THE NETL CARBON SEQUESTRATION NEWSLETTER: ANNUAL INDEX

SEPTEMBER 2006 – AUGUST 2007

This is a compilation of the past year's monthly National Energy Technology Laboratory Carbon Sequestration Newsletter. The newsletter is produced by the NETL to provide information on activities and publications related to carbon sequestration. It covers domestic, international, public sector, and private sector news. This compilation covers newsletters issued between September 2006 and August 2007. 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 Information that has become outdated (e.g. conference dates, paper submittals, etc.)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 2006

"Carbon Sequestration Technology Roadmap and Program Plan (2006)." The Department of Energy (DOE) National Energy Technology Laboratory (NETL) has released its annual update of the "Carbon Sequestration Technology Roadmap and Program Plan (Roadmap)." The Carbon Sequestration Program is managed within DOE's Office of Fossil Energy and implemented through the National Energy Technology Laboratory (NETL). The Roadmap (1) defines the current status of carbon dioxide (CO_2) capture and sequestration technology, (2) identifies research pathways that lead to achievement of the Carbon Sequestration Program goal, and (3) describes efforts that the DOE program is pursuing along priority pathways. Among the past year's Program highlights contained in the Roadmap are the following: 1. The Regional Carbon Sequestration Partnerships have progressed to a validation phase in which they will conduct 25 field tests involving the injection of CO_2 into underground formations where it will be stored and monitored. 2. Pilot-scale tests and modeling of amine-based CO_2 capture have shown that operating an amine stripper at vacuum can reduce energy use 5–10 percent per unit of CO_2 captured; and 3. Novel metal organic frameworks have shown significant potential as CO_2 sorbents. http://www.netl.doe.gov/publications/carbon_seq/2006%20Sequestration%20Roadmap%20FINAL.pdf.

"Carbon Sequestration Project Portfolio (2006)." The Department of Energy National Energy Technology Laboratory has released its annual update of the Carbon Sequestration Project Portfolio (Project Portfolio). The Carbon Sequestration Project Portfolio 2006 is a comprehensive document, designed to serve as a key resource of the National Energy Technology Laboratory's Carbon Sequestration Program. The Project Portfolio includes maps of project distribution; a copy of the new "Carbon Sequestration Technology Roadmap and Program Plan 2006"; budget information; details about each individual research project; programmatic papers; and an index of project participants. The Project Portfolio is designed to be printed for use in a three-ring binder, or to be viewed online. Frequent updates will be posted to ensure that any new information is incorporated. To view and/or download the various sections of this document, go to the pdf table of contents: http://www.netl.doe.gov/publications/carbon_seq/project%20portfolio/project_portfolio2/1_CarbonSequestrationProjectPortfolio2005.pdf. To access each section of the document though the table of contents online, click on: http://www.netl.doe.gov/publications/carbon_seq/project%20portfolio/project_portfolio2/table_contents.pdf. http://www.fossil.energy.gov/programs/sequestration/publications/programplans/2006/project_portfolio_sequestration_06.pdf.

October 2006

DOE Fossil Energy Techline, **"Critical Carbon Sequestration Assessment Begins: Midwest Partnership Looks at Appalachian Basin for Safe Storage Sites. Seismic Surveys to Determine Viability of Rock Formations for CO_2 Storage."** The US Department of Energy's National Energy Technology, through the work of the Midwest Regional Carbon Sequestration Partnership, is conducting seismic testing of the Appalachian Basin geology to determine whether the sites can serve as reservoirs for carbon dioxide (CO_2) storage. The testing is being conducted at FirstEnergy Corp's R.E. Burger plant in Shadyside, Ohio, and in nearby areas. The program falls under the President's Global Climate Change Initiative, which aims to reduce greenhouse gas intensity-the ratio of greenhouse gas emissions to economic output-by 18 percent by 2012. An earlier phase of the project determined that the sandstone and limestone rock formations around the plant held potential for serving as a repository for CO_2-estimated storage of at least 200 years. The current phase of the project utilizes truck-mounted seismic equipment to generate pulses in the ground around the Burger plant. The seismic signal from the

vibrations is used to create images of the subsurface area and determine its suitability for injecting CO_2. The surveys focuses on the area immediately surrounding the Burger Plant but also extends 10 miles in length, and along other routes in order to provide a "quasi three-dimensional" survey, at a lower cost than a full-three dimensional survey. Wells will be drilled at depths of 4,000 to 7,000 feet, well below drinking water supplies, which are at 100 feet in that region. Eventually, CO_2 will be injected into the brine field to test the feasibility of geologic sequestration in this type of setting. Battelle of Columbus, Ohio, leads this project in cooperation with the Midwest Regional Carbon Sequestration Partnership, which includes 38 partners in seven states: Indiana, Kentucky, Maryland, Michigan, Ohio, Pennsylvania, and West Virginia. In addition to this geologic project, the Battelle-led partnership will later conduct two additional geologic and three terrestrial projects throughout its multi-state region. To see a video of NETL project manager Charlie Byrer discussing the project, go to: http://ims.netl.doe.gov/video/TL-Byrer-256k.wmv. September 12, 2006, http://www.fossil.energy.gov/news/techlines/2006/06052-Sequestration_Assessment_Begins.html.

November 2006

DOE Techline, **"DOE Project Injects 700 Tons of Carbon Dioxide Into Texas Sandstone Formation; Researchers to Determine the Ability of Brine Formations to Sequester Greenhouse Gas," and** ***United Press International,*** **"US Tests CO_2 Underground Storage Options."** As part of the Carbon Sequestration program, the US Department of Energy's National Energy Technology Laboratory is following up on its 2004 effort to determine the feasibility of storing carbon dioxide in brine formations though the Frio Brine Project. The Frio Brine test site is located 40 miles northeast of Houston, Texas near Dayton, Texas. The latest stage in the research consists of pumping more than 700 tons of carbon dioxide (CO_2) underground to determine how the CO_2 moves though brine-filled highly porous sandstone. This sandstone is representative of formations found worldwide. The Frio Brine project is a carbon sequestration project funded by the US Department of Energy and managed by the DOE's National Energy Technology Laboratory. The lead project partner is the University of Texas at Austin's Bureau of Economic Geology, and the research team includes: Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, the US Geological Survey, and Sandia Technologies LLC. The Frio Brine Pilot project falls within the Gulf Coast Carbon Center area, a participant in DOE's Southeast Regional Carbon Sequestration Partnership. In 2004, the researchers used computer models to predict that the CO_2 would stop quickly after traveling a short distance through the formation, and that the researchers were able to accurately measure the pattern of movement and the final distribution of the CO_2. For the current year-long monitoring project, researchers have begun to collect chemistry, pressure and temperature data, and by the end of the project, will have collected information to better assess and monitor larger-scale, longer-duration injections of CO_2. "This current project will ... help to advance our injection and monitoring technology to the point where we know what formations can safely and effectively store greenhouse gases in each region of the country to address global climate change," said Assistant Secretary for Fossil Energy Jeffrey Jarrett. October 12, 2006, http://www.netl.doe.gov/publications/press/2006/06057-Frio_CO2_Injection.html, and October 12, 2006, http://www.upi.com/NewsTrack/view.php?StoryID=20061012-011940-4991r.

China Daily, **"Nation Ready To Join US FutureGen Power Project."** At the 12th US-China Joint Commission Meeting on Scientific and Technological Co-operation, China announced that it plans to join the FutureGen International Partnership. The US Department of Energy's plans to collect about $950 million in international funds to help to build FutureGen, a zero-emission, coal-fired electric and hydrogen production plant. As a member of the International Partnership, China would need to contribute $10 million to the FutureGen program. India and South Korea are already members of the International Partnership. China's Huaneng Group, the country's leading power corporation, is one of the corporate members that are part of the FutureGen Industrial Alliance. Final talks between the US and China regarding the International Partnership will be held once the draft of the general agreement for the

FutureGen partners is finalized by the US Department of State. November 19, 2006, http://www.chinadaily.com.cn/china/2006-10/19/content_711519.htm.

December 2006

Fossil Energy Techline, **"Secretary of Energy Announces Nearly $24 Million in Grants for Carbon Sequestration Research."** On October 23, US Department of Energy Secretary Samuel W. Bodman announced grant recipients for carbon capture projects. Nine projects will receive a total of almost $24 million toward the development of novel and cost effective technologies utilizing carbon dioxide (CO_2) capture from coal-fired power plants, and sequestration of the CO_2. Recipients of the funds will contribute $8 million in cost sharing funds. The projects support the President's Global Climate Change Initiative, which requires an 18 percent reduction in US greenhouse gas intensity (a ratio of greenhouse gas emissions to economic output) by 2012. Established by the Department of Energy's Office of Fossil Energy and managed by the National Energy Technology Laboratory, the Carbon Sequestration Program aims to develop safe, effective, low-cost carbon sequestration technologies; as well as reduction of greenhouse gas emissions and controlling climate change. Grant recipients are working on three methods of CO_2 capture: 1.) Precombustion capture, in which fuel is gasified to form a mixture of hydrogen and CO_2, called synthesis gas or 'syngas,' where CO_2 is captured from the syngas before it is combusted; 2.) Post-combustion, which involves capturing CO_2 from flue gas after fuel has been combusted in air; and 3.) Oxycombustion, in which fuel is combusted in pure, or nearly pure, oxygen rather than in air, producing an exhaust mixture of CO_2 and water that can easily be processed to produce pure CO_2. See the news link below for a list of the recipients of the grants and a description of the projects. October 23, 2006, http://www.fossil.energy.gov/news/techlines/2006/06061-Sequestration_Research_Grants.html.

Fossil Energy Techline, **"Department of Energy Advances Commercialization of Climate Change Technology."** On October 31, the US Department of Energy (DOE) Assistant Secretary Jeffrey D. Jarrett announced plans to provide $450 million in federal funding to support seven tests for the advancement of carbon sequestration technologies in the United States. The announcement was delivered during the Assistant Secretary's attendance at the Asia-Pacific Partnership on Clean Development and Climate, a multilateral partnership comprised of government and private sector partners from Australia, China, India, Japan, the Republic of Korea, and the United States. DOE will distribute the funding over the next ten years and will work with the seven Regional Carbon Sequestration Partnerships to develop large volume sequestration tests. This will be a follow-on activity to the current work being completed by the Partnerships, which has involved working to characterize their regions' opportunities and existing infrastructure for carbon sequestration. Results from the newly funded development phase will then be used to identify deployment opportunities for carbon sequestration technologies throughout North America. Additionally, the results will be applied to further development of DOE's FutureGen power plant, a zero emissions coal-fired power plant and potential sites for other plants similar to FutureGen. DOE's seven Regional Carbon Sequestration Partnerships currently include more than three hundred organizations in forty states, three Indian nations, and four Canadian provinces. They have collaborated to establish NATCARB, a comprehensive mapping tool which has identified sources that produce carbon dioxide and sinks where it can be stored. (For more information concerning the Regional Carbon Sequestration Partnerships and links to their current activities, please refer to the following: Midwest Regional Carbon Sequestration Partnership (Battelle Columbus Laboratories, Ohio), http://198.87.0.58/; Midwest Geological Sequestration Consortium (The Board of Trustees of the University of Illinois, Illinois State Geological Survey), http://www.sequestration.org/; West Coast Regional Carbon Sequestration Partnership (California Energy Commission), http://www.westcarb.org/; Big Sky Regional Carbon Sequestration Partnership (Montana State University), http://www.bigskyco2.org/ ; Southwest Regional Partnership on Carbon Sequestration (New Mexico Institute of Mining and Technology), http://www.southwestcarbonpartnership.org/; Southeast Regional Carbon Sequestration Partnership

(Southern States Energy Board), http://www.secarbon.org/; Plains CO_2 Reduction Partnership (University of North Dakota Energy and Environmental Research Center), http://www.undeerc.org/pcor/.) October 31, 2006, http://www.fossil.energy.gov/news/techlines/2006/06062Carbon_Sequestration_Testing_Suppo.html.

January 2007

***FutureGen Alliance,* "Xstrata Coal Joins FutureGen Alliance," and *Xstrata Press Release,* "Xstrata Coal Commits $25 Million To FutureGen Clean Coal Project."** Xstrata Coal has become a member of the FutureGen Alliance (Alliance) and will put $25 million toward the $1 billion FutureGen Initiative. FutureGen is a project to build a first-of-a-kind near zero emissions 275 megawatt (MW) prototype coal-fueled power plant. The Alliance is a non-profit consortium of global electric utilities and coal companies working with the US Department of Energy to design and build the FutureGen to generate electricity by hydrogen-driven turbines and capture and permanently store carbon dioxide deep underground. Xstrata is the world's largest exporter of thermal coal, and is joining the Alliance to demonstrate its commitment to work collaboratively to reduce greenhouse gas emissions resulting from the use of coal in power generation. Xstrada joins 11 other companies to become a member of the Alliance. These other companies include: American Electric Power, Anglo American, BHP Billiton, the China Huaneng Group, CONSOL Energy Inc., E.ON US, Foundation Coal, Rio Tinto Energy America, Peabody Energy, PPL Corporation, and Southern Company. Four candidate sites are in the running to host FutureGen, two in Texas and two in Illinois. The US Department of Energy is reviewing the candidate sites in accordance with the National Environmental Policy Act prior to the Alliance's selection of a final site by late summer 2007. For more information visit http://futuregenalliance.org/. December 6, 2006, http://www.futuregenalliance.org/news/releases/pr_12-06-06.pdf, and December 7, 2006, http://www.freemarketnews.com/Press-Release.asp?nid=12585.

***E&E News PM,* "Supreme Court Appears Divided in Greenhouse Gas Case," and *Reuters,* "Supreme Court Hears First Global Warming Case."** The Supreme Court considered the oral arguments of its first global warming case on November 29. The case, *Massachusetts v. EPA,* was brought against the US Environmental Protection Agency (EPA) by Massachusetts, 11 other US states, and 13 organizations. The plaintiff argues that greenhouse gases from vehicles and factories should be regulated by the US government. The EPA maintains that it lacks the authority to limit greenhouse gases such as carbon dioxide (CO_2), and that even if it did have this authority, the science on global warming is so uncertain no regulation should be made. The plaintiffs argue that if the greenhouse gases fit the federal Clean Air Act's definition of a pollutant, EPA has the power to regulate the emissions. During the hour long oral arguments, the justices examined whether the plaintiffs had standing under the Constitution to challenge EPA's decision not to regulate vehicle greenhouse gas emissions. Chief Justice John Roberts and Justice Antonin Scalia had doubts about the plaintiff's ability to show standing in the case. Legal analysts have predicted that Justice Anthony Kennedy will provide the swing vote regarding standing, and hinted during oral arguments that the plaintiffs have room to advance their case. Justice Stephen Breyer indicated that a new rule by the EPA could trigger wider action domestically, including sequestration of CO_2 emissions from power plants. The Supreme Court is expected to issue its opinion by next summer. The case is *Massachusetts v. Environmental Protection Agency*, 05-1120. To view the oral argument transcript, see: http://www.supremecourtus.gov/oral_arguments/argument_transcripts/05-1120.pdf. (Subscription may be required.) November 29, 2006, http://www.eenews.net/eenewspm/2006/11/29/archive/1/?terms=sequestration, and November 30, 2006, http://www.alertnet.org/thenews/newsdesk/N29372625.htm.

February 2007

***DOE Press Release,* "U.S. and China Announce Cooperation on FutureGen and Sign Energy Efficiency Protocol at the U.S.-China Strategic Economic Dialogue."** China will follow India and

South Korea in becoming the third country to join the United States in the FutureGen International Partnership. They will also participate in the Government Steering Committee of the FutureGen Initiative. FutureGen is a $1 billion initiative to build a near-zero emission fossil fuel-fired power plant run by both electricity and commercial-grade hydrogen from coal. The two nations also signed an Energy Efficiency and Renewable Energy Protocol during the US-China Strategic Economic Dialogue session, which was held in Beijing. This agreement renews the joint collaboration in developing and deploying clean, energy efficient and renewable energy technologies including solar, wind, biomass, geothermal, and hydrogen energy. US Secretary of Energy Samuel W. Bodman joined other US government and industry officials on a five day trip to Asia that began on December 12. He met with senior Chinese government officials to discuss ongoing cooperative efforts to continue the advancement of energy security and other energy related issues. The Asia Pacific Partnership on Clean Development and Climate; the International Partnership for a Hydrogen Economy; the Carbon Sequestration Leadership Forum; the International Thermonuclear Experimental Reactor; and the Generation IV International Forum are examples of these cooperative efforts. Secretary Bodman expressed his appreciation of China's commitment to join the United States in their advancement of new technologies to enhance energy efficiency and reduce emissions. December 15, 2006, http://www.energy.gov/news/4535.htm.

March 2007

***DOE News Release,* "President Requests $863 Million for Fossil Energy Programs: FY2008 Fossil Budget Request One of Largest Since Taking Office."** President Bush's Fiscal Year (FY) 2008 budget for the Office of Fossil Energy totals $863 million, a 33 percent increase over last year's budget. The proposal focuses on early initiation of an expansion of the Strategic Petroleum Reserve to 1.5 billion barrels by 2027; accelerating the development of carbon sequestration technologies to manage and virtually eliminate emissions of the greenhouse gas carbon dioxide from fossil fuel use in power generation and other industrial activity; and moving forward with the design and early work on the FutureGen Initiative. Funding for the FutureGen Initiative will increase two-fold from $54 million in the FY2007 budget to $108 million in the FY 2008 budget. FutureGen is currently in the site selection phase. The FY 2008 FutureGen funding will be used to support detailed plant design and procurement, ongoing permitting, preliminary design and site characterization work. A core Fossil Energy program receiving heavy emphasis is Carbon Sequestration. Sequestration research and development increases its budget from $74 million in FY 2007 to $79 million in FY 2008. This budget request will allow for continued research and development into carbon dioxide capture and storage, as well as measurement, monitoring and verification technologies and processes. The program will focus on developing capture and separation technologies in order to lower the costs and energy requirements for reducing carbon dioxide emissions from fossil-based (especially coal) energy generating plants. Of primary importance is to dramatically lower the cost and energy requirements of pre- and post-combustion carbon dioxide capture. The Regional Partnerships Initiative, comprised of the federal government, state agencies, universities and private industry, will continue its work to determine which options for capturing and sequestering carbon dioxide are most feasible for various regions of the country. The Carbon Sequestration Leadership Forum will continue to execute its mission of gathering data, exchanging information and participating in joint projects to advance carbon sequestration technology. The goal is to have a technology portfolio enabling safe, cost-effective and long-term carbon mitigation, management and storage, which will lead to substantial market penetration after 2012. Technology developments within the Carbon Sequestration Program are expected to significantly contribute to the President's goal of developing technologies to substantially reduce greenhouse gas intensity by 18 percent by 2012 and to fill a critical need in efforts to ultimately stabilize US greenhouse gas emissions. To view a chart of DOE's Fossil Energy Budget for Fiscal Year 2008, go to: http://www.fossil.energy.gov/aboutus/budget/08/FY_2008_Budget.html. February 5, 2007, http://www.fossil.energy.gov/news/techlines/2007/07004-FY_2008_Budget_Request.html.

***DOE Press Release,* "Bush Administration Plays Leading Role in Studying and Addressing Global Climate Change."** The Intergovernmental Panel on Climate Change (IPCC) released its findings

on February 2 in Paris in its *Fourth Assessment Report*. The report confirms that climate change is a global challenge that will require continued US leadership in the advancement of climate research, while at the same time maintaining the economic competitiveness of the nation. Energy Secretary Samuel Bodman, Environmental Protection Agency Administrator Stephen Johnson, and National Oceanic and Atmospheric Administration (NOAA) Administrator Vice Admiral Conrad Lautenbacher discussed the findings from the Working Group I, which included significant involvement from US climate science experts in its draft and review. Dr. Susan Soloman, a climate expert from NOAA served as the Working Group I co-chair. In order to meet his goal to reduce greenhouse gas emissions by 18 percent by 2012, President Bush has devoted approximately $29 billion to the cause, which is more than any other nation's expenditures on climate-related science, technology, international assistance, or incentive programs. Through the multi-agency Climate Change Science Program, a total of $9 billion has been spent on climate change science research by the Administration since 2002. Federal funding dedicated to these causes helps US scientists to develop and deploy the types of research efforts summarized in the IPCC report. **(See News section of this newsletter for more information in news item "Science Panel Calls Global Warming 'Unequivocal'.")** *The Summary for Policymakers* can be downloaded from the IPCC's website at: http://www.ipcc.ch/, or by clicking on a direct link to the pdf document at: http://www.ipcc.ch/SPM2feb07.pdf. A webcast of the IPCC Press Conference held on February 2 can be heard by clicking on: http://www.empreinte.com/richmediaevent/20070202/vod/ipc_audio_en_900x540_WindowsLD.htm. To read a Fact Sheet on Global Climate change, see: http://energy.gov/media/FactSheetOnGlobalClimateChange.pdf. February 2, 2007, http://energy.gov/news/4704.htm.

April 2007

***Fossil Energy Techline,* "DOE Lab Teams with Universities to Develop New Carbon Capture Technology."** Researchers at the Department of Energy's (DOE) National Energy Technology Laboratory (NETL) are collaborating with scientists from West Virginia University and the University of Pittsburgh to develop improved carbon dioxide (CO_2) sorbents, a new carbon capture technology that could help address the issue of global warming. The technology is called electrostatic layer-by-layer self-assembly, or LBL, and is currently used to prevent infection in patients with medical implants and to deliver precise doses of medicine. NETL researchers are hoping that the nanotechnology could be used to remove CO_2 from fossil fuel combustion gases. In order to do this, the researchers are searching for a way to produce a higher quality, more uniform sorbent. Typically, NETL researchers prepare amine sorbents by a process that deposits the amines (the chemical compounds that contain nitrogen as the key atom) on the substrate (the base onto which the active material is deposited). The sorbent becomes more effective when it is distributed with greater uniformity on the substrate, thus capturing more CO_2 in the process. As much as 100 times more amine could be deposited using the new technology than is currently being used. The research is possible through a program called the University Research Initiative, a program that teams NETL researchers with university professors and students from West Virginia University, the University of Pittsburgh, and Carnegie Mellon University. The program is value-added in that it allows for technologies to be used in applications where they would otherwise not be applied. For more information on DOE's Carbon Sequestration Program, go to: http://www.fossil.energy.gov/programs/sequestration/index.html. March 20, 2007, http://www.fossil.energy.gov/news/techlines/2007/07013-FE_Science_Meets_Medicine.html.

***DOE Press Release,* "Department of Energy Submits $23.6 Billion Spending Plan to Congress for FY'07."** On March 16, the US Department of Energy submitted their Fiscal Year 2007 spending plan to Congress totaling $23.598 billion. This marks a $45 million (0.2 percent) increase over the original request, as a result of the Continuing Resolution signed by President Bush on February 15. Significant to the plan is the amount of funding allocated in order to meet the President's goal of developing technologies to substantially reduce the nation's dependency on fossil fuels, as laid out in his most recent State of the Union Address. A highlight of the spending plan is the President's $2 billion

commitment to clean coal technologies. This includes the funding for projects aimed at near-zero emissions goals, including carbon emissions. A 55 percent increase in funding for carbon sequestration will help initiate the deployment of large scale geologic field projects. Funding for research and development into clean coal technologies is also allocated in the budget. Emphasis on investments in alternative fuel technologies is part of the current spending plan, and President Bush's Twenty in Ten Initiative will direct funding to areas aiming to reduce the country's dependence on foreign energy and fossil fuels. March 16, 2007, http://energy.gov/news/4884.htm.

May 2007

***Fossil Energy Techline,* "DOE Signs FutureGen Cooperative Agreement."** On April 10, The US Department of Energy (DOE) and the FutureGen Alliance agreed to terms of the next phase of the FutureGen project, valued at $42.5 million. FutureGen is a first-of-its-kind, near-zero emissions coal-fueled power plant that will integrate carbon dioxide capture and storage technology to reduce greenhouse gas emissions. The cooperative agreement outlines the inclusions in the current project phase and updates to overall cost estimates for the project. Current funding will pay for a detailed summary of the project's conceptual designs, final site selection, negotiation of a site agreement, and release of required National Environmental Policy Act (NEPA) documentation. By 2016, the total cost for FutureGen is projected to increase from $950 million to $1.7 billion, due to the increased cost of materials and labor in heavy construction. An expected $300 million in power revenue will help to offset the more than $1 billion and $400 million to be funded by DOE and the FutureGen Alliance, respectively. Both parties will continue to monitor expenses for future phases of the project. To read the FutureGen Alliance press release on this development, see: http://www.futuregenalliance.org/news/releases/pr_04-13-07.pdf. For a link to the FutureGen Alliance website, click on: http://www.futuregenalliance.org/. For a link to DOE's FutureGen Initiative webpage, go to: http://www.fossil.energy.gov/programs/powersystems/futuregen/index.html. April 10, 2007, http://www.fossil.energy.gov/news/techlines/2007/07019-DOE_Signs_FutureGen_Agreement.html.

***Fossil Energy Techline,* "DOE Regional Partnerships Find More Than 3,500 Billion Tons of Possible Carbon Dioxide Storage Capacity."** The "Carbon Sequestration Atlas of the United States and Canada," made available online on March 27, describes in great detail the stationary sources of carbon dioxide (CO_2) emissions in the two countries, suitable geologic storage formations for CO_2, as well as the capacity estimates for CO_2 in these formations. By first identifying the sources of the greenhouse gas CO_2, efforts can be initiated to greatly reduce the amount of the gas emitted into the atmosphere by capturing and safely sequestering it in geologic formations. Power plants and other stationary sources of CO_2 account for more than 3.8 billion tons of CO_2 emissions per year in the US and Canada. The Atlas was created by researchers at the National Energy Technology Laboratory (NETL) in cooperation with the seven Regional Carbon Sequestration Partnerships and the National Carbon Sequestration Database and Geographical Information System (NATCARB). Altogether, the Partnerships comprise more than 400 organizations, including 40 states, four Canadian provinces, and three Indian nations. The main objectives of the Atlas are to: (1) provide an overview of the lifecycle of CO_2 through the capture and sequestration processes; (2) summarize the Energy Department's activities in sequestration research and development; and, (3) present information about the Regional Carbon Sequestration Partnerships' activities. The Atlas is currently available in both static and interactive versions. The printed version will be available in May 2007. To download the Carbon Sequestration Atlas from the NETL website, go to: http://www.netl.doe.gov/publications/carbon_seq/atlas/index.html. To access the link to the frequently updated, interactive version of the Atlas from the NATCARB website, see: http://www.natcarb.org/. March 27, 2007, http://www.fossil.energy.gov/news/techlines/2007/07016-Carbon_Sequestration_Atlas_Publish.html.

June 2007

***NETL News Release,* "DOE Releases 2007 Carbon Sequestration Technology Roadmap, Marks Tenth Year of Carbon Sequestration Program."** On May 10, the US Department of Energy's (DOE) Carbon Sequestration Program announced the release of "The 2007 Carbon Sequestration Technology Roadmap and Program Plan." The roadmap contains a carbon sequestration program overview with highlights and accomplishments to date, a section describing the challenges facing the program, and an extensive description of the program portfolio of technologies. The Carbon Sequestration Program is managed by DOE's National Energy Technology Laboratory (NETL) and has been very successful in researching, developing, and deploying technologies for the advancement of carbon sequestration technologies. The capture and storage of carbon dioxide (CO_2) and other greenhouse gases is the focus of the program, whose overall goal is to develop fossil fuel conversion systems by 2012 that achieve 90 percent CO_2 capture with 99 percent storage permanence at less than a 10 percent increase in the cost of energy services. To download the 2007 Carbon Sequestration Roadmap from the NETL website, go to: http://www.netl.doe.gov/publications/carbon_seq/project%20portfolio/2007/2007Roadmap.pdf. May 10, 2007, http://www.netl.doe.gov/publications/press/2007/PrinterFriendlyHTML_1_104305_104305.html.

***Fossil Energy Techline,* "DOE, EPA Launch Coordinated Carbon Sequestration Project."** As part of DOE's Carbon Sequestration Program, researchers from DOE and the US Environmental Protection Agency (EPA) are collaborating on a joint carbon sequestration research project. DOE will fund Lawrence Berkeley National Laboratory (LBNL) to examine the potential impact that carbon sequestration will have on groundwater resources, ensuring that the US drinking water supply will not be adversely affected. In general, DOE will focus on large-scale injection of CO_2 into deep saline formations and the potential for water displacement into shallow groundwater systems, and the EPA will concentrate on the migration of CO_2 and its possible impact on underground sources of drinking water. To date, LBNL has completed simulation modeling and initiated a literature review on the effects of water displacement and pressure buildup in various geologic formation parameters. Findings from the three-year long project will assist DOE's Regional Carbon Sequestration Partnership Program by identifying potential areas of concern in each of the seven partnerships' regions of the country. It will also contribute to meeting the goals set forth in the President's Global Climate Change Initiative. May 1, 2007, http://www.fossil.energy.gov/news/techlines/2007/PrintVersion_1_29071_29071.html?print.

July 2007

***Fossil Energy Techline,* "DOE Releases Draft EIS Statement for FutureGen Project."** The US Department of Energy (DOE) has released a Draft Environmental Impact Statement (EIS) for the FutureGen Project, a detailed document describing the potential environmental effects of constructing the state-of-the-art 275-megawatt coal-fired power plant with hydrogen production capabilities. The near zero-emissions plant will use carbon sequestration technology to capture carbon dioxide (CO_2) emissions from the plant and pump the gas underground for permanent storage. The draft EIS provides detailed descriptions of the proposed power plant, CO_2 capture and storage methods, monitoring activities, planned and potential research activities, resources required for the proposed project, and construction and operation plans. The EIS also considers the various human and environmental impacts at the site and surrounding community that could result with the construction and operation of the power plant. These include potential impacts on land resources, water supply, air quality and noise, ecological resources, human health, and socioeconomics, among other factors. Comments from DOE-hosted public hearings conducted in the communities located near the four candidate sites were also incorporated into the EIS. Locations under consideration for the FutureGen site include Mattoon, Illinois; Tuscola, Illinois; Jewett, Texas; and Odessa, Texas. Additionally, the draft EIS suggests mitigation options that will be considered as the project develops. This comprehensive assessment will be used for reference in the design, construction, and eventual operation of the FutureGen plant. DOE's National Energy Technology Laboratory will oversee the project, which is a partnership between DOE and the FutureGen Alliance, Incorporated, the non-profit consortium responsible for the design and construction of the facility. Comments to the draft EIS will be considered for inclusion in the final EIS. To read the

complete FutureGen Draft Environmental Impact Statement, click on: http://www.netl.doe.gov/technologies/coalpower/futuregen/EIS/. To read the Federal Registrar Notice, go to: http://www.fossil.energy.gov/programs/powersystems/futuregen/futuregen_frnotice_060107.pdf. May 25, 2007, http://www.fossil.energy.gov/news/techlines/2007/07044-FutureGen_Draft_EIS_Released.html.

August 2007

***NETL News Release,* "Department of Energy Supported Technologies Recognized with R&D 100 Awards."** R&D Magazine has awarded the prestigious R&D 100 Awards to three technologies developed at the US Department of Energy's (DOE) National Energy Technology Laboratory (NETL). The magazine annually recognizes organizations for the most technologically significant products introduced into the marketplace. SEQURE™, a commercially available well finding technology that locates potential carbon sequestration sites, was designated as one of the winners. SEQURE™ effectively locates abandoned and leaking oil and gas wells by using magnetic and methane sensors deployed on helicopters. The technology ultimately provides for the secure and successful storage of carbon dioxide (CO_2) that may otherwise be released back into the atmosphere. The CO_2 sequestration technology offers a promising solution to mitigating global warming. The other award recipients include Armstrong Process CP (Continuous Process) Ti (Titanium) and Ti Alloy Powder and Products, and MFIX (Multiphase Flow with Interphase eXchanges). The September issue of R&D Magazine will feature the awards. July 9, 2007, http://www.netl.doe.gov/publications/press/2007/PrinterFriendlyHTML_1_108430_108430.html.

Sequestration in the News

September 2006

***The Intelligencer,* "Experiment to Begin at Burger Plant."** The Midwest Regional Carbon Sequestration Partnership (MSRCP), under contract with the National Energy Technology Laboratory, is coordinating with First Energy at its R.E. Burger Plant outside Shadyside, Ohio to conduct a geologic carbon sequestration demonstration project pilot validation test. The pilot test is in its early stages. First Energy spokesperson Mark Durbin stated that geologists and seismologists are currently examining old mining records and maps, and are conducting tests to determine the underground geological makeup of the site. The plan is to pump pressurized carbon dioxide directly into a brine formation located between 4,000 and 7,000 feet below the surface. The MRCSP is evaluating the possibility of capturing the carbon dioxide produced at the Burger Plant for the pilot test. Initial plans call for injecting about 3,000 tons of carbon dioxide at the site over a period of several months. This is about the same amount of CO2 that would be produced in two days during operations at the Plant. July 24, 2006. (Link not available.14 day online archive of news story only.)

***The Globe and Mail (Canada),* "Oil Industry to Study CO2 Potential."** The Petroleum Technology Alliance Canada (PTAC), a not-for-profit association that facilitates collaborative research and technology development for the Canadian upstream conventional oil and gas industry, announced a major study in enhanced oil recovery. PTAC has issued an RFP, due August 31, 2006, for the estimation of capital and operating costs for capturing, purifying/separating, and transporting carbon dioxide (CO2) that is emitted from Edmonton-area industrial operations, in particular oil refineries. (See link for RFP: http://www.ptac.org/co2/co2r0601.html.) PTAC's goal for the project is to establish a rough cost estimate to support the initiation and ongoing operation of commercial enhanced recovery of conventional oil in specific Alberta oil fields, allowing private industry to establish deals to start construction of CO2 plants with the next year. The study may also make a case for the need for government assistance for these types of projects. The study is being sponsored by the CO2 committee within PTAC whose members include Penn West, Enbridge Inc, Suncor Energy Inc., Husky Energy Inc., Shell Canada Ltd., EnCana

Corp, and several representatives from the Alberta and Canadian governments. July 7, 2006, http://www.ptac.org/about/dl/media0601.pdf.

***Cincinnati Post,* "Project Traps Carbon Dioxide."** The Midwest Regional Carbon Sequestration Partnership is conducting a field demonstration at Duke Energy's East Bend Generating Station in Boone County, Kentucky. After seismic tests are conducted in late September or early October to gain more information regarding the geologic formations, 3,000 to 10,000 tons of carbon dioxide will be sequestered at 3,000-4,000 feet below the surface beginning within a year. The brine saturated rock of the area's Mount Simon Sandstone formation is considered to be ideal for containing the carbon dioxide. The project is testing the drilling technology, the injection process, the environmental and safety impacts, and public acceptance of the sequestration concept. Also tested will be the containment of the carbon dioxide and the movement of the carbon dioxide within the porous rock. August 9, 2006, http://news.cincypost.com/apps/pbcs.dll/article?AID=/20060809/NEWS01/608090348.

***Clean Coal Today,* "Sequestration Conference Explored Technology Progress."** Over 400 persons attended the Fifth Annual Conference on Carbon Capture and Sequestration on May 8–11, 2006, in Alexandria, Virginia, which was partly sponsored by the U.S. Department of Energy, and the National Energy Technology Laboratory. The conference focused on carbon capture, geological and terrestrial sequestration of carbon dioxide, including regulatory and economic aspects of sequestration, and international cooperation. The keynote address was given by the Department of Energy's Secretary Samuel Bodman in which he outlined the US Government's multi-faceted approach toward ensuring clean and reliable sources of energy as presented in the Advanced Energy Initiative, announced by President Bush in his January 2006 State of the Union address. The Initiative supports transformational technologies including carbon sequestration. (Highlights of many other speakers' presentations are outlined in this news article.) Spring/Summer 2006, http://www.netl.doe.gov/technologies/coalpower/cctc/newsletter/documents/cctoday_spring_summer_2006.pdf.

***USA Today,* "Burying the Evidence of Global Warming."** Carbon dioxide (CO_2) can be sequestered in sandstone in the Midwestern United States, where there are plenty of sandstone layers, in contrast to the Pacific Northwest and Southeast that lack sandstone formations. Environmental scientist B. Peter McGrail of the Pacific Northwest National Laboratory in Richland, WA reports that carbon dioxide can be sequestered under the hardened lava of volcanic eruptions. In a study in the *American Geophysical Union's Journal of Geophysical Research-Solid Earth*, McGrail and his team report that ancient lava flows, approximately 10 million years old and located in Washington State, form layers with deep basalt rock that could serve as potential sites for CO_2 sequestration. The layers are located about 3,000 feet deep and were formed as bubbles in lava flows became trapped between the cooling outer crust, making the interior of the lava layer permeable. The study reports that the lava basalt within those water-filled layers appears to mix with carbon dioxide to form limestone rock, which can serve to enhance the sequestration process. The study further states that the limestone formation process starts within one to three years of carbon dioxide injection. August 21, 2006, http://www.usatoday.com/tech/science/columnist/vergano/2006-08-20-carbon-sequestration_x.htm.

***Clean Coal Today,* "NatCarb Evaluating Carbon Sequestration Potential."** The National Carbon Sequestration Database and Geographical Information System (NatCarb) is a mapping and analysis tool funded under an agreement by the National Energy Technology Laboratory (NETL) and the University of Kansas Center for Research. Geological Survey organizations in Illinois, Indiana, Kansas, Kentucky, and Ohio, the US Geological Survey, NETL's seven Regional Partnerships, and the Massachusetts Institute of Technology are all participating in this project which provides access to natural resource data related to carbon management. NatCarb data include data collected from the characterization phase of NETL's Regional Partnerships Program, as well as several national data sources including data from the USGS Earth Resources Observation Systems (EROS) center, the Geography Network, the US Environmental Protection Agency, and the US Energy Information Administration. Access the database at:

http://www.natcarb.org/. Spring/Summer 2006, http://www.netl.doe.gov/technologies/coalpower/cctc/newsletter/documents/cctoday_spring_summer_2006.pdf.

***Greenwire,* "Underground Movement Emerges for Sequestering CO_2."** An overview of many aspects of carbon capture and sequestration are discussed. Three major commercial projects currently underway and implementing sequestration technology include: 1. The Sleipner project which began in 1966 and injects about 1 million tons of CO2 per year into saline aquifers in the North Sea, with an estimated project capacity of 20 million tons; 2. The Great Plains Synfuels natural gas power plant in Beulah, North Dakota which has captured about 1 million tons of carbon dioxide (CO_2) per year since 1999, with a 200-mile pipeline to the Weyburn field in Saskatchewan, Canada, for Enhanced Oil Recovery operations; and 3. Sonatrach, the state energy company in Algeria, which partners with Statoil and BP on a project to reinject 17 million tons of CO_2 that is extracted from a natural gas field. The 2005 report by the Intergovernmental Panel on Climate Change (http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/IPCCSpecialReportonCarbondioxideCaptureandStorage.htm) estimated that geologically there is 200 to 2,000 gigatons of CO_2 storage capacity worldwide that is economically available for sequestration. Also, the Battelle report from April 2006 (http://www.battelle.org/news/06/CCS_Climate_Change06.pdf#search=%22%22carbon%20dioxide%20capture%20and%20geologic%20storage%22%22) estimated 11,000 gigatons of geologic CO_2 storage with 3,400 gigatons of capacity in the US. Humans produce about 7 gigatons of greenhouse gas emissions per year. Ocean sequestration would provide for additional storage. August 14, 2006. http://www.eenews.net/Greenwire/2006/08/14/#1. (Subscription may be required.)

***Nature,* "Putting the Carbon Back: The Hundred Billion Tonne Challenge,"** and ***Nature,* "Putting the Carbon Back: Black is the New Green."** This two-part series of articles discusses 1. geological carbon sequestration technology and 2. "terra preta" soils as a tool for carbon sequestration. The first article mentions the upcoming project in Ketzin, Germany that, within the next two years, will be the site of Europe's first large-scale carbon capture and storage demonstration project. About 60,000 tons of carbon dioxide will be injected into a saline formation over 2,000 feet below the surface. The capacity of the Earth for geological sequestration is discussed, as is implementing carbon capture and storage at power plants, including integrated gasification combined cycle (IGCC) plants. The article on "terra preta" discusses the origin of the scientific study of "terra preta" soils which started with Wim Sombroek. "Terra preta" is the dark and fertile soil of the Amazon that is fortified with material including char, organic matter that smolders in an oxygen-poor environment rather than burning. "Terra preta" soils can contain 250 tons of carbon, as opposed to 150 tons that is contained in unimproved soil. The production of char is discussed, including turning farm waste into biofuel while producing char. Robert Brown, an engineer from Iowa State University working on "terra preta" production technology, estimates that a 250-hectare farm which uses a char created from biowaste which is then combined with ammonium bi-carbonate, a nitrogen fertilizer, can help to sequester roughly 1,900 tons of carbon per year. August 10, 2006, http://www.nature.com/news/2006/060807/full/442624a.html, and http://www.nature.com/news/2006/060807/full/442620a.html. (Subscription required.)

***The New York Times,* "Team Looks At Seafloor As Gas Trap."** A paper was published in the August 7 edition of the weekly Proceedings of the National Academy of Sciences in which a team of researchers identified seafloor sediments that are suitable for carbon sequestration. The research, partly funded by the Department of Energy, shows that there are ideal depths of ocean water and sediment that would allow carbon dioxide to stay denser than the water above; at about 10,000 feet deep where the temperature is typically about 35 degrees and the pressure from the water above would cause liquid carbon dioxide pumped into porous sediment to stay denser than water. Experts who were not involved in the analysis say that the concept would need to be extensively tested in the field. The lead author of the study, Kurt Zenz House said that the study showed there was "an inherently stable and permanent storage option that could bite off a huge chunk of the CO_2." **(For an abstract of the proceedings**

"Permanent carbon dioxide storage in deep-sea sediments" **see this Newsletter's Terrestrial/Ocean section.)** August 8, 2006, http://www.nytimes.com/2006/08/07/science/07cnd-carbon.html?_r=1&ei=5094&en=d638052622c63014&hp=&ex=1155009600&adxnnl=1&partner=homepage&adxnnlx=1155128076-qXekUhbJIQKkfqjHBj1vJQ&oref=slogin. (Subscription Required.)

October 2006

DOE Fossil Energy Techline, **"Two-For-One Solution....Alabama Project Plans to Store Carbon Dioxide, Boost Oil Production."** In the Department of Energy's (DOE's) efforts to pursue demonstration projects to promote the capture, transportation, and injection of produced carbon dioxide (CO_2) for sequestration into oil and gas fields while boosting oil and natural gas production (mandated in the Energy Policy Act of 2005), a funding opportunity was announced earlier in 2006 for research in enhanced oil recovery (EOR) with carbon sequestration. The project selected for funding was University of Alabama-Birmingham's (UAB) CO_2 flooding of the Citronelle oilfield in Mobile County, Alabama. Citronelle is Alabama's largest producer and a mature field that has undergone primary and secondary recovery (waterflooding) efforts, and is now a candidate for tertiary recovery, or EOR. Typically, an additional 20 percent of the original-oil-in-place in a reservoir can be recovered using CO_2 EOR, with an estimated 64 million barrels of oil that could be recovered in Citronelle. Southern Company of Atlanta, Georgia, a large electrical power producer, is evaluating the capacity of reservoirs such as Citronelle for possible sequestration of any CO_2 that it might capture and separate from its emissions. Sequestration potential and estimated oil yields will be studied under this project, as will computer simulations of the oil yield and sequestration capacity of a given geologic formation and the rate at which CO_2 can be introduced into the underground formations. Partners with UAB and Southern Company in the project are Citronelle field owner and operator Denbury Resources Inc., Plano, Texas; University of Alabama, Tuscaloosa, Alabama; Alabama A&M University, Huntsville, Alabama; Geological Survey of Alabama, Tuscaloosa; and the University of North Carolina at Charlotte, North Carolina. Total project cost is about $6 million, with a little under $3 million to be cost-shared by DOE. September 6, 2006. http://www.fossil.energy.gov/news/techlines/2006/06050-DOE_Awards_EOR_Project.html.

Air Liquide Press Release, **"Air Liquide Partners in CO_2 Sequestration Project Sponsored by U.S. Department of Energy."** Air Liquide is collaborating on a project with the Midwest Geological Sequestration Consortium (MGSC) in a project sponsored by the US Department of Energy, National Energy Technology Laboratory and the Illinois Office of Coal Development. The project is being led by the Illinois State Geological Survey (ISGS). Air Liquide's R&D center in Countryside, Illinois has been involved in a carbon sequestration project since 2003. Phase II of the project has begun under which 6 real-scale CO_2 injection tests will be conducted, lasting until 2009. Air Liquide's subsidiary, Air Liquide Industrial US LP serves on the project's Advisory Group. Air Liquide will provide 19,000 tons of liquid CO_2 to be injected during these tests as well as storage tanks for the CO_2. Expertise will be provided by Air Liquide regarding the design of the injection skid, and analysis of the results to ensure that the buried CO_2 will remain trapped geologically. August 28, 2006, http://home.businesswire.com/portal/site/google/index.jsp?ndmViewId=news_view&newsId=20060828005624&newsLang=en.

BBC News, **"BP Warning On 'Clean' Power Plant."** BP has warned that without more financial incentives from the UK government it may have to pull out of its Peterhead project for hydrogen power generation and carbon capture and storage. The project, which would generate 'carbon-free' electricity from hydrogen and reduce greenhouse gas emissions by capturing carbon dioxide (CO_2) and storing it, was slated to be operational by the end of 2009. Energy Minister Malcolm Wicks confirmed further CCS measures would be outlined in a pre-budget report later this year. August 25, 2006, http://news.bbc.co.uk/2/hi/uk_news/scotland/north_east/5284800.stm.

***Energy Business Review Online,* "RWE CEO Calls for Cooperation for Zero-Emission Plant,"** RWE presented its plans to the general assembly of the European Commission's ZEP (European Technology Platform for Zero Emission Fossil Fuel Power Plant) in Brussels. RWE plans to build a large-scale power plant with integrated coal gasification, and carbon dioxide (CO_2) separation and storage, resulting in no emissions of CO_2. The plant would have a gross output of 450MW and could be operational by 2014. The decision to use hard coal or lignite as the plant's primary fuels will occur in 2007, and approval for the construction of the plant should be received by 2010. September 13, 2006, http://www.energy-business-review.com/article_news_print.asp?guid=D64FBDAB-45AE-4FA7-8B8B-95B33BD70A18.

***Casper Star Tribune,* "Thomas, Feinstein Talk Coal Plant."** US Senator Craig Thompson, R-Wyoming, and Dianne Feinstein, D-California, met with representatives of utilities and government agencies about planning to build a 200-megawatt integrated gasification combined cycle plant, with sequestration of its carbon dioxide, in Wyoming. The plant would cost between $500 million and $600 million, and would send its produced power to California. Congress has approved an initiative that calls for a coal gasification demonstration plant to be built at an elevation of at least 4,000 feet above sea level and to use Western coal, but Congress has yet to appropriate money for the project. The senators will look into funding a study to prove that carbon sequestration will be viable with Wyoming's geology. September 20, 2006, http://www.casperstartribune.net/articles/2006/09/20/news/wyoming/63804a435f7a11ea872571ef0004303a.txt.

November 2006

***E&E News,* "Idaho Considers Carbon Sequestering Projects."** Idaho is exploring the possibility of sequestering carbon dioxide (CO_2) in lava flow formations and using the projects to offset carbon emissions in the state. In 2002, the Idaho Soil Conservation Commission created an advisory committee at the request of the state. Two pilot project areas have been proposed by the committee. The Idaho National Laboratories are trying to inject CO_2 into lava formation in east-central Idaho. The Soil Conservation Commission met with a group of carbon emitters in January, and also with members of the National Carbon Offset Coalition, a Montana-based group that helps landowners plan sequestration activities. September 27, 2006, http://www.eenews.net/Greenwire/print/2006/09/27/17. (Subscription may be required.)

***Reuters,* "Norway To Build World's Biggest CO_2 Capture Facility."** The Norwegian government will help finance carbon capture and storage for the Statoil project in Mongstad, Norway. Statoil is building the world's largest facility for carbon dioxide (CO_2) capture and storage, near where Statoil plans to build a gas-fired power plant to feed one of its refineries. A technology company will be created of which the government will own 80 percent. Norway will spend $594 million on the facility, which will capture 100,000 tons of CO_2 in 2010, and 1.3 million tons in 2014. October 13, 2006, http://www.planetark.org/dailynewsstory.cfm/newsid/38487/story.htm.

***Energy Central,* "ALSTOM, EPRI and We Energies To Build Pilot Plant In the US To Demonstrate Its Unique CO2 Capture Process."** A five megawatt pilot plant will be built in order to demonstrate a carbon dioxide (CO_2) capture process, capturing CO_2 from a portion of boiler flue gas at the We Energies power plant in Pleasant Prairie, Wisconsin. This capture process was developed by the engineering firm ALSTOM, and uses chilled ammonia to capture the CO_2. This specific process has not yet been demonstrated in the US. The process reduces the required energy for capture and isolation of the CO_2 in a highly concentrated, highly pressurized form. In previous laboratory testing, the process was shown to be 90 percent efficient at removing CO_2, at a much lower cost than other methods. The pilot project will be commissioned in mid-2007 at the We Energies Pleasant Prairie Power Plant and operated for approximately one year. An engineering/environmental performance and cost analysis will be conducted by Electric Power Research Institute (EPRI) during the operation. October 3, 2006,

http://www.energycentral.com/centers/news/daily/article.cfm?aid=7226310. (Registration may be required.)

***Central Valley Business Times (California),* "Central Valley May Be Site for 'Carbon Repository' In Global Warming Battle," and *San Mateo County Times,* "Delta Explored As Place To Stash Carbon Dioxide: Global Warming Solution Could Be To Put Gases In Underground Caverns."** The West Coast Regional Sequestration Partnership (WestCarb)—comprised of industry and government from California, Nevada, Arizona, Oregon, Washington and British Columbia—is planning a sequestration project at a site near Thorton, California. Westcarb is part of the National Energy Technology Laboratory's Regional Carbon Sequestration Partnerships program. The project site consists of a saline deposit (salt water and sand 3,500 feet underground) which is capped by a thick layer of shale, above which is a depleted natural gas deposit also topped by a layer of shale. Plans are to inject carbon dioxide (CO_2) into both formations. The site will be the first tested, among other potential sites in the northern Central Valley of California, for its potential to store carbon dioxide (CO_2) from 20 power plants from the Bay area. Before pumping the CO_2 underground, public hearings will be held and permits obtained from the US Environmental Protection Agency, state oil and gas regulators, or both. The volume of carbon dioxide injected will be small, roughly amounting to what a coal-fired power plant would release in a day. The scientists will then monitor the CO_2 in the formations. The injection could begin as early as spring 2007. October 12, 2006, http://www.centralvalleybusinesstimes.com/stories/001/?ID=3265, and October 1, 2006, http://www.insidebayarea.com/sanmateocountytimes/localnews/ci_4426718.

