. The observed seismic waveforms associated with the other 224 events were quite unusual in that they appear to contain dominantly compressional (P) but no (or extremely weak) shear (S) waves, indicating that they are not associated with shear slip on faults. The microseismic events were unusual in two other ways. First, almost all of the events occurred prior to the start of injection into the BILD formation. Second, hypocenters of the 94 locatable events cluster around the wells where the sensor arrays were deployed, not the injection well. While the temporal evolution of these events shows no correlation with the BILD injection, they do correlate with CO_2 injection for EOR into the 1670 m deep Coral Reef formation that had been going on for 2.5 years prior to the pilot injection experiment into the BILD formation. [The authors] conclude that the unusual microseismic events reflect degassing processes associated with leakage up and around the monitoring wells from the EOR-related CO_2 injection into the Coral Reef formation, 700 m below the depth of the monitoring arrays. This conclusion is also supported by the observation that as soon as injection into the Coral Reef formation resumed at the conclusion of the BILD demonstration experiment, seismic events (essentially identical to the events associated with the Coral Reef injection prior to the BILD experiment) again started to occur close to a monitoring arrays. Taken together, these observations point to vertical migration around the casings of the monitoring wellbores. Detection of these unusual microseismic events was somewhat fortuitous in that the arrays were deployed at the depth where the CO_2 undergoes a strong volume increase during transition from a supercritical state to a gas. Given the large number of pre-existing wellbores that exist in depleted oil and gas reservoirs that might be considered for CO_2 sequestration projects, passive seismic monitoring systems could be deployed at appropriate depths to systematically detect and monitor

leakage along them." **M. Bohnhoff, M.D. Zoback, L. Chiaramonte, J.L. Gerst, and N. Gupta**, *International Journal of Greenhouse Gas Control*, Available online February 26, 2010, doi:10.1016/j.ijggc.2010.01.009, http://www.sciencedirect.com/science/article/B83WP-4YGHKKY-1/2/b0cb00e5b28ff4ec1aca428fb492508c. (Subscription may be required.)

"Coda-wave interferometry analysis of time-lapse VSP data for monitoring geological carbon sequestration." The following is the Abstract of this article: "Injection and movement/saturation of CO_2 in a geological formation will cause changes in seismic velocities. [The authors] investigate the capability of coda-wave interferometry technique for estimating CO_2-induced seismic velocity changes using time-lapse synthetic vertical seismic profiling (VSP) data and the field VSP datasets acquired for monitoring injected CO_2 in a brine aquifer in Texas, USA. Synthetic VSP data are calculated using a finite-difference elastic-wave equation scheme and a layered model based on the elastic Marmousi model. A possible leakage scenario is simulated by introducing seismic velocity changes in a layer above the CO_2 injection layer. [The authors] find that the leakage can be detected by the detection of a difference in seismograms recorded after the injection compared to those recorded before the injection at an earlier time in the seismogram than would be expected if there was no leakage. The absolute values of estimated mean velocity changes, from both synthetic and field VSP data, increase significantly for receiver positions approaching the top of a CO_2 reservoir. [The authors] results from field data suggest that the velocity changes caused by CO_2 injection could be more than 10 [percent] and are consistent with results from a crosswell tomogram study. This study demonstrates that time-lapse VSP with coda-wave interferometry analysis can reliably and effectively monitor geological carbon sequestration." **Rongmao Zhou, Lianjie Huang, James T. Rutledge, Michael Fehler, Thomas M. Daley, and Ernest L. Majer**, *International Journal of Greenhouse Gas Control*, Available online February 26, 2010, doi:10.1016/j.ijggc.2010.01.010, http://www.sciencedirect.com/science/article/B83WP-4YGHKKY-2/2/f000221ae44c2df8f06c71dcfa1f2c71. (Subscription may be required.)

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

May 2010

"High-resolution simulation and characterization of density-driven flow in CO_2 storage in saline aquifers." The following is the Abstract of this article: "Simulations are routinely used to study the process of CO_2 sequestration in saline [formations]. In this paper, [the authors] describe the modeling and simulation of the dissolution-diffusion-convection process based on a total velocity splitting formulation for a variable-density incompressible single-phase model. A second-order accurate

sequential algorithm, implemented within a block-structured adaptive mesh refinement (AMR) framework, is used to perform high-resolution studies of the process. [The authors] study both the short-term and long-term behaviors of the process. It is found that the onset time of convection follows closely the prediction of linear stability analysis. In addition, the CO_2 flux at the top boundary, which gives the rate at which CO_2 gas dissolves into a negatively buoyant aqueous phase, will reach a stabilized state at the space and time scales [the authors] are interested in. This flux is found to be proportional to permeability, and independent of porosity and effective diffusivity, indicative of a convection-dominated flow. A 3D simulation further shows that the added degrees of freedom shorten the onset time and increase the magnitude of the stabilized CO_2 flux by about 25 [percent]. Finally, [the authors'] results are found to be comparable to results obtained from TOUGH2-MP." **George S.H. Pau, John B. Bell, Karsten Pruess, Ann S. Almgren, Michael J. Lijewski, and Keni Zhang**, *Advances in Water Resources*, Available online February 4, 2010, doi:10.1016/j.advwatres.2010.01.009, http://www.sciencedirect.com/science/article/B6VCF-4Y9XM19-1/2/7a4fb2b870dd37307414661adc778083. (Subscription may be required.)

"CO_2 sequestration in coals and enhanced coalbed methane recovery: New numerical approach." The following is the Abstract of this article: "Mixed gases injection into a large coal sample for CO_2 sequestration in coals and ECBM recovery was investigated using a new numerical approach. A dynamic multi-component transport (DMCT) model was applied to simulate ternary gas (CH_4-CO_2-N_2) diffusion and flow behaviors for better understanding and prediction of gas injection ECBM recovery processes. Several cases were designed to analyze the effects of injection gas composition and pressure on gas displacement dynamics in a large coal sample. The calculated results suggest that mixed gas injections have similar profiles of methane recovery as pure N_2 injection, and mixtures of N_2 and CO_2 reduce the ultimate methane recovery compared to pure CO_2. The breakthrough time of pure CO_2 injection is longer than mixed gas injections. Injection gas composition has significant effect on produced gas composition." **Xiaorong Wei, Paul Massarotto, Geoff Wang, Victor Rudolph, and Sue D. Golding**, *Fuel*, Available online February 4, 2010, doi:10.1016/j.fuel.2010.01.024, http://www.sciencedirect.com/science/article/B6V3B-4Y9TYBK-2/2/74555145111256c7ba2e93d67b6a89a1. (Subscription may be required.)

"Time-window-based filtering method for near-surface detection of leakage from carbon sequestration sites." The following is the Abstract of this article: "[The authors] use process-based modeling techniques to characterize the temporal features of natural biologically controlled surface CO_2 fluxes and the relationships between the assimilation and respiration fluxes. Based on these analyses, [the authors] develop a signal-enhancing technique that combines a novel time-window splitting scheme, a simple median filtering, and an appropriate scaling method to detect potential signals of leakage of CO_2 from geologic carbon sequestration sites from within datasets of net near-surface CO_2 flux measurements. The technique can be directly applied to measured data and does not require subjective gap filling or data-smoothing preprocessing. Preliminary application of the new method to flux measurements from a CO_2 shallow-release experiment appears promising for detecting a leakage signal relative to background variability. The leakage index of ±2 was found to span the range of biological variability for various ecosystems as determined by observing CO_2 flux data at various control sites for a number of years." **Lehua Pan, Jennifer L. Lewicki, Curtis M. Oldenburg, and Marc L. Fischer**, *Environmental Earth Sciences*, Available online February 9, 2010, doi:10.1007/s12665-009-0436-3, http://www.springerlink.com/content/b55v485161121410/?p=3c5c743728ef4e6399e57e439e1e7d78&pi=20. (Subscription may be required.)

June 2010

"A review of studies on CO_2 sequestration and caprock integrity." The following is the Abstract of this article: "This review presents a comprehensive overview of the technologies and science of CCS, including a brief description of the key aspects of CO_2 transport and subsequent trapping. It focuses on

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

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

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

July 2010

"Monitoring CO_2 response on surface seismic data; a rock physics and seismic modeling feasibility study at the CO_2 sequestration site, Ketzin, Germany." The following is the Abstract of this article: "An important component of any CO_2 [storage] project is seismic monitoring for tracking changes in subsurface physical properties such as velocity and density. Reservoir conditions and CO_2 injection quantities govern whether such changes may be observable as a function of time. Here we investigate surface seismic response to CO_2 injection at the Ketzin site, the first European onshore CO_2 [storage] pilot study dealing with research on geological storage of CO_2. First, a rock physics model was built to evaluate the effect of injected CO_2 on the seismic velocity. On the basis of this model, the seismic response for different CO_2 injection geometries and saturation was studied using 1D elastic modeling and 2D acoustic finite difference modeling. Rock-physics models show that CO_2 injected in a gaseous state, rather than in a supercritical state, will have a more pronounced effect on seismic velocity, resulting in a stronger CO_2 response. However, reservoir heterogeneity and seismic resolution, as well as random and coherent seismic noise, are negative factors that need to be considered in a seismic monitoring program. In spite of these potential difficulties, our seismic modeling results indicate that the CO_2 seismic response should be strong enough to allow tracking on surface seismic data. Amplitude-related attributes (i.e., acoustic impedance versus Poisson's ratio cross-plots) and time-shift measurements are shown to be suitable methods for CO_2 monitoring." **Sayed Hesammoddin Kazemeini, Christopher Juhlin, and Sergey Fomel**, *Journal of Applied Geophysics*, Available online June 12, 2010, doi:10.1016/j.jappgeo.2010.05.004, http://www.sciencedirect.com/science/article/B6VFC-5093N3M-1/2/4712629cedf4458b6c1129fdb80375d3. (Subscription may be required.)

"Mathematical modeling and simulation of gasification processes with Carbon Capture and Storage (CCS) for energy vectors poly-generation." The following is the Abstract of this article: "Gasification of solid fuels is a partial oxidation process which converse the solid feedstock into syngas which can be used in a large number of applications e.g. power generation, manufacture of various chemicals and fuels (hydrogen, methanol, ammonia, fertilizers etc.). Not all of the gasification systems are suitable for energy vectors polygeneration with [CCS]. This paper is proposing to evaluate various gasification technologies by mathematical modeling and simulation methods (especially for entrained flow types as these gasifiers are more suitable for implementing carbon capture technologies). In this paper a particular accent will be put on the selection of the most promising gasifier, as not all are appropriate for a carbon capture Integrated Gasification Combined Cycle (IGCC) applied for energy vectors poly-generation (with a particular focus on hydrogen and electricity co-production case) with [CCS]. For the selection of the most appropriate gasifier technologies the process were mathematical modeled and simulated with process flow modeling software (e.g. ChemCAD, Aspen). In the evaluation of various gasification technologies (e.g. Shell, Siemens, GE-Texaco, Conoco-Phillips etc.) a multi-criteria analysis was performed." **Victoria Maxim, Calin-Cristian Cormos, Ana-Maria Cormos, and Serban Agachi**, *Computer Aided Chemical Engineering*, Available online May 28, 2010, doi:10.1016/S1570-7946(10)28117-8, http://www.sciencedirect.com/science/article/B8G5G-505XT0T-48/2/01e3df41fe01b2df2d0bd33d71d19229. (Subscription may be required.)

"Predictions of the impurities in the CO_2 stream of an oxy-coal combustion plant." The following is from the Abstract of this article: "Whilst all three main carbon capture technologies (post-combustion, pre-combustion and oxy-fuel combustion) can produce a CO_2 dominant stream, other impurities are expected to be present in the CO_2 stream. The impurities in the CO_2 stream can adversely affect other processes of the CCS chain including the purification, compression, transportation and storage of the CO_2 stream. Both the nature and the concentrations of potential impurities expected to be present in the CO_2 stream of a CCS-integrated power plant depend on not only the type of the power plant but also the carbon capture method used. The present paper focuses on the predictions of impurities expected to be present in the CO_2 stream of an oxy-coal combustion plant…" **Hao Liu and Yingjuan Shao**, *Applied Energy*, Available online May 26, 2010, doi:10:1016/j.apenergy.2010.04.014, http://www.sciencedirect.com/science/article/B6V1T-505FHWV-2/2/7af47f626ee4323d07447fa10f34732d. (Subscription may be required.)

August 2010

"Impact of coal seam as interlayer on CO_2 storage in saline aquifers: A reservoir simulation study." The following is from the Abstract of this article:" Geological storage of CO_2 is a viable option for the mitigation of [GHG] emissions. Two main reservoir types exist; porous formations such as saline aquifers or depleted oil or gas reservoirs and, of lesser importance in terms of storage capacity, coal or shale reservoirs. These reservoirs have distinct storage mechanisms; in the porous formations the CO_2 is stored within the porosity by compression and/or dissolution in the formation fluid, whereas in coal or shale, the CO_2 is primarily stored by adsorption. Geological storage scenarios exist where these two reservoir types could be present within a geological sequence and come into contact with migrating CO_2. In order to simulate this situation simulators are required which represent the mechanisms operating for both reservoir types. One aspect of the work presented in this paper involves further development of the coal seam gas reservoir simulator, SIMED II, to include CO_2 dissolution in formation waters and a more accurate Equation of State, the Span and Wagner model, to describe CO_2 density. The modified model is first tested through a code comparison study with TOUGH2 for CO_2 storage in a saline aquifer with dissolution in formation water, which finds that the two simulators are in close agreement. The second component of this paper involved investigating the potential impact that coal seams could have on CO_2 storage in saline formations. A series of hypothetical cases are constructed to investigate the impact of coal seams as (1) a layer within the target aquifer above the injection point, (2) two layers separated by an aquifer above the injection point, (3) a layer in the target aquifer below the point of injection, and (4) a layer in the overburden. The results show that coal seams can have a significant impact on CO_2 storage and migration behavior by providing extra storage capacity and influencing the CO_2 flow path both vertically and horizontally. The potential impact of coal seams in these scenarios is related to a range of factors but key ones are the adsorption capacity and the permeability. The results also demonstrate that coal seam permeability decrease due to CO_2 adsorption induced coal swelling, although regarded as a technical obstacle to CO_2 injection in the deep unmineable coal seams to [ECBM] recovery and for CO_2 storage in coal, would further influence the CO_2 flow path, helping to reduce the upward CO_2 flow due to buoyancy and pressure. This could act to reduce CO_2 contact with cap rocks and lower the risk of CO_2 leakage." **Zhejun Pan and Luke D. Connell**, *International Journal of Greenhouse Gas Control*, Available online July 15, 2010, doi:10.1016/j.ijggc.2010.06.012, http://www.sciencedirect.com/science/article/B83WP-50J3DDW-1/2/28b1fd7cf9b2245fe80310304838c186. (Subscription may be required.)

