

THE NETL CARBON SEQUESTRATION NEWSLETTER: ANNUAL INDEX

SEPTEMBER 2005 – AUGUST 2006

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 2005 and August 2006. 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 Information that has become outdated (e.g. conference dates, paper submittals, etc.)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	2
SEQUESTRATION IN THE NEWS	5
ANNOUNCEMENTS	29
SCIENCE.....	32
POLICY	42
GEOLOGY	55
TECHNOLOGY	59
TERRESTRIAL	72
OCEAN.....	76
TERRESTRIAL/OCEAN.....	79
TRADING	85
RECENT PUBLICATIONS	94
LEGISLATIVE ACTIVITY	107



HIGHLIGHTS

February 2006

US State Department Press Release, “Climate Change Partnership Looks to Private Sector for Help,” The Asia-Pacific Partnership for Clean Development and Climate meeting was held in Sydney, Australia, January 11-12. The Asia-Pacific Partnership on Clean Development and Climate meeting concluded with the establishment of eight public-private task forces serving to accelerate clean technology deployment and share best practices in key business sectors. The task forces are described in detail in the work plan and include: (1) cleaner fossil energy; (2) renewable energy and distributed generation; (3) power generation and transmission; (4) steel; (5) aluminum; (6) cement; (7) coal mining; and (8) buildings and appliances. Partner countries have agreed to work together with private companies to expand markets for investment and trade in cleaner, more efficient energy technologies, goods, and services. On the last day of the meeting, the ministers adopted three documents: a charter that provides a framework and a structure, a communiqué that highlights key outcomes, and a work plan that maps out an intensive agenda of near-term work for the task forces. Australian Foreign Minister Alexander Downer said that over the next year “we want to find out from the working groups what specific progress they’re making in those areas, not just to facilitate access to technology but to see that technology is evolving in ways that are going to contribute to alleviating the problems of climate change.” Downer said that Australia will contribute \$100 million over five years to the partnership. (See: <http://www.dfat.gov.au/environment/climate/ap6/> for links to the charter, communiqué, and work plan.) January 13, 2006, <http://usinfo.state.gov/qi/Archive/2006/Jan/13-487324.html>.

March 2006

DOE Techline, and FutureGen Alliance Website, “FutureGen Industrial Alliance Announces Site Selection Process for World’s First “Zero Emissions” Coal Plant,” The FutureGen Alliance (the Alliance) will build the FutureGen plant on a site selected through an open, competitive site-selection process. According to the FutureGen Alliance website, they accepted comments and clarifying questions on the draft Request for Proposals (RFP) through midnight (Eastern Standard Time) on February 28, 2006, with a final RFP targeted for release on March 7, 2006. View the draft RFP at: http://www.futuregenalliance.org/news/draft_siting_rfp.pdf. The proposals for the host site are due in May 2006. The Alliance will develop a list of candidate sites by the summer of 2006 based on an evaluation of the proposals received. Information about the process is provided on the FutureGen Alliance website: <http://www.futuregenalliance.org/>. Prospective site offerors, architecture and engineering firms, technology suppliers and other service providers are encouraged to monitor the Alliance website for participation opportunities. Draft RFPs, Request for Qualifications, and questions and answers to appear at: <http://www.futuregenalliance.org/news.stm>. Members of the Alliance include: American Electric Power; BHP Billiton; the China Huaneng Group; CONSOL Energy Inc.; Foundation Coal; Kennecott Energy, a member of the Rio Tinto Group; Peabody Energy; and Southern Company. February 8, 2006, http://www.netl.doe.gov/publications/press/2006/06007-FutureGen_Site_Selection_Process.html.

April 2006

DOE Techline, “Industrial Alliance Searches for FutureGen Facility Host Site.” The FutureGen Industrial Alliance, Inc. (Alliance) invites proposals for sites upon which the Alliance will build and operate the world’s first coal-based, zero emissions power plant. The FutureGen power plant will produce electricity and hydrogen-rich synthetic gas from coal while capturing and permanently storing carbon dioxide (CO₂) in a deep geologic formation. The Request for Proposals (RFP) describes the site requirements including site access, ownership, CO₂ storage potential, and other related issues. Based on the responses to the RFP and using the selection process described in the RFP, the Alliance will identify candidate sites for the FutureGen facility. After the conclusion of the Department of Energy’s National

Environmental Policy Act compliance process, the Alliance expects to select a preferred host site. For the host site, the Alliance will determine the final design for the power plant and the specifications for safe and permanent CO₂ storage based on the specific characteristics of the selected site. Proposals submitted in response to the RFP must be received by the Alliance no later than 4:00 p.m. Eastern Time on May 4, 2006. Download the RFP at:

http://www.fossil.energy.gov/programs/powersystems/futuregen/futuregen_siting_final_rfp_3-07-2006.pdf. Also see <http://www.futuregenalliance.org/news.stm> for more information, including RFP amendments. March 8, 2006, http://www.fossil.energy.gov/news/techlines/2006/06016-Alliance_Seeks_FutureGen_Host_Site.html.

May 2006

DOE Press Release, “US and India Sign Historic Agreement on FutureGen Project.” The US Department of Energy has announced that India is the first country to join the US on the government steering committee for the FutureGen Initiative. The agreement was signed by Department of Energy Assistant Secretary Jeffrey Jarrett on behalf of the United States, and on behalf of India, by Honorable R. V. Shahi, Secretary, India Ministry of Power. The signing followed President Bush’s March 2-4 trip to India, during which Indian Prime Minister Singh first announced the joint agreement on FutureGen. India’s participation in the \$1 billion FutureGen project also builds upon the US-India Energy Dialogue that was launched in May 2005. Secretary of Energy Samuel W. Bodman has invited government members of the international Carbon Sequestration Leadership Forum (CSLF), a voluntary climate initiative that includes 20 developed and developing nations plus the European Commission, to become active participants in the FutureGen project. India is the first of the CSLF members to participate in FutureGen. April 3, 2006, <http://www.energy.gov/news/3420.htm>.

June 2006

DOE Techline, “Twelve Sites Proposed for FutureGen Plant.” Secretary Samuel Bodman announced the 12 candidate sites for the FutureGen project that were submitted in response to the Request for Proposals, issued by the FutureGen Alliance (the Alliance). The announcement was made at the Fifth Annual Conference on Carbon Capture and Storage held in Alexandria, Virginia. The proposals would host the project in or near: 1. Effingham, Illinois; 2. Marshall, Illinois; 3. Mattoon, Illinois; 4. Tuscola, Illinois; 5. Henderson County, Kentucky; 6. Bowman County, North Dakota; 7. Meigs County, Ohio; 8. Tuscarawas County, Ohio; 9. Odessa, Texas; 10. Jewett, Texas; 11. Point Pleasant, West Virginia; and 12. Gillette, Wyoming. The Alliance, which is overseeing the site selection process, plans to deliver a list of finalist sites to the Department of Energy this summer, following a rigorous evaluation and review of the site in accordance with the National Environmental Policy Act. Final site selection is scheduled for the fall of 2007, and plant start-up is planned for 2012. Secretary Bodman’s remarks and a video of his presentation can be accessed at: <http://www.netl.doe.gov/publications/press/2006/bodman-remarks.html>. May 9, 2006, http://www.fossil.energy.gov/news/techlines/2006/06024-FutureGen_Sites_Proposed.html.

July 2006

Department of Energy Press Release, “US and South Korea Sign Agreement on FutureGen Project.” US Department of Energy Secretary Samuel W. Bodman and South Korean Minister of Commerce, Industry and Energy Chung Sye Kyun signed an agreement on June 26 making South Korea the second country, following India, to join the US in the FutureGen International Partnership. South Korea has pledged \$10 million to help construct and operate FutureGen, the world’s first zero-emissions coal-fired power plant, and will sit on a government steering committee which will oversee the initiative. “This agreement signifies our collective commitment to global technological leadership on climate change and future energy needs,” said Secretary Bodman. He added, “This bold and revolutionary initiative known as FutureGen will ensure that clean coal continues to globally supply our energy needs in ways

that are environmentally sustainable and responsible.” Secretary Bodman has also invited government members of the international Carbon Sequestration Leadership Forum (CSLF) to become active participants in project. The CSLF is a voluntary climate initiative that includes 20 developed and developing nations (including India and Korea) and the European Commission. The FutureGen project will be led by the FutureGen Industrial Alliance, an industrial consortium representing the coal and power industries, with the project results being shared among all participants, and industry as a whole. June 26, 2006, <http://energy.gov/news/3778.htm>.

Associated Press, “States Vie For Next-Generation Power Plant.” Seven states, with 12 candidate sites overall, are vying to host the FutureGen project. All of the states are offering some incentives to support the project. “One of these sites ultimately will become known worldwide as the place where a new generation of zero-emission energy plants made its debut,” Energy Secretary Samuel Bodman said, highlighting the importance of the project when announcing the candidate sites. The FutureGen Industrial Alliance (FutureGen Alliance, or Alliance), a non-profit consortium of some of the largest coal producers and users, will partner with the US Department of Energy to site, develop and operate the coal-fueled, zero emissions FutureGen plant. The Alliance is committing \$250 million and the US government \$700 million. “It’s a big deal,” said John Grasser, spokesman for the US Department of Energy’s Office of Fossil Energy. With two dozen states having inquired about the FutureGen Project, for the selected site “it’s going to be an honor to have that science in that state,” said Grasser. Illinois is offering a \$17 million grant towards project costs, an estimated \$15 million in sales tax exemptions, \$50 million for lower rate loans to the FutureGen Alliance, and other property and sales tax abatements. Kentucky is offering 215 acres of free land and \$2.5 million in incentives. North Dakota is offering a total of about \$20 million, including various tax exemptions, \$10 million in matching funds and \$1.56 million in work force training. Ohio is offering a total of up to \$164 million in grants, low-interest loans, and infrastructure support. Texas officials are offering \$20 million to the FutureGen Alliance for use on infrastructure or development, and have recently passed a law indemnifying the FutureGen Alliance of any legal issues arising from the plant’s carbon dioxide. West Virginia is offering 387 acres of state land. Wyoming is offering over \$30 million in incentives including sales tax and use tax exemptions, and 640 acres of land worth \$900,000. The Alliance will deliver list of finalist sites to the Department of Energy this summer, with final site selection scheduled for fall of 2007. June 18, 2006, <http://www.cbsnews.com/stories/2006/06/18/ap/business/mainD8IASIGO1.shtml>.

August 2006

DOE Fossil Energy Techline , “FutureGen Alliance Announces Final Candidate Host Sites.” The FutureGen Alliance announced its short list of candidate sites on July 25 for the FutureGen near-zero emissions coal-fueled power plant. Following an extensive technical review of the 12 competing site proposals from seven states, the final candidate sites chosen for consideration include: Mattoon, IL; Tuscola, IL; Heart of Brazos near Jewett, TX; and Odessa, TX. With input from the US Department of Energy (DOE), independent technical experts, Battelle, and other stakeholders, the FutureGen Alliance’s Site Selection Team developed approximately 100 criteria against which each potential site was evaluated. The criteria were peer-reviewed, publicly-vetted, and designed to reflect the scientific and technical goals of the project, as well as being consistent with the schedule and budget agreed to with the DOE. Three types of criteria were used in the evaluation: 1. qualifying criteria, which are minimum requirements each site had to meet to be considered further; (for example, a minimum of 200 acres of land was required along with adequate cooling water); 2. scoring criteria, which gauge desirable attributes of each site; (for example, sites in close proximity to transmission lines and suitable geology for CO₂ sequestration scored better than sites that were not); and 3. best value criteria, which capture additional factors that affect the sites suitability for the specific mission of the project; (for example: the ability to access hydrogen and power markets). The candidate sites will move to the next step which includes a National Environmental Policy Act (NEPA) evaluation by DOE and more detailed site characterization. Engineering for the power plant will also move forward. Final site selection will occur in

late 2007, with the FutureGen plant going online 2012. For more information, the “Results of Site Offeror Proposal Evaluation” report is available at:

http://www.fossil.energy.gov/programs/powersystems/futuregen/fg_proposal_evaluation_report.pdf. July, 25, 2006, http://www.fossil.energy.gov/news/techlines/2006/06044-FutureGen_Candidate_Sites_Narrowed.html.

The Seattle Times, “Supreme Court To Rule on Regulating Carbon Dioxide,” and *Energy and Environment Daily*, “Supreme Court Mixes Up Global Warming Debate.” The Supreme Court agreed on June 26 to hear arguments on whether the US Government should regulate carbon dioxide (CO₂) as a pollutant. The Supreme Court will hear the case *Massachusetts v. Environmental Protection Agency*, filed by 12 states, 13 environmental groups, two cities and American Samoa against the US Government. The case centers around whether the EPA violated the Clean Air Act in 2003 when it opted not to regulate motor vehicle emissions of greenhouse gases. (Click here to read the 2003 memo explaining the ruling: http://www.eenews.net/features/documents/2006/06/26/document_gw_01.pdf. Subscription may be required to access pdf file.) The plaintiffs’ argument is that the President has the legal authority to regulate CO₂ under the Clean Air Act, since it is linked to climate change and poses a threat to the environment. The Clinton administration endorsed that legal reasoning, but did not issue rules regulating CO₂. The Bush administration rejected the reasoning, and now must convince the Supreme Court that it has no legal obligation to regulate greenhouse gases, including CO₂. The EPA successfully defended its position to the US Court of Appeals for the DC Circuit in 2005, and has issued a statement saying it was “confident in its decision” not to regulate carbon dioxide. The ruling on the case is likely to come next year. June 27, 2006, http://seattletimes.nwsources.com/html/nationworld/2003087868_scotus27.html, and June 27, 2006, <http://www.eenews.net/EEDaily/print/2006/06/27/1>.

Sequestration in the News

September 2005

Fuel Processing Technology, Special Issue on CO₂ capture and sequestration. The latest issue of *Fuel Processing Technology* reports on a symposium titled, “Carbon Dioxide Capture and Sequestration,” held at the 227th American Chemical Society National Meeting in Anaheim, California, in March 2004. A number of articles are cited in the respective sections of the newsletter (see Geology, Technology, and Ocean sections). The general link is: <http://www.sciencedirect.com/science/journal/03783820>. Volume 86, Issues 14-15, Pages 1421-1706, October 2005 (subscription required).

Wall Street Journal, “To Cut Pollution, Dutch Pay a Dump In Brazil to Clean Up; Kyoto Treaty Creates Market In Gas-Emission Credits.” This article profiles the Dutch government’s investment in a Brazilian landfill that will capture methane emissions and generate credits under the Kyoto Protocol’s Clean Development Mechanism (CDM). The article provides background on how the deal was reached, and it highlights some of the setbacks the project is experiencing; mainly, the landfill is not capturing as much methane as expected. August 11, 2005, <http://www.wsj.com> (subscription required).

SRiMedia, “Can the oil barons and big power companies use emission credits from carbon sequestration to finance clean projects?” Article discusses the proposed CO₂ capture project at the Peterhead plant in Scotland and the storage of 1.3 million tonnes per year of CO₂ in the Miller Field. An illustrative schematic of the proposed project is shown. According to a spokesman for one of the project partners, the project does not qualify for emission credits under U.K. Renewable Energy Incentives or for EU Allowances under the European Union Emission Credits Scheme. The project may be financially unviable without such incentives, says the spokesman. August 11, 2005, http://www.srimedia.com/artman/publish/article_904.shtml. Two other articles on the Peterhead project:

"BP trumpets Peterhead as beacon for clean energy," *The Scotsman*, August 10, 2005, <http://www.scotsman.com/?id=1755572005> ; "Science rises to the challenge of global warming," *Financial Times*, August 22, 2005, <http://news.ft.com/cms/s/a67d43de-132f-11da-beee-00000e2511c8.html>. (subscription required).

Cleveland Plain Dealer, "Coal becoming the hot fuel in our energy future." Article discusses the history of coal gas and coal-derived liquid fuels. Highlights an NETL-funded project in Pottsville, Pennsylvania, that will produce about 5,000 gallons per day of diesel fuel from waste coal. Also mentions Syntroleum Corp.'s gas-to-liquids demonstration plant in Oklahoma (200,000 gallons per year of coal-derived diesel fuel) and the Great Plains Synfuels plant (150 million cubic feet per year of coal-derived natural gas). July 31, 2005, <http://www.cleveland.com/energy/plaindealer/index.ssf?/base/isene/112281300730350.xml&coll=2>.

Business Wire, "Syntroleum and Linc Energy Plan to Integrate Air-Based Fischer-Tropsch Technology with Underground Coal Gasification." A planned 17,000 bpd coal-to-liquids plant in Queensland, Australia will integrate Syntroleum's air-based Fischer-Tropsch technology with Linc Energy's underground coal gasification expertise. According to a press release announcing a partnering agreement between the two companies, underground sequestration of carbon dioxide is often an important component of commercial designs. August 15, 2005, http://home.businesswire.com/portal/site/google/index.jsp?ndmViewId=news_view&newsId=20050815005646&newsLang=en

MyWestTexas.com, "Upcoming carbon management workshop to focus on activity." Article discusses the upcoming Carbon Management Workshop set for December 6-7 in Midland, Texas (see *Events* section for more information). Michael Moore, director of the workshop, said this year's workshop will focus more on projects and project-oriented activity. "Economic recovery" is the buzzword. August 28, 2005, http://www.mywesttexas.com/site/news.cfm?newsid=15112090&BRD=2288&PAG=461&dept_id=474107&rfti=6

Cleveland Plain Dealer, "Coal's increasing importance guarantees a fight." Article argues that coal will be the fuel of choice in the future, citing soaring natural gas prices and stagnant nuclear energy generation. "Coal's bright future is all but inevitable, say major producers, because it's the least expensive, even when cleaned up." Article mentions peaking coal production rates in Ohio and the environmental challenges to coal mining and combustion. July 31, 2005, <http://www.cleveland.com/energy/plaindealer/index.ssf?/base/news/1122809455280760.xml&coll=2>

The Observer (UK), "Can coal clean up its act and keep the home fires burning?" High prices for natural gas and crude have caused an increase in the use of coal for power generation in Great Britain since 2000 (currently at 33 percent of total generation). The UK is looking to CO₂ capture from coal-fired power plants to help it meet both energy supply and environmental goals. The author notes that China, India, and the U.S. plan more than 800 new coal-fired power stations between now and 2012. "The CO₂ emitted by these is estimated to be five times the savings made by those adopting Kyoto. In that context, what happens in the UK is a mere puff of smoke." August 21, 2005, <http://observer.guardian.co.uk/business/story/0,6903,1553114,00.html>

The Oxford Press (Ohio), "Search is on way to trap planet-heating carbon dioxide." According to the article, the need to capture CO₂ and store it in safe places is "becoming urgent – and increasingly feasible." The article describes amine scrubbing and geologic sequestration and highlights analysis by Robert Socolow of Princeton University indicating that carbon dioxide capture and storage may add as little as 25 cents to the cost of a gallon of gasoline or \$40 a month to a typical residential electric bill. August 19, 2005, http://www.oxfordpress.com/news/content/shared/news/nation/stories/08/21COAL_SEQUESTER.html

The Navhind Times (India), "Climate Change Project." Highlight the efforts of the Virginia Centre for Coal and Energy Research at Virginia Tech to develop and test technology to store carbon dioxide in coal beds as part of the South-East Regional Carbon Sequestration Partnership (SECARB). August 2, 2005, http://www.navhindtimes.com/stories.php?part=news&Story_ID=08021

The Australian, "Safe, cheap storage of CO₂ 'some way off'." Article discusses the feasibility of geosequestration in Australia. "All the latest clean-coal technologies being pursued around the world depend on being able to show that the storage of carbon dioxide in the various receiving environments is safe, permanent and cost-effective," says the CSIRO's John Wright. "I think we're still some way from that." August 6, 2005, http://www.theaustralian.news.com.au/common/story_page/0.5744.16168650%255E30417.00.html

The Forum (North Dakota), "Non-CO₂ technologies would be the best option." In this op-ed, Joe Richardson, a wind and renewable energy advocate, argues that the best solution to the global warming problem is to accelerate the commercialization of non-CO₂ emitting energy technologies. On the topic of carbon sequestration Richardson says, "sequestering CO₂ in order to increase production of another product that produces more CO₂ may actually be net-negative with respect to the environment and global warming problem...However, if we are to use sequestration we should at least establish a trust fund for the future expenses associated with monitoring sequestration sites." August 27, 2005, <http://www.in-forum.com/articles/index.cfm?id=101211§ion=Opinion> (registration required)

October 2005

The Australian, "Gorgon Project Reaches Environmental Impact Statement (EIS) Stage." A 2,500-page EIS for the Gorgon Project off the West Australian coast has been released and is open for public comment until November 21, 2005. To download the document in PDF format visit http://www.gorgon.com.au/03moe_eis.htm. The Gorgon project proposes to capture CO₂ from produced natural gas (14% CO₂) and inject it into a geologic formation. CO₂ capture and sequestration will reduce the projects GHG emissions from 6.7 million tons of CO₂ equivalent per annum (MTPA) to 4.0 MTPA. The EIS addresses three main issues: quarantining Barrow Island from the introduction of plants and animals from outside; the impact of dredging a 70km pipeline from the Gorgon gas fields; and the challenge of disposing of carbon dioxide. Regarding the geologic sequestration component, the EIS states, "The probability of CO₂ migrating to the surface has been determined to be remote, with potential environmental consequences limited to localized impacts on flora and possible detrimental impacts on subterranean fauna." "Radical method may bury gas plant," September 13, 2005, http://www.theaustralian.news.com.au/common/story_page/0.5744.16583997%255E30417.00.html

PWR Newswire, "FutureGen Industrial Alliance Announced." A coalition of the largest electric utilities and coal companies in the United States announced that they have created the FutureGen Industrial Alliance, a non-profit company that will partner with the U.S. Department of Energy to facilitate the design, construction and operation of a 275 MW coal-fired power plant with zero emissions. The seven founding members of the FutureGen Industrial Alliance are: American Electric Power, BHP Billiton, CONSOL Energy Inc., Foundation Coal Corporation, Kennecott Energy Company, Peabody Energy, and Southern Company. The Alliance is also in discussions with other companies, both domestic and international, and expects membership to grow. September 13, 2005, <http://www.prnewswire.com/cgi-bin/stories.pl?ACCT=104&STORY=/www/story/09-13-2005/0004105900&EDATE>

Onpoint, "DOE Official Talks About FutureGen, explains blueprint for DOE's zero-emissions coal plant." In an interview with Darren Samuelson, Victor Der, director of the Office of Power Systems at the Energy Department, talks about the road ahead for FutureGen, negotiations with Congress over clean coal funding, and DOE's efforts to involve other countries in carbon sequestration research. Der states that the Department of Energy is in the early stages of building FutureGen, with a recent commitment by

electric utilities and coal companies to pick up one-quarter of the project's cost. *E&ETV News*, September 23, 2005. You can watch video of the interview at <http://www.eande.tv/main/?date=092305&page=1>

Business Wire, "GE Energy, Bechtel Get Approval from AEP to Proceed with Plans for IGCC Project; A Milestone for Cleaner Coal Technology in the United States." GE Energy and Bechtel announced the signing of an agreement with AEP to proceed with the front-end engineering design (FEED) phase for a proposed commercial, 629-megawatt IGCC plant to be built at a site in Meigs County, Ohio. The FEED process is expected to take 10 to 12 months. Target for commercial startup of the new IGCC plant is 2010. The new AEP facility would be the first commercial-scale, IGCC plant built in the United States since Tampa Electric's Polk Power Station came online in 1996. Says John Krenicki, Jr., president and CEO of GE Energy, "Today's announcement is a clear sign that the energy industry is ready to enter a new era of cleaner coal power plants." A press release notes that the IGCC process generates lower sulfur dioxide, nitrogen oxide, mercury and particulate matter emissions, uses less water, and can be more economically retrofitted for carbon capture than a traditional pulverized coal plant. September 29, 2005, http://home.businesswire.com/portal/site/google/index.jsp?ndmViewId=news_view&newsId=20050929005350&newsLang=en

New York Times, "Steps to Limit Global-Warming Gas." Capturing and storing the carbon dioxide generated by power plants and factories could play an important role in limiting global warming caused by humans, says the Intergovernmental Panel on Climate Change (IPCC). In the Special Report on Carbon Capture and Storage (CCS) the IPCC says doing so could cut the cost of stabilizing carbon dioxide concentrations in the atmosphere as much as 30 percent compared with other options, like switching to cleaner technologies. Altogether, the report says sequestering carbon dioxide could eventually account for slightly more than half of what is needed to prevent dangerous concentrations in the atmosphere. But the report cautions that while the method is cheaper than others, it would significantly raise the cost of electricity for many years. For that reason, several authors and United Nations officials said, it is unlikely that the technique will be adopted voluntarily by industries in wealthy countries. "First there has to be a policy in place to provide the incentive" to adopt such technologies, said Bert Metz, a Dutch environmental official who was the lead author of the report. September 28, 2005, <http://www.climateark.org/articles/reader.asp?linkid=46698>. Also see, "Carbon dioxide storage holds limited promise: Approach could halve industrial emissions by 2050," *news@nature*, September 27, 2005, <http://www.nature.com/news/2005/050926/full/050926-6.html> (subscription required). A summary of the report, which was released on September 26, is available online at <http://www.ipcc.ch>

East Bay Express, "Down with Greenhouse Gas." Article highlights an upcoming geologic sequestration field test in Solano County, California's Rio Vista gas fields. The pilot projects will be overseen by the West Coast Regional Carbon Sequestration Partnership (WESTCARB). In the next year, it is expected that two thousand to four thousand tons of carbon dioxide will be purchased, trucked to Solano County, and injected into a layer of sandstone five thousand feet beneath the Earth's surface. The total effort will cost \$29.9 million over the next four years, with the government contributing \$14.3 million. "The Central Valley in general is a very attractive place to think about the storage of CO₂ in the subsurface," says Larry Myer, WESTCARB's technical director. Estimates show the area's rock formations could hold eighty billion to five hundred billion tons of carbon dioxide, the equivalent of hundreds of years of emissions from California's power plants and industrial sources. The Partnership will also work on terrestrial sequestration. September 14, 2005, <http://www.eastbayexpress.com/Issues/2005-09-14/news/cityside.html>

Nature, "Deadly lakes may explode again: Pipes to avert disaster are working, but not quickly enough." This article highlights an ongoing project to remove dangerous levels of carbon dioxide from the bottom of two lakes sitting over volcanic sites in Cameroon. One of these, Lake Nyos, exploded in 1986, suffocating more than 1,700 people in the surrounding area with a plume of carbon dioxide.

Nearby Lake Monoun killed about 40 people when it exploded in 1984. September 26, 2005, <http://www.nature.com/news/2005/050926/full/050926-4.html> (subscription required)

BBC News, "UK, China in cleaner power plan." Article highlights a proposed British plan to transfer clean coal technology to China. Britain's Department of Environment, Food and Rural Affairs is proposing joint research and development between UK, European and Chinese partners – involving academic, research institutions and industry partners – leading towards a demonstration project starting up between 2010 and 2015. The article mentions the planned BP storage project in the North Sea and says a medium scale demonstration capture and storage plant is being developed by the EU in Germany and should be ready by 2008. According to the article, "the U.S. hopes to have a large-scale demo plant operating by around 2015 and EU officials hope the Chinese venture will also deliver by around the same date." September 1, 2005, http://news.bbc.co.uk/go/pr/fr/-/2/hi/uk_news/4204812.stm

November 2005

Reuters, "Coal challenging gas as power-plant fuel." Worldwide demand for coal is growing faster than expected, rising 25 percent in the last three years, to 1.1 billion tonnes. "Coal has stepped up to fill the void left by the limitations on oil and gas," said Gregory Boyce, president of Peabody Energy. "When it comes to coal, progress is being made on reducing the CCS cost and as soon as it gets down from \$100 now to around \$40, the coal business will be able to say they can deliver cheaper electricity and meet the CO₂ requirements," said Gerald Doucet of the World Energy Council. October 27, 2005, http://news.yahoo.com/s/nm/20051027/sc_nm/coal_power_dc

Reuters, "Clean coal Isn't Climate-Friendly Yet." Only a fraction of planned coal fired power plants in the United States will use "the Holy Grail of clean coal technology" – integrated gasification combined cycle (IGCC) – because of the high initial cost. Says John Stowell, environmental strategist at utility Cinergy Corp, "This is the way we need to go to preserve the coal option." American Electric Power Co Inc. and Cinergy plan to build IGCC plants in the Midwest in the next decade. But they don't plan yet to add the capturing equipment on the IGCC plants they aim to build. "Until there is such a requirement we're not going to put that technology in place at this point," said Melissa McHenry, a spokeswoman for AEP. October 7, 2005, <http://www.planetark.com/dailynewsstory.cfm/newsid/32896/newsDate/10-Oct-2005/story.htm>

Toledo Blade, "The battle is on to capture, store carbon dioxide." Mainstream article discusses increasing evidence of climate change and the emergence of CO₂ capture and sequestration as an option for reducing emissions. Highlights the Midwest Regional Carbon Sequestration Partnership and mentions geologic and terrestrial carbon sequestration projects throughout the world. October 17, 2005, <http://toledoblade.com/apps/pbcs.dll/article?AID=/20051017/NEWS08/510170310/-1/NEWS>

Seattle Post Intelligencer, "Washington State Proposes New Power Plant." Article discusses how demand for electricity in the Pacific Northwest is gradually increasing and some argue that conservation and investment in renewable energy resources will meet rising demand. Energy Northwest supports and has participated in those efforts but does not believe they alone will meet demand, said Tom Krueger, the agency's project manager. In addition, he said, the region won't support hydropower expansion, a new nuclear plant in Washington simply isn't an option, and natural gas has become inordinately expensive. Instead, Energy Northwest is proposing to build an IGCC plant that would gasify coal or petcoke to generate power. The plant could also burn natural gas if the price declines, said Krueger. He added that the proposed plant would capture the carbon dioxide emissions for storage, and he said Energy Northwest is already taking part in a study to inject emissions into basalt deposits, which are common in the region. October 21, 2005, http://seattlepi.nwsourc.com/business/1310AP_Deja_WPPSS.html

Environmental Finance, “New industry group aims to promote carbon capture and storage.” A group of large UK-based companies, including some of the world's biggest oil producers, have formed a new organization to promote technology for storing greenhouse gases underground. The Carbon Capture and Storage (CCS) Association believes this technology can help the UK meet its emission reduction goals and may also extend the life of North Sea oil fields. The founding members of the association are: BP, E.ON UK, Progressive Energy, Air Products, Alstom Power UK, AMEC, ConocoPhillips, Mitsui Babcock, Schlumberger Oilfield UK, Scottish & Southern Energy, and Shell. “CCS is absolutely essential if the world is serious about limiting greenhouse gas emissions”, said Lord Oxburgh, president of the new association and former chairman of Shell Transport and Trading. October 6, 2005, <http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=16733>

Bozeman Daily Chronicle, “Coal-to-fuel proposal raises environmental concerns.” Article highlights a proposal by Montana Governor Brian Schweitzer to build 150,000 barrel-per-day coal liquid fuel plant in the state. The plan has been met with resistance from the Northern Plains Resource Council and others who cite the SASOL synfuel facility in South Africa that consumes five barrels of water per barrel of fuel produced and also emits large amounts of sulfur dioxide and nitrous oxides. Schweitzer proposes to build a plant based on IGCC technology which uses less water, emits less pollution, and produces a capture-ready exhaust of highly concentrated CO₂. October 16, 2005, <http://www.bozemandailychronicle.com/articles/2005/10/16/news/01synfuels.txt>

ElectricNet, “The China Huaneng Group Joins FutureGen Industrial Alliance.” The FutureGen Industrial Alliance announced that the China Huaneng Group – China's largest coal- fueled power generator – has joined a coalition of global electric utilities and coal companies that plan to design, construct and operate the world's first “zero-emission” coal-fueled power plant. The Huaneng Group is one of the top ten power companies in the world and is the largest coal-based power generator in China, representing about 9 percent of China's generating capacity. October 27, 2005, <http://www.electricnet.com/content/news/article.asp?DocID=%7BAFA1D271-D2ED-4A59-81B1-7ED8A341B4DE%7D&Bucket=Current+Headlines&VNETCOOKIE=NO>

BBC News, “MP's clean coal energy solution.” According to a Member of Parliament (MP), unmined coal in Wales could be the answer to Britain's energy crisis, and “clean coal” technology could make the fuel eco-friendly. “Clean coal technology with zero emissions from these new generating plants is one of the ways forward and I'm optimistic the government will look at this quite favorably,” the MP said. He also said carbon sequestration under the North Sea could also be used. Said Huw Irranca-Davies MP, “It seems like absolutely amazing science fiction...but it's already being done in Algeria and elsewhere, and highly productively.” October 12, 2005, http://news.bbc.co.uk/go/pr/fr/-/2/hi/uk_news/wales/4333534.stm

MSNBC, “Cleaner coal? Activists now say it's possible.” Article claims that the notion of IGCC technology having a role in future electricity supply, once heresy in environmental activist circles, is now gaining some acceptance. That is, as long as the industry goes a step further by trapping carbon dioxide. “We believe it [IGCC] should be considered the requirement for a modern power plant, but until [carbon capture] happens, this is still just the shiny object that distracts us from the nearly 500 dirty coal plants that are polluting the air,” said Greenpeace energy policy specialist John Coequyt. October 10, 2005, <http://msnbc.msn.com/id/9619627/>. Also see, “How to Clean Coal,” *onearth*, Fall 2005, <http://www.nrdc.org/onearth/05fal/coal1.asp>

Forbes, “Statoil CEO Lund sees UK-Norway collaboration on carbon dioxide capture.” Speaking at a conference in London, Statoil chief executive Helge Lund said that he sees a potential for collaboration between the oil and gas industries in Norway and Britain in using carbon dioxide for improved oil recovery (IOR). Statoil has pioneered CO₂ capture and injection through the Sleipner and Snohvit projects, and seeks to build on its capability. October 26, 2005, <http://www.forbes.com/markets/feeds/afx/2005/10/26/afx2300586.html>

Oil & Gas Journal, "Australia seeks CO₂ sequestration program." Australia wants to become a world leader in reducing greenhouse gas emissions through the capture and long-term geological storage of carbon dioxide, according to Ian Macfarlane, Australia's Minister for Industry, Tourism, and Resources. Speaking at the fourth multinational Carbon Sequestration Leadership Forum in Berlin, he said, "Australia has the geology, the scientific expertise, the industry enthusiasm, and the political will to capitalize on the carbon capture opportunity." October 4, 2005, <http://ogj.pennnet.com> (subscription required)

December 2005

Associated Press, "Carbon Dioxide Storage a Success." According to the Department of Energy, the Weyburn EOR project in Canada has proven to be a success, removing 5 million tons of CO₂, while enhancing oil recovery. If the methodology could be applied worldwide, from one-third to one-half of the carbon dioxide emissions that go into the atmosphere could be eliminated over the next century and billions of barrels of additional oil could be recovered, the department said. "The success of the Weyburn Project could have incredible implications on reducing CO₂ emissions and increasing America's oil production," said Energy Secretary Samuel Bodman. In a statement released by his office, Bodman said that if the process were used in all the oil fields of western Canada, "we would see billions of additional barrels of oil and a reduction of CO₂ emissions equivalent to pulling more than 200 million cars off the road for a year." This AP article was picked up by news organizations throughout the world including: *Yahoo News*, *Washington Post*, *USA Today*, *LA Times*, *Seattle Post-Intelligencer*, and the *Peoples Daily* (China). November 15, 2005, <http://www.enn.com/today.html?id=9261>

Oil & Gas Journal, "Weyburn project demonstrates CO₂ sequestration, EOR." Highlighting the success of the Weyburn project, this article says scientists project that knowledge gained from the project will keep the Weyburn oil field viable for an additional 20 years, produce an additional 130 million bbl of oil, and sequester as much as 30 million tons of CO₂. The project now will move into a second phase, where researchers will compile a best practices manual to serve as a reference in the design and implementation of CO₂ sequestration in conjunction with enhanced recovery projects. Researchers also will expand their efforts to the neighboring Midale Unit, develop more rigorous risk-assessment modeling techniques, improve injection efficiencies, and monitor CO₂ flooding and storage with a variety of methods, including seismic wave technologies and geochemical surveys, DOE said. November 16, 2005, http://ogj.pennnet.com/articles/article_display.cfm?Section=ONART&C=GenIn&ARTICLE_ID=241606&p=7 (subscription required)

Star Tribune, "Cleaning up coal: Promising new, cleaner technologies." Article chronicles the development of what some environmentalist and industry folks say could be a watershed case in determining the future role of coal-fired generation in several Upper Midwest states. Lines are being drawn in response to a proposal by Great River Energy and its partners to build the Big Stone II plant in South Dakota that would bring coal-fired power to the Twin Cities. The \$1.2 billion Big Stone II plant will generate less mercury and other pollutants than the smaller Big Stone I plant in eastern South Dakota generates today, thanks to waste-heat usage, pretreatment of the coal and advance scrubbers that will be installed in both units. However, environmentalists argue that the proposed pulverized-coal plant will do little to mitigate carbon dioxide emissions. Environmental groups plan to fight the necessary construction and transmission permits before state regulators and they will insist that it's foolish to proceed with old, pulverized-coal technology and that the plant can wait until carbon-capturing technologies are in place. Great River CEO Dave Saggau has said he believes new technologies (IGCC with CCS) are too far off to be included in Big Stone II, which is scheduled to start construction in 2007. November 9, 2005, <http://www.startribune.com/stories/1069/5715770.html>

Greenwire, "In Florida, Residents Stop Proposed Power Plant." A plan by Florida Power & Light, which sought to build two 850-megawatt coal units on a 3,000-acre tract in rural southwest St. Lucie

County, was dealt a blow when the County Commission voted down the proposal with a 5-0 commission vote. The utility had tried to win public support for the plant with assurances that it would be equipped with state-of-the-art pollution controls allowing for minimal air and water emissions. It also said the plant would be an economic boon to the county by providing nearly 200 jobs and millions of dollars in tax revenue. But such arguments did not win favor with the commission, which ultimately decided that concerns about noise, light and air emissions were enough to derail the project. FPL planned to use supercritical pulverized coal combustion technology. Stephen Smith, executive director of the Southern Alliance for Clean Energy, which worked to stop the project, said that while his organization and others encouraged FPL to adopt coalbed gasification technology for the St. Lucie County plant, the company refused on grounds that IGCC was unproven and that the same environmental protections could be achieved with pulverized coal. The article points out that IGCC technology was selected for another Florida power plant being built by Southern Co. and the Orlando Utilities Commission. That project, known as the Stanton Energy Center, is expected to come online by 2012 and has faced minimal public opposition. November 8, 2005, <http://www.nrdc.org/news/newsDetails.asp?nID=1910>

Fox News, "FOX News Poll: Global Warming." Most Americans believe global warming exists and a majority thinks it is a major problem – if not a crisis, according to a recent FOX News poll. However, less than half think they personally can do anything about the problem. The new national poll finds that 77 percent of Americans believe global warming is happening and, of those, more than twice as many think it is caused by human behavior (46 percent) than by normal climate patterns (17 percent). All in all, Americans take the issue of global warming seriously. A 60 percent majority describes the situation as either a crisis (16 percent) or a major problem (44 percent), while about one in five say it is a minor problem (22 percent) and one in ten "not a problem at all" (12 percent). "Despite the skepticism that has been expressed by some business, scientific and political leaders, the existence and importance of global warming seems to be the consensus position of Americans," comments Opinion Dynamics Chairman John Gorman. "This lopsided acceptance of the problem is something we don't see for many other issues." November 10, 2005, <http://www.foxnews.com/story/0,2933,175070,00.html>

Science Daily, "Western states to host first test of carbon sequestration in lava rock." Article highlights upcoming field tests by the Big Sky Carbon Sequestration Partnership, which the U.S. Department of Energy and private companies awarded \$17.9 million in June. Researchers are making preparations to inject carbon dioxide into subterranean volcanic basalt rock and monitor whether the rock can hold it. At first, basalt seemed an unlikely candidate for sequestration; engineers regarded it as too dense. But basalt accumulates in layers, as successive lava outpourings spread out and cool, forming a stack like pancakes, each tens to hundreds of feet thick. The fast-cooled, rubbled tops are full of cracks and gas bubbles; the slow-cooled, dense interiors form impermeable barriers. Using computer models of the rocks' porosity and chemistry, the group reported in 2004 that layered basalts appeared to be well suited for secure, long-term storage. November 7, 2005, <http://www.sciencedaily.com/releases/2005/11/051107081311.htm>

Houston Chronicle, "Spinning Tar into Oil." Article focuses on Alberta oil sands and discusses how the recent run up of oil prices has made this unconventional resource profitable, adding more than 170 billion barrels of oil to Canada's reserve base. Also highlighted is the effect of these operations on Canada's commitments under the Kyoto Protocol. Carbon sequestration is mentioned as a solution that can keep the oil sands progressing while keeping Kyoto alive. The article says that Kinder Morgan is interested in carbon sequestration in Alberta. Alberta Energy Minister Greg Melchin likes the idea of sequestration but said that, as it stands, the economics are marginal at best. November 6, 2005, <http://www.chron.com/cs/CDA/ssistory.mpl/business/energy/3440367>

South China Morning Post, "Despite its problems, coal is here to stay." According to this article, which focuses mainly on coal mining in China and much needed safety and infrastructure improvements, the long run answers to China's energy and environmental problems may be found in cutting-edge technologies such as underground gasification and carbon sequestration. The article says these

techniques will take decades to develop on a commercial scale, however. "Until then, China will have to continue mining and burning coal the bad old way, at a heavy cost to both the country's miners and its environment." November 7, 2005,

<http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTcxNjE>

RigZone, "Statoil Says IOR Challenges Offer Potential for UK-Norwegian Cooperation." Speaking at a conference in London, Statoil chief executive Helge Lund urged that the use of carbon dioxide for improved oil recovery (IOR) could address growing energy demand while simultaneously reducing greenhouse gas emissions which affect the global climate. "We've been a pioneer in carbon capture and storage," said Lund. "Since 1996, we have separated carbon from the gas stream on our Sleipner fields and injected it into a permanent sub-surface store. The next step could be to establish a carbon dioxide value chain where, in addition to storage, an improved oil recovery (IOR) effect could be included."