December 2006

***FutureGen Alliance Press Release*, "E.ON U.S. Joins FutureGen Alliance News."** E.ON U.S., a leading US utility, joined the FutureGen Alliance, the non-profit consortium of global electric and utility companies working with the US Department of Energy to develop FutureGen, the near-zero emissions power plant. E.ON is a subsidiary of E.ON A.G., the world's largest investor-owned energy services provider. E.ON U.S. owns and operates Louisville Gas and Electric Company, a utility that serves 321,000 natural gas and 394,000 electric customers in Louisville, Kentucky, and Kentucky Utilities Company, a utility based in Lexington, Kentucky that serves 525,000 customers in 77 Kentucky counties and 5 counties in Virginia. E.ON U.S. joins 10 other members of the FutureGen Alliance including American Electric Power, Anglo American, BHP Billiton, the China Huaneng Group, CONSOL Energy Inc., Foundation Coal, Rio Tinto Energy America, Peabody Energy, PPL Corporation, and Southern Company. Four sites are candidates for FutureGen, 2 located in Texas and 2 located in Illinois, with a National Environmental Policy Act review occurring prior to the site selection scheduled for late summer of 2007. October 31, 2006, http://www.futuregenalliance.org/news/releases/pr_10-31-06.pdf.

***Washington Business Journal,* "NM Tech Gets $67 Million for Carbon Sequestration Research."** Through a cost-share program, the US Department of Energy's National Energy Technology Laboratory awarded the New Mexico Institute of Mining and Technology $67 million to conduct carbon sequestration (CO_2) research. The goal of this project is to sequester hazardous emissions by injecting an estimated 1 million tons of CO_2 into geological formations. The remaining $17 million of the $84 million total cost must be provided by New Mexico Tech and could be in the form of loans or through contributions made directly to the project. The funding to New Mexico Tech will be distributed over a ten-year period. October 30, 2006, http://washington.bizjournals.com/albuquerque/stories/2006/10/30/daily4.html.

***E&E News,* "Asia-Pacific Partnership Spawns 98 New Projects, Administration Says."** On October 31, the Bush Administration revealed plans for 98 new clean energy products as part of the US commitment to reduce harmful carbon dioxide (CO_2) emissions into the atmosphere. The unveiling coincided with the meeting of participant countries at American Electric Power Corporation headquarters in Columbus, Ohio. The US will implement these projects through its membership in the Asia-Pacific Partnership on Clean Development and Climate, which is comprised of six countries whose common

objective is to address climate change issues through private sector investment and technology exchange among the member countries. This public-private initiative involves technology exchange visits between the member countries to see firsthand what is being done to provide clean power generation and reduced emissions, as well as specific project endorsements. Two such projects include a joint Australia-Japan venture to build a 30-megawatt pulverized coal plant that will demonstrate the capture and storage of carbon dioxide emissions and use of an Australian-developed solar technology in China and the United States. For links to the projects, refer to a list of US Department of State fact sheets at http://www.state.gov/g/oes/climate/app/c19376.htm. October 31, 2006, http://www.eenews.net/eenewspm/print/2006/10/31/2. (Subscription may be required.)

***ExxonMobil Corporation Press Release,* "ExxonMobil Supports European Research Initiative into Reducing Greenhouse Gas Emissions."** Exxon Mobil Corporation, a leader in carbon capture and storage (CCS) technology, announced that it will contribute 1 million Euros and provide expert technical guidance to participate in a project called CO2ReMoVe. CCS technology removes carbon dioxide from flue gases, compresses it to reduce the volume, and then transports it by pipeline to a site for sequestering in geologic formations. The purpose of this project is to evaluate a range of technologies to monitor the injection and storage of carbon dioxide (CO_2) from various sites and then establishing guidelines that will be used for the certification of future sites where CO_2 will be sequestered. Over the next five years, Exxon Mobil will partner with other energy industry partners, including BP, ConocoPhillips, Schlumberger, Statoil, Total, Vattenfall and Wintershall in the CO2ReMoVe project, which is being sponsored by the European Commission Directorate General for Research. The International Energy Agency, DNV (an organization specializing in risk management in the oil and gas industry), and other national agencies and academic research organizations will also participate in the research. Sites identified for this initiative include the Sleipner and Snohvit fields in the Norwegian North Sea, at In Salah in the southern Saharan desert in Algeria, and in the German locality of Ketzin. The effort will involve the participation of technical experts from ExxonMobil's Upstream Research Company, which will be important to the success of the project. Successful use of the CCS technology could be applied to many other large scale sources of CO_2 emissions and play a significant role in reducing greenhouse gas emissions. November 2, 2006, http://www.csrwire.com/PressRelease.php?id=6715.

***International Herald-Tribune (Asia-Pacific),* "Australia Pledges $500 Million Australian ($379 Million US) to Fight Global Warming."** Australian Prime Minister John Howard announced that the country plans to invest $379 million in new technologies aimed at reducing greenhouse gas emissions. Although the package does not elaborate on exactly which technologies will be designated to receive the funds, Australia has made previous investments in carbon sequestration projects in recent years. The country's economy relies heavily upon profits from coal exports, a major source of greenhouse gas emissions. Rainfall levels have consistently fallen below average over the past several years in Australia, and the country is currently plagued by draught. Even with growing concerns of global warming, Australia has refused to pledge their participation in the Kyoto Protocol. October 22, 2006, http://www.iht.com/articles/ap/2006/10/22/asia/AS_GEN_Australia_Climate_Change.php.

January 2007

***Reuters,* "Clean Coal Power Plant for Norway."** An international group of companies, including France's Eramet, US Alcan, Norway's Norsk Hydro, and Norwegian family-owned industrial company Tinfos are seeking bids from construction firms for a 400-megawatt coal-fired power plant to be built in west Norway, utilizing a carbon capture technology developed by the Norwegian clean energy group Sargas. The plant itself will cost approximately $700 million. Ninety-five percent of the carbon dioxide, as well ***Reuters,* "Clean Coal Power Plant for Norway."** An international group of companies, including France's Eramet, US Alcan, Norway's Norsk Hydro, and Norwegian family-owned industrial company Tinfos are seeking bids from construction firms for a 400-megawatt coal-fired power plant to be built in

west Norway, utilizing a carbon capture technology developed by the Norwegian clean energy group Sargas. The plant itself will cost approximately $700 million. Ninety-five percent of the carbon dioxide, as well as nitrous oxide, will be captured. The 2.6 million tons of carbon dioxide captured would be piped or shipped to offshore oil or gas fields and sequestered deep below the sea floor. The timeline for the project is for a bid in 2007, to start the project in 2008, and production to begin in 2011. Power generation costs are estimated at $0.047-$0.055 per kilowatt hour, including costs of capture, equivalent to about 25 percent above power generation costs without capture. November 26, 2006, http://www.theage.com.au/news/World/Clean-coal-power-plant-plan-for-Norway/2006/11/27/1164476105162.html .

***Agence France-Presse,* "Australia Plans Massive Carbon Storage System."** The Australian government has committed $46.5 million to the Gorgon gas project, a large carbon capture and storage system, located off the West Australian coast. The plan is to sequester 125 million tons of carbon dioxide, two-thirds of the total emissions, which is equal to two-thirds of the total CO_2 that the plant would emit over 20 years of operations. The carbon dioxide removed while processing the natural gas will be injected 1.6 miles underground. Australian Environmental Minister Ian Campbell believes that carbon sequestration is "one of the key technologies that the world will need if we are to address climate change." The funding is dependant on environmental approval for the development of the massive natural gas field on Barrow Island by Chevron Corp and its partners Exxon Mobil and Royal Dutch Shell. November 23, 2006, http://www.energy-daily.com/reports/Australia_Plans_Massive_Carbon_Storage_System_999.html.

***DOE Techline,* "DOE Advances Production of Hydrogen from Coal."** The US Department of Energy (DOE) selected six research and development projects for funding, with the aim to promote large-scale production of hydrogen from coal. Production of hydrogen from coal will combat climate change by allowing for the capture and sequestration of carbon dioxide during hydrogen production. The projects chosen support President Bush's Hydrogen Fuel Initiative, which provides research and development funding for these types of projects with the aims to minimize America's growing dependence on foreign oil and reduces greenhouse gas emissions. Several technological challenges must be overcome before the use of large-scale production of hydrogen from coal can become wide spread. The projects are focused in two area of interest including: 1.) Ultra-Pure Hydrogen, which investigates the purity standard of hydrogen in a number of end-use applications, including hydrogen turbines, fuel cells, and modified internal combustion engines; and 2.) Process Consolidation, which considers strategies for selectively removing pure hydrogen, carbon dioxide, and synthesis gas impurities in a single-reactor configuration that can operate simultaneously at high temperature and high conversion (of synthesis gas to hydrogen). Six projects were chosen to be funded, with $7.4 million to be provided by the DOE and $1.8 to be contributed by industry partners. (To view a detailed list of project descriptions, see the link at the end of this news item.) December 6, 2006, http://www.fossil.energy.gov/news/techlines/2006/06070-Hydrogen_from_Coal_Projects.html.

***Reuters,* "Clean" Coal Seen in 5-10 Years."** Harry Audus, general manager of the International Energy Agency IEA's Greenhouse Gas Research and Development Program commented that carbon capture and sequestration for "clean" coal-fired power plants would be demonstrated technically viable within 5 to 10 years, but that there are still no commercial incentives to do so. He also remarked that it is up to politicians to institute the commercial incentives. Enabling power generators to capture and sequester carbon dioxide (CO_2) would be a technological step toward "clean coal" worth tens of billions of dollars. A 2005 United Nations report stated that capture and storage of CO_2 could meet 15 to 55 percent of the world's greenhouse gas reduction needs by 2100, making storage the largest contributor to the reductions. Carbon storage, according to Mr. Aldus, is only economically feasible to power generators if carbon prices trade for $25-$30 per ton. They are currently traded at $24 per ton for 2008 delivery, but after 2012 when many emissions targets expire under the Kyoto Protocol, there will be a price vacuum. Nations under the Kyoto Protocol are looking at ways to extend the agreement beyond 2012. Many companies are working to develop capture and storage technologies including American Electric Power,

BP, E.ON, Statoil and Vattenfall. "The fundamental problem is that carbon capture and storage now costs around $100 a ton," said David Garman, US Under Secretary of Energy. "We have to cut that cost to $10 a ton or thereabouts in order for it to be widely adopted and available." The US Department of Energy is in the process of choosing between sites in Illinois and Texas for the $1 billion FutureGen project. The European Union (EU) is planning to build a near-zero emissions coal-fired plant in China by 2020, and hopes to commercially operate carbon capture and storage plants as early as 2010 in both the United Kingdom and Norway. Norway's planned gas-fired Mongstad plant will capture 100,000 tons of carbon a year in 2010, with full carbon capture from 2014. Carbon taxes in Norway led to CO_2 capture and storage at Statoil's Sleipner gas field in 1996, and these taxes in 2006 ranged from $255 to $300 per ton. In Canada, EnCana is injecting CO_2 from a US lignite gasification plant in an enhanced oil recovery project in Weyburn, Saskatchewan. BP and Algerian company Sonatrach are injecting carbon dioxide from the In Salah natural gas field in Algeria due to a high percentage of CO_2 in the gas. December 8, 2006, http://today.reuters.co.uk/news/articlenews.aspx?type=reutersEdge&storyID=2006-12-08T122452Z_01_NOA840704_RTRUKOC_0_CLIMATE-COAL.xml&WTmodLoc=Editors+Choice-C1-Headline-9.

***Illinois Government News Network,* "Governor Blagojevich Takes First Step Toward Building Innovative and Environmentally Friendly Carbon Dioxide Pipeline; Major Component of His Energy Independence Plan."** As part of Illinois Governor Rod R. Blagojevich's Energy Independence Plan, a Request for Information (FRI) was submitted to acquire the necessary information for the construction and operation of a carbon dioxide (CO_2) pipeline. The pipeline would become part of the $775 million investment plan which calls for the construction of ten new coal gasification plants to be completed by 2017. The proposed pipeline would run from the coal gasification plants planned for central and southern Illinois to Illinois Basin oilfields in southeastern Illinois. The outcome of this initiative is that 50 percent of Illinois' oil would be used to meet their energy needs, thus reducing their dependence on foreign oil. The 140-mile CO_2 pipeline would transport carbon dioxide captured by the coal gasification plants and pipe it to oil fields. The pressurized CO_2 would be used to extract more oil from existing reserves though enhanced oil recovery (EOR). Illinois will also be the second state to join the Chicago Climate Exchange. To read a bullet list of the specifics on Illinois' EOR and carbon sequestration potential, see the news item link. November 6, 2006, http://www100.state.il.us/PressReleases/ShowPressRelease.cfm?SubjectID=18&RecNum=5500.

***St. Petersburg Times,* "Carbon Goes Undercover."** Carbon sequestration, along with energy efficiency and clean alternative fuels, are part of the three-pronged approach that the US government is using to cut greenhouse gases. Several Florida Power companies, as part of the National Energy Technology Laboratory's Southeast Regional Carbon Sequestration Partnership, including Progress Energy Inc., TECO Energy Inc., Gulf Power Co. and Florida Power & Light Co. are working to advance carbon sequestration technology. TECO anticipates using carbon sequestration at its Polk County Power Plant. Gulf Power is currently surveying potential carbon dioxide storage sites, including oil wells located throughout northwest Florida. A Gulf Power sister company is participating in a demonstration project to pump carbon dioxide (CO_2) into a salt formations 9,000 feet underground in South Mississippi. Formations for sequestration exist along the Gulf Coast and cover all of Florida south of Citrus County. Florida power companies anticipate future regulation of CO_2. The biggest challenge has not been storage of CO_2, but how to capture, condense and transport the gas. The federal government estimates that current methods of isolating flue gas from power plants could double the price of electricity. The government's goal is for sequestration to add no more than 10 percent to the cost of power. TECO's Polk County Power Plant fits the bill since the technology used promotes cheaper CO_2 capture. Researchers estimate that half of all man-made CO_2 could be sequestered by 2050.
December 11, 2006, http://www.sptimes.com/2006/12/11/Business/Carbon_goes_undercove.shtml.

***Reuters,* "Carbon Capture Decision to Be Made in 2007," and Reuters, "BP Seeks Clean Power Plant Talks."** United Kingdom's Chancellor Gordon Brown announced in his pre-budget report that the Secretary for Industry will appoint engineers to the first carbon capture and storage (CCS) demonstration

plant in the United Kingdom (UK). After this announcement, BP said that it would like to meet with UK for discussions. BP is already planning to build the world's first industrial-scale hydrogen power plant with CCS at Peterhead power station, but wants a promise of financial incentives from the UK government before proceeding. The $985 million project could be operational by the end of 2009. December 6, 2006, http://today.reuters.co.uk/news/articlenews.aspx?type=domesticNews&storyID=2006-12-06T140237Z_01_L06832895_RTRUKOC_0_UK-BRITAIN-CARBONCAPTURE.xml&WTmodLoc=NewsLanding-C3-UK-3, and December 6, 2006, http://news.bbc.co.uk/2/hi/uk_news/scotland/north_east/6214490.stm.

***Business Wire,* "ADA-ES Announces Greenhouse Gas Mitigation Project."** ADA-ES Inc. and RTI (Research Triangle Institute) International will collaborate on a project for the development and demonstration of a novel carbon dioxide capture process. RTI is the prime contractor to the US Department of Energy's National Energy Technology Laboratory on a $4 million cooperative agreement. The capture technology is a sorbent injection system technology which can be applied to existing power plants. November 13, 2006, http://home.businesswire.com/portal/site/google/index.jsp?ndmViewId=news_view&newsId=20061113005746&newsLang=en.

***Austin-American Statesman,* "TXU Gets Resolutions on New Plant Plans."** TXU Corporation is building 11 new coal-burning power generating plants in Texas, at least doubling its carbon dioxide emissions. Kimberly Morgan, a TXU spokeswoman stated that they are building their new units to be carbon-capture ready by building in space to install the appropriate equipment when it becomes available, but that it is not economically feasible to do so yet. December 8, 2006, Link Unavailable.

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***Greenwire,* "Appropriations Delays Pose Threat to FutureGen."** Plans to utilize $54 million toward building FutureGen, a near-zero emissions coal-fueled power plant, may be delayed if Congress fails to approve the new budget in fiscal year 2007. The result would be a continuing resolution, whereby federal programs would be forced to operate at fiscal 2006 funding levels. That would mean that only $18 million would be available for the FutureGen operating budget until Congress passes their annual spending legislation. House and Senate Republicans had agreed to give the Bush administration $54 million in 2007, which would add to the already approved $45 million in funding since President Bush first introduced the concept in his 2003 State of the Union address. In total, Congress has been asked to supply two thirds of the $1 billion cost for FutureGen, with the remainder of the funding coming from private industry and foreign countries. If 2007 funding is not approved, FutureGen will face competition from other specialized contractors who are already bidding on other power plant construction projects and industrial expansions. The site selection for FutureGen is expected by next September and construction is slated to start in 2009. December 8, 2006, http://www.eenews.net/Greenwire/2006/12/08/archive/4/?terms=greenhouse%20gases.

***Herald Sun,* "Carbon Storage Project to Go Ahead."** The Australian government granted $4.8 million ($6.1 million Australian) to the Co-operative Research Centre for Carbon Dioxide ($CRCCO_2$) to undertake a major carbon dioxide (CO_2) capture and geological sequestration project in the Otway Basin of Victoria, Australia. This grant will add to the $23.5 million ($30 million Australian) already obtained for the project scheduled to begin in early 2007. The first stage of the project will involve drilling a well to a depth of 2000 meters, followed by separation of CO_2 from methane. The CO_2 will subsequently be compressed and injected into a deep geological formation in western Victoria. Long-term monitoring will be conducted. $CRCCO_2$ and its partners have established a new company called CO_2CRC Pilot Project. Carbon capture and storage technology will allow Australia and other countries to utilize existing energy infrastructure and enable the continued use of coal as a viable energy source. December 22, 2006, http://www.news.com.au/heraldsun/story/0,21985,20965269-5005961,00.html.

CNW Telbec. **"Canada's New Government Launches ecoEnergy Technology Initiative."** In Canada, Gary Lunn, Minister of Natural Resources, and John Baird, Minister of the Environment, announced the ecoEnergy Technology Initiative on January 17. The initiative is a $197 million ($230 million Canadian) investment in research, development and demonstration of clean-energy technologies, including carbon dioxide sequestration, clean coal, clean oil sands production and renewable energy. Priorities within the program will be further developed with provinces and industry partners through consultations. January 17, 2006, http://www.cnw.ca/fr/releases/archive/January2007/17/c6537.html.

Rancher Energy Corporation Press Release**, "Rancher Energy Secures CO_2 for Enhanced Oil Recovery via Supply Agreement with Anadarko Petroleum,"** and ***Rancher Energy Corporation Press Release,*** **"Rancher Energy Completes Acquisition of Highly Prospective Big Muddy Oil Field."** Rancher Energy Corporation has completed the purchase of the Big Muddy Oil Field in Wyoming's Powder River Basin for $25 million. The oil field acquisition will allow the company to pursue enhanced oil recovery (EOR) projects by injecting carbon dioxide (CO_2) into the reservoirs to stimulate oil production. Prior to the purchase, Rancher Energy Corporation announced that it will obtain the supply of CO_2 for the EOR project through an agreement with Anadarko Petroleum Corporation. The company hopes to generate substantial sequestration credits through its use of carbon sequestration through EOR. The newly acquired field covers an area of 8,500 acres and currently produces about 60 barrels of oil per day. Rancher Energy Corp. also hopes to acquire Cole Creek South and South Glenrock B fields, which also hold excellent potential for EOR using CO_2 injection. The Big Muddy field was discovered in 1916 and has produced approximately 52 million barrels of oil (MMBO) from several producing zones. It is also the second most prolific field in the State of Wyoming. Rancher Energy Corp. focuses on the oil and gas sector by specializing in evaluating older, historically productive fields in order to determine their potential for secondary and tertiary recovery. December 19, 2006, http://www.marketwire.com/mw/release_html_b1?release_id=196718, and January 8, 2007, http://www.marketwire.com/mw/release_html_b1?release_id=200509.

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The New York Times, **"Science Panel Calls Global Warming 'Unequivocal'."** The Intergovernmental Panel on Climate Change released their *Fourth Assessment Report* on February 2 from Paris, concluding for the first time that global warming is "unequivocal" and that carbon dioxide emissions and other greenhouse gas releases from human activities are the main cause. The 20-page *Summary for Policymakers* is the work product of a three-year review of hundreds of climate shift studies, observations of retreating ice, warming and rising seas, and other scientific observations made about the planet. Scientists also used computer modeling to determine the effects of the prolonged presence of greenhouse gases in the atmosphere. The consensus of those who contributed to the report is that although uncertainty surrounds the extent or timing of impending changes, prompt action is critical in delaying the effects of global warming and a shift to alternative energy sources must occur. The main findings of the IPCC are that the temperatures could rise by 3.5 to 8 degrees Fahrenheit, which could also cause a rise in global sea levels. Those estimates predict sea level rises of 7 to 23 inches by 2100, in comparison to 6 to 9 inch increases in the 20th century. Additionally, scientists predict that more precipitation will fall at higher latitudes, while semi-arid subtropical regions could see a twenty percent drop in rainfall totals. A new finding in the report also describes how the buildup of carbon dioxide will adversely impact sea waters by causing an imbalance in pH levels. The panel's full report, which contains thousands of pages of more detailed information, will be released in sections throughout the year. **(See Highlights section of this newsletter, "Bush Administration Plays Leading Role in Studying and Addressing Global Climate Change," for a link to the report.)** February 3, 2007, http://www.nytimes.com/2007/02/03/science/earth/03climate.html?_r=1&th=&oref=slogin&emc=th&pagewanted=print. (Subscription required.)

DOE News Release, **"Another Milestone Reached in Coal Gasification Revenue-Sharing: DOE Receives $39.2 Million from Dakota Gasification/Basin Electric."** Dakota Gasification Company

recently made a payment of $39.2 million to the US Department of Energy (DOE) under a revenue sharing agreement signed in 1988, bringing the total revenue sharing payments to over $285 million. The payments are received from the sale of synthetic natural gas from the Great Plains Synfuels Plant near Beulah, North Dakota. The Great Plains Synfuels Plant transports its carbon dioxide (CO_2) via a 205-mile pipeline to the Weyburn Oil Field in southwestern Saskatchewan, Canada where it is used for enhanced oil recovery (EOR). A large portion of the CO_2 used for EOR remains permanently sequestered. More than 10 million tons of CO_2 has been captured and transported to the Weyburn Oil Field. Dakota Gasification Company is a member of the Plains CO_2 Reduction Partnership, one of seven Carbon Sequestration Regional Partnerships established by DOE. For more information about the Great Plains Coal Gasification Plant, see: http://www.fossil.energy.gov/programs/powersystems/gasification/gasificationpioneer.html. For more information about the Plains CO_2 Reduction Partnership, see: http://www.fossil.energy.gov/programs/sequestration/partnerships/2003sel_gplains.html. February 7, 2007, http://www.fossil.energy.gov/news/techlines/2007/07005-Dakota_Gasification_Milestone_Reac.html.

***Nature,* "India's Carbon Dioxide Trap."** India's Deccan Traps, a thick pile of solidified lava from volcanic eruptions 65 million years ago, has been identified as a prime candidate for storing carbon dioxide (CO_2) captured from coal-fired power stations and injecting it into the porous sedimentary rocks below the basalt layer. The area in India is also the world's largest continental flood-basalt province outside Siberia. The National Thermal Power Corporation (NTPC) in New Delhi, the company that builds and runs India's coal-fired power stations, estimates that the Deccan basalts could potentially hold 150 gigatons of CO_2, an amount equal to what the world's power industry might emit in 15 years. Research scientists at the Pacific Northwest National Laboratory (PNNL) in Richland, Washington, found that water saturated with CO_2 reacts rapidly with basalt to form stable carbonate minerals. PNNL's research findings were reported at a conference on CO_2 capture and storage held in Hyderabad, India in January 2007. The US Pacific Northwest is home to the Columbia River basin basalts, which are similar to the Deccan Traps, but on a scale one-third the size. PNNL, NTPC and the National Geophysical Research Institute will initiate a pilot study to test the storage capability of the Deccan basalt formation. Although the porosity of the basalt layer is not optimal, it has a high reactivity to CO_2. The initial phase of the project will characterize the permeability and porosity of the rock, as well as examine the nature of the faults within the rock to determine how CO_2 would flow through the rock once injected. The actual test would involve pumping supercritical CO_2 into porous sedimentary rocks below the basalt layer. The gas would move upwards through the rock and react with the basalt above, forming a "cap" that would stop any unreacted gas from escaping. India has committed $1.3 million to the Deccan Traps project, which is also being endorsed by the Carbon Sequestration Leadership Forum, of which India was a founding member. Prior to injection tests of CO_2 into the Deccan basalt formations, PNNL will conduct similar tests in the Columbia River basin basalts. January 25, 2007, http://www.nature.com/news/2007/070122/full/445350a.html. (Subscription required.)

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***The New York Times,* "In a Test of Capturing Carbon Dioxide, Perhaps a Way to Temper Global Warming,"** and ***Alstom Press Release,* "Alstom and American Electric Power Sign Agreement to Bring Carbon Dioxide Capture Technology to Commercial Scale by 2011."** On March 14, an announcement was made to conduct a large-scale, post-combustion carbon capture project between American Electric Power (AEP) and Alstom, a large manufacturer of generating equipment. The project will utilize chilled ammonia to capture the carbon dioxide (CO_2) that is emitted from coal-fired power plants and will isolate it into a highly concentrated, high-pressure form. The new process, developed by Alstom, dramatically reduces the energy required to capture the CO_2, which can amount to as much as a third of a power plant's energy output needed to extract the flue gas. Results of testing the technology have shown capture rates exceeding 90 percent of CO_2 and at a cost significantly lower than other capture methods. The technology is also significant in that it can be retrofitted for application in existing

coal-fired power plants. The project will be implemented in two phases. The initial pilot test will take place in late 2008 at the company's Mountaineer plant in New Haven, West Virginia and will capture 100,000 tons of CO_2 per year and then sequester it 9,000 feet underground in saline formations at the site. The demonstration is expected to cost $800 million, and the company is expected to request federal money to fund the project, as well as passing the cost to customers if state regulators permit it. A much larger commercial demonstration, scheduled to begin in late 2011, will follow at AEP's 450 megawatt plant at the Northeastern Station location in Oklahoma. As much as 1.5 million tons of CO_2 will be captured for this test and subsequently sold for enhanced oil recovery operations. The project is expected to last for twelve to eighteen months. This initiative signifies that AEP may be expecting government regulations in the form of carbon emission limits, according to some climate policy specialists. March 15, 2007, http://www.nytimes.com/2007/03/15/business/15carbon.html?pagewanted=print, (Subscription required.) and March 15, 2007, http://home.businesswire.com/portal/site/google/index.jsp?ndmViewId=news_view&newsId=20070315005762&newsLang=en.

***Geo-Processors USA, Inc. Press Release,* "Geo-Processors Breakthrough in Carbon Capture and Storage Technology."** Geo-Processors USA recently announced the development of a unique carbon capture and storage (CCS) technology called Carbon Capture and Products Recovery (CCPR). The CCPR system differs from traditional capture methods in that it converts the carbon dioxide from ambient air or point-sources into mineral products that can be utilized in other industrial applications, recycled, or sequestered. Geo-Processors USA, which focuses on the development and commercialization of cost-effective sustainable energy technologies, successfully conducted testing of the process in Australia. Significant to the development of this technology is that the alkaline-produced water from oil and gas industries, coal mining, and coal power stations will now be able to be used as a resource rather than a waste stream, and will eliminate the cost associated with the use of synthetic caustic sorbents in other CCS processes. February 26, 2007, http://www.geo-processors.com/files/GeoProc-PressRelease-26Feb07.pdf.

***Reuters,* "Norway Says to Form State Carbon Dioxide Storage Company."** In efforts to contribute to technological development and broad use of carbon capture and storage (CCS) technology, the government of Norway announced that it will form a state-owned company to manage such projects. The new company will be responsible for the government's CCS projects, including plans to construct two of the country's first gas-fired power plants. The first project, which would be the world's largest full-scale carbon dioxide (CO_2) capture and storage project, is a combined heat and power plant at the state-controlled oil and gas company Statoil's Mongstad refinery on the west coast. The facility will capture partial CO_2 emissions from the power plant beginning in 2010, with plans for full-scale capture in operation by the end of 2014. Initially, the government will own 80 percent of the project, but hopes to bring in more industrial partners in order to eventually decrease the government's interest in it. Statoil has been involved in an offshore carbon sequestration project at the Sleipner gas field since 1996. In a second project, the government will be involved in building another gas-fired power plant at the Kaarstoe gas-processing plant north of Stavanger. Currently, Norway relies almost exclusively on hydro-powered plants for electricity, even though the country is the world's largest exporter of crude oil and Western Europe's biggest natural gas producer. The government is planning for the new plants to integrate CCS into their operations. March 6, 2007, http://www.planetark.org/avantgo/dailynewsstory.cfm?newsid=40664.

***The Age,* "Carbon Storage Plan Gains Momentum."** Australia's Otway Basin is home to the country's first carbon dioxide (CO_2) geosequestration project, which has received international attention. The $23.6 million ($30 million Australian) endeavor has received $3.1 million ($4 million Australian) in funding from the Australian government. Plans to sequester the CO_2 may begin as early as July 2007. Researchers from the Research Centre for Greenhouse Gas Technologies (CO_2CRC) will be conducting the tests. The local government is currently filing a permit to rezone the site so that non-agricultural development can take place on the farmland. According to CO_2CRC chief executive Peter Cook, the rezoning

application should not cause delays in launching the project. CO_2CRC will carry out a sophisticated monitoring program that aims to demonstrate to the community, government regulators and industry that the technology is a safe, viable greenhouse gas mitigation option. February 19, 2007, http://www.theage.com.au/news/business/carbon-storage-plan-gains-momentum/2007/02/18/1171733612638.html#.

Australian Broadcasting Corporation, **"New South Wales Government Launches Carbon Capture Project."** On March 2, the New South Wales government launched a $17 million ($22 million Australian) carbon capture and storage project. The announcement was made by the government's Mineral Resources Minister Ian Macdonald, who also commented on other carbon sequestration projects taking place overseas where carbon dioxide (CO_2) is safely transported via pipelines. The project will take place on the central coast of the country and involves capturing CO_2 from regional power plants and subsequently storing it underground. Additionally, the government of New South Wales is also considering ultra clean coal technology to minimize greenhouse gas emissions. March 2, 2007, http://www.abc.net.au/news/items/200703/1861927.htm?midnorthcoast.

C News (Canada), "**Alberta Plans $1.5 Billion Carbon Dioxide Pipeline."** The Canadian province of Alberta plans to construct a $1.3 billion ($1.5 billion Canadian) carbon dioxide (CO_2) pipeline. Alberta Premier Ed Stelmach said that the monies would come from Prime Minister Stephen Harper's EcoFund. Alberta plans to capture CO_2 emissions from heavy emitters and pump them into mature oil fields in the Alberta oil patch for enhanced oil recovery. Additional funds for construction of the pipeline will be generated through a provincial technology fund. Emitters will pay into the fund according to how many metric tons of emissions they produce over the target level, which will be set by the government in the spring. The Alberta government is aiming to reduce emissions by 12 percent, and plans to set the targets by July 1, 2007. March 5, 2007, http://www.freedominion.ca/phpBB2/viewtopic.php?t=76911&sid=9ce5d490888b51a6f354fae28b51755f.

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Fossil Energy Techline, **"First Utility-Scale Carbon Dioxide Deployment Shows Value of Private-Public Joint Ventures."** The first commercial carbon sequestration project will begin at American Electric Power (AEP), following a combined ten-year effort between AEP and the US Department of Energy's (DOE) National Energy Technology Laboratory (NETL). Carl Bauer, NETL's Director, was commended for his efforts in the success of the joint venture between DOE and AEP. DOE contributed $7.2 million and $1.4 million came from industry partners to fund the three initial phases of the project leading up to the deployment of the carbon dioxide (CO_2) capture phase. AEP will begin demonstration of the capture technology using chilled ammonia, followed by sequestration of 100,000 tons of CO_2 at its Mountaineer Plant in West Virginia. The captured CO_2 will be pumped into a saline formation located below the site. Success of this demonstration will be followed by a 1.5 million ton capture project at AEP's 450 megawatt plant in Oklahoma, which will be used for enhanced oil recovery efforts in 2011. To read more about the Office of Fossil Energy's Carbon Sequestration Program, go to: http://www.fossil.energy.gov/programs/sequestration/index.html. March 20, 2007, http://www.fossil.energy.gov/news/techlines/2007/07014-DOE_Commends_AEP_Project.html.

Fossil Energy Techline, **"DOE-Funded Research at Maryland Marsh Aids Climate Change Solutions."** Members of the Midwest Regional Carbon Sequestration Partnership (MRCSP), one of the seven Regional Carbon Sequestration Partnerships formed by the US Department of Energy (DOE), met at the Blackwater National Wildlife Refuge to evaluate the progress made to date to reclaim the marshland for carbon sequestration purposes. By maintaining and restoring the wetlands and tidal marshes, it will be possible to successfully demonstrate terrestrial carbon sequestration and avoid the negative impact on the Blackwater site caused by rising sea waters. The DOE's National Energy Technology Laboratory and the State of Maryland are working to preserve the estuary by replenishing

the 150-400 acres per year lost to sea level rise, sinking, erosion, salt water intrusion, and plant-eating invasive species such as nutria (rodents) and Canadian geese. Clean dredged material, which needs to be disposed of in order to keep the Port of Baltimore channels open, is transferred to the Blackwater Refuge and then planted with grasses to restore the marsh. Researchers from the University of Maryland, an MRCSP partner, also hope to identify specific types of wetlands best suited for storing carbon. Twenty-seven acres of the marsh have been restored to date, with the goal to rebuild up to 20,000 acres. March 22, 2007, http://www.fossil.energy.gov/news/techlines/2007/07015-Marsh_Restoration_Aids_Climate.html.

***Jackson Hole Star Tribune,* "State Has Vast Capacity for Carbon Dioxide Sequestration."** Wyoming could play an important role in combating the harmful effects of carbon dioxide (CO_2) emissions because of the potential to store large amounts of CO_2 in coal seams and oil reservoirs across the state. Sequestering CO_2 in coal seams has the added benefit of producing methane gas that otherwise might be left behind; additionally, sequestering CO_2 in depleted oil fields can be used for enhanced oil recovery methods. An estimated 4.15 billion barrels of oil and 19.6 trillion cubic feet of methane could be recovered using sequestration technologies. Carl Bauer, Director of the National Energy Technology Laboratory (NETL), delivered the keynote address at the Western Research Institute-sponsored symposium held at the University of Wyoming's School of Energy Resources, "CO_2 Sequestration: Opportunities for Wyoming." There he addressed the importance of Wyoming's sequestration opportunities in fighting global warming. The Big Sky Regional Carbon Sequestration Partnership, directed by Susan Capalbo, is involved in sequestration projects in the state of Wyoming. April 5, 2007, http://www.jacksonholestartrib.com/articles/2007/04/05/news/top_story/7ae7cfcede80d12e872572b400037b89.prt.

***Reuters,* "US Sees Ample Room to Bury Carbon Dioxide But Costs Unknown."** Underground storage capacity for carbon dioxide (CO_2) emissions is abundant in the United States and Canada, with widespread storage sites capable of storing more than 3,500 billion tons of CO_2 in underground saline formations alone. Carbon burial costs have yet to be determined, but underground storage of CO_2 is an emerging technology that could help slow the effects of global warming. Emissions of the gas could be captured from power plants that burn fossil fuels, including coal, the largest source of CO_2 emissions. Dawn Deel, Carbon Sequestration Project Manager at the US Department of Energy's National Energy Technology Laboratory, contributed to the release of the first *Carbon Sequestration Atlas of the United States and Canada*, a comprehensive assessment of carbon capture and storage potential in the United States and portions of Canada. Included in the document is an analysis of stationary CO_2 sources, including 4,000 power plants, to determine whether they lay above potential CO_2 storage sites. It was determined that the majority of power plants have the underground storage capacity at the site or are within close proximity. Currently, the US has not implemented a mandatory emissions reduction policy, but leading Presidential contenders from both parties are expressing support for such legislation. **(See the Publications section of this newsletter for detailed information about the Carbon Sequestration Atlas.)** March 29, 2007, http://www.alertnet.org/thenews/newsdesk/N29192907.htm.

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***Fossil Energy Techline,* "Carbon Sequestration Field Test Begins in Illinois Basin."** The Midwest Geological Sequestration Consortium (MGSC), one of DOE's seven Regional Partnerships, initiated its first validation phase field test, an enhanced oil recovery project in the Louden Field in Illinois. Also known as the "huff-n-puff" project, the test will evaluate the potential for geologic sequestration of CO_2 in mature oil reservoirs in the Illinois Basin, an area underlying most of Illinois, western Indiana, and western Kentucky and covering 60,000 square miles. During the testing process CO_2 gas is injected into a producing well (the "huff" phase) and allowed to penetrate the formation. The well is then placed back on production (the "puff" phase) after a short waiting period. Benefits of this test include a potential to recover oil that otherwise would remain in the reservoirs, as well as proving the safety and effectiveness

of geologic sequestration of CO_2 to reduce greenhouse gas emissions. For more information about the MGSC, visit their website at: http://www.sequestration.org/. May 15, 2007, http://www.fossil.energy.gov/news/techlines/2007/PrintVersion_1_29149_29149.html?print.

***Fossil Energy Techline,* "Regional Partnership Completes 8,000-foot Well for Critical Carbon Sequestration Assessment."** On April 24, DOE announced that the Midwest Regional Carbon Sequestration Partnership (MRCSP) completed drilling of an 8,000-foot carbon sequestration test well at FirstEnergy's R. E. Burger Plant near Shadyside, Ohio. Researchers will use the well in order to determine the geology of the rock strata at the test site, thus determining whether the location is suitable for safe and permanent storage of CO_2. MRCSP is working to assess the potential for geologic sequestration of CO_2 in depleting oil and gas wells, unmineable coal seams, and deep saline and other geologic formations in the Appalachian Basin. This field test, sponsored by DOE's National Energy Technology Laboratory, is the first of three similar tests that will be conducted by the MRCSP to determine the best sequestration options in the partnership's seven-state region of Indiana, Kentucky, Maryland, Michigan, Ohio, Pennsylvania, and West Virginia. If test results obtained from the Burger plant are approved by Ohio regulators, the next step of testing will involve injecting a small amount of CO_2 into the well, permanently storing it into an underlying saline formation. Powerspan Corporation will conduct a pilot demonstration of a CO_2 capture technology at the Burger plant, anticipating the use of the captured CO_2 for the injection phase of the test. MRCSP anticipates conducting large-scale geologic storage of CO_2 upon completion of the small-scale test at this site. Similar projects are currently being conducted across the country by the other Regional Sequestration Partnerships, formed as part of DOE's Carbon Sequestration Program in 1992. April 24, 2007, http://www.fossil.energy.gov/news/techlines/2007/07025-Sequestration_Well_Completed.html.

***Fossil Energy Techline,* "Petroleum Geologists Recognize DOE for Environmental Stewardship."** The American Association of Petroleum Geologist's (AAPG) Division of Environmental Geosciences presented a prestigious award to DOE, recognizing them for their accomplishments in advancing carbon sequestration technology through research and funding efforts. Specific acknowledgement was given to DOE's Regional Carbon Sequestration Partnerships Program. The AAPG Corporate Award for Excellence in Environmental Stewardship Award was accepted at the AAPG Annual Convention in Long Beach, California by John Litynski, Regional Carbon Sequestration Program Coordinator at DOE's National Energy Technology Laboratory. DOE has made significant progress, especially in geologic sequestration, through the Regional Carbon Sequestration Partnerships Program, started in 2002 to research and develop ways to capture and permanently store CO_2, a greenhouse gas. To date, the Regional Partnerships have completed the characterization phase of their work by evaluating and identifying sequestration opportunities in various regions of the country. They will now initiate field tests for the injection of carbon dioxide at various sites that have been selected as potential storage locations for the geologic storage of CO_2. April 26, 2007, http://www.fossil.energy.gov/news/techlines/2007/07026-DOE_Earns_Environmental_Award.html.

July 2007

***Houston Chronicle*, "Going Underground for a Greenhouse Gas Solution."** Geologists from the University of Texas and representatives from Praxair are monitoring CO_2 injected into an underground brine-saturated formation at a depth of 4,000 feet. The carbon sequestration test, called the Frio Brine Project, was initiated near Houston two years ago and is being funded by DOE. Sue Hovorka, a geologist and principal investigator for the project, is working with her research colleagues to monitor the capacity of the brine formation to store the CO_2 and determine whether any of the injected CO_2 has been displaced. The permanent storage of CO_2 and other gases in this manner will play a major role in reducing the effects of greenhouse gases associated with global warming. Although the researchers found traces of CO_2 in the soil around the inactive oil wellheads where the injection occurred, it was determined that the gas came from a tiny leak in the wellhead and not from the injected formation. Hovorka and her team anticipate the start of a large-scale injection test in the fall. The test will inject one

million tons of CO_2 into an underground formation in Mississippi. June 11, 2007, http://www.chron.com/disp/story.mpl/business/4875523.html.

***Bloomberg News,* "BP and Rio Tinto Study Clean Power Project."** Hydrogen Energy, a joint venture company recently formed by BP and Rio Tinto Group on May 17, has begun looking into the prospect of a 500-megawatt coal-fired power plant fitted with carbon capture and storage technology. The project will cost an estimated $1.5 billion ($2 billion Australian) and will be capable of generating enough electricity to meet 15 percent of the electricity demand in western Australia, while at the same time capturing approximately four million metric tons of CO_2 emissions. The technology that will be used in operating the plant will reduce output of the greenhouse gas CO_2 by converting the coal used to fire the plant into hydrogen gas, which will then be used to power gas turbines to generate low-carbon electricity. The sequestered CO_2 will then be injected and permanently stored beneath the seabed of the Perth Basin. Hydrogen Energy believes that in order for the project to be successful, government policy regulating emissions will need to be in place, and government grants will need to be awarded to supplement the cost of the project. A local utility company capable of selling the base-load power may also be necessary for the project to be economically viable. Investment decisions are expected to be made by 2011, and the project would begin after a three year construction period. Similar projects proposed by BP include a 500-megawatt plant at the Carson oil refinery in California and a 475-megawatt plant in Scotland. May 21, 2007, http://www.iht.com/articles/2007/05/21/business/sxclean.php.

***National Coal Council Press Release,* "National Coal Council Calls for Increased Funding to Accelerate Development of Promising Carbon Dioxide Management Technologies."** Following a year-long study at the request of US Secretary of Energy Samuel Bodman, the National Coal Council released findings that detail technologies to accelerate carbon dioxide management. The study makes recommendations for more efficient and environmentally sound methods for coal use, while maintaining the nation's reliance on it for electricity production. The report details the necessity to develop technologies for carbon capture and storage, including development of storage sites and related infrastructure within the next ten years. In order to achieve these goals, the report emphasizes the need to accelerate public-private partnerships for commercialization of these projects within the next 15 years. Additionally, affordability in commercializing these technologies will allow for retrofitting of existing plants. To visit the National Coal Council website, go to: http://www.nationalcoalcouncil.org/.
June 14, 2007, http://sev.prnewswire.com/oil-energy/20070614/AQTH14214062007-1.html.

August 2007

***Gaylord Herald Times,* "Carbon Dioxide Storage?"** The Midwest Regional Carbon Sequestration Partnership (MRCSP), one of the seven Regional Carbon Sequestration Partnerships funded by DOE, will conduct a public meeting to focus on the MRCSP's proposed geologic field demonstration in Otsego County, Michigan of sequestering 10,000 tons of CO_2. The purpose of the test is to determine the feasibility of sequestration in deep geologic formations, such as those in the Michigan basin. A natural gas processing plant owned by DTE Energy will supply the CO_2 for the pilot test. Although the Regional Partnership is awaiting final Environmental Protection Agency permitting, it hopes to begin injection sometime this summer. The public meeting, scheduled for July 18, will allow the public to learn more about carbon sequestration technology and provide them with details about the test. MRCSP plans to conduct two additional geologic field tests in the near future. To learn more about the MRCSP and to view the official notice and public meeting agenda, visit the partnership's website at: http://198.87.0.58/Default.aspx.
July 14, 2007, http://www.gaylordheraldtimes.com/articles/2007/07/15/news/top_stories/doc4697dd33a0f82872157458.prt.

***The Seattle Times,* "Power Plant Would Bury Greenhouse Gas."** Wallula Resource Recovery, a small Northwest company with financial backing from a division of Edison International, is proposing to

build a coal-fired power plant using carbon capture and sequestration technology. At a cost of $2.2 billion, the power plant would be located in the vicinity of Wallula, Washington near the banks of the Columbia River and would produce enough power to supply one third of Seattle's power needs. The plant would meet a new requirement under Washington State law that requires new coal-fired plants to sequester CO_2 emissions. In order to reduce its emissions output, the plant would capture CO_2 from the flue gas, convert it into a liquid, and then pump the CO_2 into basalt formations located underground near the proposed plant site. Emissions could be reduced by 65 percent using this sequestration technique. Scientists at DOE's Pacific Northwest National Laboratory (PNNL) are currently conducting tests to sequester CO_2 in basalt formations and plan to drill a test well near the proposed plant site. PNNL has been able to demonstrate the advantages of storing CO_2 in basalt formations through extensive laboratory testing. Results show that when injected into the porous rock, the CO_2 reacts with it to form calcium carbonate, which is a solid. If approved by the state, the company hopes to have the plant in operation by 2013. July 5, 2007, http://seattletimes.nwsource.com/cgi-bin/PrintStory.pl?document_id=2003775192&slug=power05m&date=20070705.

***Greenwire,* "Norwegian Refinery to Test CO_2-Capture Technology."** Alstom Power Systems has selected Statoil's chilled ammonia facility in Mongstad, Norway for testing their new carbon capture technology. The initial small-scale test will use the novel CO_2 technology to capture 80,000 tons of annual emissions generated by Statoil's cracker unit or from a combined-cycle heat and power plant that is under construction on the site. If successful, Statoil intends to conduct large-scale use of the chilled ammonia technology to capture more than 2 million tons of CO_2 annually at Mongstad. Preceding this announcement, Alstom reached an agreement with power and gas provider E.ON, to launch a 5-megawatt CO_2 capture demonstration plant at the Kalshamn Power Plant in southern Sweden. These projects follow two other projects announced by Alstom earlier this year that will take place at two US-operated coal-fired power plants. American Electric Power's Mountaineer Plant in West Virginia will be the location of the first test. The second test will take place at a plant in Oklahoma. June 22, 2007, http://www.eenews.net/Greenwire/print/2007/06/22/13.

***The Guardian*, "Energy Firms Seek One Billion British Pounds for Carbon Capture Projects."** Companies planning to utilize carbon capture and storage (CCS) in newly proposed facilities are pressuring the British government to move forward with plans to invest in the technology. E.ON, RWI, and British Gas parent, Centrica, are requesting more than $610 million (£300 million) to build each of three state-of-the-art facilities. Power companies E.ON and RWE are both planning "supercritical" clean coal power plants utilizing CO_2 capture technology, and Centrica is planning to build an 800 megawatt, low emission coal-fired plant. Prime Minister Gordon Brown has talked about Britain's role in adopting CCS technologies to reduce emissions levels, and the country's recently released Energy White Paper describes the funding criteria for the projects. However, due to government funding delays, BP has opted to forego the construction of a hydrogen plant with CO_2 capture capabilities due to government delays for funding commitments. July 9, 2007, http://environment.guardian.co.uk/energy/story/0,,2121951,00.html?gusrc=rss&feed=29.

Science

September 2006

***Washington Post,* "More Frequent Heat Waves Linked to Global Warming,"** Scientists who have studied decades of weather records and computer climate models say that recent heat waves that have hit the United States and Europe have become more frequent because of global warming. Though one single weather event cannot be attributed to climate change, recent studies have suggested that human-generated emissions are causing both overall higher temperatures and greater weather variability. Paul Della-Marta, a researcher at Switzerland's Federal Office of Meteorology and Climatology, presented findings that the duration of heat waves since 1880 in Western Europe has doubled and the number of

unusually hot days in the region has nearly tripled. In 2004, researchers at Britain's Hadley Centre for Climate Prediction and Research produced computer models that showed that greenhouse gas emissions have doubled the likelihood of heat wave events like what occurred in 2003 in Europe, and that by 2040 it is likely that such heat waves will take place there every other year. The National Climatic Data Center (Data Center) in Asheville, North Carolina reported that nighttime summer temperatures across the United States have been unusually high for the past eight years, a record streak. Richard Hime of the Data Center stated that only the Dust Bowl Period of the 1930's rivaled recent summers for sustained heat levels. Some researchers say that it is hard to correlate severe heat waves and climate change because heat waves occur less often than other weather events and arise from specific weather conditions. National Weather Service meteorologist Dennis Feltgen says that the current heat wave is caused by "a large persistent area of high pressure in the upper atmosphere" that has drifted from the West to the East Coast of the United States. August 4, 2006, http://www.washingtonpost.com/wp-dyn/content/article/2006/08/03/AR2006080301489.html

October 2006

***BBC News,* "Ocean Plankton Absorb Less CO_2."** According to an article in the journal *Nature*, the amount of carbon dioxide absorbed by plant plankton in the Pacific Ocean is up to 4 percent less than the 50 billion tons estimated to be absorbed. Phytoplankton play a key role in the ocean's food web, and in the carbon cycle, accounting for around one half of the Earth's photosynthesis. The phytoplankton were being monitored via satellite, which could not distinguish a glowing green color, caused by lack of iron, from the color of healthy plankton. Data was examined from 12 years of data gathered from 36,000 miles of ship tracks to establish an indicator of the iron-poor and stressed plankton. The researchers identified three large areas of the Pacific where phytoplankton appeared to be suffering from a lack of iron: 1.) the southern ocean around Antarctica, 2.) the sub-arctic north below Alaska, and 3.) a vast area in the tropical Pacific centered on the equator. September 30, 2006, http://news.bbc.co.uk/2/hi/science/nature/5298004.stm.

November 2006

***Reuters,* "US Northeast Could Warm Drastically by 2100 – Study."** In a two-year study by the Northeast Climate Impacts Assessment group, the US Northeast could see a rise in average summer temperatures of more than 12 degrees Fahrenheit (F) by 2100 if emissions go unchecked. The Northeast region is comprised of nine states and ranks just behind Germany for quantity of emissions, and ahead of all of Canada. If 3 percent of the emissions are cut, then the temperatures may only rise to between 3.5 degrees and 6.5 degrees F by 2100. With the higher emissions projections, cities would see 60 or more summer days over 90 degrees, and 14 to 28 days with temperatures over 100 degrees F by 2100. With lower emissions projections, cities may see 30 or more days over 90 degrees F and 9 days with over 100 degrees F by 2100. Currently, Northeast cities have one or two days each year with temperatures over 100 degrees F. October 5, 2006, http://www.planetark.com/dailynewsstory.cfm/newsid/38380/story.htm.