"Single-well experimental design for studying residual trapping of supercritical carbon dioxide." The following is from the Abstract of this article: "The objective of [this] research is to design a single-well injection-withdrawal test to evaluate residual phase trapping at potential CO_2 geological storage sites. Given the significant depths targeted for CO_2 storage and the resulting high costs associated with drilling to those depths, it is attractive to develop a single-well test that can provide data to assess reservoir properties and reduce uncertainties in the appraisal phase of site investigation. The main challenges in a single-well test design include (1) difficulty in quantifying the amount of CO_2 that has dissolved into brine or migrated away from the borehole; (2) non-uniqueness and uncertainty in the estimate of the residual gas saturation (S_{gr}) due to correlations among various parameters; and (3) the potential biased S_{gr} estimate due to unaccounted heterogeneity of the geological medium. To address each of these challenges, [the authors] propose (1) to use a physical-based model to simulation test sequence and inverse modeling to analyze data information content and to quantify uncertainty; (2) to jointly use multiple data types generated from different kinds of tests to constrain the S_{gr} estimate; and (3) to reduce the sensitivity of the designed tests to geological heterogeneity by conducting the same test sequence in both a water-saturated system and a system with residual gas saturation. To perform the design calculation, [the authors] build a synthetic model and conduct a formal analysis for sensitivity and uncertain quantification. Both parametric uncertainty and geological uncertainty are considered in the analysis. Results show (1) uncertainty in the estimation of S_{gr} can be reduced by jointly using multiple

data types and repeated tests; and (2) geological uncertainty is essential and needs to be accounted for in the estimation of S_{gr} and its uncertainty. The proposed methodology is applied to the design of a CO_2 injection test at CO2CRC's Otway Project Site, Victoria, Australia." **Yingqi Zhang, Barry Freifeld, Stefan Finsterle, Martin Leahy, Jonathan Ennis-King, Lincoln Paterson, and Tess Dance**, *International Journal of Greenhouse Gas Control*, Available online July 13, 2010, doi:10.1016/j.ijggc.2010.06.011, http://www.sciencedirect.com/science/article/B83WP-50HN7P5-1/2/38f3e470dc23c2882895543c128286d6. (Subscription may be required.)

"Analytical solution for Joule–Thomson cooling during CO_2 geo-sequestration in depleted oil and gas reservoirs." The following is from the Abstract of this article: "Mathematical tools are needed to screen out sites where Joule–Thomson cooling is a prohibitive factor for CO_2 geo-sequestration and to design approaches to mitigate the effect. In this paper, a simple analytical solution is developed by invoking steady-state flow and constant thermophysical properties. The analytical solution allows fast evaluation of spatiotemporal temperature fields, resulting from constant-rate CO_2 injection. The applicability of the analytical solution is demonstrated by comparison with non-isothermal simulation results from the reservoir simulator TOUGH2. Analysis confirms that for an injection rate of 3 kg s^{-1} (0.1 MT yr^{-1}) into moderately warm (>40 °C) and permeable formations (>10^{-14} m^2 (10 mD)), JTC is unlikely to be a problem for initial reservoir pressures as low as 2 MPa (290 psi)." **Simon A. Mathias, Jon G. Gluyas, Curtis M. Oldenburg, and Chin-Fu Tsang**, *International Journal of Greenhouse Gas Control*, Available online June 17, 2010, doi:10.1016/j.ijggc.2010.05.008, http://www.sciencedirect.com/science/article/B83WP-50B5WJB-1/2/a266a6b345ede2114a504a46fdd5b848. (Subscription may be required.)

Terrestrial

September 2009

"A review of applications of model-data fusion to studies of terrestrial carbon fluxes at different scales." The following is the Abstract of this article: "Model-data fusion is defined as matching model prediction and observations by varying model parameters or states using statistical estimation. In this paper, [the authors] review the history of applications of various model-data fusion techniques in studies of terrestrial carbon fluxes in two approaches: top-down approaches that use measurements of global CO_2 concentration and sometimes other atmospheric constituents to infer carbon fluxes from the land surface, and bottom-up approaches that estimate carbon fluxes using process-based models. [The authors] consider applications of model-data fusion in flux estimation, parameter estimation, model error analysis, experimental design and forecasting. Significant progress has been made by systematically studying the discrepancies between the predictions by different models and observations. As a result, some major controversies in global carbon cycle studies have been resolved, robust estimates of continental and global carbon fluxes over the last two decades have been obtained, and major deficiencies in the atmospheric models for tracer transport have been identified. In the bottom-up approaches, various optimization techniques have been used for a range of process-based models. Model-data fusion techniques have been successfully used to improve model predictions, and quantify the information content of carbon flux measurements and identify what other measurements are needed to further constrain model predictions. However, [the authors] found that very few studies in both top-down and bottom-up approaches have quantified the errors in the observations, model parameters and model structure systematically and consistently. [The authors] therefore suggest that future research will focus on developing an integrated Bayesian framework to study both model and measurement errors systematically." **Ying-Ping Wang, Cathy M. Trudinger, and Ian G. Enting**, *Agricultural and Forest Meteorology*, Available online August 15. 2009, doi: 10.1016/j.agrformet.2009.07.009, http://www.sciencedirect.com/science/article/B6V8W-4X0W4H0-1/2/4acb106f0b982a481f5094b3e700764a. (Subscription may be required.)

October 2009

"Forest carbon sequestration changes in response to timber harvest." The following is the Abstract of this article: "Forest succession contributes to the global terrestrial carbon (C) sink, but changes in C sequestration in response to varied harvest intensities have been debated. The forests of the Central Appalachian region have been aggrading over the past 100 years following widespread clear-cutting that occurred in the early 1900s and these forests are now valuable timberlands. This study compared the history of ecosystem C storage in four watersheds that have been harvested at different frequencies and intensities since 1958. [The authors] compared NPP, NEP, and component ecosystem C fluxes ($g\ C\ m^{-2}\ year^{-1}$) in response to the four different harvest histories (no harvest, clear-cutting, single tree selection cutting, and 43 cm diameter-limit cutting). Clear-cutting had short-term negative effects on NEP but harvest did not significantly impact long-term average annual C sequestration rates. Average plant C ($g\ C\ m^{-2}$) since 1950 was about 33 [percent] lower in response to a clear-cut event than plant C in an un-harvested forest, suggesting that the C sequestration associated with clear-cutting practices would decline over time and result in lower C storage than diameter-limit cut, selective cut, or un-harvested forests. Total C stored over a 55-year period was stimulated ~37 [percent] with diameter-limit cutting and selective cutting relative to un-harvested forests." **Sarah C. Davis, Amy E. Hessel, Carrie J. Scott, Mary Beth Adams, and Richard B. Thomas**, *Forest Ecology and Management*, Available online September 1, 2009, doi: 10.1016/j.foreco.2009.08.009, http://www.sciencedirect.com/science/article/B6T6X-4X4G2NG-1/2/6b6a4cfc45dad50bfdba39dd1776a32e. (Subscription may be required.)

November 2009

"Wetland uses in the tropics and their implications on the world carbon cycle." The following is from the Introduction of this article: "[Mankind's] understanding of the ecology of wetlands has long been based on their bioenergetics and habitat functions. More recently, emphasis has been made on their value as major carbon sinks. It has been recently recognized that the alterations of wetlands results in the oxidation of stored carbon. The release of CO_2 could create a net carbon source that can be significant enough to cause imbalance in the carbon cycle of the biosphere. Thus, the ways by which the wetlands of the world are used presently have attained a new dimension of global implication. The aim of this paper is to summarize the uses of wetlands in the tropics, to discuss some ecological implications of these uses, and to illustrate two contrasting uses relative to the carbon cycle. The materials presented in this paper were based on [the author's] studies in Southeast Asia and Papua New Guinea under two grants from the International Division of the U.S. National Science Foundation, and on [the author's] observations." **Armando A. de la Cruz**, *Wetlands*, Available online September 29, 2009, doi:10.1007/BF03160545, http://www.springerlink.com/content/q25g714922n12137/?p=2f065847cb434343981eba58d3c78749&pi=1. (Subscription may be required.)

December 2009

"IA-SDSS: A GIS-based land use decision support system with consideration of carbon sequestration." The following is the Abstract of this article: "Land use, land use change and forestry (LULUCF) can play a positive role in mitigating global warming by sequestering carbon from the atmosphere into vegetation and soils. Local entities (e.g. local government, community, stockholders) have been making great efforts in enhancing carbon sequestration (CS) of local forests for mitigating global climate change and participating in international carbon-trade promoted by the Kyoto Protocol. Approaches and tools are needed to assess the enhancement of CS through land use changes and proper policy decisions. This paper presents an integrated assessment framework and a spatial decision support system (IA-SDSS) as a tool to support land-use planning and local forestry development with consideration of CS. The IA-SDSS integrates two process-based carbon models, a spatial decision

(EMDS) module, a spatial cost-benefit analysis (CBA) module, and the analytic hierarchy process (AHP) module. It can provide spatially explicit CS information as well as CS-induced economic benefits under various scenarios of the carbon credit market. A case study conducted in Liping County, Guizhou Province, China demonstrated that the IA-SDSS developed in this study is applicable in supporting decision-making on 'where' and 'how' to adopt forestry land use options in favor of CS." **Jun Wang, Jingming Chen, Weimin Ju, and Manchun Li**, *Environmental Modelling & Software*, Available online November 7, 2009, doi: 10.1016/j.envsoft.2009.09.010, http://www.sciencedirect.com/science/article/B6VHC-4XMTFRC-3/2/331c1a97dc5641efcd03dc487b151bc0. (Subscription may be required.)

January 2010

"Rapid Assessment of U.S. Forest and Soil Organic Carbon Storage and Forest Biomass Carbon Sequestration Capacity." The following is the Abstract of this article: "This report provides results of a rapid assessment of biological carbon stocks and forest biomass carbon sequestration capacity in the conterminous United States. Maps available from the U.S. Department of Agriculture are used to calculate estimates of current organic carbon storage in soils (73 petagrams of carbon, or PgC) and forest biomass (17 PgC). Of these totals, 3.5 PgC of soil organic carbon and 0.8 PgC of forest biomass carbon occur on lands managed by the U.S. Department of the Interior (DOI). Maps of potential vegetation are used to estimate hypothetical forest biomass carbon sequestration capacities that are 3-7 PgC higher than current forest biomass carbon storage in the conterminous United States. Most of the estimated hypothetical additional forest biomass carbon sequestration capacity is accrued in areas currently occupied by agriculture and development. Hypothetical forest biomass carbon sequestration capacities calculated for existing forests and woodlands are within ±1 PgC of estimated current forest biomass carbon storage. Hypothetical forest biomass sequestration capacities on lands managed by the DOI in the conterminous United States are 0-0.4 PgC higher than existing forest biomass carbon storage. Implications for forest and other land management practices are not considered in this report. Uncertainties in the values reported here are large and difficult to quantify, particularly for hypothetical carbon sequestration capacities. Nevertheless, this rapid assessment helps to frame policy and management discussion by providing estimates that can be compared to amounts necessary to reduce predicted future atmospheric [CO_2] levels." **Eric T. Sundquist, Katherine V. Ackerman, Norman B. Bliss, Josef M. Kellndorfer, Matt C. Reeves, and Matthew G. Rollins**, *U.S. Geological Survey Open-File Report 2009–1283*, Available online December 2009, http://pubs.usgs.gov/of/2009/1283/pdf/ofr20091283.pdf.

February 2010

"The spatial variability of CO_2 storage and the interpretation of eddy covariance fluxes in central Amazonia." The following is the Abstract of this article: "The landscape of central Amazonia is composed of plateaus and valleys. Previous observations have shown preferential pooling of CO_2 in the valleys, suggesting that the change in CO_2 storage in the canopy air space (S) will be spatially variable at the scale of the topography. This may affect the interpretation of the net ecosystem CO_2 exchange (NEE) rates measured on the plateaus if they have used one single atmospheric CO_2 concentration ([CO_2]) vertical profile measurement system. [The authors] have measured the diel, spatial and seasonal variation of S along the topography by using a set of automated [CO_2] vertical profile measurement systems. In addition, NEE, the above-canopy turbulent exchange of CO_2 (F_c) and meteorological variables were also measured on a micrometeorological tower located on the plateau. The nocturnal accumulation of CO_2 was larger on the slopes and in the valleys than on the plateau and was larger in the dry period than in the wet period. In addition, the release of this CO_2 occurred later in the day on the slopes and in the valleys than on the plateau. Differences in the flow regime above the canopy along the topographical gradient, lateral drainage of respired CO_2 downslope, and temporal, spatial, and seasonal variation of soil CO_2 efflux (R_{soil}) are thought to have contributed to this. These conditions cause S to be

higher in magnitude on the slopes and in the valleys than on the plateau during midmorning hours. [The authors] demonstrate that there is a larger underestimation of R_{eco} by nighttime eddy covariance (EC) measurements in the dry period than in the wet period. In addition, R_{eco} – as derived from measurements only on the plateau ($F_c + S_P$) – does not agree with that derived by an independent method. Yet *S* fluxes peaked at about 18:00-20:00 on the slopes and in the valleys, following a continuous decrease after this period until reaching a minimum just after dawn. *NEE* derived from F_c measured on the plateau and *S* measured on the plateau, slope and valley increased the estimates of R_{eco} on the plateau by about 30 [percent] and 70 [percent] in the wet and dry periods, respectively. Particularly for flux-tower sites over complex terrain, we recommend measuring the spatial variability of CO_2 at, at least two, more points along the topography to determine to what extent horizontal gradients and storage changes may contribute to tower fluxes. Finally, for sites that present topographical characteristics similar to that described in this study, care must be taken with the use of single in-canopy profiles of [CO_2] to correct EC fluxes." **A.C. de Araújo, A.J. Dolman, M.J. Waterloo, J.H.C. Gash, B. Kruijt, F.B. Zanchi, J.M.E. de Lange, R. Stoevelaar, A.O. Manzi, A.D. Nobre, R.N. Lootens, and J. Backer**, *Agricultural and Forest Meteorology*, Available online December 16, 2009, doi: 10.1016/j.agrformet.2009.11.005, http://www.sciencedirect.com/science/article/B6V8W-4XY4S9M-2/2/dc702470e037abfb8d2583fb638091c8. (Subscription may be required.)

March 2010

"Soil organic carbon changes in the cultivation of energy crops: Implications for GHG balances and soil quality for use in LCA." The following is the Abstract of this article: "The environmental impact of different land-use systems for energy, up to the farm or forest 'gate,' has been quantified with life cycle assessment (LCA). Four representative crops are considered: oilseed rape (OSR), *Miscanthus*, short-rotation coppice (SRC) willow and forest residues. The focus of the LCA is on changes in soil organic carbon (SOC) but energy use, emissions of GHGs, acidification and eutrophication are also considered. In addition to providing an indicator of soil quality, changes in SOC are shown to have a dominant effect on total GHG emissions. *Miscanthus* is the best land-use option for GHG emissions and soil quality as it sequesters [carbon] at a higher rate than the other crops, but this has to be weighed against other environmental impacts where *Miscanthus* performs worse, such as acidification and eutrophication. OSR shows the worst performance across all categories. Because forest residues are treated as a by-product, their environmental impacts are small in all categories. The analysis highlights the need for detailed site-specific modeling of SOC changes, and for consequential LCAs of the whole fuel cycle including transport and use." **Miguel Brandão, Llorenç Milà i Canals, and Roland Clift**, *Biomass and Bioenergy*, Available online January 12, 2010, doi:10.1016/j.biombioe.2009.10.019, http://www.sciencedirect.com/science/article/B6V22-4Y4XCMW-1/2/26051898140dc493640a7c3fe71df0fb. (Subscription may be required.)