October 26, 2005, http://www.rigzone.com/news/article.asp?a_id=26316

January 2006

Department of Energy Press Release, "FutureGen Project Launched." In a press release issued on December 6th, Secretary of Energy Samuel W. Bodman announced the official "kick off" of the FutureGen project by the Department of Energy with the signing of the FutureGen Industrial Alliance agreement. The FutureGen Industrial Alliance consists of: American Electric Power (Columbus, OH); BHP Billiton (Melbourne, Australia); CONSOL Energy Inc. (Pittsburgh, PA.); Foundation Coal (Linthicum Heights, MD.); China Huaneng Group (Beijing, China); Kennecott Energy (Gillette, WY); Peabody Energy (St. Louis, MO); and Southern Company (Atlanta, GA). The Alliance members will contribute \$250 million toward the project to build FutureGen, a prototype of the zero emissions fossil-fueled power plant. The Alliance will issue a site selection solicitation in early 2006, with final site selection in mid-to-late 2007, and the plant is planned to be operational around 2012. The project will integrate testing of emerging energy supply and utilization technologies as well as advanced carbon capture and sequestration systems. The initial goal for carbon sequestration for FutureGen is to capture 90 percent of the plant's CO₂, with 100 percent possible through implementation of advanced technologies. The FutureGen Initiative is funded through the Department's Office of Fossil Energy and will be managed by the National Energy Technology Laboratory. December 6, 2005,

http://www.energy.gov/engine/content.do?PUBLIC_ID=19301&BT_CODE=PR_PRESSRELEASES&TT_CODE=PRESSRELEASE

St Louis Business Journal, "Illinois, Indiana join to attract FutureGen project," Indiana Gov. Mitch Daniels and Illinois Gov. Rod Blagojevich agreed on December 14 to make a united bid to bring FutureGen to the Illinois Coal Basin. US Rep. Jerry Costello (D-Belleville) and US Rep. John Shimkus (R-Collinsville) have lead the effort to locate FutureGen in Southern Illinois, which has high-sulfur coal reserves, oil and gas reserves, well-suited geography and the Coal Center at the Southern Illinois University Carbondale. December 15, 2005,

<http://stlouis.bizjournals.com/stlouis/stories/2005/12/12/daily50.html>

The Daily Texan, "CO₂ Use Found in Oil Project," Texas plans to aggressively pursue the bid for FutureGen. The state Legislature has allotted \$2 million to fund a team of researchers at the University of Texas (UT) who are working on a bid proposal. Scott Tinker, director of the UT's FutureGen project, said Texas is the best candidate to house the prototype because of its geology, with large coal deposits, oil fields and places to store sequestered carbon dioxide. In addition, the state has a thriving oil industry with the necessary infrastructure, Tinker said. December 8, 2005,

<http://www.dailytexanonline.com/media/paper410/news/2005/12/08/University/Co2-Use.Found.In.Oil.Project-1124534.shtml?nrewrite&sourcedomain=www.dailytexanonline.com>

The Engineer Online, "North Sea Rim Accord," United Kingdom Energy Minister Macolm Wicks and Norwegian Energy Minister Odd Roger Enoksen pledged to undertake a bilateral effort to explore areas of cooperation to encourage injection and permanent storage of CO₂ beneath the North Sea. Said Wicks, "It is estimated that we have the capacity under the UK continental shelf to store our total carbon emissions for decades to come." Wicks added, "Norway has already taken a significant world lead in offshore geologic storage of CO₂ with the Sleipner project, building up considerable knowledge and experience in the field. Here in the UK, I welcome BP/Scottish and Southern Energy Peterhead project in the North Sea which will demonstrate the full carbon capture and storage process." The Carbon Abatement Technology Strategy, announced in June this year, recognized that incentives may be need to encourage this technology development. The Climate Change Programme Review will review and comment on the incentives, including details on the need and scope of the incentives. November 30, 2005, <http://www.e4engineering.com/Articles/292935/North+Sea+rim+accord+.htm>

Science Daily and University of Michigan press release, "Crystal Sponges Excel At Sopping Up Carbon Dioxide," A new class of materials called metal-organic frameworks (MOFs) have been shown to have great potential for storing hydrogen and methane. On the molecular level, MOFs (also known as crystal sponges) are scaffolds made up of metal hubs with struts of organic compounds, maximizing surface area. One particular "star performer" in the class of compounds, MOF-177, can store 140 percent of its weight in CO₂ at room temperature and at 32 bar pressure. For comparison, in a tank filled with MOFs, one can store as much carbon dioxide as nine tanks that do not contain MOFs; whereas a tank filled with porous carbon—one of the current state of the art materials used for capturing CO₂ in power plant flues—could hold only four tanks worth of CO₂.

December 1, 2005, <http://www.sciencedaily.com/releases/2005/12/051201164914.htm>

See Technology section of this newsletter for reference to December 1, 2005 web release of American Chemical Society journal article.

RGGI Press Release, "States Announce RGGI MOU Today," On December 20, seven Northeast governors announced a historic regional agreement to reduce greenhouse gas emissions from power plants, an important step to protect the environment and meet the significant challenge of climate change. Under the Regional Greenhouse Gas Initiative (RGGI) "ReGGie," seven Northeast states have agreed to implement a cap-and-trade program to lower carbon dioxide (CO₂) emissions. This is the first mandatory cap-and-trade program for CO₂ emission in US history. The states signing the regional Memorandum of Understanding for RGGI are: Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York and Vermont. December 20, 2005. Copies of the MOU and related documents are available at: <http://www.rggi.org/agreement.htm>

Associated Press, "Connecticut Governor Says She'll Sign Regional Emissions Deal," Connecticut Gov. Jodi Reil said December 15 that she will sign the agreement. Her decision comes after officials from Connecticut, Rhode Island, and Massachusetts decided after a conference call December 14 that they weren't prepared to sign the RGGI. Rell, in a written statement, called the pact a "historic milestone" that addresses climate change issues while moving the region down the path of energy independence. "The agreement creates incentives that will reduce our reliance on fossil fuels and help free our economy from the price volatility of world oil and gas markets," she said. Adding, "The agreement is also structured in a manner that protects consumers from sharp increases in energy costs." December 15, 2005, http://www.boston.com/news/local/massachusetts/articles/2005/12/15/connecticut_governor_says_shell_sign_regional_emissions_deal?mode=PF

Boston Globe, "No Agreement Reached on Regional Carbon Dioxide Emissions Pact," The landmark Regional Greenhouse Gas Initiative (RGGI) multi-state agreement to reduce carbon dioxide emissions in the Northeast was in jeopardy. After the December 14 conference call among the chiefs of staff of all states involved in the program, Massachusetts, Connecticut, and Rhode Island decided they are not prepared to sign the agreement. Jeff Neil, spokesman for Rhode Island's Gov. Don Carcieri, said the Governor is concerned about the costs of the plan. "Ultimately, we don't know how much this plan will raise energy prices," said Neil. Their decision prompted cancellation of the December 15 news

conference that had been planned to announce the pact. The draft proposal would freeze utility emissions at current levels through 2015, and then require a 10 percent reduction by 2020. Excess emission "credits" could be sold. Massachusetts Gov. Mitt Romney, in an interview with the Boston Globe, confirmed that he could not endorse a plan that did not include a "safety valve," one that would cap the amount power plants would have to pay if they exceed emission limits—since those costs could be passed onto businesses and consumers. Peter Constakes, a spokesman for New York Governor George Pataki, stated "We are greatly disappointed that after two-and-a-half years of productive work we've been unable to reach a final agreement with all the states that have participated in the process." Seth Kaplan, with the Conservation Law Foundation in Boston disputed concerns that the program would cost consumers money. Matt Vogel, spokesman for Rep. Martin Meehan, D-Mass., said work needs to be continued to make the proposal a reality, stating "Massachusetts ought to be the leader on making the initiative work, but essentially we've become the leader of the opposition." December 15, 2005, http://www.boston.com/news/local/new_hampshire/articles/2005/12/15/no_agreement_reached_on_regional_carbon_dioxide_emissions_pact/

Reuters, "US States Forge on With Slimmer Plan to Cut CO₂," Massachusetts and Rhode Island did not sign the Regional Greenhouse Gas Initiative (RGGI) agreement along with the remaining seven states. Massachusetts Gov. Mitt Romney (Republican) refused to sign, saying that the agreement could boost prices for electricity in his state, which are among the Nation's highest. Rhode Island said more studies are needed on how cutting carbon emissions would affect prices for electricity. Environmentalists and carbon emissions brokers are anxious to see RGGI operational because they hope it will link with similar plans being developed in western states and could be a model for a future federal plan. December 19, 2005, <http://www.planetark.com/dailynewsstory.cfm/newsid/34100/story.htm>

The Boston Globe, "BP to Boost Renewable Energy Funds," Europe's largest oil company, BP PLC, plans to double spending on alternate and renewable energy, creating a business unit that may generate about \$6 billion per year in revenue. BP will invest \$1.8 billion over the next three years on solar, wind, hydrogen, and carbon sequestration, focusing on new technologies to replace oil-and-gas-based generation. Under sequestration, CO₂ would be pumped into oil and gas fields, curbing output into the atmosphere. Chief Executive John Brown said, "We're responding to climate change by making a business." The \$600 million investment next year equals 4 percent of BP's total capital expenditure of about \$15 billion in 2006. BP would like about 7 gigawatts of installed capacity around the world within 10 years, enough to supply 10 percent of Britain's power needs. BP Alternate Energy will be headed by Steve Westell. November 29, 2005, http://www.boston.com/business/technology/articles/2005/11/29/bp_to_boost_renewable_energy_funds/?rss_id=Boston+Globe+---+Business+News

Greenwire, "Tall buildings could pose threat to carbon sequestration," As the world sees construction of increasingly tall structures, seismic activity has risen. Implications could affect plans for carbon sequestration and nuclear waste storage. Taipei has seen a rise in micro-earthquakes since the construction of the world's tallest building, Taipei 101. Stresses in the earth's outer layer can push the sides of the fault together until rocks plummet and release energy in waves that cause the ground to shake. Geologist Lin Cheng-horng, from the Institute of Earth Sciences, said Taipei 101 weighed 700,000 tons, estimating stress from vertical loading on its foundation at 4.7 bars, of which some would be transferred to the earth's upper crust due to extremely soft sedimentary rocks beneath the Taipei basin. "If a fault is about to crack," says Lin, "then a little pressure can trigger an earthquake. It's like the last straw that breaks the camel's back." In May 2001, the magnitude 5 earthquake in the North Sea is thought to have been caused by a release in pressure from oil and gas extraction. And in 1967, waste injected into the Rocky Mountains set off a magnitude 5.5 earthquake under Denver in Colorado. December 5, 2005, http://www.eenews.net/Greenwire/searcharchive/test_search-display.cgi?q=tall+buildings&file=%2FGreenwire%2Fsearcharchive%2FNewsline%2F2005%2FDecember5%2F12050516.htm (subscription may be required)

Business Wire, “GreenShift Acquires Rights to Patented Carbon Dioxide Reduction Technology; New Strain of Thermophilic Cyanobacteria Converts Exhaust Carbon Dioxide Into Pure Oxygen and Clean Water,” GreenShift Corporation has announced the execution by its wholly-owned technology transfer and industrial design company, GreenShift Industrial Design Corporation ("GIDC"), of a license agreement with Ohio University ("Ohio") for its patented bioreactor process for reducing greenhouse gas emissions from fossil-fuelled combustion processes. The technology was developed by Dr. David Bayless, Director of Ohio's Ohio Coal Research Center, who targeted a carbon-hungry thermophilic photosynthetic organism, which thrives in the mineral hot springs of Yellowstone, for use in a bioreactor. The iron-loving cyanobacterium (blue-green algae), tentatively named *Chroocloeocystis siderophila*, grows on membranes of woven fibers resembling window screens, that are layered with “glow plates”—a system of parabolic mirrors, fiber optic cables and slabs of acrylic plastic. The membranes allow for growth of the algae on a large surface area, using only 10 percent of “full strength” sunlight. The algae metabolize the carbon dioxide and water, giving off oxygen and water vapor. The organisms also absorb nitrogen oxide and sulfur dioxide, acid rain contributors. A prototype of the technology was built that can handle 140 cubic meters of flue gas per minute, equivalent to the exhaust of 50 cars or a 3 megawatt power plant. GIDC's license with Ohio provides for non-exclusive rights to the technology for the purpose of air pollution control of exhaust gas streams from electrical utility power generation facilities; exclusive rights to the technology for the air pollution control of exhaust gas streams from all other sources, including mobile applications; and to process carbon-containing compounds from any other source. December 12, 2005,
http://home.businesswire.com/portal/site/google/index.jsp?ndmViewId=news_view&newsId=20051212005469&newsLang=en

Nature Conservancy, “First Conservation Initiative Certified for Reducing Greenhouse Gas Emissions,” The Noel Kempff Mercado Climate Action Project, a Bolivian project protecting 3.8 million acres of tropical forest, is the first conservation-based initiative in the world to be fully certified for reducing greenhouse gas emissions. The Société Générale de Surveillance (SGS), an internationally accredited society for the CO₂ emission certification, evaluated the project's results from 1997 to 2005. SGS fully certified the emission reductions at 989,622 metric tons, using the rigorous standards detailed in the Clean Development Mechanism initiative of the Kyoto Protocol. December 19, 2005,
<http://nature.org/initiatives/climatechange/press/press2192.html>

February 2006

CNN.com, “US to Attend Asia-Pacific Climate Talks,” Energy Secretary Samuel Bodman, Secretary of State Condoleezza Rice (who cancelled due to the health condition of Ariel Sharon), and Presidential advisor James Connaughton are to meet in Sydney Australia on January 11-12 with representatives from five Asia and Pacific Nations: Australia, China, India, Japan and South Korea. Along with the US, these countries account for almost half of the world's population, energy use, and economic output. The White House feels that these talks serve to enhance, rather than replace the Kyoto talks. The US and Australia were the only developed countries that rejected the 1997 Kyoto Protocol treaty. Connaughton said the “Asia-Pacific partnership” would drum up more private investment for common goals, including US and Chinese plans to improve energy efficiency in coal-burning power plants and cut acid rain-causing sulfur dioxide emissions. “This is harder than negotiating a diplomatic document, because this is creating real work plans,” said Connaughton. January 5, 2006,
http://www.cnn.com/2006/TECH/science/01/05/us.asia.climate.change.ap/index.html?section=cnn_latest

Environmental News Service, “Bush to Request \$52 Million for Asia-Pacific Energy Partnership,” President Bush will request that Congress budget \$52 million in the upcoming FY 2007 budget to promote clean energy technologies in the Asia-Pacific region and international cooperation in other energy areas, said US Energy Secretary Samuel Bodman addressing the inaugural gathering for the Asia-Pacific Partnership for Clean Development and Climate (APP) on January 12. Secretary Bodman said that the funding request is designed to complement the \$3 billion that the US currently spends per

year on clean energy projects. As head of the US delegation to the meeting, Bodman stated, "In order to achieve meaningful results, we must engage growing and emerging economies from the outset and encourage the implementation of technologies that have demonstrated success." Australian Industry Minister Ian Macfarlane stated that Australia has a responsibility to explore fully the potential of new and innovative emission reducing technology, such as geosequestration and clean coal technologies. He announced on January 9 that Australia's first CO₂ capture and storage demonstration project will start this year. About half of Australia's CO₂ emissions could potentially be sequestered because they are derived from stationary sources, Macfarlane stated. Secretary Bodman said that the success of the APP will be measured largely by the success of the investment and collaboration of private sector partners. (Read the full text of Secretary Bodman's remarks at: <http://www.energy.gov/news/2964.htm>.) January 13, 2006, <http://www.ens-newswire.com/ens/jan2006/2006-01-13-01.asp>

Wall Street Journal, "Coal Gasification Begins to Emerge," Integrated gasification combined cycle (IGCC) technology and implementation is discussed. In the US, there are two IGCC plants: one in Indiana and one in Florida, subsidized by the US Department of Energy. IGCC plants gasify coal and generate electricity with advanced turbines that use the gas and excess heat. American Electric Power's (AEP's) program manager for technology development, Mike Mudd, said that lowered capital costs and heavier penalties on emissions have brought the cost to within 20 percent of supercritical pulverized coal plants, "Primarily because IGCC is a new technology and it's got to go through a cost maturation." Since tax credits in the new energy bill bring the IGCC plant's life cycle cost of electricity within 10 percent of the next cheapest alternative, but with key environmental advantages, Mr. Mudd feels that utility commissions will accept slightly higher initial costs. The most compelling advantage of an IGCC plant is the ability to control CO₂ emissions. According to Ed Lowe, manager of GE's Gasification business, the additional cost of electricity for stripping CO₂ from a pulverized coal plant is 66 percent versus 25 percent for an IGCC plant. January 4, 2006,

<http://proquest.umi.com/pqdweb?did=955609771&Fmt=3&clientId=17454&RQT=309&VName=PQD>

(To access Wall Street Journal online, a subscription may be required.)

Bloomberg, "Australia's First Carbon Dioxide Storage Project Set to Start," Western Australia's Otway Basin will be the site of Australia's first carbon sequestration research project. This \$30 million (\$22.4 million USD) geosequestration project will be partly financed by companies including Chevron Corporation, Xstrata Plc and Rio Tinto. BHP Billiton, the world's biggest miner, BP Plc and Royal Dutch Shell Plc are also backing the research project. The Cooperative Research Centre for Greenhouse Gas Technologies hopes to start the operation by the end of this year. For this project, carbon dioxide will be extracted from a gas mixture, transported several kilometers by pipeline and injected about 1.2 miles underground into a depleted gas field. The project will involve the injection of about 100,000 metric tons a year of carbon dioxide, said Peter Cook, chief executive of the research project. The project announcement is timely since geosequestration is one of the technologies to be discussed January 11-12 in Sydney at the Asia-Pacific Partnership on Clean Development and Climate meeting. January 9, 2006, <http://www.bloomberg.com/apps/news?pid=10000081&sid=aRY5dPHOLyww>

Nickle's Daily Oil Bulletin, "Support Growing for CO₂ Distribution Network," Several pilot projects are underway in the Canadian province of Alberta using carbon dioxide for large-scale enhanced oil recovery (EOR), with a broad cross section of industries participating. In the September 2000 Journal of Canadian Petroleum Technology, Kelly Edwards (now an engineer for EnCana Corporation's Weyburn business unit) proposed a network that includes industrial CO₂ sources, distribution pipelines, and reservoirs for CO₂ injection. The Petroleum Technology Alliance Canada (PTAC) has set up a CO₂ enhanced hydrocarbon recovery steering committee to share research and technology options, and identify opportunities, priorities, and obstacles. The Integrated CO₂ Network (ICON) is a group of major emitters that has been doing studies on the scope, cost and potential timing of a CO₂ network. In order to help comply with the first phase of the Kyoto Protocol starting in 2008, and with timetables of two to three years on design and construction of pipeline and capture facilities, action is needed. Enbridge, which operates the world's largest crude oil pipeline, estimates the need for a 400 kilometer pipeline capable of

carrying up to 4,000 metric tons (76 million cubic feet (mmcf)) per day of CO₂ at a cost of \$160 million—not including the cost of compression—and another \$40 million to boost capacity to 22,000 metric tons (418 mmcf) per day with pumping stations. The most cost-effective way to move CO₂ over long distances is in a dense liquid-like phase, allowing for a smaller diameter pipe to be used. Though to justify costs, the pipeline would have to be sized for larger volumes than initially intended. Government support is needed for implementation due to high initial costs and extended time need for cost recovery. January 6, 2006, <http://www.dailyoilbulletin.com/> (Subscription required.)

Nickle's Daily Oil Bulletin, "CO₂ Pilot Projects in Alberta, Others Planned," In addition to a proposed CO₂ pipeline network in Alberta (see this newsletter "**Support Growing for CO₂ Distribution Network**"), high oil prices and incentives from the Alberta and Canadian governments have encouraged pilot projects in CO₂ injection for enhanced oil recovery (EOR). Several companies have current projects in EOR which were described in detail in the article. Listed here are the companies, their current project site(s), location of the site(s), and short description of the project(s): 1. Anadarko Canada Corporation's Enchanted Arcs project in southern Alberta. A CO₂ injector and three CO₂ producers in the Enchant Arcs A&B pool. The second pilot in Enchant Arcs F&G pool is planned. In the US, Anadarko Petroleum Company has a 16-inch, 125 mile pipeline across central Wyoming delivering to its Salt Creek EOR project. 2. Apache Canada Ltd.'s Zama field in northwestern Alberta. Acid gas is injected into pinnacle reefs where one-third of the gas is hydrogen sulfide, rather than pure CO₂. 3. Apache Canada Ltd.'s Midale project in southern Saskatchewan. A pipeline was built to tap into the pipeline that delivers CO₂ to Weyburn from North Dakota. The current supplier is Dakota Gasification Company, which will increase CO₂ delivery when it installs additional compression. 4. Devon Canada Corporation's Swan Hills pilot injection, northwest of Edmonton. The existing wellbores are used, with CO₂ trucked from Fort Saskatchewan and Medicine Hat Air by Liquide Canada, Inc. 5. Penn West Energy Trust's Joffre Viking plant, northeast of Red Deer. This is the longest running CO₂ EOR in Canada. CO₂ from a petrochemical plant that is 96 to 98 percent pure is combined with produced CO₂ and hydrocarbon gases for 82 to 84 percent concentration injected, which is then cut with water. 6. Penn West Energy Trust pilot at Canada's biggest onshore oil pool Pembina Cardium. The company is currently trucking in the CO₂, and is interested in a pipeline. 6. Glencoe Resources Ltd. in central Alberta. CO₂ is piped in from nearby petrochemical plants. 7. EnCana Corporation's Weyburn site in southeastern Saskatchewan. The company injects purchased CO₂ into the Weyburn oilfield and some of the recycled CO₂ is then reinjected. Dakota Gas is the supplier. Weyburn is to increase injection of CO₂ when the Beulah North Dakota plant adds a third compressor, which will result in more CO₂ as bi-product from the coal gasification plant. Projects are also planned for: Judy Creek by Pengrowth; Pembina/Redwater by ARC Energy Trust; and Mitsue by Canetic Energy Trust. January 6, 2006, <http://www.dailyoilbulletin.com/> (Subscription required.)

AP, "Underground Basalt Promising As a Repository For Excess CO₂," A Basalt formation in the Pacific Northwest that was created millions of years ago by lava flow and flooding, now covers an area of more than 60,000 square miles, thousands of feet thick. This porous rock can be used for storage of CO₂ emissions from power plants. Peter McGrail, a researcher at Battelle Pacific Northwest Division, a US Department of Energy-supported science laboratory and partner in the Big Sky Carbon Sequestration Partnership, is participating with other researchers in an investigation of sites for a pilot test slated to begin in 2007. The Big Sky Carbon Sequestration Partnership is a regional study into carbon capture and sequestration technologies. For the pilot test, carbon dioxide would be injected into basalt at about 3,000 feet, where the water is not suitable for drinking or irrigation. A traditional power plant can use up to one third of its power capturing CO₂, which would double the costs to consumers, says Stuart Dalton director for generation for the Electric Power Research Institute. The impact is less significant for IGCC plants, which use coal or petcoke (the waste product from oil refineries), turn it into gas, and use it generate electric power. IGCC plants use about 6 percent of their power to separate the CO₂, increasing the cost of power by about one third. The Big Sky project is one of seven regional partnerships backed by the US Department of Energy. January 17, 2006, http://www.sltrib.com/utah/ci_3426715

The Enquirer (Cincinnati), "State Stays Mum on FutureGen Site," At a January 26 press briefing for Ohio's efforts on the FutureGen project, state officials and consultants did not identify specific sites for the project, saying that doing so could aid land speculators, and undermine Ohio's efforts to obtain the project. Jacqueline Bird, director of Ohio Coal Development Office, said there are 12 possible sites in 8 counties for the project. She also said that the geology of the sites, access to roads and powerlines are key. 400 to 600 acres are needed for the site, as is proximity to unmined coal seams or depleted gas wells. State representative Jimmy Stewart, R-Athens, said that siting the plant near the Ohio River where coal could be transported into Ohio would also be helpful. Larry Wickstrom, geologist/supervisor with the Ohio Department of Natural Resources said the federal government would also be looking for sites located on sandstone. Wickstrom also said that recovery of oil and gas at the site helps to recuperate costs, and that the plant needs to be sited 10 miles from the CO₂ storage site. January 27, 2006, <http://news.enquirer.com/apps/pbcs.dll/article?AID=/20060127/NEWS01/601270420/1077/NEWS01>

Business Wire, "The US Department of Energy Provides \$310,000 Grant to ThermoEnergy to Begin Development of Zero-Air-Emission Industrial Power Plants," ThermoEnergy Corporation announced the start of a \$310,000 federally funded project to develop compact zero air emission power plants for medium to heavy industry. Combined Heat & Power (CHP) plants allow industries to switch from natural gas to lower priced alternative fuels, resulting in cost savings. The CHP plans are based on the company's patented power plant design called ThermoEnergy Integrated Power System, or TIPS. TIPS systems eliminate emissions of NO_x, SO_x, mercury, and particulates, and captures and recovers CO₂ in pressurized liquid form for sequestration or beneficial reuse. The Canadian energy laboratory CANMET, and Reaction Systems Engineering of Kent, UK will also participate in the project. This project is the second of three grants with a third grant, totaling \$1.5 million, to focus on the development of TIPS as a cost-effective upgrade for existing coal-fired power plants designed to convert them to zero air emission facilities. January 17, 2006, http://home.businesswire.com/portal/site/google/index.jsp?ndmViewId=news_view&newsId=20060117005116&newsLang=en

March 2006

DOE Techline, "DOE Launches Carbon Dioxide Sequestration Initiative," The US Department of Energy (DOE) has launched a new research effort aimed at enhancing recovery of oil and natural gas while sequestering carbon dioxide (CO₂). A solicitation has been issued to provide oil and gas producers grants to conduct field testing and validation of enhanced recovery/sequestration technologies. (See this newsletter's Announcement inset box for **Funding Opportunity Announcement for 'Enhanced Oil and Natural Gas Production through Carbon Dioxide Injection,'** and link to the RFP at: <http://www.grants.gov/search/search.do?mode=VIEW&oppld=7838>.) The projects will be managed by the National Energy Technology Laboratory (NETL). Currently, the use of enhanced oil recovery (EOR) accounts for 4 percent of US oil production. Enhanced gas recovery (EGR), flooding natural gas reservoirs with carbon dioxide (CO₂) to move previously bypassed natural gas to producing wells, is not widely used. Oil and gas fields' capacity for CO₂ sequestration was shown to equate to 125 years of current worldwide emissions from fossil-fuel-fired power plants in a study conducted for DOE. The growth potential of CO₂ flooding was detailed in a series of reports on six regions of the US released in April 2005 by the Office of Fossil Energy. The reports concluded that CO₂ flooding in large, favorable reservoirs could yield more than 43 barrels of incremental oil, increasing US oil production by 2-3 million barrels per day by 2025. See reports at: http://www.fossil.energy.gov/programs/oilgas/eor/Six_Basin-Oriented_CO2-EOR_Assessments.html. A DOE sponsored workshop on Enhanced Oil Recovery was hosted by the Petroleum Technology Transfer Council in Houston, Texas on February 22. February 13, 2006, http://www.netl.doe.gov/publications/press/2006/06008-EOR_Sequestration_Initiative.html.

BP Press Release, "BP and Edison Mission Group Plan Major Hydrogen Power Project for California," BP and Edison Mission Group, a subsidiary of Edison International, are planning a \$1 billion hydrogen-fueled power plant and petroleum coke gasification project adjacent to a BP refinery in Carson,

California. The 500 megawatt plant will combine a number of technologies to reduce carbon dioxide (CO₂) emissions. Petroleum coke will be converted to hydrogen and CO₂ gases, with 90 percent of the CO₂ captured and separated. The hydrogen gas stream will fuel the gas turbine to generate electricity. The captured CO₂ will be liquefied and piped to oil fields for enhanced oil recovery. BP is discussing options for sequestering the CO₂ in Occidental Petroleum's California oilfields. Occidental currently operates the Elk Hills field in California's southern San Joaquin Valley, the THUMS operation in Long Beach and other properties in the Sacramento Valley in northern California. A final decision on the plant is expected in 2008 with operations to begin in 2011. For more information on the Carson project visit:

<http://www.bp.com/hydrogenpower>. February 10, 2006,

http://www.bpalternativeenergy.com/liveassets/bp_internet/alternativenenergy/press_10_02_06.html.

Also see article in *The New York Times*, "**Power Plant Would Reuse Carbon Dioxide**,"

<http://www.nytimes.com/2006/02/11/business/11power.html>. (Subscription may be required), *Natural Gas*

Week's "**Hydrogen Growth Spurring Gasification Projects**," <http://www.energyintel.com>

(Subscription may be required), and *Occidental Oil's Press Release* "**Occidental and BP to Evaluate CO₂ Sequestration Options for California**,"

<http://www.primezone.com/newsroom/news.html?d=93867>.

Press Release (Western Governors' Association), "WGA Advisory Committee to Consider Array of Options for Increasing Clean Energy, Efficiency in the West," The Western Governors'

Association's Clean and Diversified Energy Advisory Committee (CDEAC) is set to consider an array of options for bringing on-line 30,000 megawatts of clean energy by 2015, increasing energy efficiency 20 percent by 2020 and providing adequate transmission for their region. The Western Governors'

Association (WGA) is an independent, nonprofit organization representing the governors of 18 states and three US-Flag islands in the Pacific. The WGA identifies and addresses key policy and governmental issues in natural resources, the environment, human services, economic development, international relations and public management. A policy resolution outlining their visions and goals was launched in 2004 called the Clean and Diversified Energy Initiative. On January 10, the CDEAC released several task force reports that examine the feasibility of and options for reaching their goals, including reports in the area of advanced coal. The reports will be utilized by the CDEAC in developing recommendations for the WGA to consider at their 2006 annual meeting, June 11-13 in Sedona, Arizona. See:

<http://www.westgov.org/wga/initiatives/cdeac/index.htm> for links to the reports and also the Reports

section of this newsletter "**Carbon Management Working Group Report for the Advanced Coal Task Force, Western Governors' Association**," for more information. January 10, 2006,

<http://www.westgov.org/wga/press/cdeac1-10-06.htm>.

Reuters, "US Power Providers Say They Expect Carbon Regime," At the Cambridge Energy Research Associates' CERA Week 2006 Energy Conference held in Houston, Texas, February 6-10, US power company executives said they expect a series of rules and taxes will be imposed on carbon pollution, possibly within five years. James Rogers, chairman and chief executive of Cinergy Corp, felt there is a 25 percent chance that carbon will be regulated by 2009. The executives said carbon sequestration will likely be a focus of future legislation with taxes and a pollution credit trading system. Walter Higgins, chairman, president and chief executive of Sierra Pacific Resources, said, "All of forms of power generation create carbon. Some sort of carbon sequestration is the most likely intermediate-term carbon solution." February 10, 2006,

<http://www.planetark.com/dailynewsstory.cfm?newsid=35019&newsdate=10-Feb-2006>.

Oil and Gas Journal, "Shell CEO Says Technology Needed to Meet Fuel Demand," At the CERA Week 2006 Energy Conference in Houston, Jeroen van der Veer, chief executive of Royal Dutch Shell PLC, stated that the oil and gas industry needs to apply new technologies on an unprecedented scale and pace to meet the world's demand for fossil fuels. Assuming continued economic growth, the world's energy needs may increase by 100 million barrels per day of crude over the next 25 years—"more than we added over the past quarter century," said Van der Veer. He stated that most of the increased

demand will be in new markets where infrastructure and international trade must be developed. "And this has to go together with cutting carbon dioxide emissions from energy," he said.

"I have a vision of green—or greener—fossil fuels with much of their carbon dioxide captured and sequestered either underground or in inert materials," Van der Veer said. He stated that he feels sequestration for power plants should be a priority. February 10, 2006,

http://ogj.pennnet.com/articles/article_display.cfm?Section=ONART&C=GenIn&ARTICLE_ID=247775&p=7.

BBC News, "Rocks Could Store All Europe's CO₂," On BBC World's Service's One Planet program, Statoil's Senior Vice President for the Environment, Tor Fraeren, stated that one million tons of carbon dioxide (CO₂) are stored every year in the formations under the Sleipner platforms in the North Sea. He also said that there are calculations which say these same formations could handle all of Europe's CO₂ emissions for several hundred years, illustrating the site's potential capacity for CO₂ storage. He then pointed out how in actuality countries other than Norway would incur large costs to pipe CO₂ to the site. The Norwegian Energy Minister, Odd Roger Enoksen, explained Norway's plan to link the Sleipner platforms to a gas power plant on Norway's west coast, with CO₂ capture starting in 2009. The One Planet Program toured the Sleipner platform to look at its CO₂ capture and storage systems and discuss carbon sequestration. February 16, 2006,

<http://news.bbc.co.uk/2/hi/business/4717578.stm>.

Chemistry World (UK), "Calls for UK Investment in Carbon Capture," The Science and Technology Committee of the House of Commons of the Parliament of the United Kingdom (UK) has released a report **"Meeting UK Energy and Climate Needs: The Role of Carbon Capture and Storage."** In the report, the parliamentary committee urged the UK government to invest in carbon capture and sequestration. The committee called on the government to invest in UK-based technology for storing carbon dioxide (CO₂) in geologic formations. They also urged that new UK industrial plants should be obliged to incorporate carbon capture and storage (CCS) technology. The report also said that the government's energy review, currently in progress, must ensure full scale CCS demonstration projects are in place by 2009. Annette Cutler, founder of the European Knowledge Transfer Network CO₂NET, commented on the contents of the report saying, "For climate needs, emissions reductions by other heavy industry, such as fertilizer and chemical plants, aluminum smelters and iron and steel works are of significance and could utilize CCS technology as effectively as the power industry." To access the report online in the pdf or html version see: <http://www.publications.parliament.uk/pa/cm/cmsctech.htm>, far left under the heading: "Report, February 9, 2006, First Report, Meeting UK Energy and Climate Needs." February 9, 2006, <http://www.rsc.org/chemistryworld/News/2006/February/09020601.asp>.

The Times-Reporter (OH), "State Commits Money for Plant Project," Ohio has committed to securing \$2 million in funding for test drilling for potential sites for the FutureGen facility. The test drilling will document geologic characteristics of proposed sites to help determine the best location for the plant. Tuscarawas County is proposing a 790-acre site between Port Washington and Gnadenhutten. Coshocton and Stark counties are actively supporting the Tuscarawas County site, while Carroll County is pushing two sites of its own, according to a community development representative. February 17, 2006, <http://www.timesreporter.com/left.php?ID=50801&r=3>.

Waco Tribune-Herald (TX), "Mexia Won't Host Experimental Power Plant, But a Nearby Site Might," Although the city of Mexia in Central Texas will not be considered for a FutureGen proposed site, another location—near the city of Jewett, located at the junction of the counties of Limestone, Freestone and Leon—will be considered by the state. Nine Texas groups have submitted proposals to the state, and a state task force will pick an appropriate site to propose for the plant in the next few months. The Mexia site was not chosen due to a number of uncapped wells in the old Mexia oil field. February 12, 2006,

<http://www.wacotrib.com/news/content/news/stories/2006/02/12/20060212wacmexiaplant.html>.

April 2006

Environmental News Service, "Europe Tests Carbon Capture at Coal-Fired Power Plant." The world's largest pilot plant for carbon dioxide capture from a conventional power station was opened in Denmark on March 15, 2006. The Elsam plant near Esbjerg, Denmark is the site of the CASTOR project (CASTOR, which stands for "CO₂ from CAPture to STORage," is a European initiative grouping 30 partners from industry, research institutes, and 11 European countries.) The pilot CO₂ capture unit, coordinated by the Institut Français du Pétrole, will be in demonstration phase for 2 years to ensure reliable industrial application. The pilot unit absorbs 90 percent of the CO₂ in the flue gases emitted by the station. The pilot installation is designed to capture one metric ton of CO₂ per hour. Comparing to CO₂ capture costs of flue gases of large industrial facilities already operational in Japan, this project is expected to halve the cost per ton of CO₂ avoided to between 20 and 30 Euros. The total cost of the project is 16 million euros, with half of the funding coming from the European Commission and half from private partners. The strategic objective of CASTOR is to enable the capture and geological storage of 10 percent of the CO₂ emissions of Europe, which corresponds to 30 percent of the CO₂ emitted by European power and industrial plants. Seventy percent of the project budget is allocated to capture technology and 30 percent to storage. March 15, 2006, <http://www.ens-newswire.com/ens/mar2006/2006-03-15-06.asp>.

Reuters, "Statoil, Shell Set World's Biggest CO₂ Seabed Plan." Norway's Statoil and Anglo-Dutch Shell are planning a \$1.2-\$1.5 billion project off the coast of Norway—the world's first project to use carbon dioxide (CO₂) to boost oil recovery offshore. Statoil will capture CO₂ from a 860-megawatt gas-fired power plant to be built at the company's Tjeldbergodden methanol complex in mid-Norway, and then pipe the CO₂ to Shell's Draugen oilfield off of Norway to inject it into subsea reservoirs. Plans are for: (1) a final decision to invest by the end of 2008; (2) the power plant to be started in 2010-2011; and (3) the first CO₂ delivered to Draugen in 2011-2012. Future plans are to also include injection into Statoil's Heidrun field. Estimates are that 2 to 2.5 million metric tons of carbon per year will be sequestered. Substantial governmental funding and support will be needed. March 8, 2006, <http://today.reuters.com/news/articlebusiness.aspx?type=naturalResources&storyid=nL08362188&imageid=&cap=>.

DOE News Release, "New CO₂ Enhanced Oil Recovery Technology Could Greatly Boost US Oil Supplies." The Department of Energy has determined that the use of state-of-the-art enhanced oil recovery with carbon dioxide (CO₂) could add 89 billion barrels to the recoverable reserves of the US. The current level of proved reserves is 21.9 billion barrels. Longer term, multiple advances in technology and widespread sequestration of industrial carbon dioxide could eventually add as much as 430 billion additional barrels. Efforts to develop the additional reserves would depend on availability of large volumes of commercial CO₂. Next-generation enhanced recovery with CO₂ was judged to be a "game-changer" in oil production, one capable of doubling recovery efficiency. Geologic sequestration of industrial CO₂ in declining oil fields was endorsed last year as a potential method of reducing greenhouse gas accumulation in the atmosphere by the Intergovernmental Panel on Climate Change. The findings are consolidated in the February 2006 report "Undeveloped Domestic Oil Resources: The Foundation for Increasing Oil Production and a Viable Domestic Oil Industry." (See Publications section of this newsletter for this and related reports.) March 3, 2006, http://www.fossil.energy.gov/news/techlines/2006/06015-Oil_Recovery_Assessments_Released.html.

DOE Techline, "United States and India Reach Historic Agreement on FutureGen Project." President Bush announced that India will become the first nation to participate on the government steering committee for FutureGen. The Indian government will contribute \$10 million to the FutureGen Initiative and Indian companies will be invited to participate in the private sector segment of the project. Secretary Bodman has invited government leaders of the Carbon Sequestration Leadership Forum (CSLF) to become active participants in the FutureGen project. The CSLF is a voluntary climate initiative that includes 20 nations and the European Commission, working cooperatively on technology

development for the early reduction and steady elimination of carbon dioxide. India is the first CSLF member to participate in FutureGen, building on the US–India Energy Dialogue launched in May of 2005. The Dialogue aims to increase US–India trade and investment in the Indian energy sector by bringing together public agencies and private industries to develop secure, clean, reliable and affordable sources of energy. March 2, 2006, http://www.fossil.energy.gov/news/techlines/2006/06014-US_and_India_FutureGen_Agreement.html.

Reuters, “US Hopes to Reverse Oil Decline by Burying CO₂.” In order to utilize carbon dioxide (CO₂) for enhanced oil recovery, and increase oil reserves in the US (as reported in the February 2006 report “Undeveloped Domestic Oil Resources: The Foundation for Increasing Oil Production and a Viable Domestic Oil Industry”) the US would need to use 350 trillion cubic feet of carbon dioxide, more than 10 times the amount in natural underground deposits of CO₂. Vello Kuuskraa, president of Advanced Resources International, who authored the February 2006 study for the Department of Energy, stated that the greatest portion of the carbon dioxide is going to have to come from industrial sources. Commenting on costs, Kuuskraa said that the use of carbon sequestration technology makes sense so long as the oil price remains above \$30 a barrel. The price of CO₂ itself, now at \$1 per thousand cubic feet, would have to fall to 75 to 80 cents per cubic feet to be cost effective. March 13, 2006, http://news.yahoo.com/s/nm/20060313/sc_nm/energy_crude_carbon_dc_1.

Oil and Gas Journal Online, “Otway Basin CO₂ Sequestration Trial Advances.” The Australian Cooperative Research Centre for Greenhouse Gas Technologies (CO₂CRC) has been awarded two production licenses in the onshore Otway basin of western Victoria to conduct its first carbon dioxide geosequestration trial. The pilot gas injection, storage and monitoring demonstration project will begin by the end of 2006, subject to environmental approvals. The Otway project is thought to be the only project in the world where researchers own the petroleum leases, the CO₂ source, and the depleted storage reserve. The Australian government has allocated \$2.96 million to the trial with funding also coming from petroleum companies and overseas research groups. About 30 researchers will be involved in the project. February 27, 2006. http://ogj.pennnet.com/articles/article_display.cfm?Section=ONART&C=DriPr&ARTICLE_ID=249013&p=7. (Subscription may be required.)

Environmental Finance, “Companies Join Forces On Carbon Capture and Storage.” On March 13, thirteen companies formed the Carbon Capture & Storage Association (CCSA) with an aim to promote technology for geologic sequestration. The members will work with the government of the United Kingdom to resolve regulatory issues to avoid delay of technology deployment, and to develop fiscal and legislative support for demonstration projects. The members are Air Products, Alstom, AMEC, BP, ConocoPhillips, E.ON UK, Mitsui Babcock, Progressive Energy, Schlumberger, Scottish & Southern Energy, Shell, RWE and Chevron. March 16, 2006, <http://www.environmental-finance.com/onlinews/16marccs.htm>.