December 2006

***The New York Times* "New Culprit in Climate Change? Try Airlines."** The airline industry, under recent scrutiny from environmentalists and consumer advocacy groups, is making efforts to address concerns that air travel is a major contributor to carbon dioxide (CO_2) emissions linked to global warming. Public awareness of the problem is being addressed through such "green" initiatives as offering airline passengers the option to purchase carbon credits at the time of booking. British Airways operates such a program whereby money earned on ticket surcharges for carbon credits are donated to sustainable energy programs. The airline industry is expected to raise further awareness of the issue by redirecting the focus of their advertising campaigns whereby emissions reduction will take the forefront to lower

fares or other enticements. October 29, 2006, http://select.nytimes.com/gst/abstract.html?res=F70F14FE395B0C738FDDA90994DE404482

***The Independent (UK),* "Flat Screen Televisions 'Will Add to Global Warming'."** Research conducted by Britain's Liberal Democrats reported that the recent increase in the purchase of flat screen televisions in Great Britain could result in an increase in carbon emissions by as much as 70 percent. Contrary to the Stern report's (a UK report on the economics of climate change) objective to spur changes in consumer behavior, the 700,000 ton per year increase in carbon dioxide (CO_2) would only hamper the country's attempts to reduce global warming. November 1, 2006, http://news.independent.co.uk/environment/article1945758.ece.

***Reuters,* "Californian Greenhouse Emissions Up 14 Percent 1990-2004."** According to a report released this week by the California Energy Commission, California's greenhouse gas emissions rose more than 14 percent between 1990 and 2004. Dan Kammen of the energy and resources group at the University of California-Berkeley says that an increase is the wrong direction for a state that has made a law to cut emissions, the Global Warming Solutions Act of 2006, though the level is considerably less than the national average (which is about double the rate of California's increase). The report is significant since it is the first time the state has accounted for emissions in such detail. The Global Warming Solutions Act of 2006 sets caps on emissions at 25 percent by 2020, and for 2000 levels of emissions by 2010. For the 15 years covered by the study, 81 percent of the greenhouse gas emissions were due to fossil fuels usage. The emissions percentages were 40.7 percent due to mobile sources, 22.2 percent due to electricity generation, 20.5 percent due to industrial emissions, 8.3 percent due to agriculture and forestry, and 8.3 percent due to other sources. Economic growth does not mean a comparable increase in emissions of greenhouse gases. The report entitled "Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004," and supporting figures can be seen at: http://www.climatechange.ca.gov/policies/greenhouse_gas_inventory/index.htm. November 6, 2006, http://www.planetark.com/dailynewsstory.cfm?newsid=38824&newsdate=06-Nov-2006.

January 2007

***AP,* "Forest Fires May Cool Area Climate Rather Than Warm It, Researchers Say."** According to a study in the journal *Science* by James T. Randerson, Associate Professor of Earth System Science at the University of California, Irvine, forest fires could have a cooling effect which cancels the impact of the greenhouse gases released from the fire. It was long thought that forest fires would worsen global warming by adding carbon dioxide to the atmosphere. Fires in northern forests release greenhouse gases, but also cause changes in the forest canopy. The result is more sunlight being reflected back into space during the spring and summer for many decades after the fire. The net cooling effect is close to neutral when averaged globally, and may lead to slightly cooler temperatures in Northern regions. November 16, 2006, http://www.iht.com/articles/ap/2006/11/16/america/NA_GEN_US_Cooling_Fires.php**.**

***Agence France-Presse,* "Climate Change Worsening Biodiversity Crisis: UN Report."** According to a report by the UN Environment Programme (UNEP), climate change is impacting the survival of whales, dolphins, turtles, birds, and other rare species that migrate over long distances. Changes in the habitat, including changes in temperature and food, are affecting many species. Rising temperatures already are having an effect on the species' food, habitat, health and reproduction. The North Atlantic right whale is at risk due to its food supply of plankton declining with a shift in ocean currents. White-beaked dolphins cannot adapt to the warmer waters now occupied by its prey. Green turtles have developed tumors due to warmer waters, allowing disease to thrive. Also, higher temperatures of nesting beaches result in a greater number of female turtles, with ratios of four females to one male soon to threaten the species. Lower water tables and more frequent droughts will reduce the habitat of the Baikal teal and aquatic warbler birds. November 16, 2006, Link Unavailable.

***Reuters,* "Arctic May Be Ice-Free by Summer 2040 – Study."** According to the research to be published by the journal *Geophysical Research Letters* on December 12, computer modeling has shown that, due to global warming, most of the ice in the Arctic basin may retreat by September of 2040. The study was jointly conducted by the US National Center for Atmospheric Research, the University of Washington, and Montreal's McGill University. The modeling showed that if greenhouse gases continue to increase at the current rate, the Arctic's future ice cover will experience periods of relative stability followed by an abrupt retreat of the ice cover as the Artic Ocean warms. In one model simulation, the September ice shrinks from 2.3 million square miles to 770,000 square miles over a 10-year period; winter ice thins from about 12 feet to less than 3 feet. December 12, 2006, http://www.planetark.com/dailynewsstory.cfm?newsid=39423&newsdate=12-Dec-2006.

"Possible role for dust or other northern forcing of ice-age carbon dioxide changes," A simple impulse-decay model driven by the history of atmospheric dust loading from Greenland can match the history of glacial–interglacial changes in atmospheric carbon dioxide concentration rather accurately, if model parameters are tuned within physically possible ranges; forcing with the Greenland temperature record produces a similarly good match. Calculations using southern forcing do not match as accurately. These results leave open the possibility of northern control of glacial–interglacial carbon dioxide changes. Qu*aternary Science Reviews,* **T.C. Johnston and R.B. Alley,** Available online November 27, 2006, http://www.sciencedirect.com/science/article/B6VBC-4MFCW7D-2/2/4be3232f89d4a91b8ea8aab26cf9a4b4**.** (Subscription may be required.)

February 2007

***Reuters,* "2007 Predicted to be World's Warmest Year."** Global warming and El Niño could result in temperatures that would mark 2007 as the warmest year on record, surpassing the previous record set in 1998. Many scientists claim that this increase is due mainly to carbon dioxide emissions from electricity generation and mobile sources. The past year is set to be the sixth warmest on record globally, and the ten warmest years have all occurred since 1994. Prior to that year, temperature records had not been broken in 150 years. Britain's Meteorological Office has forecast the world's average temperature to be 0.54 degrees Celsius above the 1961-1990 long-term average of 14.0 degrees Celsius, or an increase from 57.2 to 58.2 degrees Fahrenheit. Scientists also predict that temperatures will rise between two and six degrees Celsius in this century. It is hopeful that the G8 summit scheduled for June 2007 will initiate discussions for global action beyond the Kyoto Protocol, which is set to expire in 2012. January 4, 2007, http://today.reuters.com/news/articlenews.aspx?type=scienceNews&storyID=2007-01-04T113318Z_01_L03183156_RTRUKOC_0_US-CLIMATE-WARMEST.xml&WTmodLoc=NewsHome-C3-scienceNews-2.

March 2007

***Popular Science*, "Turning Black Coal Green."** FutureGen, a $1 billion project sponsored by The Department of Energy (DOE) in partnership with 11 leading energy companies, may become the model for future coal-burning power plants. The DOE estimates that 10.6 billion tons of coal will be burned for fuel consumption by 2030, almost doubling the amount burned in 2003. Mike Mudd, CEO of FutureGen, describes how the near-zero emission coal-fired plant will utilize gasification technologies to dramatically reduce emissions and sequester carbon dioxide (CO_2) by pumping captured CO_2 2,700 to 16,000 feet underground into deep saline formations. Typically, when coal is burned it combines with oxygen to release energy, while at the same time producing CO_2 and other emissions. The FutureGen plant will gasify coal to produce a syngas consisting primarily of CO_2, carbon monoxide, hydrogen, and water (steam). Typical power generation facilities burn the syngas (both the carbon monoxide and hydrogen) to fuel the turbines. FutureGen differs from typical coal gasification systems by reacting the carbon monoxide in the syngas stream with steam to produce hydrogen and CO_2. The hydrogen is separated from the CO_2 stream and is used to fuel the turbines. The CO_2 is pumped underground for sequestration.

The US has the capacity to store up to 2.2 trillion tons of CO_2 in geological formations, an amount equal to 1,000 years' worth of US power-plant emissions. Locations in Illinois and Texas are under consideration, and site selection for the plant should be decided by the end of the year with the completion of environmental impact assessments on four possible sites. To access a diagram of how FutureGen technology works, click on the link to this article. February 2007, http://www.popsci.com/popsci/science/3e2f391531470110vgnvcm1000004eecbccdrcrd.html.

***The Associated Press,* "Global Warming May Affect Indonesia Isles," and *France24,* "Indonesia Could Lose 2,000 Islands with Rise in Sea Level, Finds Study."** Forecasters predict that Indonesia could lose as many as 2,000 of the nation's islands due to a rise in sea levels as a result of global warming. Scientific studies, including a report to the UN's Intergovernmental Panel on Climate Change, show that by 2030 the Southeast Asian nation could lose many of its lower-lying islands due to sea level rises ranging between three and 12 inches (eight and 29 centimeters). Indonesia is an archipelago made up of more than 17,000 islands, most of them unpopulated. In the short term, rice shortages are forecast for next year because crops were not planted according to schedule due to abnormal weather patterns. Farmers are seeing significant increases in temperatures and higher than average rainfall in the wet seasons. Indonesia's Environment Minister, Rachmat Witoelar, made the announcement on January 29 at a media conference attended by Yvo de Boar, executive secretary of the UN Climate Treaty Secretariat. De Boer was in Jakarta to discuss plans for the 13th UN Climate Change Conference, where talks are scheduled to begin on global action that will be taken following expiration of the Kyoto Protocol in 2012. The conference will be held in Bali, Indonesia in December 2007 and will bring between 7,000 and 10,000 participants from more than 100 countries. January 29, 2007, http://abcnews.go.com/Technology/wireStory?id=2830876, and January 29, 2007, Link unavailable.

***Reuters,* "13 Percent of Americans Not Heard of Global Warming – Report."** According to a 46-country survey conducted by ACNielsen of more than 25,000 Internet users, thirteen percent of US citizens have never heard or read anything about global warming, even though the US is the top emitter of greenhouse gases. Fifty-seven percent of people around the world consider global warming a "very serious problem" and a further 34 percent rated it a "serious problem." Latin Americans were the most worried about the issue with 75 percent rating it "very serious," while US citizens were the least concerned with only 42 percent rating global warming "very serious." Overall, 91 percent of people had heard of global warming, with 50 percent attributing it to human activity. People in China and Brazil were most convinced of the link to human activities, with Americans the least convinced. January 30, 2007, http://www.planetark.com/dailynewsstory.cfm/newsid/40057/story.htm.

April 2007

***Greenwire,* "Asian Smog Disrupting Northwestern US Weather, Study Shows."** In a study published in the Proceedings of the National Academy of Sciences, air pollution from Asia is worsening the severity of storms in the northwestern United States. Texas A&M University scientist and lead author of the report, Renyi Zhang, studied the Pacific United States storms from 1994 to 2005 and concluded that air pollution from Asia is increasing the severity of storms by as much as 20 to 50 percent. The reasoning behind the data shows that emissions of dust, sulfur, carbon grit, and trace metals from the Asian industrial sources are interfering with rain drop formation, causing the creation of deep convective clouds. This type of cloud creates more intensive updrafts that result in more severe and more intense thunderstorms. March 6, 2007, http://www.eenews.net/Greenwire/print/2007/03/06/15.

***The Australian,* "Heating Planet 'Makes Children Sick'."** Findings from a two-year study completed at the University of Sydney have found a link between rise in temperature and childhood illness. Increased instances of fever and gastroenteritis in children under six years of age were sited, and more specifically the study showed that for every five-degree rise in temperature, two more children in that age group were admitted with fever to the hospital. The study's lead researcher and pediatric specialist, Dr. Lawrence

Lam, collected data from the Bureau of Meteorology in 2001 and 2002 and analyzed several different climate factors for his study. They included UV index, rainfall and humidity. Dr. Lam admits that further studies may be needed to ascertain whether illnesses were triggered as a direct result of the increased temperatures or whether problems stemming from the heat, like pollution, were the cause. Dr. Lam does contend, however, it is clear that children are not able to regulate their bodies to overheating as well as adults, since their brains' thermal regulation mechanisms are not as well developed. Furthermore, they are particularly at risk of extreme changes, more so than adults. **(See Publications section of this newsletter, "The association between climatic factors and childhood illnesses presented to hospital emergency among young children," for an abstract and link to the full study.)** February 22, 2007, http://www.theaustralian.news.com.au/story/0,20867,21268910-1702,00.html.

"Regional patterns of radiocarbon and fossil fuel-derived CO_2 in surface air across North America." Radiocarbon levels in annual plants provide a means to map out regional and continental-scale fossil fuel plumes in surface air. The authors collected corn (*Zea mays*) across North America during the summer of 2004. Plants from mountain regions of western North America showed the smallest influence of fossil fuel-derived carbon dioxide (CO_2) with a mean delta carbon 14 ($\Delta^{14}C$) of 66.3 parts per thousand ±1.7 parts per thousand. Plants from eastern North America and from the Ohio-Maryland region showed a larger fossil fuel influence with a mean $\Delta^{14}C$ of 58.8 parts per thousand. ± 3.9 parts per thousand and 55.2 parts per thousand ± 2.3 parts per thousand respectively, corresponding to 2.7 parts per million (ppm) ± 1.5 ppm and 4.3 ppm ± 1.0 ppm of added fossil fuel CO_2 relative to the mountain west. A model–data comparison suggests that surveys of annual plant $\Delta^{14}C$ can provide a useful test of atmospheric mixing in transport models that are used to estimate the spatial distribution of carbon sources and sinks. **Diana Y. Hsueh, Nir Y. Krakauer, James T. Randerson, Xiaomei Xu, Susan E. Trumbore, and John R. Southon.** *Geophysical Research Letters,* Volume 34, L02816, doi: 10.1029/2006GL027032, January 23, 2007, http://www.agu.org/pubs/crossref/2007/2006GL027032.shtml. (Subscription required.) See the related University of California, Irvine press release, **"Scientists Map Air Pollution Using Corn Grown in US Fields"** at: http://today.uci.edu/news/release_detail.asp?key=1564. Also, view a color-coded US Fossil Fuel Carbon Dioxide map (Note the key: red equals most polluted, blue equals least polluted) at this link: http://today.uci.edu/news/images/carbon_display_head.jpg.

May 2007

***ABC News,* "Panel: Global Warming a Threat to Earth."** On April 6, the Intergovernmental Panel on Climate Change (IPCC) released the second of four reports from the IPCC this year. The February report laid out the scientific case for how global warming is happening. This report, drawn up by the IPCC Working Group II, assesses the latest scientific knowledge on the current impacts of climate change and what the effects of global warming will be. It also presents a breakdown according to regions as to how climate change will affect billions of people. Representatives from more than 120 nations attended the meeting. Disagreement on final editing occurred between the climate scientists who wrote the report and government negotiators. Several scientists disputed with government delegates attempting to tone down the language of the report and diminish the evidence of already apparent climate changes. At the end of the negotiating, the final 21-page Summary for Policyholders was approved, which drew on information from the full 1,500-page technical document. The summary will be presented at the G8 Summit in June 2007, and it is expected that the European Union will again urge the United States to set mandatory regulations to control greenhouse gas emissions. **(See the Recent Publications section of this newsletter, "Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, 'Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability'," for a reference and link to download the report.)** April 10, 2007, http://abcnews.go.com/Technology/wireStory?id=3014590.

***Greenwire,* "Tree Planting May Add to Warming, Says DOE-Funded Study."** Contrary to the belief that tree planting halts the effects of global warming by absorbing carbon dioxide gases that contribute to

it, a US Department of Energy-funded study demonstrates the opposite under certain conditions. The findings suggest that trees planted at higher latitudes cause a phenomenon to occur called the "albedo effect" that occurs when dark surface masses, such as dense forests, absorb more heat from the sun than they reflect, causing a warming effect. The authors of the study point out that they are not condoning the logging of northern forests, but instead are confirming the importance of preserving and restoring tropical forests. The trees at lower, tropical latitudes serve a two-fold importance because they promote the formation of convective clouds that help to cool the planet, in addition to absorbing carbon dioxide. The data was first introduced at the American Geophysical Union meeting in San Francisco in December 2006. **(See the Terrestrial/Ocean section of this newsletter, "Combined climate and carbon-cycle effects of large-scale deforestation," to read an abstract of the study.)** April 10, 2007, http://www.eenews.net/Greenwire/print/2007/04/10/13. (Subscription may be required.)

June 2007

The New York Times, **"Climate Panel Reaches Consensus on the Need to Reduce Harmful Emissions."** On May 4, the Working Group III contribution to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report was released in Bangkok. While the preceding report released by the Working Group II in April 2007 concluded that CO_2 emissions are causing apparent and measurable changes in weather patterns, this report described a number of actions that will need to be taken in the near future. The report describes how individuals, industry, and governments can slow and eventually reverse greenhouse gas (GHG) levels by implementing current and emerging technologies and adopting more aggressive climate change policies. The report underscores the need for immediate action, as GHG emission levels have risen 70 percent since 1970, and claims that inactivity by individuals and countries will only worsen the problem. The report states that countries will need to adhere to emissions targets described in the Kyoto Protocol, either by the implementation of fuel taxes, or by pursuing alternative energy sources. Although the cost to the global economy is not clear, agreement exists that inactivity is no longer a viable option, given the current situation. It is expected that findings from the three IPCC reports released to date will be discussed at the June Group of Eight Summit and at talks to be held in Bali, Indonesia concerning post-Kyoto emissions restrictions. May 4, 2007, http://www.nytimes.com/2007/05/04/science/04climate.html?ref=environment&pagewanted=print. (Subscription required.) **(See "Working Group III Contribution to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, "Mitigation of Climate Change" in the Recent Publications Section of this newsletter for a link to the report.)**

International Herald Tribune, **"Recruiting Plankton to Fight Global Warming."** A California-based company has started a commercial project involving the massive growth of plankton to absorb CO_2 and then sequester it into the ocean floor. Russ George, chief executive of Planktos, the company pursuing the project, sees profitability in commercializing the science behind this global warming solution. The process is analogous to the terrestrial sequestration solution of planting trees to offset CO_2, in that both processes involve accelerating the absorption of CO_2 from the atmosphere. The commercial project is expected to start in May 2007 and will involve scattering large quantities of iron into the ocean over an area equivalent to 2.47 million acres of land. The project acquired its name "WeatherBird II" from the 115-foot research vessel that will be used to transport and dissolve the iron in the Galapagos and South Pacific. Planktos hopes to bring in $5 a ton for capturing the CO_2, an amount that would make the venture a profitable one. The company is confident that the price of carbon offsets will rise as limits set by the Kyoto Protocol approach their deadline. Controversy over the iron fertilization solution has been raised because some scientists have expressed doubts as to whether long-term absorption of CO_2 from the atmosphere will occur with the process. Also, some feel that an increase in greenhouse gases may actually result by creating plankton blooms, as methane and nitrous oxide could be released into the atmosphere. A conference has been scheduled for the fall to discuss whether iron fertilization is a valid carbon sequestration option. April 30, 2007, http://www.iht.com/articles/2007/04/30/business/0430plankton.php.

July 2007

***Reuters,* "Thunder? It's the Sound of Greenland Melting."** Greenland, the world's largest island, is melting at an accelerated rate. Blamed on a five degree Fahrenheit temperature rise in the spring and fall, causing a longer melting period of the ice cap in those seasons, the total melt area over the last 30 years has increased by 30 percent. Consensus points to human activity, namely the burning of fossil fuels, as the culprit in the upward shift in temperatures and altering of Greenland's characteristic makeup. The ice cap covering Greenland measures 624,000 cubic miles (2.6 million cubic kilometers), but is diminishing by 24 to 36 cubic miles (100 to 150 cubic kilometers) of ice each year. The amount of fresh water which forms this ice cap comprises ten percent of all the earth's fresh water supply, and a complete meltdown of the ice cap would cause a 23 foot (7 meter) rise in sea levels. The accelerated melting of Greenland's ice cap is having the ironic benefit of attracting tourists who are now able to enjoy the warmer temperatures in an area that did not historically attract many visitors. Likewise, it is also benefiting local fishermen, as warmer waters are drawing certain varieties of fish not usually found in Greenland's waters. June 7, 2007, http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=42460.

***Science Daily,* "Human Activities Increasing Carbon Sequestration in Forests."** Researchers from the United States, Canada and Europe completed a terrestrial sequestration study on nitrogen deposition by humans. Conclusions show that humans are influencing the carbon balance of forests across the Northern Hemisphere through the nitrogen produced by automobile engines, factories, and intensive agriculture. This study is unique in that the effects of low levels of nitrogen deposition were examined for the first time, proving that carbon sequestration by temperate and boreal forests is directly effected by nitrogen inputs. Nitrogen is often used as a plant nutrient found in fertilizers. When pumped into the environment by human activities, plant and tree growth is accelerated which, in turn, increases the ability of the trees to absorb CO_2. Researchers will need to continue their studies to determine what proportion of CO_2 emissions are being offset by the anthropogenic release of nitrogen, because too much could have adverse ecological effects. **(See Terrestrial/Ocean section of this newsletter for the abstract and link to this study.)** June 13, 2007, http://www.sciencedaily.com/releases/2007/06/070613131909.htm.

August 2007

***Science Daily,* "Antarctic Icebergs: Hotspots of Ocean Life."** Researchers at the University of California in San Diego are studying the effects of global climate change on Antarctic ice shelves broken apart into thousands of icebergs by rising temperatures. They have found that the floating islands of ice have a major impact on the ecology of the ocean around them, with large numbers of seabirds above them and phytoplankton, krill, and fish present below the surface. As the icebergs melt, the terrestrial material which was trapped within them is dispersed out to a radius of more than two miles, producing a "halo effect." Research results produced from extensive study of the icebergs suggests that they may influence global climate change by serving as a route for CO_2 drawdown and sequestration of particulate carbon as it sinks into the deep sea as a result of increased biological productivity. The new findings may have implications for global climate models that have, to date, considered only the variables of the melting Antarctic ice shelves and their contribution to rising sea levels and other climate change dynamics. June 22, 2007, http://www.sciencedaily.com/releases/2007/06/070621140754.htm.

Policy

September 2006

E&E News PM, **"Interior Shelves Rulemaking on CO_2 Sequestration Incentives."** The US Department of the Interior has decided against crafting royalty incentives to promote using carbon dioxide (CO_2) injection for enhanced oil recovery (EOR) and carbon sequestration. The Energy Policy Act of 2005 requested that the Department's Bureau of Land Management and Minerals Management Service explore the use of royalty waivers for oil and gas produced via EOR for both on shore and off shore applications, provided the incentive would increase the use of the technique. Several memos outlined reasons why rulemaking will be shelved. One memo stated that current EOR production areas and new target areas are on state and private lands, not federal lands, and that a limit cited regarding the use of EOR is the availability and cost of sufficient volumes of CO_2. Another point made is that CO_2 is not fully sequestered using most EOR technologies, though the Department of Energy is currently studying the amounts of CO_2 that can be sequestered using EOR. Also, the memo stated that there are already existing federal and state tax incentives in place that provide sufficient incentive for EOR projects. Another memo states that the deferred rulemaking does not prevent the Department's Bureau of Land Management from providing royalty reductions for specific EOR projects under regulations currently in place. Regarding using the technology on the outer continental shelf, a separate memo stated that more must be know about the technology and economics that apply with respect to offshore applications, therefore rulemaking would be premature. August 23, 2006, http://www.eenews.net/eenewspm/2006/08/23/archive/1/?terms=CO2.

Reuters, **"EU CO_2 Plans For 2008-12 "Ambitious Enough" – Piebalgs."** European Union Energy Commissioner Andris Piebalgs responded to a question regarding the possibility of the carbon price collapsing in the EU carbon trading scheme, given a market concern that the Phase II National Allocation Plans to be submitted to the European Commission would be too lenient. Piebalgs feels that the plans that have been submitted thus far have proposed ambitious emission cuts. Estonia, Poland, Latvia and Luxembourg have all proposed large increases in carbon credit quotas reflecting their desire to cut greenhouse gases. Germany, Ireland, Latvia, Lithuania and Britain have also submitted their plans thus far. August 24, 2006, http://www.planetark.com/dailynewsstory.cfm?newsid=37819&newsdate=24-Aug-2006.

October 2006

AP, **"Emission Targets Set at Helsinki Summit."** At ASEM 6, a forum that promotes various levels of cooperation among Asian and European countries that was held September 10-11 in Helsinki, Finland, European and Asian leader pledged to set new carbon dioxide emissions target that go beyond those set under the Kyoto Protocol for 2012. In a joint declaration, the 25 EU and 13 Asian leaders said they were determined to cooperate on an international level in response to climate change. No targets were set, but each side pledged to do its best, which was considered a setback for the Europeans who had hoped for tougher action by their Asian counterparts, notably China. Europe and Asia promised to share low carbon "cleaner and climate-friendly" technologies, both existing and new technologies. Both agreed that long term answers will be through technological breakthroughs. For more information, visit the ASEM website at: http://www.asem6.fi/. September 11, 2006, http://abcnews.go.com/International/wireStory?id=2419679&CMP=OTC-RSSFeeds0312.

EurActiv.com, **"EU in Attempt to Link Car Taxes to CO_2 Pollution."** On September 5, the European Parliament backed a proposal to introduce a European Union (EU) wide car tax based on CO_2 emissions, that that would subsequently abolish the car registration tax. Any approval on car taxation at the EU level would require unanimity backing from all the 25 Member States. Unanimity voting in Council means the proposal is likely to be vetoed. The European Parliament is consulted on an advisory basis. Proposed in July of last year by the European Commission, the carbon dioxide (CO_2) based tax is meant to allow citizens to avoid being doubly taxed when moving around Europe and create level tax conditions for automakers on the European car market. September 5, 2006, http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MjAzMTQ.

November 2006

***Reuters,* "Branson Commits US$3 Billion to Fight Global Warming."** British billionaire Richard Branson has committed to spending all the profits from his airline and rail businesses on combating global warming, approximately $3 billion over the next 10 years. One venture already in existence, Virgin Fuels, will invest $400 million over three years in renewable energy initiatives. Profits from the transport business which comprises one half of the company, will be invested in biofuels research, development, production and distribution, and also used to fund projects to combat emissions though a planned Environmental Trust. September 22, 2006, http://www.planetark.com/dailynewsstory.cfm?newsid=38212&newsdate=22-Sep-2006.

***EPA Press Release,* "Companies Set Aggressive Greenhouse Gas Emissions Reduction Goals."** Through the US Environmental Protection Agency's (EPA) Climate Leaders program, 13 companies are setting new emission reduction targets and 21 new companies are joining the program. The greenhouse gas emissions reduction targets for the 13 companies range from 9 percent to net zero emissions. The Climate Leaders represent a broad range of industry sectors and more than $1 trillion in revenue. Over 100 companies take part, and represent more than 8 percent of the total annual US greenhouse gas emissions. Reduction efforts by the group are estimated to prevent greenhouse gas emissions equivalent to those from 7 million cars. See the news link at the end of this paragraph to view a list of the companies and their reduction goals. For more information on the EPA's Climate Leaders program, see: http://epa.gov/climateleaders/. October 12, 2006, http://yosemite.epa.gov/opa/admpress.nsf/4d84d5d9a719de8c85257018005467c2/abaf76a31c93d2e685257205006305cb!OpenDocument.

"Geographically explicit global modeling of land-use change, carbon sequestration, and biomass supply." This study aims to determine whether carbon sequestration policies could present a significant contribution to the global portfolio of climate change mitigation options. The objective is to model the effects of policies designed to induce landowners to change land use and management patterns with a view to sequester carbon or to reduce deforestation. The approach uses the spatially explicit Dynamic Integrated Model of Forestry and Alternative Land Use (DIMA) to quantify the economic potential of global forests. The model chooses which of the land-use processes (afforestation, reforestation, deforestation, or conservation and management options) would be applied in a specific location, based on land prices, cost of forest production and harvesting, site productivity, population density, and estimates of economic growth. The approach is relevant in that it (1) couples a revised and updated version of the Special Report on Emissions Scenarios with the dynamic development of climate policy implications through integration with the Model for Energy Supply Strategy Alternatives and their General Environmental Impact (MESSAGE); (2) is spatially explicit on a 0.5 degree grid; and (3) is constrained by guaranteeing food security and land for urban development. As outputs, DIMA produces 100-year forecasts of land-use change, carbon sequestration, impacts of carbon incentives (e.g., avoided deforestation), biomass for bioenergy, and climate policy impacts. The modeling results indicate that carbon sequestration policies could contribute to a significant part of the global portfolio of efficient climate mitigation policies, dependent upon carbon prices. **Dmitry Rokityanskiy, Pablo C. Benítez, Florian Kraxner, Ian McCallum, Michael Obersteiner, Ewald Rametsteiner and Yoshiki Yamagata,** Technological Forecasting and Social Change, Available online October 4, 2006. http://www.sciencedirect.com/science/article/B6V71-4M1TSSW-1/2/47317f4790cb9904c5823656b6af0d6e. (Subscription may be required.)

December 2006

***E&E News,* "U.N. Conference Opens in Kenya."** The 12th UN Framework Convention on Climate Change (UNFCCC) meeting opened on November 6 in Nairobi, Kenya. More than 6,000 participants from 189 counties are meeting to discuss climate change and the urgent actions needed to combat the

consequences of global warming. Attendees are planning to pressure the US and Australia, two countries that have not ratified the Kyoto Protocol, to pledge to reduce their emissions. For more information on the November 6-17 conference, see the UNFCC website at: http://unfccc.int/meetings/cop_12/items/3754.php, November 11, 2006, http://www.eenews.net/Greenwire/print/2006/11/06/10.

***Reuters,* "Verification Problems May Delay '07 Kyoto Projects."** Project evaluations aimed at decreasing global warming and redirecting funds to poorer nations in 2007 are being delayed due to delays in the Clean Development Mechanism (CDM) review process. The CDM is an arrangement under the Kyoto Protocol allowing industrialized countries to invest in global warming reduction projects in developing nations, rather than making reduction in their own countries, which are often more costly. However, determining whether projects meet CDM rules, a more than 50 percent increase in the number of projects up for review, complaints of bureaucratic delays, and a lack of uniform review guidelines are only some of the recurring problems causing backlogs in the system. Additionally, applications that are rejected are often not accompanied by suggestions for corrective measures, making it difficult for the applicants to amend their applications to fit proper guidelines. The current CDM arrangement is due to expire in 2012, which is forcing many project developers to push for validation of their applications before then. October 30, 2006, http://www.planetark.org/dailynewsstory.cfm/newsid/38719/newsDate/30-Oct-2006/story.htm.

***Reuters,* "US, EU Hold Climate Talks Despite Kyoto Rift." and *Finland EU Presidency Press Release,* "EU and U.S. Will Continue Dialogue on Climate Change, Clean Energy and Sustainable Development."** The US and the European Union met in Helsinki, Finland on October 24-25 for a two-day dialogue on climate change, clean energy and sustainable development, despite the lack of participation in the Kyoto Protocol by the US. Carbon capture and storage was also among the topics discussed, including capturing CO_2 from power plants. The meeting was hosted by Finnish Environment Minister Jan-Erik Enestam, who holds the current presidency of the European Union. The US delegation was headed by Paula Dobriansky, US Under Secretary of State for Democracy and Global Affairs. An outcome of the meeting was that the EU and US delegations agreed to strengthen bilateral cooperation in several areas including promoting the "commercial deployment of clean coal and carbon sequestration technologies, including through the Carbon Sequestration Leadership Forum." October 24, 2006, http://www.planetark.com/dailynewsstory.cfm/newsid/38622/story.htm, and October 25, 2006, http://www.eu2006.fi/news_and_documents/press_releases/vko43/en_GB/172262/.

***Reuters,* "Rare Russian CO_2 Data Shows 11 Percent Rise Since 1999**," According to an official document submitted by the Russian environmental monitoring agency, Roshydromet, to the United Nations on Oct 23, Russia's emissions of greenhouse gases rose about 11 percent between 1999 and 2004, from 1.873 billion tons in 1999 to 2.074 billion tons in 2004. This is the first time in 5 years that Russia has submitted its greenhouse gas emissions data. Russia is the world's third largest polluter, and had previously submitted data in 1998 and 1999. After the 1991 collapse of the Soviet Union, Russia's emissions levels have dropped nearly 40 percent. Though it is still awaiting official UN verification, Russia's document to the UNFCC is available online in Russian, at: http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=5698&suchen=n. See the news item link for a small table of emissions data. October 24, 2006, http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=38618.

January 2007

***Reuters,* "U.N. Climate Talks Make Progress on Kyoto Overhaul,"** and ***Earth Negotiations Bulletin,* "Summary Of The Twelfth Conference Of The Parties To The UN Framework Convention On Climate Change And Second Meeting Of The Parties To The Kyoto Protocol: November 6-17, 2006."** From November 6-17, 2006, climate change meetings were held in Nairobi, Kenya. The "UN

Climate Change Conference – Nairobi 2006" included the twelfth Conference of the Parties (COP12) to the UN Framework Convention on Climate Change (UNFCCC) and the second Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (COP/MOP 2). Over 5,900 people attended. At COP/MOP2, the Clean Development Mechanism and Joint Implementation were discussed, as were parties' compliance with the Protocol and a proposed amendment to the Protocol. At COP12, the adverse effect of climate change on developing and least developed countries was discussed, as was the response measures and needs of the least developed countries. Both COP/MOP 2 and COP 12 focused on long-term action regarding climate change, and for developing a framework for action once the Kyoto Protocol's "first commitment period" ends in 2012. A review of the Protocol will be completed by 2008. For a detailed reporting on the meetings, see: http://www.iisd.ca/vol12/enb12318e.html. November 17, 2006, http://today.reuters.com/news/articlenews.aspx?type=worldNews&storyID=2006-11-17T162443Z_01_L1343825_RTRUKOC_0_US-ENVIRONMENT-CLIMATE.xml&pageNumber=1&imageid=&cap=&sz=13&WTModLoc=NewsArt-C1-ArticlePage1, and November 20, 2006, http://www.iisd.ca/vol12/enb12318e.html.

***Reuters,* "Calls for Climate Change Action at Asia-Pacific Summit."** Plans to examine the issue of global warming were in the forefront at the Asia Pacific Economic Cooperation (APEC) Summit, held on November 16-19, 2006 in Hanoi, Vietnam. APEC is comprised of 21 nations, including the US and China, and accounts for half of the world's global trade market. Member countries were encouraged to pledge their efforts in transitioning to low-carbon energy systems and promote the transfer of similar technologies to less developed countries. Commitments to address clean energy initiatives and climate change were also discussed. During his attendance at the summit, President Bush voiced his support to Australia's Prime Minister John Howard, who is taking proactive steps to address climate change issues, despite his country's refusal to sign the Kyoto Protocol. Howard is pushing for Asia-wide emissions trading and has set up a task force to examine a possible role for Australia to address global warming issues. He has also proposed a joint alliance with the US, China, India, South Korea, and Japan to address the same issues. Australia, the world's biggest exporter of coal, will also establish a joint working group on clean coal technology with China. November 18, 2006, http://today.reuters.co.uk/news/articlenews.aspx?type=scienceNews&storyID=2006-11-18T225544Z_01_BKK212827_RTRIDST_0_SCIENCE-APEC-ENVIRONMENT-DC.XML&WTmodLoc=NewsArt-C2-NextArticle-1.

***Reuters,* "Four States Set to Join EU Carbon Market – UK."** and ***Reuters*, "Norway To Join EU CO_2 Scheme In 2008 – EU Source."**
On December 6, Britain's Finance Minister Gordon Brown announced that Iceland, Liechtenstein, Norway and Switzerland have agreed in principle to join the European Union's emissions trading scheme. Norway will submit their plan to the executive European Commission, which will outline the limits that Norwegian industries will have regarding carbon dioxide emissions. Norway would become the twenty-eighth country to join the EU's carbon market. In November, Australia and Canada were investigating their own domestic carbon markets, which could join the European scheme. The various independent carbon markets could make way for competitive pricing of emissions permits.
December 7, 2006, http://www.planetark.com/dailynewsstory.cfm/newsid/39366/story.htm, and November 28, 2006, http://www.planetark.com/dailynewsstory.cfm/newsid/39176/story.htm.

***Reuters,* "London Targets Gas-Guzzlers with Congestion Charge."** London's mayor, Ken Livingstone, has proposed to charge the more polluting cars, which emit more than 225 grams of CO_2 per kilometer 25 pounds (about $47) per day to enter the central London traffic congestion zone. Eco-friendly cars would travel free. Other vehicles would continue to pay the current rate of 8 pounds, about $16, when entering the congestion zone between 6:30 a.m. and 7:00 p.m. Only one in 20 Londoners overall drives the more polluting cars, but the rate increases to 1 in 5 for cars in the congestion zone. A poll in August found that over two-thirds of Londoners backed the mayor's plan to discourage the use of 4x4 vehicles. November 15, 2006, http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=38981.

February 2007

***Reuters,* "EU Environment Chief Seeks 30 Percent Emissions Cut."** European Union (EU) Environment Commissioner Stavros Dimas announced that he will set a target for a 30 percent reduction in EU greenhouse gas emissions by 2020. Originally, EU heads of state and government called for a 15-30 percent reduction by 2020. This announcement comes in anticipation of the series of energy and environmental proposals for fighting global warming that will be announced by the Commission on January 10. These proposals will provide additional options for international climate change initiatives after the Kyoto Protocol expires in 2012. December 19, 2006, http://www.planetark.com/dailynewsstory.cfm/newsid/39548/story.htm.

***Greenwire,* "EU Dismisses Carbon Tax on Kyoto Dissidents."** A proposal by French Prime Minister Dominique de Villepin to tax the carbon emissions of countries that do not participate in the Kyoto Protocol has been dismissed. Peter Mandelson, the European Union Trade Commissioner, pointed out that nonparticipation is not illegal and would be very difficult to put into practice. Furthermore, implementing such a tax would violate World Trade Organization rules. December 18, 2006, http://www.eenews.net/Greenwire/print/2006/12/18/9. (Subscription may be required.)

***Reuters,* "Schwarzenegger Signs California Carbon Emissions Cut."** California Governor Arnold Schwarzenegger signed an executive order on January 18, the first of its kind in the US to cut carbon levels in vehicle fuels by at least 10 percent by 2020. The order will also implement the law adopted last summer mandating state emissions caps to reduce greenhouse gas levels 25 percent by 2020. The order is also intended to encourage the development and use of alternative vehicle fuels. The new fuel regulations will go into effect no later than December 2008. The Air Resources Board, the California Environmental Protection Agency and the California Energy Commission will work out the details of the new regulations. January 19, 2007, http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=39911.

March 2007

***Reuters*, "China Preparing National Plan for Climate Change."** The Chinese government is developing the country's first national program to address global warming. Approval of the comprehensive document on climate change is awaiting official endorsement from China's cabinet, or State Council, and could be released this year. It is expected to outline a broad set of goals for emissions reductions and how the country will cope with abnormal weather patterns. China's President Hu Jintao is faced with the challenge of presenting the idea of continued economic growth and future prosperity, while at the same time advocating a reduction in the use of fossil fuels and greenhouse gas emissions. With China expected to become the world's third-largest economic power by 2008 and forecasts that it may overtake the United States in greenhouse gas emissions, many Chinese officials are confronted with the reality that global warming is an issue that must be addressed with urgency. In particular, environmental threats to China's northwest could have detrimental effects to the nation's economic development. Climate experts estimate that China's current reduction in yearly GDP by nearly 2 percent will only be exacerbated as a result of floods, droughts, hurricanes and other climate disasters brought about by further climate changes. February 6, 2007, http://www.planetark.com/dailynewsstory.cfm/newsid/40197/story.htm.

***Reuters,* "EU Commission Approves Slovenia's Carbon Plan**." The European Commission approved Slovenia's Emissions Trading Scheme CO_2 plan for the second phase (2008-2012) of the Kyoto Protocol, allowing for a carbon quota of 8.3 million tons of carbon dioxide emissions, and representing a 9 percent cut in allowances from the first phase (2005-2007). Though the European Commission has reviewed 13 plans of European Union (EU) nations thus far for the 2005-2007 trading phase, only

Slovenia and Britain have had their quota approved. The other EU nations are required to lower their carbon quotas and resubmit. Slovenia with its population of 2 million people, accounted for less than one percent of the EU's emissions under the scheme in 2005. Brussels is being pressured to create scarcity in the market for emissions permits after 2005 data revealed that EU states had given more allowances to industry than needed, leading to a crash in carbon prices for the 2005-2007 trading phase. Denmark and Cyprus have not yet submitted their 2008-2012 plans, which, though due in June, were turned in late by many member states. February 6, 2007, http://www.planetark.com/dailynewsstory.cfm?newsid=40200&newsdate=06-Feb-2007.

"Social acceptance of carbon dioxide storage." This article discusses public acceptance of carbon capture and storage (CCS). Responses by citizens are described in relation to responses by professionally involved actors. Interviews with members of the government, industry and environmental non-government organizations (NGOs) showed that these professional actors are interested in starting up storage projects, based on thorough evaluation processes, including discussions on multi-actor working groups. As appeared from a survey among citizens living near a potential storage site (*N*=103), public attitudes in general were slightly positive, but attitudes toward storage nearby were slightly negative. The general public appeared to have little knowledge about carbon dioxide storage, and have little desire for more information. Under these circumstances, trust in the professional actors is particularly important. NGOs were found to be trusted most, and industry least by the general public. Trust in each of the three actors appeared to depend on perceived competence and intentions, which in turn were found to be related to perceived similarity of goals and thinking between trustee and trustor. Implications for communication about CCS are discussed. **Nicole M.A. Huijts, Cees J.H. Midden and Anneloes L. Meijnders,** *Energy Policy,* Published online February 1, 2007, http://www.sciencedirect.com/science/article/B6V2W-4MYFG16-1/2/674d5590b3027c2acd4184908aa5d8c0. (Subscription may be required.)

April 2007

***E&E News PM,* "Global Lawmakers Urge G8 to Set Emissions Goal**." A group of international legislators, including members of the US Congress and parliamentary representatives of 20 industrialized countries, urged their countries' leaders to set a long-term goal for stabilizing greenhouse gas emissions. The formal, although nonbinding statement, is being released in advance of the upcoming G8 summit scheduled for June 2007 in Heiligendamm, Germany, a seaside resort in the Baltic Sea. Lawmakers noted that in order to meet the aggressive goals being proposed to stabilize greenhouse gases, the world's largest economies need to combine a binding United Nations framework signed by all major nations, along with bilateral and multilateral partnerships. One of the initiatives set forth by German Chancellor Angela Merkel in anticipation of the G8 summit is to add post-Kyoto talks to the agenda. The lawmakers also highlighted the necessity to establish a global carbon market as an incentive to pursue technologies aimed at energy efficiency. Although each country faces varying degrees of economic development, the statement underscores the importance of each country to take action in line with their capabilities and "historic responsibilities." February 15, 2007, http://www.eenews.net/eenewspm/print/2007/02/15/2. (Subscription may be required.)

***Greenwire,* "Small Cost Would Bring Canada into Kyoto Compliance, Study Says."** A recent study conducted in Canada indicates that adding a tax of $1 Canadian to the current cost of producing a barrel of oil would be sufficient enough for Canadian compliance to the Kyoto Protocol. Research pointing in this direction provides one option available for the country to meet the target of a six percent reduction in emissions below 1990 levels by 2012. Oil industry leaders feel the necessity to combine that approach with intensity-based targets, which calculate reductions as a percentage of production, coupled with a cap-and-trade system. They also advocate government funding of carbon capture and storage technologies, which could be funded by the tax. The current cost to produce a barrel of oil from oil sands is about $21 ($25 Canadian). Raising the price by $1 would raise $640 million ($750 Canadian) per year.

February 22, 2007, http://www.eenews.net/Greenwire/print/2007/02/22/13. (Subscription may be required.)

May 2007

***Reuters,* "Japan, China to Take Part in Post-Kyoto Talks,"** and ***Reuters,* "China to Unveil Climate Plan Next Month."** Following a summit meeting held on April 11 between Chinese Premier Wen Jiabao and Japanese Prime Minister Shinzo Abe, the two leaders pledged their willingness to take part in post-Kyoto negotiations to limit global warming in their countries. The Kyoto Protocol, set to expire in 2012, is supported by thirty-five developed nations, but participation by the highest polluters, such as China and the United States, has not ensued. According to Gao Guangsheng, head of the Chinese Office of the National Coordination Committee for Climate Change, China will define what policies for reducing emissions should be developed and in which areas the country plans to reduce greenhouse gas emissions, but declined China's commitment to reveal an overall national target or establishment of an emissions trading exchange. China and Japan also agreed to other bilateral environmental initiatives during the summit, including technical assistance by Japan on desulphurization of Chinese coal-fired thermal power plants. April 11, 2007, http://www.alertnet.org/thenews/newsdesk/T231974.htm, and March 30, 2007, http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=41173.

"Regulatory challenges to the implementation of carbon capture and geological storage within the European Union under EU and international law." Carbon dioxide capture and storage (CCS) is a relatively new technology in the context of climate change mitigation strategies, and its legal and regulatory implications are not yet broadly understood. This paper takes a brief look at international environmental law principles relevant to CCS, identifies key environmental and safety risks associated with the technology, and highlights significant legal frameworks that pose challenges to the implementation of CCS within the European Union (EU) under EU and international law. It then notes continuing regulatory gaps that will need to be addressed for large-scale CCS to take place. The paper concludes that the clear inclusion or exclusion of CCS activities from the range of relevant legal frameworks will increase transparency, provide regulatory certainty and ultimately facilitate CCS in appropriate contexts. **M.J. Mace, Chris Hendriks and Rogier Coenraads,** *International Journal of Greenhouse Gas Control,* Available online March 30, 2007. doi:10.1016/S1750-5836(07)00028-X, http://www.sciencedirect.com/science/article/B83WP-4NCKK7W-1/2/422f865f315b3e8985e23296b8787795. (Subscription may be required.)

June 2007

***News Blaze,* "U.S. Energy Agency Leads Effort to Cut Carbon Dioxide Emissions."** On May 7 and May 10, the Carbon Sequestration Leadership Forum (CSLF) conducted a "Capacity Building in Emerging Economies Workshop," held in conjunction with the Sixth Annual Conference on Carbon Capture and Sequestration (CCS) in Pittsburgh, Pennsylvania. Fifty-five delegates from the six emerging nation countries, including Brazil, China, Columbia, India, Mexico, and South Africa, attended the workshop. Discussions focused on international efforts in developing improved cost-effective technologies related to the separation, capture, transport, and long-term storage of CO_2. International delegates presented concerns they face in advancing CCS development and deployment in their countries, citing that technology transfer will play a major role in building CCS capacity. The delegates also discussed the importance of implementation, regulatory aspects, environmental issues, and public perception in building capacity for CCS. The CSLF workshop concluded with a visit to NETL in Pittsburgh. More information about this recent CSLF workshop is available at the organization's web site: http://www.cslforum.org/may072007.htm, which includes links to download the complete agenda, introductory remarks, and presentations. May 12, 2007, http://newsblaze.com/story/20070512073935leon.nb/newsblaze/TOPSTORY/Top-Stories.html.

The Australian, **"On Track to Meet Kyoto Targets."** Australian Environmental Minister Malcolm Turnbull announced that the country is on track to meet their commitment under the Kyoto Protocol. The Australian Greenhouse Office compiled the data which shows that CO_2 emission levels decreased slightly between 2004 and 2005 from 564 million metric tons to 559 million metric tons (102 percent of 1990 levels). More significant is the fact that the country's economy has grown 61 percent while sustaining growth in greenhouse gas emissions to only two percentage points above 1990 levels. At this pace, predictions indicate that the country will be able to meet its Kyoto targets to within one percentage point for 2008 through 2012, the dates established under the agreement. Although Australia has not ratified the Kyoto Protocol, the country has voluntarily tried to keep to its commitments. May 2, 2007, Link unavailable.

"A synopsis of land use, land-use change and forestry (LULUCF) under the Kyoto Protocol and Marrakech Accords." The complexities inherent in land use, land-use change and forestry (LULUCF) activities have led to contentious and prolonged debates about the merits of their inclusion in the 2008–2012 first commitment period of the Kyoto Protocol. Yet the inclusion of these activities played a key role in agreement on the general framework of the Kyoto Protocol, and LULUCF will likely continue to play a substantial part in negotiations on national commitments post-2012. The Marrakech Accords dictate which LULUCF activities are to be included under the Kyoto Protocol and provide rules on how they are to be accounted in the first commitment period. However, these rules have limitations and drawbacks that may be avoided in the structure of future commitments beyond 2012. Through adherence to the objectives of the United Nations Framework Convention on Climate Change (UNFCCC), and the incorporation of several critical features, a future framework can more effectively address the mitigation challenges and opportunities of this sector. **B. Schlamadinger, N. Bird, T. Johns, S. Brown, J. Canadell, L. Ciccarese, M. Dutschke, J. Fiedler, A. Fischlin, P. Fearnside, C. Forner, A. Freibauer, P. Frumhoff, N. Hoehne, M.U.F. Kirschbaum, A. Labat, G. Marland, A. Michaelowa, L. Montanarella, P. Moutinho, D. Murdiyarso, N. Pena, K. Pingoud, Z. Rakonczay, E. Rametsteiner, J. Rock, M.J. Sanz, U.A. Schneider, A. Shvidenko, M. Skutsch, P. Smith, Z. Somogyi, E. Trines, M. Ward and Y. Yamagata,** *Environmental Science and Policy*, Published online March 26, 2007, doi:10.1016/j.envsci.2006.11.002, http://www.sciencedirect.com/science/article/B6VP6-4NBR47S-2/2/50d2307857e7d9307e7cbd1ff74368a8#FCANote. (Subscription may be required.)

July 2007

Greenwire, **"G8 Agreement Helps Shape Post-Kyoto Debate."** Despite the absence of concrete commitments, the Group of Eight (G8) summit has succeeded in making advances towards a post-Kyoto climate agreement. For the first time, the United States has agreed to participate and work with other countries on a new international agreement that will take place after the protocol's expiry in 2012. Before leaving the G8 summit, President George Bush discussed plans to host his own global warming summit in the United States, but a specific venue or timeframe has yet to be established. He also proposed his own set of goals separate from the United Nations' Framework Convention on Climate Change, which initially sparked concern among the European nations. The President's plan will force Congress to move forward to enact legislation concerning emissions targets, although it appears unlikely that the President would sign such legislation. Nonetheless, efforts to address global warming will continue with several events scheduled to occur in the coming months, including the annual United Nations Climate Change Conference in Bali, Indonesia in December. Concern over China and India's active participation in those talks remains a concern. June 12, 2007, http://www.eenews.net/Greenwire/print/2007/6/12/12. (Subscription may be required.)