April 2010

"Modeling interannual variability of global soil respiration from climate and soil properties." The following is the Abstract of this article: "To develop a model describing the dependence of annual soil respiration on climate and soil properties, [the authors] compiled 657 published annual soil respiration (R_s) measurements that were assembled from 147 sites globally, representing croplands, grasslands, forests and tundra ecosystems. Each of these annual soil respiration data was then aggregated with the appropriate mean air temperature (*T*) and annual precipitation (*P*) data derived from geographically referenced datasets and with soil properties gathered from the original literature. Partial correlation analyses showed that global annual R_s significantly related to annual mean temperature, annual precipitation, and topsoil (0-20 cm) organic carbon (SOC) storage, while topsoil total nitrogen (SN) and pH did not show a direct and clear relationship with R_s across ecosystems. While [the authors] employed the T&P-model that used temperature and annual precipitation to globally predict annual soil respiration, it was able to explain 41 [percent], 57 [percent], and 31 [percent] of the variability of soil respiration for

croplands, grasslands and forests, respectively. However, the residuals were significantly related to SOC for croplands and grasslands. Thus, [the authors] developed a T&P&C-model that includes SOC as an additional predictor of annual R_s. This extended but still simple model performed better than the T&P-model and explained 69 [percent], 89 [percent], and 47 [percent] of the interannual and intersite variability of R_s with a mean absolute error of 0.11, 0.18, and 0.28 kg C m^{-2} yr^{-1} for croplands, grasslands and forests, respectively. Overall, the modeling efficiency of the T&P&C-model was nearly 60 [percent] across ecosystems. Globally, the mean turnover time of topsoil carbon (SOC/R_s) was highly comparable among croplands, grasslands and forests, equivalent to 6.1-6.3 years. Therefore, better estimates of global annual soil respiration would be obtained with the new model driven by climate and soil properties together. [The authors] expect significant improvements of global annual soil respiration predictions given that measurements of soil respiration coupling with soil properties and site productivities are widely taken across ecosystems over the world." **Shutao Chen, Yao Huang, Jianwen Zou, Qirong Shen, Zhenghua Hu, Yanmei Qin, Haishan Chen, and Genxing Pan**, *Agricultural and Forest Meteorology*, Available online March 1, 2010, doi:10.1016/j.agrformet.2010.02.004, http://www.sciencedirect.com/science/article/B6V8W-4YH4PPX-1/2/a7aaf504e5c1509a375158cbf460eac9. (Subscription may be required.)

May 2010

"Tillage effects on soil organic carbon storage and dynamics Corn Belt of Ohio USA." The following is the Abstract of this article: "No-till (NT) agriculture reduces soil disturbance, conserves soil and water, and lowers the cost of agricultural production. However, its role in soil organic carbon (SOC) sequestration can be soil and site specific. The applicability of the results from long-term tillage experiments (LTTEs) showing positive rate of carbon (C) sequestration is being questioned under large scale farmers' field conditions. Therefore, this study assessed the soil C dynamics under conventional till (CT) and NT practices using three LTTEs and three farmer's field sites in Ohio, USA with diverse soil types, and environmental and management conditions. The hypothesis tested was that reduced soil disturbance in NT management system enhances soil C sequestration in comparison to CT management. Soils were sampled (0-40 cm) from adjacent CT, NT and woodlot (WL) plots at each site. Total C and nitrogen (N) pools were calculated based on equivalent soil mass basis. The SOC was fractioned into old C and new (corn C) using $\delta^{13}C$ natural abundance. The CT soils had 26-55 [percent] lower SOC and [seven to] 34 [percent] lower N pool compared to forest soils. Most of the historic SOC and N losses in cultivated soils occurred within the plow (0-25 cm) layer. The SOC pool in the top 40 cm was significantly greater under NT than CT at LTTEs and Coshocton farm. There were no significant differences in SOC pool of the top 40 cm among CT and NT at Delaware and Hoytville farms. Old C accounted for 69 [percent] and 66 [percent] of SOC under CT and NT, respectively at Northwestern Agricultural Research Station. However, at Western Agricultural Research Station, corn-derived C dominated CT and NT soils, accounting for 55 [percent] and 66 [percent] of SOC in the top 40 cm, respectively. At North Appalachian Experimental watersheds, corn-derived C dominated NT soils (64 [percent]), while old C dominated CT soils (64 [percent]). Result of this study indicated that a decrease in SOC and N pools occurs when forest soil is cultivated. Conversion of CT to NT restores some of the depleted SOC and N pools. This supports [the authors'] hypothesis that the reduced soil disturbance in NT system slows the decomposition of SOC which increases soil C sequestration. The quantity and rate of loss or sequestration depends on several factors including soil type, texture and drainage, tillage intensity, and duration of NT practice." **Umakant Mishra, David A.N. Ussiri, and Rattan Lal**, *Soil and Tillage Research*, Available online March 17, 2010, doi:10.1016/j.still.2010.02.005, http://www.sciencedirect.com/science/article/B6TC6-4YMHFJT-1/2/9d3531c0d4aeb37611729f2c41d4d192. (Subscription may be required.)

June 2010

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

July 2010

"Carbon contents and respiration rates of aggregate size fractions under no-till and conventional tillage." The following is the Abstract of this article: "The purpose of the present study was to evaluate the long-term (14 [years]) effect of no-till (NT) compared with conventional tillage (CT) on the distribution of dry sieved aggregate size fractions, their carbon (C) and nitrogen (N) contents and respiration activity. Soil samples were taken from a long-term (14 years) tillage experiment with a rotation of [six] cash crops, [four] years pasture and another [six] cash crops in the sandy plains region of semiarid central Argentina, on an Entic Haplustoll. Sampling was carried out at 0.06 m intervals to 0.18 m depth, with [four] replicates per tillage treatment. Bulk density (BD), C and N were determined on air dried samples. Dry aggregate size distribution (fractions: >4, 1–4, and <1 mm) and C and N contents of these size fractions were determined. Samples of fractions and of undisturbed soil were incubated and respiration was measured by trapping evolved CO_2 in NaOH. The NT soil had 25 [percent] more macroaggregates in surface 0.06 m samples than CT, while at 0.06-0.12 and 0.12-0.18 m, these increased by 38 and 17 [percent] respectively. This indicated that the effect of NT on aggregate size distribution extended towards deeper soil regions. The intermediate aggregate fraction of surface soil under NT had 8.2 g kg^{-1} more C than under CT, while for >4 and <1 mm aggregates the differences between tillage systems were smaller (6.8 and 7.6 g kg^{-1} respectively). The data confirmed [the] hypothesis with respect to higher C accretion in intermediate aggregates under NT, approaching values of a permanent pasture soil. Large aggregates did not sequester more C than small aggregates, as would be expected according to the conceptual model of aggregate hierarchy. At 0.06-0.12 m depth these differences in C concentrations were less pronounced. Thus, although the effect of tillage on aggregate size distribution extended below the upper 0.06 m, C [storage] occurred mainly in this depth interval. While intermediate aggregates represented 12 and 15 [percent] of total C under NT and CT respectively, their contribution to soil respiration was19 and 21 [percent] for the same treatments. This would indicate that C losses from soil through mineralization are mostly associated with intermediate aggregate size." **Romina Fernández, Alberto Quiroga, Carlos Zorati, and Elke Noellemeyer**, *Soil and Tillage Research*, Available online June 8, 2010, doi:10.1016/j.still.2010.05.002, http://www.sciencedirect.com/science/article/B6TC6-50867FX-2/2/a499ef6fbc8acec0ea1ee5b34ce939d4. (Subscription may be required.)

August 2010

"Soil Carbon Accumulation During Temperate Forest Succession on Abandoned Low Productivity Agricultural Lands." The following is from the Abstract of this Article: "Carbon sequestration in soils that have previously been depleted of organic matter due to agriculture is an important component of global strategies to mitigate rising atmospheric CO_2 concentrations. Extensive areas of low productivity farmland have been abandoned from agriculture in eastern North America and elsewhere over the past century, and are naturally regenerating to temperate forests. [The authors] investigated the soil carbon sequestration potential of such lands by sampling adjacent mature forest and agricultural field sites, and replicated chronosequences of forest succession on Podzol, Brunisol, and Luvisol soil types that are considered 'marginal' for agriculture and have been abandoned extensively across southeastern Ontario, Canada. Total soil organic carbon and nitrogen stocks to 10 cm depth were approximately 32 [percent] and 18 [percent] lower, respectively, in agricultural fields compared to mature forests. Furthermore, carbon stocks across [the authors'] 100-year chronosequences increased most within the 0–5 cm soil depth interval, tended to increase within the 5–10 cm interval, and were unaltered within the 10–20 cm interval. Soil type had little effect on the potential magnitude or rates of soil carbon sequestration (~10 g C m^{-2} y^{-1} in the top 10 cm), perhaps because all sites shared a common vegetation successional pattern. Finally, [the authors'] investigations of the 'labile' free-light carbon and nitrogen fractions in the Brunisol soil type indicated no increases across the chronosequence, implying that soil carbon accumulation was primarily in more recalcitrant pools. [The authors'] results indicate that each of these low productivity soil types can be moderate carbon sinks for a century following agricultural abandonment, and strongly suggest that time since abandonment is more important than soil type in determining the potential magnitude of carbon sequestration within this climatic region." **Robyn L. Foote and Paul Grogan**, *Ecosystems*, Available online June 30, 2010, doi:10.1007/s10021-010-9355-0, http://www.springerlink.com/content/621k285750720481/?p=b1325ea06ce84a3cbb841c0d1ee6ad2d&pi=5. (Subscription required.)

Trading

September 2009

***RGGI News Release*, "RGGI Participating States Open Fifth Auction Cycle with Release of Application Materials."** The 10 states participating in RGGI released the Auction Notice and application materials for the fifth regional CO_2 allowance auction scheduled for Wednesday, September 9, 2009. The materials provide the information needed to submit a qualification application. In Auction 5, the states will continue to employ a reserve price of $1.86 for all allowances; 28,408,945 allowances for the current control period (all for the 2009 vintage) and 2,172,540 allowances for the future control period (all for the 2012 vintage) will be auctioned. Auction 5 will be the third auction held since compliance obligations under each participating state's CO_2 Budget Trading Program took effect on January 1, 2009 (RGGI's participating states also held two "pre-compliance" auctions in September 2008 and December 2008). To date, the states participating in RGGI have auctioned more than 110 million allowances. Under RGGI protocols, the power sector in participating states caps CO_2 emissions at current levels through 2014; the cap will then be reduced by 2.5 percent each year from 2015 to 2018, totaling a 10 percent reduction. For more information, visit: http://www.rggi.org/, or click: http://www.rggi.org/co2-auctions/information to download the auction materials. July 15, 2009, http://www.rggi.org/docs/Auction_5_notice_release.pdf.

October 2009

***RGGI News Release*, "Market for RGGI CO_2 Allowances Competitive and Efficient."** The secondary market for Regional Greenhouse Gas Initiative (RGGI) CO_2 allowances saw a significant increase in the number of market participants and the volume of allowances traded throughout the second quarter of 2009, according to a report released by the 10 Northeast and Mid-Atlantic states participating in RGGI. The report, titled, "Report on the Secondary Market for RGGI CO_2 Allowances," was prepared by Potomac Economics. In addition to this finding, the report also states that during the reporting period the

number of participants in the market for RGGI allowance derivatives increased; futures contract trading saw a five-fold increase from the end of the first quarter of 2009; prices for RGGI futures stabilized; and the ownership of allowances more than doubled from the end of the first quarter of 2009. The conclusions are based on the analysis of data reported to the Commodity Futures Trading Commission, the Chicago Climate Futures Exchange, the New York Mercantile Exchange, and other data. The complete report is available at: www.rggi.org/Secondary_Market_Report_September_2009.pdf. September 4, 2009, http://www.rggi.org/docs/Secondary_Market_Report_September_2009.pdf.

November 2009

***RGGI News Release*, "RGGI States Initiate Bidding Process for December 2009 Auction."** On October 6, 2009, the 10 Northeast and Mid-Atlantic states participating in the Regional Greenhouse Gas Initiative (RGGI) released the Auction Notice and application materials for their sixth regional CO_2 allowance auction, which is scheduled for December 2, 2009. According to the release, the participating states will offer more than 28.5 million allowances for the 2009 vintage and more than 2.1 million allowances for the 2012 vintage. The reserve price for allowances in Auction 6 will continue to be $1.86. Potential bidders must complete the qualification process in order to participate in the December auction; the necessary documentation is available on the RGGI website at: http://www.rggi.org/co2-auctions/information. Auction 6 will be the fourth such auction since compliance obligations under each member state's CO_2 Budget Trading Program took effect on January 1, 2009. The participating states have auctioned more than 140 million allowances to date. Created in September 2007, RGGI has designed and implemented the first market-based, mandatory cap-and-trade program in the United States to reduce GHG emissions. Power sector CO_2 emissions are capped at 188 million short tons per year through 2014; the cap will then be reduced by 2.5 percent each year through 2018, for a total reduction of 10 percent. October 6, 2009, http://www.rggi.org/docs/Auction_6_Notice_Release_FINAL.pdf.

December 2009

***European Environment Agency Press Release*, "Non-Industrial Emissions Key for Meeting Kyoto Targets."** On November 12, 2009, the European Environment Agency (EEA) released a report that shows the majority of EU member states are on track to meet their Kyoto Protocol commitments to reduce GHG emissions. The Kyoto Protocol requires the EU member states to reduce their average emissions during 2008 through 2012 to eight percent below 1990 levels; however, recent projections indicate that the member states are on pace to exceed the number, reaching a total reduction of more than 13 percent below the base year. According to the EEA report, reductions during the period will be achieved through a combination of existing and additional policies, the purchase of credits from emission-reducing projects outside the EU, the trading of emission allowances by participants in the EU emission trading scheme (EU ETS), and forestry activities that absorb CO_2 from the atmosphere. To view the EEA report, titled, "Greenhouse gas emission trends and projections in Europe 2009," click: http://www.eea.europa.eu/publications/eea_report_2009_9. November 12, 2009, http://www.eea.europa.eu/pressroom/newsreleases/non-industrial-emissions-key-for-meeting-kyoto-targets.

January 2010

***RGGI News Release*, "RGGI States Complete Sixth Successful CO_2 Auction."** The 10 Northeast and Mid-Atlantic states participating in the Regional Greenhouse Gas Initiative (RGGI) completed the sixth regional auction of CO_2 allowances on December 2, 2009. All of the allowances for the 2009 vintage offered in the auction (28,591,698) sold at a price of $2.05; 1,599,000 of the 2,172,540 allowances for the 2012 vintage sold at a price of $1.86. In total, the auction yielded $61,587,120.90, increasing the total amount of proceeds from RGGI auctions to more than $494.4 million. The participating states chose to

auction nearly all allowances and to invest the proceeds in a variety of programs aimed at reducing emissions and consumer costs, creating jobs, and building the clean energy economy. The states participating in RGGI designed and implemented the first market-based, mandatory cap-and-trade program in the United States to reduce GHG emissions. Power sector CO_2 emissions are capped at 188 million short tons per year through 2014, at which point the cap will then be reduced by 2.5 percent in each of the four years through 2018, for a total reduction of 10 percent. For more information, visit: http://www.rggi.org/. To learn more about how each state is investing RGGI auction proceeds, click: http://www.rggi.org/states/program_investments. December 4, 2009, http://www.rggi.org/docs/Auction_6_Results_Release_MMrep.pdf.