Bloomberg, “Xstrata and Other Coal Miners to Invest A\$300 Million in Green Fund,” and Dow Jones Newswires, “DJ Australian Coal Miners Agree to a A\$300M Greenhouse Levy.” Coal producers in Australia have agreed to set up a \$222 million demonstration project fund, the Coal21 Fund, for demonstration and development of technologies aimed at reducing greenhouse gas emissions from coal-fired power stations. The fund will be the world’s first whole-industry approach to greenhouse gas abatement. Mining companies, including Xstrata, Plc; Rio Tinto Group, BHP Billiton, Excel Coal Ltd., and Macarthur Coal, accounting for 90 percent of Australia’s coal production will contribute to the fund for five years. Projects being studied include capture and geological storage of CO₂, coal gasification, oxy-fuel combustion technology, and post-combustion capture of CO₂. March 16, 2006, <http://www.bloomberg.com/apps/news?pid=10000102&sid=aQ6bAmnOkcD0&refer=uk#> and <http://www.tmcnet.com/usubmit/2006/03/15/1461395.htm>.

Gasification News, “Shell: Coal Gasification to Boom in US: CO2 Sequestration Risks Will be Low.” In his keynote speech in Dubai at the Middle East Petro-Tech conference in January, Greg Lewin, president of Shell Global Solutions, predicted the strong growth of coal gasification and that carbon sequestration risk will be “low.” He stated that Shell has been a pioneer in both geological carbon storage and in “mineralization.” Lewin outlined what he felt were the four most important points regarding carbon sequestration: 1.) That there is significant CO2 storage capacity available, but without using that capacity, “stabilization” of CO2 levels in the atmosphere will be difficult to achieve; 2.) CO2 storage mechanisms are known, and storage can be safe if sites are properly selected and monitored; 3.) CO2 can be stored for thousands of years or longer; and 4.) Much work has been performed to understand the hazards involved and the probability of failure, with results indicating that the risks involved will be low. He stated that although geologic sequestration can store more carbon, mineralization of CO2 using calcium or magnesium, for example, also plays a role. In addition to its projects in geologic sequestration, Shell is pursuing proprietary mineralization technology. To read the transcript of the speech, see: http://www.shell.com/static/globalsolutions-en/downloads/news_and_library/2006/press_petrotech_130206.pdf. February 2006, <http://www.worldfuels.com/sample.php?GTLN#A9>.

Great Falls Tribune Online, “Farmers Poised to Harvest Profit from Carbon ‘Crop.’”

One of the partners of the National Energy Technology Laboratory’s Big Sky Carbon Sequestration Partnership program, the National Carbon Offset Coalition, is working on a pilot project to link industries that produce carbon dioxide with landowners who store carbon in the ground through conservation practices. The National Carbon Offset Coalition is based in Butte, Montana, and is working with farmers and landowners to assist them in earning carbon credits which they could in turn sell to industries to offset their CO2 emissions. Dave Gettel is one of several farmers near Power, Montana who participate in the program. The research effort for the Big Sky Carbon Sequestration Partnership is led by Montana State University (MSU). As part of this project, a variety of farming techniques are being used on side-by-side plots on land, including crop rotation and no-till farming. The MSU staff members conduct measurements on the soil carbon levels to determine how much carbon is kept in the soil in order to determine how many carbon offsets the farmer can sell. Currently, a metric ton, which trades for \$1.50 to \$3, is the amount of carbon saved in about 10 acres of no-till cropland. Carbon credits may not generate large amounts of income for the landowners but may serve as incentive for additional conservation practices. March 9, 2006,

<http://www.greatfallstribune.com/apps/pbcs.dll/article?AID=/20060309/BUSINESS/603090335/1046>.

May 2006

FutureGen Alliance Press Release, “Widespread Interest Shown in Bid to Host FutureGen Project.”

The FutureGen Industrial Alliance (Alliance) reported that offerors in nine states, offering a total of 22 sites, have expressed an interest in hosting the FutureGen Project. The Alliance extended the deadline from March 24 to April 7, 2006 for the submission of the Notice of Intent (NOI) to submit a proposal. The Request for Proposals states that the names of offerors submitting notices will not be publicly released. Given the complexity and rigors of the proposal process, the Alliance expects that a smaller number of sites may be offered than originally submitted via the NOI. The Alliance is seeking sites that are consistent with the requirements and objectives of the FutureGen project and have broad applicability domestically and internationally. FutureGen’s schedule is aggressive, with plant siting and construction to begin within three years. Proposals to host the site are due May 4, 2006. March 29, 2006, http://www.futuregenalliance.org/news/releases/pr_3-29-06.pdf.

Government of India Press Release, “CSLF Meet Suggests Time Bound Action Plan for Cost Effective Technologies,” and New Karala.com, “India, 21 Others Adopt Plan for Carbon Capture, Storage.” The Carbon Sequestration Leadership Forum (CSLF) met in New Delhi, India on April 3 - 5. The international CSLF is a voluntary climate initiative of developed and developing nations that account for 75 percent of all manmade carbon dioxide emissions. CSLF was formed to facilitate the development

of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term safe storage; to make these technologies broadly available internationally; and to identify and address wider issues relating to carbon capture and storage. During the meeting, a draft Strategic Plan and Action Plan were adopted, and the progress of 17 research projects was reviewed. All member countries will have to approve the plans for the projects to move forward. US Assistant Secretary, Office of Fossil Energy Jeffrey Jarrett served as Chairman of the CSLF Policy Group. See the CSLF website for meeting documents: <http://www.csforum.org/apr032006.htm>. Also, the welcome remarks for the meeting by India's Minister of Power Shri Sushil Kumar Shinde are found at: <http://pib.nic.in/release/release.asp?relid=16939>. April 4, 2006, <http://pib.nic.in/release/release.asp?relid=16995>, and April 5, 2006, <http://www.newkerala.com/news2.php?action=fullnews&id=36946>.

Expatica, "German Power Plant Will Store CO₂ Underground." Germany's largest utility, RWE, plans to invest \$1.2 billion in a coal-fired power plant that integrates carbon dioxide (CO₂) sequestration with electrical power generation. RWE is aiming to have the 400-450 megawatt plant operational by 2014. Planning for the plant has already begun, and testing will be done with hard coal and gasified lignite. A decision on the plant siting is expected by the latter half of 2007. RWE favors a location close to its opencast lignite mines in the west of Germany but will have to determine a geologically suitable depository for the CO₂. March 30, 2006, <http://www.planetark.com/dailynewsstory.cfm/newsid/35847/story.htm>.

AP, "Iceland Set To Capture Carbon In Its Rocks." Iceland is planning to test its basalt rock for carbon dioxide (CO₂) storage. If this experiment is successful, it could also be useful in other countries which have basalt formations, such as the United States, India, Brazil and Russia. Wallace Broecker, a professor at Columbia University who is joining Iceland scientists in the project, said that CO₂ capture and storage is going to be needed even with conservation efforts and the use of renewable energy sources. Scientists have known for more than 50 years that the natural chemical weathering of rocks consumes some atmospheric CO₂. In countries such as Iceland, rain pulls a small amount of CO₂ out of air, and when the rain hits rocks, chemical weathering initiates, dissolving solids such as calcium. The water reacting with rocks then absorbs even more CO₂ from the atmosphere. Rivers capture this water and carry the dissolved CO₂, and other chemical constituents from the weathering process, to the ocean. In the ocean, the calcium and dissolved CO₂ combine to form solid calcium carbonate (similar to the material that makes up sea shells), which sinks to the bottom. The Earth Institute at Columbia University is raising the \$4 to 5 million needed for the pilot project. Scientists, Iceland's government and local power companies hope to finalize the plan in June 2006, with a launch of the experiment planned for some time next year. April 12, 2006, <http://msnbc.msn.com/id/12034963/>.

DOE Website, "Secretary Bodman Addresses the National Coal Council." Secretary of Energy Samuel W. Bodman discussed the development of clean coal technologies in remarks to the National Coal Council in Washington, DC, on March 22, 2006. Comments included the FutureGen Initiative. Read his comments here: <http://www.energy.gov/news/3390.htm>.

June 2006

DOE Techline, "PPL Corporation Joins FutureGen Industrial Alliance." PPL Corporation has become the tenth member of the FutureGen Industrial Alliance (the Alliance), the non-profit consortium of global electric utilities and coal companies working with the US Department of Energy to site and develop the FutureGen power plant. PPL Corporation, headquartered in Allentown, Pennsylvania, controls about 12,000 megawatts of generating capacity in the US, sells energy in key US markets and delivers electricity to more than 5 million customers in Pennsylvania, the United Kingdom and Latin America. The Alliance represents some of the world's largest coal companies and electric utilities including: American Electric Power, Anglo American, BHP Billiton, the China Huaneng Group, CONSOL Energy Inc.,

Foundation Coal, Rio Tinto Energy America, Peabody Energy and Southern Company. May 23, 2006, http://www.fossil.energy.gov/news/techlines/2006/06028-PPL_Joins_FutureGen_Alliance.html.

DOE Techline, “Coal Gasification Plant Returns \$79 Million to DOE in Revenue-Sharing Gas Sales.” In 1998, the Dakota Gasification Company (DGC) purchased the Great Plains Synfuels Plant from the Department of Energy (DOE) and signed a revenue sharing agreement. DGC announced a payment of \$79 million payment to the DOE as part of that agreement—the third such payment with revenue share to DOE from gas sales totaling more than \$241 million to date. Carbon dioxide (CO₂) from the plant is transported from the Great Plains Synfuels Plant to the Weyburn Oil field via a 200-mile pipeline for sequestration and/or enhanced oil recovery. The Weyburn project was started in July 2000 by the Petroleum Technology Research Centre of Regina, Saskatchewan, Canada, and cosponsored by the oil field operator, EnCana Resources of Calgary, Alberta, Canada. The project is funded by at least 15 sponsors from government and industry, including DOE, and 10 industrial sponsors in the United States, Canada, and Japan. The project has sequestered about five million tons of CO₂ into the Weyburn oil field since its beginnings. While much of the injected CO₂ is permanently sequestered, some of it is injected into the reservoir for enhanced oil recovery (EOR). The EOR has doubled the field's oil recovery rate, increasing the field's oil production by an additional 10,000 barrels per day. Phase II of the project is underway, a \$27 million project including a \$4 million share by DOE over a four year time frame. May 12, 2006, http://www.fossil.energy.gov/news/techlines/2006/06025-Dakota_Gasification_Revenue_Sharing.html.

Albany Democrat-Herald, “Pulling CO₂ Out Of Thin Air.” Research in carbon sequestration conducted at the National Energy Technology Laboratory in Albany, Oregon was highlighted in this article. Geologist Bill O'Connor was quoted, saying “Our research has focused on converting carbon dioxide from coal-fired power plants into a solid or slurry solution and keeping it out of the atmosphere.” The Department of Energy's goal is to develop cost-effective technology in the next 10 to 15 years. Various sequestration technologies are also described. May 3, 2006, <http://www.gazettetimes.com/articles/2006/04/30/news/community/local03.txt>.

Air Liquide Press Release, “Air Liquide Announces New Program to Promote the Use of Carbon Dioxide for Enhanced Oil Recovery.” Air Liquide Canada Inc., an industrial gas supplier to the oil and gas industry, has announced a program to promote carbon dioxide (CO₂)-based enhanced oil recovery (EOR) projects in Western Canada. A pilot project will be launched to boost oil production rates from the Swan Hills reservoir, by injecting liquid CO₂ into the reservoir to improve the fluidity of the oil, thereby making it easier to force the oil to the producing wells. This will be the first phase of a potentially large-scale project, unique in Alberta, combining EOR and CO₂ sequestration at extreme depths and temperatures. May 1, 2006, <http://www.ccnmatthews.com/news/releases/show.jsp?action=showRelease&searchText=false&showText=all&actionFor=592105>.

AP, “UW Scientists Seek Ways to Store Excess Carbon.” University of Wyoming scientists are partnering with other scientists in the Northern Plains and northwestern states to study carbon sequestration. The Big Sky Carbon Sequestration Partnership—comprised of universities, government agencies and businesses from Idaho, Montana, Oregon, South Dakota, Washington and Wyoming, including the University of Wyoming—focuses on studying geological sequestration. Regarding geological sequestration, said Jim Steidtmann, director of the Enhanced Oil Recovery Institute, “(We want) to see how well carbon dioxide stayed put, and (whether) anything happened over the longterm that would give us clues as to how well carbon dioxide could be sequestered over time.” April 23, 2006, <http://www.missoulain.com/articles/2006/04/23/breaker/doc444bad915f3c6228719164.prt>.

Greenwire, “E.ON US to Partner with University of Kentucky to Study Sequestration.” The utility company E.ON US is partnering with the University of Kentucky's Center for Applied Energy Research. The three-year, \$1.5 million grant and partnership will examine technology that separates and captures

carbon dioxide emitted by coal-fired power plants for either geologic storage or a terrestrial sequestration application. April 29, 2006, <http://www.eenews.net/Greenwire/print/2006/04/28/8>. (Subscription may be required.)

Zeenews.com, “Japan to Capture CO₂ at Australian Power Plant.” A Japanese consortium is planning construction of a carbon dioxide (CO₂) liquefying facility, slated to cost about \$124 million, with construction to begin in 2007, and startup by 2009. Twenty percent of the CO₂ from a power plant in Queensland, Australia would be captured, liquefied and geologically stored. The consortium would be led by J Power and Ishikawajima-Harima Heavy Industries, alongside the Japanese industry ministry and Australian, US and European firms. May 4, 2006, <http://www.zeenews.com/znnew/articles.asp?aid=292761&ssid=51&sid=BUS>.

July 2006

Powerspan Corp. Press Release, “Powerspan CO₂ Pilot Combined with FirstEnergy Carbon Sequestration Project Offers Unique Testing Opportunity.” For the first time in the United States, combined carbon dioxide capture and sequestration from a conventional pulverized coal-fired power plant will be demonstrated. Powerspan and FirstEnergy previously announced their plans for a pilot test of a carbon dioxide capture technology at FirstEnergy’s R.E. Burger Plant (Burger plant) in Shadyside, Ohio. The Burger Plant was selected as a carbon sequestration test site by the Midwest Regional Carbon Sequestration Partnership (MRCSP), one of seven regional partnerships set up by the US Department of Energy (DOE) National Energy Technology Laboratory. The Burger plant will be the site of the pilot scale demonstration of CO₂ capture with subsequent injection of the captured CO₂ into a test well on the property. Geological site characterization will be conducted for the project to determine suitability for geosequestration in the area. If results are favorable, permits will be pursued and test wells drilled, followed by an injection of a small amount of CO₂ into the well. Powerspan’s CO₂ pilot unit will process a 1-megawatt (MW) slipstream from the company’s 50-MW Electro-Catalytic Oxidation (ECO) commercial demonstration unit, where the CO₂ capture process will be integrated with the ECO multi-pollutant control process (which reduces sulfur dioxide, nitrogen oxides, mercury, and fine particulate matter). The CO₂ capture process uses an ammonia-based solution to capture the CO₂ in the flue gas, with regeneration of the ammonia solution for additional CO₂ capture. May 30, 2006, http://www.powerspancorp.com/news/release_27.shtml.

NETL Press Release, “Sequestration Test to Demonstrate Carbon Dioxide Storage While Increasing Oil Production.” The US Department of Energy’s Regional Carbon Sequestration Partnerships program will oversee its first geologic carbon sequestration project in Alberta, Canada. Funding for the project is provided by the National Energy Technology Laboratory. The project itself will be conducted by the Energy and Environmental Research Center at the University of North Dakota Plains CO₂ Reduction Partnership, in collaboration with an industry partner Apache Canada Ltd., and the Alberta Department of Energy and Natural Resources Canada. The project will evaluate the potential for geological sequestration of carbon dioxide as part of an acid gas stream that also includes high concentrations of hydrogen sulfide. Apache Canada Ltd’s Zama gas-processing plant will provide the gas which will be injected into the Zama oil field at a rate of 100 tons per day over the next two years. This project has the potential to sequester 67,000 tons of carbon dioxide annually. June 26, 2006, http://www.netl.doe.gov/publications/press/2006/06037-Carbon_Storage_Test_Begins.html.

Times-Colonist (Canada), “Prairie Project Captures Carbon.” The Weyburn project in Saskatchewan, Canada, is an enhanced oil recovery operations and globally visited carbon sequestration project. The project is financed largely by Natural Resources Canada and the US Department of Energy’s National Energy Technology Laboratory. Since 2000, more than seven million tons of carbon dioxide (CO₂) have been geologically sequestered, with plans to eventually sequester at least 30 million tons of CO₂. The CO₂ is transported from the Great Plains Synfuels Plant near Beulah, North Dakota via a 323-km long pipeline. The pipeline snakes through a lake and over the border into Canada, emerging from the ground

onto the Weyburn site. The pipeline then leads into a large building where compressors liquefy the CO₂ for injection underground. From there the liquid CO₂ is fed through the maze of piping buried at the 180-square-kilometre operation. Injection wells which are housed in igloo-shaped fiberglass sheds transport the CO₂ underground where it floods into horizontal channels bored into oil-rich rock. The CO₂ seeps into the rocks' pores to liberate the oil. The oil migrates to collection wells and is pulled to the surface by hundreds of pump jacks operating on the farmers' fields. About 2,500 tons of CO₂ per day returns with the emulsion of oil and water back up from the production wells, which is then recompressed and reinjected. This closed loop process cost about \$1.5 billion to build and generates 30,000 barrels of oil per day. May 24, 2006, <http://www.canada.com/victoriatimescolonist/news/story.html?id=04357c12-5a28-4f5b-9a3d-b45b1328101a&p=2>.

LCG Consulting Online, "Construction Begins on Carbon-Free Coal Plant." Groundbreaking occurred in eastern Germany for a 30-MW coal-fired power plant that will incorporate oxyfuel technology. The plant is being build by Vattenfall AB, an electric utility owned by the Swedish government. The project cost is \$64 million with operations to begin in 2008. With oxyfuel technology, the coal is combusted in pure oxygen, resulting in a lower volume of flue gas which consists of mostly carbon dioxide and water. The water can be condensed and separated, and the carbon dioxide can be liquefied and stored. The plans for storing the CO₂ have not been finalized but underground storage in aquifers or spent oil wells are being considered. There are also plans by Vattenfall to develop a 330 MW plant by 2015, and a 1000 MW plant by 2020. May 31, 2006, http://www.energyonline.com/Industry/News.aspx?NewsID=7050&Construction_Begins_on_Carbon-Free_Coal_Plant.

The Japan Times, "Underground CO₂ Storage Planned." The Ministry of Economy, Trade and Industry of Japan announced on June 12 that in an effort to cut greenhouse gas emissions, Japan plans to capture and geologically store carbon dioxide (CO₂) from its factories and power plants. Using carbon dioxide capture and storage (CCS) technology, Japan's goal is to sequester one half of the 200 million tons annually of CO₂ in Japan, and one half of the CO₂ in sites overseas. The government will spearhead research, build facilities, and pursue the legislation necessary to implement CCS. An estimated 150 billion tons of CO₂ could potentially be stored underground nationwide. June 20, 2006, <http://search.japantimes.co.jp/cgi-bin/nb20060620a2.html>. (Subscription required.)

The Engineer Online, "Carbon Capture Ready Clean Coal Power." Mitsui Babcock has secured a contract with Scottish and Southern Energy (SSE) for engineering design of a carbon "capture-ready" 500 megawatt (MW) clean coal plant retrofit at SSE's Ferrybridge Power Station in Yorkshire, United Kingdom. This project would be the first application of "capture-ready" clean coal technology in the United Kingdom. The retrofit installation of the 500 MW supercritical boiler and turbine unit technology, at a cost of 250 million British pounds (\$463 million), will result a reduction of 500,000 tons of carbon dioxide (CO₂) per year from the current conventional subcritical power station plant. Subsequent deployment of post-combustion carbon dioxide capture equipment at a cost of 100 million British pounds (\$185 million) would result in a saving of 1.7 million tons of carbon dioxide per year. May 31, 2006, <http://www.e4engineering.com/Articles/294699/Carbon%20capture-ready%20clean%20coal%20power.htm>. (Subscription required.)

August 2006

DOE Press Release, "Secretary Bodman Visits Alberta, Canada." US Secretary of Energy Samuel W. Bodman visited Alberta, Canada to encourage the development of oil sands and other unconventional oil resources, supported increasing North America's natural gas supply, and explored with government and industry the challenges to optimal and sustainable energy resource development. The Secretary met with many governmental and business leaders, including Canadian Natural Resources Minister Gary Lunn, with whom he discussed several issues including carbon sequestration initiatives. July 14, 2006, <http://energy.gov/print/3842.htm>.

BP Press Release, "BP and GE to Develop Hydrogen Power Plants and Technologies." BP and General Electric (GE) announced an effort to jointly develop and deploy hydrogen power projects which incorporate carbon capture and sequestration technologies. BP had previously announced plans for two hydrogen power projects with carbon capture and sequestration in Peterhead, Scotland and Carson, Southern California, where Scottish and Southern Energy and Edison Mission Energy are partners, respectively. Both projects will use GE technology. Over the next decade, 10 to 15 total projects are planned. The Peterhead, Scotland project will be a 475MW hydrogen fired power plant based on natural gas, which will sequester 1.8 million tons annually of carbon dioxide (CO₂) about 13,000 feet below the seabed into the Miller oil field for enhanced oil recovery. A final investment decision is due in early 2007, with commercial operation in 2010. The second project is a 500MW hydrogen power plant at Carson, Southern California. Scheduled for completion in 2011, the plant would take petroleum coke, a refinery by-product and synthetic form of coal, to create the hydrogen, and will capture and store 4 million tons per year of CO₂. July 18, 2006, <http://www.webwire.com/ViewPressRel.asp?ald=16888>.

Defra Press Release, "Landmark Carbon Capture and Storage Workshop in Beijing: July 4-5 2006." A workshop funded by the United Kingdom (UK) Department for the Environment Food and Rural Affairs (DEFRA) and the Department for Trade and Industry, supported by the European Commission's (EC) research Framework Programme, organized by The Administrative Centre for China's Agenda 21, in collaboration with the Chinese Ministry of Science and Technology, was held in Beijing China from July 4 to 5. The meeting considered the potential for carbon dioxide capture and storage in the Chinese power generation sector, and was part of the UK's collaboration with China under the European Near Zero Emission Coal (NZEC) initiative. More than 70 European representatives and 80 Chinese participants attended the workshop, making this the largest gathering on carbon dioxide capture and storage thus far in China. The European Union supports a large portfolio of research projects in the field of NZEC, with a total value of \$94.62 million (75 million euros) with the participation of key research Chinese Institutes. The total European Commission funding toward Chinese Institutes is approximately \$1.89 million (1.5 million euros). July 6, 2006, <http://www.qnn.gov.uk/Content/Detail.asp?ReleaseID=212415&NewsAreaID=2>.

Announcements

September 2005

Edinburgh Center of Excellence. Edinburgh's top two universities have been awarded a £1.5 million grant from the Scottish Higher Education Funding Council to create a center of excellence to monitor the long-term effects of dissolving carbon dioxide in deep sea reservoirs and in porous rock containing oil. "City experts team up to fight global warming," *The Scotsman*, August 2, 2005, <http://www.scotsman.com/?id=1718252005>

October 2005

DOE Announces Delay of Effective Date for the 1605b Program Revised Guidelines. On September 19, 2005, the U.S. Department of Energy's Office of Policy and International Affairs issued a Federal Register Notice announcing the delay in the effective date of the 1605b Program's Revised General and Technical Guidelines for reporting. The effective date has been changed to June 1, 2006. The Federal Register Notice is available in PDF format at <http://www.eia.doe.gov/oiaf/1605/FR-Notice09-19-05.pdf>. For additional information, visit <http://www.eia.doe.gov/oiaf/1605/aboutcurrent.html>

"Duke Energy Pledges \$2.5 Million for Climate Change Policy Partnership." Duke Energy has pledged \$2.5 million to Duke University to support the Climate Change Policy Partnership – a new industry-university collaboration that will develop policies to address the problems of global climate

change. Duke Energy's gift will come in two segments: \$1.5 million to fund Phase I of the partnership, expected to be completed by January 2007; and an additional \$1 million to fund Phase II, which depends on the successful completion of the first phase and the recruitment of other corporate partners. Researchers will assess the environmental and economic costs and benefits of federal policy options for addressing emissions of carbon dioxide and other greenhouse gases, including market-based cap-and-trade programs and a nationwide tax on the carbon content of fossil fuels. In addition, researchers will assess the potential for using carbon sequestration to store atmospheric carbon dioxide in forests, soils or underground reservoirs. *Duke University Press Release*, September 12, 2005, <http://biz.yahoo.com/prnews/050912/clm089.html?v=9>

November 2005

Proceedings of the Fifth Annual Workshop on GHG Emissions Trading now online. This joint event between the IEA, the International Emissions Trading Association and the Electric Power Research Institute took place September 27th and 28th, 2005 at the IEA offices in Paris. It provided an opportunity for government, industry, brokers, finance, and NGO delegates to discuss some of the key issues relating to market developments. The workshop combined presentation of papers on recent research, together with extended discussion sessions on the following subjects: Market news, Emissions trading and compatibility with future international architectures, Industry experience with emissions trading, Extending the coverage of domestic systems, and Progress on project mechanisms. A website with relevant information on the Workshop has been created and can be found at http://www.iea.org/textbase/work/workshopdetail.asp?WS_ID=213.

December 2005

Presentations from the 2005 Gasification Technologies Conference. Numerous sequestration-related presentations from the 2005 Gasification Conference are available online. The conference had a session devoted to sequestration titled, "Carbon Sequestration Ready: What Does It Mean & Who Can Do It?" This site also provides an extensive library of papers addressing gasification-related issues as well as papers and presentations from previous Gasification Technologies Conferences, <http://www.gasification.org/Presentations/2005.html>.

March 2006

UNFCCC Newsletter. On February 16, 2006, the United Nations Framework Convention on Climate Change (UNFCCC) launched the inaugural edition of the UNFCCC newsletter. Distributed bimonthly, the UNFCCC Newsletter will provide a comprehensive overview of major news and announcements, along with practical information about upcoming events. To subscribe, visit: http://unfccc.int/essential_background/newsletter/items/3642.php.

UNFCCC interactive map and reporting system for the CDM. To coincide with the one-year anniversary of the Kyoto Protocol coming into force (February 16, 2005), the United Nations Framework Convention on Climate Change has launched an interactive map and reports on its website showing Clean Development Mechanism project locations and status. See map at: <http://cdm.unfccc.int/Projects/MapApp> and reports at: <http://cdm.unfccc.int/Statistics>.

May 2006

"US Secretary of Energy Samuel W. Bodman to Keynote the Fifth Annual Conference on Carbon Capture & Sequestration." Additional featured Department of Energy speakers include:

- Jeffrey Jarrett, Assistant Secretary, Office of Fossil Energy

- Dr. Raymond Orbach, Director, Office of Science
- Carl Bauer, Director, National Energy Technology Laboratory
- Steve Eule, Director, Climate Change Technology Program.

Click here for the latest agenda for the May 8-11 conference:

http://www.carbonsq.com/pdf/2006/06ccs_agenda.pdf.

“1605(b) Greenhouse Gas Registry Guidelines.” On April 17, 2006, the US Department of Energy (DOE) issued revised General and Technical Guidelines for the voluntary reporting of greenhouse gas emissions, sequestration and reductions, known as the 1605(b) Program. The Program will be implemented by DOE during 2007. The new guidelines establish an accurate and transparent national registry where businesses and institutions can submit comprehensive reports on their greenhouse gas emissions, sequestration and reductions. The revised guidelines include “state-of-the-science” guidance and tools for estimating emissions from agricultural, forestry, and conservation activities important for carbon sequestration efforts, as well as from other sources of greenhouse gases. Other provisions encourage participation in the program by small emitters of greenhouse gases, such as farmers and small businesses. A notice containing the General Guidelines, and DOE’s response to the latest round of public comments, is to be published in the Federal Register on April 21, 2006. DOE’s Energy Information Administration (EIA) has initiated the development of the forms and software necessary to implement the revised guidelines. Draft forms are expected to be made available for public review and comment during the summer of 2006. Final forms are expected to be issued before the end of 2006. EIA expects to complete the software necessary for electronic reporting by spring or summer 2007, in time to permit full implementation of the revised program during 2007. See:

<http://www.eia.doe.gov/energy.cfm?id=2526>, and

http://www.usda.gov/oce/global_change/gg_reporting.htm for more information.

“DOE Appoints Stephen Eule As Director of the Climate Change Technology Program.” On March 31, 2006, US Secretary of Energy Samuel W. Bodman announced the appointment of Stephen D. Eule as the Director of the Climate Change Technology Program (CCTP) in the Office of Policy and International Affairs. As director of the CCTP, Mr. Eule will coordinate the federal government’s technology research and development (R&D) activities. Through a multi-agency structure, Mr. Eule will oversee a comprehensive, sound, multi-year R&D program plan for the development of climate change technology, specifically in regards to climate change goals and objectives. CCTP is organized under the auspices of the Cabinet-level Committee on Climate Change Science and Technology Integration (CCCSTI), established by President Bush on February 14, 2002. CCTP was authorized in the Energy Policy Act of 2005. March 31, 2006, <http://www.energy.gov/news/3417.htm>.

June 2006

Release of the Film “An Inconvenient Truth.” Coinciding with the May 24, 2006 release of Al Gore’s book on global warming, *An Inconvenient Truth*, is the showing of the film production by the same name. The film was released in Los Angeles and New York with expansion to other theaters to occur in June 2006. To locate a theater or watch the film trailer, go to: <http://www.climatecrisis.net>.

New for 2007—the International Journal of Greenhouse Gas Control. The publisher Elsevier, in association with the IEA Greenhouse Gas R&D Programme, is launching a new journal in 2007 that will cover developments in greenhouse gas control in the power sectors, and major manufacturing and production industries. It will cover all greenhouse gas (GHG) emissions and the range of abatement options available, and be comprised of both technical and non-technical related literature. The scope of the journal will include emissions, capture, transmission, and storage of CO₂, as well as alternative mitigation options, non-CO₂ GHGs, technology implementation, and economic considerations. The quarterly journal will be available in print and online, with online submissions and peer review, and an

international board of editors. Online via ScienceDirect in 2007 at: www.sciencedirect.com. See: www.elsevier.com/locate/jggc.

July 2006

“Brennan Takes Helm of US Climate Change Science Program.” The secretaries of commerce and energy have designated Dr. Bill Brennan (<http://www.noaa.gov/brennan.html>) as the acting director of the US Climate Change Science Program (CCSP) (<http://www.climate-science.gov>), the interagency program that coordinates and integrates scientific research on changes in climate and related systems. CCSP is composed of 13 federal scientific agencies and integrates the planning and budgeting of federal climate and global change activities. CCSP was launched in 2002 as a collaborative interagency program under a new cabinet-level organization designed to improve the government-wide management of climate science and climate-related technology development. The CCSP incorporates and integrates the U.S. Global Change Research Program (USGCRP) (<http://www.usgcrp.gov/>) with the Administration's U.S. Climate Change Research Initiative (CCRI) (<http://www.climate-science.gov/about/ccri.htm>). *National Oceanic and Atmospheric Administration Press Release*, June 19, 2006, <http://www.climate-science.gov/Library/pressreleases/pressrelease19jun2006.htm>.

“Carbon Value Analysis Tool (CVAT) Released By World Resources Institute.” World Resources Institute has released their Carbon Value Analysis Tool (CVAT), a Microsoft Excel-based program that allows energy managers to compare the emissions and financial impacts for a full range of energy-efficient and renewable energy projects. The analysis helps corporate energy managers to assess the value of emissions reductions and make decisions on financing new projects. The CVAT is designed to be especially useful for multinational corporations with greenhouse gas reduction targets as well as facilities that operate under carbon-limiting government mandates, such as those throughout Europe. Several Fortune 500 companies have tested CVAT and have released case study examples. CVAT is available at: http://pubs.wri.org/pubs_description.cfm?PubID=4199. The case studies are available at: <http://www.climate-northeast.org/ClimateNortheastCaseStudies.php>. June 6, 2006, http://newsroom.wri.org/newsrelease_text.cfm?NewsReleaseID=364.

Science

September 2005

“Errors Cited in Assessing Climate Data.” Three papers published in the online edition of the journal *Science* address what has been a lingering source of uncertainty in tropospheric temperature estimates since 1979. That is, records of the atmosphere's lowest layer, the troposphere, had not warmed over the last two decades and had cooled in the tropics. Two independent studies have found errors in the complicated calculations used to generate the old temperature records, which involved stitching together data from thousands of weather balloons lofted around the world and a series of short-lived weather satellites. A third study shows that when the errors are taken into account, the troposphere actually got warmer. Moreover, that warming trend largely agrees with the warmer surface temperatures that have been recorded and conforms to predictions in recent computer models. *New York Times*, August 12, 2005, <http://www.forestrycenter.org/headlines.cfm?RefID=76286>. For a more technical discussion on this topic see, “Some Convergence of Global Warming Estimates,” *Tech Central Station*, August 11, 2005, <http://www.techcentralstation.com/081105RS.html>

“Faster CO₂ emissions will overwhelm earth's capacity to absorb carbon.” Rising fossil fuel emissions may decrease the Earth's natural capacity to absorb carbon dioxide from the atmosphere, according to a study published August 1 in *Proceedings of the National Academy of Sciences* journal. New computational simulations by Dr. Inez Fung at the University of California at Berkeley and her

colleagues at UC Berkeley, Woods Hole, and the National Center for Atmospheric Research found that the faster carbon dioxide is emitted, the less the land and oceans can absorb it. "Our finding implies that carbon storage by the oceans and land will lag farther and farther behind as climate change accelerates with growing carbon dioxide emissions, creating an amplifying loop between the carbon and climate systems," says Dr. Fung. *UC Berkeley News*, August 5, 2005, http://www.berkeley.edu/news/media/releases/2005/08/02_carbon.shtml

October 2005

"Heat Wave makes plants warm planet." A new study shows that during the 2003 heat wave, European plants produced more carbon dioxide than they absorbed from the atmosphere. The study also found European lands were 20 percent less productive than during an average year. During an average year, plants in Europe absorb approximately 125 million tonnes of carbon (MtC). However, in 2003, they released 500 MtC to the atmosphere. By comparison, global emissions from burning fossil fuels amount to about 7,000 MtC. The study shows that ecosystems which currently absorb CO₂ from the atmosphere may produce it in the future, adding to the greenhouse effect. *BBC News*, September 21, 2005, <http://news.bbc.co.uk/2/hi/science/nature/4269066.stm>. Also see, "Heat Waves May Compound Global Warming," *NPR's Morning Edition*, September 22, 2005, <http://www.npr.org/templates/story/story.php?storyId=4858811> (audio)

"Global Warming 'Past the Point of No Return'." A record loss of sea ice in the Arctic this summer has convinced scientists that the northern hemisphere may have crossed a critical threshold beyond which the climate may never recover. Scientists fear that the Arctic has now entered an irreversible phase of warming which will accelerate the loss of the polar sea ice that has helped to keep the climate stable for thousands of years. Satellites monitoring the Arctic have found that the extent of the sea ice this August has reached its lowest monthly point on record, dipping an unprecedented 18.2 percent below the long-term average. *The Independent* (UK), September 16, 2005, <http://www.commondreams.org/headlines05/0916-09.htm>. Also see, "In a Melting Trend, Less Arctic Ice to Go Around," *New York Times*, September 29, 2005, <http://www.nytimes.com/2005/09/29/science/29ice.html>

November 2005

"World Temperatures Keep Rising With a Hot 2005." New international climate data show that 2005 is on track to be the hottest year on record, continuing a 25-year trend of rising global temperatures. Climatologists at NASA's Goddard Institute for Space Studies calculated the record-breaking global average temperature, which now surpasses 1998's record by a tenth of a degree Fahrenheit, from readings taken at 7,200 weather stations scattered around the world. "At this point, people shouldn't be surprised this is happening," said Goddard atmospheric scientist David Rind, noting that 2002, 2003 and 2004 were among the warmest years on record. *Washington Post*, October 13, 2005, <http://www.washingtonpost.com/wp-dyn/content/article/2005/10/12/AR2005101202498.html>

"The Truth About Global Warming." The *Seattle Times* devoted 3+ pages, no ads to its lead story, The Truth About Global Warming. The author, Sandi Doughton, was prompted to research the story after attending a forum for science writers in 2004, where "several speakers involved with climate science complained that skeptics of global warming get equal treatment in news coverage, as if scientists are hopelessly divided on the question. The speakers insisted they are not." *Seattle Times*, October 9, 2005, <http://archives.seattletimes.nwsourc.com/cgi-bin/texis.cgi/web/vortex/display?slug=globewarm11&date=20051009> (registration required)

"Sun's changes play role in global warming." Climate models of global warming should be corrected to better account for changes in solar activity, according to Nicola Scafetta and Bruce West of Duke

University. The new study is based in part on Columbia University research from 2003 in which scientists found errors in how data on solar brightness is interpreted. The researchers found that increased output from the sun might be to blame for 10 to 30 percent of the global warming. The Duke analyses examined solar changes over 22 years versus 11 years used in previous studies – a time frame long enough to isolate the effect of volcanoes and cyclical shifts in ocean currents. *LiveScience*, September 30, 2005, <http://msnbc.msn.com/id/9544093/>

“Antarctic ice melts as sea warms but cause unknown.” Leading scientists attending a British Royal Society conference in London said Antarctica is melting, adding to the rise in global sea levels and putting millions of lives and whole economies at risk. Said Anthony Payne of the University of Bristol, “We know a lot more about the ice sheets than we did before. We know change is happening and that it is rapid. What we don't know is why or what is causing it – what proportion is anthropomorphic.” *Reuters*, October 18, 2005, <http://www.enn.com/today.html?id=9047>

“Global Warming Sparks Increased Plant Production in Arctic Lakes.” Biological activity in some Arctic lakes has ratcheted up dramatically over the past 150 years as a result of global warming, according to a new study. In six lakes, researchers dug deep into the sediment to measure the amount “chlorophyll-a,” the main pigment involved in photosynthesis. The amount of chlorophyll-a is two to five times higher in recent times compared to ancient sediment, said Neal Michelutti of the University of Alberta. “Lakes in the Arctic have extremely short growing seasons – typically they remain ice-covered for up to 10 months of the year,” Michelutti explained. “A difference of only a few weeks [in the growing season] can have a huge impact biologically.” *LiveScience*, October 24, 2005, http://www.livescience.com/environment/051024_arctic_lakes.html

December 2005

“Unabated fossil-fuel use will replace polar ice with forests, DOE lab warns.” Continued burning of fossil fuels at the current pace will raise sea levels nearly 23 feet and lead to polar forests instead of ice caps in 300 years, a new Department of Energy report says. Scientists at DOE's Lawrence Livermore National Laboratory in California called the findings “stunning results of climate and carbon cycle model simulations” in a statement accompanying the report's release. Their study found that the Earth would warm by 8 degrees Celsius (14.5 degrees Fahrenheit) if humans use the entire planet's available fossil fuels by the year 2300. The scientists used models that coupled climate with the carbon cycle in the atmosphere to measure changes in both global climate and the carbon cycle. The data used included actual carbon emissions and climate change from pre-industrial levels (1870) to what is projected through 2300. *Greenwire*, November 3, 2005, <http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=17142>. Also see, “Modeling of long-term fossil fuel consumption shows 14.5-degree hike in Earth's temperature,” *LLNL Press Release*, November 1, 2005, http://www.llnl.gov/pao/news/news_releases/2005/NR-05-11-01p.html

“Climate Study Warns of Warming and Losses of Arctic Tundra.” If emissions of heat-trapping gases continue to accumulate in the atmosphere at the current rate, there may be many centuries of warming and a near total loss of Arctic tundra, according to a new climate study. The researchers ran a computer model that simulates the climate system and the flow of heat-trapping carbon dioxide into the air, then back into soils and the ocean. In the simulation, the atmospheric concentration of carbon dioxide rises about 0.45 percent a year through 2300. That is slightly less than the current rate, about 0.5 percent. But even at the lower rate, the concentration of carbon dioxide would double from preindustrial levels by 2070, triple by 2120 and quadruple by 2160. Consistent with many other studies, the model showed that the Arctic would see the most warming, with average annual temperatures in many parts of Arctic Russia and northern North America rising by more than 25 degrees by around 2100. In the simulation, the scrubby Arctic tundra largely vanishes as climate zones shift hundreds of miles north.

Tundra would decline to 1.8 percent of the world's land area from about 8 percent. *New York Times*, November 2, 2005, <http://www.mezomorf.com/science/news-9976.html>

“Global Warming Supercharged by Water Vapor?” Water vapor, experts say, is the culprit behind Europe's rapidly rising temperatures. Evaporated H₂O is a known greenhouse gas – a gas that absorbs and re-emits infrared radiation in Earth's atmosphere, thereby increasing temperatures. But only now has a study uncovered evidence that water vapor is a major public enemy in Europe. According to a team of Swiss scientists, heat from other greenhouse gases is causing more water to evaporate, releasing the vapor into the atmosphere above Europe. That vapor in turn, adds to the greenhouse effect, further warming the region. Temperatures throughout the Northern Hemisphere have been increasing in recent years. But Europe has been heating up especially quickly, leading to studies, theories, and debate as to why. The scientists calculated that 70 percent of the recent increase in temperatures in central Europe is due to water vapor, and 30 percent is due to other greenhouse gases. *National Geographic*, November 10, 2005, http://news.nationalgeographic.com/news/2005/11/1110_051110_warming.html

“Climate Shift Tied To 150,000 Fatalities: Most Victims Are Poor, Study Says.” Earth's warming climate is estimated to contribute to more than 150,000 deaths and 5 million illnesses each year, according to the World Health Organization, a toll that could double by 2030. The data, published in the journal *Nature*, indicate that climate change is driving up rates of malaria, malnutrition and diarrhea throughout the world. Health and climate scientists at the University of Wisconsin at Madison, who conducted one of the most comprehensive efforts yet to measure the impact of global warming on health, said the WHO data also show that rising temperatures disproportionately affect poor countries that have done little to create the problem. *Washington Post*, November 17, 2005, <http://www.washingtonpost.com/wp-dyn/content/article/2005/11/16/AR2005111602197.html>.