"Societal acceptance of carbon capture and storage technologies." For the actual implementation of carbon capture and storage (CCS) technologies, societal support is a crucial precondition. This paper describes an extensive study on the acceptance of CCS by stakeholders in the Netherlands and explores one of the determining factors in the acceptance of CCS by the lay public, [that is] the way the Dutch

press perceives and portrays CCS. The stakeholder analysis shows that there is a positive attitude towards CCS by industry, government, and environmental [non-governmental organizations], provided that the conditions they pose on the deployment of CCS are met. The content analysis of Dutch news articles conveys that the media portrayal of CCS is—to a certain extent—a balanced reflection of the way CCS is perceived by the stakeholders. Both analyses show that the concerns about CCS have not overshadowed the main promise that CCS is part of the solution to climate change. However, the current negative aspects of CCS as raised by different stakeholders and the media will remain if no action is taken. Therefore, the conditions posed on the use of CCS, as well as the actions required to meet these conditions, could function as a proxy for the 'societal voice', articulating the most important issues concerning the future acceptance of CCS technology. **Klaas van Alphen, Quirine van Voorst tot Voorst, Marko P. Hekkert and Ruud E.H.M. Smits,** *Energy Policy,* Published online April 20, 2007, doi:10.1016/j.enpol.2007.03.006, http://www.sciencedirect.com/science/article/B6V2W-4NJ26S3-6/2/e539e492dbe4e1738533b28d7c1259eb. (Subscription may be required.)

August 2007

***San Francisco Chronicle,* "US is Pressured to Help China Curb Emissions."** The United States is being urged to assist China in reducing emissions generated from the country's coal-fired power plants. With China overtaking the United States in CO_2 emissions, there is growing concern that China's emissions output will cancel out current and future global efforts to curb global warming. Recent data suggests that China's coal-fired power plants are releasing annual emissions quantities twice as great as the amount emitted by all of the word's industrialized economies combined. In 2006, China released 6.2 billion tons of CO_2 emissions, which is an increase of 8.4 percent from the prior year. Democratic representative Steve Israel of New York is proposing legislation to create a $20 million program that would fund US research and development assistance with Chinese universities for low-emissions energy technology. Mr. Israel is urging US policymakers to seize this opportunity. The US-China Economic and Security Review Commission, a bipartisan congressional advisory panel, conducted hearings last month to discuss the issues facing the two nations and offer support for the formation of a US emergency program to assist China to reduce emissions from coal-fired power plants and improve their efficiency. The US currently spends approximately $1 million per year in energy cooperation with China. July 5, 2007, http://www.sfgate.com/cgi-bin/article.cgi?file=/c/a/2007/07/05/MNG1QQR9RO1.DTL&type=printable.

***Oilvoice Press Release,* "Carbon on the Agenda in Oslo."** On June 22, the International Energy Agency (IEA) and the Carbon Sequestration Leadership Forum (CSLF) conducted a workshop in Oslo, Norway for G8 summit participants to discuss CO_2 capture and sequestration opportunities. Statoil served as the seminar's co-organizer. The goal of the seminar was to provide the attendees with national and international policy-making suggestions on the subject of carbon capture and storage, in addition to incentives, regulations and legislation that must be in place for the successful implementation of the technology. Possible considerations for the next G8 summit in 2008 were also discussed. To view the keynote speech presented at the IEA-CSLF Workshop for the G8, "Early Opportunities for Carbon Capture and Storage – Global Assessment," see: http://www.iea.org/CSLF_Workshop.pdf. June 22, 2007, http://www.oilvoice.com/Carbon_on_the_Agenda_in_Oslo/9949.htm.

Geology

September 2006

"CO_2 storage and gas diffusivity properties of coals from Sydney Basin, Australia." Measurements of carbon dioxide (CO_2) adsorption and diffusion properties of coals are reported for various coalfields within Sydney Basin, New South Wales (NSW), Australia. Adsorption measurements were undertaken

using a gravimetric method. Measurements carried out on 27 coals show that Sydney Basin coals at CO_2 sub-critical conditions, namely gas pressures below 6 mega pascals (MPa) and temperatures below 39 degrees Celsius (C), can adsorb a maximum volume (Langmuir volume) of 40 to 80 cubic meters (m^3) of CO_2 per ton of coal on a dry ash free (daf) basis. The coals used in this study are of sub-bituminous to bituminous rank, ranging from 0.66 to 1.45 percent mean maximum vitrinite reflectance, and are from depths ranging from about 27 meters to 723 meters. The highest adsorption capacity applies to the highest rank coal, which is also the deepest coal. The standard deviation between Langmuir modeled and measured values is less than 1.5 cubic meters per ton (m^3/t), corresponding to a relative error of less than 2.7 percent for all except one coal. Based on adsorption isotherms, the CO_2 storage capacity for in-situ seam pressure conditions range from about 6 to 51 m^3/t. CO_2 diffusion properties of 15 of these coals, determined using a newly developed system capable of accurately measuring diffusivity of gases in solid coal indicate that CO_2 diffusivity (diffusion coefficient) in the Sydney Basin coals varies from 1.2×10^{-6} to 10.2×10^{-6} centimeters squared per second (cm^2/s). The diffusivity does not show any discernable trend with the variation in depth and rank. Porosity measured by a mercury injection method varies from 4 to 10 percent and decreases with increase in coal depth and rank. For some of the coal samples adsorption measurements for pure methane (CH_4), CO_2 and nitrogen (N_2) indicate that the Sydney Basin coals can store twice as much CO_2 as CH_4 and six times more CO_2 than N_2 (volume basis). Also, measurement of diffusivity in solid coal samples shows that CO_2 diffuses twice as quickly as CH_4. The data obtained from this study and the estimated coal resources in the state of New South Wales, allow CO_2 sequestration potentials to be calculated. **A. Saghafi, M. Faiz and D. Roberts,** *International Journal of Coal Geology*, Available online July 7, 2006, http://www.sciencedirect.com/science/article/B6V8C-4KBVV1S-4/2/f5ff10ec703fe2e2c400eb9ad292f9b6. (Subscription may be required.)

October 2006

"Detailed compositional analysis of gas seepage at the National Carbon Storage Test Site, Teapot Dome, Wyoming, USA." A baseline determination of carbon dioxide (CO_2) and methane (CH_4) fluxes and soil gas concentrations of CO_2 and CH_4 was made over the Teapot Dome oil field in the Naval Petroleum Reserve No. 3 (NPR-3) in Wyoming, USA. This was done in anticipation of experimentation with CO_2 sequestration in the Pennsylvanian Tensleep Sandstone underlying the field at a depth of 1680 meters. The baseline data were collected during the winter 2004, in order to minimize near-surface biological activity in the soil profile. The baseline data were used to select anomalous locations that may be the result of seeping thermogenic gas, along with background locations. Five 10-meter holes were drilled, 3 of which had anomalous gas microseepage, and 2 were characterized as "background." These were equipped for nested gas sampling at depths of 10-, 5-, 3-, 2-, and 1-meter depths. Methane concentrations as high as 170,000 parts per million by volume (ppmv) (17 percent) were found, along with high concentrations of ethane (C_2H_6), propane (C_3H_8), n-butane (n-C_4H_{10}), and isobutene (i-C_4H_{10}). Much smaller concentrations of ethylene (C_2H_4) and propene (C_3H_6) were observed indicating the beginning of hydrocarbon oxidation in the anomalous holes. The anomalous 10-meter holes also had high concentrations of isotopically enriched CO_2, indicating the oxidation of hydrocarbons. Concentrations of the gases decreased upward, as expected, indicating oxidation and transport into the atmosphere. The ancient source of the gases was confirmed by carbon 14 (^{14}C) determinations on CO_2, with radiocarbon ages approaching 38 radio carbon years (ka) within 5 meters of the surface. Modeling was used to analyze the distribution of hydrocarbons in the anomalous and background 10-meter holes. Diffusion alone was not sufficient to account for the hydrocarbon concentration distributions, however the data could be fit with the addition of a consumptive reaction. First-order rate constants for methanotrophic oxidation were obtained by inverse modeling. High rates of oxidation were found, particularly near the surface in the anomalous 10-meter holes, demonstrating the effectiveness of the process in the attenuation of CH_4 microseepage. The results also demonstrate the importance of CH_4 measurements in the planning of a monitoring and verification program for geological CO_2 sequestration in sites with significant remaining hydrocarbons (i.e. spent oil reservoirs). **Ronald W. Klusman,** *Applied Geochemistry,* Volume 21, Issue 9, September 2006, Pages 1498-1521. Available online September 26,

2006, http://www.sciencedirect.com/science/article/B6VDG-4KPX8T1-3/2/686b4a45f405af8ecf48bbd58ed1838c. (Subscription may be required.)

November 2006

"Enhanced geothermal systems (EGS) using CO_2 as working fluid—A novel approach for generating renewable energy with simultaneous sequestration of carbon." Responding to the need to reduce atmospheric emissions of carbon dioxide, Brown [Brown, D., 2000. A Hot Dry Rock geothermal energy concept utilizing supercritical CO_2 instead of water. In: Proceedings of the Twenty-Fifth Workshop on Geothermal Reservoir Engineering, Stanford University, pp. 233–238] proposed a novel enhanced geothermal systems (EGS) concept that would use carbon dioxide (CO_2) instead of water as heat transmission fluid, and would achieve geologic sequestration of CO_2 as an ancillary benefit. Following up on his suggestion, the authors have evaluated thermophysical properties and performed numerical simulations to explore the fluid dynamics and heat transfer issues in an engineered geothermal reservoir that would be operated with CO_2. The authors find that CO_2 is superior to water in its ability to mine heat from hot fractured rock. Carbon dioxide also offers certain advantages with respect to wellbore hydraulics, in that its larger compressibility and expansivity as compared to water would increase buoyancy forces and would reduce the parasitic power consumption of the fluid circulation system. While the thermal and hydraulic aspects of a CO_2-EGS system look promising, major uncertainties remain with regard to chemical interactions between fluids and rocks. An EGS system running on CO_2 has sufficiently attractive features to warrant further investigation. **Karsten Pruess**, *Geothermics*, Volume 35, Issue 4, August 2006, Pages 351-367. Available online September 27, 2006. http://www.sciencedirect.com/science/article/B6VCN-4M0BHBT-1/2/37fce8fddfd341ff8190583b6c62e25c. (Subscription may be required.)

January 2007

"Opportunities for low-cost CO_2 storage demonstration projects in China," Several carbon dioxide (CO_2) storage demonstration projects are needed in a variety of geological formations worldwide to prove the viability of CO_2 capture and storage as a major option for climate change mitigation. China has several low-cost CO_2 sources at sites that produce NH_3 from coal via gasification. At these plants, CO_2 generated in excess of the amount needed for other purposes (e.g., urea synthesis) is vented as a relatively pure stream. These CO_2 sources would potentially be economically interesting candidates for storage demonstration projects if there are suitable storage sites nearby. In this study a survey was conducted to estimate CO_2 availability at modern Chinese coal-fed ammonia plants. Results indicate that annual quantities of available, relatively pure CO_2 per site range from 0.6 to 1.1 million tons. The CO_2 source assessment was complemented by analysis of possible nearby opportunities for CO_2 storage. CO_2 sources were mapped in relation to China's petroliferous sedimentary basins where prospective CO_2 storage reservoirs possibly exist. Four promising pairs of sources and sinks were identified. Project costs for storage in deep saline aquifers were estimated for each pairing ranging from $15–21 per ton of CO_2. Potential enhanced oil recovery and enhanced coal bed methane recovery opportunities near each prospective source were also considered. **Kyle C. Meng, Robert H. Williams and Michael A. Celia,** *Energy Policy,* Available online October 27, 2006, http://www.sciencedirect.com/science/article/B6V2W-4M6SG95-1/2/99822ea843b49648303a7cdfdcd64102. (Subscription may be required.)

"Heterogeneous saline formations for carbon dioxide disposal: Impact of varying heterogeneity on containment and trapping," Natural gas fields often contain carbon dioxide in their reservoir fluids. Exploitation of these resources requires the removal of carbon dioxide (CO_2) from produced fluids to meet quality standards for sale into a domestic market or for the processing of the gas into liquefied natural gas (LNG). To limit the atmospheric emissions of carbon dioxide, a major greenhouse gas, it has been proposed that one method of abatement could be to inject the CO_2 into deep saline formations. This study shows that the selection process for identifying appropriate saline formations should not only

consider their size and permeability but should also consider their degree of heterogeneity. To this end, notional yet realistic geological marine sand models were constructed, on an areal scale of 50 square kilometers (km^2), to examine the effects of reservoir heterogeneity on the migration and storage of a 50 million tonne plume over a time scale of 1000 years. The models were identical in geometry and in their distribution of porosity and permeability but were individually populated with facies realizations for different net-to-gross ratios. Standard geostatistical techniques were used to generate the various distributions. With regard to the shale content, the ratio of sand to shale was varied from 100:0 (i.e. homogeneous) to 40:60. A radial shale variogram, with a length of 300 meters was used. The models were up-scaled, using flow-based methods, to make the computation feasible. A set of metrics were developed and used to compare plume migration (both vertically and laterally) and containment (through dissolution and residual phase trapping) between the various scenarios. The study showed that heterogeneity had a significant impact on the subsurface behavior of the carbon dioxide. Increasing the shale content, corresponding to a gradual decrease in reservoir quality, progressively inhibited vertical flow of the plume whilst promoting its lateral flow. This increase in the tortuosity of the carbon dioxide migration pathways resulted in a reduction in the rate of residual gas trapping through hysteresis effects. Ultimately, however, less carbon dioxide is likely to collect under the seal, thereby reducing the risk of seepage to overlying formations. It is evident that for the time scales of containment being considered here simulation periods of the order of tens of thousands of years, or even longer, will be required to demonstrate the onset of an equilibrium state. **Matthew Flett, Randal Gurton and Geoff Weir**, *Journal of Petroleum Science and Engineering,* Available online November 30, 2006. http://www.sciencedirect.com/science/article/B6VDW-4MG1P1G-2/2/68b42f95e1b0ee6b2891f76a44049a1b. (Subscription may be required.)

"Reducing energy-related CO_2 emissions using accelerated weathering of limestone." The use and impacts of accelerated weathering of limestone (AWL; reaction: $CO_2+H_2O+CaCO_3 \rightarrow Ca^{2+}+2(HCO_3^-)$) is explored as a carbon dioxide (CO_2) capture and sequestration method. It is shown that significant limestone resources are relatively close to a majority of CO_2-emitting power plants along the coastal US, a favored siting location for AWL. Waste fines, representing more than 20 percent of current US crushed limestone production (>10^9 tons per yr), could provide an inexpensive or free source of AWL carbonate. With limestone transportation then as the dominant cost variable, CO_2 mitigation costs of $3-$4/ton appear to be possible in certain locations. Perhaps 10–20 percent of US point–source CO_2 emissions could be mitigated in this fashion. It is experimentally shown that CO_2 sequestration rates of 10^{-6} to 10^{-5} moles per second per square meter (moles/sec per m^2) of limestone surface area are achievable, with reaction densities on the order of 10^{-2} tons CO_2 cubic meters per day ($m^{-3}day^{-1}$), highly dependent on limestone particle size, solution turbulence and flow, and CO_2 concentration. Modeling shows that AWL would allow carbon storage in the ocean with significantly reduced impacts to seawater pH relative to direct CO_2 disposal into the atmosphere or sea. The addition of AWL-derived alkalinity to the ocean may itself be beneficial for marine biota. **Greg H. Rau, Kevin G. Knauss, William H. Langer and Ken Caldeira**, *Energy*, Available online November 29, 2006, http://www.sciencedirect.com/science/article/B6V2S-4MFTVGD-1/2/f4b9dd99d12f90f6b4814a789ab1fcde. (Subscription may be required.)

February 2007

"Specific Storage Volumes: A Useful Tool for CO_2 Storage Capacity Assessment." Subsurface geologic strata have the potential to store billions of tons of anthropogenic carbon dioxide (CO_2); therefore, geologic carbon sequestration can be an effective mitigation tool used to slow the rate at which levels of atmospheric CO_2 are increasing. Oil and gas reservoirs, coal beds, and saline reservoirs can be used for CO_2 storage; however, it is difficult to assess and compare the relative storage capacities of these different settings. Typically, CO_2 emissions are reported in units of mass, which are not directly applicable to comparing the CO_2 storage capacities of the various storage targets. However, if the emission values are recalculated to volumes per unit mass (specific volume) then the volumes of geologic reservoirs necessary to store CO_2 emissions from large point sources can be estimated. The

factors necessary to convert the mass of CO_2 emissions to geologic storage volume (referred to here as Specific Storage Volume or 'SSV') can be reported in units of cubic meters, cubic feet, and petroleum barrels. The SSVs can be used to estimate the reservoir volume needed to store CO_2 produced over the lifetime of an individual point source, and to identify CO_2 storage targets of sufficient size to meet the demand from that given point source. These storage volumes also can then be projected onto the land surface to outline a representative "footprint," which marks the areal extent of storage. This footprint can be compared with the terrestrial carbon sequestration capacity of the same land area. The overall utility of this application is that the total storage capacity of any given parcel of land (from surface to basement) can be determined, and may assist in making land management decisions. **Sean T. Brennan and Robert C. Burruss,** *Natural Resources Research,* Published online December 15, 2006, http://www.springerlink.com/content/n1g6686n60v621p0/?p=4bf567fe1bf74862a44bbdd969af73d1&pi=27. (Subscription required.)

"Thermo-hydro-mechanical Modeling of CO_2 Sequestration System Around Fault Environment." Geological sequestration of carbon dioxide (CO_2) shows great potential to reduce greenhouse gas emissions. However, CO_2 injection into geological formations may give rise to a variety of coupled chemical and physical processes. The thermo-hydro-mechanical (THM) impact of CO_2 injection can induce fault instability, even possibly lead to seismic activities in and around the disposal reservoir. A sequential coupling approach under some assumptions was proposed in the numerical study to investigate the THM behavior of the CO_2 sequestration system concerning the temperature, initial geological stress, injection pressure and CO_2 buoyancy. The fault was treated as a flexible contact model. The effects of CO_2 injection on the mechanical behavior of the faults were investigated. The Drucker-Prager model and the cap model were used to model the constitutive relationship of formations. The numerical results show that injection pressure sensitively affects the relative slip change of the fault. At the initial stage of the sequestration process, the injection pressure plays a key role in affecting the pore pressure of the formations. However, as time continues, the influence of CO_2-induced buoyancy becomes obvious on the pore pressure of the formations. In general, The THM effects of CO_2 geosequestration do not affect the mechanical stability of formations and faults. **Qi Li, Zhishen Wu, Yilong Bai, Xiangchu Yin and Xiaochun Li,** *Pure and Applied Geophysics,* Published online December 20, 2007, http://www.springerlink.com/content/b24t48566625775t/?p=edfad81ea2624efb8a5571342c9904b2&pi=1. (Subscription required.)

March 2007

"Geologic Carbon Sequestration: CO_2 Transport in Depleted Gas Reservoirs." Chapter on geologic carbon sequestration from book entitled *Gas Transport in Porous Media* in the series, *Theory and Applications of Transport in Porous Media*. The book presents a compilation of state-of-the-art studies on gas and vapor transport processes in porous and fractured media. A broad set of models and processes is presented, including advection/diffusion, the Dusty Gas Model, enhanced vapor diffusion, phase change, coupled processes, solid/vapor sorption and vapor-pressure lowering. Numerous applications are also presented that illustrate these processes and models in current problems facing the scientific community. This book fills a gap in the general area of transport in porous and fractured media – an area that has historically been dominated by studies of liquid-phase flow and transport. This book identifies gas and vapor transport processes that may be important or dominant in various applications, and it exploits recent advances in computational modeling and experimental methods to present studies that distinguish the relative importance of various mechanisms of transport in complex media. Pages 419-426, Edited by **Clifford K. Ho and Stephen W. Webb**, Published by Springer Netherlands, ISBN 978-1-4020-3961-4 (Print), ISNB 978-1-4020-3962-1 (Online), Copyright 2006, http://www.springerlink.com/content/w75675370226h538/?p=c2d10807ce06412caa5a09f81ceb13cf&pi=0. (Subscription required.)

April 2007

"Joule-Thomson cooling due to carbon dioxide injection into natural gas reservoirs." Depleted natural gas reservoirs are a promising target for Carbon Sequestration with Enhanced Gas Recovery (CSEGR). The focus of this study is on evaluating the importance of Joule-Thomson cooling during carbon dioxide (CO_2) injection into depleted natural gas reservoirs. Joule-Thomson cooling is the adiabatic cooling or heating that accompanies the expansion of a real gas. During CO_2 injection into a natural gas reservoir, the pressure near the injection well declines rapidly as gas expands into the reservoir. If Joule-Thomson cooling during this expansion were large, injectivity and formation permeability could be altered by formation of hydrates, freezing of residual water, and fracturing due to thermal stresses. The TOUGH2/EOS7C module for carbon dioxide-methane-water (CO_2–CH_4–H_2O) mixtures is used as the simulation analysis tool. For verification of EOS7C, the classic Joule-Thomson expansion experiment is modeled for pure CO_2 resulting in Joule-Thomson coefficients in agreement with standard references to within five to seven percent. For demonstration purposes, a case with a large pressure drop (≈50 bars) is presented in order to show that temperature can drop by more than 20 degrees Celsius by this effect. Lower permeability increases Joule-Thomson cooling while lower porosity decreases it for a system with constant-rate injection. Two additional constant-rate injection cases show that for typical systems in the Sacramento Valley, California, with much smaller pressure drops (<10 bars), the Joule-Thomson cooling effect is minimal. This simulation study shows that for constant-rate injections into high-permeability reservoirs, the Joule-Thomson cooling effect is not expected to create significant problems for CSEGR. **Curtis M. Oldenburg,** *Energy Conversion and Management,* Published online February 27, 2007, http://www.sciencedirect.com/science/article/B6V2P-4N4S61G-5/2/82f0fa35656cfbb4de31141b098d5370. (Subscription may be required.)

"Black carbon sequestration as an alternative to bioenergy." Most policy and much research concerning the application of biomass to reduce global warming gas emissions has concentrated either on increasing the Earth's reservoir of biomass or on substituting biomass for fossil fuels, with or without carbon dioxide (CO_2) sequestration. Suggested approaches entail varied risks of impermanence, delay, high costs, and unknowable side-effects. An under-researched alternative approach is to extract from biomass black (elemental) carbon, which can be permanently sequestered as mineral geomass and may be relatively advantageous in terms of those risks. This paper reviews salient features of black carbon sequestration and uses a high-level quantitative model to compare the approach with the alternative use of biomass to displace fossil fuels. Black carbon has been demonstrated to produce significant benefits when sequestered in agricultural soil, apparently without bad side-effects. Black carbon sequestration appears to be more efficient in general than energy generation, in terms of atmospheric carbon saved per unit of biomass; an exception is where biomass can efficiently displace coal-fired generation. Black carbon sequestration can reasonably be expected to be relatively quick and cheap to apply due to its short value chain and known technology. However, the model is sensitive to several input variables, whose values depend heavily on local conditions. Because characteristics of black carbon sequestration are only known from limited geographical contexts, its worldwide potential will not be known without multiple streams of research, replicated in other contexts. **Malcolm Fowles,** *Biomass and Bioenergy,* Published online March 6, 2007, http://www.sciencedirect.com/science/article/B6V22-4N6FNT8-3/2/fa54c2bc1f5892234cd290d0b1877f70. (Subscription may be required.)

May 2007

"CO_2 storage capacity estimation: Issues and development of standards." Associated with the endeavors of geoscientists to pursue the promise that geological storage of carbon dioxide (CO_2) has of potentially making deep cuts into greenhouse gas emissions, Governments around the world are dependent on reliable estimates of CO_2 storage capacity and insightful indications of the viability of geological storage in their respective jurisdictions. Similarly, industry needs reliable estimates for business decisions regarding site selection and development. If such estimates are unreliable, and

decisions are made based on poor advice, then valuable resources and time could be wasted. Policies that have been put in place to address CO_2 emissions could be jeopardized. Estimates need to clearly state the limitations that existed (data, time, knowledge) at the time of making the assessment and indicate the purpose and future use to which the estimates should be applied. A set of guidelines for estimation of storage capacity will greatly assist future deliberations by government and industry on the appropriateness of geological storage of CO_2 in different geological settings and political jurisdictions. This work has been initiated under the auspices of the Carbon Sequestration Leadership Forum (www.cslforum.org), and it is intended that it will be an ongoing taskforce to further examine issues associated with storage capacity estimation. **John Bradshaw, Stefan Bachu, Didier Bonijoly, Robert Burruss, Sam Holloway, Niels Peter Christensen and Odd Magne Mathiassen,** *International Journal of Greenhouse Gas Control,* Available online March 26, 2007, doi:10.1016/S1750-5836(07)00027-8, http://www.sciencedirect.com/science/article/B83WP-4NBRG1R-1/2/8e64629160f1a76f9c3353b047a207a9. (Subscription may be required.)

"Permitting issues for CO_2 capture, transport and geological storage: A review of Europe, USA, Canada and Australia." The paper reviews the environmental, health and safety permitting/regulatory issues presented by carbon capture and storage (CCS) operations across the full project cycle, and reviews existing regulations in the European Union, North America and Australia to assess their applicability to CCS, and identify regulatory gaps. **Paul Zakkour and Mike Haines**, *International Journal of Greenhouse Gas Control,* Available online January 30, 2007, doi:10.1016/S1750-5836(06)00008-9, http://www.sciencedirect.com/science/article/B83WP-4MY11CV-1/2/223c2999e3c747374981c8b15a89169a. (Subscription may be required.)

"System-level modeling for economic evaluation of geological CO_2 storage in gas reservoirs." One way to reduce the effects of anthropogenic greenhouse gases on climate is to inject carbon dioxide (CO_2) from industrial sources into deep geological formations such as brine aquifers or depleted oil or gas reservoirs. Research is being conducted to improve understanding of factors affecting particular aspects of geological CO_2 storage (such as storage performance, storage capacity, and health, safety and environmental (HSE) issues) as well as to lower the cost of CO_2 capture and related processes. However, there has been less emphasis to date on system-level analyses of geological CO_2 storage that consider geological, economic, and environmental issues by linking detailed process models to representations of engineering components and associated economic models. The objective of this study is to develop a system-level model for geological CO_2 storage, including CO_2 capture and separation, compression, pipeline transportation to the storage site, and CO_2 injection. Within [their] system model [the authors] are incorporating detailed reservoir simulations of CO_2 injection into a gas reservoir and related enhanced production of methane. Potential leakage and associated environmental impacts are also considered. The platform for the system-level model is GoldSim [GoldSim User's Guide. GoldSim Technology Group; 2006, http://www.goldsim.com]. The application of the system model focuses on evaluating the feasibility of carbon sequestration with enhanced gas recovery (CSEGR) in the Rio Vista region of California. The reservoir simulations are performed using a special module of the TOUGH2 simulator, EOS7C, for multicomponent gas mixtures of methane and CO_2. Using a system-level modeling approach, the economic benefits of enhanced gas recovery can be directly weighed against the costs and benefits of CO_2 injection. **Yingqi Zhang, Curtis M. Oldenburg, Stefan Finsterle and Gudmundur S. Bodvarsson,** *Energy Conversion and Management,* Available online March 6, 2007. http://www.sciencedirect.com/science/article/B6V2P-4N6FYTY-2/2/5b48cc6388ca8eef4a2bac6621376ee7. (Subscription may be required.)

June 2007

"Coupling of geochemical reactions and convective mixing in the long-term geological storage of carbon dioxide." The effect of coupling of geochemical reactions with convective mixing of dissolved

carbon dioxide during geological storage is investigated by both analytical and numerical techniques. In the limit of fast reactions, scaling arguments and stability analysis show that the time for the onset of convection could be increased by up to an order of magnitude due to consumption of the dissolved CO_2 in mineralization. Numerical simulations are then used to investigate the effect of general reaction rates in two contrasting mineralogies, including overall dissolution and the distribution of ion and mineral concentrations. **Jonathan Ennis-King and Lincoln Paterson,** *International Journal of Greenhouse Gas Control,* Published online March 26, 2007, doi:10.1016/S1750-5836(07)00034-5, http://www.sciencedirect.com/science/article/B83WP-4NBR48X-1/2/74b4cb407c2a187ceaa90b29ade7b7f3. (Subscription may be required.)

"Evaluating geological sequestration of CO_2 in bituminous coals: The southern Sydney Basin, Australia as a natural analogue." Carbon dioxide contents of coals in the Sydney Basin vary both aerially and stratigraphically. In places, the coal seam gas is almost pure CO_2 that was introduced from deep magmatic sources via faults and replaced pre-existing CH_4 [methane]. In some respects this process is analogous to sequestration of anthropogenic CO_2. Laboratory studies indicate that CO_2:CH_4 storage capacity ratios for Sydney Basin coals are up to ~2 and gas diffusivity is greater for CO_2 by a factor of up to 1.5. Present-day distribution of CO_2 in the coals is controlled by geological structure, depth and a combination of hydrostatic and capillary pressures. Under present-day *P–T* conditions, most of the CO_2 occurs in solution at depths greater than about 650 meters; at shallower depths, larger volumes of CO_2 occur in gaseous form and as adsorbed molecules in the coal due to rapidly decreasing CO_2 solubility. The CO_2 has apparently migrated up to structural highs and is concentrated in anticlines and in up-dip sections of monoclines and sealing faults. CO_2 sequestered in coal measure sequences similar to those of the Sydney Basin may behave in a similar way and, in the long term, equilibrate according to the prevailing *P–T* conditions. In situ CO_2 contents of Sydney Basin coals range up to 20 m^3/t [cubic meters per ton]. Comparisons of adsorption isotherm data measured on ground coal particles with in situ gas contents of Sydney Basin coals indicate that the volumes of CO_2 stored do not exceed ~60 [percent] of the total CO_2 storage capacity. Therefore, the maximum CO_2 saturation that may be achieved during sequestration in analogous coals is likely to be considerably lower than the theoretical values indicated by adsorption isotherms. **M.M. Faiz, A. Saghafi, S.A. Barclay, L. Stalker, N.R. Sherwood, D.J. Whitford and Commonwealth Scientific and Industrial Research Organisation (CSIRO) Energy Transformed Flagship,** *International Journal of Greenhouse Gas Control*, Available online March 28, 2007, doi:10.1016/S1750-5836(07)00026-6, http://www.sciencedirect.com/science/article/B83WP-4NC5VCG-1/2/588443b7a8c6883f0ad06e51b8ca614d. (Subscription may be required.)

July 2007

"The mechanical behaviour of coal with respect to CO_2 sequestration in deep coal seams." Carbon dioxide displays a strong affinity for coal due to its propensity to adsorb to the coal surface. The process of CO_2 adsorption on coal causes lowering of surface energy and, it is hypothesised that an associated decrease in surface film confinement results in a decrease in material tensile resistance. Following the results of work carried out on the mechanical influence of CO_2 on brown coal under in situ conditions [Viete DR, Ranjith PG. The effect of CO_2 on the geomechanical and permeability behaviour of brown coal: implications for coal seam CO_2 sequestration. Int J Coal Geol 2006;66(3):204–16], a theoretical explanation is proposed for the perceived lack of a weakening effect with the adsorption of CO_2 to coal at significant confining pressures. [The authors] propose that at significant hydrostatic stresses, resistance to failure is otherwise provided (by external confinement) and the effects of adsorptive weakening are concealed. [The authors'] model predicts that adsorptive weakening, fracturing under in situ stresses, and associated permeability increases are not an issue for coal seam CO_2 sequestration for sufficiently deep target seams. Lowering of the elastic modulus of coal upon introduction of CO_2 may proceed by means other than surface energy lowering and could well occur irrespective of the depth of sequestration. The effect of elastic modulus lowering under in situ conditions would be beneficial for the long-term retention of sequestered gases. **D.R. Viete and P.G. Ranjith,** *Fuel,*

Published online April 9, 2007, doi:10.1016/j.fuel.2007.03.020, http://www.sciencedirect.com/science/article/B6V3B-4NFS18V-5/2/e09fc1140c45d8ca1c142766881c9d42. (Subscription may be required.)

August 2007

"Time-lapse carbon dioxide monitoring with pulsed neutron logging." Elevated levels of CO_2 in the atmosphere have been linked to the rise in land and sea temperature [Climate Change, 2001. In: Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Xiaosu, D. (Eds.), The Scientific Basis Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, UK, p. 944]. To demonstrate geological [CO_2] sequestration as a mitigation technique, a carbon dioxide injection experiment was conducted in East Texas. The target – Frio formation – is a highly porous, permeable and unconsolidated sandstone. The specific interval is the Frio C [carbon] sand, which originally was saturated with saline formation water. At the injection location, the Frio C sand dips 18 [degrees] to the south. To monitor the injected CO_2 spreading in the formation, an old well from 1956 drilled into the deeper Yegua formation was selected as the observation well. The injection well was drilled at a distance of 100 [feet] downdip from the monitoring well. Several borehole measurement methods were available to monitor the CO_2 injection, but the most suitable technology was thought to be the pulsed neutron logging. This logging is used widely in cased hole, and the measured macroscopic thermal absorption cross-section (Σ) is sensitive to CO_2 saturation in high porosity saline water environments. Several log examples are given demonstrating successful the monitoring of the CO_2 plume moving through the two boreholes and the resulting saturation changes. **Nadja Müller, T.S. Ramakrishnan, Austin Boyd and Shinichi Sakruai,** *International Journal of Greenhouse Gas Control,* Published online June 18, 2007, doi:10.1016/S1750-5836(07)00071-0, http://www.sciencedirect.com/science/article/B83WP-4P0N2C8-1/2/0e586e1881861b0383d03b849ca088c9. (Subscription may be required.)

"Numerical simulation of multicomponent gas diffusion and flow in coals for CO_2 enhanced coalbed methane recovery." This paper presents an alternative model of multicomponent gas diffusion and flow in bulk coals, focusing on CH_4 [methane]–CO_2 counter-diffusion associated with CO_2-sequestration enhanced coalbed methane (CO_2-ECBM) recovery. The model was developed based on the bidisperse diffusion mechanism and the Maxwell–Stefan (MS) diffusion theory, which provides an improved simulation of multicomponent gas diffusion dynamics. The model was firstly validated under the condition of pure gas diffusion by comparing with the analytical solutions of a bidisperse diffusion model and the experimental data obtained from pure-gas sorption kinetic tests. Then it was numerically solved by considering CH_4–CO_2 counter-diffusion and flow in a large coal sample to simulate a laboratory CO_2-injection core flush experiment. The simulation shows an excellent agreement with the CO_2 flush experiment. A quantitative description of the relationship between micropore diffusivity and concentration has been achieved, which is a deficiency in currently available CBM/ECBM models. The concentration-dependent diffusivities need to be taken into account in modeling the coalbed methane (CBM) recovery, in particular for simulation of ECBM production from and CO_2 sequestration in coal seams. **X.R. Wei, G.X. Wang, P. Massarotto, S.D. Golding and V. Rudolph,** *Chemical Engineering Science,* Published online May 10, 2007, doi:10.1016/j.ces.2007.04.032, http://www.sciencedirect.com/science/article/B6TFK-4NPG0FN-2/2/ce7a7b7fd5415a8ad48dcf9804e47617. (Subscription may be required.)

"Numerical modeling of injection and mineral trapping of CO_2 with H_2S and SO_2 in a sandstone formation." Carbon dioxide (CO_2) injection into deep geologic formations could decrease the atmospheric accumulation of this gas from anthropogenic sources. Furthermore, by co-injecting H_2S [hydrogen sulfide] or SO_2 [sulfur dioxide], the products respectively of coal gasification or combustion, with captured CO_2, problems associated with surface disposal would be mitigated. [The authors] developed models that simulate the co-injection of H_2S or SO_2 with CO_2 into an arkose formation at a

depth of about 2 [kilometers] and 75 [degrees Celsius]. The hydrogeology and mineralogy of the injected formation are typical of those encountered in Gulf Coast aquifers of the United States. Six numerical simulations of a simplified 1-D radial region surrounding the injection well were performed. The injection of CO_2 alone or co-injection with SO_2 or H_2S results in a concentrically zoned distribution of secondary minerals surrounding a leached and acidified region adjacent to the injection well. Co-injection of SO_2 with CO_2 results in a larger and more strongly acidified zone, and alteration differs substantially from that caused by the co-injection of H_2S or injection of CO_2 alone. Precipitation of carbonates occurs within a higher pH (pH > 5) peripheral zone. Significant quantities of CO_2 are sequestered by ankerite, dawsonite, and lesser siderite. The CO_2 mineral-trapping capacity of the formation can attain 40–50 kg/m^3 [kilograms per cubic meter] medium for the selected arkose. In contrast, secondary sulfates precipitate at lower pH (pH < 5) within the acidified zone. Most of the injected SO_2 is transformed and immobilized through alunite precipitation with lesser amounts of anhydrite and minor quantities of pyrite. The dissolved CO_2 increases with time (enhanced solubility trapping). The mineral alteration induced by injection of CO_2 with either SO_2 or H_2S leads to corresponding changes in porosity. Significant increases in porosity occur in the acidified zones where mineral dissolution dominates. With co-injection of SO_2, the porosity increases from an initial 0.3 to 0.43 after 100 years. However, within the CO_2 mineral-trapping zone, the porosity decreases to about 0.28 for both cases, because of the addition of CO_2 mass as secondary carbonates to the rock matrix. Precipitation of sulfates at the acidification front causes porosity to decrease to 0.23. The limited information currently available on the mineralogy of naturally occurring high-pressure CO_2 reservoirs is generally consistent with [the authors'] simulations. **Tianfu Xu, John A. Apps, Karsten Pruess and Hajime Yamamoto,** *Chemical Geology,* Published online May 4, 2007, doi:10.1016/j.chemgeo.2007.03.022, http://www.sciencedirect.com/science/article/B6V5Y-4NN0WDJ-2/2/5111183747c7e74b3f5133ed24a6dc29. (Subscription may be required.)

Technology

September 2006

"Process evaluation of an 865 MW_e lignite fired O_2/CO_2 power plant" In order to reduce emissions of carbon dioxide from large point sources, new technologies can be used in capture plants for combustion of fossil fuel for subsequent capture and storage of carbon dioxide (CO_2). One such technology is the O_2/CO_2 combustion process (also termed oxy-fuel combustion) that combines a conventional combustion process with a cryogenic air separation process so that the fuel is burned in oxygen and recycled flue gas, yielding a high concentration of CO_2 in the flue gas, which reduces the cost for its capture. In this work, the O_2/CO_2 process is applied using commercial data from an 865 MW_e (mega watt net electricity output) lignite fired reference power plant and large air separation units (ASU). A detailed design of the flue gas treatment pass, integrated in the overall process layout, is proposed. The essential components and energy streams of the two processes have been investigated in order to evaluate the possibilities for process integration and to determine the net efficiency of the capture plant. The electricity generation cost and the associated avoidance cost for the capture plant have been determined and compared to the reference plant with investment costs obtained directly from industry. Although an existing reference power plant forms the basis of the work, the study is directed towards a new state of the art lignite fired O_2/CO_2 power plant. The boiler power of the O_2/CO_2 plant has been increased to keep the net output of the capture and the reference plant similar. With the integration possibilities identified, the net efficiency becomes 33.5 percent, which should be compared to 42.6 percent in the reference plant. With a lignite price of 5.2 dollars per megawatt hours ($/MW h) and an interest rate of 10 percent, the electricity generation cost increases from 42.1 to 64.3 $/MW h, which corresponds to a CO_2 avoidance cost of 26 dollars per ton ($/ton) CO_2. **Klas Andersson and Filip Johnsson,** *Energy Conversion and Management,* Volume 47, Issues 18-19, November 2006, Pages 3487-3498, http://www.sciencedirect.com/science/article/B6V2P-4KD5BK1-1/2/2fe89144fb001cbcde411a6a87791801. (Subscription may be required.)

"Incorporating carbon capture and storage technologies in integrated assessment models." Low-carbon emitting technologies are a key component of technical change in integrated assessment models. The authors develop a methodology for incorporating technologies into computable general equilibrium economic models and demonstrate this methodology by implementing carbon capture and storage technologies in the MIT Emissions Prediction and Policy Analysis (EPPA) model. Three primary implementation issues are discussed: characterization of the technical system, translation of bottom-up engineering information into an economic model, and the depiction of realistic technology adoption rates. The specification of input substitution, relative costs, and plant dispatch are the most critical factors in technology representation. Technology adoption rates in economic models are governed by exogenous and endogenous constraints. A comparison of the current approaches used in economic models with the theoretical and empirical factors affecting adoption rates highlights opportunities for refining the current methods. **James R. McFarland and Howard J. Herzog,** *Energy Economics,* Available online July 7, 2006, http://www.sciencedirect.com/science/article/B6V7G-4KBVVDM-2/2/14ae1e8dbe56dba7b6457d36a69dd7f3. (Subscription may be required.)

"Techno-economic modeling and cost functions of CO_2 capture processes." The paper presents the techno-economic modeling of CO_2 capture process in coal-fired power plants. An overall model is being developed to compare carbon capture and sequestration options at locations within the United Kingdom, and for studies of the sensitivity of the cost of disposal to changes in the major parameters of the most promising solutions identified. Technological options of CO_2 capture have been studied and cost estimation relationships (CERs) for the chosen options calculated. Created models are related to the capital, operation and maintenance cost. A total annualized cost of plant electricity output and amount of CO_2 avoided have been developed. The influence of interest rates and plant life has been analyzed as well. The CERs are included as an integral part of the overall model. **Jirí Klemes, Igor Bulatov and Tim Cockerill,** *Computers & Chemical Engineering,* Available online July 20, 2006, http://www.sciencedirect.com/science/article/B6TFT-4KFMMC2-1/2/5911705c2cc0f639878e9881b0b59b1b. (Subscription may be required.)

October 2006

"Can Advances in Science and Technology Prevent Global Warming?: A Critical Review of Limitations and Challenges." The most stringent emission scenarios published by the Intergovernmental Panel on Climate Change (IPCC) would result in the stabilization of atmospheric carbon dioxide (CO_2) at concentrations of approximately 550 parts per million (ppm) which would produce a global temperature increase of at least 2 degrees Celsius by 2100. Given the large uncertainties regarding the potential risks associated with this degree of global warming, it would be more prudent to stabilize atmospheric CO_2 concentrations at or below current levels which, in turn, would require more than 20-fold reduction (i.e., greater than or equal to 95 percent) in per capita carbon emissions in industrialized nations within the next 50-100 years. Using the Kaya equation as a conceptual framework, this paper examines whether CO_2 mitigation approaches such as energy efficiency improvements, carbon sequestration, and the development of carbon-free energy sources would be sufficient to bring about the required reduction in per capita carbon emissions without creating unforeseen negative impacts elsewhere. In terms of energy efficiency, large improvements (greater than or equal to 5-fold) are in principle possible through aggressive investments in research and development and the removal of market imperfections such as corporate subsidies. However, energy efficiency improvements per se will not result in a reduction in carbon emissions if, as predicted by the IPCC, the size of the global economy expands 12-26-fold by 2100. Terrestrial carbon sequestration via reforestation and improved agricultural soil management has many environmental advantages, but has only limited CO_2 mitigation potential because the global terrestrial carbon sink (ca. 200 gigatons of carbon) is small relative to the size of fossil fuel deposits (greater than or equal to 4000 gigatons of carbon). By contrast, very large amounts of CO_2 can potentially be removed from the atmosphere via sequestration in geologic formations and oceans, but carbon storage is not permanent and is likely to

create many unpredictable environmental consequences. Renewable energy can in theory provide large amounts of carbon-free power. However, biomass and hydroelectric energy can only be marginally expanded, and large-scale solar energy installations (i.e., wind, photovoltaics, and direct thermal) are likely to have significant negative environmental impacts. Expansion of nuclear energy is highly unlikely due to concerns over reactor safety, radioactive waste management, weapons proliferation, and cost. In view of the serious limitations and liabilities of many proposed CO_2 mitigation approaches, it appears that there remain only few no-regrets options such as drastic energy efficiency improvements, extensive terrestrial carbon sequestration, and cautious expansion of renewable energy generation. These promising CO_2 mitigation technologies have the potential to bring about the required 20-fold reduction in per capita carbon emission only if population and economic growth are halted without delay. Therefore, addressing the problem of global warming requires not only technological research and development but also a reexamination of core values that equate material consumption and economic growth with happiness and wellbeing. **Michael H. Husemann,** *Mitigation and Adaptation Strategies for Global Change,* 2006, Volume 11, Pages 539-577, DOI: 10.1007/s11027-006-2166-0. http://www.springerlink.com/content/9024t888tr0m778r/. (Fee or subscription may be required.)

"CCS: A future CO2 mitigation option for Germany?--A bottom-up approach." The role that carbon capture and storage (CCS) technologies could play within the framework of an overall CO_2 mitigation strategy is examined in the form of scenarios up to 2030 with the example of Germany. As the calculations show, the use of CCS can represent an interesting mitigation option in view of stringent CO_2 reduction goals. The scenarios, performed with the aid of the IKARUS optimization model, however, also show that according to cost-efficiency criteria a large number of measures would have to be taken covering all energy sectors. CCS can at best represent one element in an overall strategy. The model results show that a mitigation goal for 2030 corresponding to a 35 percent reduction of CO_2 as compared to 1990 is necessary to trigger a significant contribution of CCS. As an alternative to a CO_2 restriction, we also calculated reduction scenarios based on CO_2 penalties. These scenarios showed that a penalty price of approximately \$38/tCO_2 dollars per ton of CO_2 is necessary before CCS can be included in the model. **Dag Martinsen, Jochen Linssen, Peter Markewitz and Stefan Vögele, *Energy Policy,* Available online September 1, 2006.** http://www.sciencedirect.com/science/article/B6V2W-4KSSWHP-1/2/57a869c18475437bb0bb0cffa5dc4708. (Subscription may be required.)

November 2006

"Characterization and selectivity for methane and carbon dioxide adsorption on the all-silica DD3R zeolite." Clathrasil Deca-dodecasil 3R (DD3R) zeolite was synthesized in this study. Then, adsorption properties of carbon dioxide and methane were examined on the all-silica DD3R zeolite. Pure component adsorption isotherms are reported at temperatures of 273–348 Kelvin (K) and pressures as high as 3 megapascals (MPa). The isotherms follow a typical Type-I shape according to the Brunauer classification. They are well described using Langmuir and multi-site Langmuir models. Isosteric heats of adsorption and Henry's Law constants of all adsorbates were determined. High selectivity of adsorption for carbon dioxide over methane suggests that the all-silica DD3R is an effective adsorbent or zeolite membrane material that can separate carbon dioxide and methane gaseous mixtures. **Shuji Himeno, Toshihiro Tomita, Kenji Suzuki and Shuichi Yoshida,** *Microporous and Mesoporous Materials,* Available online October 2, 2006, http://www.sciencedirect.com/science/article/B6TH4-4M1D0HR-3/2/1333505f2fe51b588a8072b3fa0d2fb5. (Subscription may be required.)

"Production of hydrogen through the carbonation-calcination reaction applied to CH_4/CO_2 mixtures." The production of hydrogen combined with carbon capture represents a possible option for reducing carbon dioxide (CO_2) emissions in atmosphere and anthropogenic greenhouse effect. Nowadays the worldwide hydrogen production is based mainly on natural gas reforming, but the attention of the scientific community is focused also on other gas mixtures with significant methane (CH_4) content. In particular mixtures constituted mainly by methane and carbon dioxide are extensively used in energy

conversion applications, as they include land-fill gas, digester gas and natural gas. The present paper addresses the development of an innovative system for hydrogen production and CO_2 capture starting from these mixtures. The plant is based on steam methane reforming, coupled with the carbonation and calcination reactions for CO_2 absorption and desorption, respectively. A thermodynamic approach is proposed to investigate the plant performance in relation to the methane content in the feeding gas. The results suggest that, in order to optimize the hydrogen purity and the efficiency, two different methodologies can be adopted involving both the system layout and operating parameters. In particular such methodologies are suitable for a methane content, respectively, higher and lower than 65 percent. **L. Barelli, G. Bidini, A. Corradetti and U. Desideri,** *Energy,* Available online September 12, 2006. http://www.sciencedirect.com/science/article/B6V2S-4KW5W8H-1/2/73d3abb827e7617976c93284610c69ea. (Subscription may be required.)

December 2006

"Layered Double Hydroxides for CO_2 Capture: Structure Evolution and Regeneration." Mg-Al-CO_3 layered double hydroxide (LDH) was synthesized, and its thermal evolution was investigated using X-ray diffraction, FTIR (Fourier Transform Infrared Spectroscopy) spectroscopy, and thermogravimetric analysis (TGA). The resultant LDH derivatives showed excellent carbon dioxide (CO_2) adsorption capabilities, especially suitable for high-temperature CO_2 separation from flue gases. Calcination of crystalline LDHs at 400 degrees Celsius led to phase transformation yielding amorphous Mg-Al mixed oxides having a CO_2 sorption capacity of 0.49 micromoles per gram (mmole/g) at 200 degrees Celsius. Reversible and irreversible CO_2 sorption was determined to be approximately 88 percent and approximately 12 percent of the total CO_2 sorption, respectively. Regeneration restored the Mg-Al mixed oxide to 98 percent of its initial CO_2 sorption after several cycles of CO_2 adsorption testing. This clearly indicates the desirable properties of Mg-Al mixed oxide for CO_2 capture from flue gases at high temperatures (up to 200 degrees Celsius). **M. K. Ram Reddy, Z. P. Xu, G. Q. (Max) Lu, and J. C. Diniz da Costa**, *Industrial and Engineering Chemistry Research,* **45** (22), 7504 -7509, 2006, 10.1021/ie060757k S0888-5885(06)00757-3, Web release date, October 4, 2006. http://pubs.acs.org/cgi-bin/abstract.cgi/iecred/2006/45/i22/abs/ie060757k.html. (Subscription required.)