February 2010

***RGGI News Release*, "States Initiate Bidding Process for March 2010 CO_2 Allowance Auction."** On January 12, 2010, the 10 states participating in the Regional Greenhouse Gas Initiative (RGGI) released the Auction Notice and application materials for their seventh CO_2 allowance auction, scheduled for March 10, 2010. The materials provide potential auction participants the information needed to submit a Qualification Application and signify their intent to bid in RGGI Auction 7. According to the Auction Notice for RGGI Auction 7, 40,612,408 CO_2 allowances for the current control period (2009 and [mostly] 2010 vintages), and 2,137,992 CO_2 allowances for the future control period (2013 vintage), will be offered for sale; states will continue to use a reserve price of $1.86 for all allowances in Auction 7. In addition, the participating states released the auction schedule for 2010; the schedule includes dates for the four quarterly auctions to be held in 2010 and projected quantities of CO_2 allowances to be offered in auctions in 2010 and 2011. The final allowance quantities are published in the Auction Notice prior to each quarterly auction (www.rggi.org/co2-auctions/upcoming_auctions). The March 10, 2010, auction will be the seventh held since the debut of the RGGI auctions on September 25, 2008, and the fifth since compliance obligations under each participating state's CO_2 Budget Trading Program took effect on January 1, 2009. To date, RGGI has auctioned more than 170 million CO_2 allowances; additional information about previous auction results is available at: http://www.rggi.org/co2-auctions/market_monitor. January 12, 2010, http://www.rggi.org/docs/Auction_7_notice_news_release.pdf.

March 2010

"An overview of current research on EU ETS: Evidence from its operating mechanism and economic effect." The following is the Abstract of this article: "The European Union Emissions Trading Scheme (EU ETS) is supposed to be an important mechanism for addressing climate change. Up to now, the theoretical foundation of EU ETS has been widely acknowledged, but empirical research on its current situation has only been published recently or is forthcoming. Therefore, this paper is aimed to summarize the main arguments of empirical studies on the EU ETS, in terms of two aspects, i.e., the operating mechanism and economic effect of the EU ETS, which are two crucial topics and have been attached much attention. Based on the shortcomings of current research and future requirements of the EU ETS evolution, finally, [the authors] also present some further directions of the EU ETS research. Overall, the research overview here may be helpful to recognize the features of the EU ETS and its effect on others." **Yue-Jun Zhang and Yi-Ming Wei**, *Applied Energy*, Available online January 21, 2010, doi:10.1016/j.apenergy.2009.12.019, http://www.sciencedirect.com/science/article/B6V1T-4Y6T82B-6/2/646c17a9b105b72dae5b9a6d624ba61d. (Subscription may be required.)

April 2010

***RGGI News Release*, "RGGI CO_2 Auctions Yield Millions for Investment in Clean Energy, Job Creation."** On March 10, the 10 Northeast and Mid-Atlantic states participating in the Regional Greenhouse Gas Initiative (RGGI) held the first quarterly auction of CO_2 allowances in 2010. All of the

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

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

May 2010

***The Independent*, "Tokyo Launches Asia's First Carbon Emissions Trade Scheme,"** and ***United Press International*, "Tokyo Adopts Carbon-Trading Scheme."** Tokyo launched Asia's first mandatory cap-and-trade scheme on April 1, 2010, in an effort to reduce the city's CO_2 emissions by 25 percent from 2000 levels by 2020. Businesses in Tokyo will have to cut CO_2 emissions by six to eight percent from 2010 to 2014, compared with their highest three-year average from 2002 to 2007. In Phase II of the plan (FY 2015 to 2019), commercial buildings and factories would be required to cut emissions by 17 percent from base-year levels. Businesses in Tokyo can comply with the emissions targets by implementing their own energy-saving measures; purchasing emissions credits from other entities that have reduced their emissions beyond obligatory levels; purchasing credits earned through reduction efforts by small- and medium-sized Tokyo companies; or purchasing renewable energy certificates issued by power generators. Trading under the mandatory cap-and-trade system will begin in FY 2011. April 4, 2010, http://www.independent.co.uk/environment/tokyo-launches-asias-first-carbon-emissions-trade-scheme-1935627.html, and April 8, 2010, http://www.upi.com/Science_News/Resource-Wars/2010/04/08/Tokyo-adopts-carbon-trading-scheme/UPI-39261270751006/.

"Estimates of GHG emission reduction potential by country, sector, and cost." The following is the Abstract of this article: "In this study, emission reduction potentials in GHG are assessed by country, sector, and cost using a GHG emission reduction assessment model with high resolutions with respect to region and technology and high consistency in terms of assumptions, interrelationships, and solution principles. Model analyses show that large potential reductions can be achieved at low cost in developing countries and power sectors. In addition, cost-efficient emission reductions were evaluated for some international emission reduction targets that have been derived on the basis of the principle of common

but differentiated responsibilities among developed and developing countries. If (1) emission reduction measures at negative costs and below 50 $/tCO$_2$ for developed countries, (2) intensity improvement measures for selected sectors at negative costs and below 20 $/tCO$_2$ for major developing countries, and (3) all emission reduction measures with negative costs for other developing countries in 2020 are adopted, then emission reductions of 8.9, 14.8, and 27.7 GtCO$_2$ eq./yr compared to the technology-frozen case can be expected in developed countries, major developing countries, and globally, corresponding to a 11 [percent] decrease, 40 [percent] increase, and 17 [percent] increase from 2005 levels, respectively. Large-scale emission reductions can be achieved even if CO$_2$-intensity targets for major sectors are assumed for major developing countries." **Keigo Akimoto, Fuminori Sano, Takashi Homma, Junichiro Oda, Miyuki Nagashima, and Masanobu Kii**, *Energy Policy*, Available online March 2, 2010, doi:10.1016/j.enpol.2010.02.012, http://www.sciencedirect.com/science/article/B6V2W-4YH9YSC-1/2/4f71ecec7b325c56e3a1993128f3f4e5. (Subscription may be required.)

June 2010

***Reuters*, "EU Approves Bulgaria's Delayed [2008-2012] CO$_2$ Plan,"** and ***France24*, "EU Approves Bulgaria's Long-Delayed CO$_2$ Emissions Plan."** The European Commission has approved Bulgaria's CO$_2$ plan, which will allow companies to join the European Union's (EU) carbon trading scheme. Under the plan, Bulgaria will be able to distribute 42.4 million tonnes of CO$_2$ permits a year to 132 industrial installations; utilities and industrial companies will receive 40.3 million tonnes for 2009 and 34.7 million tonnes for 2010. Bulgaria had been the only EU member state without an approved plan. According to the ministry of environment, industrial companies' EU allowances for 2008 were approximately the same as their emissions. However, industry had more than 6 million excessive credits to trade in 2009. Bulgaria has agreed to cut its CO$_2$ emissions by eight percent compared to their 1988 level, while emitting no more than 130 million tonnes of CO$_2$ a year. April 22, 2010, http://uk.reuters.com/article/idUKLDE62313W20100422, and April 24, 2010, http://www.france24.com/en/20100424-eu-approves-bulgarias-long-delayed-co2-emissions-plan.

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

"Carbon Trading Thickness and Market Efficiency." The following is the Abstract of this article: "This note tests for the efficient market hypothesis (EMH) in the market for CO$_2$ emission allowances in Phase I and Phase II of the European Union Emissions Trading Scheme (EU ETS). As usually is the case in emerging and non-competitive markets such as the EU ETS, trading often not occurs on a frequent basis. This has adverse implications for both the gains from permit trade as well as biases the EMH tests. Variance ratio tests are employed to adjust for the thin trading effect. The results indicate that Phase I –the trial and learning period– was inefficient, whereas the first period under Phase II shows signs of restoring market efficiency." **Alberto Montagnoli and Frans P. de Vries**, *Energy Economics*, Available online April 16, 2010, doi:10.1016/j.eneco.2010.04.001, http://www.sciencedirect.com/science/article/B6V7G-4YVY76D-1/2/d11a8d72d881ff69abb091782d5f6937. (Subscription may be required.)

July 2010

***RGGI News Release*, "Release of Joint Offset Quality White Paper."** The three North American regional climate initiatives – the Northeast and Mid-Atlantic RGGI, the Midwestern GHG Reduction Accord, and WCI – are releasing a joint white paper, entitled, "Ensuring Offset Quality: Design and Implementation Criteria for a High-Quality Offset Program," to promote the consistency and integrity of offsets throughout North America. The three regional programs have joined a cooperative effort to share experiences in the design and implementation of regional cap-and-trade programs, inform Federal decision making on climate change policy, and explore the potential for additional future collaboration. The offset quality white paper outlines the key design and implementation criteria necessary to establish a high-quality offset program. All three regional programs incorporate an offset component in order to reduce compliance costs and increase compliance flexibility for sources covered by the programs. Together, the three regional programs account for approximately 50 percent of the U.S. population, more than 33 percent of U.S. GHG emissions, more than 75 percent of the Canadian population, and 50 percent of Canadian GHG emissions. To view the white paper, visit: http://www.rggi.org/docs/Three_Regions_Offsets_Whitepaper_05_17_10.pdf. May 19, 2010, http://www.rggi.org/docs/3_Regions_Offsets_Announcement_05_17_10.pdf.

***RGGI News Release*, "RGGI CO_2 Auction Fuels Clean Energy Economy with $80.4 Million in Proceeds."** The 10 Northeast and Mid-Atlantic states participating in RGGI, the Nation's first mandatory, market-based program to reduce GHGs, announced the results of the second quarterly auction of CO_2 allowances in 2010. The auction yielded a total of $80,465,566.78 for states to invest in the clean energy initiatives. The 40,685,585 CO_2 allowances offered for the first three-year control period (2009-2011) sold at a price of $1.88; the 2,137,993 CO_2 allowances for the second control period sold at a price of $1.86. Proceeds from all the RGGI auctions now total more than $662.8 million. States are investing the proceeds to improve energy efficiency; accelerate the deployment of renewable energy technologies; and fund consumer benefit programs that further reduce emissions, save consumers money, and create jobs. States are beginning to document both the direct consumer benefits and the broad economic gains resulting from RGGI proceeds in the region. To learn more about how each state is investing RGGI auction proceeds, click: http://www.rggi.org/states/program_investments. June 11, 2010, http://www.rggi.org/docs/Auction_8_NewsRelease_MMReport.pdf.

"Public acceptability of personal carbon trading and carbon tax." The following is the Abstract of this article: "Climate change is one of the greatest challenges confronting the international community requiring action to achieve deep cuts in carbon emissions. The implementation of potentially uncomfortable but necessary policy measures is, though, critically dependent upon public acceptability. This paper reports a novel application of stated preference techniques to explore the influence of key design attributes on the acceptability of a personal carbon trading scheme in isolation and when compared to a carbon tax. Illustrative forecasts from the models developed indicate the importance of design attributes, especially the basis of the initial permit allocation for personal carbon trading and the use to which revenues are put for carbon tax. Results indicate that the 'best' scheme designs could be acceptable to a majority of respondents." **Abigail L. Bristow, Mark Wardman, Alberto M. Zanni, and Phani K. Chintakayala**, *Ecological Economics*, Available online May 23, 2010, doi:10.1016/j.ecolecon.2010.04.021, http://www.sciencedirect.com/science/article/B6VDY-504YBRW-1/2/9fce0bbb1bc93c2468d613c788a2790f. (Subscription may be required.)

August 2010

***RGGI News Release*, "RGGI States Initiate Bidder Application Process for September 2010 CO_2 Allowance Auction."** The 10 Northeast and Mid-Atlantic RGGI states have released the Auction Notice and application materials for the third quarterly CO_2 allowance auction of 2010. The materials provide potential auction participants with the information needed to submit a Qualification Application and indicate their intent to bid in the auction, scheduled for September 8, 2010. According to the Auction Notice, the participating states will offer 45,595,968 CO_2 allowances for the current control period (2009-

2011) and 2,137,992 for the future control period (2012-2014); states will continue to use the reserve price of $1.86. This will be the ninth auction held since the debut of the RGGI auctions on September 25, 2008. To date, the participating states have auctioned more 250 million CO_2 allowances. Additional information about previous auction results is available at: http://www.rggi.org/co2-auctions/market_monitor. July 13, 2010, http://www.rggi.org/docs/Auction_9_Notice_News_Release.pdf.

"An emerging equilibrium in the EU emissions trading scheme." The following is from the Abstract of this article: "The European Union's Emissions Trading Scheme (ETS) is the key policy instrument of the European Commission's Climate Change Program aimed at reducing [GHG] emissions to eight percent below 1990 levels by 2012. A critically important element of the EU ETS is the establishment of a market determined price for EU allowances. This article examines the extent to which several theoretically founded factors including, economic growth, energy prices and weather conditions determine the expected prices of the [EU] CO_2 allowances during the 2005 through to the 2009 period. The novel aspect of [this] study is that [the authors] examine heavily traded futures instruments that have an expiry date in Phase 2 of the EU ETS. [The authors'] study adopts both static and recursive versions of the Johansen multivariate cointegration likelihood ratio test as well as a variation on this test with a view to controlling for time varying volatility effects. [The authors'] results are indicative of a new pricing regime emerging in Phase 2 and point to a maturing market driven by the fundamentals. These results are valuable both for traders of EU allowances and for those policy makers seeking to improve the design of the [EU] ETS." **Don Bredlin and Cal Muckley**, *Energy Economics*, Available online July 6, 2010, doi:10.1016/j.eneco.2010.06.009, http://www.sciencedirect.com/science/article/B6V7G-50G698G-1/2/c891586466e081e24abd5f0e1c6eb2a8. (Subscription may be required.)