January 2006

“2005 Continues the Warming Trend,” Scientists in the US and Britain reported that 2005 was one of the hottest on record, putting 8 of the 10 past years at the top of the charts in terms of high temperatures. NASA's Goddard Institute for Space Studies has concluded 2005 was the warmest year in recorded history, while the National Oceanic and Atmospheric Administration and the U.K. Meteorological Office report it the second hottest, after 1998. All three reports agree that 2005 is the hottest year on record for the Northern Hemisphere, at roughly 1.3 degrees Fahrenheit above the historical average. James Hansen, who directs NASA's Goddard Institute, said this year's statistics were particularly significant because in 1998 the world experienced El Niño, which drove up temperatures dramatically, whereas this year the temperature reached record levels without such a dramatic climatic event. *Washington Post*, Friday December 16, 2005, <http://www.washingtonpost.com/wp-dyn/content/article/2005/12/15/AR2005121501637.html>

“Most of Arctic's Near-Surface Permafrost to Thaw by 2100,” New simulations from the National Center for Atmospheric Research (NCAR), show that over half of the area covered by the topmost layer of permafrost in the Northern Hemisphere could thaw by 2050 and as much as 90 percent by 2100. Scientists expect the thawing to increase runoff to the Arctic Ocean and release vast amounts of carbon into the atmosphere. The study used a fully interactive climate system model, the Community Climate System Model (CCSM), to examine the state of permafrost, including interactions among the atmosphere, ocean, land, sea ice and soil. The new study highlights concern about carbon dioxide and methane being released from thawing soils, since permafrost may hold 30 percent or more of all the carbon stored in soils worldwide. Results appear online in the December 17 issue of *Geophysical Research Letters*. Ascribe, December 19, 2005, <http://newswire.ascribe.org/cgi-bin/behold.pl?ascribeid=20051219.091021&time=09%2028%20PST&year=2005&public=0>.

February 2006

Greenwire, "Experts Urge Caution in Application of New Methane Studies," An article published in the January 12 journal *Nature* by German researchers suggests that plants in open-air conditions contribute between 10 to 30 percent of the annual global flow of methane. Scientists had long believed that plants only produced methane in the absence of oxygen. Experts caution that the policymakers should wait until scientists know more about how plants produce methane before implementing policy shifts. Additionally in the same issue of *Nature*, an editorial was written by David Lowe of New Zealand's National Institute of Water and Atmospheric Research. Lowe stated, "We now have the specter that new forests might increase greenhouse warming through methane emissions rather than decrease it by sequestering CO₂," referring to reforestation incentives agreed to by parties to the Kyoto Protocol. "This paper will undoubtedly unleash controversy, not the least of which will be political." Jay Gulledge, a senior research fellow with the Pew Center of Global Climate Change stated, "Relative to the amount of plant biomass, this is a very small amount of methane compared to the carbon dioxide plants take up to make that biomass," disagreeing with Lowe's contention that the new knowledge of plants' greenhouse gas contributions exposes a major drawback to planting trees as carbon sinks. Other research by a different group of German scientists showed high concentrations of methane over tropical rainforests. Also the USDA Forest Service found high levels of methane at upland forest sites in the Brazilian Amazon. (See Terrestrial section of this newsletter for the *Nature* paper's abstract "**Methane Emissions from Terrestrial Plants under Aerobic Conditions.**"), January 12, 2006, http://www.eenews.net/Greenwire/searcharchive/test_search-display.cgi?q=methane&file=%2FGreenwire%2Fsearcharchive%2FNewsline%2F2006%2FJanuary12%2F01120610.htm (Subscription may be required.)

SciDev.Net, "Global Warming: Plants Are Not To Blame," The authors of a recent study in the journal *Nature* released a statement that plants are not to blame for climate change. The researchers from the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, Utrecht University in the Netherlands, and the Department of Agriculture and Rural Development for Northern Ireland, United Kingdom, reported that plants emit up to a third of the methane (a greenhouse gas) that is in the atmosphere. (See Terrestrial section of this newsletter for the *Nature* paper's abstract "**Methane Emissions from Terrestrial Plants under Aerobic Conditions.**") A wave of media attention followed as did emails from concerned scientists and citizens regarding the role of plants and implications for global warming. Frank Keppler at the Max Planck Institute for Nuclear Physics wants to make 3 points clear to the public. First, the findings do not mean that reforestation programs should be condemned. Trees absorb carbon dioxide, so planting them is still beneficial. Second, changes in the overall amount of methane emitted by plants are likely to be caused by human activities such as deforestation. Finally, much more research is needed to discover how methane emissions from plants vary according to species, temperature, humidity, sunlight and other factors, as well as how these emissions may change as the environment changes. (See: <http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTc5NDY> for the full statement released by the authors in response to the public's questions "Global Warming - The Blame Is Not With the Plants," and for an explanation of their calculations.) January 20, 2006. <http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTc5NDY>

BBC News website, "Experiment Probes Climate Riddle," In one of the biggest climate experiments ever mounted, scientists will use radar, airplanes, weather balloons and a ship to study the life cycle of tropical clouds in order to gain a better understanding of how clouds form and carry heat high into the atmosphere. Approximately 200 scientists from 30 institutions in 10 countries will collaborate on the project over 23 days, with data analysis and modeling to extend that timeframe. Investigators and funding for the Tropical Warm Pool International Cloud Experiment (TWP-ICE) come from many countries including Australia, the US, Britain, Japan and Canada. Tropical clouds carry heat and moisture from the Earth's surface high in the atmosphere, which is a key process in moving heat around the globe. By better understanding what goes on inside clouds, how they form and how they behave, computer models can be developed to predict the extent of global climate warming more accurately. Existing computer models do not reflect the processes of convection and cloud formation accurately, said

Tom Ackerman of the University of Washington in Seattle, because they typically treat them as separate processes. "But in order to do that you need to understand this total life cycle of air going into the clouds, condensation, vertical lifting and then cloud being dumped out at other levels," he stated. January 18, 2006. <http://news.bbc.co.uk/2/hi/science/nature/4624520.stm>

Reuters, "2005 Was Australia's Hottest Yet," Australia's Bureau of Meteorology said temperatures were on average 1.09 degrees Celsius (1.96 degrees Fahrenheit) higher than normal in 2005, making it the hottest year since the first records from 1910. Meteorologist Mike Coughlan said previous record hot years in 1988, 1998 and 2002 were caused by El Niño events, where warmer waters in the southwest Pacific led to lower rainfall and hotter weather in Australia. But there was no El Niño in 2005. "The strong culprit has to be global warming," Coughlan told Reuters. "The 2005 record is yet another sign that our climate is changing," he said. The Bureau of Meteorology report came ahead of the January 11-12 inaugural gathering of the Asia-Pacific Partnership on Clean Development and Climate in Sydney. Australia's Environment Minister Ian Campbell said the latest data on Australia's weather proved countries needed to work together on cleaner technology. "It is a huge and serious challenge. These figures add to the weight of evidence that climate change is real and it's a problem that the world needs to work together to seek to solve," Campbell told Australian Broadcasting Corporation radio. January 4, 2006, <http://www.cnn.com/2006/WEATHER/01/04/waether.australia.reut/index.html>

Reuters, "Gore to Publish Book on Global Warming," Former Vice President Al Gore is to release his second book in April entitled "An Inconvenient Truth" published by Rosdale Books. The book is associated with a documentary of the same name that was shown at the Sundance Film festival. According to Rosdale "In the film, Mr. Gore guides audiences through indisputable evidence of the environmental impact of global warming. In the book, the former US Vice President writes about global warming and shares his personal story about how the issue became of urgent importance to him." January 24, 2006, http://today.reuters.com/news/NewsArticle.aspx?type=scienceNews&storyID=2006-01-24T174509Z_01_N24233070_RTRUKOC_0_US-ENVIRONMENT-GORE.xml.

March 2006

Palladium Item (Richmond, IN), "No-Till Historic Experiment Reaches Middle Age," After 45 years, the no-till soil plots set up in 1962 by scientists Glover Triplett and Dave VanDoren may not have enough funding to be maintained. The Triplet-Van Doren plots were critical in supporting some of the earliest work on no-till carbon sequestration. On average, the Ohio soils can sequester about 500 pounds of carbon per acre. Supporters have mounted a campaign to fund the research and upkeep of the plots. February 12, 2006, <http://www.pal-item.com/apps/pbcs.dll/article?AID=/20060212/NEWS01/602120322/1008>.

Reuters, "Greenland Glaciers Melting Faster, Study Finds," The authors of the article "Changes in the Velocity Structure of the Greenland Ice Sheet," from the February 17, 2006 **Science** magazine, find that the ice loss due to glacier flow in Greenland has increased from 12 cubic miles of ice loss per year in 1996 to 36 cubic miles of ice per year in 2005. Rising temperatures are a factor, with the temperature in southeast Greenland rising by 5.4 degrees Fahrenheit over the last 20 years. The authors calculated that Greenland contributes 0.02 inch to the annual 0.1 inch rise in global sea levels. One author stated that the southern half of Greenland is reacting to climate warming with the northern half waiting, though it may not take long for the northern part to react. February 17, 2006, http://today.reuters.com/news/newsArticle.aspx?type=scienceNews&storyID=2006-02-16T193330Z_01_N16367561_RTRUKOC_0_US-ENVIRONMENT-GLACIERS.xml&archived=False

Defra Press Release, "How much climate change can we take?" A new book "Avoiding Dangerous Climate Change" was released with the forward written by Britain's Prime Minister Tony Blair. The government-commissioned book collates evidence for global warming presented at the conference of the same name, which took place at Britain's meteorological office (the Met) in February 2005 at the start of

the UK's G8 Presidency. The book and an executive summary are available on the Department for Environment, Food and Rural Affairs (Defra) website at:

www.defra.gov.uk/environment/climatechange/internat/dangerous-cc.htm. January 30, 2006,
<http://www.defra.gov.uk/news/2006/060130c.htm>.

April 2006

BBC News, "Huge Polar Initiative Announced." Activities are underway for the planning and launch of International Polar Year (IPY) 2007-2008. This international polar science research initiative will conduct scientific research and observations focusing on the Earth's polar regions. IPY will involve over 50,000 participants from more than 60 countries, with a cost of \$3 to 3.6 billion. IPY is sponsored by the International Council of Science and the World Meteorological Organization, and is to take place from March 2007 to March 2009. Dr. David Carlson, IPY's program director, says understanding the polar region is essential in order to understand the global carbon cycle, the global water cycle, the global weather cycle, or global economics. Proposed activities include various ice coring projects and projects involving CO₂ monitoring. See <http://www.ipy.org/> for further information. March 15, 2006,
<http://news.bbc.co.uk/1/hi/sci/tech/4806146.stm>.

WMO Press Release, "First WMO Greenhouse Gas Bulletin: Greenhouse Gas Concentrations Reach New Highs in 2004," The globally averaged concentrations of carbon dioxide (CO₂), methane, and nitrous oxide in the planet's atmosphere reached their highest recorded levels in 2004, according to the World Meteorological Organization's (WMO) first annual Greenhouse Gas Bulletin. CO₂ was recorded at 377.1 parts per million (ppm). The level of CO₂ supersedes the value from the late 1700's by 35 percent, largely due to emissions from the combustion of fossil fuels. In 2004, CO₂ increased by 1.8 ppm or 0.47 percent when compared with the previous year. WMO secretary-general Michel Jarraud said the atmospheric CO₂ levels continue to increase and show no sign of leveling off. Download the first annual Greenhouse Gas Bulletin at: <http://www.wmo.int/web/arep/gaw/ghg/ghg-bulletin-en-03-06.pdf>. See http://www.wmo.int/web/arep/gaw/gaw_home.html for more information. March 14, 2006,
http://www.wmo.int/web/arep/gaw/ghg/press_release_744_en.doc.

AP, "Carbon Dioxide Hit Record in 2005." The Office of Atmospheric Research at the US National Oceanic and Atmospheric Administration has said that the concentration of carbon dioxide in the atmosphere climbed to a record 381 parts per million last year, up 2.6 parts per million from the previous year. Final calculations from reporting stations around the world will not be available until later in the spring when a final report will be released. March 14, 2006,
<http://abcnews.go.com/Politics/print?id=1725818>.

Ceres Press Release, "BP and DuPont Receive Top Scores in First-Ever Ranking of 100 Global Companies on Climate Change Strategies." The business environmental stewardship group Ceres, Coalition for Environmentally Responsible Economies, has released a report to present an analysis of how 76 US companies and 24 non-US companies are addressing the business challenges of climate change. The study ranks the largest companies with operations in the US in 10 business sectors including: oil/gas, electric power, auto, chemical, industrial equipment, mining/metals, coal, food products, forest products, and air transportation. Five broad areas were evaluated using a "Climate Governance Checklist": board oversight, management performance, public disclosure, greenhouse gas emissions accounting, and strategic planning. The report was requested by over two dozen institutional investors, and prepared by the Investor Responsibility Research Center, as part of an action plan announced at the Institutional Investor Summit on Climate Risk in May 2005 at the United Nations. Visit the Ceres website to see the rankings and details in the report named "2006 Corporate Governance and Climate Change: Making the Connection": <http://www.ceres.org/pub/>. March 21, 2006,
http://www.ceres.org/news/news_item.php?nid=154.

Greenwire, “Princeton Professor Lays Out Broad Strategy on Greenhouse Emissions.” At World Bank Energy Week 2006 on March 3, 2006, Professor Robert Socolow explained a broad blueprint to deal with global warming—his “wedge technology” theory—and why he is so optimistic about the potential for carbon sequestration. The theory is from the paper “Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies” which he wrote with Steve Pacala last year. (The paper can be found in the August 13, 2004 issue of *Science*, Volume 305, Number 5686, Pages 968-972, DOI: 10.1126/science.1100103, <http://www.sciencemag.org/cgi/content/full/305/5686/968?ijkey=K6cRPbiYRFwus&keytype=ref&siteid=sc> i or at <http://www.s-e-i.org/polreports/pswedges.pdf>.) For more information on the topic, also see: <http://www.princeton.edu/~cmil/>. View a video of Socolow’s talk on E&E TV online at: <http://www.eande.tv/main/?date=030906>. March 9, 2006, <http://www.eenews.net/Greenwire/2006/03/09/#25>. (Subscription may be required.)

May 2006

CBC News, “Venus Express Probe Enters Into Orbit.” The European Space Agency’s robotic space craft, the Venus Express, will orbit Venus for 1 ½ years to help increase our understanding of the greenhouse effect. Venus and the Earth are of similar size and composition, but Venus evolved differently and shows much stronger effects of global warming. Scientist hope that information and measurements gathered on Venus will allow for an increased understanding of how Earth might evolve in the future. The average temperature on Venus is 477 degrees Celsius (891 degrees Fahrenheit), and its toxic atmosphere is mainly composed of carbon dioxide, with clouds of sulfuric acid and 400 kilometers (249 miles) per hour winds. April 11, 2006, <http://www.cbc.ca/story/science/national/2006/04/11/venus-express060411.html>.

Time Magazine, Special Report on Global Warming, Time Magazine has published a special report on Global Warming covering many aspects of the topic including: a cover story overview of the issues and action that can be taken; global warming’s effect on species and possible health effects on humans; and economic, policy, legislative, regulatory, and global aspects of the issue. See the index of April 3, 2006, Volume 167, Number 14, *Time* magazine at: <http://www.time.com/time/magazine/0,9263,7601060403,00.html>. (Subscription required.)

NOAA Press Release, “NOAA/NSF Cruise Reveals Impacts of Ocean Acidification on Chemistry, Biology of North Pacific Ocean.” Preliminary data from a recent field study in the Pacific Ocean shows that the oceans are becoming more acidic. NOAA scientists measured a decrease in pH of approximately 0.025 units and increases in dissolved inorganic carbon of about 15 micromoles per kilogram ($\mu\text{mol/kg}$) in surface waters over a large section of the northeastern Pacific. The findings of an increase in acidity are consistent with data from previous field studies conducted in other oceans. Richard Feely, an oceanographer with the NOAA Pacific Marine Environmental Laboratory and the chief scientist on the study said that the dramatic changes can be attributed, in most part, to the uptake of anthropogenic CO_2 by the ocean over the past 15 years. This verifies earlier model projections that the oceans are becoming more acidic because of the uptake of carbon dioxide released as a result of fossil fuel burning. As levels of dissolved CO_2 in the sea waters rise, the skeletal growth rates of calcium-secreting organisms will be reduced, and the combined effects of other climatic changes in salinity, temperature and upwelled nutrients, could substantially alter the biodiversity and productivity of the ocean. April 5, 2006, <http://www.noaanews.noaa.gov/stories2006/s2606.htm>.

Reuters, “World’s Oldest Ice Could Hold Climate Clues,” and Outside Online, “Oldest Ice Sample Could Offer Clues to Climate Change.” Japanese scientists from the National Institute of Polar Research have obtained a one million year old ice core from the Antarctic. The sample is the oldest ice core sample to be retrieved, with the previously oldest core estimated at 750,000 years old. Researchers at the Dome Fuji base in eastern Antarctic spent more than two years drilling down and obtaining the

sample from a depth of 9,936 feet under the ice. The core will be used to examine changes in temperature, levels of carbon dioxide and methane over time. Research published in the journal *Nature* in 2005 states that concentrations of CO₂ and methane are far higher now than at any time in the last 650,000 years. April 18, 2006, <http://msnbc.msn.com/id/12371432/>, and April 19, 2006, http://outside.away.com/outside/news/20060419_1.html.

June 2006

Reuters, "Greenhouse Gases Showed Steady Rise in 2005." The US National Oceanic and Atmospheric Administration (NOAA) reported on May 1, 2006 that carbon dioxide levels increased from 2004 to 2005, according to the agency's Annual Greenhouse Gas Index, or AGGI. Nitrous oxide levels also rose, but methane and chlorofluorocarbon levels decreased. The AGGI showed a 1.25 percent rise in overall greenhouse gases in 2005. The AGGI stood at 1.215 in 2005 compared to the 1990 baseline value of 1.00, showing a steady rise in greenhouse gases over the past 15 years. The 1.25 percent rise in greenhouse gases was comparatively smaller than the increases of previous years, with the largest annual increase at 2.8 percent (1987 to 1988), and the smallest of .81 percent (1992 to 1993). Global levels of carbon dioxide increased from an average of 376.8 parts per million in 2004 to 378.9 parts per million in 2005. To access the NOAA AGGI website, go to: <http://www.cmdl.noaa.gov/aggi/>. May 3, 2006, <http://www.planetark.com/dailynewsstory.cfm/newsid/36210/story.htm>.

"Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences." The Climate Change Science Program and the Subcommittee on Global Change Research, Washington, DC, has released the first of a series of 21 reports aimed at providing current evaluations of climate change science to inform public debate, policy, and operational decisions. This first Synthesis and Assessment Product addresses previously identified discrepancies between observations and simulations of surface and atmospheric temperature trends. Previously reported discrepancies between the amount of warming near the surface and higher in the atmosphere have been used to challenge the reliability of climate models and the reality of human induced global warming. Specifically, surface data showed substantial global-average warming, while early versions of satellite and radiosonde data showed little or no warming above the surface. This significant discrepancy no longer exists because errors in the satellite and radiosonde data have been identified and corrected. New data sets have also been developed that do not show such discrepancies. This Synthesis and Assessment Product is an important revision to the conclusions of earlier reports from the US National Research Council and the Intergovernmental Panel on Climate Change. For recent decades, all current atmospheric data sets now show global-average warming that is similar to the surface warming. While these data are consistent with the results from climate models at the global scale, discrepancies in the tropics remain to be resolved. Nevertheless, the most recent observational and model evidence has increased confidence in the understanding of observed climatic changes and their causes. Further information on the process for preparing Synthesis and Assessment products and the CCSP itself can be found at: www.climatechange.gov. April 2006. Download the report or sections of the report at: <http://www.climatechange.gov/Library/sap/sap1-1/finalreport/default.htm>.

Contra Costa Times, "Livermore Lab's 'Nanotube' Work Could Help Curb Global Warming." Scientists from Lawrence Livermore and Lawrence Berkeley laboratories have created a filtration membrane comprised of carbon nanotubes, which could be useful for removing carbon dioxide directly from power plant emissions. The carbon nanotubes that comprise the membrane are 50,000 times thinner than a human hair and over a trillion microscopic pores per square inch, but have a greater than expected flow rate for gasses and liquids passing through it. The research team is not sure of why the rate is faster than one would expect, but postulated that it is because the carbon atoms that make up the tubes fit together perfectly, and the surface of the tubes is extremely slippery. The technical paper describing the nanotubes transport process is in the May 19, 2006 issue of *Science*. ("Fast Mass Transport Through Sub—2-Nanometer Carbon Nanotubes, *Science*, May 19, 2006, Vol. 312. no. 5776,

pp. 1034 – 1037, doi:10.1126/science.1126298.) May 19, 2006,
http://www.smalltimes.com/document_display.cfm?document_id=11557.

July 2006

Reuters, “Gore To Train 1,000 to Spread Word About Climate.” Former Vice President Gore will begin a bi-partisan national education campaign by the end of the summer to train 1,000 people to give a version of his slide show talk on global warming. The slide show is the basis for the book and film “An Inconvenient Truth.” June 12, 2006,
http://today.reuters.com/news/newsArticle.aspx?type=topNews&storyID=2006-06-13T025339Z_01_N12361864_RTRUKOC_0_US-ENVIRONMENT-GORE.xml&archived=False.

Greenwire, “National Academy of Science Finds ‘Hockey Stick’ Graph’s Conclusion ‘Plausible’ ” and The National Academies Press Release, “ ‘High Confidence’ That Planet Is Warmest in 400 Years; Less Confidence in Temperature Reconstructions Prior to 1600.” The National Academy of Science released a report on June 22, with the conclusion that the controversial “hockey stick” climate graph is plausible. The graph, published in the journal *Nature* in 1998, draws on “proxy evidence,” which includes data on tree rings, corals, ocean and lake sediments, cave deposits, ice cores, boreholes, and glaciers, to reconstruct global temperatures over the last 1000 years. The report concludes with a high level of confidence that global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding four centuries, supporting the idea that the climate is warming due to human influence. The analysis was conducted in response to a request from Congress. (See this newsletter’s **Recent Publications** section for link to the NAS report: **“Surface Temperature Reconstructions for the Last 2,000 Years (2006).”** To view the *Nature* report and graph, refer to: “Global-scale temperature patterns and climate forcing over the past six centuries,” Michael E. Mann, Raymond S. Bradley and Malcolm K. Hughes, *Nature*, Volume 392, pages 779 – 787, April 23, 1998, doi:10.1038/33859,
http://www.nature.com/nature/journal/v392/n6678/full/392779a0_fs.html.) June 22, 2006,
<http://www.eenews.net/Greenwire/2006/06/22/#11>, (Subscription may be required), and June 22, 2006,
<http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=11676>.

August 2006

Energy and Environment Daily, “ ‘Hockey Stick’ Analysis Still Ruffling Feathers in Congress.” In the US House of Representatives, a pair of hearings were to be held regarding the viability of the “Hockey stick” climate change analysis by the US House of Representatives Committee on Energy and Commerce and the Committee on Government Reform. The committees are discussing the often cited upwardly curving “hockey stick” graph that was published in 1998 in the journal *Nature*, and prominently featured in the 2001 report of the Intergovernmental Panel on Climate Change. The *Nature* study reconstructed past global average temperatures using data from corals, tree rings, ice cores and bore holes deep within the Earth. On July 19, the Oversight and Investigations Subcommittee will hold a hearing to review the *Nature* paper. (For the review, see:
http://energycommerce.house.gov/108/home/07142006_Wegman_Report.pdf.) On July 20, the Committee on Government Reform held a hearing on Climate Change: Understanding the Degree of the Problem. (For Full Transcript, see:
<http://reform.house.gov/GovReform/Hearings/EventSingle.aspx?EventID=46863>.) A recent report by a scientific panel for the Committee on Energy and Commerce stated that the *Nature* paper’s authors relied on statistics in order to graph the hockey stick shape, and that the authors claim that unprecedented global warming occurred during the 20th century “cannot be supported by [the] analysis.” (To read a press release regarding the report, see:
http://energycommerce.house.gov/108/News/07142006_1989.htm.) The panel’s view contradicted the view of the recent report by the National Academy of Sciences that found the *Nature* paper’s conclusions

plausible. (Access a summary or the paper here:

<http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=11676>.) July 17, 2006,

http://www.eenews.net/EEDaily/sr_climate_change/2006/07/17/3/. (Subscription may be required.)

***The Washington Post*, “Pollution in Overdrive, New Report Cites US Motorists For Production of Greenhouse Gases.”**

The non-profit group Environmental Defense has released a report entitled “Global Warming on the Road,” in which they point out the global emissions of US vehicles by manufacturer. The report states that the US, which represents 5 percent of the world population, contributes 45 percent of the world’s vehicular-based CO₂ emissions. Americans own 30 percent of the world’s vehicles yet drive farther than the international average, burning more fuel per mile. The report outlines three factors which contribute to the amount of CO₂ emissions from automobiles: amount of driving, fuel economy and the carbon content of the gas used. In 2004, the “Big Three” auto manufacturers accounted for 73 percent of the CO₂ emissions of all US cars and trucks partly due to having the greatest number of vehicles on the road, with General Motors contributing 99 metric tons carbon equivalent (MMTc) (31 percent), Ford at 80 MMTc (25 percent), and Daimler Chrysler at 51 MMTc (16 percent); 203 million total MMTc for the three auto makers. Environmental Defense said that auto companies should not be singled out for blame because consumer choices also play a role. To download the full report or fact sheet on “Global Warming on the Road, see:

<http://www.environmentaldefense.org/article.cfm?contentID=5300&campaign=>, June 27, 2006,

<http://www.washingtonpost.com/wp-dyn/content/article/2006/06/27/AR2006062701757.html>.

Policy

September 2005

Energy Policy Act of 2005 authorizes suspension of royalty payments for CO₂ EOR. The Energy Policy Act of 2005, recently signed into law by president Bush, authorizes suspension of royalties on up to 5 million bbl of oil equivalent/lease where CO₂ injection is used for enhanced recovery. Royalty suspension could be limited based on market price. The provision, which also is designed to promote carbon sequestration, mandates that the energy secretary establish a CO₂ injection demonstration program for up to \$3 million. The program would involve up to 10 projects in the Williston basin and one project in Alaska’s Cook Inlet.” *Oil & Gas Journal*, August 3, 2005,

<http://ogj.pennnet.com/> (subscription required)

“9 States in Plan to Cut Emissions by Power Plants.” Officials in New York and eight other Northeastern states have come to a preliminary agreement to freeze power plant emissions at their current levels and then reduce them by 10 percent by 2020, according to a draft proposal. Once a final agreement is reached, the legislatures of the nine states will have to enact it, which is considered likely. Enforcement of emission controls could potentially result in higher energy prices in the nine states, which officials hope can be offset by subsidies and support for the development of new technology that would be paid for with the proceeds from the sale of emission allowances to the utility companies. *New York Times*, August 24, 2005, <http://history.berkeley.edu/faculty/Frydl/emissions.html>. For additional information visit the Regional Greenhouse Gas Initiative website at <http://www.rggi.org/>

“Governor Announces New Step to Curb Global Warming in Oregon.” Oregon looks set to become the tenth U.S. state to adopt California’s strict rules on vehicle emissions, as Governor Ted Kulongoski vetoed a legislative provision that prohibits the state Department of Environmental Quality from adopting the standards. The Governor also announced the formation of a workgroup, The Carbon Allocation Workgroup, charged with developing strategies to reduce carbon emissions in the electric utility sector. *Press Release*, August 29, 2005, http://governor.oregon.gov/Gov/press_082905.shtml

“Federal Judge OKs Global Warming Lawsuit.” Environmental groups and four U.S. cities can sue federal development agencies on allegations the overseas projects they back financially contribute to global warming, a judge has ruled. A coalition of environmental groups sued two government agencies that provide loans and insure billions of dollars of U.S. investors' money for development projects overseas. Many are power plants that emit greenhouse gases such as carbon dioxide. It is argued that the National Environmental Policy Act, the law requiring environmental assessments of proposed projects in the United States, should apply to the U.S.-backed projects overseas because they contribute to the degradation of the U.S. environment. *Washington Post*, August 24, 2005, <http://www.washingtonpost.com/wp-dyn/content/article/2005/08/24/AR2005082402080.html>

“Designing a Greenhouse Gas Offset System for Canada.” On August 11 the Canadian government released for public consultation the document, “Offset System for Greenhouse Gases: Overview Paper and Technical Background Document.” The goal of Canada's planned offset system is to enable the country to meet its commitments under the Kyoto Protocol. Written comments are welcome until September 30, 2005 and should be submitted to Judith Hull; Project Manager, Offsets; Environment Canada at offsets-compensations@ec.gc.ca. *Government of Canada*, <http://www.climatechange.gc.ca/english/offsets/>

“Underground off the ground.” The August 2005 edition of Foundation JIN's *Joint Implementation Quarterly* has an article that explores why public awareness and support for CO₂ capture and underground storage has been negligible. The article says “It may be time to get the option ‘out of the shadow’.” The same edition also contains an article on the Asia-Pacific Partnership and its role in the post-Kyoto Debate. *Jl Quarterly*, August 2005, <http://jiq.wiwo.nl/ejiq405.pdf>

“Energy: using our brains and our resources.” Article sets forth the recent Asia-Pacific Greenhouse Agreement as an opportunity for Australia to develop GHG mitigation technologies and potentially reap economic benefits. Advanced coal utilization technology with the possibility of producing transportation fuels is highlighted as an important option for Australia. *On Line Opinion* (Australia), August 25, 2005, <http://www.onlineopinion.com.au/view.asp?article=207>

“World Officials Want Global Warming Action.” From August 16-19, representatives of 23 nations, including the United States, Japan, China, India, Mexico, and the European Union, attended the Greenland Dialogue on Climate Change, hosted by the Danish government in Ilulissat, Greenland. The representatives toured the Sermeq Kujalleq glacier, which has retreated nearly seven miles since 1960. The conference took no decisions on how to fight global warming, but the article does mention the Asia-Pacific Partnership on Clean Development and Climate. According to British environment minister Elliot Morley, participants in the Greenland meeting said that the Kyoto Protocol and the U.S. initiative should be regarded as “complimentary, not in opposition.” *Associated Press*, August 19, 2005 <http://abcnews.go.com/Technology/Science/wireStory?id=1050498&CMP=OTC-RSSFeeds0312>

October 2005

“California approves world's toughest vehicle emissions rules.” The California Air Resources Board (CARB) announced that the state's greenhouse gas (GHG) regulations for vehicles were unanimously approved by the California Office of Administrative Law on September 16, and filed with the Secretary of the State. Beginning with Model Year 2009, the new rules set limits for the total GHG emissions that new vehicles can emit per mile. The limits tighten each year after that, and by 2016, GHG emissions from lighter vehicles will be cut by one-third, while GHG emissions from heavier vehicles will be cut by about one-quarter. *USA Today*, September 25, 2005, http://www.usatoday.com/news/nation/2004-09-25-calif-rule_x.htm

“Court dismisses global-warming case.” A U.S. federal district court dismissed a lawsuit filed by eight states that claimed emissions released by the coal-fired power plants of a handful of U.S. utilities contribute to global warming and create a “public nuisance.” Judge Loretta Preska of the U.S. District Court for the Southern District of New York said in her opinion that the case presented “political questions” that should be dealt with outside the judicial branch of government. *CBS Marketwatch*, September 15, 2005,

<http://www.marketwatch.com/news/story.asp?dist=¶m=archive&siteid=mktw&guid=%7BAAE8BEEE%2D9920%2D4F6C%2D88F9%2DAAFEC0DB8B95%7D&garden=&minisite> (registration required)

“Northeast Greenhouse Gas Control Plan Far From Sealed.” The Northeast Regional Greenhouse Gas Initiative (RGGI) is on the verge of issuing a preliminary proposal, but sources familiar with the nation's first broad-based, mandatory CO₂-reduction cap caution that an agreement is far from sealed as a slew of questions remain on a number of critical details. The plan – which would cut CO₂ emissions in the nine participating states by 10 percent in 2020 – will include an initial proposed regional CO₂ cap of about 150 million tons along with suggested caps for individual states, according to a memo outlining the plan. However, the plan will not explicitly explain how those numbers were derived – a concern for some observers because it could limit the plan's value for other regional efforts, such as the one being undertaken by California, Oregon and Washington. Some observers are also disappointed that the proposal would allow offsets from activities other than emissions reductions, such as carbon sequestration, to account for up to 50 percent of the costs. In addition, there is concern that the plan does not require states to specifically correct for “leakage,” or the amount of CO₂ created through purchase of electricity generated in states not subject to the cap. *EnergyWashington*, August 31, 2005, <http://www6.lexisnexis.com/publisher/EndUser?Action=UserDisplayFullDocument&orgId=1925&topicId=100002042&docId=I:306481874&start=3>

“Global Treaties Ineffective Against Warming, Experts Say.” According to a study by three California scientists, wide-ranging international treaties like the Kyoto Protocol may not be the best ways to battle global warming. Arguing that global treaties are only as effective as their least willing signatories, the team says that climate change is better fought from the bottom up. Countries, regional partnerships, U.S. states, and even individual private firms, the scientists believe, can establish various controls to limit climate-changing activities. *National Geographic News*, September 15, 2005, http://news.nationalgeographic.com/news/2005/09/0915_050915_warming.html
For the original article, see “A Madisonian Approach to Climate Policy,” *Science*, September 16, 2005, <http://www.sciencemag.org/content/vol309/issue5742/index.shtml> (subscription required)

“Blair falls into line with Bush view on global warming.” Sharing a platform with the U.S. Secretary of State, Condoleezza Rice, in New York this month, Tony Blair changed his views on combating global warming. Mr. Blair told this month's meeting at the Clinton Global Initiative that he was putting his faith in “developing science and technology.” His remarks reportedly outraged environmentalists. *The Independent* (UK), September 25, 2005, <http://www.climateark.org/articles/reader.asp?linkid=46654>

“Japan Government may buy Heavy CO₂ Credit Volume from 2006.” Japan's government said it might begin to buy carbon dioxide credits on fears that voluntary efforts by industries may not achieve the country's target to cut greenhouse gases. Japan's Ministry of Economy, Trade and Industry (METI) estimates the country will need 20 million tonnes worth of emission rights a year to meet its commitments by 2008-2012 under the UN Kyoto Protocol on climate change. “It is necessary to set up systems to acquire credits by the government from the fiscal year (starting April) 2006 so that our country can secure necessary credit volumes for sure and with cost efficiency,” an METI document said. *Reuters*, September 22, 2005, <http://www.planetark.com/dailynewsstory.cfm/newsid/32614/story.htm>

“Aircraft set to jet into EU emissions trading.” According to this article, the airline industry will join the European Union's emissions trading system under a proposal under consideration by the EU executive Commission. The European Commission has studied three ways to include the aviation sector

in its efforts to cut greenhouse gases, either through a tax, a ticket charge, or inclusion in the emissions trading scheme. Environment Commissioner Stavros Dimas has repeatedly stated his preference for the last option, and his Commission colleagues are expected to endorse that position, officials said. *Reuters*, September 23, 2005, <http://uk.news.yahoo.com/23092005/325/aircraft-set-jet-eu-emissions-trading.html>

“BA launches scheme to offset CO₂ emissions.” British Airways has launched a government-backed scheme that allows its customers to offset the carbon dioxide emissions from their flight by making a contribution to an environmental trust. Climate Care will use the contributions to invest in sustainable energy projects that tackle global warming, the Department for the Environment, Food and Rural Affairs said in a statement. *Forbes*, September 12, 2005, <http://www.forbes.com/home/feeds/afx/2005/09/12/afx2218058.html>

“Carbonfund & Ceres Launch Carbon Offset Program.” Carbonfund, a nonprofit organization dedicated to reducing the threat of climate change, and Ceres, a coalition of investors, environmental and public interest organizations, have launched a joint carbon offset program. Under the program, participants in the Ceres network will be encouraged to offset their personal and corporate carbon footprint by making a donation to Carbonfund. Carbonfund then supports a variety of carbon reducing projects, including renewable energy, energy efficiency and sequestration that remove the equivalent carbon dioxide from the atmosphere. *CSR Wire*, September 21, 2005, <http://www.csrwire.com/article.cgi/4450.html>

November 2005

“EPA Estimates CO₂ Control Costs as Low as \$1 Per Ton.” A new cost-benefit analysis by the US Environmental Protection Agency (EPA) indicates that carbon dioxide emissions control costs could be as low as \$1 per ton. The findings, announced on October 27, are part of an extensive comparison of several pending legislative proposals designed to cut emissions from power plants in the United States. The EPA compared the Bush Administration’s Clear Skies proposal, which advocates a cap-and-trade approach for sulfur dioxides, nitrogen oxides and mercury, with alternative proposals by Senators James Jeffords (I-VT) and Thomas Carper (D-DE). Sen. Jeffords’ Clean Power Act and Sen. Carper’s Clean Air Planning Act both include mandatory emissions caps for CO₂ in addition to sulfur dioxides, nitrogen oxides and mercury. The Jeffords proposal would cap CO₂ emissions at 2.05 billion tons per year by 2010 while the Carper proposal would cap emissions at 2.65 billion tons per year by 2009. In the EPA analysis, the controls for CO₂ would cost as little as \$1 per ton if the Carper proposal was adopted, while the Jeffords proposal would cost \$16 per ton of CO₂ emissions. *EESI Climate Change News*, October 28, 2005, <http://www.eesi.org/publications/Newsletters/CCNews/10.28.05%20CCNews.htm>

“Get real on climate change.” The Kyoto protocol on climate change cannot work in its current form, Prime Minister Tony Blair has said. Writing in the *Observer*, Mr. Blair said cuts in greenhouse gas emissions can only be achieved by establishing an initiative that includes the US. His comments come ahead of a conference on climate change in London on November 1, chaired by Mr. Blair. Blair also argued that the problem of global warming cannot be dealt with unless any new agreement includes India and China. Blair added that there were “huge opportunities” in technology. “We need to see how the existing energy technologies we have such as wind, solar and - yes - nuclear, together with new technologies such as fuel cells and carbon capture and storage, can generate the low carbon power the world needs.” *The Observer*, October 30, 2005, <http://observer.guardian.co.uk/comment/story/0,6903,1604790,00.html>

“N.J. classifies carbon dioxide as air contaminant.” New Jersey’s acting Governor Richard J. Codey took action to classify carbon dioxide as an air contaminant, paving the way for the state to participate in the Regional Greenhouse Gas Initiative, which seeks to stabilize and reduce emissions of carbon dioxide. The adopted regulations amend several air pollution control rules, reflecting current scientific consensus that carbon dioxide is an air contaminant. *Waste News*, October 20, 2005,

<http://www.wastenews.com/headlines2.html?id=1129853293>. Also see, "Codey Takes Crucial Step to Combat Global Warming," *Press Release*, October 18, 2005, http://www.state.nj.us/cgi-bin/governor/njnewsline/view_article.pl?id=2779.

"Japan should introduce carbon tax in 2007-ministry." The Japanese Environment Ministry released a revised version of its carbon tax plan, aimed at discouraging fossil fuel use so Japan can fulfill its obligation under the Kyoto Protocol. The ministry said in a statement that the tax should be 2,400 yen (\$20.85) per ton of carbon emitted. That means the tax on coal could be 1.58 yen per kilogram and that on gasoline 1.52 yen per liter (4.3 cents per gallon). The tax would generate income of 37 billion yen a year for the government and result in a payment of 2,100 yen per year for an average household. The ministry said the proposed environment tax would help Japan to cut carbon emissions by about 43 million tonnes, or 3.5 percent of the greenhouse gas emitted in 1990. (\$1=115.11 yen) *AlertNet*, October 26, 2005, <http://www.planetark.com/dailynewsstory.cfm/newsid/33193/story.htm>.