"Characterization and Activity of K, CeO_2, and Mn Promoted Ni/Al_2O_3 Catalysts for Carbon Dioxide Reforming of Methane." Reforming of methane with carbon dioxide into syngas over Ni/γ-Al_2O_3 catalysts modified by potassium, MnO, and CeO_2 was studied. The catalysts were prepared by impregnation technique and were characterized by BET surface area, pore volume, X-ray diffraction, scanning electron microscopy, transmission electron microscopy, temperature-programmed studies, and pulse chemisorption. The performance of these catalysts was evaluated by conducting the reforming reaction in a fixed-bed reactor. Results of the investigation suggested that stable Ni/Al_2O_3 catalysts for the carbon dioxide reforming of methane can be prepared by the addition of both potassium and CeO_2 (or MnO) as promoters. The results of the various characterization techniques were used to relate the observed catalytic activity and stability to the catalyst property. The stability and lower amounts of coking on promoted catalysts were attributed to partial coverage of the surface of nickel by patches of promoters, strong metal-support interaction (TPR, H_2 pulse chemisorption, H_2-TPD), and their increased CO_2 adsorption (CO_2-TPD). For the stable 13.5Ni-2K/10CeO_2-Al_2O_3 catalyst, the effect of reaction temperature and contact time on conversion and product yield was studied. It was found that the conversion and product yield increased with increasing reaction temperature and $W/F_{CH4,0}$ and reached equilibrium at $W/F_{CH4,0}$ = 1.7 kg-cat·h/$kg_{methane}$. The mechanism of the CH_4/CO_2 reaction has been proposed, based on which a kinetic model was developed to estimate the kinetic parameters. The estimated kinetic parameters predicted the product yields satisfactorily. CH_4 activation to form CH_x and CH_xO decomposition are suggested to be the rate-determining steps of the CH_4/CO_2 reaction over the 13.5Ni-2K/10CeO_2-Al_2O_3 catalyst. The activation energy for methane adsorption and dissociation (E_{k1L}), CH_xO decomposition (E_{k7L}), and reverse water gas shift reaction (E_{kr}) were estimated to be 113.8 ± 5.5, 119.3 ± 4.7, and 155.3 ± 7.0 kilojoules per mole (kJ/mol), respectively. **Nandini A. Pechimuthu, Kamal K. Pant, Subhash C. Dhingra, and Rohit Bhalla,** *Industrial and Engineering Chemistry Research,* **45**

(22), 7435 -7443, 2006. 10.1021/ie060661q S0888-5885(06)00661-0, Web release date, September 29, 2006, http://pubs.acs.org/cgi-bin/abstract.cgi/iecred/2006/45/i22/abs/ie060661q.html. (Subscription required.)

"Feasibility Assessment of Microalgal Carbon Dioxide Sequestration Technology with Photobioreactor and Solar Collector." The aim of this study was to develop a feasibility model for microalgal carbon dioxide (CO_2) biofixation using photobioreactors equipped with solar collectors, which would evaluate the unit net cost of CO_2 mitigation as a function of the target total CO_2 mitigation cost, the available solar radiation, and the biological conversion efficiency, among others. The results showed that, to achieve the target CO_2 mitigation price of 30 \$ t^{-1} [CO_2] at 40 percent biological conversion efficiency, the allowable net cost should be less than \$252 m^{-2} yr^{-1} at low-light intensity (average US location), and should be less than \$3.24 m^{-2} yr^{-1} at high light intensity (sunbelt region). The model made evident the importance of using microalgae with commercially valuable byproducts (*e.g.* biofuel), especially in achieving the smaller allowable unit net costs corresponding to more stringent CO_2 mitigation costs. **E. Ono and J.L. Cuello,** *Biosystems Engineering,* doi:10.1016/j.biosystemseng.2006.08.005, Available online October 16, 2006, http://www.sciencedirect.com/science/article/B6WXV-4M4CN5S-1/2/2515673106115b3686f3d15355322e82. (Subscription may be required.)

"High efficiency electric power generation: The environmental role." Electric power generation system development is reviewed with special attention to plant efficiency. It is generally understood that efficiency improvement that is consistent with high plant reliability and low cost of electricity is economically beneficial, but its effect upon reduction of all plant emissions without installation of additional environmental equipment, is less well appreciated. As carbon dioxide (CO_2) emission control is gaining increasing acceptance, efficiency improvement, as the only practical tool capable of reducing CO_2 emission from fossil fuel plant in the short term, has become a key concept for the choice of technology for new plant and upgrades of existing plant. Efficiency is also important for longer-term solutions of reducing CO_2 emission by carbon capture and sequestration (CCS); it is essential for the underlying plants to be highly efficient so as to mitigate the energy penalty of CCS technology application. Power generating options, including coal-fired Rankine cycle steam plants with advanced steam parameters, natural gas-fired gas turbine-steam, and coal gasification combined cycle plants are discussed and compared for their efficiency, cost and operational availability. Special attention is paid to the timeline of the various technologies for their development, demonstration and commercial availability for deployment. **János M. Beér,** *Progress in Energy and Combustion Science,* Available online October 17, 2006, http://www.sciencedirect.com/science/article/B6V3W-4M4KK3C-1/2/7d6d3f50dc78ea92b377cfe4a860409f.

"Combustion processes for carbon capture," A review of the technologies for coal-based power generation closest to commercial application involving carbon capture is presented. Carbon capture and storage (CCS) developments are primarily adaptations of conventional combustion systems, with additional unit operations such as bulk oxygen supply, CO_2 capture by sorbents, CO_2 compression, and storage. They use pulverized coal combustion in entrained flow—the dominant current technology for coal-based power, or gasification in entrained flow, although similar concepts apply to other solid–gas contacting systems such as fluidized beds. Currently, the technologies have similar generation efficiencies and are associated with efficiency penalties and electricity cost increases due to operations required for carbon capture. The R&D challenges identified for the combustion scientist and engineer, with current understanding being detailed, are those of design, optimization and operational aspects of new combustion and gasification plant, controlling the gas quality required by CCS related units and associated emission compliance, and gas separations. Fundamental research needs include fuel reactions at pressure, and in O_2/CO_2 atmospheres, as few studies have been made in this area. Laboratory results interpreted and then included in CFD models of combustion operations are necessary. Also identified, but not detailed, are combustion issues in gas turbines for IGCC and IGCC-CCS. Fundamental studies should be a component of pilot-plant and demonstrations at practical scale being

planned. Concepts for new designs of combustion equipment are also necessary for the next generation of technologies. The challenges involved with the design and operation of these integrated systems, while supplying electricity on demand, are considerable. **Terry F. Wall,** *Proceedings of the Combustion Institute,* Available online October 2, 2006, http://www.sciencedirect.com/science/article/B7GWS-4M1DBB6-4/2/7e801408e48d6a0a6cc8b09aa9bbb02d.

"Narrow fluidized beds arranged to exchange heat between a combustion chamber and a CO_2 sorbent regenerator." Experiments in a cold model have been conducted to determine lateral solid diffusion coefficients in a narrow fluidized bed. The experimental data have been obtained using an image analysis technique that traces the dispersion of phosphor coated particles in the bed. A diffusion model has been used to describe lateral solids mixing in the configuration proposed for the narrow fluidized bed. The equation proposed by Shi and Fan [1984. Lateral mixing of solids in batch gas–solids fluidized beds. Industrial and Engineering Chemistry, Process Design and Development 23, 337–341] to calculate the diffusion coefficient in the radial direction fits well the available experimental data. The solid diffusion coefficients obtained have been used to solve a heat transfer problem and discuss the feasibility of a fluidized bed system that makes use of narrow fluidized beds arranged to transfer heat from bed to bed through a separating wall between them. This novel configuration of fluidized bed reactors could find application in some emerging systems that make use of solid regenerable sorbents to capture CO_2. **G.S. Grasa and J.C. Abanades,** *Chemical Engineering Science,* Available online September 15, 2006, http://www.sciencedirect.com/science/article/B6TFK-4KWT6D5-5/2/d1ed9eecc5f6d3e7e456942e8a5d4ce0.

January 2007

"Adoption of carbon dioxide efficient technologies and practices: An analysis of sector-specific convergence trends among 12 nations," Carbon dioxide intensities in economic terms (gross domestic product in Purchasing Power Parity (PPP) terms) in industrialized and developing countries have been shown to converge, and it has been argued that technology diffusion, leading to the use of similar technologies in all countries, is an important reason for this convergence. Indicators based on carbon dioxide (CO_2) per output in PPP terms, however, give in comparison to physical indicators limited understanding of the process of technology diffusion. In order to analyze the technology diffusion hypothesis in more detail, the authors therefore study the trend in carbon dioxide emissions in relation to the production output in four separate sectors: iron and steel; paper, board and pulp; coal fueled power plants; and natural gas fueled power plants, in each of 12 countries, between 1980 and 1998. The indicators converge in each sector, indicating that across countries, technologies with more similar carbon dioxide efficiencies are used today than 25 years ago. The authors also find that at least some developing countries with high energy prices use more efficient technologies than industrialized countries with low energy prices. **Tobias A. Persson, Ulrika Claeson Colpier and Christian Azar,** *Energy Policy,* Available online November 28, 2006, http://www.sciencedirect.com/science/article/B6V2W-4MFJTKJ-1/2/e3e88b9d6c9d3ff7fb52a3aff970e3df. (Subscription may be required.)

"Modeling and simulation of fixed bed adsorbers (FBAs) for multi-component gaseous separations." A rigorous model for multi-component adsorbers is developed. This considers non-isothermal effects, pressure variations, axial dispersion of components inside the gas (macro-void) phase as well as the diffusion of components inside the particles (micro-void). The partial differential equations (PDEs) for the gas phase are converted into ordinary differential equations (ODEs) or algebraic equations, using the finite difference technique in the axial direction. The method of orthogonal collocation (OC) is used to convert the PDEs for the diffusion inside the particles into ODEs. The complete set of differential-algebraic equations (DAEs) is solved using the Petzold-Gear technique. Data on two systems [O_2–N_2 on Zeolite 5A (Jee et al., 2002 [Jee, J. G., Park, M. K., Yoo, H. K., Lee, K.,& Lee, C. H. (2002). Adsorption and desorption characteristics of air on zeolite 5A, 10X, and 13X fixed beds, *Separation Science and Technology*, *37*, 3465–3490]), and CO_2–C_2H_6–N_2 on Linde 5A molecular sieves (Basmadjian and Wright, 1981 [Basmadjian, D., & Wright, D.W. (1981). Non-isothermal sorption of

ethane-carbon dioxide mixtures in beds of 5A molecular sieves. *Chemical Engineering Science*, *36*, 937–940])] are taken from the literature for validation of this model. The optimal values of the model parameters are obtained using *one* set of experimental data for each of these systems. Genetic algorithm is used for this purpose. Excellent agreement is observed between the predictions of the tuned model and the experimental data used. In addition, it was observed that the *predictions* of the tuned model agree quite well with several *other* sets of experimental data (under different operating conditions). The more popular multi-component LDF model is also tuned on the same data, but the model predictions do not match experimental data as well. Since the computational time is almost the same for the two models, the rigorous model is recommended for use. **B. Sankararao and Santosh K. Gupta,** *Computers & Chemical Engineering,* Available online November 28, 2006, http://www.sciencedirect.com/science/article/B6TFT-4MFKD7V-1/2/8a964bb6c149573351d407500b6f58e4. (Subscription may be required.)

February 2007

"Making carbon sequestration a paying proposition." Atmospheric carbon dioxide (CO_2) has increased from a pre-industrial concentration of about 280 parts per million (ppm) to about 367 ppm at present. The increase has closely followed the increase in CO_2 emissions from the use of fossil fuels. Global warming caused by increasing amounts of greenhouse gases in the atmosphere is the major environmental challenge for the 21st century. Reducing worldwide emissions of CO_2 requires multiple mitigation pathways, including reductions in energy consumption, more efficient use of available energy, the application of renewable energy sources, and sequestration. Sequestration is a major tool for managing carbon emissions. In a majority of cases CO_2 is viewed as waste to be disposed; however, with advanced technology, carbon sequestration can become a value-added proposition. There are a number of potential opportunities that render sequestration economically viable. In this study, the authors review these most economically promising opportunities and pathways of carbon sequestration, including reforestation, best agricultural production, housing and furniture, enhanced oil recovery, coalbed methane (CBM), and CO_2 hydrates. Many of these terrestrial and geological sequestration opportunities are expected to provide a direct economic benefit over that obtained by merely reducing the atmospheric CO_2 loading. Sequestration opportunities in 11 states of the Southeast and South Central United States are discussed. Among the most promising methods for the region include reforestation and CBM. The annual forest carbon sink in this region is estimated to be 76 teragrams of carbon per year (Tg C/year), which would amount to an expenditure of $11.1–13.9 billion/year. Best management practices could enhance carbon sequestration by 53.9 Tg C/year, accounting for 9.3 percent of current total annual regional greenhouse gas emission in the next 20 years. Annual carbon storage in housing, furniture, and other wood products in 1998 was estimated to be 13.9 Tg C in the region. Other sequestration options, including the direct injection of CO_2 in deep saline aquifers, mineralization, and biomineralization, are not expected to lead to direct economic gain. More detailed studies are needed for assessing the ultimate changes to the environment and the associated indirect cost savings for carbon sequestration. **Fengxiang X. Han, Jeff S. Lindner and Chuji Wang,** *Naturwissenschaften*, Published online November 14, 2006, http://www.springerlink.com/content/h1t0115881365472/?p=68bebc293219422d8a059349b4f5889d&pi=9. (Subscription required.)

March 2007

"Use of a vehicle-modeling tool for predicting CO2 emissions in the framework of European regulations for light goods vehicles." The reduction of carbon dioxide (CO_2) emissions and fuel consumption from road transportation constitutes an important pillar of the EU commitment for implementing the Kyoto Protocol. Efforts to monitor and limit CO_2 emissions from vehicles can effectively be supported by the use of vehicle modeling tools. This paper presents the application of such a tool for predicting CO_2 emissions of vehicles under different operating conditions and shows how the results

from simulations can be used for supporting policy analysis and design aiming at further reductions of the CO_2 emissions. For this purpose, the case of light duty goods (N1 category) vehicle CO_2 emissions control measures adopted by the EU is analyzed. In order to understand how certain design and operating aspects affect fuel consumption, a number of N1 vehicles were simulated with ADVISOR for various operating conditions and the numerical results were validated against chassis dynamometer tests. The model was then employed for analyzing and evaluating the new EU legislative framework that addresses CO_2 emissions from this vehicle class. The results of this analysis have shown the weaknesses of the current regulations and revealed new potential in CO_2 emissions control. Finally, the TREMOVE model was used for simulating a possible scenario for reducing CO_2 emissions at fleet level. **Georgios Fontaras, Hariton Kouridis, Zissis Samaras, Daniel Elst and Raymond Gense**, *Atmospheric Environment,* Published online January 22, 2007. http://www.sciencedirect.com/science/article/B6VH3-4MW95P7-2/2/efd45e603c94132287cb82f4714e8bb5. (Subscription may be required.)

April 2007

"Sustainable clean coal power generation within a European context – The view in 2006." The future use of coal will require strict environmental compliance with an increasing need to minimize emissions of carbon dioxide (CO_2), particularly from power plants. A pan-European approach is being established to ensure that European Union industry can have available, by 2020, fossil fuel power plants that are either capable of capturing almost all their CO_2 emissions in an economically viable manner, or are designed to include CO_2 capture systems ("capture-ready"). The overall aim is to provide a significant impetus to research, development, demonstration and deployment activities such that coal and other fossil fuels can be used in a sustainable manner. **A.J. Minchener and J.T. McMullan**, *Fuel*, Published online February 21, 2007, http://www.sciencedirect.com/science/article/B6V3B-4N3PY24-1/2/422d8192cdba1092d30a7dd2a5680ca9. (Subscription may be required.)

"Initial evaluation of the impact of post-combustion capture of carbon dioxide on supercritical pulverized coal power plant part load performance." Pulverized coal-fired plants often play an important role in electricity grids as mid-merit plants that can operate flexibly in response to changes in supply and demand. As a consequence, these plants are required to operate over a wide output range. This paper presents an initial evaluation of some potential impacts of adding post-combustion carbon dioxide (CO_2) capture on the part load performance of pulverized coal-fired plants. Preliminary results for ideal cases analyzed using a simple high-level model indicate that post-combustion CO_2 capture could increase the options available to power plant operators. In particular, solvent storage could allow higher effective plant load factors to be achieved to assist with capital recovery while still permitting flexible operation for grid support. A number of areas for more detailed analysis are identified. **Hannah Chalmers and Jon Gibbins,** *Fuel*, Published online February 27, 2007. http://www.sciencedirect.com/science/article/B6V3B-4N4YTKP-3/2/19c2ddb9877481d5ae36679ac9831b2d. (Subscription may be required.)

May 2007

"Capture-ready coal plants – Options, technologies and economics." This paper summarizes the spectrum of options that can be employed during the initial design and construction of pulverized coal (PC), and integrated gasification and combined cycle (IGCC) plants to reduce the capital costs and energy losses associated with retrofitting for carbon dioxide (CO_2) capture at some later time in the future. It also estimates lifetime (40 year) net present value (NPV) costs of plants with differing levels of pre-investment for CO_2 capture under a wide range of CO_2 price scenarios. Three scenarios are evaluated—a baseline supercritical PC plant, a baseline IGCC plant and an IGCC plant with pre-investment for capture. This analysis evaluates each technology option under a range of CO_2 price scenarios and determines the optimum year of retrofit, if any. The results of the analysis show that a

baseline PC plant is the most economical choice under low CO_2 prices, and IGCC plants are preferable at higher CO_2 prices (e.g., an initial price of about $22/ton CO_2 starting in 2015 and growing at 2 percent per year). Little difference is seen in the lifetime NPV costs between the IGCC plants with and without pre-investment for CO_2 capture. This paper also examines the impact of technology choice on lifetime CO_2 emissions. The difference in lifetime emissions becomes significant only under mid-estimate CO_2 price scenarios (roughly between $20 and 40/ton CO_2) where IGCC plants will retrofit sooner than a PC plant. **Mark C. Bohm, Howard J. Herzog, John E. Parsons and Ram C. Sekar,** *International Journal of Greenhouse Gas Control*, Available online March 23, 2007, doi:10.1016/S1750-5836(07)00033-3, http://www.sciencedirect.com/science/article/B83WP-4NB38PW-1/2/0f9786693be185b20c0f97df15232f80. (Subscription may be required.)

"Use of experience curves to estimate the future cost of power plants with CO_2 capture." Given the dominance of power plant emissions of greenhouse gases, and the growing worldwide interest in carbon dioxide (CO_2) capture and storage (CCS) as a potential climate change mitigation option, the expected future cost of power plants with CO_2 capture is of significant interest. Reductions in the cost of technologies as a result of learning-by-doing, R&D investments and other factors have been observed over many decades. This study uses historical experience curves as the basis for estimating future cost trends for four types of electric power plants equipped with CO_2 capture systems: pulverized coal (PC) and natural gas combined cycle (NGCC) plants with post-combustion CO_2 capture; coal-based integrated gasification combined cycle (IGCC) plants with pre-combustion capture; and coal-fired oxyfuel combustion for new PC plants. [The authors] first assess the rates of cost reductions achieved by other energy and environmental process technologies in the past. Then, by analogy with leading capture plant designs, [the authors] estimate future cost reductions that might be achieved by power plants employing CO_2 capture. Effects of uncertainties in key parameters on projected cost reductions also are evaluated via sensitivity analysis. **Edward S. Rubin, Sonia Yeh, Matt Antes, Michael Berkenpas and John Davison**, Available Online February 26, 2007, *International Journal of Greenhouse Gas Control*, doi:10.1016/S1750-5836(07)00016-3, http://www.sciencedirect.com/science/article/B83WP-4N4S69V-1/2/0a29f2daa919c8f774445b761eef6404. (Subscription may be required.)

"Modeling the impacts of climate policy on the deployment of carbon dioxide capture and geologic storage across electric power regions in the United States." This paper summarizes the results of a first-of-its-kind holistic, integrated economic analysis of the potential role of carbon dioxide (CO_2) capture and storage (CCS) technologies across the regional segments of the United States (US) electric power sector, over the time frame 2005–2045, in response to two hypothetical emissions control policies analyzed against two potential energy supply futures that include updated and substantially higher projected prices for natural gas. This paper's detailed analysis is made possible by combining two specialized models developed at Battelle: the *Battelle CO_2-GIS* to determine the regional capacity and cost of CO_2 transport and geologic storage; and the *Battelle Carbon Management Electricity Model*, an electric system optimal capacity expansion and dispatch model, to examine the investment and operation of electric power technologies with CCS against the background of other options. A key feature of this paper's analysis is an attempt to explicitly model the inherent heterogeneities that exist in both the nation's current and future electricity generation infrastructure and in its candidate deep geologic CO_2 storage formations. Overall, between 180 and 580 gigawatts (GW) of coal-fired integrated gasification combined cycle with CCS (IGCC + CCS) capacity is built by 2045 in these four scenarios, requiring between 12 and 41 gigatonnes of CO_2 storage in regional deep geologic reservoirs across the US. Nearly all of this CO_2 is from new IGCC + CCS systems, which start to deploy after 2025. Relatively little IGCC + CCS capacity is built before that time, primarily under unique niche opportunities. For the most part, CO_2 emissions prices will likely need to be sustained at over $20/tonne CO_2 before CCS begins to deploy on a large scale within the electric power sector. Within these broad national trends, a highly nuanced picture of CCS deployment across the US emerges. Across the four scenarios studied here, power plant builders and operators within some North American Electric Reliability Council (NERC) regions do not employ any CCS while other regions build more than 100 GW of CCS-enabled generation capacity. One region sees as much as 50 percent of its geologic CO_2 storage reservoirs' total theoretical

capacity consumed by 2045, while most of the regions still have more than 90 percent of their potential storage capacity available to meet storage needs in the second half of the century and beyond. A detailed presentation of the results for power plant builds and operation in two key regions: East Central Area Reliability Coordination Agreement (ECAR) in the Midwest and Electric Reliability Council of Texas (ERCOT) in Texas, provides further insight into the diverse set of economic decisions that generate the national and aggregate regional results. **Marshall Wise, James Dooley, Robert Dahowski and Casie Davidson,** *International Journal of Greenhouse Gas Control,* Available online February 26, 2007, doi:10.1016/S1750-5836(07)00017-5, http://www.sciencedirect.com/science/article/B83WP-4N4S13R-2/2/422118edf280434f7c4c1df360c45400. (Subscription may be required.)

June 2007

"A novel process integration, optimization and design approach for large-scale implementation of oxy-fired coal power plants with CO_2 capture." The widespread use of fossil fuels within the current energy infrastructure is considered as the largest source of anthropogenic emissions of carbon dioxide [CO_2], which is largely blamed for global warming and climate change. At the current state of development, the risks and costs of non-fossil energy alternatives, such as nuclear, biomass, solar, and wind energy, are so high that they cannot replace the entire share of fossil fuels in the near future timeframe. Additionally, any rapid change towards non-fossil energy sources, even if possible, would result in large disruptions to the existing energy supply infrastructure. As an alternative, the existing and new fossil fuel-based plants can be modified or designed to be either "capture" or "capture-ready" plants in order to reduce their emission intensity through the capture and permanent storage of carbon dioxide in geological formations. This would give the coal-fired power generation units the option to sustain their operations for longer time, while meeting the stringent environmental regulations on air pollutants and carbon emissions in years to come. Currently, there are three main approaches to capturing CO_2 from the combustion of fossil fuels, namely, pre-combustion capture, post-combustion capture, and oxy-fuel combustion. Among these technology options, oxy-fuel combustion provides an elegant approach to CO_2 capture. In this approach, by replacing air with oxygen in the combustion process, a CO_2-rich flue gas stream is produced that can be readily compressed for pipeline transport and storage. In this paper, [the authors] propose a new approach that allows air to be partially used in the oxy-fired coal power plants. In this novel approach, the air can be used to carry the coal from the mills to the boiler (similar to the conventional air-fired coal power plants), while O_2 is added to the secondary recycle flow as well as directly to the combustion zone (if needed). From a practical point of view, this approach eliminates problems with the primary recycle and also lessens concerns about the air leakage into the system. At the same time, it allows the boiler and its back-end piping to operate under slight suction; this avoids the potential danger to the plant operators and equipment due to possible exposure to hot combustion gases, CO_2 and particulates. As well, by integrating oxy-fuel system components and optimizing the overall process over a wide range of operating conditions, an optimum or near-optimum design can be achieved that is both cost-effective and practical for large-scale implementation of oxy-fired coal power plants. **Kourosh E. Zanganeh and Ahmed Shafeen,** *International Journal of Greenhouse Gas Control,* Published online March 26, 2007, doi:10.1016/S1750-5836(07)00035-7, http://www.sciencedirect.com/science/article/B83WP-4NBR48X-2/2/0c4c28f2bfb47d74035258ee5115e87c. (Subscription may be required.)

July 2007

"Trade-off in emissions of acid gas pollutants and of carbon dioxide in fossil fuel power plants with carbon capture." This paper investigates the impact of capture of [CO_2] from fossil fuel power plants on the emissions of nitrogen oxides (NO_X) and sulphur oxides (SO_X), which are acid gas pollutants. This was done by estimating the emissions of these chemical compounds from natural gas combined cycle and pulverized coal plants, equipped with post-combustion carbon capture technology for the removal of CO_2 from their flue gases, and comparing them with the emissions of similar plants

without CO_2 capture. The capture of CO_2 is not likely to increase the emissions of acid gas pollutants from individual power plants; on the contrary, some NO_X and SO_X will also be removed during the capture of CO_2. The large-scale implementation of carbon capture is however likely to increase the emission levels of NO_X from the power sector due to the reduced efficiency of power plants equipped with capture technologies. Furthermore, SO_X emissions from coal plants should be decreased to avoid significant losses of the chemicals that are used to capture CO_2. The increase in the quantity of NO_X emissions will be however low, estimated at 5 [percent] for the natural gas power plant park and 24 [percent] for the coal plants, while the emissions of SO_X from coal fired plants will be reduced by as much as 99 [percent] when at least 80 [percent] of the CO_2 generated will be captured. **Evangelos Tzimas, Arnaud Mercier, Calin-Cristian Cormos and Stathis D. Peteves,** *Energy Policy,* Published online March 26, 2007, doi:10.1016/j.enpol.2007.01.027, http://www.sciencedirect.com/science/article/B6V2W-4NBRFXP-1/2/102cce4148093cece5fa1da5e933eed0. (Subscription may be required.)

August 2007

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

"Novel Regenerable Sodium-Based Sorbents for CO_2 Capture at Warm Gas Temperatures." A novel sorbent consisting of NaOH/CaO [sodium hydroxide/calcium oxide] was developed for CO_2 capture at 315° C [degrees Celsius] suitable for high-temperature CO_2-capture applications, such as coal gasification systems. The sorbent is regenerable at 700° C, and steam does not affect the sorbent performance. A multicycle test conducted in the atmospheric reactor at 315° C indicated that the sorbent improved the performance with an increased number of cycles. The sorbent can also capture CO_2 at a wide range of temperatures from ambient to 500° C. However, the mechanism of CO_2 capture is different at ambient temperature. The sorbent is unique because it has a high CO_2-capture capacity of more than 3 mol/kg at 315° C and is regenerable at 700° C. **Ranjani V. Siriwardane, Clark Robinson, Ming Shen, and Tom Simonyi,** *Energy Fuels,* Published online June 9, 2007, doi: 10.1021/ef070008v, Link unavailable.

Terrestrial/Ocean

September 2006

"Policy and technological constraints to implementation of greenhouse gas mitigation options in agriculture." A recent assessment of agricultural greenhouse gas (GHG) emissions has demonstrated significant potential for mitigation, but suggests that the full mitigation will not be realized due to significant barriers to implementation. In this paper, the authors explore the constraints and barriers to implementation important for GHG mitigation in agriculture. The authors also examine how climate and non-climate policy in different regions of the world has affected agricultural GHG emissions in the recent past, and how it may affect emissions and mitigation implementation in the future. The authors examine

the links between mitigation and adaptation and drives for sustainable development and the potential for agricultural GHG mitigation in the future. The authors describe how some countries have initiated climate and non-climate policies believed to have direct effects or synergistic effects on mitigating GHG emissions from agriculture. Global sharing of innovative technologies for efficient use of land resources and agricultural chemicals, to eliminate poverty and malnutrition, will significantly mitigate GHG emissions from agriculture. Previous studies have shown that as less than 30 percent of the total biophysical potential for agricultural GHG mitigation might be achieved by 2030, due to price- and non-price-related barriers to implementation. The challenge for successful agricultural GHG mitigation will be to remove these barriers by implementing creative policies. Identifying policies that provide benefits for climate, as well as for aspects of economic, social and environmental sustainability, will be critical for ensuring that effective GHG mitigation options are widely implemented in the future. **Pete Smith, Daniel Martino, Zucong Cai, Daniel Gwary, Henry Janzen, Pushpam Kumar, Bruce McCarl, Stephen Ogle, Frank O'Mara, Charles Rice et al,** *Agriculture, Ecosystems & Environment,* Available online July 18, 2006, http://www.sciencedirect.com/science/article/B6T3Y-4KF6BK4-1/2/91b9e64a0c7ec66d438899c86dc09c3d. (Subscription may be required.)

October 2006

"Soil Properties and Carbon Sequestration of Afforested Pastures in Reclaimed Minesoils of Ohio." Land-use change affects many soil properties, including soil organic carbon (SOC) pool, and the transfer of atmospheric carbon dioxide (CO_2) to terrestrial landscapes. The objective of this study was to evaluate the effects of converting pastureland to Australian pine (*Casuarina spp*) and black locust (*Robinia pseudoacacia* L) forest on selected soil physical and chemical properties and SOC sequestration in reclaimed minesoils (RMS) of southeastern Ohio. The study sites were surface mined for coal, reclaimed and managed as pasture, and then converted into woodland 10 years before the present study. Soil pH and electrical conductivity (EC) were higher in the RMS than in a nearby undisturbed hardwood forest. Conversion to Australian pine decreased soil pH and EC in the top 20 centimeters (cm). Bulk densities of the RMS ranged from 1.24 to 1.82 megagrams per cubic meter (Mg m^{-3}), and only minor changes were observed in soil bulk density after land-use conversion. Mean weight diameter (MWD) and root biomass increased significantly ($P < 0.05$) with conversion of pasture to Australian pine or black locust. In addition, aggregate stability was greater in RMS under hardwood forest than under pasture. Conversion to the Australian pine forest increased the SOC pool in the top 50 cm by 6 megagrams per hectare (Mg ha^{-1}) (11 percent) in 10 yr. However, the nitrogen pool in the top 50 cm was not affected by the land-use conversion from pasture to Australian pine. Conversion to black locust increased the SOC pool in the top 50 cm by 24 Mg ha^{-1} (42 percent), while the nitrogen pool increased by 10 percent under Black locust in year 10. The increase in the SOC pool was accompanied by an increase in the carbon/nitrogen (C/N) ratios and root biomass in both Australian pine and black locust sites in the 20- to 50-cm depth. Establishment of tree plantation has a greater potential for SOC sequestration than pastures in the RMS. **D. A. N. Ussiri, R. Lal and P. A. Jacinthe,** *Soil Science Society of America Journal,* 70:1797-1806 (2006), Published online August 22, 2006. DOI: 10.2136/sssaj2005.0352. http://soil.scijournals.org/cgi/content/abstract/70/5/1797. (Subscription may be required.)

"Methodological issues in developing a community forestry greenhouse gas emissions mitigation project in Mancherial forest division of Andhra Pradesh, India." There are several contentious issues related to forestry mitigation projects. The special report of the IPCC and literature published so far have shown that permanence, leakage, baseline establishment, measurement, monitoring, etc., could be addressed satisfactorily using existing scientific methods and accounting rules. To understand the methodological issues of developing community forestry projects, a case study was conducted in Mancherial forest division of Adilabad district in Andhra Pradesh, India. This paper addresses: the setting of project boundaries, baseline selection, establishment of additionality and the calculation of carbon sequestration as a result of the project, prior to project implementation. The steps

involved in development of the project and the different methods used for establishing baseline, estimating leakage and transaction cost of developing a community forestry project are presented. The stock is projected to increase by 1480 × 10^3 tons of Carbon (t C) during 2000-2012 over the baseline scenario under the modeling approach and the cost of establishing a baseline and project formulation for a project extending over 32,956 hectare (ha) is estimated to be US $1.25 per hectare ($ha^{?1}$) and $4 per ton of carbon (t $C^{?1}$). **I.K. Murthy, G.T. Hegde, P. Sudha and N.H. Ravindranath,** *Environmental Science & Policy*, Volume 9, Issue 6, , October 2006, Pages 525-537, http://www.sciencedirect.com/science/article/B6VP6-4KKNNJ9-1/2/efa0201faa473eefe72d4f0c330bbcbd. (Subscription may be required.)

"Storage and forms of organic carbon in a no-tillage under cover crops system on clayey Oxisol in dryland rice production (Cerrados, Brazil)." The management and enhancement of soil organic carbon (SOC) is very important for agriculture (fertility) as well as for the environment (carbon sequestration). Consequently, changes in soil management may alter SOC content. No-tillage (NT) practices are potential ways to increase SOC. We studied the SOC from agricultural soils in the Cerrados in Central Brazil. We compared two different tillage systems: conservation agriculture with no-tillage under cover crops (NT) and disc tillage (DT) for 5 years in a context of rainfed rice production. The soil is a dark red Oxisol with high clay content (about 40 percent). The objectives of the study were: (i) to evaluate the short-term (5 years) impact of tillage systems on SOC stocks in an Oxisol and (ii) to better understand the dynamics of SOC in different fractions of this soil. The authors first studied the initial situation in 1998, and compared it to the 2003 situation. NT with cover crop (*Crotalaria*) was found to increase the storage of carbon in the topsoil layer (0-10 centimeters (cm)) compared to DT. The difference observed for the 0-10 cm layer under NT in comparison with DT represented carbon enrichment under no-tillage amounting to 0.35 megagrams of carbon per hectare per year (Mg C ha^{-1} $year^{-1}$) and corresponding to less than 10 percent of cover crops residues returned to the soil. A particle-size fractionation of soil organic matter (SOM) showed that differences in total SOC between NT and DT mainly affected the 0-2 microgram (µm) fraction and, to a smaller extent the 2-20 µm fraction. This specific enrichment of SOC in the silt and clay fraction was attributed to (i) the storage of a water soluble carbon in the field and (ii) the effect of soil biota and especially fauna activity. The mean residence time of carbon associated with the fine fractions being rather long, it might be assumed that the preferential storage in fine fractions resulted in a long-term carbon storage. This study suggests a positive short-term effect of a no-tillage system on carbon sequestration in an Oxisol. **Aurélie Metay, José Aloisio Alves Moreira, Martial Bernoux, Thomas Boyer, Jean-Marie Douzet, Brigitte Feigl, Christian Feller, Florent Maraux, Robert Oliver and Eric Scopel,** *Soil and Tillage Research,* Available online September 7, 2006. http://www.sciencedirect.com/science/article/B6TC6-4KV2R9B-1/2/54bc59a525bac6678ef0afc1bc9c4d63. (Subscription may be required.)

November 2006

"Management Practice Effects on Surface Total Carbon, Differences in Spatial Variability Patterns." Lack of information about the spatial variability of soil carbon in different management systems limits accurate extrapolation of carbon sequestration findings to large scales. The objectives of this study were to: (i) describe and quantify variability of total carbon in three management systems, chisel-plow (CT) and no-till (NT) with conventional chemical inputs and a chisel-plow organic management practice with cover crops (CT-cover) 15 years after conversion from conventional management; (ii) assess the strengths of spatial correlation in the three studied systems; and (iii) evaluate contributions of topography and texture to the overall total carbon variability and its spatial components. The data were collected at 12 60 by 60 meter plots at the Long Term Ecological Research site, Kellogg Biological Station, MI. The data consisted of elevation measurements taken on a 2 by 5 meter grid and a total of 1160 measurements of total carbon, sand, silt, and clay contents taken from the 0- to 5-centimeter depth. Overall variability of total carbon in NT was more than four times greater than in CT, and in CT-cover the variability was more than two times greater than CT. Spatial correlation of total

carbon was the strongest in NT, followed by CT-cover, and then by CT. Stronger spatial structures in NT and CT-cover were found to form in response to topographical and texture gradients. Effects of texture were largely associated with topographical effects; however, even when topography was controlled for, texture still substantially contributed to explaining total carbon variability. **A. N. Kravchenko, G. P. Robertson, X. Hao and D. G. Bullock,** *Agronomy Journal,* 98:1559-1568 (2006), Published online October 3, 2006. http://agron.scijournals.org/cgi/content/abstract/98/6/1559. (Subscription required.)

December 2006

"How strongly can forest management influence soil carbon sequestration?" The authors reviewed the experimental evidence for long-term carbon (C) sequestration in soils as consequence of specific forest management strategies. Utilization of terrestrial C sinks alleviates the burden of countries which are committed to reducing their greenhouse gas emissions. Land-use changes such as those which result from afforestation and management of fast-growing tree species, have an immediate effect on the regional rate of C sequestration by incorporating carbon dioxide (CO_2) in plant biomass. The potential for such practices is limited in Europe by environmental and political constraints. The management of existing forests can also increase C sequestration, but earlier reviews found conflicting evidence regarding the effects of forest management on soil C pools. The authors analyzed the effects of harvesting, thinning, fertilization application, drainage, tree species selection, and control of natural disturbances on soil C dynamics. The authors focused on factors that affect the C input to the soil and the C release via decomposition of soil organic matter (SOM). The differentiation of SOM into labile and stable soil C fractions is important. There is ample evidence about the effects of management on the amount of C in the organic layers of the forest floor, but much less information about measurable effects of management on stable C pools in the mineral soil. The C storage capacity of the stable pool can be enhanced by increasing the productivity of the forest and thereby increasing the C input to the soil. Minimizing the disturbances in the stand structure and soil reduces the risk of unintended C losses. The establishment of mixed species forests increases the stability of the forest and can avoid high rates of SOM decomposition. The rate of C accumulation and its distribution within the soil profile differs between tree species. Differences in the stability of SOM as a direct species effect have not yet been reported. **Robert Jandl, Marcus Lindner, Lars Vesterdal, Bram Bauwens, Rainer Baritz, Frank Hagedorn, Dale W. Johnson, Kari Minkkinen and Kenneth A. Byrne,** *Geoderma,* Available online October 31, 2006, http://www.sciencedirect.com/science/article/B6V67-4M7KB1B-1/2/417832004a3fec643e32303a400054a9.

January 2007

"Carbon and nitrogen in a temperate agroforestry system: Using stable isotopes as a tool to understand soil dynamics," Natural exchanges of carbon (C) between the atmosphere, the oceans, and terrestrial ecosystems are currently being modified through human activities as a result of fossil fuel burning and the conversion of tropical forests to agricultural land. These activities have led to a steady increase of atmospheric carbon dioxide (CO_2) over the last two Centuries. The goal of this study was to determine the potential of temperate agroforestry systems to sequester C in soil. Therefore, changes in the soil organic C (SOC) and nitrogen (N) pools were quantified and the $\delta^{13}C$ and $\delta^{15}N$ stable isotope technique was applied to assess soil C and N dynamics in a 13-year old hybrid poplar alley cropping system in Southern Canada. Results from this study showed that after 13 years of alley cropping the SOC and N pools did not differ significantly ($p = 0.01$) with distance from the tree row, although a trend of a larger SOC and N pool near the tree row could be observed. Soil organic C after 13 years of alley cropping, was 19 milligrams of carbon per gram (mg C g^{-1}) compared to 11 mg C g^{-1} upon initiation of agroforestry. Soil organic C and N were not evenly distributed throughout the plow layer. The largest C and N pool occurred in the top 20 centimeters (cm), which is due to the accumulation of organic material in the upper horizons as a result of no-till cultivation. The entire soil, to a 40 cm depth, showed a $\delta^{13}C$ shift to that of C_3 residue. This shift reflects the greater input of residues from C_3 plants such as that

derived from beans, wheat, and hybrid poplar leaf litterfall. The proportion of C derived from a C_3 source ranged from 64 to 69 percent to a 40 cm depth. The soil $\delta^{15}N$ signature of this study is similar to that of mineral soil, and reflect values characteristic of N mineralization processes. However, the entire soil shows a positive shift in $\delta^{15}N$ as a result of historical additions of manure and current use of mineral fertilizers, and ongoing processes of denitrification and nitrate leaching, which leads to an enrichment of the soil. **Maren Oelbermann and R. Paul Voroney**, *Ecological Engineering,* Available online November 16, 2006, http://www.sciencedirect.com/science/article/B6VFB-4MC0TCD-1/2/d1fca1c73964fc964af77c14f2d79ca6. (Subscription may be required.)

"Carbon sequestration in wood products: a method for attribution to multiple parties," When forest is harvested some of the forest carbon ends up in wood products. If the forest is managed so that the standing stock of the forest remains constant over time, and the stock of wood products is increasing, then carbon dioxide is being removed from the atmosphere in net and this should be reflected in accounting for greenhouse gas emissions. The authors suggest that carbon sequestration in wood products requires cooperation of multiple parties; from the forest owner to the product manufacturer to the product user, and perhaps others. Credit for sequestering carbon away from the atmosphere could acknowledge the contributions of these multiple parties. Accounting under a cap-and-trade or tax system is not necessarily an inventory system, it is a system designed to motivate and/or reward an environmental objective. The authors describe a system of attribution whereby credits for carbon sequestration would be shared among multiple, contributing parties. It is hoped that the methodology outlined herein proves attractive enough to parties concerned to spur them to address the details of such a system. The system of incentives one would choose for limiting or controlling greenhouse gas emissions could be quite different, depending on how the attribution for emissions and sequestration is chosen. **Bruce Tonn and Gregg Marland,** *Environmental Science & Policy,* November 22, 2006, http://www.sciencedirect.com/science/article/B6VP6-4MD95F2-1/2/5075797d87a730d253657a051877a7b3. (Subscription may be required.)

"Some perspectives on carbon sequestration in agriculture," One of the main options for greenhouse gas (GHG) mitigation identified by the Intergovernmental Panel on Climate Change (IPCC) is the sequestration of carbon in soils. Since the breaking of agricultural land in most regions, the carbon stocks have been depleted to such an extent, that they now represent a potential sink for carbon dioxide (CO_2) removal from the atmosphere. Improved management will however, be required to increase the inputs of organic matter in the top soil and/or decrease decomposition rates. In this paper the authors use data from selected regions to explore the global potential for carbon sequestration in arable soils. While realizing that carbon sequestration is not limited to the selected regions, the authors have, however, focused their review on two regions: (i) Canadian Prairies and (ii) The Tropics. In temperate regions, management changes for an increase in carbon involve increase in cropping frequency (reducing bare fallow), increasing use of forages in crop rotations, reducing tillage intensity and frequency, better crop residue management, and adopting agroforestry. In the tropics, agroforestry remains the primary method by which sequestration rates may be significantly increased. Increases in soil carbon may be achieved through improved fertility of cropland/pasture; on extensive systems with shifting cultivation cropped fallows and cover crops may be beneficial, and adopting agro forestry or foresting marginal cropland is also an alternative. In addition, in the tropics it is imperative to reduce the clearing of forests for conversion to cropland. Some regional analyses of soil carbon sequestration and sequestration potential have been performed, mainly for temperate industrialized North America where the majority of research pertaining to carbon sequestration has been carried out. More research is needed, especially for the Tropics, to more accurately capture the impact of region-specific interactions between climate, soil, and management of resources on carbon sequestration, which are lost in global level assessments. By itself, carbon sequestration in agricultural soils can make only modest contributions (3–6 percent of fossil fuel contributions) to mitigation of overall greenhouse gas emissions. However, effective mitigation policies will not be based on any single 'magic bullet' solutions, but rather on many modest reductions which are economically efficient and which confer additional benefits to society. In this context, soil carbon sequestration is a significant mitigation option. **J.J. Hutchinson, C.A.**

Campbell and R.L. Desjardins. *Agricultural and Forest Meteorology,* Available online November 28, 2006, http://www.sciencedirect.com/science/article/B6V8W-4MFJJ0K-3/2/620a0b36c4b24faace27735d1c691238. (Subscription may be required.)

February 2007

"Satellite-derived estimates of potential carbon sequestration through afforestation of agricultural lands in the United States." Afforestation of marginal agricultural lands represents a promising option for carbon sequestration in terrestrial ecosystems. An ecosystem carbon model was used to generate new national maps of annual net primary production (NPP), one each for continuous land covers of 'forest', 'crop', and 'rangeland' over the entire U S continental area. Direct inputs of satellite "greenness" data from the Advanced Very High Resolution Radiometer (AVHRR) sensor into the NASA-CASA carbon model at 8-kilometer spatial resolution were used to estimate spatial variability in monthly NPP and potential biomass accumulation rates in a uniquely detailed manner. The model predictions of regrowth forest production lead to a conservative national projection of 0.3 petagrams of carbon (Pg C) as potential carbon stored each year on relatively low-production crop or rangeland areas. On a regional level, the top five states for total crop afforestation potential were: Texas, Minnesota, Iowa, Illinois, and Missouri, whereas the top five states for total rangeland afforestation potential are: Texas, California, Montana, New Mexico, and Colorado. Afforestation at this level of intensity has the capacity to offset at least one-fifth of annual fossil fuel emission of carbon in the United States. These projected afforestation carbon gains also match or exceed recent estimates of the annual sink for atmospheric CO_2 in currently forested area of the country. **Christopher Potter, Steven Klooster, Seth Hiatt, Matthew Fladeland, Vanessa Genovese and Peggy Gross,** *Climatic Change,* Published online January 7, 2007, http://www.springerlink.com/content/644174p5877522r7/?p=edfad81ea2624efb8a5571342c9904b2&pi=0. (Subscription required.)

"Carbon sequestration in the U.S. forest sector from 1990 to 2010." Forest inventory data supplemented with data from intensive research sites and models were used to estimate carbon stocks and sequestration rates in US forests, including effects of land use change. Data on the production of wood products and emission from decomposition were used to estimate carbon stocks and sequestration rates in wood products and landfills. From 1990 through 2005, the forest sector (including forests and wood products) sequestered an average 162 teragrams of carbon per year (Tg C $year^{-1}$). In 2005, 49 percent of the total forest sector sequestration was in live and dead trees, 27 percent was in wood products in landfills, with the remainder in down dead wood, wood products in use, and forest floor and soil. The pools with the largest carbon stocks were not the same as those with the largest sequestration rates, except for the tree pool. For example, landfilled wood products comprise only 3 percent of total stocks but account for 27 percent of carbon sequestration. Conversely, forest soils comprise 48 percent of total stocks but account for only 2 percent of carbon sequestration. For the tree pool, the spatial pattern of carbon stocks was dissimilar to that of carbon flux. On an area basis, tree carbon stocks were highest in the Pacific Northwest, while changes were generally greatest in the upper Midwest and the Northeast. Net carbon sequestration in the forest sector in 2005 offset 10 percent of US carbon dioxide emissions. In the near future, the authors project that US forests will continue to sequester carbon at a rate similar to that in recent years. Based on a comparison of the authors' estimates to a compilation of land-based estimates of non-forest carbon sinks from the literature, the authors estimate that the conterminous US annually sequesters 149–330 Tg C $year^{-1}$. Forests, urban trees, and wood products are responsible for 65–91 percent of this sink. **Peter B. Woodbury, James E. Smith and Linda S. Heath,** *Forest Ecology and Management,* Available online January 16, 2007. http://www.sciencedirect.com/science/article/B6T6X-4MV19VM-3/2/d5d65e9f2b93b324785a2f7ae2a52978. (Subscription may be required.)

"Sequestration offsets versus direct emission reductions: Consideration of environmental co-effects." Atmospheric greenhouse gas accumulation, and consequential temperature increase, can be remedied by emission reductions or agricultural carbon sequestration. Both options have direct and external environmental effects. This paper examines the magnitudes of existing estimates of corresponding external co-effects and how they could affect optimal combination of emission reductions and agricultural carbon sequestration. The authors discuss whether government intervention, in the form of taxation/subsidization, is justified for internalizing the externalities considering their relative magnitudes, implementation costs and potential benefits that could be derived from such intervention. The authors conclude that the existing estimates of external benefits from sequestration and emission reduction do not provide enough support for allocating resources to alter the market mix of carbon sequestration and direct emission reduction strategies. **Levan Elbakidze and Bruce A. McCarl,** *Ecological Economics,* Volume 60, Issue 3, January 15, 2007, Pages 564-571. http://www.sciencedirect.com/science/article/B6VDY-4JCCH2T-2/2/6ba72c884dfde6ffe749e63e95ad4655. (Subscription may be required.)

"Transfers and environmental co-benefits of carbon sequestration in agricultural soils: retiring agricultural land in the Upper Mississippi River Basin." This study investigates the carbon sequestration potential and co-benefits from policies aimed at retiring agricultural land in the Upper Mississippi River Basin, a large, heavily agricultural area. In addition to empirically measuring environmental co-benefits, the authors also compute economic transfers, which have sometimes been referred to as a co-benefit. Very little empirical work measuring the potential magnitude of these transfers has previously been undertaken. The authors compare and contrast alternative targeting schemes. They find that there are considerable amount of co-benefits and transfers and that the geographic distribution of co-benefits and transfers varies significantly with the specific benefit targeted. This implies that policy design related to targeting can have very important implications for both environmental conditions and income distributions in sub-regions. Issues related to policy design in the presence of co-benefits are considered. **Hongli Feng, Catherine L. Kling and Philip W. Gassman, *Climatic Change,*** Published online December 21, 2006, http://springerlink.metapress.com/content/b15716t573043j64/?p=3062f6e110254017a86197a3f145dd0e&pi=6. (Subscription required.)

March 2007

"Optimizing carbon sequestration in commercial forests by integrating carbon management objectives in wood supply modeling." This paper provides a methodology for generating forest management plans, which explicitly *maximize* carbon sequestration at the forest-landscape level. This paper takes advantage of concepts first presented in a paper by Meng et al. (*2003*; Mitigation Adaptation Strategies Global Change 8:371–403) by integrating carbon sequestration objective functions in existing wood supply models. Carbon-stock calculations performed in Woodstock™ (RemSoft Inc.) are based on carbon yields generated from volume table data obtained from local Forest Development Survey plots and a series of wood volume-to-carbon content conversion factors specified in von Mirbach (*2000*). The approach is used to investigate the impact of three demonstration forest-management scenarios on the carbon budget in a 110,000 hectare (ha) forest in south-central New Brunswick, Canada. Explicit demonstration scenarios addressed include (1) maximizing timber extraction either by clearcut or selection harvesting for greatest revenue generation, (2) maximizing total carbon storage in the forest landscape and in wood products generated from harvesting, and (3) maximizing carbon storage together with revenue generation. The level of clearcut harvesting was greatest for *scenario 1* (≥15 Ã— 10^4 cubic meter (m^3) of wood and ≥943 ha of land per harvesting period), and least for *scenario 2* (=0 m^3 per harvesting period) where selection harvesting dominated. Because softwood saw logs were worth more than pulpwood ($60 m^{-3} vs. $40 m^{-3}) and were strategic to the long-term storage of carbon, the production of softwood saw logs exceeded the production of pulpwood in all scenarios. Selection harvesting was generally the preferred harvesting method across scenarios. Only in *scenario 1* did levels of clearcut harvesting occasionally exceed those of selection harvesting, mainly in the removal of old,

dilapidated stands early in the simulation (i.e., during periods 1 through 3). *Scenario 2* provided the greatest total carbon-storage increase over 80 years (i.e., 14 Ã— 10^6 Milligrams (Mg) carbon, or roughly 264 Mg per hectare) at a cost of $111 per Mg carbon due to lost revenues. *Scenarios 3* and *1* produced reduced storage rates of roughly 9 Ã— 10^6 Mg carbon and 3 Ã— 10^6 Mg carbon, respectively; about 64 percent and 22 percent of the total, 80-year carbon storage calculated in *scenario 2*. The bulk of the carbon in *scenario 2* was stored in the forest, amounting to about 76 percent of the total carbon sequestered. **Charles P.-A. Bourque, Eric T. Neilson, Chris Gruenwald, Samantha F. Perrin Jason C. Hiltz, Yvon A. Blin Geoffrey V. Horsman, Matthew S. Parker, Christie B. Thorburn, Michael M. Core, Fan-rui Meng and D. Edwin Swift,** *Mitigation and Adaptation Strategies or Global Change,* Published online January 30, 2007, http://www.springerlink.com/content/g721742q12218446/?p=d2ed7fa071cf41ccb2355292e08ceb17&pi=6#ContactOfAuthor1. (Subscription required.)