Recent Publications

September 2009

"Near-Term Technologies for Retrofit CO_2 Capture and Storage of Existing Coal-fired Power Plants in the United States." The following is the Summary of this White Paper: "Coal-fired power plants, as large point sources of CO_2, are the logical choice for CO_2 mitigation, via CCS and other options. However, continuing life extension of the relatively old and inefficient fleet of existing U.S. coal power plants undermines potential CO_2 mitigation efforts. New coal power plants, with CO_2 capture and geologic storage will slow the rate of growth of CO_2 emissions but the large existing fleet of coal power plants needs to be replaced with lower CO_2 power sources or retrofitted with CCS to significantly lower CO_2 emissions. In the near term, and perhaps medium term, there are inadequate non-coal, low-CO_2 emitting alternatives to replace the existing 50 [percent] coal-based electricity in the U.S. and 40 [percent] worldwide. Therefore to become serious about major CO_2 reductions, consideration should be given to CCS retrofits of existing coal power plants. Existing coal plants represent approximately 33 [percent] of total U.S. CO_2 emissions. As such, the retrofit or rebuild of U.S. existing coal power plants with CCS represents significant opportunities for major CO_2 reductions. Retrofits and rebuilds, however, face many technical, economic and political challenges. The low cost electricity from these mostly paid-off (fully amortized) existing coal plants leads to very high CO_2 avoidance costs. In addition, the simpler and less capital-intensive retrofit add-on for post-combustion CCS leads to large net efficiency and capacity losses. This type of retrofit will likely favor the newer supercritical steam cycle coal units that already have good [sulfur dioxide (SO_2)] and [nitrogen oxide (NO_X)] controls. Rebuilds of the older subcritical steam cycle coal units have added advantages and flexibility. Due to the lower efficiency and generally higher SO_2, NO_X, [mercury (Hg)] and particulate emissions of the older existing subcritical coal units, rebuilds can avoid most net efficiency and capacity losses while reducing all emissions to near zero. This is an important advantage. Rebuilds can come in the form of a state-of-the-art supercritical coal boiler steam cycle of post- or oxy-combustion CCS or an integrated gasification combined cycle (IGCC) for pre-combustion CCS. Combined cycle repower rebuilds can also be fueled with natural gas (without CCS) or off-site CCS based on coal gasification to synthetic natural gas or [hydrogen (H_2)]. This

enables major repowering capacity increases and CO_2 reductions at old coal plant sites considered hopeless for retrofit CCS." To view this White Paper, visit: http://web.mit.edu/mitei/docs/reports/simbeck-near-term.pdf.

"Carbon Capture and Storage: Full-Scale Demonstration Progress Update." The following is from the Background of this document: "Secure, reliable and affordable energy supplies are needed for sustainable economic growth, but increases in associated CO_2 emissions, and the associated risk of climate change, are a cause of major concern. The IEA analysis in Energy Technology Perspectives 2008 (ETP) projects that the CO_2 emissions attributable to the energy sector will increase by 130 [percent] by 2050 in the absence of new policies or supply constraints as a result of increased fossil fuel usage. To address this increase will require an energy technology revolution involving greater energy efficiency, increased renewable energies and nuclear power, and the near-decarbonization of fossil fuel-based power generation. Nonetheless, fossil fuel usage is expected to continue to play a major role in delivering global energy supply, with the latest IEA projections showing a global increase in fossil fuel usage through 2030. The only technology available to mitigate GHG emissions from large-scale fossil fuel usage is CCS. The ETP BLUE scenario, which assessed strategies for reducing GHG emissions by one-half in 2050, concluded that CCS will need to contribute one-fifth of the necessary emissions reductions to achieve stabilization in the most cost-effective manner. CCS is therefore an essential part of the portfolio of technologies that is needed to achieve deep global emission reductions." This International Energy Agency (IEA) document is available at: http://www.iea.org/G8/docs/ccs_g8july09.pdf.

"WCI Regional Emissions Database Options White Paper." The following is from the Purpose and Background of this White Paper: "The purpose of the Options White Paper is to present the fundamental design choices for the [Western Climate Initiative (WCI)] Regional Emissions Database (RED). The RED will be a system of database components developed by The Climate Registry (The Registry) for collecting, transferring, storing and analyzing GHG emissions data from facilities and entities in WCI states and provinces. This White Paper will explore numerous options for managing data and designing database functions in order to provide guidance to The Registry. A key function of the RED will be to meet WCI partner jurisdiction data collection, recovery and analysis needs while at the same time minimizing the burden of satisfying WCI partner jurisdictions' collective and individual GHG reporting requirements as well as the Federal GHG reporting requirements. After engaging in internal review and discussion of, and receiving stakeholder comments on, the White Paper, WCI will provide The Registry with guidance and direction on how it should proceed in defining detailed specifications for the RED. The options that are suggested throughout the White Paper are based on realistic expectations for the cost and schedule of the project." To download WCI's Regional Emissions Database Options White Paper, go to: http://www.westernclimateinitiative.org/component/remository/func-startdown/129/.

October 2009

"A Technical Basis for Carbon Dioxide Storage." The following is from the Introduction of this document: "The geological storage of CO_2 may enable real progress in the global effort to make meaningful near-term reductions in greenhouse gas (GHG) emissions especially from large-point source emitters such as power plants, refineries, cement plants and steel mills. CCS is not a panacea, but it does offer a tangible means to deal with large volumes of gas emissions by using technologies already in-hand, and improving them. CCS is a bridging technology during the transition to an alternative energy future. Optimism for its success is based on industrial experience, but even proponents acknowledge that there are several issues that need to be addressed before it can achieve widespread application. Typically, CCS or CO_2 capture and storage is defined as the integrated process of gas separation at industrial plants, transportation to storage sites, and injection into subsurface formations. US government agencies will use the word 'sequestration' instead of 'storage,' but the meaning is the same and the acronym for all, including many international organizations, is CCS. When CO_2 is stored or sequestered, it is injected into the pore space of rocks deep in the earth's subsurface (at depths typically greater than

1,000 meters) and carefully designed operational protocols are observed to provide for safe operations. Once the CO_2 is safely injected in the ground, it is expected to remain there for a geological period of time. Drawing on the wide variety of practical experience in the oil and gas industry, this document addresses key technical aspects and technological innovations used in the geological storage of CO_2. The text cites numerous examples of projects comparable in size and scope to large CCS operations. The document is not a comprehensive review of geological storage or industry best practice, but in its four chapters addresses frequently discussed areas where there is likely to be particular value in sharing industry knowledge." To view the rest of this document, visit: http://www.cplccp.net/co2_storage_technical_book.html#Contents. (Subscription may be required.)

"A Technical Appraisal of the Feasibility for CO_2 Sequestering Operations for the Gorgon Gas Field Development Proposal – Phase IV." The following is from the Executive Summary of this document: "The Greater Gorgon Area gas fields lie off the northwest coast of Australia in an area known geologically as the Carnarvon Basin. These gas fields represent a world class gas resource containing approximately 25 [percent] of all the natural gas discovered to date in Australia. It is proposed that the exploitation of these fields will commence with the development of the Gorgon and Jansz-Io fields with the natural gas piped to [an LNG] processing facility to be constructed on Barrow Island some 60 km off the northwest coast of Western Australia. The natural gas in the Gorgon field contains approximately 14 [percent] CO_2 while the natural gas in the Jansz-Io field contains less than [one percent] CO_2. This CO_2 will be produced with the hydrocarbon gases as the fields are developed. Along with minor concentrations of other substances, the CO_2 will be separated from the hydrocarbon gases at the proposed LNG processing facility to be built on Barrow Island. Established global practice is for the reservoir CO_2 to be vented to the atmosphere; however the Gorgon Joint Venturers plan to dispose of this reservoir [CO_2] by injecting it underground into the Dupuy Formation beneath Barrow Island. Chevron, as Operator of the Gorgon Joint Venture (GJV), propose to utilize the Dupuy Formation beneath Barrow Island as the host reservoir for the permanent (i.e., >1,000 years) disposal of the 1.5-3.1 trillion standard cubic feet (TCF) of CO_2 which is expected to be produced in conjunction with hydrocarbon gases from the Gorgon and Jansz-Io gas fields. The objective of permanently disposing of the CO_2 in this deep underground reservoir is to prevent it entering the atmosphere, where it would act as a greenhouse gas and potentially contribute to global climate change. The Gorgon CO_2 disposal project will be potentially the largest such project in the world, and has attracted international attention." The complete Executive Summary is available at: https://extra.co2crc.com.au/modules/pts2/download.php?file_id=3505&rec_id=1826.

November 2009

Investigating the prospects for Carbon Capture and Storage technology in India. The following is the Executive Summary of this document: "The use of CCS technologies to mitigate the risk of climate change has received relatively little attention until recent years. They are, however, increasingly being proposed as potentially important contributors in global action on climate change. For example, the Stern Review notes that: '[CCS] is a technology expected to deliver a significant portion of the emission reductions. The forecast growth in emissions from coal, especially in China and India, means CCS technology has particular importance.' Chinese companies have recently started planning and constructing pilot scale (and larger) CCS schemes. The Indian Government and industry has, however, tended to take a more cautious approach. In this context, this study aims to examine whether CCS could be a suitable option for India and, if so, what role would be appropriate for various stakeholders, including developed countries, to play in its development within India. The primary research reported here is a survey-based exploration of stakeholder views on the suitability of CCS for India and how CCS could be developed and deployed. There is a lively debate about whether CCS should be deployed in India. It is expected that coal will play a significant role in providing energy and electricity in India until 2050, at least, despite measures to significantly increase the role of other energy sources. Although CCS is not seen as an immediate priority for Indian Government or industry, survey respondents do expect it to become more important in the future, particularly for industry. Thus, it is appropriate to consider

whether CCS is a technically feasible option for India and, if so, if and when it should be used. Although there are some significant challenges, it seems likely that introducing CO_2 capture at Indian power plants could be technically feasible especially in locations where it is considered appropriate to apply 'capture ready' concepts for new build plants before CCS is deployed. Identifying both suitable storage sites and routes for transporting captured CO_2 safely to these sites also requires careful consideration. One important factor in shaping views on whether CCS is an appropriate option for India is the proposed timing of any deployment of possible projects. In particular, survey respondents typically suggest that it is necessary for developed countries to demonstrate CCS at commercial scale before any commercial-scale CCS projects in India are considered. In fact, most survey respondents suggested that any consideration of deployment of CCS in India should be within an appropriate international framework, including measures for knowledge sharing and technology transfer that consider local conditions carefully. The importance of establishing reasonable methods to help with early engagement on CCS between India and developed countries was also noted by some respondents. For example, one respondent suggested that consideration should be given to establishing local knowledge/training centers within India. Survey respondents also suggested that it was reasonable for developed country governments to contribute to financing of both initial projects and wider deployment of CCS in India. This could partly be through international finance institutions such as the World Bank, the International Monetary Fund and the Asian Development Bank." To view the rest of the document, go to: http://www.geos.ed.ac.uk/sccs/India__CCS_Report-Oct2009.pdf.

"IEA Technology Roadmap: Carbon Capture and Storage." The following is the Forward of this document: "Current trends in energy supply and use are patently unsustainable – economically, environmentally and socially. Without decisive action, energy-related emissions of CO_2 will more than double by 2050 and increased oil demand will heighten concerns over the security of supplies. We can and must change our current path, but this will take an energy revolution and low-carbon energy technologies will have a crucial role to play. Energy efficiency, many types of renewable energy, CCS, nuclear power and new transport technologies will all require widespread deployment if we are to reach our greenhouse gas emission goals. Every major country and sector of the economy must be involved. The task is also urgent if we are to make sure that investment decisions taken now do not saddle us with suboptimal technologies in the long-term. There is a growing awareness of the urgent need to turn political statements and analytical work into concrete action. To spark this movement, at the request of the G-8, the International Energy Agency (IEA) is developing a series of roadmaps for some of the most important technologies. These roadmaps provide solid analytical footing that enables the international community to move forward on specific technologies. Each roadmap develops a growth path for a particular technology from today to 2050, and identifies technology, financing, policy and public engagement milestones that need to be achieved to realize the technology's full potential. Roadmaps also include special focus on technology development and diffusion to emerging economies. International collaboration will be critical to achieve these goals. This roadmap on CCS identifies, for the first time, a detailed scenario for the technology's growth from a handful of large-scale projects today to over three thousand projects by 2050. It finds that the next decade is a key "make or break" period for CCS; governments, industry and public stakeholders must act rapidly to demonstrate CCS at scale around the world in a variety of settings. The roadmap concludes with a set of near-term actions that stakeholders will need to take to achieve the roadmap's vision. The IEA presents this roadmap not only to provide additional focus and urgency to the international discussions about the importance of CCS as a technology solution, but to chart the course to make CCS a reality worldwide." The complete technology roadmap is available at: http://www.iea.org/papers/2009/CCS_Roadmap.pdf.

December 2009

Carbon Dioxide Capture for Storage in Deep Geologic Formations – Results from the CO_2 Capture Project. The following is from the Preface of this document: "The CO_2 Capture Project (CCP) is a collaborative partnership of eight of the world's leading energy companies and three government organizations. The initiative undertakes research and develops technologies to help make CCS a

practical reality for reducing global CO_2 emissions and tackling climate change – one of the great international challenges of [this] time. Since 2000, CCP has been at the very forefront of advancing CCS; a process that involves capturing the CO_2 emitted from industrial and energy-related sources and then securely storing the CO_2 deep underground in geological formations. Phase 1 of CCP identified next generation capture technologies that had the potential to deliver performance and efficiency improvements resulting in close to a 50 [percent] reduction in the cost of CO_2 capture. It also pioneered a risk-based approach for geological site selection, operation and abandonment; and developed new CO_2 monitoring tools and the science behind CO_2 geological storage. In Phase 2, CCP has continued to build on achievements in capture and storage. The culmination of this five year study is found in this book." To view the rest of this document, visit: http://www.co2captureproject.org/ccp_results3.html.

An Ideal Portfolio of CCS Projects and Rationale for Supporting Projects. The following is from the Executive Summary of this document: "The potential impact from climate change brought about by increasing atmospheric concentrations of [GHGs] is widely acknowledged as a global problem that requires urgent global action. CCS will need to play an important role within the portfolio of approaches required to achieve a material reduction in [CO_2] for two reasons, namely: (1) The continued importance of fossil fuels to future energy supply; and (2) The scale of CO_2 emissions from industries where there are limited other abatement options. Accordingly, the [G-8] supports the launch of 20 large-scale projects by 2010 that will help to bring about broad scale deployment of CCS by 2020. The Global CCS Institute was launched by the Australian Government in April 2009. The objective of the Global CCS Institute is to accelerate the broad-based commercial deployment of CCS technologies, so that CCS forms an integral part of the portfolio of technologies required to make significant reductions in the level of CO_2 emissions. In June 2009, L.E.K. Consulting (L.E.K.) was commissioned by the Global CCS Institute to characterize an Ideal Portfolio of CCS project types and develop a Rationale for Supporting Projects." To view the full document, click: http://www.globalccsinstitute.com/downloads/FP_Global_CCS_Portfolio_Final%20Report_2009OCT16_v2.pdf.

Near Zero Emissions Coal (NZEC) Initiative. The following is from the Executive Summary of this document: "The China-UK Near Zero Emissions Coal (NZEC) Initiative has examined the merits of various options for CCS in China, including the potential for the development of CCS technology and its deployment in the future. It was developed under the wider 2005 EU-China NZEC Agreement which aims to demonstrate CCS in China and the EU. Reconciling the potential for economic growth in China with the global need to reduce CO_2 emissions, as well as making best use of national resources of coal, is a complicated issue. A range of measures is being put in place in China to tackle [GHG] emissions, including energy efficiency improvements as well as the introduction of significant amounts of energy from nuclear, wind, solar and other renewable sources. For the power generation and energy intensive industrial sectors, such as iron/steel and cement, all of which remain heavily dependent on coal, CCS is the only option that can ensure a significant reduction in CO_2 emissions." To view the entire report, click: http://www.nzec.info/en/assets/Reports/China-UK-NZEC-English-031109.pdf.