December 2005

"US States say Power Bills Won't Soar on CO2 Plan." Businesses who oppose a plan to cut greenhouse gas emissions in nine Northeastern U.S. states have overestimated how much the plan will raise electric bills, according to a study released by the states. The study sponsored by the Northeast states showed the plan by nine governors to cut greenhouse emissions would raise electricity rates only between 0.3 and 6.9 percent – not by 23 percent, as a business group had contended. By the end of the year, the states hope to pass the Regional Greenhouse Gas Initiative aimed at cutting greenhouse gas emissions 10 percent by 2010. *Reuters*, November 8, 2005, <http://www.planetark.com/dailynewsstory.cfm/newsid/33372/story.htm>

"US to push at UN meeting for voluntary carbon cuts." The Bush administration will use a United Nations climate change meeting in Canada to tout a voluntary plan to store heat-trapping gases underground, says an Energy Department official. Officials from some 150 countries will meet in Montreal on November 28 to discuss how to curb greenhouse gas emissions when the first phase of the Kyoto treaty ends. The White House prefers a voluntary, multi-national plan to sequester and store carbon dioxide. It would encourage nations to separate carbon dioxide from industrial emissions and pipe it into geologic formations or deep beneath the ocean floor for permanent storage, the Energy Department official said. The U.N. meeting is "an important moment for this technology – we are hopeful it would be endorsed in Montreal," said Mark Maddox, the deputy assistant secretary of energy. Says John Grasser, an Energy Department spokesman, "There's got to be a better and cheaper way to do this [than mandatory cuts envisioned by Kyoto]...that's why sequestration is taking off – it might be our ace in the hole." David Doniger, a climate change expert at the Natural Resources Defense Council, says he is "bullish" on sequestration technology, but it must be accompanied by specific carbon cuts. The federal government should give U.S. utilities incentives to capture carbon emissions from coal-fired power plants, and introduce a cap-and-trade system similar to one being used in the European Union, Doniger said. *Leading the Charge*, November 16, 2005, <http://www.leadingthecharge.com/stories/news-00100778.html>

"International Climate Efforts – Beyond 2012." The Pew Center on Global Climate Change released a new report outlining options and recommendations for advancing the international climate change effort post-2012. The report is from the Climate Dialogue at Pocantico, a group of 25 senior policymakers and stakeholders from 15 countries convened by the Pew Center. The report was formally released at an event in the hearing room of the U.S. Senate Foreign Relations Committee hosted by Senator Richard G. Lugar (R-Indiana) and Senator Joseph R. Biden Jr. (D-Delaware), the committee's Chairman and Ranking Minority Member. At the event, Senators Lugar and Biden also announced the introduction of a Sense of the Senate resolution calling for the United States to participate in negotiations under the Framework Convention on Climate Change to establish mitigation commitments by all major emitting countries (see *Legislative Activity* section of this newsletter). For information on the Pocantico dialogue

and report, and on the Lugar-Biden Climate Change resolution, please visit http://www.pewclimate.org/global-warming-in-depth/international/reports/pocantico_release.cfm. Also see, "Panel Calls for Flexible Climate Treaty," *Wall Street Journal*, November 16, 2005, http://online.wsj.com/public/article/SB113211692367798698-JVlk5nCdZw2CrRmY6BgM_Hts6Y8_20061116.html?mod=tff_main_tff_top

"New Technologies to Reduce Global Warming." During a follow-up meeting to the climatic agreement established during the G-8 Summit in Gleneagles in July 2005, the Ministries of Energy and Environment of the G-8 member countries discussed how to reduce global warming with new technologies. Delegates from China, Brazil, Mexico and India took part in the summit, at which British PM Tony Blair said science and technology will permit the solution of climatic problems, not the agreements taken. He mentioned a technique to capture and store carbon dioxide through plants, which break it down in photosynthesis, liquefy it and store it in the subsoil. *Prensa Latina*, November 2, 2005, <http://www.plenglish.com/article.asp?ID=%7BE92F4E2B-5F6D-4551-B889-4510D4636C88%7D&language=EN>

"G20 climate summit pushes technology not targets." The industrialized and developing nations that emit the most greenhouse gases have pledged to work together to develop and deploy "clean technologies" to tackle climate change. Meeting in London, energy and environment ministers from the G20 group of nations also agreed to work with the World Bank to create incentives for large-scale private investment in such technologies. The meeting took place in the run-up to the UN conference in Montreal that is expected to focus on how to tackle climate change once the Kyoto Protocol expires in 2012. Regarding the development of renewable energy sources and technologies to capture and store carbon emissions from coal-fired power stations, UK Prime Minister Tony Blair said, "The blunt truth about the politics of climate change is that no country will want to sacrifice its economy in order to meet this challenge. The solutions will come in the end, in part at least, through the private sector developing the technology and science." *SciDev.net*, November 3, 2005, <http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=17144>

"Germany to Link Up with Mexico and Brazil on CO2." Germany hopes to sign partnership deals for greenhouse gas emission cuts with Mexico and Brazil at the United Nations climate change conference in Montreal, a government official said. Germany is in talks with a raft of countries on memoranda of understanding (MOUs) aimed at helping German firms earn carbon dioxide reduction credits abroad, said Franzjosef Schafhausen, head of the Berlin government's climate working group. "There are about 30 MOUs under negotiation and those with Mexico and Brazil are the furthest advanced so their realization by Montreal is highly likely," Schafhausen said at an emissions trading conference in Frankfurt. The MOUs will create the legal foundation for Joint Implementation (JI) and Clean Development Mechanism (CDM) programs, two of the main emissions reduction tools promoted in the Kyoto Protocol on climate change. The other Kyoto mechanism is emissions trading. By agreeing JIs and CDMs, companies in industrialized countries can earn credits towards their mandatory greenhouse gas reduction targets by investing in green projects in poorer countries, where it can be cheaper and easier to curb pollution. *Reuters*, September 11, 2005, <http://www.planetark.com/dailynewsstory.cfm/newsid/33387/story.htm>

"China Unlikely to Sign on to Kyoto Emissions Cuts." China is unlikely to commit to cutting emissions in the next phase of the Kyoto Protocol, fearing it would retard economic growth, but analysts say the government is waking up to the threat of climate change. China, now the world's second largest emitter of greenhouse gases after the United States, recently unveiled a five-year economic plan that stresses sustainable rather than breakneck growth, an acknowledgment of the environmental and social costs of its economic success. "China might be willing to commit to a cap at some time if there is a package on the table, for instance a technology transfer from the EU," says Yu Jie, a climate and energy campaigner at Greenpeace. "I think developing countries have made it pretty clear from the beginning that they weren't going to accept cuts because that would impede their capacity to grow," said Alan

Oxley, an environment and trade expert and head of the Australia APEC Study Centre. "That situation hasn't changed." *Reuters*, November 14, 2005, <http://www.planetark.com/dailynewsstory.cfm/newsid/33446/story.htm>

"Energy Bill Impacts R&D, Conservation, Nuclear, Wind, Solar, Coal, Oil, Oil Shale and Ethanol Endeavors." Senate Energy & Natural Resources Chairman Pete V. Domenici outlined some of the tangible results already seen from the enactment of the Energy Policy Act of 2005. In a statement, Chairman Domenici said "Coal companies are seeking to partner with the federal government on clean coal projects while innovative strategies are already producing more oil from our own mature oil fields and sequestering carbon at the same time...The energy bill is making a difference. It's already evident in the energy production sector. In the next year or two, I hope that difference will be evident at the gas pump and in our electric bills." *Press Release*, November 18, 2005, http://energy.senate.gov/public/index.cfm?FuseAction=PressReleases.Detail&PressRelease_id=234792&Month=11&Year=2005

Norway: "Efforts to realize capture, use and storage of carbon dioxide have commenced."

According to a press release issued by the Norwegian Ministry of Petroleum and Energy, "the Government has ambitious goals regarding capture, use and storage of carbon dioxide and our timetable is demanding." NOK 20 million is allocated to this work, says Mr. Odd Roger Enoksen, Minister of Petroleum and Energy. The Government will also contribute substantially to the development of technology for capture of carbon dioxide through Gassnova – the Norwegian state centre for sustainable gas technologies – as well as on R&D through the Norwegian Research Council. The release also says the government will proceed with the planning of CO₂ capture at the Kårstø gas fired power plant. *Press release*, November 10, 2005, <http://www.odin.dep.no/oed/english/026001-070329/dok-bn.html>

"Greenhouse gas to rise by 52%." In a new report, the IEA warns that energy consumption must be reduced. Global greenhouse gas emissions will rise by 52% by 2030, unless the world takes action to reduce energy consumption, the study says. The prediction comes from the latest annual World Energy Outlook report from the International Energy Agency. It says that under current consumption trends, energy demand will also rise by more than 50% over the next 25 years. The IEA adds that oil prices will "substantially" rise unless there is extra investment in oil facilities. It says the world has seen "years of under-investment" in both oil production and the refinery sector. The organization estimates that the global oil industry now needs to invest \$20.3 trillion in fresh facilities by 2030, or else the wider global economy could suffer. *BBC News*, November 7, 2005, <http://news.bbc.co.uk/2/hi/business/4414000.stm>

"N.Y. adopts new emissions standards." New York became the second of six Northeastern states considering similar rules to adopt emissions standards like those in California – the only state with stricter guidelines than the federal government. Vermont adopted the guidelines last week. Under the new carbon dioxide emissions guidelines all 2009 and later model cars sold in New York and Vermont will have to meet higher fuel efficiency standards. *E&E Daily*, November 10, 2005, <http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTcyMjg>. Also see, "Vt. adopts new rules to cut car emissions," *Associated Press*, November 3, 2005, <http://www.enn.com/today.html?id=9166>

January 2006

UNCCC Website, "United Nations Climate Change Conference agrees on future critical steps to tackle climate change." The UNCCC closed with the adoption of more than forty decisions that will strengthen climate change. The Conference President, Canadian Environment Minister Stéphane Dion felt that the conference was a success, that the Kyoto Protocol has been switched on, a dialogue about future action has begun, and parties are moving forward to adapt and advance the implementation of the regular work program of the Convention and the Protocol. During the first week of the conference, the rulebook of the 1997 Kyoto Protocol was adopted, the so-called "Marrakesh accords." Developed

countries committed to fund the operation of the clean development mechanism (CDM) with over 13 million in US dollars in 2006-2007, and the process for methodologies under CDM was simplified and its governing body strengthened. The second Kyoto mechanism was launched and its governing body set up—Joint Implementation, which allows developed countries to invest in other developed countries and earn carbon allowances they can use to meet their emission reduction commitments. The compliance committee with its enforcement and facilitative branches was elected, a key to ensuring that the Parties to the Protocol have a clear accountability regime in meeting their emissions reductions targets. The conference also agreed on a one-year process to define how the Adaptation Fund will be managed and operated. This fund will draw on money generated by the CDM and will support concrete adaptation activities in developing countries. Technology was at the center of discussion on efforts to reduce emissions and adapt to climate impacts. Countries agreed on further steps to promote the development and transfer of technologies. Carbon capture and storage was estimated to have the potential to reduce the costs of mitigation by up to 30 percent, based on the recent report by the Intergovernmental Panel on Climate Change (IPCC). Parties agreed to move forward with deeper analysis of Carbon Capture and Storage technology. December 10, 2005. See: http://unfccc.int/meetings/cop_11/items/3394.php for the press release and for pdf files of the final decisions.

Bloomberg, "US Delegates Refuse to Participate in Global Warming Talks," US delegates to Montreal refused to participate in Kyoto Protocol talks after objecting to non-binding negotiations to limit carbon dioxide emissions. About 10,000 representatives from almost 200 countries gathered in Montreal to plan the next round of greenhouse gas cuts before Kyoto expires in 2012. In 2001 the Bush Administration rejected an agreement to cut carbon dioxide and other gases to 7 percent below 1997 levels as too costly for the US, which emits 25 percent of the world's greenhouse gases. The other Kyoto parties reached an informal agreement to continue talks on reducing emissions over the next few years without the US. December 9, 2005, http://www.bloomberg.com/apps/news?pid=10000087&sid=al_VP7vXpswU&refer=top_world_news. For the specifics on the UNCCC decisions, see this newsletter's Policy section.

Business Standard, Economy Bureau, (New Delhi, India), "Draft Proposes 0.1 Percent Cess on Energy Firms," India's draft energy policy proposes a National energy fund to be set up through a cess (tax) of 0.1 percent on all petroleum, power, and coal companies. Technology missions will be used for research and development in areas such as carbon sequestration, efficiency improvement, in situ gasification, developing solar technologies for thermal and photovoltaics, bio-fuels such as producing of bio-diesel and ethanol, bio-mass plantation and wood gasification, and community-based bio-gas plants. A rebate of up to 80 percent of this tax is proposed to firms for in-house research and development. December 16, 2005, <http://www.business-standard.com/common/storypage.php?hpFlag=Y&chklogin=N&autono=208729&leftnm=lmnu2&lselect=0&leftindx=2>

February 2006

IPPR Press Release, "Two Thirds of European Union Countries Set to Miss Kyoto Commitments," Ten of 15 European Union countries that are part of the Kyoto Protocol will fall short of their targets, according to a report published December 27, 2005 by the United Kingdom's think tank Institute for Public Policy Research (IPPR). The United Kingdom and Sweden are on course to meet their targets. Three countries, France, Greece and Germany, will only meet their targets if new policies are implemented. Ten countries will fail to meet their targets even with planned additional measures, including: Finland, Austria, Belgium, Luxembourg, Netherlands, Italy, Spain, Portugal, Ireland, and Denmark. December 27, 2005, <http://www.ippr.org.uk/pressreleases/?id=1863>

Oil & Gas Journal, "European Union, France Seek Integrated Energy Policy," The European Union (EU) is pursuing an integrated, efficient energy policy. At a meeting of 25 EU finance ministers in Brussels on January 24, Austrian Minister Martin Bartenstein said he would focus on energy during his

country's 6-month presidency of the European Union. French Economic and Finance Minister Thierry Breton presented a memorandum which outlined many energy policy recommendations to the EU including encouraging continued development of hydrogen, fuel cell, and carbon dioxide sequestration technology. January 26, 2006,
http://ogj.pennnet.com/articles/article_display.cfm?Section=ONART&C=GenIn&ARTICLE_ID=246636&p=7

March 2006

Greenwire, "Kyoto Goal Can Be Met, But Tougher Rules are Needed, UN Says," The United Nations Framework Convention on Climate Change (UNFCCC) said that the report filed by industrialized nations to the organization in the beginning of 2006 showed "significant progress," but that stricter greenhouse gas emissions-curbing efforts are needed. Richard Kinley, acting head of the UNFCCC, said that as a whole the countries were progressing toward lowering emissions levels by at least 3.5 percent below 1990 levels by the 2008-2012 target. With tougher reduction measures, the countries may reach target of at least 5 percent cut below 1990 levels. Download UNCCC Press Release at:
http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/20060215_anniversary_kp_entry_into_force.pdf. February 15, 2006, <http://www.eenews.net/Greenwire/2006/02/15/#9>. (Subscription maybe required.)

BBC News, "Britain's Emissions Plan Rejected," The European Commission rejected Britain's revised carbon dioxide (CO₂) emissions plans on procedural grounds. Britain made changes to its original plan, increasing it by nearly 3 percent (about 20 million metric tons) of CO₂ for 2005-2007, which was then disputed by the Commission. The European Union (EU) Court of First Instance sided with Britain in the dispute, ruling in November that the country could make changes, even those which would mean easing pollution limits for industry. Now the commission has rejected Britain's amended plan on the grounds of late submission, saying that Britain missed the September 30, 2004 deadline. February 22, 2006, http://news.bbc.co.uk/2/hi/uk_news/4740878.stm.

Reuters, "EU's Dimas Says to Approve Italy CO₂ Plan Shortly," Italy's allocation plan for carbon dioxide (CO₂) emissions will receive final approval from the European Union's executive arm in a few days, said EU's Environment Commissioner Stavros Dimas. February 16, 2006,
<http://www.planetark.com/dailynewsstory.cfm?newsid=35140&newsdate=16-Feb-2006>

BBC News, Carbon Map Shows Worst Offenders." The Carbon Trust published a map detailing the amount of carbon emitted per square kilometer per year, and emissions per person for 33 urban areas in the UK. London leads the list with 9.46 million metric tons of carbon emitted annually (1.09 metric tons per person). To view the map see: <http://www.carbonmap.co.uk/>. February 21, 2006,
http://news.bbc.co.uk/2/hi/uk_news/4735872.stm

April 2006

Bloomberg, "Canada, Head of UN Kyoto Group, May Not Meet Emission Targets." Canada's Environment Minister Rona Ambrose said in an interview that Canada is unlikely to meet its emissions reduction targets set under the Kyoto Protocol. In 2002, Canada set a target to decrease emissions by 6 percent from 1990 levels by 2012. Canada serves as chair of the Conference of Parties to the United Nations Framework Convention on Climate Change, which created the Kyoto Protocol. Canada will have less credibility in talks to add conditions to the treaty or convince other nations to sign if that country does not meet its targets, said John Bennett, senior policy advisor at the environmental lobby group Sierra Club of Canada. March 9, 2006,

<http://www.bloomberg.com/apps/news?pid=10000082&sid=a02Zv4lWMw38&refer=canada#>.
(Subscription may be required.)

Slovene Press Agency STA, "Slovenia Will Meet Kyoto Obligations, Minister Says." Slovenian Environment minister Janez Podobnik said that Slovenia is on course to meet its targets for 2008-2012 under the Kyoto Protocol, despite the findings published to the contrary in mid-February by the European Commission. Slovenia plans to implement additional reduction measures including carbon sequestration in forests. "Slovenia is currently in an unequal position as it is not part of the joint strategy for lowering emissions that was adopted...in 2002 by the EU-15," Podobnik pointed out. March 13, 2006, <http://www.gzs.si/eng/news/sbw/head.asp?idc=20913>.

Newsroom Finland, "Statistics Finland says CO₂ emissions near Kyoto level in 2005." In 2005, Finnish carbon dioxide (CO₂) emissions fell by 17 percent to about 54 million metric tons, putting them close to their Kyoto target level, *Statistics Finland* said in a statement. The fall in CO₂ emissions was attributed to decreased use of fossil fuels and peat. Also, a record 17 terawatt-hours of power, a fifth of total consumption, was imported in 2005, due to a good water reservoir situation in Norway and Sweden. Warm weather and a seven week dispute in the pulp and paper industries also contributed to the lower levels of emissions. February 24, 2006, <http://newsroom.finland.fi/stt/showarticle.asp?intNWSAID=11868&group=Business>.

"Trade-offs in assessing different energy futures: a regional multi-criteria assessment of the role of carbon dioxide capture and storage." The authors examine the responses of stakeholders from the public and private sectors to future energy scenarios for the year 2050 for the North West of England. The main focus of the paper is to examine the stakeholders' reactions to the mitigation option of capturing CO₂ from power stations and storing it in suitable off-shore geological reservoirs. Five energy scenarios were developed which involved a range of levels of CO₂ capture and storage (CCS): Fossilwise, Nuclear Renaissance, Renewable Generation and Spreading the Load high and low scenarios. A multi-criteria assessment method (MCA) was used as a way of elucidating stakeholders' views on the desirability or otherwise of each scenario against nine stakeholder-derived criteria. The authors found that stakeholders were either business-focused or environment/society-focused with respect to weighting of the criteria. Scoring of the scenarios did not follow such a straightforward pattern. Most respondents scored and weighted strategically and tended to express a clear preference for a form of energy generation. The results suggest that there is unlikely to be a wide-ranging consensus amongst energy stakeholders on the desirability of specific future forms of energy generation. On balance, the results support the inclusion of CCS within scenarios of a low-carbon energy system. *Environmental Science and Policy*, doi:10.1016/j.envsci.2006.01.006, Available online February 28, 2006. <http://www.sciencedirect.com/science/article/B6VP6-4JCCM8V-2/2/0573827d9d24c007249b398df68461d9>. (Subscription may be required.)

"Atmospheric and geological CO₂ damage costs in energy scenarios." Geological carbon dioxide (CO₂) capture and storage (CCS) is currently seriously considered for addressing, in the near term, the problem of climate change. CCS technology is available today and is expected to become an increasingly affordable CO₂ abatement alternative. Whereas the rapidly growing scientific literature on CCS as well as experimental and commercial practice demonstrate the technological and economic feasibility of implementing this clean fossil fuel option on a large scale, relatively little attention has been paid so far to the risks and environmental externalities of geological storage of CO₂. This paper assesses the effects of including CCS damage costs in a long-term energy scenario analysis for Europe. An external cost sensitivity analysis is performed with a bottom-up energy technology model that accounts not only for CCS technologies but also for their external costs. The authors' main conclusion is that in a business-as-usual scenario (i.e. without climate change intervention or externality internalization), CCS technologies are likely to be deployed at least to some extent, mainly in the power generation sector, given the economic benefits of opportunities such as enhanced coal bed methane, and oil and gas

recovery. Under a strict climate (CO₂ emissions) constraint, CCS technologies are deployed massively. With the simultaneous introduction of both CO₂ and CCS taxation in the power sector, designed to internalize the external atmospheric and geological effects of CO₂ emissions and storage, respectively, the authors find that CCS will only be developed if the climate change damage costs are at least of the order of 100 euros per ton of carbon dioxide (€/t CO₂) (approximately \$119) or the CO₂ storage damage costs not more than a few €/t CO₂. (One Euro = approximately \$1.1905 US dollars.) When the internalized climate change damage costs are as high as 67 €/t CO₂ (approximately \$80), the expensive application of CCS to biomass-fuelled power plants (with negative net CO₂ emissions) proves the most effective CCS alternative to reduce CO₂ emissions, rather than CCS applied to fossil-based power plants. *Environmental Science and Policy*, Available online March 6, 2006, doi:10.1016/j.envsci.2006.01.004, <http://www.sciencedirect.com/science/article/B6VP6-4JDMR64-1/2/9646bdbb9f0577166033edb961f4b205>. (Subscription may be required.)

May 2006

Reuters, “EU Executive Gets Tough On Environmental Violations,” and European Commission Press Release, “EU Climate Change Policies: Commission Asks Member States to Fulfill Their Obligations.” The European Union’s (EU) European Commission is taking legal action against several EU member states for failing to comply with four climate change policies. The aim of these actions is to ensure that EU and its member states meet all of the reporting obligations under the UN Climate Change Convention and the Kyoto Protocol. Cyprus, Greece, Luxembourg, Malta and Poland were sent warning letters for failure to link national registries with the EU-wide registry system. Each member state was to establish a national registry in the form of a standardized database and communications link, which was to occur by December 31, 2004. Austria, Cyprus, Luxembourg, Malta, and Poland were sent second and final written warnings for not communicating their greenhouse gas emissions projections, nor their policies and measures to reduce their emissions level by March 15, 2006. Cyprus, Italy, Malta and Spain received warnings for failing to submit information on greenhouse gas emissions by January 15 each year. Germany, Italy, Luxembourg and Spain have failed to adequately prepare for international emissions trading under the Kyoto protocol, and have been sent their first written warnings. April 6, 2006, http://today.reuters.com/news/articlenews.aspx?type=scienceNews&storyid=2006-04-06T102511Z_01_L06691570_RTRUKOC_0_US-EU-ENVIRONMENT-INFRINGEMENTS.xml and <http://www.europa.eu.int/rapid/pressReleasesAction.do?reference=IP/06/469&format=HTML&aged=0&language=EN&guiLanguage=en>.

Greenwire, “US to Host Asia-Pacific Partnership Talks This Week.” The United States will host talks starting April 18 in Berkeley, California. Representatives of the Asia-Pacific Partnership, including Australia, China, Japan, India, South Korea, and the US, will attend closed-door meetings lasting for four days. The US delegation will be led by Undersecretary of State Paula Dobriansky and White House Council on Environmental Quality Chairman Jim Connaughton. Approximately 250 attendees will draft agendas for eight industries with regard to developing and sharing technologies to curb greenhouse gas emissions. The industries include: fossil fuel energy; renewable energy; power generation and transmission; steel; aluminum; cement; coal mining; and buildings and appliances. April 17, 2006, <http://www.eenews.net/Greenwire/2006/04/17/#1>. (Subscription may be required.)

Reuters, “Spain’s CO₂ Emissions Rose 48 Percent From 1990 to 2004.” Spain’s carbon dioxide emissions rose 47.87 percent between 1990 and 2004, two percentage points higher than was previously calculated, said Spain’s Environment Ministry. The rise may be in part due to the impact of a 2004/2005 (hydrogeologic year) drought which reduced power companies’ hydroelectric generating capacity and increased the use of fossil fuels for power generation. The number shows Spain as the worst performer among rich nations with regard to their greenhouse gas emissions. Spain’s Kyoto protocol target is such that it can increase emissions by only 15 percent between the base year 1990 and 2008. The new data are contained in a report from Spain to the European Commission. April 17, 2006,

http://today.reuters.co.uk/news/newsArticle.aspx?type=scienceNews&storyID=2006-04-17T113410Z_01_L17632860_RTRIDST_0_SCIENCE-ENVIRONMENT-SPAIN-DC.XML.

June 2006

Globe and Mail, "Ottawa Now Wants Kyoto Deal Scrapped." According to private instruction for negotiators at a climate change conference in Bonn, Germany, Canada will not support stricter emissions for the second phase of the Kyoto Protocol, which begins after 2012. The Canadian Foreign Affairs Department sent the negotiation instructions to the Canada delegation at the talks in Bonn, which were then obtained by Globe and Mail. "Canada will not support ... agreement on language in the work program that commits developed countries to more stringent targets in the future," states a line contained in 22 pages of instructions. The document also shows that Canada is threatening to pull out of the United Nations climate-change process unless it includes the United States and all other major polluters. From May 15-26, two sets of talks are taking place in Bonn, Germany, the UN Framework Convention on Climate Change (UNFCCC) talks and the talks regarding the Kyoto Protocol. The UNFCCC is a 1994 international treaty supported by 189 countries involving voluntary commitments to address climate change. One hundred and sixty three countries are in the Kyoto protocol, but only Canada and 34 other countries took on targets for the first phase. May 20, 2006, <http://www.theglobeandmail.com/servlet/story/LAC.20060520.KYOTO20/TPStory>. (Subscription or registration may be required.)

Earth Negotiations Bulletin, "UNFCCC Sessions of the Subsidiary Bodies (SB-24), May 2006, Bonn, Germany." The twenty-fourth sessions of the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI) of the United Nations Framework Convention on Climate Change (UNFCCC) were held from May 18-26, 2006. Also the first session of the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG) took place from May 17-25. These sessions were preceded by the dialogue on long-term cooperative action to address climate change by enhancing implementation of the convention, held from May 15-16, 2006. All of these meeting were held in the Hotel Maritim in Bonn, Germany. On May 20, a workshop on carbon capture and storage was held, with the objective of improving understanding of carbon capture and storage through an overview of the document "Intergovernmental Panel on Climate Change (IPCC) Special Report on Carbon Dioxide Capture and Storage." The workshop covered relevant provisions of the forthcoming 2006 IPCC Guidelines for National Greenhouse Gas Inventories and discussed demonstration and pilot projects, and capacity-building for the development and use of the technology. See: <http://unfccc.int/meetings/sb24/in-session/items/3623.php> for an agenda of the CCS workshop, and the following link: <http://www.iisd.ca/vol12/enb12301e.html> to scroll down for a summary of the workshop as reported by Earth Negotiations Bulletin. On May 22, a workshop on carbon capture and storage as development mechanism (CDM) project activities was held to consider carbon dioxide capture and storage as clean development mechanism project activities while taking into account issues relating to the projects including boundaries and permanence. See: <http://unfccc.int/meetings/sb24/in-session/items/3716.php> for the agenda of the workshop on CCS as CDM project activities, and the following link: <http://www.iisd.ca/vol12/enb12302e.html> to scroll down for the workshop's coverage by Earth Negotiations Bulletin. <http://www.iisd.ca/climate/sb24/>.

July 2006

Environmental Finance Publications Online News, "US, EU Agree to High-Level Talks on Climate Change." The annual EU-US Summit attended by US President George Bush and European Union (EU) President Manuel Barroso, was held on June 21 in Vienna, Austria. (For details on the summit, see the website: http://ec.europa.eu/comm/external_relations/us/sum06_06/index.htm.) As part of the joint declaration adopted by the EU and US, the parties agreed, among four main areas, to promote strategic cooperation on energy, energy security, climate change and sustainable development. The parties also

agreed to “work more closely to address the serious and long-term challenge of climate change, biodiversity loss and air pollution and will act with resolve and urgency to reduce greenhouse gas emissions.” The joint declaration also states that the EU and the US will work to reinforce technological cooperation and partnerships, in areas including carbon sequestration. To read the joint declaration, see: http://ec.europa.eu/comm/external_relations/us/sum06_06/docs/decl_final_210606.pdf. While dialog will continue under the UN Framework Convention on Climate Change (UNFCCC), the parties have established an “EU-US High Level Dialogue on Climate Change, Clean Energy and Sustainable Development,” which will meet in the Fall of 2006 in Helsinki, Finland. This dialogue will be guided by the ultimate objective of the UNFCCC, with discussions to include experiences with different market-based mechanisms to promote cost-effective reductions in greenhouse gas emissions, and advancing the development and deployment of existing and transformational technologies that are cleaner and more efficient. On June 20, EU environment commissioner Stavros Dimas told the European Parliament's Environment Committee that “clear market signals” are needed to promote technological solutions to climate change. “Mandatory reductions, an international price on carbon and a global cap-and-trade scheme are necessary,” he said. Dimas also said other aspects of the EU's climate policy would be strengthened with “a legislative framework for carbon capture and storage that will provide clarity for future investments.” See:

<http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/06/393&format=HTML&aged=0&language=EN&guiLanguage=en> to read the speech by Stavros Dimas as an html, pdf or doc file. June 22, 2006, <http://www.environmental-finance.com/onlinews/22junets.htm>.

Agence France-Presse, “EU Way Off Course For Meeting Kyoto Targets: Latest Figures.” A report published June 22 by the European Environment Agency, showed the European Union (EU) remains off course for meeting its greenhouse gas reduction pledges under the Kyoto Protocol, and that greenhouse gas emissions actually rose 0.3 percent (11.5 million tons) between 2003 and 2004, or 11.5 million tons. This marks the second annual year of increase. (To link to the report, see this newsletter's **Recent Publications** section for the report entitled: “Annual European Community Greenhouse Gas Inventory 1990-2004 and Inventory Report 2006.”) June 22, 2006, <http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTk0ODM>.

August 2006

Greenwire, “G8 Gives Nod to Post-Kyoto Talks, Voluntary Programs.” The Group of Eight (G8) leaders released a statement at the end of their annual summit which was held on July 15-17, 2006, in St. Petersburg, Russia. In the statement, the leaders reaffirmed their support for several existing global warming pacts and pledged to continue discussions on what is to happen once the Kyoto Protocol expires in 2012. During the summit, Energy Security and other issues took precedence over global warming topics. As part of the statement's pledge to diversify the energy mix (in order to reduce global energy security risks) the G8 pledged to work to develop low-carbon and alternative energy, to make wider use of renewables and to develop and introduce innovative technologies throughout the entire energy sector. Part of that commitment also encourages the activities of the Carbon Sequestration Leadership Forum (CSLF) (which is aimed at preparing and implementing demonstration projects on CO₂ capture and storage and on the development of zero emission power plants), and commends the participation of the G8 countries in the CSLF, and in other initiatives which address climate change. The G8 also pledged to work with the private sector to accelerate utilization of innovative technologies that advance more efficient hydrocarbon production and reduce the environmental impact of its production and use, including clean coal technologies with carbon capture and storage. To view the joint statement, go to: <http://en.g8russia.ru/docs/11.html>. July 17, 2006, <http://www.eenews.net/Greenwire/print/2006/07/17/3>. (Subscription may be required.)

Geology

September 2005

“IEA GHG Weyburn CO₂ monitoring and storage project.” This paper presents an integrated overview of the results from over 50 individual technical research projects related to the IEA GHG Weyburn CO₂ Monitoring and Storage Project. Research activities in the project were divided into four “themes” that applied leading-edge science and engineering in geophysics, geomechanics, geochemistry, geology, reservoir engineering, risk assessment, and economics. *Fuel Processing Technology*, Volume 86, Issues 14-15, October 2005, Pages 1547-1568, <http://www.sciencedirect.com/science/journal/03783820> (subscription required)

“Experimental investigation of CO₂–brine–rock interactions at elevated temperature and pressure: Implications for CO₂ sequestration in deep-saline aquifers.” This paper explores the reactivity of supercritical CO₂ with host aquifer fluids and formation minerals through experiments reacting supercritical CO₂ with natural and synthetic brines in the presence and absence of limestone and sandstone. *Fuel Processing Technology*, Volume 86, Issues 14-15, October 2005, Pages 1581-1597, <http://www.sciencedirect.com/science/journal/03783820> (subscription required)

“Modeling carbon dioxide sequestration in saline aquifers: Significance of elevated pressures and salinities.” This study attempts to predict the capacity of saline formations to sequester carbon dioxide by determining solubility and mineral trapping through simulating sequestration with geochemical models. Several models have been used to make estimates of carbon dioxide solubility and mineral formation as a function of pressure and fluid composition. Overall, the paper concludes it is difficult to confidently predict the ultimate sequestration capacity of deep saline aquifers using geochemical models. *Fuel Processing Technology*, Volume 86, Issues 14-15, October 2005, Pages 1569-1580, <http://www.sciencedirect.com/science/journal/03783820> (subscription required)

“Carbon sequestration using brine of adjusted pH to form mineral carbonates.” The effects of temperature, pressure, and pH on the formation of carbonates, such as calcite, during the reaction of CO₂ with natural gas well brine were investigated. Results show that temperature has a greater control on changes in pH than pressure. However, initial brine pH is the main factor controlling the formation of carbonates. *Fuel Processing Technology*, Volume 86, Issues 14-15, October 2005, Pages 1599-1614, <http://www.sciencedirect.com/science/journal/03783820> (subscription required)

December 2005

“Field-Project Designs for Carbon Dioxide Sequestration and Enhanced Coalbed Methane Production.” In this study, reservoir-simulation computations are performed for a hypothetical pilot-scale project in coal seams. The authors vary operational parameters, such as injector length, injection well pressure, time to injection, and production well pressure, in order to evaluate different production schemes and determine an optimum for various coal types. Values of total CO₂ sequestered and methane produced are presented for multiple coal types and different operational designs. *Energy & Fuels*, Volume 19 Issue 6 (November 16, 2005), <http://pubs.acs.org/cgi-bin/abstract.cgi/enfuem/2005/19/i06/abs/ef049667n.html> (subscription required)

January 2006

“Convective stability analysis of the long-term storage of carbon dioxide in deep saline aquifers,” Deep saline aquifers are one of the most suitable geologic formations for carbon sequestration. The linear and global stability analysis of the time-dependent density-driven convection in deep saline

aquifers is presented for long-term storage of carbon dioxide (CO₂). The convective mixing that can greatly accelerate the CO₂ dissolution into saline aquifers arises because the density of brine increases upon the dissolution of CO₂ and such a density difference may induce instability. The effects of anisotropic permeability on the stability criteria, such as the critical time for the appearance of convective phenomena and the critical wavelength of the most unstable perturbation, are investigated with linear and global stability analysis. The linear stability analysis provides a sufficient condition for instability while the global stability analysis yields a sufficient condition for stability. The results obtained from these two approaches are not exactly the same but show a consistent trend, both indicating that the anisotropic system becomes more unstable when either the vertical or horizontal permeability increases. *Advances in Water Resources*, Volume 29, Issue 3, March 2006, Pages 397-407.

<http://www.sciencedirect.com/science/article/B6VCF-4GNKS55-2/2/3a236275433494d932f82a227670610a> (subscription may be required)

“TOUGHREACT—A simulation program for non-isothermal multiphase reactive geochemical transport in variably saturated geologic media: Applications to geothermal injectivity and CO₂ geological sequestration,” TOUGHREACT is a numerical simulation program for chemically reactive non-isothermal flows of multiphase fluids in porous and fractured media. The program was written in Fortran 77 and developed by introducing reactive geochemistry into the multiphase fluid and heat flow simulator TOUGH2. A variety of subsurface thermo-physical-chemical processes are considered under a wide range of conditions of pressure, temperature, water saturation, ionic strength, and pH and Eh. Interactions between mineral assemblages and fluids can occur under local equilibrium or kinetic rates. The gas phase can be chemically active. Precipitation and dissolution reactions can change formation porosity and permeability. The program can be applied to many geologic systems and environmental problems, including geothermal systems, diagenetic, and weathering processes, subsurface waste disposal, acid mine drainage remediation, contaminant transport, and groundwater quality. This paper presents two examples to illustrate the applicability of the program. *Computers & Geosciences*, Volume 32, Issue 2, March 2006, Pages 145-165. <http://www.sciencedirect.com/science/article/B6V7D-4GY8752-1/2/dc69951e6d547a839471ae697370c72c> (subscription may be required)

February 2006

“Japanese potential of CO₂ sequestration in coal seams.” As a reduction strategy for global warming by greenhouse gases, underground storage or sequestration of CO₂ into coal beds or seams has been studied by the Japanese government and some associated organizations. The principle of this study depends on the adsorption of CH₄ or CO₂ on the surface of coal molecules as well as nearly twice the amount of adsorption of CO₂ compared with CH₄. One of the authors had experimentally clarified the adsorption abilities of the coals in each Japanese coalfield. Based on these adsorption-abilities, the amount of the coal-bed methane resources was calculated, and also the sequestration-potential of carbon dioxide was estimated for each coalfield. In this paper, the CO₂ sequestration-potential obtained from each coalfield is compared with the potentials from the other coalfields in Japan. Among the Japanese coalfields, the Ishikari coalfield in Hokkaido is the biggest and shows 50 percent of Japanese CO₂ sequestration potential. And the other big coalfields are the solitary island area in the northwestern district of Kyushu and the Miike-Ariake Sea area. Their potential percentages are 14 percent and 13 percent, respectively. *Applied Energy*, Available Online January 6, 2006, <http://www.sciencedirect.com/science/article/B6WHR-4J0PF96-9/2/5f9feeabb2e97a1b595692261e4f8463> (Subscription may be required.)

March 2006

“Seismic Imaging for Site Selection and Monitoring of Carbon Dioxide Sequestration Part 1—Field Studies.” This is the first in a two part series from the *GasTips*, a publication of Gas Technology

Institute, the US Department of Energy and Hart Energy Publishing which covers technology developments in natural gas exploration, production and processing. The Gas Technology Institute, with support from Illinois Clean Coal Institute and cooperation of the Illinois State Geological Survey, designed and implemented a comprehensive research project aimed at determining the viability of seismic techniques for site selection and monitoring of carbon dioxide sequestration in Illinois coals. Read details of the studies starting on page 3 of the pdf file of the Fall 2005 *GasTips*, which is available at: <http://www.netl.doe.gov/technologies/oil-gas/publications/GasTIPS/GasTIPS-Fall2005.pdf>

“The influence of temperature on adsorption capacity of Malaysian coal,” The paper highlights the study of carbon dioxide (CO₂) adsorption profiles of local coal samples of varying mean size distributions (1000 and 2000 micrometers (µm)) obtained from Miri, Sarawak situated in the East of Malaysia, at different temperatures (24.6, 30, 40 and 55 degrees Celsius). Parameters such as the moisture content, ash content, carbon content and mineral content of the coal sample were investigated. Based on the physical analysis of the coal, it was classified as lignite, which exhibits a better adsorptive affinity for CO₂. In addition, the coal sample having the smaller mean particle size distribution of 1000 µm shows a better rate of adsorption compared to the 2000 µm size distribution. The adsorption capacity of the coal sample shows an inverse relationship with temperature. These findings open a platform for CO₂ sequestration to be implemented in Malaysia. *Chemical Engineering and Processing*, Volume 45, Issue 5, May 2006, Pages 392-396. <http://www.sciencedirect.com/science/article/B6TFH-4HNSJC1-1/2/f8508e07ca6ddd8f3b502605bcffc684>. (Subscription may be required.)

April 2006

“Experimental identification of CO₂–water–rock interactions caused by sequestration of CO₂ in Westphalian and Buntsandstein sandstones of the Campine Basin (NE-Belgium).” Geological sequestration of carbon dioxide (CO₂) is one of the options studied to reduce greenhouse gas emissions. Although the feasibility of this concept is proven, apart from literature data on modeling, still little is known about the CO₂–water–rock interactions induced by CO₂ injection. To evaluate the effect of CO₂–water–rock interactions on three sandstone aquifers in Northeastern Belgium, an experimental setup was built. Eighteen experiments were performed in which sandstones were exposed to supercritical CO₂. CO₂–water–rock interactions were deduced from the evolution of aqueous concentrations of 25 species and a thorough characterization of the sandstones before and after treatment. The results show that dissolution of ankerite/dolomite and aluminum silicates could enhance porosity/permeability. The observed precipitation of end-member carbonates could increase storage capacity if it exceeds carbonate dissolution. Precipitation of the latter and of potassium-rich clays as observed, however, can hamper the injection. *Journal of Geochemical Exploration*, Available online March 9, 2006, doi:10.1016/j.gexplo.2005.11.005, <http://www.sciencedirect.com/science/article/B6VCP-4JF97BJ-2/2/d1a57de4882cf5730bc850ebdf5bfff5>. (Subscription may be required.)

May 2006

“Gas–water–rock interactions in sedimentary basins: CO₂ sequestration in the Frio Formation, Texas, USA.” To investigate the potential for the geologic storage of carbon dioxide (CO₂) in saline sedimentary aquifers, 1600 tons of CO₂ were injected at approximately 1500 meter (m) depth into a 24-m sandstone section of the Frio Formation — a regional reservoir in the US Gulf Coast. Fluid samples obtained from the injection and observation wells before, during and after CO₂ injection show a Na–Ca–Cl type brine with 93,000 milligrams per liter (mg/L) total dissolved solids (TDS) and near saturation of methane (CH₄) at reservoir conditions. As injected CO₂ gas reached the observation well, results showed sharp drops in pH (6.5 to 5.7), pronounced increases in alkalinity (100 to 3000 mg/L as hydrogen carbonate (HCO₃) and iron (Fe) (30 to 1100 mg/L), and significant shifts in the isotopic compositions of water (H₂O) and dissolved inorganic carbon (DIC). Geochemical modeling indicates that brine pH would have dropped lower, but for buffering by dissolution of calcite and Fe oxyhydroxides. Post-injection

results show the brine gradually returning to its pre-injection composition. *Journal of Geochemical Exploration*, Volume 89, Issues 1-3, *GEOFLUIDS V: 5th International Conference on Fluid Evolution, Migration and Interaction in Sedimentary Basins and Orogenic Belts*, April-June 2006, Pages 183-186, [doi:10.1016/j.gexplo.2005.11.077](https://doi.org/10.1016/j.gexplo.2005.11.077), <http://www.sciencedirect.com/science/article/B6VCP-4JGJJ2R-J/2/f0a78dca20716616646af66c2abab5cc>. (Subscription may be required.)

June 2006

“In situ CO₂–coal reactions in view of carbon dioxide storage in deep unminable coal seams.”

Injection of carbon dioxide (CO₂) in coalbed is considered to be an attractive option for storage. Large amounts of carbon dioxide are generated during the burial history of coal. In commercially produced coalbed gas, however, only small amounts of CO₂ are found. This has motivated the present investigation of the long-term stability of sequestered CO₂ in coal seams. Thus, the purpose of this study is to examine whether reactions with carbon dioxide can occur in coal at reservoir temperatures. The question is whether a relatively small decomposition of CO₂ to form carbon monoxide (CO) can become significant in periods of 10,000 years. High pressure high temperature static and dynamic experiments with CO₂ and coal were performed, which led to the opinion that chemical reactions involving CO₂ cannot be ruled out. All CO concentrations from CO₂ dynamic pressure experiments appear elevated compared to the nitrogen dynamic pressure experiment. The experiments do strongly point towards the reactivity of CO₂ to form CO but because of limited experimental data the chemical involvement cannot be articulated in detail. *Fuel*, Volume 85, Issues 12-13, September 2006, Pages 1904-1912, available online April 18, 2006. <http://www.sciencedirect.com/science/article/B6V3B-4JRV77S-5/2/63e5f8cc6f3b7f9d4e073201bc08adfe>.