"Simulation of fluxes of greenhouse gases from European grasslands using DNDC model." Agricultural management of grasslands results in sequestration and emission of greenhouse gases (GHGs, particularly carbon dioxide [CO_2], nitrous oxide [N_2O] and methane [CH_4]). Here, the authors used a process-based model (DNDC) to estimate the fluxes of the major GHGs from grasslands at 0.5° resolution across Europe, and combined these to produce a spatially explicit estimate of the total global warming potential (GWP, expressed in CO_2 equivalents). The DNDC model [Li, C., Frolking, S., Crocker, G.J., Grace, P.R., Klir, J., Korchens, M., Poulton, P.R., 1997. Simulating trends in soil organic carbon in long-term experiments using the DNDC model. Geoderma 81, 45–60] simulates carbon and nitrogen cycling in agro-ecosystems at a sub-daily time step and consists of four interacting submodels: soil and climate (including water flow and leaching), plant growth, decomposition, and denitrification. Input data sets for grassland area, climate, nitrogen deposition, and soil properties were collated. The typical current grassland management regime was established for ten biogeographical regions on the basis of questionnaires sent to national experts, and used to derive model input data. A 20-year simulation was carried out using DNDC for each site. Simple estimates of methane emissions from grazing livestock were made according to the IPCC Tier 1 method. Most grassland areas are net sources for GHGs in terms of total global warming potential—the beneficial effect of sequestering carbon in soil is outweighed by the emissions of N_2O from soil and (predominantly) CH_4 emissions from livestock. The net effect of European grasslands on GWP (emission of 23 teragrams of carbon per year) corresponds to a 2.5 percent increase on the EU-15 fossil fuel CO_2 emissions (907 teragrams of carbon per year). **P.E. Levy, D.C. Mobbs, S.K. Jones, R. Milne, C. Campbell and M.A. Sutton,** *Agriculture, Ecosystems and Environment,* Published online January 23, 2007, http://www.sciencedirect.com/science/article/B6T3Y-4MWGYBX-2/2/8d7c4db3af9e50f9e9792df227522107. (Subscription may be required.)

"Quantification of the regional carbon cycle of the biosphere: Policy, science and land-use decisions." This paper addresses some issues related to the carbon cycle and its utilization by society. Traditional uses for agriculture, forestry, as a source of fuel and other products, and for pastoral farming, among others, have recently been supplemented by identifying its potential for mitigating the increasing concentration of greenhouse gases in the atmosphere. Through the Kyoto Protocol, carbon has become a commodity and the carbon dioxide-absorbing capability of the vegetation and soils an economically valuable asset. The multi-facetted roles of the carbon cycle and its sensitivity to human activities present a demand for techniques that permit accurate, timely and affordable characterization of the various components of this cycle, especially on land where most human activities take place. Such techniques must satisfy a range of demands in terms of purpose, clients for the information, and biosphere properties. However, if successful, they offer the potential to support monitoring, reporting, policy setting, and management of terrestrial biospheric resources. The context for these requirements and possibilities is illustrated with reference to the China Carbon Sequestration Project and its findings. **Josef Cihlar,** *Journal of Environmental Management,* Published online January 2, 2007, http://www.sciencedirect.com/science/article/B6WJ7-4MR1RS5-1/2/bc67cc500fbaa370d52a17c5b0085ff9. (Subscription may be required.)

April 2007

"Small Phytoplankton and Carbon Export from the Surface Ocean." Autotrophic picoplankton dominate primary production over large oceanic regions but are believed to contribute relatively little to carbon export from surface layers. Using analyses of data from the equatorial Pacific Ocean and Arabian Sea, the authors show that the relative direct and indirect contribution of picoplankton to export is proportional to their total net primary production, despite their small size. The authors suggest that all primary producers, not just the large cells, can contribute to export from the surface layer of the ocean at rates proportional to their production rates. **Tammi L. Richardson and George A. Jackson,** *Science*, February 9, 2007, Volume 315, Issue 5813, pages 838-840, DOI: 10.1126/science.1133471, http://www.sciencemag.org/cgi/content/abstract/315/5813/838. (Subscription required.)

"Plant crown traits and carbon sequestration capability by *Platanus hybrida* Brot. in Rome." Measurements of carbon dioxide (CO_2) concentration carried out in the city of Rome in the period January–December 2005 showed a mean yearly CO_2 concentration of 414 ± 45 parts per million; polluted sites (P sites) had 21 percent higher CO_2 concentration than control sites (C sites). The significant ($p < 0.01$) correlation analysis between CO_2 concentration and traffic density measured during the study period at P sites showed that traffic density explained 51 percent of the CO_2 variation. The CO_2 trend during the traffic limitation days (provision imposed by ordinance of the City Council) did not show significant differences as regards regular traffic days, suggesting the ineffectiveness of this provision. Leaf area index (LAI) of *Platanus hybrida* Brot. was on an average 11 percent lower at P sites than at C ones associated with a lower total photosynthetic leaf surface area (SPT, 34 percent lower at P sites than at C ones). *P. hybrida* had a total carbon sequestration of 117 ± 13 kg year^{-1} (mean value of P and C sites) playing an important role in sequestering CO_2. Thus, the choice of plant species for urban areas may be set out taking into account their own air amelioration capability. Plant traits of each species may be used for urban tree planting programs to ameliorate urban air pollution. **Loretta Gratani and Laura Varone,** *Landscape and Urban Planning,* Published online February 16, 2007, http://www.sciencedirect.com/science/article/B6V91-4N2M685-1/2/ff70e17f2d6ffa926d90e689ebebc3ac. (Subscription may be required.)

May 2007

"Combined climate and carbon-cycle effects of large-scale deforestation." The prevention of deforestation and promotion of afforestation have often been cited as strategies to slow global warming. Deforestation releases carbon dioxide (CO_2) to the atmosphere, which exerts a warming influence on Earth's climate. However, biophysical effects of deforestation, which include changes in land surface albedo, evapotranspiration, and cloud cover also affect climate. Here [the authors] present results from several large-scale deforestation experiments performed with a three-dimensional coupled global carbon-cycle and climate model. These simulations were performed by using a fully three-dimensional model representing physical and biogeochemical interactions among land, atmosphere, and ocean. [The authors] find that global-scale deforestation has a net cooling influence on Earth's climate, because the warming carbon-cycle effects of deforestation are overwhelmed by the net cooling associated with changes in albedo and evapotranspiration. Latitude-specific deforestation experiments indicate that afforestation projects in the tropics would be clearly beneficial in mitigating global-scale warming, but would be counterproductive if implemented at high latitudes and would offer only marginal benefits in temperate regions. Although these results question the efficacy of mid- and high-latitude afforestation projects for climate mitigation, forests remain environmentally valuable resources for many reasons unrelated to climate. **(See Science section of this newsletter, "Tree Planting May Add to Warming, Says DOE-Funded Study," for an article referencing this journal abstract.) G. Bala, K. Caldeira, M. Wickett, T. J. Phillips, D. B. Lobell, C. Delire, and A. Mirin,** *Proceedings of the National Academy of*

Sciences, Published online April 9, 2007, http://www.pnas.org/cgi/content/abstract/0608998104v1. (Subscription required.)

"The GEFSOC soil carbon modeling system: A tool for conducting regional-scale soil carbon inventories and assessing the impacts of land use change on soil carbon." The GEFSOC soil carbon modeling system was built to provide interdisciplinary teams of scientists, natural resource managers and policy analysts (who have the appropriate computing skills) with the necessary tools to conduct regional-scale soil carbon (C) inventories. It allows users to assess the effects of land use change on soil organic carbon (SOC) stocks, soil fertility and the potential for soil carbon sequestration. The tool was developed in conjunction with case-studies of land use and management impacts on SOC in Brazil, Jordan, Kenya and India, which represent a diversity of land use and land management patterns and are countries where sustaining soil organic matter and fertility for food security is an on-going problem. The tool was designed to run using two common desktop computers, connected via a local area network. It utilizes open-source software that is freely available. All new software and user interfaces developed for the tool are available in an open source environment allowing users to examine system details, suggest improvements or write additional modules to interface with the system. The tool incorporates three widely used models for estimating soil carbon dynamics: (1) the Century ecosystem model; (2) the RothC soil carbon decomposition model; and (3) the Intergovernmental Panel on Climate Change (IPCC) method for assessing soil C at regional scales. The tool interacts with a Soil and Terrain Digital Database (SOTER) built for the specific country or region the user intends to model. A demonstration of the tool and results from an assessment of land use change in a sample region of North America are presented. **M. Easter, K. Paustian, K. Killian, S. Williams, T. Feng, R. Al-Adamat, N.H. Batjes, M. Bernoux, T. Bhattacharyya, C.C. Cerri, C.E.P. Cerri, K. Coleman, P. Falloon, C. Feller, P. Gicheru, P. Kamoni, E. Milne, D.K. Pal, D.S. Powlson, Z. Rawajfih, M. Sessay and S. Wokabi,** *Agriculture, Ecosystems & Environment,* Available online February 15, 2007, doi:10.1016/j.agee.2007.01.004, http://www.sciencedirect.com/science/article/B6T3Y-4N2DRBJ-1/2/7f151403695b84df48ef38bf63b97b62. (Subscription may be required.)

June 2007

"Total Soil Carbon and Water Quality: An Implication for Carbon Sequestration." Carbon sequestration in soil has been suggested as a means of reducing the rate of increase of atmospheric CO_2. Most soil science research has been on soil organic carbon (SOC) sequestration but in arid and semiarid climates, soil inorganic carbon (SIC) may offer another option for carbon sequestration. A field study was conducted in Bakersfield, California, to determine if irrigation water quality (fresh water [FW] vs. treated effluent [TE]) affected the distribution and amount of SIC and SOC in the upper 4 m [meters] of soil and parent material compared to a nonirrigated (NI) field. Significant carbonate depletions were found in the upper 2 m in both irrigated fields compared with the NI. Differences in carbonate content between irrigated fields were also related to soil texture. Total carbonate and clay-size carbonate were more abundant at the sites irrigated with TE than at the sites irrigated with FW, indicating that the TE had inhibited carbonate dissolution. Based on stable isotope analyses (^{13}C and ^{18}O) and radiocarbon dating, [the authors] estimated that irrigation for greater than 75 years sequestered about 7.15 kilograms per meters squared (kg m^{-2}) (4 $m)^{-1}$ of SIC under FW and between 0.9 and 2.4 kg m^{-2} (4 $m)^{-1}$ under TE, if carbonate dissolution is carbon sequestration. Adding carbon loss due to SOC decomposition to the SIC sequestration, the fields may be a source for 8.8 and 17.4 to 15.9 kg m^{-2} (4 $m)^{-1}$ of carbon under FW and TE, respectively. This study provides some of the first evidence of how water quality affects the carbon budget in an arid region. **Gil Eshel, Pinchas Fine and Michael J. Singer,** *Soil Science Society of America Journal,* Published online March 12, 2007, DOI: 10.2136/sssaj2006.0061, http://soil.scijournals.org/cgi/content/abstract/71/2/397. (Subscription may be required.)

July 2007

"The human footprint in the carbon cycle of temperate and boreal forests." Temperate and boreal forests in the Northern Hemisphere cover an area of about 2 x 10^7 square [kilometers] and act as a substantial carbon sink (0.6–0.7 petagrams of carbon per year). Although forest expansion following agricultural abandonment is certainly responsible for an important fraction of this carbon sink activity, the additional effects on the carbon balance of established forests of increased atmospheric [CO_2], increasing temperatures, changes in management practices and nitrogen deposition are difficult to disentangle, despite an extensive network of measurement stations. The relevance of this measurement effort has also been questioned, because spot measurements fail to take into account the role of disturbances, either natural (fire, pests, windstorms) or anthropogenic (forest harvesting). Here [the authors] show that the temporal dynamics following stand-replacing disturbances do indeed account for a very large fraction of the overall variability in forest carbon sequestration. After the confounding effects of disturbance have been factored out, however, forest net carbon sequestration is found to be overwhelmingly driven by nitrogen deposition, largely the result of anthropogenic activities. The effect is always positive over the range of nitrogen deposition covered by currently available data sets, casting doubts on the risk of widespread ecosystem nitrogen saturation under natural conditions. The results demonstrate that mankind is ultimately controlling the carbon balance of temperate and boreal forests, either directly (through forest management) or indirectly (through nitrogen deposition). **(See "Human Activities Increasing Carbon Sequestration in Forests" in the Science Section of this newsletter for an article referencing this journal abstract.) Federico Magnani, Maurizio Mencuccini, Marco Borghetti, Paul Berbigier, Frank Berninger, Sylvain Delzon, Achim Grelle, Pertti Hari, Paul G. Jarvis, Pasi Kolari, Andrew S. Kowalski, Harry Lankreijer, Beverly E. Law, Anders Lindroth, Denis Loustau, Giovanni Manca, John B. Moncrieff, Mark Rayment, Vanessa Tedeschi, Riccardo Valentini and John Grace,** *Nature,* Volume 447, June 14, 2007, Pages 849-851, doi:10.1038/nature05847, Link unavailable.

"Sensitivity of the Century Model to Scale-Related Soil Texture Variability." Sequestering C [carbon] in agricultural soils presents an immediate viable option to reduce atmospheric CO_2 to help mitigate global warming. Agricultural land managers who adopt practices that sequester C might market the sequestered (i.e., stored) C as a C credit to industrial CO_2 emitters who wish to reduce their net CO_2 emissions. Land managers or landowners will need to verify changes in soil organic carbon (SOC) related to a change in management practice to facilitate C credit trading. The objective of this study was to assess the accuracy of Century model predictions of SOC change due to the adoption of no-tillage using site-specific data and data from existing soil databases. [The authors] hypothesized that (i) using site-specific soil data would result in the most accurate Century estimates and (ii) Century estimates are sensitive to soil clay percentage. Five paired tillage/no-tillage farm sites in north-central Montana were used to test model predictions. Sites were chosen such that soil, landscape, climatic conditions, and historical cropping systems were similar within each tillage/no-tillage pair. The Century model overestimated SOC content using site-specific soils data by an average of 10 [percent]. Century was sensitive to the effects of clay content when predicting the total amount of SOC in a particular field. There was insufficient evidence to suggest that a linear association exists between clay content and Century-estimated C change due to no-tillage. Results suggest that (i) the effect of clay percentage on the rate of C change is not well understood and (ii) the Century model is an acceptable predictor of soil C for C trading. Further examination of the relationship between soil clay content and the rate of C storage in agricultural systems is needed to determine if adjustments to the Century model are required. **Ross S. Bricklemyer, P. R. Miller, P. J. Turk, K. Paustian, T. Keck and G. A. Nielsen,** *Soil Science Society of America Journal,* Published online April 5, 2007, http://soil.scijournals.org/cgi/content/abstract/71/3/784. (Subscription may be required.)

"A numerical study with an eddy-resolving model to evaluate chronic impacts in CO_2 ocean sequestration." To evaluate chronic impacts of CO_2 ocean sequestration, [the authors] simulated the distribution of injected CO_2 using an oceanic general circulation model (OGCM) with a horizontal resolution of 0.1 [degree]. The model can explicitly express transport and dispersion of dissolved CO_2 by mesoscale eddies. The CO_2 which is continuously injected by a moving ship dissolves and accumulates

within the first several to 10 years, but the CO_2 concentration has an upper limit after its initial increase as a result of the dilution effect of mesoscale eddies which counterbalances the accumulation effect of injection. [The authors] can estimate the CO_2 injection flux with the CO_2 maximum concentration below the "Predicted No Effect Concentration" (PNEC), an index to estimate concentration causing no effects on biota. **Yoshio Masuda, Yasuhiro Yamanaka, Yoshikazu Sasai, Michimasa Magi and Takashi Ohsumi,** *International Journal of Greenhouse Gas Control,* Published online April 26, 2007, doi:10.1016/S1750-5836(07)00039-4, http://www.sciencedirect.com/science/article/B83WP-4NKB28N-1/2/b5086b71d7293e1a2396e598fa2e0021. (Subscription may be required.)

August 2007

"Terrestrial carbon pools in southeast and south-central United States." Analyses of regional carbon sources and sinks are essential to assess the economical feasibility of various carbon sequestration technologies for mitigating atmospheric CO_2 accumulation and for preventing global warming. Such an inventory is a prerequisite for regional trading of CO_2 emissions. As a US Department of Energy Southeast Regional Carbon Sequestration Partner, [the authors] have estimated the state-level terrestrial carbon pools in the southeast and south-central US. This region includes: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia. [The authors] have also projected the potential for terrestrial carbon sequestration in the region. Texas is the largest contributor (34 [percent]) to greenhouse gas emission in the region. The total terrestrial carbon storage (forest biomass and soils) in the southeast and south-central US is estimated to be 130 Tg C/year [teragrams carbon per year]. An annual forest carbon sink (estimated as 76 Tg C/year) could compensate for 13 [percent] of the regional total annual greenhouse gas emission (505 Tg C, 1990 estimate). Through proper policies and the best land management practices, 54 Tg C/year could be sequestered in soils. Thus, terrestrial sinks can capture 23 [percent] of the regional total greenhouse emission and hence are one of the most cost-effective options for mitigating greenhouse emission in the region. **Fengxiang X. Han, M. John Plodinec, Yi Su, David L. Monts and Zhongpei Li,** *Climatic Change,* Published online March 1, 2007, DOI: 10.1007/s10584-007-9244-5, http://www.springerlink.com/content/j86t187ur3u6nt53. (Subscription may be required.)

"A pilot-scale continuous-jet hydrate reactor." A three-phase, pilot-scale continuous-jet hydrate reactor (CJHR) has been developed for the production of gas hydrates. The reactor receives water and a hydrate-forming species to produce the solid gas hydrate. The CJHR has been tested for the production of CO_2 hydrate for the purpose of ocean carbon sequestration. Formation of CO_2 hydrate was investigated using various reactor/injector designs in a 72-l high-pressure vessel. Designs of the CJHR varied from single-capillary to multiple-capillary injectors that dispersed (1) liquid CO_2 into water or (2) water into liquid CO_2. The novel injector is designed to improve the dispersion of one reactant into the other and, thus, eliminate mass transfer barriers that negatively affect conversion. An additional goal was an increase in production rates of two orders of magnitude. The designed injectors were tested in both distilled and saline water. Hydrate production experiments were conducted at different CO_2 and water flow rates and for pressures and temperatures equivalent to intermediate ocean depths (1100–1700 [meters]). The pilot-scale reactor with the novel injection system successfully increased hydrate production rates and efficiency. **Phillip Szymcek, Scott D. McCallum, Patricia Taboada-Serrano and Costas Tsouris,** *Chemical Engineering Journal,* Published online March 24, 2007, doi:10.1016/j.cej.2007.03.029, http://www.sciencedirect.com/science/article/B6TFJ-4NB99NK-1/2/941654ab98c370806b7ab30e0d8511b1. (Subscription may be required.)

Trading

September 2006

***RGGI Press Release,* "States Reach Agreement on Proposed Rules for the Nation's First Cap-and-Trade Program to Address Climate Change."** On August 15, 2006 the seven Northeast states under the Regional Greenhouse Gas Initiative (RGGI) release a model set of regulations to be proposed in each state to implement the program. Also released was an amendment to the December 2005 Memorandum of Understanding, serving to simplify the way "offset credits" will be implemented. The states participating in RGGI include Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York, and Vermont, with Maryland to join by 2007. Under RGGI, the states will launch a regional cap and trade system in which emissions credits will be issued to limit the total amount of carbon dioxide (CO_2) emissions. The State will issue one credit or allowance to permit one ton of CO_2 emissions. Coal, gas and oil-fired electric generating units with a capacity of 25 megawatts or more will be able to buy and sell allowances and will be required to have enough allowance to cover its reported emissions of CO_2. Starting in 2009, the emissions of CO_2 from power plants in the region would be capped at 121 mission tons annually until 2015. The states would then be required to reduce emissions in increments over a four year span to achieve a 10 percent reduction by 2019. Twenty-five percent of a states allowance will be allocated to strategic energy or consumer benefit purposes such as energy efficiency, new clean energy technologies and ratepayer rebates, with funds generated from the sale of these to be used for beneficial energy programs. Offset projects, which serve to "offset" CO_2 emissions from outside the electricity sector, will be allowed for up to 3.3 percent of the plant's overall emissions. Off-set projects such as natural gas end-use efficiency, landfill gas recovery, reforestation, and methane capture from farms will allow the power plant owner/operator to select the lowest cost emissions reductions and apply them to a portion of the plants' emissions requirements. Offset projects can be conducted in other states, as long as that state agrees to certain administrative requirements. After the states adopt the program, the RGGI program will begin on January 1, 2009. To read the RGGI model rule, and post-model rule action plan, see: http://www.rggi.org/modelrule.htm. For more information, see http://www.rggi.org/. August 15, 2006, http://www.rggi.org/docs/model_rule_release_8_15_06.pdf.

***AP,* "Blair, Schwarzenegger Unite Against Global Warming."** British Prime Minister Tony Blair and California Governor Arnold Schwarzenegger announced an agreement on July 31 to share information and ideas regarding ways to fight global warming. Specifically the two agreed to collaborate on research into cleaner-burning fuels and technologies and the possibility of setting up a carbon dioxide emissions trading system. A main target of the agreement is carbon dioxide from cars, trucks and other modes of transportation, since 41 percent of California's and 28 percent of Britain's greenhouse gas emissions are from transportation. California is looking to cut greenhouse gas emissions to 2000 levels by 2010, and Britain to reduce carbon dioxide emissions to 60 percent of its 2000 level by 2050. California was the 12th largest source of greenhouse gas emissions in 2005, greater than most countries. August 1, 2006, http://www.ctv.ca/servlet/ArticleNews/story/CTVNews/20060801/blair_schwarzenegger_global_warming_060801/20060801?hub=SciTech.

***The Australian,* "States Go Cool on Carbon Trading."** The Australian states have withdrawn their plan for a carbon trading system, due to government concerns that the scheme would affect low income households. The extent of the exemptions contained in the program also makes the scheme more complex than the European Union's carbon trading system. "The states' scheme has exclusions, generous permit allocations, offset credits, gateways, soft starts and compensation for loss of profits and no effective global greenhouse response," said John Howard, the Prime Minister of Australia. A green paper that was to outline the proposed system released the week of August 28 will be downgraded to a "discussion paper" and the 2010 deadline for carbon trading will not be met. August 4, 2006, http://www.theaustralian.news.com.au/story/0,20867,20013169-2702,00.html.

October 2006

***Greenwire,* "Massachusetts Delegation Urges Governor Romney to Rejoin RGGI."** Two senators and several members of congress, all Democrats, sent a letter to Massachusetts Governor Mitt Romney questioning Romney's decision to withdrawal from the Regional Greenhouse Gas Initiative (RGGI). Both Massachusetts and Rhode Island have pulled out of RGGI after initial discussions. RGGI is a cap-and-trade program with a goal to cap carbon dioxide emissions from power plants at the current level of 121 million tons per year, to year 2015. Also by 2020 the member states must cut CO_2 emissions by 10 percent. Member states currently include: Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York and Vermont. Maryland will join RGGI in June 2007, and Pennsylvania is an observer of the program. The final model rule was released last month and will take effect January 1, 2009. Each state is now tasked with developing regulations to implement the plan. To view the letter to Governor Romney, see: http://www.eenews.net/features/documents/2006/09/12/document_gw_01.pdf. September 12, 2006, http://www.eenews.net/Greenwire/print/2006/09/12/9.

***Reuters,* "Californian Climate Registry Seeks National Expansion."** The California Climate Action Registry is in discussions with 30 states regarding creating a multi-state greenhouse gas registry. Companies document their greenhouse gas reductions with the registry which then verifies them though a third party. By logging their emissions reductions, companies hope to avoid the penalties such as those that early actors received in the first cap-and-trade pollution market for sulfur dioxide (SO_2) emissions. More than half of the emissions logged have been from outside the state. "Our standards are so broadly respected, that people feel it's the best place to log their reductions even they are outside the state," a source from the California Registry said. In the absence of federal laws, regulations are slowly taking shape in the States. September 19, 2006, http://www.planetark.com/dailynewsstory.cfm/newsid/38152/story.htm.

November 2006

***Reuters,* "EU Warns 8 States Over Late CO_2 Emissions Plans."** On October 12, the European Commission began legal action against eight of European Union states, sending warning letters to Austria, the Czech Republic, Denmark, Hungary, Italy, Portugal, Slovenia, and Spain for failing to submit their 2008-2012 national allocation plans, required under the Kyoto Protocol. The plans, which were due in June, are to outline the carbon dioxide (CO_2) emissions limits that large factories can release and enable the states to buy and sell emissions permits. The Commission is also taking Luxembourg to the European Court of Justice "for not providing sufficient information on its policies and measures to reduce greenhouse gas emissions and on its projected future emissions." Also the Commission is sending seven other warning letters to states "for not communicating important technical information relating to their emission targets." October 13, 2006, http://www.planetark.com/dailynewsstory.cfm?newsid=38492&newsdate=13-Oct-2006.

***Reuters*, "California seeks CO_2 market with EU, US Northeast."** California Governor Arnold Schwarzenegger met with New York Governor George Pataki to discuss a plan for California and the Regional Greenhouse Gas Initiative (RGGI) to work to create a market-based carbon trading program with the European Union. Last month, Schwarzenegger signed into law the Global Warming Solutions Act of 2006, which caps greenhouse gas emissions by 25 percent by 2020. Pataki was responsible for spearheading RGGI once President George H.W. Bush withdrew from the Kyoto Protocol in 2001. RGGI is an alliance of seven Northeastern and Mid-Atlantic states working to reduce carbon dioxide emissions starting in 2009. On Oct 17, Schwarzenegger will sign an executive order to "develop a comprehensive market-based compliance program with the goal of creating a program that permits trading with the European Union, the Regional Greenhouse Gas Initiative and other jurisdictions," according to document obtained by Reuters. October 16, 2006,

http://today.reuters.com/news/articlenews.aspx?type=domesticNews&storyID=2006-10-16T171015Z_01_N16459595_RTRUKOC_0_US-ENVIRONMENT-SCHWARZENEGGER-EMISSIONS.xml&WTmodLoc=USNewsHome_C2_domesticNews-6.

***Reuters,* "Rhodia, SOCGEN Form Carbon Trading Joint Venture."** French companies Rhodia and Societe Generale will form a joint venture company ORBEO to handle all of their carbon trading interests. ORBEO will start by marketing pollution reductions at Rhodia's chemical plants in Brazil and South Korea for 11 to 13 million ton of carbon credits per year from 2007-12. These credits are trading at approximately $17.50 per ton, making Rhodia's sales of credits worth $114.2 million annually. ORBEO will be one of the largest holders of emissions credits worldwide. Rhodia generates carbon credits by destroying the potent greenhouse gas nitrous oxide, a by-product of nylon manufacture. Two of Rhodia's plants in Brazil and South Korea are among the world's 10 biggest such Kyoto projects worldwide. ORBEO is pursuing carbon trading deals in China, Brazil and Eastern Europe. October 10, 2006, http://www.planetark.com/dailynewsstory.cfm/newsid/38442/story.htm.

***Reuters,* "UK Sees EU-Wide Carbon Capture Incentive from 2008."** European power plants which use carbon capture and storage will receive some exemptions from pollution caps under the European carbon trading scheme, beginning in the second phase of the scheme, from 2008-2012. Currently under the scheme, carbon sequestration is treated as if the CO_2 were emitted. The United Kingdom's Department for Environment Food and Rural Affairs plans to work with the European Commission to gain recognition of the storage element of sequestration in the second phase of the trading scheme. The European Commission has not made any definite plans yet in incorporating carbon capture and storage into the scheme, but is looking into the matter. Some energy analysts see carbon sequestration as a technology that can cut the greatest amount of emissions before 2050, to help avert climate change. October 6, 2006, http://www.planetark.com/dailynewsstory.cfm?newsid=38397&newsdate=06-Oct-2006.

December 2006

***Greenwire,* "Market for CO_2 Credits Reaches $22B."** The carbon dioxide emissions trading market grew to $22 billion worldwide, which equates to more than double its size last year. These figures are according to a report by the World Bank and the International Emissions Trading Association entitled: "State and Trends of the Carbon Market 2006: Update: January 1 – September 30, 2006." **(See Recent Publications section of this Newsletter for a link to the report.)** For the first nine months of 2006, the market totaled $21.47 billion in comparison to the level for all of 2005 which stood at under $11 billion. Launched at the start of 2005, the European Union's Emissions Trading Scheme accounted for $19 billion dollars of trade this year. The report pointed out the noteworthy developments in carbon markets including the northeastern U.S.'s Regional Greenhouse Gas Initiative and California's efforts to establish a trading system. The report also warned of an uncertain future for carbon emissions trading past the year 2012 which is when the Kyoto Protocol expires. October 27, 2006, http://www.eenews.net/Greenwire/2006/10/27/archive/12/?terms=co2. (Subscription may be required.)

***Reuters,* "Japan Firms Win OK For $24 Million Carbon Projects."** On October 24, the Japanese government approved seven joint Clean Development Mechanism (CDM) projects that will be implemented by five of the country's companies in efforts to reduce greenhouse gas emissions. Under the CDM scheme, the companies will receive 360,000 tons of carbon dioxide (CO_2) emission credits, through investments via a World Bank Fund, with $24 million given to countries where the projects will be carried out. The host countries include Honduras, Peru, Moldova, Nepal and Argentina. One project identified is a wind power plant that is expected to produce less CO_2 emissions by operating on reduced amounts of fossil fuels. The five Japanese companies receiving the approval include Fujifilm Corporation, a wholly owned subsidiary by Fujifilm Holdings Corporation, Daiwa Securities SMBC Principal Investments Company, Nippon Oil Corporation, Idemitsu Kosan Company, and Okinawa Electric Power Company. Redirecting funds to poorer nations is one way that Japan will try to meet its goal to reduce emission levels by 6 percent from their 1990 level. Nonetheless, Japan has fallen short of that goal, since

emission levels in 2005 were fourteen percent above its Kyoto reduction target. October 26, 2006, http://www.planetark.com/dailynewsstory.cfm/newsid/38680/story.htm.

***The Age (Australia),* "Qantas Plan to Offset Its Carbon Emissions."** The Australian airline Qantas is making plans to allow its customers to offset the carbon emissions from their flights taken. Qantas is working with its code share partner British Airways to allow customers to pay a fee to offset their carbon emissions via a link from the British Airways website. For example a flight from Melbourne to Singapore on a 747 produces about 1.36 tons of carbon dioxide, and the offset charge would be approximately $19.46. Fees raised by this program will go to sustainable energy projects via a company called Climate Care. November 2, 2006, http://www.theage.com.au/news/business/qantas-plan-to-offset-its-carbon-emissions/2006/11/01/1162339917973.html.

January 2007

***Reuters,* "EU's Dimas Says CO_2 Emission Decisions Due November 29."** Stavros Dimas, Environment Commissioner to the European Union (EU), announced that initial decisions concerning member states' carbon dioxide (CO_2) emissions allocations plans would be issued on November 29. Current efforts will focus on reducing emissions levels in the 2008-2012 plans, since poor efforts in 2005 by some governments to control the number of pollution permits to industries resulted in a crash in carbon prices. EU countries who fail to provide the necessary emissions reductions and Kyoto Protocol targets will be sent back for revisions. The EU trading scheme sets limits on the amount of CO_2 that factories can release, otherwise requiring those companies to purchase carbon credits when caps are exceeded. October 11, 2006, http://www.planetark.com/dailynewsstory.cfm?newsid=38916&newsdate=10-Nov-2006.

***Reuters,* "Banks Buy Over 200 Million Euro Chinese Carbon Credits."** On November 30, over $263 million worth of carbon credits were bought from a Chinese mining company by banks including Lehman, Fortis and BNP Paribas. The investors will fund two projects to destroy the greenhouse gas methane in the coal mines at Yangquan Coal Industry Company, using the gas to generate power. Investors have been buying carbon credits inexpensively from countries like China and are selling them to European countries which face emissions targets enforced by the European Union. According to the World Bank, global carbon trade was worth $21.5 billion in the first nine months of 2006 versus $11.1 billion for the whole of last year. December 1, 2006, http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=39268.

***Reuters,* "NY Plans To Auction 100 Percent of CO_2 Permits – Source."** As part of the Regional Greenhouse Gas Initiative (RGGI), New York State plans to distribute its carbon emissions permits via auction. This method was chosen in order to avoid the European Union's mistake of giving away carbon permits which caused a drop in the carbon trading prices last year. The carbon permits will function to set emissions limits for businesses, and allow businesses to buy carbon credits in order to emit over that limit. It is thought that the power plants which have more carbon dioxide emissions will be shorter on emissions credits, and would have the strongest money in the market. This would prevent the lesser emitting plants from hoarding credits. Vermont will also auction permits but has limited power generation in the state. The other RGGI states, including Maine, New Hampshire, Connecticut, New Jersey and Delaware, have not determined how they will distribute credits. A lawyer from the National Resources Defense Council advising RGGI feels that New York's decision on how to distribute permits will influence decisions in other states regarding distribution of their allowances. December 6, 2006, http://www.planetark.com/dailynewsstory.cfm/newsid/39347/story.htm.

***Greenwire,* "Nonprofit Floats Emissions Certification Tool For Consumers."** The San Francisco-based non-profit Center for Resource Solutions (CRS) is developing a retail greenhouse gas reduction product standard, its "Green-e" emissions product certification standard. CRS will open its proposed standard for public comment in December and will promulgate it early next year. CRS is aiming to

provide consumers third-party verification of greenhouse gas offsets in order to ensure that a vendor is supplying equal sales and retired offsets as advertised. The proposed standard was developed with input from the US government, World Resources Institute, National Resources Defense Council, Interface Inc., and others. The Green-e logo is currently used to certify renewable energy products, and would expand to include offsets. For more information, see: http://www.resource-solutions.org/where/pressreleases/2006/Upcoming_Comment_Period_for_Retail_GHG_Reduction_Certification_Program_Announced.11.20.06.htm. November 21, 2006, http://www.eenews.net/Greenwire/print/2006/11/21/7.

February 2007

***Reuters,* "UK to Offset Pollution from Jet-Setting Ministers."** On December 28, the British government confirmed their purchase of 255,000 tons worth of carbon credits in order to offset emissions generated from airline flights taken by UK government officials while on travel. The credits were bought at a price of $19.27 (9.76 pounds) per ton, for a total purchase price of almost $4.8 million (2.5 million pounds). The carbon credits will be used from 2007 to 2009, and the option to purchase an additional 50,000 tons of credits may be taken. The government has plans to invest in projects registered under the Kyoto Protocol. In order to alleviate concern expressed by some environmental organizations in Britain, the government will publish a consultation paper in January 2007 which will outline the details of the various carbon offsetting schemes. It will then issue a follow-up report in April 2007 with recommendations to participate in the most environmentally sound schemes. The credits were purchased from Trading Emissions Plc, an investment fund run by EEA Fund Management which invests in renewable energy projects in developing countries including Brazil, Thailand and the Philippines. December 29, 2006, http://www.planetark.org/avantgo/dailynewsstory.cfm?newsid=39649.

***Greenwire*, "Dell Launches Carbon Sequestration Initiative."** Michael Dell, chairman of Dell Incorporated, launched the company's "Plant a Tree for Me" initiative in an effort to offset greenhouse gas emissions produced by computers. This is Dell's second green initiative following the company's industry-first pledge made last fall to recycle customers' Dell-branded computers and peripheral equipment at no charge. The new program gives Dell customers the opportunity to make a donation to The Conservation Fund and Carbonfund.org when they buy a computer. Donations can range from $2 with a notebook computer purchase to $6 for purchase of a desktop PC. Money from the donations will be used by the nonprofit groups to plant trees that convert carbon dioxide into oxygen, thus reducing the greenhouse gases that contribute to global warming. The Conservation Fund estimates that one laptop computer emits 0.42 tons of carbon dioxide (CO_2) over its lifetime, and a desktop model releases 1.26 tons of CO_2. Over a seven year period one tree could sequester 1.33 tons of CO_2, enough carbon to offset those amounts. Trees will be planted in areas where they will not be harvested for timber, such as wildlife refuges and county parks. Emissions created during the shipping of Dell products will also be targeted in the donation program, and other larger companies, including Travelocity and Expedia, offer similar opportunities to their customers. January 10, 2007, http://www.eenews.net/Greenwire/print/2007/01/10/16. (Subscription may be required.)

March 2007

***Chicago Climate Exchange Press Release*, "Kodak Joins Chicago Climate Exchange."** Eastman Kodak Company announced that it will become a member of the Chicago Climate Exchange (CCX). CCX is the world's first and North America's only legally binding rules-based greenhouse gas emissions allowance trading system, as well as the world's only global system for emissions trading based on all six greenhouse gases. Dr. Richard Sandor, CCX Chairman and CEO, welcomed the company and expressed his gratitude for Eastman Kodak's commitment to reduce their greenhouse gas emissions. As part of Kodak's "Responsible Growth" goals program, the company has made a commitment to achieve a 20 percent reduction in carbon dioxide (CO_2) emissions between 2003 and 2008. A ten percent reduction

in CO_2 emissions has already been reached during 2003-2005. Adding to the company's reputation for addressing the environmental impacts of their operation, Kodak is a charter partner in the US Environmental Protection Agency's Climate Leaders Program. Kodak was recognized in 2006 by the California Climate Action Registry for becoming that agency's first participant to report all six greenhouse gases identified by the Kyoto Protocol on a worldwide basis. Eastman Kodak Company specializes in imaging products and services to the photographic, graphic communications, and healthcare markets and reported sales of $14.3 billion in 2005. To read more about Kodak (NYSE: EK), go to: www.kodak.com. For a full list of CCX members, daily prices and other program information, see www.chicagoclimateexchange.com. January 30, 2007, http://www.chicagoclimateexchange.com/news/press/release_20070130_Kodak.pdf.

"A laboratory investigation of compliance behavior under tradable emissions rights: Implications for targeted enforcement." This paper uses laboratory experiments to test theoretical predictions concerning compliance behavior in competitive emissions trading programs. The authors test the hypotheses that both the violations of competitive risk neutral firms and the marginal effectiveness of increased enforcement across firms are independent of differences in their benefits from emissions (abatement costs) and their initial permit allocations. This conclusion suggests that regulators have no conceptual justification for targeting their enforcement effort based on firm-level characteristics. Consistent with theory, the authors find that violations were independent of parametric differences in emissions benefits. However, subjects who were predicted to buy permits tended to have higher violation levels than those who were predicted to be sellers. Nevertheless, the authors find no evidence that the marginal effectiveness of enforcement depends on any firm-specific characteristic. The authors also examine the determinants of compliance behavior under fixed emissions standards. As expected, the authors find significant differences between compliance behavior under fixed standards and emissions trading programs. **James J. Murphy and John K. Stranlund,** *Journal of Environmental Economics and Management,* Published online January 26, 2007, http://www.sciencedirect.com/science/article/B6WJ6-4MX4VMD-1/2/67300411559329d45f4b2f6c81cf841c. (Subscription may be required.)

April 2007

***Greenwire,* "Five Western States to Launch Greenhouse Gas Trading Program," and *The Associated Press,* "Governors Team to Reduce Gas Emissions."** On February 26, five governors from the states of Arizona, California, New Mexico, Oregon and Washington signed a global warming agreement, pledging their commitment to cut greenhouse gas emissions. This latest agreement, signed during the annual winter meeting of the National Governors Association, is called the Western Regional Climate Action Initiative and will add to each of the states' existing plans to reduce pollution levels and implement regulations. A coalition of ten Northeast and Mid-Atlantic States has already established their own program through the Regional Greenhouse Gas Initiative or RGGI. Other topics of discussion at the meeting included a plan by Western states to launch a regional cap-and-trade program, legislation to encourage clean-coal technology, alternative energy sources, and tax incentives to encourage the use of renewable energy. The five Western states have also agreed to start a registry to track and manage their emissions. In 2006, California Governor Arnold Schwarzenegger became the first governor to impose state legislation for emissions caps on utilities, refineries and manufacturing plants, with a goal to cut greenhouse gas emissions to 1990 levels by 2020. The Western states' press release to launch their greenhouse gas trading program says that officials will develop specific regional emissions targets within six months and will set up a market-based system "such as a load-based cap-and-trade program" by August 2008. It may be possible for this program to merge with the Northeastern trading system, as well as with similar efforts from both Canadian provinces and Mexican states. More information about the National Governors Association can be found by clicking: http://www.nga.org. February 26, 2007, http://www.eenews.net/Greenwire/print/2007/02/26/1, (Subscription may be required), and February 26, 2007, http://www.cbsnews.com/stories/2007/02/26/politics/ap/main2519109.shtml. To read the keynote remarks delivered by Secretary of Energy Samuel Bodman at the National Governors Association Winter Meeting, go to: http://www.energy.gov/news/4822.htm.

***Business Wire,* "Record TXU Buyout Includes Unprecedented Global Warming, Emissions Plan," and *Greenwire,* "TXU Agrees to $45 Billion Takeover, Limits on New Coal Plants."** TXU Corporation, the largest utility company in Texas, is being sold to a group of private equity investors for a reported $32 billion plus $13 billion in debt. The purchase would mark the largest private equity deal on record. Led by Kohlberg Kravis Roberts & Company and Texas Pacific Group, the buyout deal contains several environmental provisions which include reversing TXU's plans to build 11 new coal-fired power plants in Texas, as well as proposed plants in Pennsylvania and Virginia. Conditions of the sale include investment in a number of energy efficiency strategies, commitments to tackle global warming, and support for federal legislation to establish a cap-and-trade system for greenhouse gas emissions. The buyers worked with the Natural Resources Defense Council (NRDC), a national, nonprofit organization of scientists, lawyers and environmental specialists, in order to gain their endorsements. According to the NRDC and other environmental experts, the new company will also aim to limit total carbon dioxide (CO_2) emissions from existing plants in an effort to reduce its emissions to 1990 levels by 2020. Investments in renewable energy sources and initiatives to help customers reduce their energy needs are planned, and research on alternative technologies will be explored. Residential customers will benefit from a planned 10 percent decrease in electricity prices until 2008, which could amount to more than $300 million per year in total savings. Salaries for top executives and performance measurement at the new company would be tied directly to the climate protection goals. Former EPA Administrator William Reilly and former Commerce Secretary Donald L. Evans will join TXU's board, and former Secretary of State James Baker will serve as advisory chairman. February 24, 2007, http://www.energycentral.com/centers/news/daily/printer_friendly.cfm?aid=7889031, (Subscription required), and February 26, 2007, http://www.eenews.net/Greenwire/print/2007/02/26/2. (Subscription may be required.) To listen to a story about the buyout from NPR's *Morning Edition* and to read related NPR stories on this piece, go to: http://www.npr.org/templates/story/story.php?storyId=7615613.

***Terrapass Press Release,* "Greenlighting at the Oscars."** The Academy Awards made their own contribution to global climate change this year. Instead of acknowledging the presenters and performers with the usual gift bag full of lavish and expensive gifts, the Academy opted for a more meaningful and less exotic approach by presenting the recipients with a more unique token of appreciation created in collaboration between TerraPass, the leading retailer of carbon offsets, and Simon Pearce, a distinguished designer and manufacturer of hand blown glass objects. The result was a gift that consisted of a "Year of Carbon Balanced Living," an original Simon Pearce glass sculpture and 100,000 pounds of carbon dioxide reductions from TerraPass' suite of verified clean energy projects. Also included as part of the gift was a handbook for climate-conscious living, which describes several simple suggestions for increasing energy efficiency and decreasing the amount of greenhouse gases each person produces, a term that TerraPass describes as reducing your "carbon footprint." For $2,100 the same sculpture given to presenters and performers at the 79th Annual Academy Awards can be purchased online at: http://www.lohacharasculpture.com/products-5yr.html. The price includes a tour of the Simon Pearce glass workshop in Queechee, Vermont, lunch or dinner for two at a Simon Pearce restaurant, and five years of carbon balanced living (equal to 150 metric tons of greenhouse gas reductions). To read the TerraPass handbook for climate conscious living given to the Academy Award presenters, go to: http://www.terrapass.com/handbook/. February 26, 2006, http://www.terrapass.com/lp/index.oscars.html.

***Chicago Climate Exchange Press Release,* "Chicago Climate Exchange Sets New Record Trading Month."** On March 1, Chicago Climate Exchange (CCX) announced a new record for carbon dioxide (CO_2) trading volumes in February 2007. Trading numbers reached 3,712,100 metric tons of CO_2, which is the highest trading month in the history of the CCX. The cap-and-trade program is the world's first and North America's only legally binding greenhouse gas reduction and trading system for emissions sources and offset projects. March 1, 2007, http://www.chicagoclimatex.com/news/press/release_20070301_CCX.pdf.

May 2007

The Sydney Morning Herald, **"Energy Giant Embraces Carbon Trading."** AGL Energy Limited (AGL), one of Australia's leading energy conglomerates, will become the country's first company to join the Chicago Climate Exchange (CCX). Membership in the carbon trading scheme will enable AGL to benefit from their efforts to reduce emissions and cut greenhouse gas pollution in Australia by marketing their carbon offsets to less efficient companies around the world. Additionally, the endeavor will allow the company to expand its renewable energy operations and add to the already $1.6 billion ($2 billion Australian) they have invested in renewables over the past year. This includes plans to build the largest wind farm in the southern hemisphere, which will power almost 200,000 homes. AGL's managing director, Paul Anthony, came from Britain to join the company in 2006 and strongly endorses AGL's participation in the CCX. Australia has not committed to setting up its own carbon trading scheme. However, Australian Prime Minister, John Howard, recently established a taskforce to do so. March 20, 2007, http://www.smh.com.au/news/environment/energy-giant-embraces-carbon-trading/2007/03/19/1174152972167.html#

June 2007

The Associated Press, **"EU Makes 6 Percent Cut to Italy's Carbon Trading Cap."** On May 15, the executive body of the European Union (EU) modified Italy's original carbon trading cap to a level 6.3 percent below the amount requested. Due to the modification, Italy will now be permitted to emit 195.8 million metric tons per year of emissions versus the 201 million metric tons per year initially requested. It is the European Commission that sets the carbon trading caps for each of the 25 EU nations bound by the Kyoto Protocol. In practice, this system creates a financial incentive for emissions reductions by assigning a cost to polluting. Generally, companies that can reduce emissions at a low cost can sell off their residual permits to other companies who are not able to meet their caps. However, one recent glitch arose when it was determined that some countries were supplying a surplus of permits to power plants and factories, which gave them no incentive to reduce their greenhouse gas emission levels. The EU Commission is hoping to limit the number of permits granted in order to reach its goals to cut CO_2 emissions by eight percent from 1990 levels by 2012, and ultimately by 20 percent by 2020. May 15, 2007, http://www.iht.com/articles/ap/2007/05/15/business/EU-FIN-EU-Italy-Carbon-Trading.php.

The Atlanta Journal-Constitution, **"Delta's New Fliers' Perk: A Tree."** In conjunction with Earth Day on June 1, Delta Air Lines will kick off a voluntary carbon offsetting program with its customers. The program will be the first of its kind initiated by a US carrier and will allow customers to compensate for the CO_2 produced during their flight with the planting of a tree. Delta has teamed up with The Conservation Fund, an environmental nonprofit organization dedicated to similar terrestrial carbon sequestration projects throughout the country. The organization's efforts have allowed them to plant nine million trees in the US which will make up for 13.5 million tons of CO_2 emissions over a century. The Conservation Fund will direct donations from Delta's program to aid in the reforestation of Gulf Coast areas damaged by Hurricane Katrina. Customers willing to participate in the program will be charged $5.50 for a domestic round trip ticket and $11 for an international flight. Delta announced that the company will donate an additional $300,000 to kick off this program. Other international carriers offering similar programs to their customers include British Airways and Scandinavian Airlines Group. April 18, 2007, Link unavailable.

July 2007

U.S. House of Representatives Press Release, **"Kirk Amendment Calls for House to Offset All Greenhouse Gas Emissions."** In efforts to meet guidelines outlined in a House of Representatives report entitled "Green the Capitol," US Representative Mark Kirk of Illinois announced the approval of an amendment that will require the US House of Representatives to offset all CO_2 emissions produced by

House operations with the purchase of emissions credits through the Chicago Climate Exchange. The recommended purchase amount was set at 34,000 tons of carbon, which would cost the House approximately $122,700, including associated fees for the transaction. Combined with the recommendation by the House Chief Administrative Officer to adopt renewable energy technologies, the House could become a carbon neutral operation. Total yearly emissions from the House of Representatives buildings produce approximately 91,000 tons of CO_2. June 12, 2007, http://www.house.gov/apps/list/press/il10_kirk/Kirk_Amendment_Calls_for_House_to_Offset_All_Greenhouse_Gas_Emissions.html.

***Entergy Corporation Press Release*, Entergy Carbon Credit Purchase Makes 270,000 Megawatt Hours 'Carbon Neutral'."** On June 5, Entergy Corporation announced the purchase of 150,000 metric tons of CO_2 credits from Anadarko Petroleum Corporation, a company that supplies natural gas to Entergy for electricity production Entergy's customer base is comprised of 2.6 million utility customers in Arkansas, Louisiana, Mississippi and Texas. This deal has made 270,000 megawatt hours of electricity produced by the company as "carbon neutral," since Entergy is, in effect, paying Anadarko for polluting rights to generate electricity. The transaction will allow Entergy to meet its second voluntary greenhouse gas (GHG) stabilization commitment to reduce its GHG emissions to 20 percent below 2000 levels through 2010. The company met their first milestone of becoming the first US utility to voluntarily stabilize GHG emissions at 2000 levels through 2005 by 23 percent, while increasing megawatt hour sales by 21 percent for the period from 2001 to 2005. Entergy acquired the emission reduction credits by utilizing carbon capture and storage at its plants. Carbon dioxide emissions from the flue gases are captured from gas liquids production and then injected into oil-bearing formations for geologic sequestration and enhanced oil recovery. June 5, 2007, http://biz.yahoo.com/prnews/070605/latu127.html?.v=55.

August 2007

***Bloomberg*, "Asian Swamps Worth $39 Billion in Emission Credits."** Indonesia is seeking international assistance to help prevent the draining of tropical swamps, known as peatlands, which they develop for plantations by starting fires to clear the land. Indonesia releases approximately two billion metric tons of CO_2 per year through this practice. The request came at the global government-sponsored Convention on Biological Diversity in Paris, which was attended by twelve countries, including Indonesia, the Netherlands, Germany, Canada and Switzerland. By discontinuing the burning, the carbon could instead be stored, thus allowing Indonesia to generate emission credits worth $39 billion (29 billion euros), using the United Nations estimate of 14.59 euros per ton. The money generated would be spent towards alternative projects that would not involve intrusion of the peatlands. July 6, 2007, http://www.bloomberg.com/apps/news?pid=20601207&sid=azeZfyJQ8NIE&refer=energy.