January 2010

Clean Coal/CCS Technology Development Pathways. The following is from the Executive Summary of this document: "Senator Byron L. Dorgan believes that further R&D as well as larger-scale deployment will be essential for the continued use of [the] Nation's fossil energy resources, especially coal, in a carbon-constrained world. He has clearly heard the message from a range of interests that technology research, development, and demonstration (RD&D) are critical to resolve the twin challenges of energy security and climate change. Because a consensus on coal technology direction has been lacking in discussions about climate change, Senator Dorgan invited a wide-ranging group of organizations to participate in a meeting to better develop a strategic pathway for clean coal and CCS technology approaches. Each of these expert panels comprised representatives from industry, academia, government, and non-governmental organizations and was asked to focus on a specific area or issue

regarding the Nation's path toward effective and economic CCS deployment. The areas and issues addressed included: (1) Funding Levels and Timelines; (2) Financial Mechanisms; (3) Industrial Sector Interests and Application; (4) Addressing Economic Impacts; (5) Administration and Implementation; (6) Overcoming the CCS Penalty; (7) Domestic and International Deployment; and (8) Metrics for Success." More information about Senator Dorgan's Clean Coal and Carbon Capture and Sequestration Technology Development Pathways Initiative is available at: http://dorgan.senate.gov/issues/energy/cleancoal/index.cfm. The complete report can be found at: http://dorgan.senate.gov/issues/energy/cleancoal/cleancoal.pdf.

National and Sectoral GHG Mitigation Potential: A Comparison Across Models. The following is from the Executive Summary of this document: "This paper focuses on mitigation potential to provide a comparative assessment across key economies. GHG mitigation potential is defined here to be the level of GHG emission reductions that could be realized, relative to the projected emission baseline in a given year, for a given carbon price. Estimates of GHG mitigation potential projected in the future can be obtained via models. These estimates vary depending on the type of model employed and on the parameters and underlying assumptions used. This comparative analysis of model results aims to: identify areas of agreement in results across different models; enhance understanding of what is driving any differences in results; and indicate possible gaps and areas for improvement in data or modeling analysis. Overall, such a comparative analysis can enhance transparency and contribute to a better informed climate change policy-making process. This paper compares model estimates of national and sectoral GHG mitigation potential across six key OECD GHG-emitting economies around the world: Australia, Canada, the EU, Japan, Mexico and the [United States]. Data for these countries were obtained across the time horizon of 2005-2050 from a total of 19 models, including models that are used to inform climate policymakers in each of these economies. For these six economies, this paper examines the model structure, baseline and policy assumptions, and then compares GHG mitigation potential estimates across the available models. Due to differences in regional and economy-wide aggregation across these models, GHG mitigation potential is compared across [five] models for Australia, [nine] models for Canada, 12 models for the [EU], [eight] models for Japan, [five] across Mexico, and 13 models across the [United States]." To view the full document, click: http://www.iea.org/papers/2009/Mitigation_potentials.pdf.

February 2010

Best Practices for Public Outreach and Education for Carbon Storage Projects. The following is from the Executive Summary of this document: "This manual represents a distillation of best practices for public outreach and education to support CO_2 storage projects; it is derived from the experiences of the seven RCSPs. Within the scope of the RCSP initiative, the partnerships have recognized the importance of conducting public outreach in tandem with the pilot-scale field tests. The goal of these field tests is to validate CO_2 storage opportunities in each of the RCSP regions. Results obtained from these efforts are providing the foundation for future commercialization efforts – and even more extensive outreach efforts. The best practices highlighted in this manual add a valuable perspective by addressing the practical implications of implementing CO_2 storage projects across a variety of U.S. geologic and cultural settings. The objective of the Public Outreach and Education for Carbon Storage Projects Best Practices Manual is to communicate the lessons learned and to recommend best practices emerging from the first six years of public outreach conducted by the seven RCSPs. The manual is intended to assist project developers in understanding and adopting best practices in outreach to support CO_2 storage projects. Although project developers are the primary audience for this document, other stakeholders may find the contents of this document of interest." To view this NETL document, visit: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/BPM_PublicOutreach.pdf.

Guidelines for Public Consultation and Participation in CCS Projects. The following is from the Introduction of this document: "The implementation of CCS projects is challenging not only from a technical perspective, but also due to the way that CCS technology touches on controversial subjects.

These include human health and safety, climate change, power plant construction, use of fossil fuel resources, risk perception, and several social issues that do not necessarily relate directly to CCS technology. Companies looking to move forward with large-scale demonstration projects face difficult choices regarding when, how and where to begin a public outreach program. A CCS project is a local project but is carried out within the context of national and even international debate. This means that the group of stakeholders or potentially interested parties is considerably broad. This social process of creating support for a CCS project moreover, must occur in parallel with that of storage site selection. Knowledge of regional geology and social factors within local communities is required to execute projects successfully. A proactive approach to education and an outreach program designed to identify real and perceived risks, whilst engaging stakeholders, can build public trust through transparency and information delivery. Although the type of risks involved will vary at each stage of a CCS project, the main challenge from a community engagement perspective lies in the storage component. Nevertheless, understanding all the technologies - capture, transport, and storage - is important from a public education standpoint and it is not advisable to isolate storage when communicating with the public." To view the full document, click: http://www.bellona.org/filearchive/fil_Guidelines_public_support_for_CCS_Bellona.pdf.

Carbon Capture, Sequestration, and Emissions Trading: The Outlook for Global Carbon Markets. The following is a summary of this document: "Human-generated [CO_2] and other [GHGs] are acknowledged by the scientific community as having a contributing effect on global climate change. Two major avenues for controlling the spread of carbon are being explored: CCS, in which [CO_2] is caught at the point of production and piped to a secure facility for long-term storage, and carbon emissions trading, in which producers are allocated allowances for their anticipated carbon production, and can sell any that they do not use (or buy what they need to compensate for any over-production of carbon). This study examines both CCS and the carbon emissions trading market, delineating major drivers and issues (technical, regulatory, and business) for each sector." The complete document is available for purchase at: http://www.abiresearch.com/research/1004439-Carbon_Capture%2c_Sequestration_and_Emissions_Trading.

March 2010

Carbon Capture and Sequestration. The following is a summary of this document: "The last five years have seen a burst of activity around the prospective CCS industry, driven by concerns about the effects of CO_2 emissions on the Earth's climate. Because emissions from large point sources are a primary source of global climate change, CCS is considered a required set of technologies to mitigate, if not eliminate, the likely rise in the Earth's temperature. However, to date, no commercial-scale integrated power plant with CCS exists. What's more, the addition of CCS systems to both existing and future power plants will likely add between 50 [percent] and 70 [percent] to the cost of producing electricity. One fundamental cause of uncertainty for the emerging CCS economy is the lack of a clear price for carbon emissions. While the obstacles to full-scale implementation of CCS are significant, however, there is no doubt that the CCS industry will grow rapidly over the next two decades. This report examines the market issues, technological issues, and opportunities for players in all phases of the CCS industry, from capture technology to transport and storage. It also provides detailed market forecasts for all the major regions of the world, including costs and revenues. While the authors believe that most of the targets for CCS deployments between now and 2030 are optimistic, the industry will grow, under the most aggressive scenario, to reach annual revenues of $221.5 billion in 2030." The complete document is available for purchase at: http://www.researchandmarkets.com/reportinfo.asp?cat_id=0&report_id=1191502&q=CO2&p=3.

Carbon Capture and Storage in North East England. The following is from the Executive Summary of this document: "North East England is the birthplace of modern energy innovation, famous for the development of the steam turbine and electrical lighting. Industry, technologies and coal from the North East powered the global industrial revolution of the last century and the North East now wishes to lead the world in the next low carbon technology revolution. The Regional Development Agency One North

East, the Association of North East Councils (ANEC), industrial partners and regional universities are working together to respond to this challenge. The region aims to lead the world in the development of next generation CCS technology responding to the combined challenges of carbon pricing, climate change, rising energy costs and concerns over future security of supply. This North East CCS prospectus has developed from a recognition of the challenges and opportunities for industry and for the UK economy from both industrial process capture and clean coal power generation. The prospectus outlines the key policy drivers for this technology on an international level and the urgent requirement for the development of this technology. The prospectus gives an overview of the leading expertise and assets of the region for CCS, the strategic risks and benefits of CCS for the region and the UK and current status of key projects and next steps." To view the entire prospectus, click: http://www.onenortheast.co.uk/lib/liReport/15938/carbon%20capture%2032pp%20A4%207%20aw%20web.pdf.

Policy Brief: Carbon Dioxide Accounting in Carbon Capture and Sequestration. The following is from the Introduction of this document: "Accounting for the amount of CO_2 that is captured and sequestered is necessary to demonstrate the effectiveness of CCS as an emissions mitigation tool, and to protect the integrity of a GHG emission reduction program. This will require not only careful accounting of the amount of CO_2 injected in geologic sequestration (GS) projects, but also accounting to ensure that captured CO_2 is ultimately sequestered. In addition, any CO_2 that escapes to the atmosphere across the CCS chain will have to be properly quantified and accounted for under the regime. While accounting for CO_2 in each step in the CCS chain – capture, transport, and sequestration – is important, accounting at the sequestration site is perhaps the most difficult issue to address because it involves monitoring for and measurement of leakage…This brief deals with accounting across the entire CCS chain, but focuses primarily on accounting at GS sites, and hence addresses monitoring at these sites for the purpose of GHG accounting. Accounting for possible emissions from leakage at GS sites involves a range of technical and policy questions. Policy choices are bounded by technological feasibility as well as other considerations such as cost, measurement accuracy and precision, funding stability, and intergenerational equity. In developing [their] recommendations [the authors] analyzed the status of CCS under a GHG emission reduction program, GHG accounting policy options, and leakage monitoring technology. The underlying goal of these recommendations is to design policies and institutions that will ensure CCS supports the integrity of a carbon cap. This is critical for both industry and regulators to justify investment in CCS." To view the complete document, written for Carnegie Mellon University's (CMU) CCSReg Project, go to: http://www.ccsreg.org/pdf/GHG%20Accounting%20Policy%20Brief_01042010.pdf.

April 2010

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

quantities of CO_2, rather than emitting this GHG to the atmosphere." The complete White Paper is available at: http://www.adv-res.com/pdf/ARI%20CCS-CO2-EOR%20whitepaper%20FINAL%203-10-10.pdf.

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

May 2010

Wabamun Area CO_2 Sequestration Project (WASP). The following is from the Introduction of this document: "In order to properly assess the storage capacity, injectivity, and confinement of potential deep saline [formations] in the Wabamun region it is critical to construct a static geological model that characterizes the Nisku [formation] with sufficient accuracy. The model, presented in this section of the report, provides a working understanding of potential repositories, traps, and sealing mechanisms that will be needed to design and implement a CO_2 injection project in the area of interest. As with most geocellular models, it incorporates geological information (stratigraphy, facies mapping, and structure) with estimates of critical flow parameters (e.g., porosity and permeability) at all locations. This model serves as the basis for the fluid flow simulations – a key exercise in predicting the potential for CO_2 injection and storage in the targeted [formations]." More information on the WASP Project is available at: http://www.ucalgary.ca/wasp/. The complete document is available at: http://www.ucalgary.ca/wasp/WASP-FinalReport_(Full).pdf.

Clean Coal: An Industrial Strategy for the Development of Carbon Capture and Storage across the UK. The following is from the Executive Summary of this document: "The development of CCS in the UK, starting with coal-fired power stations, presents a major opportunity for UK businesses to capitalize on an expanding global industry. The International Energy Agency's (IEA) CCS roadmap foresees a massive requirement for capital investment in CO_2 capture, transport, and storage equipment, estimated at almost $100 billion from 2010 to 2020, increasing to over $5,000 billion from 2010 to 2050. The European Union has already recognized the importance of CCS through its aim of having up to 12 CCS demonstration projects operational by 2015 and has put in place two funding packages designed to part-fund CCS projects: the New Entrant Reserve (NER) mechanism and the Economic Recovery Package. The UK is uniquely placed to take advantage of this new market. The geology means [the UK is] well served with offshore storage sites, sufficient to take CO_2 from [domestic] projects and potentially also to

handle storage from other countries. [The UK] already [has] long experience in many of the areas that are relevant to implementing CCS, including power and offshore engineering and the high value added project management, legal and financial services needed to deliver CCS projects." The document is available for download at: http://www.decc.gov.uk/Media/viewfile.ashx?FilePath=What we do\UK energy supply\Energy mix\Carbon capture and storage\1_20100317090007_e_@@_CleanCoalIndustrialStrategy.pdf&filetype=4.

Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008. The following is from the Executive Summary of this document: "An emissions inventory that identifies and quantifies a country's primary anthropogenic sources and sinks of [GHGs] 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 [GHGs], 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 2008, total U.S. [GHG] emissions were 6,956.8 Tg CO_2 Eq. Overall, total U.S. emissions have risen by approximately 14 percent from 1990 to 2008. Emissions declined from 2007 to 2008, decreasing by 2.9 percent (211.3 Tg CO_2 Eq.). This decrease is primarily a result of a decrease in demand for transportation fuels associated with the record high costs of these fuels that occurred in 2008. Additionally, electricity demand declined in 2008 in part due to a significant increase in the cost of fuels used to generate electricity. In 2008, temperatures were cooler in the United States than in 2007, both in the summer and the winter. This lead to an increase in heating related energy demand in the winter, however, much of this increase was offset by a decrease in cooling related electricity demand in the summer." To view the complete report, go to: http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_Report.pdf.

June 2010

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

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

Climate Change Indicators in the United States. The following is the Introduction of this document: "Over the last several decades, evidence of human influences on climate change has become increasingly clear and compelling. There is indisputable evidence that human activities such as electricity production and transportation are adding to the concentrations of [GHGs] that are already naturally present in the atmosphere. These heat-trapping gases are now at record-high levels in the atmosphere compared with the recent and distant past. Warming of the climate system is well documented, evident from

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

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

July 2010

"Carbon Capture and Storage: Progress and Next Steps." The following is from the Background of this document: "Since 2008, significant progress has been made to address the high-level recommendations on CCS made by the [Group of Eight (G-8)] Leaders. CCS has advanced towards commercialization, notably through the commissioning of CCS pilot plants, continued learning from plants already in operation and the development of legal and regulatory frameworks. Several governments have committed to provide over $26 billion in funding support for demonstration projects. International collaborative and public outreach activities have increased substantially. The mapping of suitable storage sites is underway in various countries and a guide for CCS-ready plant has been developed. Critical to the deployment of CCS, however, is the experience to be gained from the operation of large-scale demonstration projects. While much progress has been achieved, the recommendation made by the G-8 Leaders at the 2008 Hokkaido Toyako Summit that 20 large-scale CCS demonstration projects should be launched by 2010 remains a challenge and will require that governments and industry work in concert. To measure progress against the goal of launching 20 large-scale CCS projects by 2010, the International Energy Agency (IEA), CSLF and the Global CCS Institute reviewed government initiatives and developed a set of assessment criteria against which to review progress by industry. Over the past two years, governments have made significant commitments that will facilitate the launch of 19 to 43 large-scale CCS integrated demonstration projects by 2020. This is promising, as government support is vital to helping projects under development overcome the final hurdles. A study commissioned by the Global CCS Institute (2010) identified 80 large-scale integrated projects at various stages of development around the world. Notable efforts from both government and industry can be found in the United States, the European Union, particularly the United Kingdom, Canada and Australia. Five large-scale CCS projects are in operation, all commissioned prior to the 2008 G-8 Summit. From the pool of 80 projects, one new project, the Australian Gorgon project, has been

launched and is proceeding to construction." The complete IEA document is available at: http://www.iea.org/papers/2010/ccs_G-8.pdf.