July 2006

“Mechanisms of aqueous wollastonite carbonation as a possible CO₂ sequestration process.” The mechanisms of aqueous wollastonite carbonation as a possible carbon dioxide (CO₂) sequestration process were investigated experimentally by systematic variation of the reaction temperature, CO₂ pressure, particle size, reaction time, liquid to solid ratio and agitation power. The carbonation reaction was observed to occur via the aqueous phase in two steps: (1) calcium (Ca) leaching from the wollastonite (CaSiO₃) matrix and (2) calcium carbonate (CaCO₃) nucleation and growth. Leaching is hindered by a Ca-depleted silicate rim resulting from incongruent Ca-dissolution. Two temperature regimes were identified in the overall carbonation process. At temperatures below an optimum reaction temperature, the overall reaction rate is probably limited by the leaching rate of Ca. At higher temperatures, nucleation and growth of calcium carbonate are probably limiting the conversion, due to a reduced (bi)carbonate activity. The mechanisms for the aqueous carbonation of wollastonite were shown to be similar to those reported previously for an industrial residue and a magnesium (Mg)–silicate. The carbonation of wollastonite proceeds rapidly relative to Mg–silicates, with a maximum conversion in 15 minutes of 70 percent at 200 degrees Celsius, 20 bar CO₂ partial pressure and particle size of less than 38 micrograms. The obtained insight in the reaction mechanisms enables the energetic and economic assessment of CO₂ sequestration by wollastonite carbonation, which forms an essential next step in its further development. **Wouter J.J. Huijgen, Geert-Jan Witkamp and Rob N.J. Comans**, *Chemical Engineering Science*, Volume 61, Issue 13, The John Bridgwater Symposium: "Shaping the Future of Chemical Engineering", July 2006, Pages 4242-4251, <http://www.sciencedirect.com/science/article/B6TFK-4JJ2BR9-2/2/147529f686327ad635e1b8df274caf79>. (Subscription may be required.)

“In situ methane hydrate dissociation with carbon dioxide sequestration: Current knowledge and issues.” There are large resources of methane gas as hydrates in permafrost and deep-sea sediments

around the world. On the other hand, the emissions of carbon dioxide into atmosphere have gone up in the last hundred years. The emitted carbon dioxide can be sequestered as hydrate while helping dissociate the in situ methane hydrates. Such approach can improve the economics of carbon dioxide sequestration and methane hydrate dissociation, and assist in global carbon emissions management and methane hydrate exploitation. This paper summarizes the current knowledge on producing methane gas from hydrates while simultaneously sequestering carbon dioxide gas as hydrates, and discusses the challenges and issues in its implementation. **Naval Goel**, *Journal of Petroleum Science and Engineering*, Volume 51, Issues 3-4, May 16, 2006, Pages 169-184, <http://www.sciencedirect.com/science/article/B6VDW-4JCBKXW-1/2/3a99a9da3cb51bf5f4a32cd0cd3953dc>. (Subscription may be required.)

August 2006

“A theoretical model for gas adsorption-induced coal swelling.” Swelling and shrinkage (volumetric change) of coal during adsorption and desorption of gas is a well-known phenomenon. For coalbed methane recovery and carbon sequestration in deep, unminable coal beds, adsorption-induced coal volumetric change may cause significant reservoir permeability change. In this work, a theoretical model is derived to describe adsorption-induced coal swelling at adsorption and strain equilibrium. This model applies an energy balance approach, which assumes that the surface energy change caused by adsorption is equal to the elastic energy change of the coal solid. The elastic modulus of the coal, gas adsorption isotherm, and other measurable parameters, including coal density and porosity, are required in this model. Results from the model agree well with experimental observations of swelling. It is shown that the model is able to describe the differences in swelling behavior with respect to gas species and at very high gas pressures, where the coal swelling ratio reaches a maximum then decreases. Furthermore, this model can be used to describe mixed-gas adsorption induced-coal swelling, and can thus be applied to CO₂-enhanced coalbed methane recovery. **Zhejun Pan and Luke D. Connell**, *International Journal of Coal Geology*, Available online June 22, 2006, [doi:10.1016/j.coal.2006.04.006](https://doi.org/10.1016/j.coal.2006.04.006), <http://www.sciencedirect.com/science/article/B6V8C-4K7NHDW-1/2/73e862d796900964a5790f7c35daf0ce>. (Subscription may be required.)

Technology

September 2005

“Improved immobilized carbon dioxide capture sorbents.” In this experiment, the capture of carbon dioxide from simulated flue gas streams has been achieved by using immobilized and aminated-SBA-15 solid sorbents. The solid sorbents prepared in this study exhibit similar or improved capacities relative to those already used to control CO₂ concentrations in submarine and spacecraft applications. The results suggest that immobilized secondary amines have a stronger affinity for the capture of carbon dioxide from simulated flue gas streams than primary amines. *Fuel Processing Technology*, Volume 86, Issues 14-15, October 2005, Pages 1449-1455, <http://www.sciencedirect.com/science/journal/03783820> (subscription required)

“Aminopropyl-functionalized mesoporous silicas as CO₂ adsorbents.” A range of mesoporous silica substrates were functionalized with 3-aminopropyltrimethoxysilane to form hybrid products suitable for carbon dioxide adsorption. Substantial reversible CO₂ adsorption capacities were observed under anhydrous conditions (at 20 °C). In the presence of water, CO₂ capacity was enhanced, but the rate of desorption was diminished. *Fuel Processing Technology*, Volume 86, Issues 14-15, October 2005, Pages 1435-1448, <http://www.sciencedirect.com/science/journal/03783820> (subscription required)

“Review of novel methods for carbon dioxide separation from flue and fuel gases.” This paper reviews some of the more novel methods for carbon dioxide separation from flue and fuel gas streams.

These methods include electrochemical pumps, membranes, and chemical looping approaches to CO₂ separation. The fundamental mechanisms behind these techniques are explained, and recent advances in these methods are emphasized. Future research directions are suggested and an extensive list of references is provided. *Fuel Processing Technology*, Volume 86, Issues 14-15, October 2005, Pages 1423-1434, <http://www.sciencedirect.com/science/journal/03783820> (subscription required)

November 2005

“Influence of membrane wetting on CO₂ capture in microporous hollow fiber membrane contactors.” Experimental studies on CO₂ absorption using an aqueous DEA solution as the absorbent in a polypropylene hollow fiber membrane contactor show that the CO₂ absorption rate in a non-wetted mode is six times higher than those of the wetted mode of operation. *Separation and Purification Technology*, Volume 46, Issues 1-2, November 2005, Pages 33-40, <http://www.sciencedirect.com/science/journal/13835866> (subscription required)

December 2005

“DOE Advances Oxycombustion for Carbon Management.” The Department of Energy has selected two projects to demonstrate “oxycombustion” – a promising carbon capture technology – in existing coal-fired power plants. The projects, valued at nearly \$10 million, are expected to help expedite the timeline for commercialization of oxycombustion technology through slip stream or pilot plant testing. In an oxycombustion-based power plant, oxygen rather than air is used to combust a fuel resulting in a highly pure carbon dioxide exhaust that can be captured at relatively low-cost and sequestered. No commercial oxygen combustion power plants are operating today, due mainly to the high cost of producing oxygen. Significant reduction in the cost of oxygen compared to today’s best cryogenic technology is a key requirement to making the oxycombustion power plant a viable future option. The two projects selected by DOE show promise for reducing those costs when compared to existing CO₂ capture systems. Babcock and Wilcox and BOC Group, Inc. will head the two projects. *DOE/FE TechLine*, November 17, 2005, http://www.fossil.energy.gov/news/techlines/2005/tl_oxycombustion_award.html

“Oxy-fuel combustion technology for coal-fired power generation.” This paper provides a comprehensive review of research on oxy-fuel combustion, gives the status of the technology development and assessments providing comparisons with other power generation options, and suggests research needs. *Progress in Energy and Combustion Science*, Volume 31, Issue 4, Pages 283-370 (2005), <http://www.sciencedirect.com/science/journal/03601285> (subscription required)

“CO₂ capture using some fly ash-derived carbon materials.” In this work, low cost carbon materials derived from fly ash are presented as effective CO₂ sorbents. The results show that for samples derived from a fly ash carbon concentrate, the CO₂ adsorption capacities were relatively high, especially at high temperatures where commercial active carbons relying on physisorption have low capacities. *Fuel*, Volume 84, Issue 17 (December 2005), <http://www.sciencedirect.com/science/journal/00162361> (subscription required)

“Economical CO₂, SO_x, and NO_x capture from fossil-fuel utilization with combined renewable hydrogen production and large-scale carbon sequestration.” The objective of this project was to investigate and demonstrate production methods at a continuous, bench-scale level and generate sufficient material for an initial evaluation of a potentially profitable method of producing bioenergy and sequestering carbon. The novel process uses agricultural, forestry, and waste biomass to produce hydrogen using pyrolysis and reforming technologies conducted in a 50 kg/h pilot demonstration. A pyrolysis temperature profile was discovered that results in a carbon char with an affinity for capturing CO₂ through gas phase reaction with mixed nitrogen-carrying nutrient compounds within the pore structures of the carbon char. The total amount of CO₂ sequestration was managed by controlling particle

discharge rates based on density. The patent-pending process is particularly applicable to fossil-fuel power plants as it also removes SO_x and NO_x, does not require energy-intensive carbon dioxide separation and operates at ambient temperature and pressure. The complete process produces three times as much hydrogen as it consumes, making it a net energy producer for the affiliated power plant. *Energy*, Volume 30, Issue 14, (November 2005), <http://www.sciencedirect.com/science/journal/03605442> (subscription required)

“Engineering economic analysis of biomass IGCC with carbon capture and storage.” This study surveys the methods of integrating biomass technologies with carbon dioxide capture, and models an IGCC electric power system in detail. *Biomass and Bioenergy*, Volume 29, Issue 6, Pages 399-466 (December 2005), <http://www.sciencedirect.com/science/journal/09619534> (subscription required)

January 2006

“Metal-Organic Frameworks with Exceptionally High Capacity for Storage of Carbon Dioxide at Room Temperature.” Metal-organic frameworks (MOFs) show high CO₂ storage capacity at room temperature. Gravimetric CO₂ isotherms for MOF-2, MOF-505, Cu₃(BTC)₂, MOF-74, IRMOFs-11, -3, -6, and -1, and MOF-177 are reported up to 42 bar. Type I isotherms are found in all cases except for MOFs based on Zn₄O(O₂C)₆ clusters, which reveal a sigmoidal isotherm (having a step). The various pressures of the isotherm steps correlate with increasing pore size, which indicates potential for gas separations. The amine functionality of the IRMOF-3 pore shows evidence of relatively increased affinity for CO₂. Capacities qualitatively scale with surface area and range from 3.2 mmol/g for MOF-2 to 33.5 mmol/g (320 cm³ (STP)/cm³, 147 wt percent) for MOF-177, the highest CO₂ capacity of any porous material reported. *Journal of the American Chemical Society*, ASAP Article 10.1021/ja0570032 S0002-7863(05)07003-4, Web release December 1, 2005, <http://pubs.acs.org/cgi-bin/sample.cgi/jacsat/asap/abs/ja0570032.html> (subscription may be required)

“Membrane processes for post-combustion carbon dioxide capture: A parametric study.” Much of the research in the area of carbon dioxide recovery and storage focuses on minimizing the energy required for CO₂ capture, as this step corresponds to the major cost contribution of the overall process (capture, transportation, injection). Out of the three traditional methods of CO₂ capture (absorption, adsorption and membrane processes), absorption is considered to be the best available technology for post-combustion application. However, amine absorption requires 4-6 GJ/tonne of recovered CO₂, in a large part due to significant energy consumption associated with the regeneration step. In this paper, [the authors] perform a systematic analysis of the separation performances and associated energy cost of a single-stage membrane module. First, the operational limits are identified in terms of permeate composition and CO₂ recovery ratio via a systematic parametric study for CO₂/N₂ mixtures. The energy consumption of the capture step is then evaluated and compared with the performance of amine absorption. Next, the search for an optimal strategy in terms of compression energy for a combination of membrane capture and CO₂ injection has been addressed. The results allow the identification of an optimal membrane pressure ratio for a given set of conditions. *Energy*, Available online December 5, 2005, <http://www.sciencedirect.com/science/article/B6V2S-4HR72B4-1/2/9de6a0d31c833d7d6e9d57005d18c71b> (subscription may be required)

“Optimization of pipeline transport for CO₂ sequestration.” Capture and disposal of CO₂ has received increased R&D attention in the last decade as the technology promises to be the most cost effective for large scale reductions in CO₂ emissions. This paper addresses CO₂ transport via pipeline from capture site to disposal site, in terms of system optimization, energy efficiency and overall economics. Technically, CO₂ can be transported through pipelines in the form of a gas, a supercritical fluid or in the subcooled liquid state. Operationally, most CO₂ pipelines used for enhanced oil recovery transport CO₂ as a supercritical fluid. In this paper, supercritical fluid and subcooled liquid transport are

examined and compared, including their impacts on energy efficiency and cost. Using a commercially available process simulator, ASPEN PLUS 10.1, the results show that subcooled liquid transport maximizes the energy efficiency and minimizes the cost of CO₂ transport over long distances under both isothermal and adiabatic conditions. Pipeline transport of subcooled liquid CO₂ can be ideally used in areas of cold climate or by burying and insulating the pipeline. In very warm climates, periodic refrigeration to cool the CO₂ below its critical point of 31.1°C, may prove economical. Simulations have been used to determine the maximum safe pipeline distances to subsequent booster stations as a function of inlet pressure, environmental temperature and ground level heat flux conditions. *Energy Conversion and Management*, Volume 47, Issue 6, April 2006, Pages 702-715.

<http://www.sciencedirect.com/science/article/B6V2P-4GPW9MR-2/2/6c358e0483b096f20b3a5b8d5668db76> (subscription may be required)

February 2006

“Pressure dependence of the contact angle in a CO₂–H₂O–coal system,” Carbon dioxide injection into coal layers serves the dual purpose of enhancing coal bed methane production (ECBM) and to storing CO₂. The efficiency of this process is expected to be much higher if water is the non-wetting phase in the coal–water–gas system. Therefore, contact angles in the coal–water–CO₂ system have been measured using the captive bubble technique in the pressure range between atmospheric pressure and 141 bar at a temperature of 45 degrees Celsius. At atmospheric pressure the contact angle of a shrinking CO₂ droplet increases with time, but stays below 90 degrees. At higher pressures (>2.6 bar) the contact angle increases beyond 90 degrees. The pressure dependence of the contact can be represented by the equation: $\theta = (111^\circ \pm 10.5^\circ) + (0.17 \pm 0.14)P$ [bar]. The exceptional behavior at atmospheric pressure is possibly related to the stability of water patches on the coal surface. It is concluded that water is the non-wetting phase in this coal–water–CO₂ system. *Journal of Colloid and Interface Science*, Available online January 9, 2006, doi:10.1016/j.jcis.2005.11.047,

<http://www.sciencedirect.com/science/article/B6WHR-4J0PF96-9/2/5f9feeabb2e97a1b595692261e4f8463>. (Subscription may be required.)

March 2006

“Using steam reforming to produce hydrogen with carbon dioxide capture by chemical-looping combustion,” In this paper, a novel process for hydrogen production by steam reforming of natural gas with inherent capture of carbon dioxide by chemical-looping combustion is proposed. The process resembles a conventional circulating fluidized bed combustor with reforming taking place in reactor tubes located inside a bubbling fluidized bed. Energy for the endothermic reforming reactions is provided by indirect combustion that takes place in two separate reactors: one for air and one for fuel. Oxygen is transferred between the reactors by a metal oxide. There is no mixing of fuel and air so carbon dioxide for sequestration is easily obtained. Process layout and expected performance are evaluated and a preliminary reactor design is proposed. It is found that the process should be feasible. It is also found that it has potential to achieve better selectivity towards hydrogen than conventional steam reforming plants due to low reactor temperatures and favorable heat-transfer conditions. *International Journal of Hydrogen Energy*, available online January 26, 2006,

<http://www.sciencedirect.com/science/article/B6V3F-4J4B93Y-1/2/6be7f6e05f3ba37380b2e01b81135079>. (Subscription may be required.)

“A comparison of electricity and hydrogen production systems with CO₂ capture and storage—Part A: Review and selection of promising conversion and capture technologies,” The authors performed a consistent comparison of state-of-the-art and advanced electricity and hydrogen production technologies with carbon dioxide (CO₂) capture using coal and natural gas, inspired by the large number of studies, of which the results can in fact not be compared due to specific assumptions made. After literature review, a standardization and selection exercise was performed to get figures on conversion

efficiency, energy production costs and CO₂ avoidance costs of different technologies, the main parameters for comparison. On the short term, electricity can be produced with 85–90 percent CO₂ capture by means of natural gas combined cycle (NGCC) and pulverized coal-fired (PC) with chemical absorption and integrated gasification combined cycle (IGCC) with physical absorption at 4.7–6.9 European union cents per kilowatt hour (€/kWh) (which is equivalent to a range of 5.3–7.8 US cents, at the 2003 average exchange rate assumed in the paper of 0.885 €/US\$), assuming a coal and natural gas price of 1.7 and 4.7 Euros per gigajoule (€/GJ) (equivalent to 1.9 and 5.3 \$/GJ). CO₂ avoidance costs are between 15 and 50 Euros per ton of CO₂ (€/t CO₂), (or approximately 17 and 57 \$/t CO₂) for IGCC and NGCC, respectively. On the longer term, both improvements in existing conversion and capture technologies are foreseen as well as new power cycles integrating advanced turbines, fuel cells and novel (high-temperature) separation technologies. Electricity production costs might be reduced to 4.5–5.3 (€/kWh), (or approximately 5.1–6.0 US cents/kWh) with advanced technologies. However, no clear ranking can be made due to large uncertainties pertaining to investment and O&M costs. Hydrogen production is more attractive for low-cost CO₂ capture than electricity production. Costs of large-scale hydrogen production by means of steam methane reforming and coal gasification with CO₂ capture from the shifted syngas are estimated at 9.5 and 7 €/GJ (or 10.7 and 8 \$/GJ), respectively. Advanced autothermal reforming and coal gasification deploying ion transport membranes might further reduce production costs to 8.1 and 6.4 €/GJ (9.2 and 7.2 \$/GJ). Membrane reformers enable small-scale hydrogen production at nearly 17 €/GJ (19 \$/GJ) with relatively low-cost CO₂ capture. *Progress in Energy and Combustion Science*, available online January 20, 2006, doi:10.1016/j.pecs.2005.11.005, <http://www.sciencedirect.com/science/article/B6V3W-4J32JB0-1/2/882ac9be2cee316554fddcab68b009f4>. (Subscription may be required.)

“Polymeric CO₂/N₂ gas separation membranes for the capture of carbon dioxide from power plant flue gases,” One mitigation option for the reduction of greenhouse gas emissions involves the capture of carbon dioxide from flue gases followed by underground sequestration. For this technology to become widespread, new methods of capturing carbon dioxide must be devised. While capture of carbon dioxide with amine solvents is the most mature technology, another possible contender is gas separation membranes. This review paper focuses on novel materials for gas separation. In particular, polymeric gas separation membranes are examined. Possible design strategies, synthesis, fabrication and role of novel materials are discussed. *Journal of Membrane Science*, available online February 17, 2006, doi:10.1016/j.memsci.2005.12.062, <http://www.sciencedirect.com/science/article/B6TGK-4J90W1G-1/2/294ee603a3982c9caf1fc40edbe752b0>. (Subscription may be required.)

“A 300 W laboratory reactor system for chemical-looping combustion with particle circulation,” Chemical-looping combustion (CLC) is a method to burn gaseous fuels with inherent separation of carbon dioxide. A continuously operated laboratory reactor system for chemical-looping combustion with two interconnected fluidized beds was designed and built. This chemical-looping combustor was designed to operate with a fuel flow corresponding to 100–300 watts (W). The CLC system was operated successfully using a highly reactive nickel-based oxygen-carrier. Furthermore, tests were carried out to determine the degree of gas leakage between the reactors. Although there was some leakage between the fuel and air reactors, it is low enough to enable evaluation of the combustion results. The combustion tests showed a high conversion of the natural gas to carbon dioxide, indicating that the particles are suitable for chemical-looping combustion. No methane was detected in the gas from the fuel reactor, and the fraction of carbon monoxide was in the range 0.5–3 percent. *Fuel*, available online February 17, 2006. doi:10.1016/j.ijhydene.2005.12.003, <http://www.sciencedirect.com/science/article/B6V3F-4J4B93Y-1/2/6be7f6e05f3ba37380b2e01b81135079>. (Subscription may be required.)

“Techno-economic prospects of small-scale membrane reactors in a future hydrogen-fuelled transportation sector,” A membrane reactor is a novel technology for the production of hydrogen from natural gas. It promises economic small-scale hydrogen production, e.g. at refueling stations, and has

the potential of inexpensive carbon dioxide separation. Four configurations of a membrane reactor have been modeled with Aspen^{plus} to determine its thermodynamic and economic prospects. Overall energy efficiency is 84%_{HHV} (higher heating value) without H₂ compression (78 percent with compression up to 482 bar). The modeling results also indicate that by using a sweep gas, the membrane reactor can produce a reformer exit stream consisting mainly of carbon dioxide (CO₂) and H₂O (>90%_{mol}) suited for CO₂ sequestration after water removal with an efficiency loss of only 1%_{pt} (pt, percentage points). Reforming with a 2 megawatt (MW) membrane reactor (250 unit production volume) costs 14 dollars per gigajoule of H₂ (\$/GJ_{H2}) including compression, which is more expensive than conventional steam reforming and compression (12 \$/GJ). It does, however, promise a cheap method of CO₂ separation, 14 dollars per ton (\$/t) CO₂ captured, due to the high purity of the exit stream. The well-to-wheel chain of the membrane reactor has been compared to centralized steam reforming to assess the trade-off between production scale and the construction of a hydrogen and a CO₂ distribution infrastructure. If the scale of centralized hydrogen production is below 40 MW, the trade-off could be favorable for the membrane reactor with small-scale CO₂ capture -18 \$/GJ including H₂ storage, dispensing and CO₂ sequestration for 40 MW steam methane reforming (SMR) versus 19 \$/GJ for the membrane reactor. The membrane reactor might become competitive with conventional steam reforming provided that thin membranes can be combined with high stability and a cheap manufacturing method for the membrane tubes. Thin membranes, industrial utility prices and larger production volumes (i.e. technological learning) might reduce the levelized hydrogen cost of the membrane reactor at the refueling station to less than 14 \$/GJ including CO₂ sequestration cost, below that of large-scale H₂ production with CO₂ sequestration (~15 \$/GJ). *Energy*, available online February 2, 2006, doi:10.1016/j.energy.2005.12.004, <http://www.sciencedirect.com/science/article/B6V2S-4J5T5RM-2/2/18f7d8576e051f4aabf48010d40593f7>. (Subscription may be required.)

“The development of nanoporous membranes for separation of carbon dioxide at high temperatures,” The development of nanoporous membranes for separation of carbon dioxide at high temperatures Initial observations from permeation experiments are reported for a class of novel membranes which display potential in the area of high temperature (~900 K) gas separations. The existence of these membranes was first postulated from theoretical studies on transport of gases through ultra-thin (~5–25 nm), nanoporous silica. The experimental results presented here confirm these observations, as demonstrated by membranes produced with kinetic selectivities for carbon dioxide/nitrogen greater than 75:1 at 873 K. *Journal of Membrane Science*, available online, January 24, 2006, doi:10.1016/j.memsci.2005.12.021, <http://www.sciencedirect.com/science/article/B6TGK-4J3WS9C-3/2/bcaaaae21f726e7cc797a3c0bbbd4577>. (Subscription may be required.)

April 2006

“A Novel Adsorption Cycle for CO₂ Recovery: Experimental and Theoretical Investigations of a Temperature Swing Compression Process.” A novel adsorption cycle is examined experimentally and theoretically for recovering carbon dioxide (CO₂) from a 50 mole percent (mol%) mixture with carbon monoxide. Several adsorbents are considered, and zeolite sodium-yttrium (NaY) is chosen for the process due to its high capacity and selectivity for CO₂ in the presence of carbon monoxide. The process consists of three steps. The bed is fed the gas mixture at 273 degrees Kelvin (°K) until CO₂ breakthrough occurs. The bed then undergoes countercurrent blowdown of CO₂ while heating at 391 °K and is finally cooled to the initial feed temperature once the bed has been depleted of CO₂. Results are presented from laboratory scale experiments and are described using numerical simulations. This novel cycle provides a method for capturing and producing CO₂ without the need for a purge gas and has low energy requirements if waste heat is available. *Separation Science and Technology*, Volume 41, Number 3, Number 3/2006, pages 485-500 (16), doi:10.1080/01496390500524834, <http://journalonline.tandf.co.uk/openurl.asp?genre=article&issn=0149-6395&volume=41&issue=3&page=485>. (Subscription or purchase may be required.)

“A simulation study for the hybrid reaction of methane steam reforming and in situ CO₂ removal in a moving bed reactor of a catalyst admixed with a CaO-based CO₂ acceptor for H₂ production.”

A hybrid reaction system of catalytic methane steam reforming (MSR) and in situ non-catalytic removal of CO₂ by the carbonation of calcium oxide (CaO) to calcium carbonate (CaCO₃) in a moving bed reactor where reforming catalyst and CaO-based CO₂ acceptor in pellets move co-currently with gaseous reactants has been simulated through a mathematical model. The model has been developed at non-isothermal, non-adiabatic, and non-isobaric operating conditions assuming that the rate of the CaO carbonation in a local zone of the reactor bed is governed by kinetic limitation or by the CO₂ limitation in bulk gas phase. The effects of major operating parameters such as the feed rates of CaO and methane (CH₄), and the reactor bed temperature on steady-state behavior of the hybrid reaction in a moving bed reactor have been determined. It was revealed that the feed rate of CaO for a given feed rate of CH₄ should be optimized in order to maximize the utilization degree of CaO carbonated through the reactor while producing the reformed gas in the possible lowest concentration of CO₂ at a given temperature of reaction. *International Journal of Hydrogen Energy*, Volume 31, Issue 5, Pages 649-657. April 2006, <http://www.sciencedirect.com/science/article/B6V3F-4GHS GF7-3/2/0dc1340b939f0ccd47d4a9de5572a72e>. (Subscription may be required.)

“Separation of CH₄/CO₂/N₂ mixtures by layered pressure swing adsorption for upgrade of natural gas.”

A novel compact adsorption-based process for removal of carbon dioxide (CO₂) and nitrogen (N₂) from low and medium natural gas flowrates is discussed. The layered pressure swing adsorption (LPSA) process studied is composed of a zeolite 13X to selectively remove carbon dioxide followed by a layer of carbon molecular sieve 3K to make the separation of nitrogen from methane (CH₄). The advantage of the process is the removal of two different contaminants in the feed step, delivering methane at high pressure without recompression requirements. A four-step cycle was studied comprising countercurrent pressurization, feed, countercurrent blowdown and countercurrent purge with product. The blowdown step was performed in vacuum to remove carbon dioxide from zeolite 13X. Experiments were performed in a single-column LPSA unit at different temperatures and using different ratios of adsorbent layers to study the effects of these parameters in overall performance of the unit. Feeding a mixture of 60 percent CH₄/20 percent CO₂/20 percent N₂, methane purity of 86.0 percent with 52.6 percent recovery was obtained at ambient temperature while 88.8 percent purity with 66.2 percent recovery was obtained at 323 °K. At both temperatures there was a ratio of adsorbent layers where purity reaches a maximum, while product recovery always decreases for larger zeolite 13X layers. *Chemical Engineering Science*, Available online March 9, 2006, <http://www.sciencedirect.com/science/article/B6TFK-4JF97PV-3/2/f6277e4641a80424b44a393748b59724>. (Subscription may be required.)

May 2006

“Internalization of external cost in the power generation sector: Analysis with Global Multi-regional MARKAL model.”

The Global MARKAL-Model (GMM), a multi-regional "bottom-up" partial equilibrium model of the global energy system with endogenous technological learning, is used to address impacts of internalization of external costs from power production. This modeling approach imposes additional charges on electricity generation, which reflect the costs of environmental and health damages from local pollutants (SO₂, NO_x) and climate change, wastes, occupational health, risk of accidents, noise and other burdens. Technologies allowing abatement of pollutants emitted from power plants are rapidly introduced into the energy system, for example, desulphurization, NO_x removal, and CO₂ scrubbers. The modeling results indicate substantial changes in the electricity production system in favor of natural gas combined cycle, nuclear power and renewables induced by internalization of external costs and also efficiency loss due to the use of scrubbers. Structural changes and fuel switching in the electricity sector result in significant reduction of emissions of both local pollution and CO₂ over the modeled time period. Strong decarbonization impact of internalizing local externalities suggests that ancillary benefits can be expected from policies directly addressing other issues than CO₂ mitigation. Finally, the detailed analysis of the total generation cost of different technologies points out that inclusion of external cost in the price of electricity increases competitiveness of non-fossil generation sources and

fossil power plants with emission control. *Energy Policy*, Available online April 17, 2006.
[doi:10.1016/j.enpol.2006.03.003](https://doi.org/10.1016/j.enpol.2006.03.003), <http://www.sciencedirect.com/science/article/B6V2W-4JRM0JS-2/2/94617fc5ec770200db1a981fa94b3511>. (Subscription may be required.)

“Hydrogen production from methane hydrate with sequestering of carbon dioxide.” Methane hydrate exists in large amounts in certain locations, in sea sediments and the geological structures below them and below arctic regions’ permafrost, at low temperature and high pressure. It has recently been shown that there are suitable methods for producing methane, perhaps on a floating platform. There it could be reformed via an endothermic process to produce hydrogen and carbon dioxide. Some of the methane could be used to provide heat energy for a power plant on the platform to produce all needed power and support for the methane and CO₂ reforming process. After separation, hydrogen is the valuable and transportable product. All carbon dioxide produced on the platform could be separated from other gases and then sequestered, in one of several possible forms. In this way, hydrogen could be made available without the release of carbon dioxide to the atmosphere and the hydrogen could be an enabling step toward a world hydrogen economy, free of particles and carbon dioxide pollution. *International Journal of Hydrogen Energy*, Available online April 4, 2006,
[doi:10.1016/j.ijhydene.2006.01.017](https://doi.org/10.1016/j.ijhydene.2006.01.017), <http://www.sciencedirect.com/science/article/B6V3F-4JMVHKC-1/2/ffcae5d815b1b21fa182743a0e22a6e>. (Subscription may be required.)

June 2006

“Global challenges and strategies for control, conversion and utilization of CO₂ for sustainable development involving energy, catalysis, adsorption and chemical processing.” Utilization of carbon dioxide (CO₂) has become an important global issue due to the significant and continuous rise in atmospheric CO₂ concentrations, accelerated growth in the consumption of carbon-based energy worldwide, depletion of carbon-based energy resources, and low efficiency in current energy systems. The barriers for CO₂ utilization include: (1) costs of CO₂ capture, separation, purification, and transportation to user site; (2) energy requirements of CO₂ chemical conversion (plus source and cost of co-reactants); (3) market size limitations, little investment-incentives and lack of industrial commitments for enhancing CO₂-based chemicals; and (4) the lack of socio-economical driving forces. The strategic objectives may include: (1) use CO₂ for environmentally-benign physical and chemical processing that adds value to the process; (2) use CO₂ to produce industrially useful chemicals and materials that adds value to the products; (3) use CO₂ as a beneficial fluid for processing or as a medium for energy recovery and emission reduction; and (4) use CO₂ recycling involving renewable sources of energy to conserve carbon resources for sustainable development. The approaches for enhancing CO₂ utilization may include one or more of the following: (1) for applications that do not require pure CO₂, develop effective processes for using the CO₂-concentrated flue gas from industrial plants or CO₂-rich resources without CO₂ separation; (2) for applications that need pure CO₂, develop more efficient and less-energy intensive processes for separation of CO₂ selectively without the negative impacts of co-existing gases such as water (H₂O), oxygen (O₂), and nitrogen (N₂); (3) replace a hazardous or less-effective substance in existing processes with CO₂ as an alternate medium or solvent or co-reactant or a combination of them; (4) make use of CO₂ based on the unique physical properties as supercritical fluid or as either solvent or anti-solvent; (5) use CO₂ based on the unique chemical properties for CO₂ to be incorporated with high ‘atom efficiency’ such as carboxylation and carbonate synthesis; (6) produce useful chemicals and materials using CO₂ as a reactant or feedstock; (7) use CO₂ for energy recovery while reducing its emissions to the atmosphere by sequestration; (8) recycle CO₂ as carbon-source for chemicals and fuels using renewable sources of energy; and (9) convert CO₂ under either bio-chemical or geologic-formation conditions into “new fossil” energies. Several cases are discussed in more detail. The first example is tri-reforming of methane versus the well-known CO₂ reforming over transition metal catalysts such as supported nickel catalysts. Using CO₂ along with H₂O and O₂ in flue gases of power plants without separation, tri-reforming is a synergetic combination of CO₂ reforming, steam reforming and partial oxidation and it can eliminate carbon deposition problem and produces syngas with desired hydrogen/carbon monoxide (H₂/CO) ratios for industrial applications. The second example is a CO₂

“molecular basket” as CO₂-selective high-capacity adsorbent which was developed using mesoporous molecular sieve MCM-41 and polyethylenimine (PEI). The MCM41-PEI adsorbent has higher adsorption capacity than either PEI or MCM-41 alone and can be used as highly CO₂-selective adsorbent for gas mixtures without the pre-removal of moisture because it even enhances CO₂ adsorption capacity. The third example is synthesis of dimethyl carbonate using CO₂ and methanol, which demonstrates the environmental benefit of avoiding toxic phosgene and a processing advantage. The fourth example is the application of supercritical CO₂ for extraction and for chemical processing where CO₂ is either a solvent or a co-reactant, or both. The CO₂ utilization contributes to enhancing sustainability, since various chemicals, materials, and fuels can be synthesized using CO₂, which should be a sustainable way in the long term when renewable sources of energy are used as energy input. *Catalysis Today*, available online May 16, 2006. [doi:10.1016/j.cattod.2006.02.029](https://doi.org/10.1016/j.cattod.2006.02.029), <http://www.sciencedirect.com/science/article/B6TFG-4JYKP82-1/2/15643dd129e6f04a5aa0ab9d56107077>.

“Oxygen efficiency with regard to carbon capture.” Carbon capture is often discussed in the literature with the sole focus on power processes, despite the fact that carbon dioxide emissions from other sources are just as relevant for the impact on the atmosphere. Furthermore, some carbon capture methods are relatively inefficient when applied to power production processes. Carbon capture should preferably be performed where the cost is as low as possible, i.e. not necessarily from power production processes. As an example, carbon capture using combustion with pure oxygen is far more energy efficient if it is used together with lime kilns or cement kilns than together with power production processes. A new concept termed “oxygen efficiency” is introduced in this paper. It describes the amount of carbon dioxide that can potentially be captured per unit of oxygen. As such, the oxygen efficiency quantifies the value of a certain unit of oxygen for carbon capture reasons. The base concept is that the energy penalty for the production of one part of oxygen is the same no matter where it is produced; hence, if this unit of oxygen can be used to capture more carbon dioxide, it is more efficient. Typically, the oxygen efficiency would be five times greater for carbon capture when utilizing pure oxygen together with cement kilns rather than together with methane-fired power plants. Furthermore, the concept of oxygen efficiency illustrates the importance of considering how carbon capture methods can be utilized in the most efficient way, in addition to evaluating which carbon capture method is the most suitable for a particular technology. *Energy*, available online April 8, 2006, <http://www.sciencedirect.com/science/article/B6V2S-4JRVFS9-2/2/a26c96289e400e62be0b0cba3a18c02c>.

“A quantitative comparison of gas turbine cycles with CO₂ capture.” Nine different concepts for natural gas fired power plants with carbon dioxide (CO₂) capture have been investigated, and a comparison is made based on net plant efficiency and emission of CO₂. The cycles are one post-combustion, six oxy-fuel and two pre-combustion capture concepts. A 400 megawatt (MW) combined cycle plant is applied as a reference case. A common basis for the comparison of all concepts is defined and employed in heat- and mass-balance simulations of the various concepts. As gas turbine cooling impacts the net plant efficiency at high turbine inlet temperatures, a simplified turbine cooling model has been applied in the simulations. It is found that the concepts, in which novel technology (the methane steam reformer with hydrogen separation (MSR-H₂), the advanced zero emission process power plant--(AZEP), the solid oxide fuel cell combined with a gas turbine—SOFC+GT and the chemical looping combustion—CLC concepts) is employed, exhibit the best performance with respect to both efficiency and in most cases also CO₂ capture (capture rates close to 100 percent). Post-combustion capture and pre-combustion capture with auto-thermal reforming, which are based on more mature technology, show a lower efficiency and a capture rate of typically 90 percent. The SOFC+GT concept exhibits the best cycle performance and even better than a standard combined cycle plant, however, any realization of a SOFC-GT 400 MW plant has a very distant future perspective. In order to conduct a complete assessment of these diverse concepts, other criteria for comparison such as e.g. technology level and costs should also be considered. This is not, however, included in the present work. *Energy*, available online, April 17, 2006, <http://www.sciencedirect.com/science/article/B6V2S-4JRKCTS-1/2/12016c77a4c8106910ef9d002d70d791>.

“Technoeconomic evaluation of IGCC power plants for CO₂ avoidance.” This paper is a technical and economic comparison of the performance of five plant designs in the 500 megawatt (MW) output range: IGCC without CO₂ capture, IGCC with 80 percent capture, IGCC with CO₂ emissions equal to those of a NGCC, IGCC with CO₂ and hydrogen sulfide (H₂S) co-capture, and NGCC without capture. ASPEN Plus™ models of the above plants were developed and the following plant performance results are discussed: net power output, efficiency, plant ancillary energy requirements and overall CO₂ emissions. Economic evaluations for all cases are presented, including the cost methodology and economic basis. The capital investment, cost of electricity and carbon dioxide mitigation costs for all plants are detailed and compared. The simulation results show that the economics favor higher capture levels in new IGCC plants. The CO₂ mitigation costs corresponding to IGCC plants with 80 percent capture are slightly lower than those corresponding to IGCC plants with equal emissions to those of NGCC plants (28 vs. 30 \$/tonne CO₂ avoided). The capital cost difference (per kilowatt (kW) of net installed capacity) between the above plants is 7 percent, while the CO₂ emissions of the former are almost half those of the latter. IGCC plants with CO₂ and H₂S co-capture have substantial technoeconomic advantages over IGCC plants that capture CO₂ and H₂S separately. Based on a 577 MW IGCC, the power output decreases only to 552 MW for the co-capture case, whereas it drops to 488 MW when CO₂ and H₂S are captured separately. The incremental capital cost of co-capture plants is 6 percent, and their electricity production cost increase is less than half a cent, with respect to an IGCC without capture. The CO₂ mitigation cost of co-capture plants is at least four times lower than their separate CO₂ and H₂S capture counterparts. *Energy Conversion and Management*, Volume 47, Issues 15-16, September 2006, Pages 2250-2259, available online February 9, 2006, <http://www.sciencedirect.com/science/article/B6V2P-4J7B0PF-1/2/3a67a6636f5dd0ec347122e9383b2714>.

“Chemical fixation of CO₂ in carbonates: Routes to valuable products and long-term storage.” Carbon dioxide emissions to the atmosphere can be reduced by chemical fixation in organic or inorganic carbonates. Many compounds can be commercially produced on an industrial scale using carbon dioxide (CO₂), allowing for turning a (nowadays problematic) waste gas into economic profit. Besides this, the carbonation of magnesium silicates and calcium silicates is an option for long-term storage of CO₂ at a capacity that exceeds that of other options for CO₂ storage by several orders of magnitude, with the inherent benefit that post-storage monitoring of the stored CO₂ is not necessary. The first part of this paper gives an overview of commercial carbonate chemical production routes that do (or in a near future can) make use of the CO₂ that is produced at a large scale from human activities. The second part addresses the process technology, market potential and other aspects of mineral carbonation for long-term CO₂ storage as an alternative for, for example, storage in underground aquifers. *Catalysis Today*, available online March 22, 2006. <http://www.sciencedirect.com/science/article/B6TFG-4JJ2BNR-2/2/ef069deabba02b1e84721ac45544dd13>.

July 2006

“Exergy regeneration in an O₂/CO₂ gas turbine cycle with chemical recuperation by CO₂ reforming of methane.” This paper proposes a novel power cycle system composed of a chemical recuperative cycle with CO₂-NG (carbon dioxide-natural gas) reforming and an ammonia absorption refrigeration cycle in which the heat is recovered from the turbine exhaust to drive the carbon dioxide-natural gas (CO₂-NG) reformer firstly, and then, lower temperature heat from the turbine exhaust is provided for the ammonia absorption refrigeration system to generate chilled media, which is used to cool the turbine inlet gas except for the exported part. Based on 1 kilograms per second (kg s⁻¹) of methane feedstock, the turbine inlet temperature of 1573 kelvin (K) and the CO₂ compressor outlet pressure of 1.01 Megapascals (MPa), the simulation results show that the new cycle system reached the net electric power production of 24.444 megawatts (MW), the power generation efficiency of 48.9 percent based on the low heating value, the export chilled load of 1.070 MW and the exergy efficiency of 47.3 percent. On the other hand, 2.743 kg s⁻¹ of liquid CO₂ was captured, which achieved the goal of zero CO₂ emission. Especially, the

authors investigate the exergy regeneration performances of the chemical recuperation with CO₂-NG reforming, the lower temperature heat from the turbine exhaust generated chilled load and inlet cooling by the aid of the energy utilization diagram to expose the thermodynamic principle of energy integration for high efficiency power conversion in the system. **Wen Cao and Danxing Zheng**, *Energy Conversion and Management*, available online April 18, 2006, [doi:10.1016/j.enconman.2006.03.010](https://doi.org/10.1016/j.enconman.2006.03.010), <http://www.sciencedirect.com/science/article/B6V2P-4JRVFK8-4/2/fda16d637f6a0f410177f65e6ff14678>. (Subscription may be required.)