***Toronto Star*, "Air Canada Goes Green."** Air Canada kicked off a voluntary carbon offsetting program to their customers. The program will allow travelers to offset the CO_2 produced during their flight at the completion of their online ticket purchase. The company's website will provide patrons with an online carbon calculator to determine how much CO_2 the trip will generate and the price to offset the emissions. Money generated from the program will be designated to a project aimed at reducing greenhouse gases, such as planting a tree. Zerofootprint is the nonprofit organization in charge of managing Air Canada's program. An Air Canada passenger would pay $19.20 to offset the CO_2 produced to fly from Toronto to London, for example. July 2, 2007, http://www.thestar.com/printArticle/231461.

Recent Publications

September 2006

"International Energy Annual (IEA) 2004." The International Energy Annual (IEA) is the Energy Information Administration's primary report of international energy statistics. For many series, data begin with the year 1980. Included are data on energy consumption and production; overviews of petroleum, natural gas, coal, and electricity, as well as carbon dioxide emissions from the use of fossil fuels, petroleum prices, energy reserves, and population; and data unit conversion tables. To view data tables of "World Carbon Dioxide Emissions from the Use of Fossil Fuels," go to: http://www.eia.doe.gov/iea/carbon.html. For the overall report, see: http://www.eia.doe.gov/iea/.

"Annual Energy Outlook Evaluation, 2005." Each year since 1996, EIA's Office of Integrated Analysis and Forecasting has produced a comparison between realized energy outcomes and the projections included in previous editions of the AEO. Each year, the comparison adds the projections from the most recent AEO and updates the historical data to the most recently available. The comparison summarizes the relationship of the AEO reference case projections since 1982 to realized outcomes by calculating the average absolute percent differences for several of the major variables for AEO82 through AEO2005. The average absolute percent difference is the simple mean of the absolute values of the percentage difference between the Reference Case projection and the actual value. The historical data are typically taken from the *Annual Energy Review (AER).* As indicated in Table 1 of the report, the reference case projections of energy consumption, energy production, and carbon dioxide emissions have been relatively close to realized outcomes. Table 7 presents detailed data of the Total Carbon Dioxide Emissions, Actual vs. Reference Case. To view the report and supporting tables, go to: http://www.eia.doe.gov/oiaf/analysispaper/forecasteval/index.html. Document number DOE/EIA-0640(2005), July 2006.

"Following The Paper Trail: The Impact of Magazine And Dimensional Lumber Production On Greenhouse Gas Emissions: A Case Study. 2006." Canfor, The Home Depot, Stora Enso in North America (SENA) and Time Inc. (listed in alphabetical order) commissioned the greenhouse gas (GHG) life-cycle analysis (LCA) of two magazine chains and a dimensional lumber chain. The collaboration of the four companies in this project reflects the flows of (i) Canfor wood fiber to The Home Depot, a large do-it-yourself remodeling and construction retailer, and (ii) flows of Canfor kraft pulp, SENA wood fiber and SENA kraft pulp used to produce magazine paper for *Time* and *InStyle* magazines. The Heinz Center for Science, Economics and the Environment, an environmental non-governmental organization (NGO), helped the participants identify and address relevant environmental issues. The participants undertook the self-initiated study to quantify sources of GHG emissions for each major step in the magazine and dimensional lumber product chains. This life-cycle analysis provides valuable information that company managers can use to increase efficiency in the production of paper and wood products by decreasing the demand for energy resources and reducing GHG emissions. [The authors] only examined the major components of GHG budgets in this study. This study is unlike other forest product LCA studies in that the participants in this study provided their product-specific data. **Dr. Stith T. Gower, Ann McKeon-Ruediger, Annabeth Reitter, Michael Bradley, David J. Reflcin, Timothy Tollefson, Fred J. Souba Jr., Amy Taup, Lynn Embury-Williams, Steven Schiavone, James Weinbauer, Anthony C. Janetos, and Ron Jarvis,** The H. John Heinz III Center for Science, Economics and the Environment, Washington, DC, 2006, http://www.heinzctr.org/publications.shtml.

October 2006

"US Climate Change Technology Program Strategic Plan September 2006." The US Department of Energy (DOE) released the Climate Change Technology Program (CCTP) Strategic Plan on September 20, which details measures to accelerate the development and reduce the cost of new and advanced technologies that avoid, reduce, or capture and store greenhouse gas emissions. CCTP is the technology component of a comprehensive US strategy introduced by President Bush in 2002, to combat climate change that include measures to slow the growth of greenhouse gas emissions through voluntary, incentive-based, and mandatory partnerships, advance climate change science, spur clean energy technology development and deployment, and promote international collaboration. The CCTP

Strategic Plan organizes roughly $3 billion in federal spending for climate technology research, development, demonstration, and deployment to reduce greenhouse gas emissions and increase economic growth. It provides a long-term planning context, taking into account many uncertainties, and establishes principles for formulating research and development portfolios to identify areas for reductions in greenhouse gas emissions and highlights an array of technology strategies and investment criteria. This Plan complements other Administration efforts including short-term measures to reduce greenhouse gas emissions intensity, advance climate change science, and promote international cooperation through partnership including the Asia Pacific Partnership on Clean Development and Climate, Methane to Markets Partnership, and the International Partnership for a Hydrogen Economy. The Plan sets six complementary goals: (1) reducing emissions from energy use and infrastructure; (2) reducing emissions from energy supply; (3) capturing and sequestering carbon dioxide; (4) reducing emissions of other greenhouse gases; (5) measuring and monitoring emissions; and (6) bolstering the contributions of basic science to climate change. The Plan outlines approaches toward attaining these goals, articulates underlying technology development strategies, and identifies a series of next steps toward implementation. To read press release, see: http://www.climatetechnology.gov/library/2006/pr20sep2006.pdf. To download the report, see: http://www.climatetechnology.gov/stratplan/final/index.htm.

"Energy and Economic Impacts of H.R.5049, the Keep America Competitive Global Warming Policy Act." The Energy Information Administration (EIA), an independent statistical and analytical agency in the US Department of Energy, released this study on September 5, 2006. This report responds to a May 2, 2006 request from Congressmen Tom Udall and Tom Petri asking EIA to analyze the impacts of their legislation implementing a market-based allowance program to cap greenhouse gas emissions at 2009 levels. The legislation, introduced March 29, 2006, limits the potential economic impact through the sale of additional allowances at a safety-valve price, an allowance allocation program, and allowance credits for carbon sequestration projects. The HTML/PDF formats of this report can be viewed at: http://www.eia.doe.gov/oiaf/servicerpt/economicimpacts/index.html, and http://www.eia.doe.gov/oiaf/servicerpt/economicimpacts/pdf/sroiaf2006(03).pdf.

"Carbon Disclosure Project Report 2006 Global FT500." The Carbon Disclosure Project (CDP) has released its CDP4 report. On behalf of its 225 signatory investors, CDP requested information on corporate risks and opportunities associated with climate change from more than 2,000 companies globally, including the world's 500 largest publicly-owned companies (FT500). The institutional investors represented by CDP will receive the companies' answers and CDP's fourth annual report (CDP4) on the FT500 companies' responses written by consultancy Innovest. The $31.5 trillion in assets behind CDP4 represents an increase of over $10 trillion (50 percent) from the $21 trillion behind CDP3 in 2005. The Carbon Disclosure Project (CDP) provides a secretariat for the world's largest institutional investor collaboration on the business implications of climate change. CDP represents an efficient process whereby many institutional investors collectively sign a single global request for disclosure of information on Greenhouse Gas Emissions. CDP has historically sent this request to the FT500 largest companies in the world. However, in 2006 they have expanded their reach to 2180 companies, with over 950 responding with an answered questionnaire. To view a press release regarding the report, see: http://www.cdproject.net/viewrelease.asp?id=8. To download the full CDP4 report as a pdf, go to: http://www.cdproject.net/download.asp?file=cdp4_report.pdf, or http://www.cdproject.net/download.asp?file=CDP4_FT500_Summary_Report.pdf for a summary of the report.

"Climate Change Action Plan, August 2006." The Action Plan is the product of more than a year's effort by the 35-member Climate Change Advisory Group (CCAG) and its five Technical Working Groups (TWGs). The full CCAG met six times between July 2005 and June 2006, and the TWGs met a total of 40 times via teleconference during this time. The Action Plan contains a comprehensive set of 49 recommendations for addressing and reducing greenhouse gas (GHG) emissions in Arizona. Of the 49 policy recommendations adopted by the CCAG, 45 received unanimous consent, two received a

supermajority of support and two received a majority of support. Pursuant to Executive Order 2005-02, the CCAG prepared an inventory and forecast of GHG emissions in Arizona, which found that between 1990 and 2005, Arizona's net GHG emissions increased by nearly 56 percent. Arizona's GHG emissions are projected to increase by 148 percent from 1990 to 2020. As the Action Plan states, "While Arizona's high emissions growth rate presents challenges, it also provides major opportunities. Because more than three-fourths of Arizona's GHG emissions are directly related to energy and transportation, the opportunity exists for Arizona to reduce its GHG emissions while continuing its strong economic growth by being more energy efficient, using more renewable energy sources, building new infrastructure "right" in the first place to produce lower emissions and increasing the use of cleaner transportation modes, technologies and fuels." http://www.azgovernor.gov/dms/upload/Climate_Change_Action_Plan_final-web.pdf.

"Evaluating the Role of Prices and R&D in Reducing Carbon Dioxide Emissions, September 2006." This report released by the Congressional Budget Office outlines concepts to address climate change through a combination of regulation and a long-term scientific investment plan. The report discusses policies for reducing carbon dioxide emissions including emissions taxes and cap and trade policies, and whether emission taxes would spur research and development of new technologies. Costs and benefits of research and development (R&D) are covered, as are current policies that support R&D. The effectiveness of policy approaches is also reviewed. http://www.cbo.gov/ftpdocs/75xx/doc7567/09-18-CarbonEmissions.pdf.

November 2006

"International Carbon Capture and Storage Projects Overcoming Legal Barriers." To assist in the development of a regulatory framework for carbon capture and storage (CCS) projects, an understanding of current practices is important. This paper therefore examines regulatory developments of major CCS projects to determine actual progress in regulating such projects. In particular, we look at five case studies of CCS projects that range from enhanced resource recovery to direct storage and which have been developed for a mix of purposes, such as commercial, research and development, and pilot demonstrations. These case studies indicate that regulatory progress varies greatly among projects, and differs depending on the size, scope, and the location of the projects. The focus of this report is the legal and regulatory context for international projects, but it should be recognized that CCS field projects in the United States are also addressing many of the regulatory issues related to CCS. **NETL contact: Sarah Forbes; Authors: Kate Robertson, Jette Findsen, Steve Messner.** DOE/NETL-2006/1236. http://www.netl.doe.gov/energy-analyses/pubs/CCSregulatorypaperFinalReport.pdf.

"Agricultural & Forestlands: U.S. Carbon Policy Strategies." This report examines the wide array of ways in which forest and agricultural lands can be managed to store or "sequester" carbon and reduce net emissions (hereafter the authors use the term "sequestration" for the process by which carbon is removed from the atmosphere by plants and stored in soils and trees). It discusses a range of policies and programs that would promote this objective and evaluates them in terms of their cost, environmental effectiveness, and other considerations. The results of this analysis suggest that, by carefully designing and implementing a large-scale forest and agricultural carbon sequestration strategy, the United States could substantially reduce its net carbon dioxide emissions. A successful strategy is likely to encompass a variety of initiatives at the national, state, and local levels, and to involve both government and private parties. **Kenneth R. Richards, R. Neil Sampson, Sandra Brown.** Prepared for the Pew Center on Global Climate Change, September 2006. September 21, 2006, http://www.pewclimate.org/global-warming-in-depth/all_reports/ag_forestlands/index.cfm.

"Agriculture's Role in Greenhouse Gas Mitigation." In this report, the authors make the case for "suitable payments" to encourage farmers to adopt new management practices to store carbon in agricultural soils and reduce agricultural emissions of methane and nitrous oxide. Policy incentives also

are needed, the authors say, to reduce costs of producing biofuels and accelerate key technologies. The report notes that climate mitigation could potentially become a source of new income and cost reductions for farmers. However, access to financing, changes in economic conditions and technologies, and policies will be key factors that will affect farmers' willingness to play a part in climate solutions. **Keith Paustian, John M. Antle, John Sheehan, Eldor A. Paul.** Prepared for the Pew Center on Global Climate Change, September 2006, September 21, 2006, http://www.pewclimate.org/global-warming-in-depth/all_reports/agriculture_s_role_mitigation/index.cfm.

"The World in 2050: Implications of global growth for carbon emissions and climate change policy." PricewaterhouseCoopers (PwC) released a report which considers six possible carbon emissions and climate change policy scenarios but focuses most attention on two key possibilities: 1.) A baseline scenario in which energy efficiency improves in line with trends of the past 25 years, with no change in fuel mix by country; this 'business as usual' scenario acts as a benchmark against which to assess the need for change, rather than as a forecast of the most likely outcome; and 2.) A scenario called 'Green Growth + CCS,' which incorporates possible emission reductions due to a greener fuel mix, annual energy efficiency gains over and above the historic trend, and widespread use of carbon capture and storage (CCS) technologies. Of the scenarios considered in the report, only this 'Green Growth Plus' strategy stabilizes atmospheric carbon dioxide concentrations by 2050 at what the current scientific consensus suggests would be broadly acceptable levels. The G7 economies — the US, Japan, Germany, UK, France, Italy and Canada — may need to take the lead in reducing their carbon emissions, given that emissions from the faster-growing emerging economies, such as China and India, will almost certainly continue to rise over the next few decades. **John Hawksworth, Head of Macroeconomics,** September 2006, http://www.pwcglobal.com/extweb/pwcpublications.nsf/docid/DFB54C8AAD6742DB852571F5006DD532.

"Global Framework for Climate Risk Disclosure," and "Guide to Using the Global Framework for Climate Risk Disclosure." A unique global partnership of 14 leading institutional investors and other organizations representing trillions in assets released the Global Framework for Climate Risk Disclosure to provide specific guidance to companies regarding the information they provide to investors on the financial risks posed by climate change. Also included is a companion tool for using the Framework. For each of the four elements of the Framework, the Guide provides specific guidance for companies about how to disclose using the most common reporting mechanisms for climate risk: securities filings, the Global Reporting Initiative, and the Carbon Disclosure Project. The Guide also contains examples of disclosure from leading companies using these disclosure mechanisms. See the website to download both pdf files of the reports and to see the list of organizations that comprise the partnership. October 2006, http://www.ceres.org/pub/publication.php?pid=225.

December 2006

"GHG Data Highlights from Greenhouse Gas (GHG) Emissions Data for 1990-2004 for Annex I Parties." Every year, Parties included in the Annex I to the United Nations Framework Convention on Climate Change (UNFCCC), which are often called Annex I Parties or "industrialized countries", submit their greenhouse gas (GHG) emissions data to the UNFCCC secretariat, which then publishes an annual report on the latest available data on GHG emissions from the Annex I Parties. This report presents some findings on the data reported in 2006, both Annex I Parties and for those Annex I Parties that are Parties to the Kyoto Protocol. One key finding is that for all Annex I Parties taken together, GHG emissions in 2004 were 3.3 percent below the 1990 level. The overall decrease is composed of 36.8 percent decrease for Parties with economies in transition (EITs) and an 11.0 percent increase for non-EIT Parties. In 22 Annex Parties GHG emissions decreased from 1990 to 2004 whereas in 19 Parties the emissions increased. In general, the message from the 2006 data is that industrialized countries will need to intensify their efforts to reduce greenhouse gas emissions. Transport remains a sector where emissions reductions are needed but seem to be especially difficult to achieve. But the challenge is well

understood, and the Kyoto Protocol, which is now firmly in place, is guiding Annex I Parties in identifying and implementing policy option, including the flexibility mechanisms, for meeting their targets under the Protocol. To access the document directly go to: http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/ghg_booklet_06.pdf. To access a table of "Changes in GHG emissions from 1990 to 2004 for Annex I Parties," go to: http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/ghg_table_06.pdf.

State and Trends of the Carbon Market 2006: Update: January 1 – September 30, 2006. This report by the World Bank and International Emissions Trading Association was released in October 2006. It states that the carbon market grew in value to an estimated $21.5 billion in the first three quarters of the year, more than doubling in value over the previous year. The market was dominated by the European Union Emissions Trading Scheme (EU ETS), which shrugged off signs of weakness following the sharp declines that accompanied the release of verified emissions data in May 2006. The project-based market also grew in value to $2.41 billion in just the first nine months of the year. The volume of European Union Allowances (EUAs) transacted on major exchanges and over-the counter rose to 764 million tons of carbon dioxide equivalent (tCO2e) by the end of September 2006 compared to approximately 324 million tCO2e in 2005. EUAs traded at a market value of $18.9 billion so far in 2006, more than twice the previous year's $8.2 billion. The Chicago Climate Exchange (CCX), the New South Wales Greenhouse Gas Abatement Scheme (NSW) and the United Kingdom Emissions Trading Scheme (UK ETS) all grew sharply, as did the trendy but non-standardized retail carbon market. Developing countries supplied 214 million tCO2e of primary project-based credits or 21 percent of total volumes traded for a total market value of $2.3 billion. China continued to have a dominant market-share of the Clean Development Mechanism (CDM) with 60 percent and exerted its market power to try and influence prices of Certified Emission Reductions (CERs), while Ukraine supplied one third of Joint Implementation (JI) volumes. CERs and Emission Reduction Units (ERUs) transacted at average prices of $10.50 and about $8 respectively across a range of prices varying with the terms of the contracts entered into. Buyers found it easier to close transactions than six months ago, while sellers managed carbon price risk by favoring fixed price forward contracts. **(Also see Trading section of this Newsletter for the news item "Market for CO_2 credits reaches $22B.")** View the report online at: http://carbonfinance.org/docs/StateandTrendsMarketUpdateJan1_Sept30_2006.pdf.

"Powering a Sustainable Future." World Business Council for Sustainable Development (WBCSD), along with eight of the world's leading electric utility companies, released this report which contains an "agenda for concerted action" to secure future electricity generation, to bring more power to more people and to decrease the industry's greenhouse gas emissions. The eight companies warn that unless there is a marked shift in the way electricity is generated and regulated worldwide, increased energy production will have serious environmental impacts. The group also urges that business and government alike need to reverse the trend of declining resources for energy research and development, to make sure that carbon capture and storage, among other technologies, will be ready for deployment in time. October 24, 2006, http://www.wbcsd.org/Plugins/DocSearch/details.asp?DocTypeId=33&ObjectId=MjEyMzE.

"Climate Change 101." In an effort to enhance the quality of the climate dialogue, The Pew Center on Global Climate Change and the Pew Center on the States have developed a series of brief reports entitled Climate Change 101: Understanding and Responding to Global Climate Change. These brief reports are meant to provide a reliable and understandable introduction to climate science and impacts, technological solutions, and recent action in the US. Report subtopics include Science and Impacts, Technological Solutions and State Actions. Download pdfs of the report at: http://www.pewclimate.org/global-warming-basics/climate_change_101/index.cfm.

"At loggerheads? Agricultural expansion, poverty reduction, and environment in the tropical forests." The World Bank's report states that a system of international payments – "forest carbon finance" can be an incentive to stop deforestation and in turn slow global warming. According to the

report, a majority of people in rural tropical areas — about 800 million — live in or around vulnerable forests or woodlands, depending on them heavily for survival. Yet deforestation at five percent a decade is steadily depleting this resource base, contributing to 20 percent of annual global CO_2 emissions and seriously threatening biodiversity. The report argues that with stronger financial incentives for avoiding cutting down trees, poor farmers in Madagascar and other forest countries could invest in sustainable agriculture in already-cleared fields, rather than cutting down more forest for paltry and often temporary gains. But current carbon markets do not tap the potential benefits of forest carbon. The report reviews the obstacles impeding the use of global carbon finance to reduce deforestation, and offers workable solutions. The report offers a simple framework for policy analysis by identifying three forest types-frontiers and disputed lands, lands beyond the agricultural frontier, and mosaiclands where forests and agriculture coexist. It collates geographic and economic information for each type that will help formulate poverty-reducing forest policy. The report highlights distinct priorities for each forest type, where deforestation incentives, remoteness, forest rights, and environment interact differently. The report and associated materials are available at: http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTPRRS/EXTTROPICALFOREST/0,,menuPK:2463898~pagePK:64168092~piPK:64168088~theSitePK:2463874,00.html.

January 2007

"Emissions of Greenhouse Gases in the United States 2005." This report, in accordance with Section 1605(a) of the Energy Policy Act of 1992, provides estimates of US emissions of greenhouse gases. US emissions of greenhouse gases in 2005 totaled 7,147.2 million metric tons carbon dioxide equivalent ($MMTCO_2e$), 0.6 percent more than in 2004 (7,104.6$MMTCO_2e$). The modest increase in total greenhouse gas emissions in 2005 is attributable mainly to below-average growth in emissions of carbon dioxide (0.3 percent). There were larger increases in emissions of nitrous oxide (1.9 percent) and methane (0.9 percent), but collectively these two gases make up only about 14 percent of total US greenhouse gas emissions. Emissions of high-GWP gases—hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6)—increased by 7.2 percent, but their share of the total is only 2.2 percent. The US economy grew by 3.2 percent in 2005. Consequently, US greenhouse gas intensity (greenhouse gas emissions per unit of real economic output) was 2.5 percent lower in 2005 than in 2004. From 1990 to 2005, US greenhouse gas intensity declined by 25 percent, or by an average of 1.9 percent per year. US greenhouse gas emissions in 2005 were 17 percent higher than the 1990 emissions level of 6,112.8 $MMTCO_2e$—an average annual increase of 1.0 percent over the period. Since 1990, US emissions have increased more slowly than the average annual growth in population (1.2 percent), primary energy consumption (1.1 percent), electric power generation (1.9 percent), or gross domestic product (3.0 percent). While the annual growth rate in carbon dioxide emissions since 1990 (1.2 percent) has closely tracked annual growth in population and energy consumption, the average annual rate of growth in total greenhouse gas emissions has been lower (1.0 percent) because of reductions in methane emissions and relatively slow annual growth in nitrous oxide emissions (0.6 percent) since 1990. The pdf of the full report and the most recent full documentation for the data and methods used to calculate the emissions estimates are available at: http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html.

Global Warming in the Courts: An Overview of Current Litigation and Common Legal Issues. This report, presented by Georgetown Environmental Law and Policy Institute, Georgetown University Law Center, provides an overview of global warming litigation, discussing the question of the judiciary's proper role in addressing this issue, identifying the cross-cutting legal topics raised by the pending litigation, and describing the specific cases before the Supreme Court and lower courts across the country. On November 29, 2006, the US Supreme Court will hear oral argument in *Massachusetts v. EPA*, addressing, for the first time, one of the most pressing and controversial environmental issues of our time — global warming. While undoubtedly important, the Massachusetts case is only the most visible in a large and growing group of lawsuits in the state and federal courts dealing with global

warming.
http://www.law.georgetown.edu/gelpi/current_research/documents/GlobalWarmingLit_CourtsReport.pdf

February 2007

"Sustainable Power Generation from Fossil Fuels: Aiming for Near-Zero Emissions from Coal After 2020." Coal and gas account for over 50 percent of the EU's electricity supply and will remain an important part of their energy mix in the future. On the international level, it is expected that twice as much electricity as today will be produced from coal by 2030. However, increasing concern over the effects of climate change means that Europe has to take the lead in undertaking serious measures to ensure that they reduce carbon emissions from coal and work on developing cleaner coal technologies. On January 10, 2007 the European Commission therefore adopted an Energy Package for Europe, which included a Communication on the sustainable use of fossil fuels in electricity generation. The Communication sets out the policy guidelines and the conditions for a continued and sustainable use of fossil fuels, in particular of coal, as primary energy sources in the power generation sector. To read the complete Communication from the Commission to the Council and the European Parliament see: http://ec.europa.eu/energy/energy_policy/doc/16_communication_fossil_fuels_en.pdf.
To view the memo regarding this report, see: http://ec.europa.eu/energy/energy_policy/doc/16_fossil_fuels_%20memo_en.pdf.

"Trends in Public Attitudes on Global Warming," Stephen Ansolabehere, Thomas E. Curry, Howard Herzog, MIT, October 2006. Any attempt by industry or governments to address greenhouse gas emissions and global warming will require wide public understanding or recognition of this problem and willingness to bear the costs of remedies. With that end in mind, MIT has instituted a cross-national survey research program aimed at tracking public understanding of this problem and support for and opposition to policies that may be required in order to lessen emissions. The first of these surveys was conducted in 2003 in the United States. It showed a relatively low level of public recognition of the problem and willingness to bear costs of a remedy. That survey was replicated in the United Kingdom, Sweden, and Japan. Across all four nations varying degrees of acceptance of the problem and varying beliefs about what national government should do were found. Researchers did find a unified response in one critical aspect – willingness to pay. In no country was the median person willing to pay 10 percent more per month on electricity bills in order to lower carbon emissions. That was 2003. The first effort to track changes in public attitudes came in 2006. Researchers replicated the 2003 survey in October 2006 using the same survey design and same questionnaire that they administered three years prior. Little has changed in public policies concerning global warming. However, there has been considerable public discussion in the United States of this problem. Findings from this survey offer the first evidence from any survey organization that there has been a real change in public attitudes on this issue. Because researchers used the same survey design and questionnaire, they were able to compare directly the public attitudes today with those just three years ago. Americans' attitudes have changed in two key respects. A sizable majority now recognizes global warming as a problem, and the salience of that problem has grown. And, perhaps more importantly, the willingness to pay for remedies has risen 50 percent. To access the MIT survey data, go to: http://www.eenews.net/features/documents/2006/12/05/document_pm_01.pdf, and to read MIT's full analysis of the survey, see: http://www.eenews.net/features/documents/2006/12/05/document_pm_02.pdf.

March 2007

"President Bush Plans to Strengthen America's Energy Security." The White House Office of Communications has released a fact sheet as a companion document to President Bush's 2007 State of the Union Address. The document outlines the President's "Twenty in Ten" initiative, whose goal is to reduce US gasoline usage by 20 percent in the next ten years. The report states that the President's plan

will help confront climate change by stopping the projected growth of carbon dioxide emissions from cars, light trucks and SUVs within ten years. By 2017, the renewable fuel and fuel efficiency components of the plan would cut annual emissions from cars and light trucks by as much as ten percent, about 175 million metric tons—equal to zeroing out the annual emissions of 26 million automobiles. The plan could cumulatively prevent the buildup of more than 600 million metric tons of carbon dioxide emissions. The President has set a target of cutting our greenhouse gas intensity by 18 percent through the year 2012 and his budgets have devoted nearly $29 billion to climate-related science, technology, international assistance, and incentive programs. January 23, 2007. To view the complete document, go to: http://usinfo.state.gov/xarchives/display.html?p=washfile-english&y=2007&m=January&x=20070123170347eaifas0.7542993. To read the State of the Union address in its entirety or to view a video webcast of the speech, go to: http://www.whitehouse.gov/news/releases/2007/01/20070123-2.html#.

Tackling Climate Change in the U.S., Potential Carbon Emissions Reductions from Energy Efficiency and Renewable Energy by 2030, American Solar Energy Society, Charles F. Kutscher, Ph.D., P.E., Editor, January 2007. For SOLAR 2006, the 35th Annual National Solar Energy Conference last July, the American Solar Energy Society (ASES) chose to address global warming. Under the theme "Renewable Energy: Key to Climate Recovery," climate experts James Hansen of the National Aeronautics and Space Administration (NASA), Warren Washington of the National Center for Atmospheric Research (NCAR), Robert Socolow of Princeton University, and Marty Hoffert of New York University (NYU) described the magnitude of the global warming crisis and what is needed to address it. A key feature of the conference was a special track of nine invited presentations by experts in energy efficiency and renewable energy that detailed the potential for these technologies—in an aggressive but achievable climate-driven scenario—to address the needed US carbon emissions reductions by the years 2015 and 2030. These presentations covered energy efficiency in buildings, industry, and transportation, as well as the following renewable technologies: concentrating solar power, photovoltaics, wind, biomass, biofuels, and geothermal. Since the conference, these studies were subjected to additional review and were revised for publication in this special ASES report. Also included are sections on Carbon Capture and Storage and Carbon Sequestration in Soils. To download the report as a pdf file, see: http://www.ases.org/climatechange/climate_change.pdf.

"A Call for Action: Consensus Principles and Recommendations from the U.S. Climate Action Partnership: A Business and NGO Partnership." A diverse group of US-based businesses and leading environmental organizations today called on the federal government to quickly enact strong national legislation to achieve significant reductions of greenhouse gas emissions. The group said any delay in action to control emissions increases the risk of unavoidable consequences that could necessitate even steeper reductions in the future. This alliance, called the US Climate Action Partnership (US-CAP), consists of companies Alcoa, BP America, Caterpillar, Duke Energy, DuPont, FPL Group, General Electric, Lehman Brothers, PG&E, and PNM Resources, along with four non-governmental organizations – Environmental Defense, Natural Resources Defense Council, Pew Center on Global Climate Change, and World Resources Institute. At a news conference January 22 at the National Press Club, US-CAP issued a landmark set of principles and recommendations to underscore the need for a policy framework on climate change. The report includes recommendations for carbon capture and storage. The solutions-based report, titled *A Call for Action*, lays out a blueprint for a mandatory economy-wide, market-driven approach to climate protection. **(See Legislative Activity section of this newsletter for more information.)** Read the report at: http://www.us-cap.org/ClimateReport.pdf. Read a related press release at: http://www.us-cap.org/media/release.pdf.

April 2007

"The Future of Coal – Living in a Carbon Constrained World." An interdisciplinary Massachusetts Institute of Technology (MIT) faculty group examined the role of coal in a world where constraints on carbon dioxide emissions are adopted to mitigate global climate change. This follows "The Future of

Nuclear Power" which focused on carbon dioxide emissions-free electricity generation from nuclear energy and was published in 2003. This report, the future of coal in a carbon-constrained world, evaluates the technologies and costs associated with the generation of electricity from coal along with those associated with the capture and sequestration of the carbon dioxide produced coal-based power generation. Growing electricity demand in the US and in the world will require increases in all generation options (renewables, coal, and nuclear) in addition to increased efficiency and conservation in its use. Coal will continue to play a significant role in power generation and as such carbon dioxide management will become increasingly important. This study, addressed to government, industry and academic leaders, discusses the interrelated technical, economic, environmental and political challenges facing increased coal-based power generation while managing carbon dioxide emissions from this sector. The full report, which was released on March 14, 2007, can be accessed by going to: http://web.mit.edu/coal/. To listen to a related story on National Public Radio's *Morning Edition,* **"**Scientists Hunt for Solution to Carbon Dioxide Problem," go to: http://www.npr.org/templates/story/story.php?storyId=7874053. This feature includes comments by Sean Plasynski, sequestration technology manager at the Department of Energy's National Energy Technology Laboratory.

"Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable." For this report, the Scientific Expert Group on Climate Change and Sustainable Development (SEG) was asked to consider innovative approaches for mitigating and/or adapting to projected climate changes and to anticipate the effectiveness, cost, and implementation of possible response measures. After addressing the comments made during a wide-reaching review process and carefully considering the actions that are needed to stem the tide of climate change, the SEG prepared this final report conveying its findings and recommendations. The authors believe that these recommendations are consistent with the findings of the Intergovernmental Panel on Climate Change and will be broadly endorsed by the expert community, which agrees that both near- and long-term efforts to mitigate and adapt to climate change need to be intensified, while at the same time strengthening efforts to promote equitable and sustainable economic development. In this report, Chapter 1 summarizes the key aspects of the science of climate change and associated environmental and societal impacts. Chapter 2 provides a review of the technological options for slowing climate change by limiting emissions of greenhouse gases. In this light, several recommendations are made to fulfill the objective set forth in the 1992 United Nations Framework Convention on Climate Change. Chapter 3 offers guidance on making society less vulnerable and even more resilient to the changing climate. These chapters make clear that it is critical to begin both mitigation and adaptation, focusing in early efforts on steps that offer cost-effective opportunities and ways to reduce pollution and other maladaptations to the current climate, while establishing the rules and incentives to spur long-term investment and change through a portfolio of approaches. The pdf of the full report, which was published in February 2007, can be accessed at: http://www.unfoundation.org/files/pdf/2007/SEG_Report.pdf.

"The association between climatic factors and childhood illnesses presented to hospital emergency among young children." This study has examined the relationship between climatic factors and common childhood illnesses among young children presented to an emergency department. To the knowledge of the author, this is one of very few studies that have investigated this specific topic of environmental child health. The results suggest that climatic factors are influential to the physical health of young children. The maximum daily temperature has been shown to be a significant risk factor for common childhood illnesses. It is positively and significantly associated with emergency presentations of fever and gastroenteritis among children younger than 6 years old. On the other hand, the UV index is negatively related to gastroenteritis only. None of the climatic variables are found to be associated with emergency presentations due to respiratory problems. These results on childhood morbidity, on the whole, are consistent with that obtained from previous studies on adults' mortality and all-ages morbidity and mortality studies by Semenza et al (1996, 1999). A detrimental effect of climatic variation, particularly temperature changes, on physical health among children has been suggested from these results. **(See Science section of this newsletter, "Heating Planet 'Makes Children Sick'," for an article pertaining to the study.) Lawrence T. Lam**, *International Journal of Environmental Health Research*,

Volume 17, Issue 1, February 2007, Pages 1-8. http://www.informaworld.com/smpp/content?content=10.1080/09603120601124264. (Subscription required.)

May 2007

"Carbon Sequestration Atlas of the United States and Canada." The US Department of Energy's (DOE) National Energy Technology Laboratory (NETL) is proud to release the first "Carbon Sequestration Atlas of the United States and Canada." Production of this Atlas is the result of cooperation and coordination among carbon sequestration experts from local, state, and government agencies, as well as industry and academia. This Atlas presents the first coordinated assessment of carbon capture and storage (CCS) potential across the majority of the US and portions of western Canada. The Atlas also provides an introduction to the carbon storage (sequestration) process, summarizes the DOE's Carbon Sequestration Program, and gives information about the CCS contributions from each Regional Carbon Sequestration Partnership (RCSP) to date. One of the key questions concerning CCS is: how much potential is there to effectively help address global climate change? As shown in this Atlas, CCS holds great promise as part of a portfolio of technologies that enables the US and the rest of the world to address climate change while meeting the energy demands of an ever increasing global population. The Atlas includes the most current and best available estimates of potential carbon dioxide (CO_2) sequestration capacities determined by a methodology applied consistently across all of the RCSPs. All data were collected before December 2006. "The Carbon Sequestration Atlas of the United States and Canada" contains three main sections: (1) Introduction, (2) National Perspectives, and (3) Regional Perspectives. The Introduction section contains an overview of CCS technologies, a summary of the DOE's efforts in the CCS area, a brief description of the RCSP Program, and information on the National Carbon Sequestration Database and Geographic Information System (NATCARB). The National Perspectives section provides maps showing the number, location, and magnitude of all CO_2 sources in the US and portions of Canada, as well as the areal extent and capacity of geologic CO_2 sequestration sites evaluated within the RCSP Regions. The National Perspectives section also contains a summary of the methodologies and assumptions employed to calculate the estimated CO_2 sequestration capacities of various geologic formations. (Appendix A contains the complete "Methodology for Development of Carbon Sequestration Capacity Estimates" document.) The Regional Perspectives section includes a detailed presentation of CO_2 sequestration capacity assessments for each RCSP based on these methodologies and assumptions. **(See article in this month's Highlights section, "DOE Regional Partnerships Find More Than 3,500 Billion Tons of Possible Carbon Dioxide Storage Capacity," and News section for the article, "US Sees Ample Room to Bury Carbon Dioxide but Costs Unknown," which reference the Atlas.)** To download the Atlas or sections of the Atlas see: http://www.netl.doe.gov/publications/carbon_seq/atlas/index.html.

Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, "Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability." This Summary sets out the key policy-relevant findings of the Fourth Assessment of Working Group II of the Intergovernmental Panel on Climate Change (IPCC). The Assessment is of current scientific understanding of impacts of climate change on natural**,** managed and human systems, the capacity of these systems to adapt and their vulnerability. It builds upon past IPCC assessments and incorporates new knowledge gained since the Third Assessment. To download the Summary for Policymakers which was released on April 6, 2007 in Brussels, go to: http://www.ipcc.ch/SPM6avr07.pdf. To listen to the audio webcast of the press conference in Brussels, go to: http://scic.cec.eu.int/streaming/archives/ipcc2007/audio.asx. **(See article entitled, "Panel: Global Warming a Threat to Earth," in the Science section of this newsletter, which references this report.)**

"Scotland's Climate Change Programme: Annual Report 2007." "Scotland's Climate Change Programme, Changing our Ways," sets out how the Scottish Executive is responding to the urgent social,

economic and environmental challenge of climate change. It quantifies Scotland's equitable contribution to UK climate change commitments in carbon terms – the Scottish Share - and has set an ambitious Target to exceed this by one million tons of carbon savings in 2010. The Programme sets out actions to reduce all greenhouse gases but most measures focus upon carbon dioxide which makes up the greatest proportion of greenhouse gases. The Scottish Share and Target are therefore expressed in terms of tons of carbon. Scotland's Climate Change Programme is work in progress towards a goal in 2010 and this is the first in a series of annual reports. "Scotland's Climate Change Programme, Changing our Ways" can be found online at: http://www.scotland.gov.uk/Publications/2006/03/30091039/0. The pdf of the subject annual report, which was laid before the Scottish Parliament by the Scottish Ministers in March 2007 can be found at: http://www.scotland.gov.uk/Resource/Doc/169305/0047159.pdf.

June 2007

"Carbon Sequestration Technology Roadmap and Program Plan 2007." This document describes the Technology Roadmap and Program Plan that will guide the Carbon Sequestration Program in 2007 and beyond. An overview of the Program and the key accomplishments in its 10-year history are presented as well as the challenges confronting deployment and successful commercialization of carbon sequestration technologies. The research pathways that will be used to achieve Program goals and information on key contacts and web links related to the Program are included. This document is intended to be a valuable tool in engaging interested stakeholders. **(See article in this month's Highlights section, "DOE Releases 2007 Carbon Sequestration Technology Roadmap, Marks Tenth Year of Carbon Sequestration Program," which references the release of the Roadmap.)** To download the 2007 Carbon Sequestration Roadmap, go to: http://www.netl.doe.gov/publications/carbon_seq/project%20portfolio/2007/2007Roadmap.pdf.

Working Group III Contribution to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, "Mitigation of Climate Change." The Working Group III contribution to the IPCC Fourth Assessment Report (AR4) focuses on new literature on the scientific, technological, environmental, economic and social aspects of mitigation of climate change, published since the IPCC Third Assessment Report (TAR) and the Special Reports on CO_2 Capture and Storage (SRCCS) and on Safeguarding the Ozone Layer and the Global Climate System (SROC). The summary is organized into five sections: Greenhouse gas (GHG) emission trends; Mitigation in the short and medium term, across different economic sectors (until 2030); Mitigation in the long-term (beyond 2030); Policies, measures and instruments to mitigate climate change; and, Sustainable development and climate change mitigation. To download the Summary for Policymakers which was released on May 4 in Bangkok, Thailand, go to: http://www.ipcc.ch/SPM040507.pdf. To watch a video webcast of the press conference in Bangkok, go to: http://ipcc.bravehost.com/. **(See article entitled, "Climate Panel Reaches Consensus on the Need to Reduce Harmful Emissions," in the Science section of this newsletter, which references this report.)**

"Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005." An emissions inventory that identifies and quantifies a country's primary anthropogenic sources and sinks of greenhouse gases is essential for addressing climate change. This inventory adheres to both 1) a comprehensive and detailed set of methodologies for estimating sources and sinks of anthropogenic greenhouse gases, and 2) a common and consistent mechanism that enables Parties to the United Nations Framework Convention on Climate Change (UNFCCC) to compare the relative contribution of different emission sources and greenhouse gases to climate change. In 1992, the United States signed and ratified the UNFCCC. As stated in Article 2 of the UNFCCC, "The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to

ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." Parties to the Convention, by ratifying, "shall develop, periodically update, publish and make available…national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the "Montreal Protocol," using comparable methodologies…"3 The United States views this report as an opportunity to fulfill these commitments. The pdf of the full report, which was published in April 2007, can be accessed by going to: http://epa.gov/climatechange/emissions/downloads06/07CR.pdf.

"U.S. Climate Change Science Program Synthesis and Assessment Product 2.2, The First State of the Carbon Cycle Report (SOCCR): The North American Carbon Budget and Implications for the Global Carbon Cycle." A primary objective of the US Climate Change Science Program (CCSP) is to provide the best possible scientific information to support public discussion, as well as government and private sector decision-making, on key climate-related issues. To help meet this objective, the CCSP has identified an initial set of 21 Synthesis and Assessment Products that address its highest priority research, observation, and decision-support needs. This Report—CCSP Synthesis and Assessment Product (SAP) 2.2—addresses Goal 2 of the CCSP Strategic Plan: Improve quantification of the forces bringing about changes in the Earth's climate and related systems. The report provides a synthesis and integration of the current knowledge of the North American carbon budget and its context within the global carbon cycle. In a format useful to decision makers, it (1) summarizes [the authors'] knowledge of carbon cycle properties and changes relevant to the contributions of and impacts upon North America and the rest of the world, and (2) provides scientific information for decision support focused on key issues for carbon management and policy. Consequently, this Report is aimed at both the decision-maker audience and to the expert scientific and stakeholder communities. The pdf of the March 2007 (Draft subsequent from National Oceanic and Atmospheric Administration review) version can be found on the SOCCR website at: http://cdiac.ornl.gov/SOCCR/pdf/SAP2.2_Entire_Report_March2007.pdf.

July 2007

"Draft Environmental Impact Statement of FutureGen Project." The Draft Environmental Impact Statement (EIS) for the FutureGen Project provides information about the potential environmental impacts of [DOE's] proposal to provide federal funding to the FutureGen Alliance, Inc. (Alliance) for the FutureGen Project. In a March 2004 Report to Congress, DOE estimated the cost of the project at $950 million in constant 2004 dollars shared at a 74/26 ratio by DOE and the Alliance. Accounting for escalation, based on representative industry indices, the project is currently estimated to cost $1,757,232,310 in as-spent dollars. Including $300,800,000 in expected revenues from the sale of electricity, which would be used to offset operational costs and research and development expenses, the total net project cost is estimated to be $1,456,432,310 in as-spent dollars. DOE will share approximately 74 percent of the net cost (estimated at $1,077,760,230), which includes at least $80 million in projected contributions from foreign governments. The Alliance will share approximately 26 percent of the net cost (estimated at $378,672,080). The cost estimate will be updated as work progresses. The Alliance is a non-profit industrial consortium led by the coal-fueled electric power industry and the coal production industry. The FutureGen Project would include the planning, design, construction, and operation by the Alliance of a coal-fueled electric power and hydrogen gas production plant integrated with [CO_2] capture and geologic sequestration of the captured gas. The FutureGen Project would employ integrated gasification combined cycle power plant technology that for the first time would be integrated with CO_2 capture and geologic sequestration. Four sites have been identified as reasonable alternatives and are considered in this EIS: (1) Mattoon, Illinois; (2) Tuscola, Illinois; (3) Jewett, Texas; and (4) Odessa, Texas. DOE determined that the proposed FutureGen Project constitutes a major federal action within the meaning of the National Environmental Policy Act. The *Federal Register* "Notice of Intent to Prepare an Environmental Impact Statement for FutureGen Project" was published on July 28, 2006 (71 FR 42840). DOE held public scoping meetings at Mattoon, Illinois, on August 31, 2006; Tuscola, Illinois, on August 29, 2006; Fairfield, Texas (near Jewett), on August 22, 2006; and Midland, Texas (near Odessa), on August 24, 2006. The Draft EIS provides an evaluation of the environmental consequences that may

result from the Proposed Action at each of the four candidate sites, including potential impacts on air quality; climate and meteorology; geology; physiography and soils; groundwater; surface water; wetlands and floodplains; biological resources; cultural resources; land use; aesthetics; transportation and traffic; noise and vibration; utility systems; materials and waste management; human health, safety, and accidents; community services; socioeconomics; and environmental justice. The Draft EIS also provides an analysis of the No-Action Alternative, under which DOE would not provide financial assistance to the FutureGen Project. A preferred alternative has not been identified. **(See article in this month's Highlights section, "DOE Releases Draft EIS Statement for FutureGen Project," which references the release of the document.)** To download the complete FutureGen EIS which is contained in two volumes, click on: http://www.netl.doe.gov/technologies/coalpower/futuregen/EIS/.

"Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California." The Secretary for Environmental Protection created the Market Advisory Committee, a committee of national and international experts, to develop recommendations concerning the design of a market-based program for reducing California's GHG emissions. The committee was formed according to Executive Order S-20-06 and will formally submit its recommendations to the California Air Resources Board (CARB) by June 30, 2007. The Market Advisory Committee has focused on the design of a mandatory cap-and-trade program for California. The Committee members have experience in the development and implementation of a number of cap-and-trade-type programs, including the European Union's Emissions Trading Scheme, the US Acid Rain Program, the NOx Budget Program, and the Northeast Regional Greenhouse Gas Initiative. This report offers the Committee's judgments as to the best design options for a mandatory GHG cap-and-trade system for California. To read the complete report, go to: http://www.climatechange.ca.gov/events/2007-06-12_mac_meeting/2007-06-01_MAC_DRAFT_REPORT.PDF.

"Pennsylvania Environmental Council releases 'Climate Change Roadmap for Pennsylvania'." In brief, the "Roadmap" presents a "base case" scenario reflecting current policies, Pennsylvania's GHG emissions are projected to grow in the coming years at roughly 10 [percent] per decade. However, Pennsylvania could lower and ultimately reverse this growth if it joins other states in setting goals for reducing GHG emissions, and adopting the necessary supporting policies. The policies should address every sector of the economy: industry, buildings, transportation, agriculture, forestry, etc. The policies should also be designed to achieve multiple goals: lower GHG emissions, energy independence, cleaner air and water for Pennsylvania, economic development and job creation. Estimates of the GHG impacts of these policies indicate that they could support a goal of reducing Pennsylvania's emissions to 25 percent below 2000 levels by the year 2025. To read the complete "Pennsylvania Climate Change Roadmap" report, click on: http://www.pecpa.org/FINAL%20PEC%20Roadmap%20Complete%20Report.pdf.

"Global Energy Technology Strategy Addressing Climate Change: Phase 2 Findings from an International Public-Private Sponsored Research Program." This report is the capstone to nine years of research in two phases of the Global Energy Technology Strategy Program (GTSP). That research was conducted at the Joint Global Change Research Institute and in collaboration with partner research institutions around the world. The first phase of that work began at a time when the importance of a technology strategy in addressing climate change was unappreciated. GTSP Phase 1 made the case that a technology strategy was an important part of a larger strategy to address climate change and needed to be included along with the other major components: climate science research, adaptation to climate change, and emissions mitigation. The second phase of the GTSP recognized that to craft a global energy technology strategy it was important to develop a deeper understanding of potentially important technologies and technology systems, and to embed that knowledge in the context of the larger global energy and economic systems. In Phase 2 [the authors] identified six energy technologies and technology systems with the potential to play a major role in a climate-constrained world: CO_2 capture and storage, biotechnology, hydrogen systems, nuclear energy, other renewable energy, and end-use technologies that might be deployed in buildings, industry and transportation. Knowledge gained

in each area has been integrated into a larger global energy-economy-climate frame. That combination of depth of study and integrated assessment produced a unique strategic perspective and a bounty of fresh insights. In this document, [the authors] have distilled and summarized some of the most salient. To download the pdf file of the full report, published in May 2007, go to: http://www.pnl.gov/gtsp/docs/gtsp_2007_final.pdf. To download the Executive Summary of this report, click on: http://www.pnl.gov/gtsp/docs/gtsp_2007_execsummfinal.pdf.

August 2007

"Legal Aspects of Storing CO_2." In 2004, the International Energy Agency (IEA) Working Party on Fossil Fuel jointly organized a workshop with the Carbon Sequestration Leadership Forum (CSLF) on the legal aspects of CO_2 storage. This workshop, held in Paris, was the first international event to systematically examine the legal issues affecting the storage of CO_2 as a greenhouse gas (GHG) mitigation strategy. The workshop concluded by highlighting the urgent need for appropriate regulatory and legal frameworks to facilitate the successful uptake of CO_2 storage, with a particular emphasis on the need to facilitate large-scale demonstration projects. The subsequent IEA publication, "Legal Aspects of Storing CO_2" (IEA, 2005), provided an overview of the main legal and regulatory issues. The publication noted five important areas that merited further work and analysis. The five areas were: (1) increase the number of CO_2 storage demonstration projects; (2) governments should ensure that there is an appropriate national legal and regulatory framework for storage demonstration projects; (3) Contracting parties to international instruments should take a proactive approach to clarifying the legal status of carbon storage in the marine environment protection instruments; (4) governments should create a level-playing field for CO_2 storage with other climate change mitigation technologies; and (5) increase public awareness and work on gaining public acceptance of CO_2 storage. In October 2006, the IEA and the CSLF revisited these themes at a follow-on workshop, the 2nd IEA Workshop on "Legal Aspects for Storing CO_2" in Paris, France. The second workshop explored the five issue areas in greater detail, asking whether these five areas merited further international attention. Workshop participants also examined additional gaps and barriers to the deployment of CO_2 capture, and identified recommendations to guide further development of appropriate legal and regulatory frameworks. This publication summarizes the discussions and developments related to the IEA/CSLF October 2006 workshop, and reorganizes issue areas to reflect changed priorities. It also includes recommendations for priorities for future work in this critical area. Each chapter is designed to provide an overview of key legal aspects of CO_2 storage, and includes relevant case studies where appropriate. Published by the International Energy Agency, ISBN 978-92-64-03408-2, Copyright 2007, Link unavailable.

"Recommendations for Designing a Greenhouse Gas Cap-and-Trade System for California, Recommendations of the Market Advisory Committee to the California Air Resources Board – Final Report." The California Global Warming Solutions Act of 2006 (Act**)** requires the State of California to dramatically reduce greenhouse gas emissions by 2020. Specifically, this forward-looking statute charges the California Air Resources Board with responsibility for overseeing the development and implementation of a plan that will reduce California's aggregate greenhouse gas emissions to 1990 levels by 2020. This challenging emissions reduction target will need to be achieved during a period of significant population growth and continued expansion of the state's economy. Successfully implementing the Act's requirements will again signal California's leadership in environmental protection and demonstrate that meaningful steps to address climate change are compatible with promoting balanced and sustainable economic growth and development. In support of the Act, Governor Arnold Schwarzenegger directed the Secretary for Environmental Protection to create a Market Advisory Committee (Committee) to advise the Air Resources Board regarding the development of a greenhouse gas-reduction plan for California. The Committee is composed of national and international experts who have backgrounds in economics, environmental policy, regulatory affairs, and energy technologies. The Act recognizes that a market-based system can be used in conjunction with regulatory and other strategies to meet an economy-wide emissions reduction target. Therefore, the Secretary for

Environmental Protection charged the Market Advisory Committee with providing recommendations to the Air Resources Board regarding the design of an appropriate cap-and-trade program for reducing the state's greenhouse gas emissions. The objective of the Committee was to design a cap-and-trade program to achieve cost-effective emissions reductions within and across all sectors of the State's economy. To achieve this objective, the Committee used a systems approach, one that considers connections among all sectors of the economy and that examines how a cap-and-trade program interacts with existing and proposed emission reduction measures including regulations, performance-based standards, price subsidies, tax credits, and other technology promoting initiatives. The Committee concluded that a well-designed cap-and-trade program is fully compatible with and complementary to these other regulatory programs and could contribute significantly to achieving the goals of the Act. To read the Market Advisory Committee's final report dated June 30, 2007, click on: http://www.climatechange.ca.gov/documents/2007-06-29_MAC_FINAL_REPORT.PDF.