Final Complementary Policies White Paper. The following is from the Background of this WCI document: "The WCI Partners have recommended a comprehensive regional effort to reduce emissions of global warming pollution, combining a broad cap-and-trade program with complementary policies to achieve the WCI 2020 regional emissions goal. Complementary policies can address market barriers that would otherwise limit the use of low-cost GHG emission-reduction options and reduce emissions from sources excluded from the cap-and-trade program. Thus, complementary policies can lower the overall cost of reducing GHG emissions. This view is supported by the 2008 economic analysis of WCI's cap-and-trade design, which incorporated complementary policies related to energy efficiency and tailpipe emission standards. The analysis found that the WCI 2020 reduction goals can be achieved with small overall net savings due to reduced energy expenditures exceeding the direct costs of greenhouse gas emission reductions. As part of the WCI 2009-2010 Workplan, the WCI Partner jurisdictions formed the Complementary Policies Committee. The charge of the Committee is to recommend to the WCI Partner jurisdictions those policies which, if harmonized across multiple states and provinces both within and outside the WCI Partner jurisdictions, would help achieve the regional emissions reduction goals and assist with the transition to a low-carbon economy. By harmonizing complementary policies, the WCI Partner jurisdictions intend to foster increased market certainty, encourage trade among participating jurisdictions, reduce administrative costs and streamline regulatory procedures." To view the final white paper, click: http://www.westernclimateinitiative.org/component/remository/func-startdown/255/.

August 2010

Design for the WCI Regional Program. The following is from the section, titled, "The [Western Climate Initiative (WCI)] Cap-and-Trade Program," of this document: "As part of a comprehensive strategy to reduce GHG emissions, the WCI Partner jurisdictions have recommended a market-based program that provides an incentive to limit emissions and promotes technological innovation. Cap-and-trade has proven to be a successful means of reducing air pollution. It also is considered one of the most cost-effective and reliable strategies for pricing carbon emissions and providing emitters of GHG emissions with an incentive to limit pollution. With the trading component, cap-and-trade allows emitters to be flexible and creative in how to make needed reductions. The WCI program design includes a broad scope, encompassing nearly 90 percent of economy-wide emissions in the WCI Partner jurisdictions. The merits of pricing emissions broadly throughout the economy have been recognized in most of the recent [Federal] proposals in the [United States]. A forthcoming study by the National Research Council also recommends a broad scope, stating: 'An economy-wide carbon pricing policy would provide the most cost-effective reduction opportunities, would lower the likelihood of significant emissions leakage, and could be designed with a capacity to adapt in response to new knowledge.' Similarly, in 2009 the National Round Table on the Environment and the Economy published a report on carbon pricing in Canada, including: 'To achieve stated reduction targets at the least possible cost, all emissions must be covered as fully as possible. This requires a unified pricing policy that consciously takes into account all emissions across all sectors and all jurisdictions.'" The complete WCI document is available for download at: http://westernclimateinitiative.org/the-wci-cap-and-trade-program/program-design.

Energy Technology Perspectives 2010. The following is from the Executive Summary of this document: "ETP 2010 feeds into this momentum by providing an IEA perspective on how low carbon energy technologies can contribute to deep CO_2 emissions reduction targets. Using a techno-economic approach that assesses costs and benefits, the book examines least-cost pathways for meeting energy policy goals while also proposing measures to overcome technical and policy barriers. Specifically, ETP 2010 examines the future fuel and technology options available for electricity generation and for the key end-use sectors of industry, buildings and transport. For the first time, this edition includes an analysis of OECD Europe, the United States, China and India, which together account for about 56 [percent] of

today's global primary energy demand. It then sets out the technology transitions needed to move to a sustainable energy future, and provides a series of technology roadmaps to chart the path. Other new elements of ETP 2010 include chapters on financing, behavioral change, the diffusion of technologies amongst developed and emerging economies, and a discussion of the environmental impacts of key energy technologies." To read the IEA press release, click: http://www.iea.org/press/pressdetail.asp?PRESS_REL_ID=395. The document is available for purchase at: http://www.iea.org/w/bookshop/add.aspx?id=401.

Legislative

September 2009

***Oregon Governor Ted Kulongoski Press Release*, "Governor Kulongoski Signs Climate Change Legislation into Law."** Oregon Governor Ted Kulongoski signed a series of bills on July 22, 2009, aimed at reducing GHG emissions, ensuring low carbon fuel, investing in green technology and jobs, and increasing energy efficiency in homes and businesses across the state. The series of bills signed into law include: (1) Senate Bill 38, which will expand the reporting requirements for GHG emissions to imported electricity, natural gas, and transportation fuel and enhance the state's ability to track the amount of GHGs emitted in Oregon; (2) Senate Bill 101, which requires that new electricity sources must be as least as clean as natural gas plants; (3) Senate Bill 79, which increases energy efficiency in building codes by 10 to 15 percent for residential structures and by 15 to 25 percent for commercial structures; (4) House Bill 2186, which authorizes the Environmental Quality Commission (EQC) to develop a low carbon fuel standard; and (5) House Bill 2626, which provides local governments with the authority to issue bonds for residential and business energy efficiency projects. These bills are available at: http://www.leg.state.or.us/. July 22, 2009, http://governor.oregon.gov/Gov/P2009/press_072209.shtml.

October 2009

***U.S. Senator John Kerry News Release*, "Kerry, Boxer Introduce 'Clean Energy Jobs and American Power Act.'"** On September 30, 2009, Senators John Kerry and Barbara Boxer introduced "The Clean Energy Jobs and American Power Act" to create clean energy jobs, reduce pollution, and protect American security by enhancing domestic energy production and addressing global climate change. The Clean Energy Jobs and American Power Act seeks to reduce carbon emissions by 20 percent by 2020 and 80 percent by 2050 from 2005 levels. The reductions will be possible through a "Pollution Reduction and Investment" system that allows companies to reduce carbon emissions at a minimal cost; rewards companies that have already taken action; and creates incentives for the companies that are most efficient in their actions in the future. In particular, the bill would: (1) provide $10 billion over 10 years to support research and development (R&D) of new CCS technologies for the next generation of coal-fired power plants; (2) provide additional funding to those who quickly implement carbon CCS technology on new or retrofitted plants; and set performance standards to provide guidance to the industry on advanced technology implementation. A summary of the bill is available at: http://kerry.senate.gov/cleanenergyjobsandamericanpower/pdf/Summary.pdf. The full text of the bill is available at: http://kerry.senate.gov/cleanenergyjobsandamericanpower/pdf/bill.pdfhttp:/kerry.senate.gov/cleanenergyjobsandamericanpower/pdf/bill.pdf. September 30, 2009, http://kerry.senate.gov/cfm/record.cfm?id=318435.

November 2009

***U.S. Senator John Barrasso Press Release*, "Barrasso Bill Builds Framework for Carbon Capture."** Wyoming Senator John Barrasso recently introduced a bill to ensure the long-term viability of

coal by establishing a framework for long-term storage of CO_2 and addressing pore space ownership below Federal lands. Modeled after similar legislation that was approved at the state level in Wyoming, the bill states that pore space under Federal lands belongs to the Federal government and that the mineral estate will be dominant over the space estate, meaning the mineral owner's use would take precedence over the use by the pore space owner. To view the bill, go to: http://climate.alston.com/files/docs/Barrasso_Pore_Space_bill.pdf. October 23, 2009, http://barrasso.senate.gov/public/index.cfm?FuseAction=PressOffice.PressReleases&ContentRecord_id=8221b0c4-c872-ab72-2106-f8df2492a5c5.

December 2009

***U.S. Senator John Barrasso Press Release*, "Barrasso, Bingaman Introduce Bill to Address Global Warming."** U.S. Senators John Barrasso and Jeff Bingaman introduced a bill that encourages the development of clean air technology that removes CO_2 from the atmosphere and permanently stores it. The Carbon Dioxide Capture Technology Act (S.2744), which will create an award system for scientists and researchers, states a program would be established by a Federal commission under DOE. Members of the commission would include climate scientists, physicists, chemists, engineers, business managers, and economists. Awards will go to the public and private entities that design technology to remove and permanently store CO_2 directly from the atmosphere. Once the technology is developed, the property rights would be shared by the United States and the inventor. To view the "Carbon Dioxide Capture Technology Act" (S.2744), click: http://www.govtrack.us/congress/bill.xpd?bill=s111-2744. November 12, 2009, http://barrasso.senate.gov/public/index.cfm?FuseAction=PressOffice.PressReleases&ContentRecord_id=e98e0891-081e-ddac-1ae4-15c3905ebef0&Region_id=&Issue_id=.

January 2010

***U.S. Senator Susan Collins Press Release*, "Senators Collins, Cantwell Propose Carbon Auction: Bill Reduces Emissions, Returns Revenue to Consumers."** On Friday, December 11, 2009, U.S. Senators Susan Collins (Maine) and Maria Cantwell (Washington) introduced legislation to address potential climate change and spur job growth in clean energy technologies. The Carbon Limits and Energy for American Renewal (CLEAR) Act aims to achieve a 20 percent reduction in GHG emissions by 2020 and 83 percent by 2050. The CLEAR Act will set up a mechanism for selling carbon shares and return most of the revenue to consumers. According to a report released by Senator Cantwell, a typical family of four would receive tax-free monthly checks from the government averaging $1,100 per year (or $21,000 from 2012 to 2030) from the CLEAR Act, opposed to a net cost increase of $175 per year under the cap-and-trade bill passed by the U.S. House of Representatives. By establishing a predictable price on the carbon, the bill would provide an incentive for businesses to develop and deploy clean energy technology. Producers would bid in monthly auctions for CO_2 shares, with the resulting revenue split for two functions: 75 percent would be refunded to American citizens; and 25 percent would be used towards clean energy R&D, assistance for communities and workers transitioning to a clean energy economy, energy efficiency programs, and reductions in non-CO_2 GHGs. A video of the bill's introduction and links to other relevant CLEAR Act background documents are available at: http://cantwell.senate.gov/issues/CLEARAct.cfm. December 11, 2009, http://collins.senate.gov/public/continue.cfm?FuseAction=PressRoom.PressReleases&ContentRecord_id=7f22c3c6-802a-23ad-4b2b-8f9bf16148e2&CFID=18273045&CFTOKEN=65256272.

February 2010

***Yahoo News*, "France Adapts Carbon Tax Climate Plan."** On January 20, 2010, France outlined a new, government-proposed carbon tax, which would reduce CO_2 emissions while protecting businesses. The legislation amends a previously rejected effort that aimed at encouraging French consumers to

conserve energy. The French government said it planned to maintain a tax of 17 Euros per tonne of CO_2 with compensation for households. There will be sector-specific measures, as certain "sensitive and energy-intensive sectors" will receive special exemptions. In addition, the government plans to consult with businesses and environmentalists in February 2010 on how to structure the tax. The French Government also said it will push for a European Union (EU)-wide carbon tax that would also apply to imports. The new bill is expected to be submitted to parliament on July 1, 2010. January 20, 2010, http://news.yahoo.com/s/afp/20100120/sc_afp/franceenvironmentclimatepoliticstax_20100120152737.

March 2010

Carbon Capture and Sequestration. The following is a summary of this document: "The last five years have seen a burst of activity around the prospective CCS industry, driven by concerns about the effects of CO_2 emissions on the Earth's climate. Because emissions from large point sources are a primary source of global climate change, CCS is considered a required set of technologies to mitigate, if not eliminate, the likely rise in the Earth's temperature. However, to date, no commercial-scale integrated power plant with CCS exists. What's more, the addition of CCS systems to both existing and future power plants will likely add between 50 [percent] and 70 [percent] to the cost of producing electricity. One fundamental cause of uncertainty for the emerging CCS economy is the lack of a clear price for carbon emissions. While the obstacles to full-scale implementation of CCS are significant, however, there is no doubt that the CCS industry will grow rapidly over the next two decades. This report examines the market issues, technological issues, and opportunities for players in all phases of the CCS industry, from capture technology to transport and storage. It also provides detailed market forecasts for all the major regions of the world, including costs and revenues. While the authors believe that most of the targets for CCS deployments between now and 2030 are optimistic, the industry will grow, under the most aggressive scenario, to reach annual revenues of $221.5 billion in 2030." The complete document is available for purchase at:
http://www.researchandmarkets.com/reportinfo.asp?cat_id=0&report_id=1191502&q=CO2&p=3.

Carbon Capture and Storage in North East England. The following is from the Executive Summary of this document: "North East England is the birthplace of modern energy innovation, famous for the development of the steam turbine and electrical lighting. Industry, technologies and coal from the North East powered the global industrial revolution of the last century and the North East now wishes to lead the world in the next low carbon technology revolution. The Regional Development Agency One North East, the Association of North East Councils (ANEC), industrial partners and regional universities are working together to respond to this challenge. The region aims to lead the world in the development of next generation CCS technology responding to the combined challenges of carbon pricing, climate change, rising energy costs and concerns over future security of supply. This North East CCS prospectus has developed from a recognition of the challenges and opportunities for industry and for the UK economy from both industrial process capture and clean coal power generation. The prospectus outlines the key policy drivers for this technology on an international level and the urgent requirement for the development of this technology. The prospectus gives an overview of the leading expertise and assets of the region for CCS, the strategic risks and benefits of CCS for the region and the UK and current status of key projects and next steps." To view the entire prospectus, click:
http://www.onenortheast.co.uk/lib/liReport/15938/carbon%20capture%2032pp%20A4%207%20aw%20web.pdf.

Policy Brief: Carbon Dioxide Accounting in Carbon Capture and Sequestration. The following is from the Introduction of this document: "Accounting for the amount of CO_2 that is captured and sequestered is necessary to demonstrate the effectiveness of CCS as an emissions mitigation tool, and to protect the integrity of a GHG emission reduction program. This will require not only careful accounting of the amount of CO_2 injected in geologic sequestration (GS) projects, but also accounting to ensure that captured CO_2 is ultimately sequestered. In addition, any CO_2 that escapes to the atmosphere across the CCS chain will have to be properly quantified and accounted for under the regime. While accounting for

CO_2 in each step in the CCS chain – capture, transport, and sequestration – is important, accounting at the sequestration site is perhaps the most difficult issue to address because it involves monitoring for and measurement of leakage…This brief deals with accounting across the entire CCS chain, but focuses primarily on accounting at GS sites, and hence addresses monitoring at these sites for the purpose of GHG accounting. Accounting for possible emissions from leakage at GS sites involves a range of technical and policy questions. Policy choices are bounded by technological feasibility as well as other considerations such as cost, measurement accuracy and precision, funding stability, and intergenerational equity. In developing [their] recommendations [the authors] analyzed the status of CCS under a GHG emission reduction program, GHG accounting policy options, and leakage monitoring technology. The underlying goal of these recommendations is to design policies and institutions that will ensure CCS supports the integrity of a carbon cap. This is critical for both industry and regulators to justify investment in CCS." To view the complete document, written for Carnegie Mellon University's (CMU) CCSReg Project, go to: http://www.ccsreg.org/pdf/GHG%20Accounting%20Policy%20Brief_01042010.pdf.