“Environmental assessment and extended exergy analysis of a “zero CO₂ emission”, high-efficiency steam power plant.” Aim of this paper is to analyze the performance of an innovative high-efficiency steam power plant by means of two “life cycle approach” methodologies, the life cycle assessment (LCA) and the “extended exergy analysis” (EEA). The plant object of the analysis is a hydrogen-fed steam power plant in which the H₂ is produced by a “zero carbon dioxide (CO₂) emission” coal gasification process (the ZECOTECH[®] cycle). The CO₂ capture system is a standard humid-calcium oxide (CaO) absorbing process and produces calcium carbonate (CaCO₃) as a by-product, which is then regenerated to CaO releasing the CO₂ for a downstream mineral sequestration process. The steam power plant is based on an innovative combined-cycle process: the hydrogen is used as a fuel to produce high-temperature, medium-pressure steam that powers the steam turbine in the topping section, whose exhaust is used in a heat recovery boiler to feed a traditional steam power plant. The environmental performance of the ZECOTECH[®] cycle is assessed by comparison with four different processes: power plant fed by hydrogen (H₂) from natural gas steam reforming, two conventional coal- and natural gas power plants and a wind power plant. **A. Corrado, P. Fiorini and E. Sciubba**, *Energy*, available online May 19, 2006, [doi:10.1016/j.energy.2006.03.025](https://doi.org/10.1016/j.energy.2006.03.025), <http://www.sciencedirect.com/science/article/B6V2S-4K0FFS5-2/2/cd480dd6670641c6afaa0ffd96c72fdc>. (Subscription may be required.)

“Process design and energy requirements for the capture of carbon dioxide from air,” A process to capture carbon dioxide from air to reduce its atmospheric concentration and to mitigate climate change is studied. It is based on the absorption of carbon dioxide in a sodium hydroxide solution, its precipitation as calcium carbonate, and its release as pure gas stream through oxy-fuel calcination. The process utilizes existing commercial technologies wherever possible, particularly in the case of the absorber, whose design is carried out in detail. The analysis allows deriving material and energy balances for the whole process and determining energy demands that can be used for a technical, economical, and environmental feasibility evaluation of the technology. In particular, it indicates that the real specific energy demand is larger than the heat released to emit the same amount of CO₂ by the combustion of coal, and smaller than that of methane. **Renato Baciocchi, Giuseppe Storti and Marco Mazzotti**, *Chemical Engineering and Processing*, available online April 25, 2006, [doi:10.1016/j.cep.2006.03.015](https://doi.org/10.1016/j.cep.2006.03.015), <http://www.sciencedirect.com/science/article/B6TFH-4JT836P-1/2/40fac7c57c5eeafc1bd68ce25fbf50cd>. (Subscription may be required.)

“Spectroscopic analysis of carbon dioxide and nitrogen mixed gas hydrates in silica gel for CO₂ separation.” In this study solid-state nuclear magnetic resonance (NMR) spectroscopy was used to identify structure and guest distribution of the mixed nitrogen (N₂) + carbon dioxide (CO₂) hydrates. These results show that it is possible to recover CO₂ from flue gas by forming a mixed hydrate that removes CO₂ preferentially from CO₂/N₂ gas mixture. Hydrate phase equilibria for the ternary CO₂-N₂-water system in silica gel pores were measured, which show that the three-phase hydrate (H)-water-rich liquid (L_w)-vapor (V) equilibrium curves were shifted to higher pressures at a specific temperature when the concentration of CO₂ in the vapor phase decreased. Carbon 13 (¹³C) cross-polarization (CP) NMR spectra of the mixed hydrates at gas compositions of more than 10 mol percent CO₂ with the balance N₂ identified that the crystal structure of mixed hydrates as structure I, and that the CO₂ molecules occupy mainly the abundant tetrakaidecahedra (5¹²6²) cages. This makes it possible to achieve concentrations of more than 96 mol percent CO₂ gas in the product after three cycles of hydrate formation and dissociation. **Jeasung Park, Yu-Taek Seo, Jong-won Lee and Huen Lee**, *Catalysis Today*, Volume

115, Issues 1-4, Proceedings of the 8th International Conference on Carbon Dioxide Utilization - Dedicated to Professor Michele Aresta, June 30, 2006, Pages 279-282,
<http://www.sciencedirect.com/science/article/B6TFG-4JP9FXT-5/2/cd994f28fb43ff03e380ec054c4f3b0e>.
(Subscription may be required.)

August 2006

“Hybrid Membranes for Selective Carbon Dioxide Separation from Fuel Gas.” The potential of hybrid membranes as a carbon dioxide (CO₂) capture technology for integrated gasification combined cycle applications was evaluated. Commercial gamma-alumina (γ-alumina) supports were modified with a variety of trichlorosilanes intended to enhance the surface adsorption of CO₂. The resulting hybrids were characterized using X-ray photoelectric spectroscopy and Fourier transform infrared spectroscopy and tested for performance in the separation of helium (He) and CO₂. The silanization temperature was determined to be important because membranes fabricated at 273 degrees Kelvin had substantially different performance properties than those fabricated at room temperature. Specifically, the permeances of membranes modified with alkyltrichlorosilanes at reduced temperatures were 1-2 orders of magnitude higher than those of membranes fabricated at room temperature, and the selectivities of these low-temperature silanized membranes were relatively similar to those expected from Knudsen diffusion. Supports modified with silanes containing one of a variety of functionalities were tested for CO₂/He selectivity. Membranes modified with 2-acetoxyethyl, 2-carbomethoxyethyl, and 3-aminopropyl groups exhibited CO₂ selectivity, with the highest values approaching 7 for 2-carbomethoxyethyl-silated membranes at 50 degrees C. Temperature dependences resulted in selectivity maxima for the 2-acetoxyethyl and 2-carbomethoxyethyl membranes. Mixed-gas selectivities were slightly higher than pure-gas selectivities because of a decrease in He permeance with a relatively minor reduction in CO₂ permeance. Transport in the selective membranes is believed to occur by a combination of activated and solution diffusion for He and a combination of activated and surface diffusion for CO₂. **David Luebke, Christina Myers, and Henry Pennline**, *Energy Fuels*, Web release date: July 15, 2006, doi: 10.1021/ef060060b. <http://pubs.acs.org/cgi-bin/abstract.cgi/enfuem/asap/abs/ef060060b.html>.
(Subscription required.) (Subscription may be required.)

“Dense inorganic membranes for production of hydrogen from methane and coal with carbon dioxide sequestration.” Principles and strategies for design and operation of catalysts associated with both dense oxygen transport membranes and dense hydrogen transport membranes are discussed. Dense ceramic oxygen transport membranes function through the diffusion of oxygen anions, O²⁻. A key catalytic step is the adsorption and dissociation of molecular oxygen, and the associated transfer of four electrons. In dense hydrogen transport membranes, whether ceramic or metallic, molecular hydrogen must be catalytically dissociated on the retentate-side membrane surface to allow transport of hydrogen through the bulk membrane in a dissociated form. Dissociated hydrogen must be re-combined and desorbed from the permeate side membrane surface. Strategies are discussed for increasing resistance of catalysts to poisons. By separating oxygen from the other components of air, oxygen transport membranes allow a potential efficient means for production of synthesis gas (H₂ + CO) from natural gas or coal, without diluting the product with nitrogen. Further reaction of CO with steam over water-gas shift catalysts produces additional hydrogen plus CO₂. Extraction of hydrogen from water-gas shift reactors through dense hydrogen transport membranes, while retaining CO₂ at operating pressures of coal gasifiers (e.g. 1000 pounds per square inch (psi) or 69 bar) produces essentially pure hydrogen in the permeate and CO₂ at high pressure and high concentration, which is ideal for efficient sequestration of CO₂. Process flow scenarios for integration of both oxygen transport membranes and hydrogen transport membranes with coal gasifiers, natural gas syngas reactors, water-gas shift reactors and systems for sequestration of CO₂ are discussed. **M.V. Mundschau, X. Xie, C.R. Evenson IV and A.F. Sammells**, *Catalysis Today*, Available online July 3, 2006, doi:10.1016/j.cattod.2006.01.042, <http://www.sciencedirect.com/science/article/B6TFG-4KB115X-3/2/f1eb96088604b218a3d88314233b17ba>. (Subscription may be required.)

“An advanced zero emission power cycle with integrated low temperature thermal energy.” An innovative zero emission hybrid cycle named HICES (hybrid and improved CES cycle) is presented in this paper. This Cycle can utilize fossil fuel and low quality thermal energy such as waste heat from industrial processes and solar thermal energy for highly efficient electric power generation. In the HICES cycle, natural gas is internally combusted with pure oxygen. External low quality thermal energy is used to produce saturated steam between 70 and 250 degrees Celsius (°C) as part of the working fluid. The thermodynamic characteristics at design conditions of the HICES cycle are analyzed using the advanced process simulator Aspen Plus. The influences of some key parameters are investigated. The results demonstrate that the thermodynamic performances of the HICES cycle are quite promising. For example, when the external heat produced saturated steam is at 70 °C, the net fuel-to-electricity efficiency is 54.18 percent even when taking into account both the energy penalties to produce pure oxygen and to liquefy the captured CO₂. The incremental low temperature heat to electric efficiency is as high as 14.08 percent at the same time. When the external heat produced saturated steam is at 250 °C, the net fuel-to-electricity efficiency reaches 62.66 percent. The incremental low temperature heat to electric efficiency achieves 48.92 percent. **Chenhua Gou, Ruixian Cai and Guoqiang Zhang, *Applied Thermal Engineering*, Volume 26, Issues 17-18, Pages 2228-2235, Available online May 12, 2006, doi:10.1016/j.applthermaleng.2006.03.012, <http://www.sciencedirect.com/science/article/B6V1Y-4JXY7DS-3/2/5037b18bdb00b259aa59544013e90afa>.** (Subscription may be required.)

“Evaluation of reaction variables in the dissolution of serpentine for mineral carbonation.” The sequestration of CO₂ through the employment of magnesium silicates, olivine and serpentine, is beyond the proof of concept stage. Serpentine has been chosen as the feedstock mineral due to its abundance and availability. Although the reactivity of olivine is greater than that of serpentine, physical and chemical treatments have been shown to greatly increase the reactivity of serpentine. A sulfuric acid leaching stage has been shown to alleviate the rate limiting step of magnesium removal, thereby accelerating the overall carbonation process. Varying reaction conditions can significantly influence the results for the dissolution process with an extreme reaction environment providing desirable results. However, a more careful assessment of the reaction variables under milder conditions is needed for a better understanding of the reaction processes and potential pathways for high extraction yields under more modest conditions. Accordingly in this work, a statistical design of experiments was conducted to ascertain the effect of acid concentration, particle size and reaction time and temperature on the leaching of magnesium from serpentine using sulfuric acid. Results demonstrated that acid concentration provided primary control on the dissolution via the removal of water, which is closely correlated with the extraction of magnesium from serpentine. Particle comminution to a median size less than 163 micrometers remained an important consideration in increasing reactivity and liberating magnetite. Single variable experimentation demonstrated dissolution enhancements with increased reaction time and temperature. An increase in magnesium dissolution of 46 percent and 70 percent, over a baseline test, occurred for increased reaction time and temperature, respectively. **George Alexander, M. Mercedes Maroto-Valer and Parvana Gafarova-Aksoy, *Fuel*, June 30, 2006, doi:10.1016/j.fuel.2006.04.034, <http://www.sciencedirect.com/science/article/B6V3B-4K9C3BS-1/2/33bccd17edc2bd1ec3f5c04d4454f852>.** (Subscription may be required.)

“Biomass-fired cogeneration systems with CO₂ capture and storage.” In this study, the authors estimate and analyze the carbon dioxide (CO₂) mitigation costs of large-scale biomass-fired cogeneration technologies with CO₂ capture and storage. The CO₂ mitigation cost indicates the minimum economic incentive required (e.g. in the form of a carbon tax) to make the cost of a less carbon intensive system equal to the cost of a reference system. If carbon (as CO₂) is captured from biomass-fired energy systems, the systems could in principle be negative CO₂ emitting energy systems. CO₂ capture and storage from energy systems however, leads to reduced energy efficiency, higher investment costs, and increased costs of end products compared with energy systems in which CO₂ is vented. Here, we have analyzed biomass-fired cogeneration plants based on steam turbine technology (CHP-BST) and integrated gasification combined cycle technology (CHP-BIGCC). Three different scales were considered

to analyze the scale effects. Logging residues was assumed as biomass feedstock. Two methods were used to estimate and compare the CO₂ mitigation cost. In the first method, the cogenerated power was credited based on avoided power production in stand-alone plants and in the second method the same reference output was produced from all systems. Biomass-fired CHP-BIGCC with CO₂ capture and storage was found very energy and emission efficient and cost competitive compared with other conversion systems. **Sk Noim Uddin and Leonardo Barreto**, *Renewable Energy*, Available online June 8, 2006, [doi:10.1016/j.renene.2006.04.009](https://doi.org/10.1016/j.renene.2006.04.009), <http://www.sciencedirect.com/science/article/B6V4S-4K4PSKR-1/2/89bfff4c65cda3a64e2ad7244b8cd461>. (Subscription may be required.)

Terrestrial

September 2005

“Weyerhaeuser Joins Carbon-Market Alliance.” Weyerhaeuser has joined the Climate, Community and Biodiversity Alliance (CCBA) “as another way to help promote responsible forest management.” The primary goal of the CCBA is to create a set of standards for evaluating projects that will help mitigate climate change, while benefiting local communities and protecting or restoring biodiversity. In addition to Weyerhaeuser, the members of the CCBA are Conservation International, The Nature Conservancy, Pelangi, the Hamburg Institute of International Economics, British Petroleum, GFA Terra, Intel and SC Johnson. *GreenBiz.com*, August 18, 2005, <http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=16208>

“Trees don't suck up carbon dioxide as hoped.” Swiss scientists have found that a large patch of deciduous forest near Basel in Switzerland, which has been artificially sprayed with excess carbon dioxide for years, has shown no increase in growth rate compared to other similar stands. *Nature*, August 25, 2005, <http://www.bioedonline.org/news/news.cfm?art=1985>

October 2005

“Forests 'may absorb less CO₂ than thought'.” Due to rising carbon dioxide levels, forests may not be able to slow down global warming as effectively as previously thought, according to a study by a team of UK based scientists from the Lancaster Environment Centre. Says Dr. James Heath of Lancaster University, “This is the first study using a wide range of tree species to show that, while trees may take up more CO₂ as CO₂ levels in the atmosphere rise, less may end up being stored in the soil.” It was assumed that under higher CO₂ conditions the trees would grow faster and release more carbon into the soil via the roots and that therefore, more carbon would be retained in the soil. The experiment showed that this may not be the case, because at increased CO₂ concentrations more of the extra carbon transferred to the soil by the tree roots was simply released back into the atmosphere through the respiration of soil micro-organisms. *Press Association*, September 9, 2005, <http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=16392>. For the original article, see “Rising Atmospheric CO₂ Reduces Sequestration of Root-Derived Soil Carbon,” *Science*, September 9, 2005, <http://www.sciencemag.org/content/vol309/issue5741/index.shtml> (subscription required)

“Vicious Circle Of CO₂ Emissions Is Speeding Up Climate Change.” A new study finds that, since 1978, the soil of Britain has released an extra 13 million tons of carbon dioxide a year, which is more than the 12.7 million tons a year saved by cleaning up industrial pollution during that period. Scientists previously thought the soil could be a major sink for about a quarter of the industrial CO₂ emissions, but the latest findings suggest that in a warmer world the soil will actually become a new source of the greenhouse gas. “Our findings suggest that the soil part of the equation is scarier than we thought. It means we've got 25 percent more carbon to think about,” said Guy Kirk of the National Soil Resources Institute at Cranfield University, who led the study. *The Independent* (London), September 8, 2005,

<http://www.wbcso.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=16394>. Also see, "Loss of soil carbon will speed global warming," *Guardian* (UK), September 8, 2005, http://www.guardian.co.uk/uk_news/story/0,3604,1565041,00.html

"CO₂ not certain to counter climate change." The world cannot count on the "fertilizing" effects of carbon dioxide to counteract the adverse impact of global warming on crop yields, according to a paper presented at the British Association Science Festival. Scientists have simulated in open fields the effects of the atmospheric changes expected to take place over the next 50 years - and discovered the benefits predicted from previous greenhouse experiments do not materialize. Steve Long, a crop scientist at the University of Illinois, told the festival in Dublin: "Current projections of global food supply under climatic and atmospheric change are likely to be very optimistic." *Financial Times*, September 6, 2005, <http://www.climateark.org/articles/reader.asp?linkid=45888>

"Tahoe National Forest Hosts Groundbreaking Climate Change Research." Article highlights research to find accurate and cost-effective ways to measure and monitor forest carbon storage (carbon sequestration). Currently underway on public lands in the North Yuba River area, the research project is a collaboration of eight private and public organizations, including the U.S. Department of Energy who is funding 80 percent of the research. The project began in July 2005 and data collection should be finished by December 2005. According to the article, forests around the globe may be able to provide carbon credits to nations and industries seeking to offset carbon dioxide emissions through forest conservation. *YubaNet.com*, September 14, 2005, http://www.yubanet.com/artman/publish/article_25085.shtml

"Rhizotron sets MTU apart." The U.S. Forest Service is building a 75-foot underground research tunnel at Michigan Tech University. Known as the Rhizotron, the tunnel will be used for research on roots and carbon sequestration. The tunnel will feature 24 removable windows so that testing may be done at the root level. The main goal of the tunnel and its overall purpose is to research more about carbon sequestration and how to implement it in such a way as to slow the process of global warming. The objective is to discover which plant species favor sequestration. *Michigan Tech University Online Lode*, September 7, 2005, <http://www.mtulode.com/index.php?issuedate=2005-09-07§ion=12&artid=4519>

November 2005

"Growers Can Profit From Parking Carbon on Farm." Article highlights "carbon parking" on agricultural lands in the Western U.S. Karl Kupers, a Washington farmer, is already selling carbon credits from his conservation-tillage (CT) wheat field. Kupers and a group of partners formed the Pacific Northwest Direct Seed Association and entered a 10-year contract with Louisiana-based Entergy Corporation. Entergy gets credit for carbon-dioxide-emissions reductions achieved by the farmers to offset the carbon dioxide emissions from the company's power plants in the United States. The project reduces carbon dioxide emissions 30,000 tons over a 10-year period, according to the contract. In addition to carbon parking potential, CT presents a spectrum of benefits to farmers - including savings in expenditures for weed control, labor and irrigation, says University of California Cooperative Extension cropping systems specialist Jeff Mitchell. *AScribe*, October 3, 2005, <http://newswire.ascribe.org/cgi-bin/ behold.pl?ascribeid=20051003.085116&time=10%2013%20PDT&year=2005&public=0>

December 2005

"Carbon sequestration potential estimates with changes in land use and tillage practice in Ohio, USA." This study estimates the carbon sequestration potential of soil in Ohio for two scenarios: (1) with reforestation of both current cropland and grassland where soil organic carbon (SOC) pools are less than the baseline SOC pool under current forest; and (2) with the adoption of no-till (NT) on all current cropland. *Agriculture, Ecosystems & Environment*, Volume 111, Issues 1-4 (December 1, 2005), <http://www.sciencedirect.com/science/journal/01678809> (subscription required)

“Carbon Sequestration in Arable Soils is Likely to Increase Nitrous Oxide Emissions, Offsetting Reductions in Climate Radiative Forcing.” The authors conducted simulations with a biogeochemical model to evaluate the impact of different cropland management strategies on the coupled cycles of C and N, with special emphasis on C-sequestration and emission of the greenhouse gases methane (CH₄) and nitrous oxide (N₂O). Reduced tillage, enhanced crop residue incorporation, and farmyard manure application each increased soil C-sequestration, increased N₂O emissions, and had little effect on CH₄ uptake. Over 20 years, increases in N₂O emissions, which were converted into CO₂-equivalent emissions with 100-year global warming potential multipliers, offset 75–310% of the carbon sequestered, depending on the scenario. *Climatic Change* (October 2005) 72, Number 3, <http://www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s10584-005-6791-5> (subscription required)

“Forest soils and carbon sequestration.” This study investigates soil carbon sequestration in boreal and temperate forests and the potential to ameliorate changes in atmospheric chemistry. *Forest Ecology and Management*, Volume 220, Issues 1-3 (December 10, 2005), <http://www.sciencedirect.com/science/journal/03781127> (subscription required)

January 2006

“Trading Water for Carbon with Biological Carbon Sequestration,” Carbon sequestration strategies highlight tree plantations without considering their full environmental consequences. [The Authors] combined field research, synthesis of more than 600 observations, and climate and economic modeling to document substantial losses in stream flow, and increased soil salinization and acidification, with afforestation. Plantations decreased stream flow by 227 millimeters per year globally (52 percent), with 13 percent of streams drying completely for at least 1 year. Regional modeling of US plantation scenarios suggests that climate feedbacks are unlikely to offset such water losses and could exacerbate them. Plantations can help control groundwater recharge and upwelling but reduce stream flow and salinize and acidify some soils. *Science*, December 23, 2005. Vol. 310. no. 5756, pp. 1944 – 1947. DOI: 10.1126/science.1119282. <http://www.sciencemag.org/cgi/content/full/310/5756/1944>

“Climate change impacts on agriculture and soil carbon sequestration potential in the Huang-Hai Plain of China.” For thousands of years, the Huang-Hai Plain in northeast China has been one of the most productive agricultural regions of the country. The future of this region will be determined in large part by how global climatic changes impact regional conditions and by actions taken to mitigate or adapt to climate change impacts. One potential mitigation strategy is to promote management practices that have the potential to sequester carbon in the soils. The Intergovernmental Panel on Climate Change (IPCC) estimates that 40 Pg (petagrams) of carbon could be sequestered in cropland soils worldwide over the next several decades; however, changes in global climate may impact this potential. [The authors] assess the potential for soil carbon sequestration with conversion of a conventional till (CT) continuous wheat system to a wheat–corn double cropping system and by implementing no till (NT) management for both continuous wheat and wheat–corn systems. To assess the influence of these management practices under a changing climate, [the authors] use two climate change scenarios (A2 and B2) at two time periods in the EPIC agro-ecosystem simulation model. The applied climate change scenarios are from the HadCM3 global climate model for the periods 2015–2045 and 2070–2099 which projects consistent increases in temperature and precipitation of greater than 5 °C and up to 300 mm by 2099. An increase in the variability of temperature is also projected and is, accordingly, applied in the simulations. The EPIC model indicates that winter wheat yields would increase on average by 0.2 Mg ha⁻¹ in the earlier period and by 0.8 Mg ha⁻¹ in the later period due to warmer nighttime temperatures and higher precipitation. Simulated yields were not significantly affected by imposed changes in crop management. Simulated soil organic carbon content was higher under both NT management and double cropping than under CT continuous wheat. The simulated changes in management were a more important factor in SOC changes than the scenario of climate change. Soil carbon sequestration rates for

continuous wheat systems were increased by an average of 0.4 Mg ha⁻¹ year⁻¹ by NT in the earlier period and by 0.2 Mg ha⁻¹ year⁻¹ in the later period. With wheat–corn double cropping, NT increased sequestration rates by 0.8 and 0.4 Mg ha⁻¹ year⁻¹ for the earlier and later periods, respectively. The total carbon offset due to a shift from CT to NT under continuous wheat over 16 million hectares in the Huang-Hai Plain is projected to reach 240 Tg carbon in the earlier period and 180 Tg carbon in the later period. Corresponding carbon offsets for wheat–corn cropping are 675–495 Tg carbon. *Agriculture, Ecosystems & Environment*, Available online December 15, 2005, <http://www.sciencedirect.com/science/article/B6T3Y-4HTCT7T-1/2/c4c308e79e3b7a5200b5bf9c7e21249d> (subscription may be required)

“Slow growth rates of Amazonian trees: Consequences for carbon cycling.” Quantifying age structure and tree growth rate of Amazonian forests is essential for understanding their role in the carbon cycle. Here, [the authors] use radiocarbon dating and direct measurement of diameter increment to document unexpectedly slow growth rates for trees from three locations spanning the Brazilian Amazon basin. Central Amazon trees, averaging only 1 mm/year diameter increment, grow half as fast as those from areas with more seasonal rainfall to the east and west. Slow growth rates mean that trees can attain great ages; across our sites [the authors] estimate 17-50 percent of trees with diameter >10 cm have ages exceeding 300 years. Whereas a few emergent trees that make up a large portion of the biomass grow faster, small trees that are more abundant grow slowly and attain ages of hundreds of years. The mean age of carbon in living trees (60-110 years) is within the range of or slightly longer than the mean residence time calculated from carbon inventory divided by annual carbon allocation to wood growth (40-100 years). Faster carbon turnover is observed in stands with overall higher rates of diameter increment and a larger fraction of the biomass in large, fast-growing trees. As a consequence, forests can recover biomass relatively quickly after disturbance, whereas recovering species composition may take many centuries. Carbon cycle models that apply a single turnover time for carbon in forest biomass do not account for variations in life strategy and therefore may overestimate the carbon sequestration potential of Amazon forests. *Proceedings of the National Academy of Sciences*, Published online before print December 9, 2005, 10.1073/pnas.0505966102. http://www.pnas.org/cgi/content/abstract/0505966102v1?maxtoshow=&HITS=10&hits=10&RESULTFOR=MAT=&fulltext=%22Carbon+Sequestration%22&searchid=1134161639062_7353&stored_search=&FIRSIINDEX=0&sortspec=date&journalcode=pnas

February 2006

“Methane emissions from terrestrial plants under aerobic conditions.” This paper demonstrates by using stable carbon isotopes that methane is readily formed *in situ* in terrestrial plants under oxic (meaning, in the presence of oxygen) conditions by a process that was previously unrecognized. Significant methane emissions from both intact plants and detached leaves were observed during incubation experiments in the laboratory and in the field. If our measurements are typical for short-lived biomass and scaled on a global basis, we estimate a methane source strength of 62–236 teragrams (Tg) per year for living plants and 1–7 Tg per year for plant litter (1 Tg = 10¹² g). The authors suggest that this newly identified source may have important implications for the global methane budget and may call for a reconsideration of the role of natural methane sources in past climate change. (See Science section of this newsletter for related news articles **“Experts Urge Caution in Application of New Methane Studies”** and **“Global Warming: Plants Are Not To Blame,”**) *Nature* 439, Pages 187-191, January 12, 2006, doi:10.1038/nature04420. <http://www.nature.com/nature/journal/v439/n7073/abs/nature04420.html> (Subscription may be required.)

“Biomass equations and carbon content of aboveground leafless biomass of hybrid poplar in Coastal British Columbia,” Hybrid poplar plantations offer opportunities for enhancing carbon sinks, but accurate assignment of carbon credits requires accurate estimation of the amount of carbon stored in poplar biomass. The authors present individual-tree bole and branch biomass equations derived for

Populus trichocarpa Torr. and Gray × *P. deltoides* Marsh. hybrids from plantations in coastal British Columbia, Canada. Trees ranged in age from 4 to 13 years and were planted at a density of 1111 stems per hectare (ha^{-1}). Equations were applied to similar short-rotation intensive-culture plantations near or at rotation age to derive estimates of aboveground leafless biomass production and amount of carbon sequestered. After 12 years, predicted aboveground leafless biomass accumulation ranged from 9.2 to 13.6 megagrams per hectare per year ($\text{Mg ha}^{-1} \text{ year}^{-1}$); predicted bole biomass accumulation ranged from 7.5 to 11.3 $\text{Mg ha}^{-1} \text{ year}^{-1}$. Total carbon in aboveground leafless biomass at age 12 ranged from 51.2 to 75.7 Mg ha^{-1} . Three of the stands reached 14 years of age prior to harvest. Predicted carbon content of aboveground leafless biomass at 14 years of age ranged from 73.7 to 88.7 Mg ha^{-1} . *Forest Ecology and Management*, Available online January 4, 2006, doi:10.1016/j.foreco.2005.11.009, <http://www.sciencedirect.com/science/article/B6T6X-4HYMW3C-2/2/d6d9adb89f29e38474675a41a31c51a6> (Subscription may be required.)

Ocean

September 2005

“Process design of a new injection method of liquid CO₂ at the intermediate depths in the ocean using a static mixer.” A static mixer invention for CO₂ injection into ocean water is proposed. By controlling CO₂ drop size and harnessing the forces of buoyancy, the mixer enables complete CO₂ dissolution before any evaporation occurs. The mixer uses very little energy. *Fuel Processing Technology*, Volume 86, Issues 14-15, October 2005, Pages 1667-1678, <http://www.sciencedirect.com/science/journal/03783820> (subscription required)

October 2005

“Climate change will affect carbon sequestration in oceans, model shows.” An Earth System model developed by researchers at the University of Illinois at Urbana-Champaign indicates that the best location to store carbon dioxide in the deep ocean will change with climate change. “Through a number of physical and chemical interactive mechanisms, the ocean circulation could change and affect the retention time of carbon dioxide injected into the deep ocean, thereby indirectly altering oceanic carbon storage and atmospheric carbon dioxide concentration,” said Atul Jain, a professor of atmospheric sciences. “Where the carbon dioxide is injected turns out to be a very important issue.” *EurekAlert*, September 7, 2005, http://www.eurekalert.org/pub_releases/2005-09/uoia-ccw090705.php

November 2005

“Global warming could threaten ocean life.” The findings of a new study reveal that coral and plankton in the waters around the southern polar region are far more at risk to carbon dioxide emissions than previously thought. The international project measured the chemical changes in the Southern Ocean caused by the absorption of CO₂. Research scientist Gian-Kasper Plattner found the resulting increased acidity in these waters dissolves calcium carbonates that corals and plankton use to make protective external skeletons. Similar experiments carried out in warmer seas projected that corals and plankton would not be seriously affected for centuries. But as colder waters contain less calcium carbonates than warmer areas, the new Ocean Carbonate Cycle Inter-Comparison Project (OCMIP) results indicate that there could be severe consequences for these organisms within 50-100 years. *swissinfo*, September 29, 2005, <http://www.swissinfo.org/sen/swissinfo.html?siteSect=105&sid=6126393>

“Scientists Investigate Ocean’s Role in Carbon Cycle, Global Warming.” Article highlights research by a team of scientists trying to improve the current understanding of the ocean’s role in transferring carbon dioxide from the surface to the deep sea. Led by University of Rhode Island Professor of

Oceanography S. Bradley Moran, the scientists have completed their second research cruise of 2005 to study the carbon cycle. "How much is sinking? What are the controlling mechanisms? Those are our most basic questions, and there's an ongoing debate in the scientific community about it," said Moran. Using particle-collecting sediment traps and measurements of the naturally occurring radioactive isotope thorium-234, the researchers have collected data from the Arctic Ocean, Mediterranean Sea, and North Atlantic Ocean to compare the magnitude of sinking carbon in different locations and at different times of the year. According to Moran, the data so far suggests that there are interesting differences from season to season and from place to place. The next step in the researchers' project is to determine what mechanisms control the sinking carbon. They will study how fast and how far the carbon sinks, and the extent to which it eventually returns to the surface or remains in the bottom waters and sediments. *Newswise*, October 3, 2005, <http://www.newswise.com/articles/view/515047/>

"North Sea Efficient Sink For Carbon Dioxide." Dutch-sponsored researcher Yann Bozec calculated that coastal seas such as the North Sea remove about three times as much carbon dioxide from the atmosphere than would be expected on the basis of their small surface area. This article highlights results from four expeditions, each of one-month duration, with the oceanographic research vessel 'Pelagia' from the Royal Netherlands Institute for Sea Research (NIOZ). The goal of the research was to produce a data set that could shed light on the concentrations and transport cycle of CO₂ in the North Sea. *Science Daily*, October 12, 2005, <http://www.sciencedaily.com/releases/2005/10/051011065902.htm>

Planktos to conduct commercial scale ocean sequestration pilot project. According to a press release, Planktos Inc. is planning to conduct a series of commercial scale pilot projects designed to sequester atmospheric CO₂ via plankton. This will be done by mimicking nature via the addition and replenishment of natural iron nutrients to stimulate phytoplankton productivity and sequestration of CO₂ from the atmosphere. Diatom Corporation will market ocean biomass carbon credits derived from the restoration of plankton productivity produced by Planktos. These carbon credits will help satisfy international agreements (such as the Kyoto Accord), domestic U.S. programs (such as Department of Energy's Voluntary Reporting Guidelines), and various state policies (such as California's climate change laws) that encourage mitigation for CO₂ emissions, says the press release. "Solar Subsidiary Planktos Commences Operations," *BusinessWire*, October 6, 2005, http://home.businesswire.com/portal/site/google/index.jsp?ndmViewId=news_view&newsId=20051006005939&newsLang=en

December 2005

"Asleep in the deep: Model helps assess ocean-injection strategy for combating greenhouse effect." Highlights a theoretical model developed by University of Michigan researcher Youxue Zhang that can be used to explore the fate of CO₂ injected into oceans under various temperature and pressure conditions. Zhang's model shows that liquid CO₂ would have to be injected to a depth of at least 800 meters (about a half mile) and possibly as much as 3,000 meters (nearly two miles) to keep it from escaping. "Droplets injected to a depth of 800 meters will rise, but if they are small enough they should dissolve completely before reaching the liquid-gas transition depth – assuming everything works perfectly," said Zhang, a professor of geological sciences. However, at a high injection rate, seawater full of CO₂ droplets would have an average density smaller than that of surrounding seawater, creating conditions that could lead to a rapidly-rising plume. *University of Michigan News Service*, November 3, 2005, <http://www.umich.edu/news/index.html?Releases/2005/Nov05/r110305>

"Dissolution mechanisms of CO₂ hydrate droplets in deep seawaters." Carbon dioxide dissolution at intermediate ocean depths was studied using physical and mass transfer models. *Energy Conversion and Management*, Volume 47, Issue 5 (March 2006), <http://www.sciencedirect.com/science/journal/01968904> (subscription required)

“Effects of Mixing Functions of Static Mixers on the Formation of CO₂ Hydrate from the Two-Phase Flow of Liquid CO₂ and Water.” Formation experiments of CO₂ hydrate from the two-phase flow of liquid CO₂ and water were carried out using static mixers with different types of mixing elements to elucidate the effects of mixing functions of the static mixer on CO₂ hydrate formation. The observed behaviors of CO₂ hydrate formation were classified into six patterns and the formation mechanisms are discussed. *Energy Fuels*, 19 (6), 2364 -2370 (November 16, 2005), <http://pubs.acs.org/cgi-bin/abstract.cgi/enfuem/2005/19/i06/abs/ef0500843.html> (subscription required)

January 2006

“Monitoring the underground migration of sequestered carbon dioxide using Earth tides,” Reliable and cost effective monitoring techniques are required to ensure safe and effective geological sequestration of carbon dioxide (CO₂), one of the promising strategies for mitigating CO₂ emissions. This study proposes and examines a practical technique for monitoring the underground migration of CO₂ using Earth tides. The gravitational attraction of the bodies in the solar system causes tidal deformation of the Earth, and the pore pressure of the geological reservoirs changes in response to such tidal phenomena. With the pressure analysis algorithm adopted in this study, pressure fluctuations can be retrieved from the continuous pressure data obtained at the monitoring well. The diurnal and semi-diurnal features of the pressure fluctuations can be explained by the Earth tides, and it is possible to estimate the poroelastic parameter [χ], a function of the CO₂ saturation in the pore space. By analyzing the [χ] profile, CO₂ migration can be monitored with a reasonable degree of accuracy. *Energy Conversion and Management*, In Press, Corrected Proof, Available online 27 December 2005, <http://www.sciencedirect.com/science/article/B6V2P-4HWXNVH-5/2/54d698703c7f2f9c52bc533f63a27290> (subscription may be required)

February 2006

“Determination of gas bubble fractionation rates in the deep ocean by laser Raman spectroscopy,” A new deep-sea laser Raman spectrometer (DORISS—Deep Ocean Raman In Situ Spectrometer) is used to observe the preferential dissolution of CO₂ into seawater from a 50:50 CO₂–N₂ gas mixture in a set of experiments that test a proposed method of CO₂ sequestration in the deep ocean. In a first set of experiments performed at 300 meters (m) depth, an open-bottomed 1000 cubic centimeters (cm³) cube was used to contain the gas mixture; and in a second set of experiments a 2.5 cm³ funnel was used to hold a bubble of the gas mixture in front of the sampling optic. By observing the changing ratios of the CO₂ and N₂ Raman bands we were able to determine the gas flux and the mass transfer coefficient at 300 meters depth and compare them to theoretical calculations for air–sea gas exchange. Although each experiment had a different configuration, comparable results were obtained. As expected, the ratio of CO₂ to N₂ drops off at an exponential rate as CO₂ is preferentially dissolved in seawater. In fitting the data with theoretical gas flux calculations, the boundary layer thickness was determined to be ~ 42 micrometers (μ m) for the gas cube, and ~165 μ m for the gas funnel reflecting different boundary layer turbulence. The mass transfer coefficients for CO₂ are $k_L = 2.82 \times 10^{-5}$ m/s for the gas cube experiment, and $k_L = 7.98 \times 10^{-6}$ m/s for the gas funnel experiment. *Marine Chemistry*, Available online January 18, 2006, doi:10.1016/j.marchem.2004.10.006, <http://www.sciencedirect.com/science/article/B6VC2-4J2M0N6-3/2/e74e856a11f958bb87cf9a0081543084> (Subscription may be required.)

“An improved model for the calculation of CO₂ solubility in aqueous solutions containing Na⁺, K⁺, Ca²⁺, Mg²⁺, Cl⁻, and SO₄²⁻.” An improved model is presented for the calculation of the solubility of carbon dioxide (CO₂) in aqueous solutions containing Na⁺, K⁺, Ca²⁺, Mg²⁺, Cl⁻, and SO₄²⁻ in a wide temperature–pressure–ionic strength range (from 273 to 533 K, from 0 to 2000 bar, and from 0 to 4.5 molality of salts) with experimental accuracy. The improvements over the previously published model include: (1) By developing a non-iterative equation to replace the original equation of state in the

calculation of CO₂ fugacity coefficients, the new model is at least twenty times computationally faster and can be easily adapted to numerical reaction-flow simulator for such applications as CO₂ sequestration and (2) By fitting to the new solubility data, the new model improved the accuracy below 288 K from 6 percent to about 3 percent of uncertainty but still retains the high accuracy of the original model above 288 K. The authors comprehensively evaluate all experimental CO₂ solubility data. Compared with these data, this model not only reproduces all the reliable data used for the parameterization but also predicts the data that were not used in the parameterization. In order to facilitate the application to CO₂ sequestration, we also predicted CO₂ solubility in seawater at two-phase coexistence (vapor–liquid or liquid–liquid) and at three-phase coexistence (CO₂ hydrate–liquid water–vapor CO₂ [or liquid CO₂]). The improved model is programmed and can be downloaded from the website <http://www.geochem-model.org/programs.htm>. *Marine Chemistry*, Volume 98, Issues 2-4, February 1, 2006, Pages 131-139. <http://www.sciencedirect.com/science/article/B6VC2-4H8MP5G-1/2/4fadd1f41afa32ef980e0b2192ea406> (Subscription may be required.)

Terrestrial/Ocean

March 2006

“An Overview of Terrestrial Sequestration of Carbon Dioxide: the United States Department of Energy's Fossil Energy R&D Program.” The US Department of Energy (DOE) is sponsoring the development of new technologies that can provide energy and promote economic prosperity while reducing greenhouse gas (GHG) emissions. One option that can contribute to achieving this goal is the capture and sequestration of carbon dioxide in geologic formations. An alternative approach is carbon sequestration in terrestrial ecosystems through natural processes. Enhancing such natural pools (known as natural sequestration) can make a significant contribution to CO₂ management strategies with the potential to sequester about 290 teragrams of carbon per year (Tg C/y) in US soils. In addition to soils, there is also a large potential for carbon sequestration in above and belowground biomass in forest ecosystems. A major area of interest to DOE's Fossil Energy Program is reclaimed mined lands, of which there may be 0.63x10⁶ hectares in the US. These areas are essentially devoid of soil carbon; therefore, they provide an excellent opportunity to sequester carbon in both soils and vegetation. Measurement of carbon in these ecosystems requires the development of new technology and protocols that are accurate and economically viable. Field demonstrations are needed to accurately determine carbon sequestration potential and to demonstrate the ecological and aesthetic benefits in improved soil and water quality, increased biodiversity, and restored ecosystems. The DOE's research program in natural sequestration highlights fundamental and applied studies, such as the development of measurement, monitoring, and verification technologies and protocols and field tests aimed at developing techniques for maximizing the productivity of hitherto infertile soils and degraded ecosystems. Authors are John T. Litynski, Scott M. Klara, Howard G. McIlvried, and Rameshwar D. Srivastava. *Climatic Change*, published online January 5, 2006, doi:10.1007/s10584-005-6960-6, [http://springerlink.metapress.com/\(rlg5uz45m0dwo5vfavqcvq45\)/app/home/contribution.asp?referrer=parent&backto=issue,5,11;journal,1,215;linkingpublicationresults,1:100247,1](http://springerlink.metapress.com/(rlg5uz45m0dwo5vfavqcvq45)/app/home/contribution.asp?referrer=parent&backto=issue,5,11;journal,1,215;linkingpublicationresults,1:100247,1). (Subscription may be required.)

“Universal scaling of respiratory metabolism, size and nitrogen in plants,” The scaling of respiratory metabolism to body size in animals is considered to be a fundamental law of nature, and there is substantial evidence for an approximate three quarter-power relation. Studies suggest that plant respiratory metabolism also scales as the three quarter-power of mass, and that higher plant and animal scaling follow similar rules owing to the predominance of fractal-like transport networks and associated allometric scaling. In this article, using data obtained from about 500 laboratory and field-grown plants from 43 species and four experiments, the authors show that whole-plant respiration rate scales approximately isometrically (scaling exponent approximately 1) with total plant mass in individual experiments and has no common relation across all data. Moreover, consistent with theories about

biochemically based physiological scaling, isometric scaling of whole-plant respiration rate to total nitrogen content is observed within and across all data sets, with a single relation common to all data. This isometric scaling is unaffected by growth conditions including variation in light, nitrogen availability, temperature and atmospheric carbon dioxide concentration, and is similar within or among species or functional groups. These findings suggest that plants and animals follow different metabolic scaling relations, driven by distinct mechanisms. January 26, 2006, *Nature*, 439, 457-461, doi:10.1038/nature04282, <http://www.nature.com/nature/journal/v439/n7075/full/nature04282.html>. (Subscription may be required.)