Legislative Activity

September 2006

***Reuters,* "Norway Demands CO_2 Capture at Gas Plant."** A decision by the Norwegian Pollution Control Authority (SFT) reversed an earlier recommendation by the Norwegian Water Resources and Energy Administration (NVE) that Statoil's planned Mongstad refinery should be allowed only if it is equipped with carbon dioxide capture technology. The Norwegian government will make the final decision regarding what type of permit will be granted to the $635 million 280 megawatt (MW) power / 350 MW heat plant, slated for a 2008-2009 start-up. Statoil's position is that a requirement for carbon capture from the start of the project would make the project impossible to implement. The SFT said that without carbon capture, the plant would emit 1.3 million tons of CO_2 annually. August 21, 2006, http://www.planetark.org/dailynewsstory.cfm?newsid=37742&newsdate=21-Aug-2006.

October 2006

***Reuters,* "California Strikes Accord on Global Warming Bill" and Pew Climate Center Website, "California Global Warming Act"** On August 30, 2006, Governor Schwarzenegger and the California Legislature passed AB32, the Global Warming Solutions Act (The Act). The Act caps California's greenhouse gas emissions at 1990 levels by 2020, with mandatory reporting for top emitters such as energy companies. The Act is the first enforceable state-wide program in the US to cap all GHG emissions from major industries that includes penalties for non-compliance. The State Air Resources Board (Board) is required to establish a program for statewide greenhouse gas emissions reporting, monitoring and enforcement. The Board will adopt market-based compliance mechanisms, including cap-and-trade, and allow a one-year extension of the emissions targets under extraordinary circumstances. California is the world's eighth-biggest economy and the 12th largest producer of greenhouse gas emissions. To read the legislation on AB 32, see: http://www.leginfo.ca.gov/cgi-bin/postquery?bill_number=ab_32&sess=CUR&house=B&author=nunez. To see a table of emissions targets worldwide, see: http://www.pewclimate.org/what_s_being_done/targets/index.cfm. To see a map of states with emissions targets, see: http://www.pewclimate.org/what_s_being_done/in_the_states/emissionstargets_map.cfm. August 31, 2006, http://www.planetark.com/dailynewsstory.cfm/newsid/37896/story.htm, and http://www.pewclimate.org/what_s_being_done/in_the_states/ab32/index.cfm.

***State of Arizona Press Release,* "Governor Napoliano Issues Executive Order to Promote Energy Efficiency: Order Steps Up Efforts to Reduce "Greenhouse Gas" Emissions,"** On September 8, 2006, Arizona Governor Janet Napolitano signed Executive Order 2006-13, which establishes a

statewide goal to reduce Arizona's future greenhouse gas emissions (GHG) to the 2000 emissions level by the year 2020, and to 50 percent below the 2000 level by 2040. The Governor's decision was made after receiving a report from the Governor's Climate Change Advisory Group (CCAG) on cleaner air. The Action Plan, a product of more than a year's work by the group, contains a report on the effects of climate changes and offers a list of recommendations to decrease GHG emissions. The Executive Order also creates a Climate Change Executive Committee which will develop a strategy to implement the plan, and explore ways to meet the targets sooner, by 2012 if possible, to coincide with Arizona's Centennial. Recommendations made by the Advisory Group include using better land and forest management practices to increase efforts to remove carbon from the atmosphere (known as "carbon sequestration"). View the August 2006 Climate Change Action Plan at: http://www.azgovernor.gov/dms/upload/Climate_Change_Action_Plan_final-web.pdf. September 08, 2006, http://azgovernor.gov/dms/upload/NR_090806_CCAG.pdf.

***Boston Channel.com,* "Massachusetts Sets Rules for CO_2 Trading on Power Plants," and *MassDep News Release,* "Romney Administration Promulgates Rules To Implement First-In-The-Nation Regulation To Limit Carbon Dioxide Emissions From Power Plants."** Massachusetts has filed regulations on September 14 that will be promulgated on October 6, which allow the state's six largest power plants to regulate carbon dioxide (CO_2) emissions while allowing for environmental projects to be funded by those plants. Regulations were established in 2001 for the CO_2 emissions to be met in 2 phases beginning in 2006. The new rule establishes the criteria by which the plants can meet those emissions limits. The rule specifies several different types of projects which fulfill the requirement of those reductions, including the capture of landfill gases, greenhouse gas sequestration, renewable energy generation and tree planting. The projects can be conducted on or off the plant sites, by the companies or by third parties whose emission reductions have been certified by Massachusetts' Department of Environmental Protection (MassDEP). Plants will be required to pay for projects in the Northeast US unless the price of those programs costs more than $6.50 per ton of CO_2, in which case they can pay for programs anywhere in the world. If the price for the programs is over $10 of CO_2 per ton, then the companies are to pay into a state trust fund. To view the rule, see: http://www.mass.gov/dep/air/laws/ghgappb.pdf. September 14, 2006, http://www.mass.gov/dep/public/press/0906ghg.htm.

***Greenwire,* "'Strange Bedfellows' File Briefs in Supreme Court Emissions Case."** A wide array of parties has filed their opening briefs for *Massachusetts v. EPA,* the lawsuit aimed at forcing the US EPA to regulate carbon dioxide from motor vehicles. The parties filing briefs include the states of California, Connecticut, Illinois, Maine, Massachusetts, New Jersey, New Mexico, New York, Oregon, Rhode Island, Vermont and the District of Columbia, environmental groups, scientists and energy companies. Other parties filing "friend of the court" briefs were energy companies Entergy and Calpine, former Secretary of State Madeleine Albright, Alaska native groups, the National Wildlife Federation, hunting and fishing groups, four former EPA administrators, the National Council of Churches, and the US Conference of Mayors. Oral arguments are expected in December after the US Circuit Court of Appeals for the District of Columbia denied the state's motion to reverse an earlier ruling. The case centers around the appeals court's decision upholding the Bush administration's refusal to regulate carbon dioxide as a pollutant under the Clean Air Act. To read the opening brief filed by Massachusetts and other plaintiffs in the case, see: http://www.eenews.net/features/documents/2006/09/05/document_gw_14.pdf. To read other briefs files by petitioners, go to the following news story weblink to view a chart of filers, and links to pdfs of the brief. September 5, 2006, http://www.eenews.net/Greenwire/print/2006/09/05/1. (Subscription may be required.)

***Bloomberg*, "California Sues GM, Ford, Toyota Over Global Warming."** California is suing the six largest automakers in the US, including General Motors, Ford, Toyota Motor Corp., DaimlerChrysler AG, Honda Motor Co. and Nissan Motor Co. arguing that the vehicles add to global warming and cost the state billions of dollars to fight pollution and erosion. The state filed a complaint in US District Court in Oakland that the companies are creating a public nuisance, with is defined as "anything which is

injurious to health," obstructs free use of property or interferes with the comfortable enjoyment of life or property. The lawsuit is California v. General Motors, 06-05755, US District Court, Northern District of California. September 20, 2006, http://www.bloomberg.com/apps/news?pid=20601103&sid=aSthCirr_IoI&refer=us .

November 2006

***Greenwire,* "Oral Arguments Set For November 29 In Supreme Court Emissions Case."** The US Supreme Court will hear arguments in its first global warming case, *Massachusetts v. U.S. EPA*, beginning on November 29. The case revolves around whether or not the federal government will regulate greenhouse gasses from new vehicles. The plaintiffs in the case argue that the EPA violated the law in 2003 when it did not designate carbon dioxide as a pollutant under the Clean Air Act. Plantiffs include Massachusetts Attorney General Tom Reilly (Democrat) and a coalition of a dozen states, New York City, Baltimore and environmental groups. The case was decided against them in two prior decisions by the U.S. Circuit Court of Appeals for the District of Columbia. October 2, 2006, http://www.eenews.net/Greenwire/print/2006/10/02/9.

Greenwire, *"California Businesses Fear A.B. 32 Will Spur 'Tax-Like' Carbon Fees."* *As California takes steps to implement its latest climate change legislation, A.B. 32 also known as the "Global Warming Solutions Act of 2006," business leaders are warning the law could lead to a tax on carbon and curbs on the state's economic growth. The California Chamber of Commerce Vice President Dominic Dimare stated, "A cap on carbon is a cap on growth." The law sets reduction levels for greenhouse gas emissions to the 1990 levels by 2020. There is also a provision through which the California Air Resources Board may adopt by regulation a fee schedule under which emitters would have to pay into an Air Pollution Control Fund. In California, these charges are known as "Sinclair fees" after a 1997 California Supreme Court decision,* Sinclair Paint Co. v. State of California, *which allowed regulators to charge mitigating pollution to the source, upholding the "polluter pays" principle. Dimare is also concerned that there is no budget allocation for economic analysis of any carbon reduction efforts. A lead agency also has yet to be determined for the law. October 12, 2006, http://www.eenews.net/Greenwire/2006/10/12/#2*

***Marin Independent Journal,* "Marin Launches Attack On Global Warming."** On October 10, Marin Country California, pledged to reduce their greenhouse gas emissions by 15 percent by 2020, using alternative energy projects. The county is one of 30 local governments in California and 134 across the nation that is participating in an international greenhouse gas reduction program. The total percent of the world's greenhouse gases produced by those municipalities is 17 percent. http://www.marinij.com/marin/ci_4479920.

December 2006

***E&E News,* "Senator Coleman Floats Plan to Set 'Clean Energy' Standard, Nix GHG Programs," and *Clean Air Report,* "Senator Prompts Debate Over Draft Plan Blocking EPA, State CO2 Rules."** Senator Norm Coleman (R-MN) is proposing legislation which would mandate clean energy purchases and promote low-carbon fossil technologies while blocking EPA and state driven climate policies. Colman's plan was first reported in the publication InsideEPA, and would require major electric utilities to transfer an increasing percentage of their energy portfolio to low and zero-carbon production methods, including wind, solar, nuclear or integrated gasification combined cycle coal plants. Preliminary proposed limits would set a national portfolio standard at 10 percent in 2015, 15 percent in 2020 and 20 percent in 2025. Caps on emissions are not included in the proposed plan. The proposal would also serve to preempt the *Massachusetts et al. v EPA* Supreme Court case, due to stating that carbon dioxide is not a pollutant under the Clean Air Act and is that "any harm allegedly caused by carbon dioxide emissions is

not actionable under federal or state common law." The proposal would also weighs a prohibition on any laws or regulations set up in states such as California, New York and across the Northeast United States which are designed to reduce carbon dioxide emissions from power plants. October 20, 2006, http://www.eenews.net/eenewspm/2006/10/20/archive/1/?terms=climate, and November 2, 2006, http://epa.iwpnewsstand.com/showdoc.asp?docnum=CLEANAIR-17-22-1. (Subscription may be required for both sources.)

January 2007

***Greenwire,* "Boxer To Use California Model For Federal Warming Initiative."** Senator Barbara Boxer (D-CA) is taking over the US Senate Committee on Environment and Public Works in January. She plans to use California's Global Warming Solutions Act (AB32) as a model in drafting the federal climate legislation for the 110th US Congress. AB32 is requiring a 25 percent cut in greenhouse gas emissions by 2020. Though there is no timetable for the legislation, a Boxer aide stated that the senator will be engaged in the issue of global warming at the start of next Congress. November 11, 2006, http://www.eenews.net/Greenwire/print/2006/11/10/1.

Reuters, "Colorado Town Passes First US Carbon Tax." Boulder, Colorado has passed the first municipal carbon tax in the US. Residents and businesses will have to pay the carbon tax according to how much electricity they use. The tax will raise the average home bill by $1.33 per month, and the business' bill by $3.80 per month. Annually, the carbon tax will generate $1 million for the city annually, and will be used to fund energy audits for homes and businesses, and energy advisors for homeowners. Residents who choose to purchase wind power will not have to pay the tax. November 13, 2006, http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=38939.

February 2007

***E&E Daily*, "Global Warming, Energy Top Senate Democrats' Floor Plans,"** and ***E&E Daily,* "Warming Policy Debate Picks Up Steam as Dems Move Into Power."** In a memo sent on January 3 to Senate Democrats, the incoming majority leader, Senator Harry Reid (D-Nevada), included global warming as one of ten specific legislative items to be addressed by the 110th Congress. Leaders from both the House and Senate also mentioned climate change and energy policy in their opening day speeches to Congress. Reid's plan to implement this legislation will begin with hearings held through a committee process. Senator Barbara Boxer (D-California), chairwoman of the Environment and Public Works Committee, and Jeff Bingaman, Senate Energy and Natural Resources Committee Chairman, (D-New Mexico) will lead the effort. Senator Bingaman has already circulated draft global warming legislation to industry, environmental groups, economists and others. The current draft legislation, which ensues an earlier draft, calls for stricter industry regulations relating to air pollution and carbon dioxide emissions. Majority Whip Dick Durbin (Illinois), the second highest ranking Senate Democrat, predicts bipartisan interest in global warming and recommended questions about climate change be put before Boxer. To read the full memo by Senator Harry Reid, go to: http://www.eenews.net/features/documents/2007/01/04/document_daily_01.pdf, and to read the Bingaman draft legislation, see: http://www.eenews.net/features/documents/2007/01/05/document_gw_01.pdf. January 4, 2007, http://www.eenews.net/EEDaily/print/2007/01/04/2, and January 8, 2007, http://www.eenews.net/EEDaily/2007/01/08/archive/1/?terms=carbon%20sequestration. (Subscription may be required.)

***AP,* "Details of Competing Global Warming Plans in the U.S. Senate."** Three global warming bills were recently introduced in the US Senate. The "Climate Stewardship and Innovation Act of 2007" was introduced on January 12 by Senators John McCain, (R-Arizona), Joseph Lieberman, (I-Connecticut), and Barack Obama, (D-Illinois). The bill aims to reduce emissions to one-third of 2000 levels by 2050. It would set up a cap-and-trade system where the US Environmental Protection Agency (EPA)

administrator would set up a system for distributing, borrowing and trading emissions credits. The act would establish a national greenhouse gas (GHS) database in order to track and analyze emissions. Companies could earn cap-and-trade credits by participating in emissions reductions projects in other countries. Also companies which reach emissions goals ahead of their timeframe would earn additional credits. The "Global Warming Pollution Reduction Act" was introduced on January 16 by Senator Bernie Sanders, (I-Vermont) and was co-sponsored by Senator Barbara Boxer, (D-California), Senator Ted Kennedy, (D-Massachusetts) and others, totaling 11 in all. The Act would require a reduction of emissions of GHG to 1990 levels by 2020, and further decreases every ten years to 80 percent below 1990 levels by 2050. This bill has no mechanism for cap-and-trade, but would establish emissions standards for vehicles. All power plants built after 2012 would have to comply with mandatory GHG emission standards, which would apply to all plants by 2030 no matter when they were built. A requirement of 0.5 percent of electricity generation would have a low carbon coal requirement by 2015, with five percent of generation to follow that requirement by 2020. The "Electric Utility Cap-and-Trade Act" was introduced by Senator Dianne Feinstein (D-California), and Tom Carper (D-Delaware) on January 17. This bill seeks to cap GHG emissions in the electricity sector at 2006 levels in 2011 and 2001 levels in 2015. By 2020 emissions would need to be reduced to 25 percent below where they would be expected to be without action. The bill sets up a cap-and-trade system with one credit equivalent to one ton of carbon dioxide emissions, with allocation based on emission reduction goals outlined in the bill. The EPA would auction credits each year and the money would go toward the development of new low-carbon technologies and mitigating the effects of climate change. A scientific panel would be established to make recommendations to the EPA every four years regarding emission reduction rates. January 17, 2006, http://www.mercurynews.com/mld/mercurynews/news/local/states/california/northern_california/16482721.htm.

***Greenwire*, "Automakers Ask Court to Dismiss California Lawsuit."** The "Big Six" automakers filed a motion on December 15 to dismiss the state of California's lawsuit, *California v. GM*, which would hold the major automobile industry financially accountable for global warming caused by new automobile emissions. Attorneys for the automobile companies, including General Motors Corporation, Toyota Motor North America Incorporated, Ford Motor Company, Honda North America Incorporated, Chrysler Motors Corporation and Nissan North America Incorporated, argue that federal courts are prohibited from intervening to create new common law on vehicle emissions and fuel economy, as written in existing congressional and executive branch regulations. California Attorney General Bill Lockyer (D), who filed California's original complaint in September 2006, is being accused of creating a tort lawsuit out of the international political debate that surrounds the subject of global warming. The Supreme Court heard arguments last month in a similar case, *Massachusetts v. EPA*. The Court is expected to hand down a decision by this summer concerning the Environmental Protection Agency's decision not to regulate greenhouse gas emissions from new cars and trucks. To read the automakers' motion, go to: http://www.eenews.net/features/documents/2006/12/18/document_gw_01.pdf, and to view California's original complaint, see: http://www.eenews.net/features/documents/2006/09/20/document_pm_01.pdf. December 18, 2006, http://www.eenews.net/Greenwire/print/2006/12/18/8. (Subscription may be required.)

***Reuters*, "Massachusetts to Join Northeast US Greenhouse Pact."** Massachusetts will join the Regional Greenhouse Gas Initiative (RGGI), a pact among northeastern US states to control emissions. The announcement was made on January 18 by Governor Deval Patrick to join the initiative to cap carbon dioxide emissions from electricity plants at current levels until 2015 and then reduce emissions by 10 percent by 2019. Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York and Vermont have also pledged their commitment to the pact, and support is also expected from Maryland, Washington D.C., and possibly California. Estimated savings from green investments funded by the pact could reduce annual household electricity bills by $21 to $26 by 2015, although in the short term electricity bills may initially increase by $3 to $16 per year. In total, the investments could reduce the states $8 billion electricity bill by $160 million. Under the RGGI plan, power plants would have limits as to

how much carbon dioxide they can emit. Once the limit is exceeded they would then have to buy carbon credits from cleaner operating plants. Profits from the emissions market would go to the state which, in turn, would invest in green technology and conservation. The regional pact would cap carbon dioxide emissions from electricity plants at current levels until 2015, and then require a 10 percent decrease by 2019. January 19, 2007, http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=39906.

March 2007

***Voice of America,* "Private Coalition Calls for Swift US Action on Global Warming," and *Voice of America,* "US Businesses, Environmental Groups Join Forces to Push for Action on Global Warming."** A coalition of US-based businesses and non-governmental environmental organizations are joining forces to confront the problem of global warming. The US Climate Action Partnership, or US-CAP, is made up of chief executives from some of the country's largest corporations, such as General Electric, DuPont, Alcoa, and Legman Brothers, who have teamed up with environmental groups including Environmental Defense, Natural Resources Defense Council, Pew Center on Global Climate Change, and World Resources Institute. Both parties are calling on the US government to address the issue of climate change by enacting national legislation to require significant reductions in greenhouse gas emissions. The proposal describes a market driven approach that places caps on emissions, while at the same time providing economic incentives to reach those targets. The goal is to see a reduction in carbon dioxide emissions by 30 percent in the next 15 years. Similar plans are in place in Europe where goals to reduce carbon dioxide emissions to pre-industrial levels by the year 2020 have been proposed by the European Commission. US-CAP supports the enactment of a number of climate change bills currently being presented to Congress. **(See Recent Publications section of this newsletter for a link to the report, *A Call for Action,* in news item "A Call for Action: Consensus Principles and Recommendations from the U.S. Climate Action Partnership: A Business and NGO Partnership.")** January 22, 2007, http://www.voanews.com/english/2007-01-22-voa46.cfm, and January 24, 2007, http://www.voanews.com/english/2007-01-24-voa31.cfm.

April 2007

***E&E Daily,* "Congress to Evaluate Carbon Taxes as Part of Warming Solution."** Two separate hearings that may address the possibility of imposing a carbon tax to reduce greenhouse gas emissions are scheduled to take place on Capitol Hill. The proposals under consideration would create new taxes on fossil fuels and carbon dioxide (CO_2) emissions. A difference of opinion exists with lawmakers, however, as many believe that a cap-and-trade system would be a better approach to resolve the problem. Advocates of a carbon tax defend their approach due to its simplicity of applying a fixed cost on coal, oil and other sources of greenhouse gas emissions. They claim that cap-and-trade programs are more difficult to administer and more susceptible to corruption. Proponents of a carbon tax also site the increased revenue that the tax could bring to the government. An estimate released by the Congressional Budget Office stated that an additional $11.8 billion in revenue could result in 2008 alone with approval of a tax of $4 per ton of CO_2 released into the atmosphere. An additional $95.4 billion in revenue could be seen by 2012. Observers of the global warming policy debate explain that a cap-and-trade system is, in effect, a carbon tax, because whether a company is paying a straight out tax or whether they are investing money from emissions into trading markets, they are still required to pay for emissions. The Senate Finance Committee will hold the first of the proposed hearings on February 27 and is likely to explore carbon taxes and other energy incentives. Similarly, Representative Charles Rangel (D-NY), the chairman of the House Ways and Means Committee, will hold the first in a series of hearings on energy and climate change issues on February 28. Proponents of a carbon tax are keeping a watchful eye on Representative. Fortney "Pete" Stark (D-CA), who is also a member of the Ways and Means Committee. He has expressed his own ideas about plans to introduce legislation that would put a tax on coal, petroleum and natural gas based on their carbon content. It may be difficult for legislation of this type to pass into law, as was the case with former President Clinton's appeal to Congress in 1993 to

pass legislation taxing energy based on its British thermal unit output, otherwise known as the Btu tax. The consensus on Capitol Hill is that lawmakers are much more likely to pass cap-and-trade legislation over the imposition of a carbon tax. For one, the Bush administration has signaled no interest in carbon taxes and, if passed, a carbon tax would undercut US farmers who would earn as much as $8 billion a year in payments through the cap-and-trade plan described in a bill by Senator Joe Lieberman (I-CT), and whereby any revenue raised by the program would be put into a "trust fund" that would be used for energy technologies, for example. Finally, opponents also state that imposing a carbon tax would not guarantee any specific reductions in emissions. February 26, 2007, http://www.eenews.net/EEDaily/print/2007/02/26/1. (Subscription may be required.)

***U.S. House of Representatives, Committee on Science and Technology, Legislative Highlights,* "National Carbon Dioxide Storage Capacity Assessment Act of 2007,"** and **"Congress Pushes to Catalog Nation's Capacity to 'Bottle' Carbon Emissions from Coal and Other Energy Plants."** US Senators Ken Salazar and Jim Webb have introduced a bill which authorizes the US Geological Service (USGS), in cooperation with the Department of Energy and the Environmental Protection Agency to conduct a comprehensive inventory of carbon dioxide storage capacity in geologic features and other natural basins. The bill was co-sponsored by Senator Jeff Bingaman (D-NM). Also introduced was the House companion bill by Representative Bart Gordon (D-TN), Chairman of the Committee on Science and Technology. The National Carbon Dioxide Storage Capacity Assessment Act of 2007 would authorize the federal government to spend $20 million on the inventory process. Congress would need to appropriate the funds. This bill would also require the USGS to develop an official methodology of the assessment that will then be reviewed by a panel of experts and the public for accuracy. To read the text of the house version as a pdf file, click on: http://democrats.science.house.gov/Media/File/Commdocs/carbondioxide_act.pdf. To read the Senate version of the bill, click on: http://salazar.senate.gov/images/pdf/070301env.pdf. March 1, 2007, http://science.house.gov/legislation/leg_highlights_detail.aspx?NewsID=1587, and http://science.house.gov/press/PRArticle.aspx?NewsID=1590.

May 2007

***Greenwire,* "Supreme Court Orders EPA to Consider Regulating Greenhouse Gases."** On April 2, the Supreme Court ruled in favor of 11 states and 13 environmental groups that the US Environmental Protection Agency (EPA) must take action to regulate carbon dioxide (CO_2) emissions from new cars and trucks. The first of its kind ruling, *Massachusetts v. EPA* rejects the notion that the EPA does not have the authority to set emissions standards or somehow regulate greenhouse gases in relation to global warming. Justice Paul Stevens, writing for the majority, also dismissed EPA's standing that a federal rule would have little or no effect on climate change in Massachusetts or other states, because US automobile emissions account for only seven percent of global fossil fuel emissions and only a third of the country's overall emissions. The consensus among environmentalists about the ruling is that it will now be up to Congress to move forward and institute legislation to regulate greenhouse gases. To read the Supreme Court opinion, go to: http://www.eenews.net/features/documents/2007/04/02/document_gw_03.pdf. To read a transcript of the oral arguments, see: http://www.eenews.net/features/documents/2006/11/29/document_pm_01.pdf. April 2, 2007, http://www.eenews.net/Greenwire/2007/04/02/archive/1/?terms="CLIMATE". (Subscription may be required.)

***Greenwire,* "EPA to Issue Decision on California Emissions Waiver" and *The Associated Press/Time,* "EPA Revives California Emissions Rule."** Following the Supreme Court decision in *Massachusetts v. EPA* on April 9, giving the agency the authority to establish vehicle emissions standards, California will now be able to move ahead with ambitions to set fuel economy standards for cars, light trucks and sport utility vehicles. While the federal Clean Air Act generally does not allow

individual states to regulate air pollution, California has special authority to do so because it began regulating air pollution before the federal government did in the 1970's. The Environmental Protection Agency will now have to consider California's waiver request to enact the standards. Ten other states have adopted similar standards to those in California, but until the waiver is granted to California, they will not be allowed to set their own emissions standards. The *Massachusetts v. EPA* ruling has caused other legal challenges to resurface. In a separate lawsuit against the "Big Six" automakers, attorneys argued that a lawsuit filed against them by the state of California should be dropped since the Supreme Court decision grants the federal government the right to regulate emissions, not the states. California interprets the ruling in a different light, however. A similar case is scheduled to be heard in Vermont where the auto industry is suing the state for their efforts to implement the same emissions regulations as those in California. April 4, 2007, http://www.eenews.net/Greenwire/print/2007/04/04/9, and April 4, 2007, http://www.time.com/time/printout/0,8816,1606584,00.html#. (Subscription may be required.)

***Great Falls Tribune,* "Tester Bill Aims to Put $315 Million into Clean-Coal Technology."** United States Senator Jon Tester (D-Montana) is co-sponsoring a bill totaling $315 million which he would like to use to fund carbon capture and storage projects throughout the United States. The proposed legislation has the support of the Senate Energy and Natural Resources Committee chairman and the ranking member. The funding, to be allocated from 2008 through 2010, would be divided among the seven US Department of Energy (DOE)-sponsored Regional Partnerships, formed by DOE in 2004 to study the feasibility and safety of capture, injection and long-term storage of carbon dioxide (CO_2). Tester's state of Montana is home to the Big Sky Regional Partnership, made up of researchers in Montana, Wyoming, Idaho, Washington, and Oregon. The partnership is based at Montana State University. Big Sky is currently hoping to initiate geologic sequestration pilot studies, which would involve small scale CO_2 injection studies at sites previously determined in their initial phase of research. Success of these tests would be followed by large-scale injections. April 8, 2007, http://www.greatfallstribune.com/apps/pbcs.dll/article?AID=/20070408/NEWS01/704080305&template=printart

June 2007

***United Press International,* "Bingaman-Domenici Bill Passed In Committee."** In a 20-3 vote, the Senate Energy and Natural Resources Committee passed the Bingaman-Domenici bill on May 2, a key piece of energy legislation encompassing incentives for energy efficiency and renewables. The bill will be brought before the Senate soon. The legislation combines energy improvement initiatives from three important bipartisan measures that have surfaced over the past several months. First, the bill includes $125 million in carbon sequestration research and development. Second, the measure calls for a 20 percent reduction in US gasoline consumption over the next ten years. Finally, increased federal funding for research and development in bioenergy technologies is authorized in the legislation. This includes new energy efficiency requirements for household appliances. Important to state and county lawmakers is the inclusion of an Energy and Environment Block Grant. This passes funding to local governments to enact energy saving programs in their communities, a grant stemming from requests voiced during the Conference of Mayors held in January. May 3, 2007, http://www.upi.com/Energy/Briefing/2007/05/03/bingamandomenici_bill_passed_in_committee/.

***Environment & Energy Daily,* "Rahall-Sponsored Climate, Energy Bill Starts to Take Shape."** Nick Rahall (D-W. Va.), chairman of the House Natural Resources Committee, is sponsoring a climate bill that will incorporate two key provisions to draft legislation expected to be brought before the House floor this summer. The first provision is to study the potential of carbon sequestration in the United States. Rahall cites legislation introduced by House Science and Technology Committee Chairman Bart Gordon (D-TN) that would produce a comprehensive inventory of the nation's ability to store CO_2 in geologic formations and other natural basins. The USGS would work with the DOE and US Environmental Protection Agency to establish this inventory, as well as developing a "rigorous methodology" for the assessment. The US Geological Survey (USGS) endorses the bill, H.R. 1267, in addition to supporting a companion bill being

brought before the Senate's Energy and Natural Resources Committee. The House and Senate versions of the legislation have been endorsed by several environmental groups and energy industry groups. The second provision repeals to Section 390 of the 2005 Energy Policy Act that allows for categorical exclusions from oil and gas National Environmental Policy Act studies of drilling projects on Western public lands. Categorical exclusions such as this one are generally opposed because they often result in shortened approval time for permit requests and do not leave time to conduct public hearings. It is often during the public comment periods that opposition and concern over wildlife and habitat concerns are voiced. The Western Governors' Association and other environmental groups endorse the repeal. To review the content of H.R. 1267, go to: http://www.eenews.net/features/bills/110/House/010507175934.pdf. May 2, 2007, http://www.eenews.net/EEDaily/print/2007/05/02/3.

July 2007

The Associated Press, **"Utah Joins Pact to Reduce Gas Emissions."** On May 21, Republican Governor Jon Huntsman of Utah signed the Western Regional Climate Action Initiative. Utah is now the sixth state to join the group of Western states that have pledged their formal commitment to reduce greenhouse gas emissions. Governors from California, Arizona, Washington, Oregon, and New Mexico are current members of the pact, which was enacted earlier this year by California Governor Arnold Schwarzenegger. The group will work together to set collective targets for greenhouse gas reductions by August 2007 and establish a protocol for tracking and registering greenhouse gas emissions. Additionally, the agreement calls for implementation of a regional carbon market by August 2008, whereby companies that pollute in excess of their allowance must purchase credits from companies who are able to meet their emissions targets. A similar scheme is being developed in a number of Northeastern and Mid-Atlantic states as a way to mitigate climate change. Utah relies almost exclusively on coal-fired power plants to generate electricity, so initiatives such as the Western Regional Climate Action Initiative present a viable option in reducing the state's carbon dioxide emissions and addressing global climate change. May 21, 2007, http://www.washingtonpost.com/wp-dyn/content/article/2007/05/21/AR2007052101280.html.

The Associated Press, **"Western Governors Target Clean Energy."** On June 10-12, the Western Governors' Association held a three-day conference to discuss global warming, clean energy alternatives, agriculture policy, and reducing the impact of climate change in the region. Attendees included ten governors and the premiers of two Canadian provinces. Considerable attention was given to carbon sequestration, with a request to the federal government to increase its research and funding efforts with the technology. Economic incentives, deployment of large-scale sequestration projects, technological advances, and long-term liability are many of the issues that will need to be addressed with carbon sequestration. The commitment to move forward with large-scale solar energy projects was also discussed. June 11, 2007, http://www.billingsgazette.net/articles/2007/06/11/news/state/40-governor.prt.

August 2007

Bloomberg, **"Bill Would Cut Greenhouse Gas Emissions Twenty Percent by 2030."** On July 11, Senators Jeff Bingaman (D-NM) and Arlen Specter (R-PA) unveiled an industry-backed climate change bill that would impose mandatory limits on US CO_2 emissions. The bill calls for emission levels to be cut by 20 percent by 2030 through a cap-and-trade system requiring industry to reduce emissions or buy credits if they exceed their quotas. If the legislation moves forward, industries affected by the regulations would begin the cap-and-trade system in 2012, with an allotment of 53 percent of their emissions allowances. Industries who fail to reduce their pollution levels would be required to purchase additional allowances in the market. To secure industry support, the bill sets limits for tradable allowances at $12 per ton of CO_2, although the price would increase by five percent per year plus the cost of inflation. Although President Bush has called for voluntary reductions in emissions, he stipulates that any

greenhouse gas trading scheme must include China and other Asian economies before becoming mandatory in the US. July 11, 2007, http://www.bloomberg.com/apps/news?pid=20601070&sid=a5qSZkX.S2kQ&refer=home.

***US House of Representatives Committee on Science and Technology Press Release,* "Energy and Climate Change R&D Measures Clear Committee, Contribute to House Energy Package."** On June 27, four bills were passed by the House Committee on Science and Technology, including H.R. 1933, the Department of Energy Carbon Capture and Storage Research, Development and Demonstration Act of 2007. The bill is designed to enhance the country's knowledge and use of carbon capture and sequestration. The primary sponsor of the legislation is Mark Udall (D-CO). H.R. 1933 reauthorizes DOE-funded research and development programs, and specifically funds demonstration of carbon sequestration field test projects currently underway by the seven Regional Carbon Sequestration Partnerships. Other bills passed by the full Committee include: H.R. 906, the Global Change Research and Data Management Act; H.R. 2773, the Biofuels Research and Development Enhancement Act; and H.R. 2774, the Solar Energy Research and Advancement Act of 2007. To read H.R. 1933 reported (as amended) by the full Committee on June 27, 2007, click on: http://democrats.science.house.gov/Media/File/Commdocs/markups/full/27jun/1933_adopted_amnds.pdf. June 27, 2007, http://science.house.gov/press/PRArticle.aspx?NewsID=1908.

***Newsday,* "NJ Enacts Long-Reaching Anti-Global Warming Law"** and ***Assembly Democrats News Release*, "'Global Warming Response Act' Signed Into Law."** On July 6, New Jersey Governor Jon S. Corzine signed the "Global Warming Response Act" into law, an initiative that places the state at the forefront in US efforts to combat global warming. The law sets forth strict emissions standards for New Jersey, requiring a reduction in greenhouse gas (GHG) emission levels to 1990 levels by the year 2020. By 2050, the law calls for emission levels not to exceed 80 percent of levels present in 2006, an objective that makes New Jersey the first state to set a global warming target so far into the future. Additionally, the mandate makes the state the first to require that energy imports adhere to New Jersey's standards. The New Jersey Department of Environmental Protection (DEP) will play an integral part in the state's efforts to reach the goals set forth in the new law. In the first year, the DEP will conduct an emissions inventory which will identify GHG emission levels from 1990, 2006, and the present. The new law mirrors an executive order signed by the governor in January. By 2009, the DEP will establish a GHG emissions monitoring and reporting program and will set standards for industry. By June 30, 2008, the DEP will report its recommendations to reach 1990 levels by 2020. The 2050 milestone recommendations will be described in a second report expected no later than June 30, 2010. The DEP will be required to inventory and establish industry emission caps for six greenhouse gases, including CO_2, methane, nitrous oxide, sulfur hexafluoride, hydroflurocarbons (HFCs), and polyflurochemicals (PFCs). Former Vice-President Al Gore was present at the signing of the law, which took place at Giant's Stadium on the eve of the "Live Earth" concert aimed at raising awareness of global warming. New Jersey joins California and Hawaii in adopting the anti-global warming law and eight other states are considering similar actions. July 6, 2007, http://www.newsday.com/news/local/wire/newjersey/ny-bc-nj--globalwarming-nj0706jul06,0,7721814,print.story?coll=ny-region-apnewjersey, and July 6, 2007, http://www.politicsnj.com/assembly-democrats-global-warming-response-act-signed-law-10157.

Announcements

October 2006

DOE Releases Climate Change Technology Program Strategic Plan: Plan Outlines Strategies for Reducing Greenhouse Gas Emissions through Development and Deployment of Advanced Technologies. On September 20**,** the US Department of Energy (DOE) released the Climate Change Technology Program (CCTP) Strategic Plan which details measures to accelerate the development and reduce the cost of new and advanced technologies that avoid, reduce, or capture and store greenhouse

gas emissions. To read the press release, see: http://www.climatetechnology.gov/library/2006/pr20sep2006.pdf. To download the report entitled **"US Climate Change Technology Program Strategic Plan September 2006,"** see: **http://www.climatetechnology.gov/stratplan/final/index.htm**. Also see this Newsletter's **Recent Publications** section for details.

"Clean Development Mechanism (CDM) and Joint Implementation (JI) in Charts" Booklet. The Institute for Global Environmental Strategies (IGES) is pleased to announce that the aforementioned booklet has now been upgraded to version 6.0. Published by IGES as part of the Integrated Capacity Strengthening (ICS) for the CDM/JI (ICS-CDM/JI) Program under the Ministry of the Environment, Japan, the booklet contains plain and easy-to-understand description of the CDM and other Kyoto mechanisms. All the changes from the previous version are listed in the book. Download at: http://www.iges.or.jp/en/cdm/report01.html.

J.D. Power and Associates Releases Alternate Powertrain Study 2006. J.D Power and Associates new Alternative Powertrain Study (APS) includes the Automotive Environmental Index (AEI), which combines US Environmental Protection Agency (EPA) publicly available information with voice-of-the-customer data related to fuel economy, air pollution and greenhouse gases for 2006 model-year vehicles. Voice-of-the-customer data is also used to help determine the relative importance of these environmental factors. The fuel economy factor represents approximately 50 percent of the index, while air pollution and greenhouse gases contribute to the remainder. The top 30 vehicle models are included in the index. To access the index and see a video explaining the ranking, see: http://www.jdpower.com/autos/green-info/green-matt.aspx.

November 2006

2006 Gasification Technologies Council Annual Conference Papers and Presentations. The papers and presentations from the 2006 Gasification Technologies Conference, which was held from October 1-4 in Washington, DC, are available to download. Visit http://www.gasification.org/Presentations/2006.htm to view the papers, with several papers under the heading of "**Carbon Management with Gasification Technologies**." Also available is a presentation given by Mike Mudd of the FutureGen Alliance on the Status and Schedule of the FutureGen Plant at: http://www.gasification.org/Docs/2006_Papers/39MUDD.pdf.

"The Great Warming," a new documentary film, to be released November 3. The film examines world-wide issues of climate change and offers many real-world solutions. Filmed on four continents and narrated by Keanu Reeves and Alanis Morissette, the film will be released nationwide through the Regal Cinema chain in the top 50 U.S. markets. http://www.prweb.com/releases/2006/10/prweb445785.htm.

Television show "The Climate Code with Dr. Heidi Cullen" to be launched on the Weather Channel. The Weather Channel is launching a new show called "The Climate Code" that will focus on global warming and environmental issues. The host is Heidi Cullen, who holds a Ph.D. from Columbia University. The show will air at 5 p.m. every Sunday with reruns on Saturdays at 5 p.m., 7 p.m. and 11 p.m. http://climate.weather.com/onair.html.

Point Carbon's Carbon Market North America free e-newsletter. View and/or register for Point Carbon's newsletter covering North America's carbon market news and commentary. Also included is a summary of global carbon politics and markets. http://www.pointcarbon.com/Home/Carbon%20Market%20North%20America/category1325.html.

January 2007

Read Jeffrey Jarrett's Opinion Column on Carbon Sequestration. Jeffrey Jarrett, Assistant Secretary, Office of Fossil Energy, of the US Department of Energy has written a guest column on Carbon Sequestration which appeared in the *Waco-Tribune Herald* on November 30, 2006. Read it at this link: http://www.signonsandiego.com/uniontrib/20061129/news_lz1e29jarrett.html.

Register for NYSERDA's Carbon Capture and Sequestration Listserv. Join New York State Energy Research and Development Authority's email listserv to receive updates on NYSERDA's and New York State's involvement with Carbon Sequestration issues. To subscribe to the list, visit: http://www.nyserda.org/programs/Research_Development/CCSListserv.asp for instructions. Or send an email to: listserv@listserv.nyserda.org. Leave SUBJECT blank, and put in the BODY of the email message (using your name): subscribe CCS-L firstname lastname. E-mail info@nyserda.org if you have questions about registering.

February 2007

DOE Announces Thomas D. Shope as New Principal Deputy Assistant Secretary for Fossil Energy. The announcement was made on December 19 by Jeffrey Jarrett, Assistant Secretary for Fossil Energy. To read the full announcement, see: http://www.fossil.energy.gov/news/techlines/2006/06074-Thomas_Shope_Named_PDAS.html.

Read Jeffrey Jarrett's Column on Carbon Sequestration. Jeffrey Jarrett, Assistant Secretary, Office of Fossil Energy, of the US Department of Energy, has contributed an article about Carbon Sequestration which appeared in *The Pittsburgh Post Gazette* on January 21, 2007. The article can be read in its entirety at: http://www.post-gazette.com/pg/07021/755289-109.stm.

IPCC will Release Its Fourth Assessment Report "Climate Change 2007" on February 2, 2007. The report will present a comprehensive and rigorous picture of the global state of knowledge of climate change. Check the website for the report. http://www.ipcc.ch/.

March 2007

NETL's Bauer Named "Laboratory Director of the Year." Carl O. Bauer, Director of the Office of Fossil Energy's National Energy Technology Laboratory (NETL), has been named a Laboratory Director of the Year by the Federal Laboratory Consortium for Technology Transfer (FLC). The annual award honors directors who have made outstanding contributions supporting technology transfer activities at their laboratories. The award will be presented May 17, 2007, at the FLC National Meeting in Arlington, Texas. To read the full announcement, link to the Department of Energy's Fossil Energy website: http://www.fossil.energy.gov/news/techlines/2007/07006-NETL_Director_Wins_Award.html.

FutureGen Alliance website updated. Changes to the website include the addition of Frequently Asked Questions (FAQs), information on the four Candidate Sites to host FutureGen, and an overview of the Alliance organizational structure. These updates can be found at: http://www.FutureGenAlliance.org.

Hear Secretary of Energy Samuel Bodman's remarks for a broadcast on NPR's *All Things Considered*, entitled "U.N. Report: Humans Behind Climate Change." The story follows the *Fourth Assessment Report* released by the Intergovernmental Panel on Climate Change on February 2, 2007. To read a brief article summarizing the main findings of the report and a link to the audio file, go to: http://www.npr.org/templates/story/story.php?storyId=7137290.

Energy Market and Economic Impacts of a Proposal to Reduce Greenhouse Gas Intensity with a Cap and Trade System. This report was prepared by the Energy Information Administration (EIA), in response to a September 27, 2006, request from Senators Bingaman, Landrieu, Murkowski, Specter,

Salazar, and Lugar. The Senators requested that EIA assess the impacts of a proposal that would regulate emissions of greenhouse gases (GHGs) through an allowance cap-and-trade system. The program would set the cap to achieve a reduction in emissions relative to economic output, or greenhouse gas intensity. To read the January 2007 report in its entirety, go to: http://www.eia.doe.gov/oiaf/servicerpt/bllmss/pdf/sroiaf(2007)01.pdf.

Branson, Gore Announce $25 Million "Virgin Earth Challenge." In a joint announcement, Sir Richard Branson and Al Gore have pledged a $25 million prize for viable solutions for carbon sequestration. The award will go to the individual or group who is able to demonstrate a commercially viable design which will remove at least 1 billion tons of atmospheric carbon dioxide per year for at least ten years without harmful effects. The removal must have long term effects and contribute materially to the stability of the Earth's climate. It is the largest science and technology prize ever offered. To read more about the Virgin Earth Prize, go to: http://www.environmentalleader.com/2007/02/09/branson-gore-announce-25-million-virgin-earth-challenge/.

April 2007

"Two Senior Energy Department Officials to Depart." On March 5, Assistant Secretary for Fossil Energy Jeffrey Jarrett, announced his resignation from the Department of Energy (DOE). Jeffrey Jarrett joined DOE in January 2006 as chief advisor to Secretary of Energy Samuel Bodman on fossil fuel policies and programs, which includes carbon sequestration research and development, as well as oversight of the FutureGen project. Mr. Jarrett has accepted the position of executive director of Coal-Based Generation Stakeholders. To read Secretary Bodman's remarks concerning the announcement and to view the full DOE press release, go to: http://energy.gov/news/4832.htm.

Secretary of Energy Participates in Online Forum, "Ask the White House." The online interactive forum allows the public to participate in online discussions with Cabinet Secretaries, senior White House officials, behind-the-scenes professionals at the White House, and others. On February 23, Secretary Bodman responded to an inquiry on advances being made with clean coal technology, saying that carbon sequestration and the FutureGen initiative are two examples of progress being made. A question inquiring about Department of Energy (DOE) advances in life sciences sparked the Secretary to comment on DOE-sponsored research into microbes to aid in carbon sequestration. To read the Q&A session in its entirety, go to: http://www.whitehouse.gov/ask/20070223.html.

Sean Plasynski on National Public Radio's *Morning Edition.* To listen to a radio story **"**Scientists Hunt for Solution to Carbon Dioxide Problem," with comments by Sean Plasynski, Sequestration Technology Manager at the Department of Energy's National Energy Technology Laboratory go to: http://www.npr.org/templates/story/story.php?storyId=7874053.

Read "Farming the Climate," an Article about Plantstone Carbon Research. Plantstone Carbon, or phytolith occluded carbon, is a process which occurs naturally in plants and could play an important role in countering carbon dioxide emissions and global warming. The authors discuss the technology and the financial and environmental benefits it could bring to the agricultural sector in Australia. The article was first published in *Australian R&D Review* on February 7, 2007 – "Linking Australian Science, Technology and Business." Read it at this link: http://www.sciencealert.com.au/farming-the-climate.html.

View a Presentation by the Electrical Power Resource Institute (EPRI) on "Electricity Technology in a Carbon-Constrained Future." EPRI has presented a technical analysis of the potential for significant carbon dioxide reductions from the US electric power sector within the next 25 years. To view the executive summary and PowerPoint presentation, see: http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=Login&parentid=1&in_hi_userid=2&control=SetCommunity&CommunityID=205&PageID=410.

May 2007

The Department of Energy's National Energy Technology Laboratory (NETL) Releases "Carbon Sequestration Atlas of the United States and Canada." The first coordinated assessment of carbon capture and storage (CCS) potential in the United States and portions of western Canada is presented in extensive detail in this document. **(See Highlights section of this newsletter for the article "DOE Regional Partnerships Find More Than 3,500 Billion Tons of Possible Carbon Dioxide Storage Capacity," the News section article, "US Sees Ample Room to Bury Carbon Dioxide But Costs Unknown," and the Publications section for more information regarding the Atlas.)** NETL has made the Atlas available online at: http://www.netl.doe.gov/publications/carbon_seq/atlas/index.html.

View a Slideshow entitled "Climate Change Issues." This slideshow contains over 200 slides related to current climate change issues, each accompanied by a related news story. The slideshow is updated daily with new photos and news stories related to the topic. To access the link to "Climate Change Issues," click on: http://news.yahoo.com/photos/ss/events/sc/120203climateissues.

June 2007

The Department of Energy's Carbon Sequestration Program Releases "2007 Carbon Sequestration Technology Roadmap and Program Plan." This year's annual update to the Carbon Sequestration Program roadmap provides a detailed analysis of the program's ten year history and the plan that will guide the program in the years to come. **(See Highlights section of this newsletter for the article "DOE Releases 2007 Carbon Sequestration Technology Roadmap, Marks Tenth Year of Carbon Sequestration Program" and the Publications section for more information regarding the document.** NETL has made the Roadmap available online at: http://www.netl.doe.gov/publications/carbon_seq/project%20portfolio/2007/2007Roadmap.pdf.

Read "Why Put CO_2 in the Air When You Can Bury It?" an article about the Recently Held Sixth Annual Conference on Carbon Capture and Storage. This article appeared in the Environment section of the Pittsburgh Post Gazette following the conference and describes briefly how carbon sequestration can be used to mitigate carbon dioxide and other greenhouse gas emissions. The article also includes comments from some of the conference keynote and other featured speakers. To read the article in its entirety, go to: http://www.post-gazette.com/pg/07133/785696-113.stm.

The United States Climate Action Partnership (USCAP) Announces Fourteen New Members on May 8. New members include American International Group (AIG), Alcan, Boston Scientific, ConocoPhillips, Deere & Company, The Dow Chemical Company, General Motors Corporation, Johnson & Johnson, Marsh, PepsiCo, Shell, and Siemens, along with the Nature Conservancy and the National Wildlife Federation. The USCAP objective calls for the federal government to enact mandatory legislation for the reduction of greenhouse gas emissions. The coalition is made up of nongovernmental businesses and environmental organizations with a collective workforce exceeding 2 million people. To read the USCAP press release of the announcement, go to: http://www.pewclimate.org/docUploads/USCAP%205%2E8%2E07%20Release%2Epdf.

July 2007

National Public Radio Story About Carbon. View a five-part animated series on National Public Radio (NPR) dedicated to carbon. This series explains how carbon atoms form bonds, break apart, and create the conditions that can lead to global warming. Listen to the accompanying story on NPR's "All Things Considered," by clicking on: http://www.npr.org/templates/story/story.php?storyId=9943298.

"Statement by the President on the Decline of United States Carbon Dioxide Emissions for 2006." Figures contained in the May 23 report from the Energy Information Administration show that the US is on track to meet national greenhouse gas emission reductions by 18 percent by 2012. The report contains a "flash estimate" of US carbon dioxide emissions for 2006, which show a decrease of 78 million metric tons over the prior year. To read the President's statement in its entirety, click on: http://www.whitehouse.gov/news/releases/2007/05/20070523-8.html.

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Proceedings available for Sixth Annual Conference on Carbon Capture & Sequestration. Individuals who were not able to attend the conference can purchase a user-friendly, searchable CD-ROM containing the presentations made by the key decision makers and the over 200 technical papers. The CD provides the latest updates on actions being taken and the status of RD&D from the leading organizations and experts on carbon capture, storage and sequestration. For order information, visit the conference website at: http://www.carbonsq.com/index.htm.

Read "Companies Judged for Global-Warming Awareness, Found Lacking." The excerpt appeared in the Wall Street Journal on June 19, 2007. Climate Counts, a nonprofit group, ranked 56 companies on their commitment to climate change based on carbon conscious criteria. The study's goal was to demonstrate that companies have a major impact on climate change. Only four companies scored a 70/100 or higher and no company exceeded 77. To read the full blog post, see: http://blogs.wsj.com/energy/2007/06/19/companies-measured-for-global-warming-awareness-found-lacking/.

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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.

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