April 2010

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

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

May 2010

***E&E News PM*, "Study Finds Economic Opportunities in Cantwell-Collins Bill."** A study written by the Institute for Policy Integrity at New York University School of Law states that "The Carbon Limits and Energy for America's Renewal (CLEAR) Act" introduced by Senators Maria Cantwell (Washington) and Susan Collins (Maine) in December 2009 would provide a price on carbon that could drive investments in a range of emission reduction strategies. The report also states that the bill would generate enough benefits to offset the legislation's costs to business. The CLEAR Act (S. 2877) would require energy producers to bid in monthly auctions for carbon shares and direct 75 percent of the auction revenue as a refund to compensate the public for increased energy costs, with the remaining 25 percent going toward clean energy technology research and development (R&D). More details about the CLEAR Act can be found at: http://cantwell.senate.gov/issues/CLEARAct.cfm, and the legislation can be viewed at: http://cantwell.senate.gov/issues/CLEAR%20Act%20-%20Leg%20Text.pdf. The study by the Institute for Policy Integrity, titled, "CLEAR & The Economy," is available at: http://policyintegrity.org/documents/ClearandTheEconomy.pdf. April 12, 2010, http://www.eenews.net/eenewspm/2010/04/12/1/. (Subscription may be required.)

June 2010

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

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

July 2010

***Washington Business Journal*, "Montgomery County Council Supports Carbon, Energy Tax."** The United States' first locally based carbon tax was passed by Montgomery County Council (Maryland) members on May 19, 2010. The measure would charge $5 per ton for any entity that emits more than 1 million tons of CO_2 in a calendar year. The money raised from this tax, expected to be approximately $15 million, would finance programs such as the Home Energy Loan Program, which helps finance energy-efficiency projects. May 19, 2010, http://washington.bizjournals.com/washington/stories/2010/05/17/daily32.html.

August 2010

***Senator Jay Rockefeller Press Release*, "Rockefeller, Voinovich Introduce Carbon Capture and Storage Deployment Act of 2010,"** and ***The Register-Herald*, "Legislation Promotes Carbon Capture and Storage Techniques."** On July 14, 2010, U.S. Senators John D. Rockefeller and George V. Voinovich introduced legislation that promotes research and creates incentives to develop and deploy full-scale CCS technologies. The "Carbon Capture and Storage Deployment Act of 2010" represents a comprehensive approach to realizing widespread deployment of CCS activities. If approved, the legislation will authorize an industry-government R&D program in DOE's Office of Fossil Energy (FE) to stimulate additional CCS-related R&D. The "Pioneer Phase" of the legislation calls for the deployment of 20 gigawatts (GW) of CCS capacity; tax credits would be provided based on the amount of CO_2 captured at the facilities, providing price certainty for investors. After CCS technology is deployed on the first 10

GW of generating capacity, the next phase of deployment would require power plants permitted between bill enactment and completion of the "Pioneer Phase" to be retrofitted with CCS technologies. To view the proposed legislation, click: http://rockefeller.senate.gov/press/CCS1X9.pdf. July 14, 2010, http://rockefeller.senate.gov/press/record.cfm?id=326356&, and July 15, 2010, http://www.register-herald.com/local/x540033253/Legislation-promotes-carbon-capture-and-storage-techniques.

Announcements

September 2009

NETL Technologies Earn Prestigious R&D 100 Awards. The Office of Fossil Energy (FE) has captured four 2009 Research and Development (R&D) 100 Awards for technologies developed at NETL. Since 2000, NETL researchers and NETL-supported technologies have won more than 30 R&D 100 Awards, which are presented to the 100 most technically significant products to enter the marketplace in the past year. For more information on the four winning technologies, click: http://www.fossil.energy.gov/news/techlines/2009/09048-NETLTechnologies_Earn_Prestigious_.html.

October 2009

Carbon Sequestration Documentary Wins Coveted Aurora Award. A DOE-supported film about carbon sequestration received a 2009 Gold Aurora Award in the documentary category for nature/environment. The film, titled, "Out of the Air – Into the Soil: Land Practices That Reduce Atmospheric Carbon Levels," discusses the effects that proper landscape management can have on carbon absorption. To learn more, go to: http://www.fossil.energy.gov/news/techlines/2009/09061-CCS_Documentary_Wins_Award.html. To view the documentary, visit: http://www.undeerc.org/pcor/documentary/.

CCS Technical Forum Launched. TUV NEL launched a new CCS technical forum to address issues and challenges associated with CCS. The forum will bring together CCS developers, operators, support services, and measurement specialists and regulators; support CCS deployment; establish solutions and options; help industry meet their CCS regulatory monitoring and reporting requirements; and provide up-to-date information on technological and legislative developments. The forum is available at: http://ccs.tuvnel.com/default.asp.

November 2009

Poland Joins International CCS Group. On October 12, 2009, the Carbon Sequestration Leadership Forum (CSLF) announced Poland as its 24th member. CSLF is a voluntary climate initiative of developed and developing nations that represents more than 3.5 billion people, or approximately 60 percent of the world's population. To read the CSLF news release, go to: http://www.cslforum.org/pressroom/publications/pr_poland_101209.pdf.

Exchanges Plan CO_2 Trading Market. The Tokyo Stock Exchange and the Tokyo Commodity Exchange have announced plans to create Japan's first market for trading GHG emissions. The market, expected to begin as early as next year, will allow for companies to purchase credits for GHG emission reduction projects in developing countries. For more information, visit: http://www.tse.or.jp/english/index.html and http://www.tocom.or.jp/.

December 2009

PCOR Releases Documentary. The Plains CO_2 Reduction (PCOR) Partnership has released a series of 30-minute documentaries, including its most recent release, titled, "Managing Carbon Dioxide: The Geologic Solution." This video discusses the history of geologic CO_2 sequestration. To view the documentary, visit: http://www.undeerc.org/PCOR/documentary/default.aspx.

U.S.-China Clean Energy Announcements. On November 17, 2009, the United States and China announced a package of measures to strengthen cooperation on clean energy between the two countries. Among the six fact sheets released, the two countries announced the establishment of the U.S.-China Clean Energy Research Center, the U.S.-China Energy Efficiency Action Plan, and the U.S.-China Renewable Energy Partnership. To learn more, view the White House Press Release at: http://www.whitehouse.gov/the-press-office/us-china-clean-energy-announcements.

January 2010

NETL Launches Online CCS Database. The National Energy Technology Laboratory's (NETL) CCS Database, which includes 192 proposed and active CCS projects worldwide (38 capture, 46 storage, and 108 capture and storage), provides information about the efforts of various industries, public groups, and governments to develop and deploy CCS technology; lists technologies being developed for capture, testing sites for CO_2 storage, and estimations of costs and anticipated project completion dates; and uses Google Earth to illustrate the location of projects and provide links for further information. The database is available at: http://www.netl.doe.gov/technologies/carbon_seq/database/index.html.

Nation's First GHG Reporting System/Monitoring to Begin in 2010. Beginning January 1, 2010, the U.S. Environmental Protection Agency (EPA) will require large facilities in the United States to collect GHG data under a new reporting system that will guide development of the best policies and programs to reduce emissions and fight potential climate change. To learn more about the new reporting system and reporting requirements, visit: http://www.epa.gov/climatechange/emissions/ghgrulemaking.html.

UN Online Tool to Track Nations' Pledges on Climate Change. The United Nations Environment Program (UNEP) has launched a new online tool that will keep track of countries' promises and proposals on combating climate change. The Climate Change Tracker, which currently lists the pledges and proposals from 25 countries and the EU's 27 member states, will be updated as new proposals are made, comparing all pledges with the goal of keeping global temperature rise at or less than two degrees centigrade from pre-industrial levels. For more information, visit: http://www.un.org/apps/news/story.asp?NewsID=33226&Cr=copenhagen&Cr1.

February 2010

Total Inaugurates CCS Demonstration Facility. On January 11, 2010, Total inaugurated its CCS demonstration facility in Lacq, southwestern France. The demonstration facility uses an oxy-combustion carbon capture technology, then pipes the CO_2 approximately 17 miles to the Rousse geological storage site where it is injected into a depleted natural gas reservoir located 4,500 meters underground. Approximately 120,000 metric tons of CO_2 will be captured and stored over the next two years, followed by three years of monitoring. For more information, visit: http://www.total.com/en/about-total/news/news-940500.html&idActu=2265.

CCS Website Launched. The Zero Emission Resource Organization (ZERO) launched a CCS website aimed at providing comprehensive and transparent information on CCS, including answers to questions related to CCS, a map, and facts on the world's various CCS projects. The website can be accessed at: http://www.zeroco2.no/.

March 2010

UNIDO Developing CCS Roadmap. The United Nations Industrial Development Organization (UNIDO) announced that it will develop a global technology roadmap for CCS in industrial processes. The project will draw from the methodologies and experience of its partners, the Norwegian Ministry of Petroleum and Energy and the Global CCS Institute, to provide a vision of industrial CCS storage up to 2050, with a focus on developing countries with energy-intensive industries. The roadmap will inform policymakers and investors about the potential of CCS, as well as the milestones that need to be achieved. For more information, visit: http://www.unido.org/index.php?id=7881&tx_ttnews[tt_news]=444&cHash=2e3e3e65dc.

DOE Awards Supercomputing Hours. DOE awarded 1.6 billion supercomputing processor hours to 69 research projects through the Innovative and Novel Computational Impact on Theory and Experiment (INCITE) Program. Projects receiving INCITE awards utilize complex simulations to accelerate groundbreaking technologies. Projects selected feature research in carbon sequestration, potential climate change, improving climate models, and other areas. To view the DOE press release, click: http://www.energy.gov/news2009/8557.htm.

April 2010

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

May 2010

Wyoming EOR Reservoir Database Updated. The updated Wyoming Enhanced Oil Recovery (EOR) Database Version 2.1 was released on March 16, 2010. The new reservoir field database, which includes interactive mapping, can be found at: http://eori.gg.uwyo.edu/Internet%20Mapping.asp. To view the updated EOR reservoir database, visit: http://eori.gg.uwyo.edu/database.asp.

ETI Launches "Next Generation" CCS Project. The Energy Technologies Institute (ETI) launched a research project designed to accelerate the development of CCS. The updated technology is expected to be capable of capturing a higher proportion of greenhouse gas (GHG) emissions than current technologies. For more information, click: http://www.businessgreen.com/business-green/news/2259886/eti-launches-generation-ccs.

EPA Finalizes 2008 U.S. GHG Inventory. EPA released the 15th annual "U.S. Greenhouse Gas Inventory Report," which shows a 2.9 percent decrease in overall emissions from 2007 to 2008 due to the drop in CO_2 emissions associated with fuel and electricity consumption. In 2008, total emissions of the six primary GHGs (CO_2, methane [CH_4], nitrous oxide [NO_X], hydrofluorocarbons [HFCs], perfluorocarbons [PFCs], and sulfur hexafluoride [SF_6]) were equivalent to 6,957 million metric tons of CO_2. Although overall emissions dropped in 2008, emissions remain 13.5 percent higher than the 1990 total. For more details, visit: http://yosemite.epa.gov/opa/admpress.nsf/0/B57052C72AB2DA3E852577060059E04E.

June 2010

Projects Selected for DOE's UCR Program. DOE selected seven projects to participate in their University Coal Research (UCR) Program. The projects are aimed at advancing coal research and development (R&D) while providing research exposure to a new generation of scientists and engineers.

For more information on the projects, visit: http://www.fossil.energy.gov/news/techlines/2010/10014-DOE_Selects_University_Projects.html.

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

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

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

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

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

July 2010

CSLF Releases CCS Papers. The Carbon Sequestration Leadership Forum (CSLF) has released a series of papers that present solutions to common issues surrounding CCS. The inFocus series of issue papers covers topics such as: safety and practicality of geological storage; CO_2 capture; and CO_2 transportation. The papers are available at: www.cslforum.org. To learn more about DOE's role in the CSLF, visit: http://www.fossil.energy.gov/programs/sequestration/cslf/index.html.

RGGI Offset Handbook Now Available. The Regional Greenhouse Gas Initiative (RGGI) has made their Offset Handbook for the RGGI Model Rule and Model Offset Applications and Monitoring and Verification (M&V) Reports available online. The purpose of the Offset Handbook is to explain RGGI Model Rule provisions for offset projects, and to explain the documentation required in model templates

to offset project Consistency Applications and M&V Reports. The RGGI Offset Handbook is available at: http://www.rggi.org/offsets/process/offset_handbook.

NMED Releases Draft Rule for GHG Cap-and-Trade Program. The New Mexico Environment Department (NMED) released a preliminary draft rule for a cap-and-trade program to reduce statewide greenhouse gas (GHG) emissions that would initially apply to sources that emit at least 25,000 metric tons of CO_2 per year. The draft rule defines conditions that would allow New Mexico to implement the program as part of the Western Climate Initiative (WCI) regional program. For additional information, as well as a link to the draft rules, visit: http://www.nmenv.state.nm.us/cc/.

New South Wales Atlas for CCS Launched. The Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) launched a new Atlas that outlines statewide opportunities for the application of CCS in New South Wales. The Atlas works through the geology of New South Wales, as well as other considerations required for CCS projects, to provide a template for regional assessments that can be used by other states and countries. For more information, click: http://www.co2crc.com.au/dls/media/10/NSW_Atlas.pdf.

CMU Releases Model Legislation. Anchored by the Department of Engineering and Public Policy at Carnegie Mellon University (CMU), the CCS Regulatory (CCSReg) Project has released recommended statutory and regulatory actions that could enable large-scale CCS. To read the document, entitled, "Model Legislation: The Carbon Capture and Sequestration Regulatory Act of 2010," visit: http://www.ccsreg.org/pdf/CCS_Draft_Leg_05192010.pdf.

August 2010

Online CCS Network Launched. CO2Sense Yorkshire, a business support and market development program, has set up an online network for organizations interested in developing CCS technologies within the Yorkshire and Humber CCS cluster in the United Kingdom. For more information, visit the Yorkshire and Humber CCS Network website at: http://www.co2sense.org.uk/networks/.

Fourth Quarterly Report on the Secondary Market for RGGI Allowances Now Available. The states participating in the Regional Greenhouse Gas Initiative (RGGI) published the fourth quarterly report on the secondary market for RGGI CO_2 allowances from independent market monitor Potomac Economics. The report, which addresses the period from September 2009 to January 2010, is part of Potomac's ongoing monitoring of the RGGI auction and the secondary markets where CO_2 allowances are traded. The complete "Report on the Secondary Market for RGGI CO_2 Allowances" is available at: http://www.rggi.org/docs/MM_Secondary_Market_Report_Q4.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.