“Carbon sequestration potential by afforestation of marginal agricultural land in the Midwestern US,” Carbon sequestration has been well recognized as a viable option to slow the rise in atmospheric greenhouse gas concentration. The main goals of this study were to assess the carbon sequestration potential (CSP) by afforestation of marginal agricultural land (MagLand) and to identify hotspots for potential afforestation activities in the US Midwest region (Michigan, Indiana, Ohio, Kentucky, West Virginia, Pennsylvania and Maryland). The 1992 USGS National Land Cover Dataset and the State Soil Geographic (STATSGO) database were used to determine MagLand. Two forest types (coniferous and deciduous) and two management practices (short-rotation versus permanent forest) were combined to form four afforestation scenarios. Simulation models were employed to predict changes in four carbon pools: aboveground biomass, roots, forest floor, and soil organic carbon (SOC). A scenario-generating tool was developed to detect the hotspots. The authors estimated that there was a total of 6.5 million hectares (Mha) MagLand available in the US Midwest region, which accounts for approximately 24 percent of the regional total agricultural land. The CSP capacity was predicted to be 508–540 teragrams of carbon (Tg C) over 20 years and 1018–1080 Tg C over 50 years. The results indicate that afforestation of MagLand could offset 6–8 percent of current carbon dioxide emissions by combustion of fossil fuel in the region. This analysis showed only slight differences in carbon sequestration between forest types or between short-rotation and permanent forest scenarios. Note that this calculation assumed that all suitable MagLand in the US Midwest region was converted to forest and that “best carbon management” was adopted. The actual CSP could be less if the economical and social factors are taken into account. The most preferred locations for implementing the afforestation strategy were found to be concentrated along a west-east axis across the southern parts of Indiana, Ohio, and Pennsylvania, as well as in an area covering southern Michigan and northern parts of Indiana and Ohio. Overall, we conclude that afforestation of MagLand in the Midwest US region offers great potential for carbon sequestration. Future studies are needed to evaluate its economic feasibility, social acceptability, and operation capability. *Forest Ecology and Management*, Volume 223, Issues 1-3, March 1, 2006, Pages 415-427, Available online January 25, 2006. doi:10.1016/j.foreco.2005.12.044, <http://www.sciencedirect.com/science/article/B6T6X-4J4404J-4/2/fe7fd2f79cd804a18cb6b9bf21618618> (Subscription may be required.)

“Carbon sequestration in semi-arid rangelands: Comparison of *Pinus ponderosa* plantations and grazing exclusion in NW Patagonia,” The large global extension of arid and semi-arid regions together with their widespread degradation give these areas a high potential to sequester carbon. The authors explored the possibilities of semi-arid ecosystems to sequester carbon by means of rangeland exclusion and afforestation with *Pinus ponderosa* in northwestern Patagonia (Argentina). The authors sampled all pools where organic carbon accumulates in a network of five trios of adjacent grazed, non-grazed and afforested stands (age: 12–25 years, density: 605–1052 trees per hectare). After 15 years since trees were planted, afforestation added approximately 50 percent more carbon to the initial ecosystem carbon pool, with annual sequestration rate ranging 0.5–3.3 megagrams of carbon per hectare per year (Mg C ha⁻¹ year⁻¹). Carbon gains in afforested stands were higher above than below-ground (150 percent vs. 32 percent). Root biomass differences (374 percent more in afforested vs. grazed stands, probability (p) = 0.0011) explained below-ground carbon contrasts whereas soil organic carbon showed no differences with afforestation. By contrast, grazing exclusions did not result in significant changes in the total carbon storage in comparison with the adjacent grazed stands (p=0.42) suggesting a slow ecosystem recovery in the time frame of this study (approximately 15 years of exclusion). Nevertheless,

higher litter amount was found in the former (+53 percent, $p=0.07$). Neither, soil organic carbon nor root carbon showed significant differences between grazed and non-grazed conditions. Considering that more than 1.1 millions of hectares of the studied ecosystems are highly degraded and suitable for tree planting, afforesting this area could result in a carbon sequestration rate of 1.7 teragrams of carbon per year (Tg C year^{-1}), almost 6 percent of the current fossil fuel emissions of Argentina; however environmental consequences which could emerge from this deep land use shift must be taken into account when afforestation program are being designed. *Journal of Arid Environments*, January 26, 2006. doi:10.1016/j.jaridenv.2005.12.008, <http://www.sciencedirect.com/science/article/B6WH9-4J4B9BJ-1/2/49f030bd625b10e468f691344865bdd6>. (Subscription may be required.)

April 2006

“Global potential for carbon sequestration: Geographical distribution, country risk and policy implications.” The authors have provided a framework for identifying least-cost sites for afforestation and reforestation and deriving carbon sequestration cost curves at a global level in a scenario of limited information. Special attention is given to country risk in developing countries and the sensitivity to spatial datasets. The authors’ model results suggest that within 20 years and considering a carbon price of \$50 per ton of carbon, tree-planting activities could offset 1 year of global carbon emissions in the energy sector. However, if the authors account for country risk considerations—associated with political, economic and financial risks—carbon sequestration is reduced by approximately 60 percent. With respect to the geography of supply, illustrated by grid-scale maps, the authors find that most least-cost sites are located in regions of developing countries such as the Sub-Sahara, Southeast Brazil and Southeast Asia. *Ecological Economics*, Available online March 9, 2006, doi:10.1016/j.ecolecon.2005.12.015, <http://www.sciencedirect.com/science/article/B6VDY-4JF97MF-2/2/6cb451553cd7200978374c6990add65>. (Subscription may be required.)

“Temperature sensitivity of soil carbon decomposition and feedbacks to climate change.” Significantly more carbon is stored in the world's soils—including peatlands, wetlands and permafrost—than is present in the atmosphere. Disagreement exists, however, regarding the effects of climate change on global soil carbon stocks. If carbon stored belowground is transferred to the atmosphere by a warming-induced acceleration of its decomposition, a positive feedback to climate change would occur. Conversely, if increases of plant-derived carbon inputs to soils exceed increases in decomposition, the feedback would be negative. Despite much research, a consensus has not yet emerged on the temperature sensitivity of soil carbon decomposition. Unraveling the feedback effect is particularly difficult, because the diverse soil organic compounds exhibit a wide range of kinetic properties, which determine the intrinsic temperature sensitivity of their decomposition. Moreover, several environmental constraints obscure the intrinsic temperature sensitivity of substrate decomposition, causing lower observed 'apparent' temperature sensitivity, and these constraints may, themselves, be sensitive to climate. *Nature*, Vol. 440, Pages 165-173, March 9, 2006, doi:10.1038/nature04514, <http://www.nature.com/nature/journal/v440/n7081/abs/nature04514.html>. (Subscription may be required.)

May 2006

“Nitrogen limitation constrains sustainability of ecosystem response to CO₂.” Enhanced plant biomass accumulation in response to elevated atmospheric CO₂ concentration could dampen the future rate of increase in CO₂ levels and associated climate warming. However, it is unknown whether CO₂-induced stimulation of plant growth and biomass accumulation will be sustained or whether limited nitrogen (N) availability constrains greater plant growth in a CO₂-enriched world. Here the authors show, after a six-year field study of perennial grassland species grown under ambient and elevated levels of CO₂ and N, that low availability of N progressively suppresses the positive response of plant biomass to elevated CO₂. Initially, the stimulation of total plant biomass by elevated CO₂ was no greater at enriched than at ambient N supply. After four to six years, however, elevated CO₂ stimulated plant biomass much

less under ambient than enriched N supply. This response was consistent with the temporally divergent effects of elevated CO₂ on soil and plant N dynamics at differing levels of N supply. The authors results indicate that variability in availability of soil N and deposition of atmospheric N are both likely to influence the response of plant biomass accumulation to elevated atmospheric CO₂. Given that limitations to productivity resulting from the insufficient availability of N are widespread in both unmanaged and managed vegetation, soil N supply is probably an important constraint on global terrestrial responses to elevated CO₂. doi:10.1038/nature04486. *Nature*, Volume 440, April 13, 2006, <http://www.nature.com/nature/journal/v440/n7086/full/nature04486.html>. (Subscription may be required.)

“Effect of sugarcane residue management (mulching versus burning) on organic matter in a clayey Oxisol from southern Brazil.” Changes in residue management may help sustain land productivity, and may have noticeable consequences in the global carbon budget when large areas are involved. The effects of sugarcane residue management on topsoil carbon were assessed in a clayey Oxisol of Brazil, largest world's producer of sugarcane. The carbon concentration of the whole soil and particle-size fractions were determined in a long-duration sugarcane plantation (50 years), with either a pre-harvest residue burning (BUR) or a 6-year green trash management (MUL, residue mulching). Soil carbon concentrations were greater in MUL than in BUR. The difference was significant at a 0–5 centimeters (cm) depth (25.2 versus 21.0 grams of carbon per kilogram (g C kg⁻¹)) but not at 5–10 cm (22.3 versus 20.5 g C kg⁻¹); nevertheless it was significant at 0–10 cm (23.7 versus 20.7 g C kg⁻¹). This difference resulted in carbon sequestration in MUL, which amounted to 0.65 megagrams of carbon per hectare per year (Mg C ha⁻¹ year⁻¹) at 0–10 cm depth and corresponded to 14 percent of aboveground residue carbon returned to the soil. Differences in soil carbon between MUL and BUR mainly affected the fraction <2 micrometers (μm). It was hypothesized that the preferential enrichment in fine fractions resulted in a long-term carbon storage. *Ecosystems & Environment*, Volume 115, Issues 1-4, July 2006, Pages 285-289, doi:10.1016/j.agee.2005.12.014, <http://www.sciencedirect.com/science/article/B6T3Y-4J8D8SX-2/2/9d55b66f54da3eacdf4a96c0e259cc9>. (Subscription may be required.)

“Maximizing the profitability of forestry projects under the Clean Development Mechanism using a forest management optimization model.” Forestry projects under the Clean Development Mechanism (CDM) may provide several benefits for developing countries. Under the current rules, these projects can participate in both timber and carbon markets. Thus, project developers need to know what the optimal forest management design would be to maximize their revenues according to timber and carbon market expectations while at the same time complying with international rules adopted for carbon sequestration projects under the CDM. The authors developed Carbomáx, a management optimization model that simulates forest growth under different forest management regimes (intensity and frequency of thinnings and rotation lengths). A genetic algorithm was used to find the management regime that maximizes the Annual Equivalent Value (AEV) of projects under different market scenarios. The authors tested their model under a wide variety of possible scenarios for forestry projects. Five tropical plantation species (*Alnus jorullensis*, *Cordia alliodora*, *Pinus patula*, *Cupressus lusitanica* and *Eucalyptus grandis*) were evaluated, at discount rates of 4, 7 and 10 percent, and certified emissions reduction (CER) prices of \$3, 7, 10 and 13. Temporary CERs (tCERs) and long-term CERs (lCERs) prices were considered in the evaluation and were calculated as a variable proportion of CER price. Results showed that optimal forest management is sensible to carbon and timber market conditions. Under each discount rate, as CER price increased, frequency and intensity of thinnings tended to decrease and optimal thinnings and rotation lengths tended to be reached at older ages. The largest AEV were obtained with discount rates of 10 percent, CER prices of 13 and rotation lengths of 40 years for all species. For those species with higher timber prices, thinnings tended to be more frequent and at early ages of the plantation. For all species optimal thinnings were found at 35 years of plantation age. tCERs was selected by the model as the best choice to maximize the profitability of the projects. *Forest Ecology and Management*, Volume 226, Issues 1-3, May 1, 2006, Pages 341-350. <http://www.sciencedirect.com/science/article/B6T6X-4JKRTP3-1/2/f43ae5203c557c774a943c6329dfa9d1>. (Subscription may be required.)

June 2006

"Do Recent Scientific Findings Undermine the Climate Benefits of Carbon Sequestration in Forests?: An Expert Review of Recent Studies on Methane Emissions and Water Tradeoffs." Two recent papers in the scientific literature have generated speculation regarding the benefits of terrestrial carbon sinks. One study, led by Frank Keppler from the Max Planck Institute found that plants emit significant amounts of methane, a potent greenhouse gas. Another study, led by Robert Jackson of Duke University found that forest plantations can reduce stream flow and increase salinization of soils more than previously thought. Some media and interested parties have speculated that this research calls into question the value of carbon sequestration from trees and plants as a climate change mitigation strategy. Others viewed this speculation as far overblown. What did the research say? What do scientific experts think about its significance? And should current policy be altered as a result? To answer these questions a group of experts gathered at Duke University. They assessed the science and its implications and came to the consensus discussed in this document. Nicholas Institute for Environmental Policy Solutions, Consensus from an Expert Roundtable held February 9, 2006 at Duke University, April 2006, <http://www.env.duke.edu/institute/methanewater.pdf>.

"Cost efficient rotation and tillage options to sequester carbon and mitigate GHG emissions from agriculture in Eastern Canada." The economic efficiency of cropping options to mitigate net greenhouse gas (GHG) emissions from agriculture in Eastern Canada was analyzed. Data on yield response to tillage (moldboard plow and chisel plow) and six-corn (*Zea mays* L.)-based rotations were obtained from a 20-year field experiment in Ontario. Budgets were constructed for each cropping system while GHG emissions were accounted for by soil carbon measurements and estimates of nitrous oxide according to Intergovernmental Panel on Climate Change methodology. Complex crop rotations with legumes, such as corn–corn–soybeans (*Glycine max.* L.)–wheat (*Triticum aestivum* L.) with red clover (*Trifolium pratense* L.) underseeded, have higher net returns and substantially lower GHG emissions than continuous corn. Conservation tillage reduces GHG emissions due to lower input use but sequestration levels did not vary significantly between tillage systems. Rotation had a much bigger effect on the mitigation potential of GHG emissions than tillage. However, opportunity costs of more than \$200 per megagram of carbon dioxide equivalent per hectare per year ($\text{Mg CO}_2 \text{ eq ha}^{-1} \text{ year}^{-1}$) indicate the limits to increase the mitigation potential beyond the level of the most profitable cropping system. *Agriculture, Ecosystems & Environment*, available online May 2, 2006. [doi:10.1016/j.agee.2006.03.023](https://doi.org/10.1016/j.agee.2006.03.023), <http://www.sciencedirect.com/science/article/B6T3Y-4JVTBHS-2/2/c2ce339e0b664deb68ea1ada7fbb2027>.

July 2006

"Ecological restoration, carbon sequestration and biodiversity conservation: The experience of the Society for Wildlife Research and Environmental Education (SPVS) in the Atlantic Rain Forest of Southern Brazil, Journal for Nature Conservation." Since 1999, SPVS has been involved in three projects that combine two fundamental goals over the course of 40 years: the conservation of one of Brazil's most important remnants of Atlantic Forest and the implementation of projects for carbon sequestration. In addition, there is an interest in replicating these projects in order to restore other degraded areas, protect the Brazilian biomes, and help to diminish deforestation and forest fire, therefore reducing carbon emissions. The acquisition of 19,000 hectares of degraded areas of high biological importance in southern Brazil was the first step towards the implementation of the projects. These areas are owned by SPVS, a Brazilian non-governmental organization (NGO), and are being restored, conserved and transformed into Private Natural Reserves, in partnership with the NGO – The Nature Conservancy, and financed by the companies – American Electric Power, General Motors and Chevron Texaco. The process of forest restoration involves several stages: soil studies, surveying the region's native plants, planning for restoration by means of a Geographical Information System, production of seedlings, application of different techniques for planting (such as manual or mechanized planting with seedlings and stakes), and biomass and biodiversity monitoring. To guarantee the survival of the seedlings on the planted areas, during the first three years, there is a continuous and systematic

maintenance program including weeding of undergrowth, crowing and organic fertilization. The three projects already planted around 500,000 seedlings of native species until September 2004, and aim to plant a further 300,000 until 2008. **André Rocha Ferretti and Ricardo Miranda de Brites**, *Journal for Nature Conservation*, Available online June 5, 2006, <http://www.sciencedirect.com/science/article/B7GJ6-4K421HP-1/2/7411afcc69e72b14741bb076018ae883>. (Subscription may be required.)

“Innovative gap-filling strategy for annual sums of CO₂ net ecosystem exchange.”

The determination of carbon dioxide net ecosystem exchange (NEE) using the eddy-covariance (EC) method has become a fundamental tool for the investigation of the carbon balance of terrestrial ecosystems. This study presents a strategy for the processing, subsequent quality control and gap-filling of carbon dioxide eddy-covariance flux measurements for the derivation of annual sums of NEE. A set of criteria is used for quality assessment and to identify periods with instrumental or methodological failures. The complete evaluation scheme was applied to data recorded above a spruce forest at the FLUXNET-Station Waldstein-Weidenbrunnen (DE-Wei) in 2003. Comparison of this new evaluation scheme to the use of a friction velocity (u^*) threshold criterion of 0.3 meter per second (m s^{-1}) indicates less systematic distribution of data gaps. The number of available high quality night-time measurements increased. This effect was most pronounced during summer, when data is essential for a robust parameterization of respiratory fluxes. Non-linear regression analysis showed that air temperature and global radiation explain most of the variability of NEE and further seasonal segregation of the data based on an objective method did not significantly improve predictions at this evergreen forest site. **J. Ruppert, M. Mauder, C. Thomas and J. Lüers**, *Agricultural and Forest Meteorology*, Available online May 9, 2006, [doi:10.1016/j.agrformet.2006.03.003](http://www.sciencedirect.com/science/article/B6V8W-4JX9V3Y-1/2/b3070be9ceb198a260ec46c21cf0c133), <http://www.sciencedirect.com/science/article/B6V8W-4JX9V3Y-1/2/b3070be9ceb198a260ec46c21cf0c133>. (Subscription may be required.)

August 2006

“Food for Thought: Lower-Than-Expected Crop Yield Stimulation with Rising CO₂

Concentrations.” Model projections suggest that although increased temperature and decreased soil moisture will act to reduce global crop yields by 2050, the direct fertilization effect of rising carbon dioxide concentration ($[\text{CO}_2]$) will offset these losses. The carbon dioxide fertilization factors used in models to project future yields were derived from enclosure studies conducted approximately 20 years ago. Free-air concentration enrichment (FACE) technology has now facilitated large-scale trials of the major grain crops at elevated $[\text{CO}_2]$ under fully open-air field conditions. In those trials, elevated $[\text{CO}_2]$ enhanced yield by approximately 50 percent less than in enclosure studies. This casts serious doubt on projections that rising $[\text{CO}_2]$ will fully offset losses due to climate change. **Stephen P. Long, Elizabeth A. Ainsworth, Andrew D. B. Leakey, Josef Nösberger, Donald R. Ort**, *Science*, June 30, 2006, Volume 312, Number 5782, Pages 1918 – 1921, [doi:10.1126/science.1114722](http://www.sciencemag.org/cgi/content/full/312/5782/1918), <http://www.sciencemag.org/cgi/content/full/312/5782/1918>. (Subscription required.)

“Nutrient additions to a tropical rain forest drive substantial soil carbon dioxide losses to the atmosphere.” Terrestrial biosphere-atmosphere carbon dioxide (CO_2) exchange is dominated by tropical forests, where photosynthetic carbon (C) uptake is thought to be phosphorus (P)-limited. In P-poor tropical forests, P may also limit organic matter decomposition and soil C losses. We conducted a field-fertilization experiment to show that P fertilization stimulates soil respiration in a lowland tropical rain forest in Costa Rica. In the early wet season, when soluble organic matter inputs to soil are high, P fertilization drove large increases in soil respiration. Although the P-stimulated increase in soil respiration was largely confined to the dry-to-wet season transition, the seasonal increase was sufficient to drive an 18 percent annual increase in carbon dioxide (CO_2) efflux from the P-fertilized plots. Nitrogen (N) fertilization caused similar responses, and the net increases in soil respiration in response to the additions of N and P approached annual soil C fluxes in mid-latitude forests. Human activities are altering natural patterns of tropical soil N and P availability by land conversion and enhanced atmospheric

deposition. Although our data suggest that the mechanisms driving the observed respiratory responses to increased N and P may be different, the large CO₂ losses stimulated by N and P fertilization suggest that knowledge of such patterns and their effects on soil CO₂ efflux is critical for understanding the role of tropical forests in a rapidly changing global C cycle. **Cory C. Cleveland and Alan R. Townsend**, Proceedings of the National Academy of Sciences of the United States of America, Published online before print June 22, 2006, doi:10.1073/pnas.0600989103, <http://www.pnas.org/cgi/doi/10.1073/pnas.0600989103>. (Subscription required.)

“Monitoring and verifying agricultural practices related to soil carbon sequestration with satellite imagery.” The Kyoto Protocol entering into force on February 16, 2005 continues to spur interest in development of carbon trading mechanisms internationally and domestically. Critical to the development of a carbon trading effort is verification that carbon has been sequestered, and field level measurement of carbon (C) change is likely cost prohibitive. Estimating C change based on agricultural management practices related to carbon sequestration seems more realistic, and analysis of satellite imagery could be used to monitor and verify these practices over large areas. The authors examined using Landsat imagery to verify crop rotations and quantify crop residue biomass in north central Montana. Field data were collected using a survey of farms. Standard classification tree analysis (CTA) and boosted classification and regression tree analysis (BCTA) were used to classify crop types. Linear regression (LM), regression tree analysis (RTA), and stochastic gradient boosting (SGB) were used to estimate crop residue. Six crop types were classified with 97 percent accuracy (BCTA) with class accuracies of 88–99 percent. Paired *t*-tests were used to compare the difference between known and predicted mean crop residue biomass. The difference between known and predicted mean residues using SGB was not different than 0 (*p*-value = 0.99); however root mean square error (RMSE) was large (1981 kilograms per hectare), implying that SGB accurately predicted regional crop residue biomass but not local predictions (i.e., field or farm level). The results of this study, and previous research classifying tillage practices and estimating soil disturbance, supports using satellite imagery as an effective tool for monitoring and verifying agricultural management practices related to carbon sequestration over large areas. **Ross S. Bricklemeyer, Rick L. Lawrence, Perry R. Miller and Norov Battogtokh**, *Agriculture, Ecosystems & Environment*, Available online June 27, 2006. doi:10.1016/j.agee.2006.05.017, <http://www.sciencedirect.com/science/article/B6T3Y-4K8S5DT-4/2/c87e3ea0faffaa9a358807ec6bbff126>. (Subscription may be required.)

Trading

September 2005

“AEP Expands CO₂ Reduction Commitment Through 2010.” American Electric Power announced the company will continue its membership in the Chicago Climate Exchange (CCX). As a founding member of CCX, AEP committed in 2003 to reduce or offset its greenhouse gas emissions by 1 percent in 2003, 2 percent in 2004, 3 percent in 2005, and 4 percent in 2006 below a baseline average of 1998 to 2001 emission levels. Phase II of CCX extends AEP's greenhouse gas reduction commitment ultimately to 6 percent below the same baseline by 2010 (4.25 percent in 2007, 4.5 percent in 2008, 5 percent in 2009 and 6 percent in 2010). With this new commitment, AEP expects to reduce or offset approximately 46 million metric tons of carbon dioxide equivalent emissions between 2003 and the end of the decade. *AEP Press Release*, August 10, 2005, <http://biz.yahoo.com/prnews/050810/clw512.html?v=7>

October 2005

“Brazil opens carbon credit market.” The Brazilian Development Ministry has launched the region's first carbon credit market in cooperation with the Brazilian Stock Exchange in Rio de Janeiro. This move paves the way for industry in developed countries to offset high levels of greenhouse gas emissions by purchasing carbon credits in Brazil. Brazilian Ministry of Science and Technology Chief Coordinator of

Research in Global Change, José Miguel, expects some 30 projects to be approved. Meanwhile, the World Bank reports that carbon sequestration projects submitted by Asian countries reached 51 percent of total projects in 2003, up from 21 percent in 2002. *ISN Security Watch*, September 15, 2005, <http://www.ieta.org/ieta/www/pages/index.php?IdSitePage=954>

“Evolution Markets Brokers First Option Trade for European Emissions Market.” Evolution Markets announced it arranged the first ever brokered option trade under the European Union’s Emissions Trading Scheme (EU ETS). The option for 160,000 European Union Allowances (EUAs) was sold by EDF Trading, the wholesale trading arm of French power company Electricite de France, to Statkraft’s Amsterdam-based carbon trading desk. Option trading structures provide market participants tools to manage risk associated with the movement in the price of carbon allowances. An option buyer has the ability but not the obligation to buy or sell emissions allowances at a set price and will often exercise this right should the price move in a particular direction. As such, options provide protection against price risk in the carbon market. *Evolution Markets Press Release*, September 27, 2005, http://www.evomarkets.com/scripts/pr_full.php?pr=49

“Indian Firms Seek \$5 Billion From Carbon Credit Sales in 7 Years.” Industries in India, exempt from emissions cuts imposed on industry in Europe and elsewhere, plan to reduce their greenhouse gas output and sell the resulting credits for up to \$5 billion over the next seven years. Analysts say countries such as India and Brazil are already leading suppliers of certified carbon emission reduction credits (CERs). “Indian companies currently supply more than 30 percent of the (traded) CERs. They could improve that share,” said Ajay Mathur, president of carbon credit trader Senergy Global Pvt. Ltd. *Brisbane’s News 1*, September 15, 2005, <http://www.leadingthecharge.com/stories/news-0072754.html>

“Swiss Re Joins Chicago Climate Exchange.” Swiss Re, the world’s largest life and health reinsurer, has announced it will join the Chicago Climate Exchange (CCX). CCX is North America’s only multisector marketplace for reducing and trading greenhouse gas emissions. “Insurance companies have a critical role to play in developing sound strategies to address the challenge of climate change. We commend Swiss Re for again taking a proactive stance and joining CCX,” said Dr. Richard Sandor, chairman and CEO of CCX. *GreenBiz*, September 20, 2005, http://www.greenbiz.com/news/news_third.cfm?NewsID=28794

November 2005

“Japan Launches Voluntary Emissions Trading Scheme.” The Japanese Ministry of the Environment has selected 34 companies and corporate groups as participants in the nation’s new Voluntary Emissions Trading Scheme. Under the scheme, the ministry subsidizes the installation cost of CO₂ emissions reduction equipment to help businesses that are actively attempting to reduce greenhouse gas emissions. In exchange for the subsidy, the participants are required to commit to a certain reduction in their CO₂ emissions. The scheme also allows them to trade CO₂ emission quotas to meet their reduction targets. The total of emissions reductions promised by the individual companies for fiscal 2006 is 276,380 tons, or 21 percent of their average annual CO₂ emissions in the base years, fiscal 2002 to 2004. The reduction in CO₂ emissions over the officially-recognized service life of the subsidized equipment is calculated at about 3.7 million tons. *GreenBiz News*, September 28, 2005, http://www.greenbiz.com/news/news_third.cfm?NewsID=28866

“Natsource Closes Greenhouse Gas Credit Pool with \$550 Million.” Natsource announced that it has closed the Greenhouse Gas Credit Aggregation Pool (GG-CAP), with total commitments of US\$550 million from 26 participants. The GG-CAP is the first private-sector initiative to provide a cost-effective means for companies to meet requirements to reduce their greenhouse gas emissions under the European Union Emissions Trading Scheme and the Kyoto Protocol. The GG-CAP is a “buyers pool” that will combine the purchasing power of the 26 participants to acquire and manage the delivery of a large

volume of compliance instruments created by the project-based mechanisms included in the Kyoto Protocol. *SustainableBusiness.com*, October 19, 2005,
<http://www.sustainablebusiness.com/news/sbnews.cfm?id=7532>

“CDM generates first carbon credits - up to a point.” The first carbon credits created by the Kyoto Protocol's Clean Development Mechanism (CDM) were issued on October 20. The Executive Board - the CDM's supervisory body - authorized the issuance of 7,304 and 2,210 Certified Emission Reductions (CERs) to the developers of two hydroelectric projects at Rio Blanco and La Esperanza in Honduras, respectively. “The CDM is for real. It is delivering sustainable development to communities and at the same time real emissions reductions,” said Sushma Gera, chair of the CDM Executive Board. *Environmental Finance*, October 20, 2005,
<http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=16964>

“Most rubber estates may not get carbon credit.” Article discusses how most of the existing rubber plantations in India are unlikely to qualify for trading in certified emission reduction (CER). This is because the United Nations Framework Convention of Climate Change (UNFCCC) stipulates that to qualify as a clean development mechanism (CDM) project, an afforestation or re-forestation activity should take place on those lands that did not have a forest as on December 31, 1989. This rule will automatically disqualify a large chunk of the existing rubber plantations since they would have been in existence much before the cut-off date set for CDM projects. According to this article, rubber trees have very high carbon sequestration capabilities. One hectare of rubber plantation can sequester about 165 tonnes of carbon over their 21-year growth period, thereby earning as much as 605 CER (605 tonnes CO₂) a hectare. *The Hindu Business Line*, October 21, 2005,
<http://www.thehindubusinessline.com/2005/10/22/stories/2005102201771200.htm>

December 2005

“European firms trade emission credits.” Volumes in the European Union's carbon dioxide emission trading scheme have soared with over 200 million tonnes of credits expected to change hands this year, says a report from consultants Prospex. Trade is expected to increase further next year as more companies, especially in southern and eastern Europe, enter the market. “The pioneering days are over. In the first three quarters of 2005 alone, we estimate trading volumes reached 177 million tonnes, or eleven times global volumes in all of 2004,” said Amsterdam-based Prospex. September was the busiest month so far with trade reaching 43 million tonnes. The EU launched the emissions trading scheme in January as part of its drive to curb heat-trapping greenhouse gas pollution which is blamed for causing climate change. *Reuters*, October 28, 2005, <http://www.climateark.org/articles/reader.asp?linkid=47737>

“Red tape slows Kyoto pollution credit scheme.” According to this article, the Clean Development Mechanism (CDM) – potentially a big source of cheap carbon dioxide reduction credits – is struggling to deliver as hundreds of climate-friendly projects in India, China and other developing countries wait in a queue for official approval to go ahead. Market sources say that calls to streamline the CDM, which allows rich nations to claim credits from projects in poor countries, will reach a crescendo at the United Nations climate change conference in Montreal later this month. “There will be major pressure in Montreal to increase funding for the CDM's executive board, and to strengthen the procedures, to speed up the process,” said Pedro Moura Costa, managing director of UK-based carbon trader EcoSecurities. “CDM will be a major issue because now the private sector has real (climate change) liabilities, it's not a joke anymore, it's a reality,” he said. *Reuters*, November 15, 2005,
http://news.yahoo.com/s/nm/20051115/sc_nm/energy_kyoto_pollution_dc_1;_ylt=AkcWQwOQfKqxybnOjS4QBd5rAIMA;_ylu=X3oDMTBiMW04NW9mBHNIYwMIJVRPUCUI

January 2006

PR Newswire, “New environmental market created: Montreal Climate Exchange,” The Montreal Exchange (MX), Canada's financial derivatives exchange, and Chicago Climate Exchange(R) (CCX(R)), the world's first and North America's only voluntary, legally binding rules-based greenhouse gas emissions allowance trading system, announced the signing of a Letter of Intent to develop a new joint venture, creating the Montreal Climate Exchange, a Canadian environmental products market. CCX and MX will develop trading, clearing, and registry services for Canadian environmental products. The announcement was made in Montreal during the 11th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). December 7, 2005.

<http://www.prnewswire.com/cgi-bin/stories.pl?ACCT=104&STORY=/www/story/12-07-2005/0004229649&EDATE=>

“Shell, TFS, ECX scoop top places in new EU carbon trading scheme: Top brokers, dealers, service providers in fast-growing environmental markets,” The readers of *Environmental Finance* magazine have voted Shell's environmental products team and inter-dealer broker TFS the top trading company and broker, respectively, in Europe's carbon emissions trading scheme (ETS). The European Climate Exchange (ECX), which trades carbon contracts via London's International Petroleum Exchange, won Best Exchange in the EU market. Allowances for more than 230 million tonnes of carbon dioxide – worth some €4.2 billion – have changed hands this year in the EU market. Mark Nicholls, editor of *Environmental Finance* stated, “This year has seen environmental markets enter the mainstream, as evidenced by the major investment banks – including Merrill Lynch, Morgan Stanley, and Barclays Capital – which won categories in the survey. The launch of the EU Emissions Trading Scheme this year has brought the reality of reducing carbon emissions to more than 4,000 companies across Europe and, more importantly, has put a financial value on emissions reductions,” he added. The results are published in the December 2005-January 2006 issue of *Environmental Finance* magazine. To read about the background and context about the various markets, see: www.environmental-finance.com/envfin/05survey.pdf December 19, 2005, <http://www.europeanclimateexchange.com/pages/page332.php>

February 2006

Bloomberg, “EU Carbon-Emission Trading on ECX Surges to Record,” On January 19, the European Climate Exchange (Exchange) surged to a record high and more than doubled the previous daily all-time high. A total of 5.2 million metric tons of CO₂ allowances were traded on the Exchange on January 19. The figure also included a 3.3 million-ton trade, where ABN Amro Futures Ltd. was one of the two parties involved in the trade. (ABN Amro Holding NV is the largest Dutch bank.) Taking into account the most recent price of 25.85 euros per ton (\$31.47 per ton), the trading value for January 19 was valued at 134 million euros (\$162 million). January 19, 2006, <http://www.europeanclimateexchange.com/pages/page344.php>

Reuters, “European Union Urges States to Simplify Emissions Trading Plans,” The European Commission (Commission) told European Union (EU) member states on January 9 to keep it simple when they formulate their emissions trading plans for 2008-2012 for environmental commitments under the Kyoto Protocol. The twenty-five EU states must submit National Allocation Plans (NAPs) to the EU executive by June 30 stating how much CO₂ their industrial factories will emit. The NAPs are part of the EU emissions trading scheme, which began last year. Drawing from experience with the first trading period from 2005-2007, the Commission feels that these plans need to be “more transparent and easier to implement.” The Commission said it will “look very closely at the overall policy mix” that member states will use to implement their pollution reduction goals, including their planned use of the emissions trading system. January 10, 2006, <http://www.planetark.com/dailynewsstory.cfm/newsid/34402/story.htm>

The Age (Australia), “Carbon Tax Too Costly, Says New Zealand,” New Zealand will not introduce a carbon tax since it would not cut emissions enough to justify the cost of its introduction. New Zealand's carbon tax was to be set at a relatively low level of \$14 Australian dollars (\$10.4) per metric ton of carbon

emissions, adding 6 percent to electricity prices. Comparatively the European emissions market trades at \$34 Australian dollars (\$25) per metric ton. A carbon tax is more punitive than credits since it is paid by all emitters and cannot be traded. New Zealand must hold its emissions at their 1990 levels, but it is currently running 37 percent above. Also despite the country's extensive use of hydropower and geothermal power, it will be 30 percent above targets for 2012. December 30, 2005, <http://www.theage.com.au/news/business/carbon-tax-too-costly-says-nz/2005/12/29/1135732693442.html>

USA Today, "Drivers Atone for Exhaust with Carbon Offsets," DriveNeutral, a non-profit launched in October by students at the Presidio School of Management in San Francisco sells "carbon offsets" to drivers to offset their vehicle emissions. DriveNeutral compensates for vehicle emissions by participating in the voluntary emissions market Chicago Climate Exchange (CCX) as an associate member, where it can buy blocks of emissions credits and divide them into increments tailored to fit the ecological footprint of an individual automobile. Though individual buyers cannot participate in CCX, there are 130 corporations, non-profits, and governments on the exchange that are legally bound to achieve annual reductions in carbon dioxide emissions, either by reducing them internally or by buying "emissions credits" from companies that have exceeded reductions targets. After purchasing the credits, DriveNeutral takes them off the market, thereby reducing the overall pool of allowable credits. As a result CO₂ emissions go down and market demand for credits increases. A California resident who drives 1,000 miles per month in the Bay Area of California spent \$25 to offset her Infiniti sedan, earning a DriveNeutral decal to display on her car, and compensating for about 5 tons of carbon emissions for the year. Over the past two months, DriveNeutral has sold 125 car certifications, compensating for 600 metric tons of CO₂. A for-profit competitor of DriveNeutral, called TerraPass and launched by Wharton School of Business students last year, has sold 2,500 certifications, or the equivalent of 19,000 tons in CO₂ reductions. CarbonFund, a non-profit that offsets home, office, and transportation emissions, has sold the equivalents of 37,000 tons in reductions. Since its launch in 2003, CCX has traded 4 million tons of CO₂ with a value of \$8 million. January 4, 2006, http://www.usatoday.com/tech/news/techinnovations/2006-01-04-carbon-offsets_x.htm

Silicon Valley/San Jose Business Journal, "PG&E Proposes Program to Make Customers 'Climate Neutral,'" Pacific Gas and Electric Co. wants to offer "offsets" to its customers and has asked for approval of the program from the California Public Utilities Commission. Through the Climate Protection Program, customers could opt to pay a premium on their monthly bills, based on their energy usage, to help offset their environmental impact associated with their energy consumption, making the net impact of their consumption "climate neutral." A fund will be set up and projects will be funded in forest restoration and other conservation aimed at removing CO₂ from the atmosphere. The projects will all be based in California, and selected through competitive bids with stringent criteria under protocols developed by the California Climate Action Registry, an independent non-profit. The projects will be overseen by an external advisory group comprised of community groups, businesses, and nonprofit conservation agencies. An estimated \$20 million may be received by the end of the three year demonstration, with a goal of removing at least two million tons of carbon dioxide from the air. January 26, 2006, <http://sanjose.bizjournals.com/sanjose/stories/2006/01/23/daily45.html>.

March 2006

Reuters, "Third Kyoto Pollution Scheme Close to Launch," Joint Implementation (JI)—which allows industrialized countries with a greenhouse gas reduction commitment to invest in emission reducing projects in another industrialized country as an alternative to emission reductions in their own countries—is expected to pave the way for hundreds of projects in Russia and Eastern Europe. JI Projects are most likely to take place in central and eastern European transitional economies and the Russian Federation since there is more scope for cutting emissions at lower cost than in other industrialized nations. The first meeting of Kyoto Protocol's Joint Implementation Supervisory Committee (JISC 01) occurred on February 2-3 on Bonn, Germany. JISC reached a quick agreement on the draft regulations. The vice

chair of the supervisory board set up to steer the JI mechanism hopes to have JI running by May, or at least by July since there are many projects waiting to file for registration. The vice chair also stated that the funding for the JI mechanism was not a problem thus far, and that some countries which have committed funds have already provided the funding. For the webcast, report and resulting documents of the First Meeting of the Joint Implementation Supervisory Committee see:

http://ji.unfccc.int/Sup_Committee/Meetings/. February 9, 2006,
http://today.reuters.com/news/newsArticle.aspx?type=scienceNews&storyID=2006-02-09T164418Z_01_L0988057_RTRUKOC_0_US-ENVIRONMENT-KYOTO.xml .

Reuters, “UK Seen Split on Key Climate Change Proposal,” and BBC News “Smaller Firms Could Trade Carbon” and “Whitehall in Greenhouse Gases Row” The British government is split on whether to adopt a proposal to curb carbon emissions from 14,000 British companies. A proposal was published in December by the government-funded initiative, The Carbon Trust, detailing a trading scheme for carbon dioxide permits for small and medium sized businesses. Heavy industry and the power sector are already under the European Union Emissions Trading Scheme. Britain has self-imposed domestic goals for cutting carbon emissions by 20 percent of 1990 levels by 2010. Existing policy is on track for 10 percent reduction, with this proposal closing the gap between the 10 and 20 percent by about one quarter. Britain states that it is on track to meet the treaty-imposed Kyoto Protocol carbon emission targets for 2008 to 2012. See proposal online at:

http://www.thecarbontrust.co.uk/carbontrust/about/about5_3.html. February 9, 2006,
http://today.reuters.com/news/newsArticle.aspx?type=scienceNews&storyID=2006-02-09T163142Z_01_L08302465_RTRUKOC_0_US-ENVIRONMENT-BRITAIN-CO2.xml and February 2, 2006, <http://news.bbc.co.uk/1/hi/sci/tech/4669868.stm>.

April 2006

Greenwire, “New Mexico Formally Becomes First State to Make Binding Commitment to Reduce Emissions.” New Mexico became the first state in the US to join the Chicago Climate Exchange, the US-based carbon emissions trading credit market. Several cities have joined the exchange, including Chicago, Oakland and Boulder, but New Mexico is the first state to do so. Credits are traded over the internet daily at a cost of about \$2 per metric ton, (as reported in the Trading section of this newsletter monthly). February 23, 2006, <http://www.eenews.net/Greenwire/2006/02/23/#15>. (Subscription may be required.)

Reuters, “UK Wants Transport Included in EU CO₂ Trade Scheme.” The United Kingdom wants to expand the European Union’s emissions trading scheme to cover surface transportation emissions, one of the greater sources of carbon dioxide (CO₂) emissions. The trading scheme imposes limited on carbon dioxide emissions on approximately 12,000 factories and power plants, but does not cover air or surface transportation. The European Commission, the trading scheme’s official administrator, is in the process of reviewing the scheme and may consider other sectors and even other greenhouse gases. A Commission official said that substantial changes, such as the inclusion of more industries would not be possible until 2010. Changing to an auctioning format for the scheme, which currently distributes emissions credits for free, may also be explored by the Commission for phase two (2008-2012) of the scheme. March 1, 2006, <http://www.planetark.com/dailynewsstory.cfm?newsid=35367&newsdate=01-Mar-2006>.

Reuters, “China's Waste Could Be Treasure for Kyoto Scheme.” Development of landfill projects in China could help counties meet their quotas under the Kyoto protocol’s Clean Development Mechanism trading scheme. Lu Guoqiang, an official at China’s State Environmental Protection Administration, announced at an emissions trading conference in Denmark—Point Carbon’s Carbon Market Insights 2006—that there are 700 registered landfill sites in China but only 10 of them have gas recovery and utilization systems installed. Foreign investors could earn Certified Emission Reduction credits under CDM by investing in projects to stream-off greenhouse gases from degrading landfills for conversion into

an energy source. March 2, 2006,

<http://www.planetark.com/dailynewsstory.cfm?newsid=35391&newsdate=02-Mar-2006>.

CCX Press Release, "Chicago Climate Exchange, Inc. (CCX) announces formation of the New York Climate Exchange (NYCX) and the Northeast Climate Exchange (NECX)." CCX announced the formation the NYCX and NECX to develop financial instruments for the Regional Greenhouse Gas Initiative (RGGI). Product development for the exchanges will begin shortly and the exchanges will be ready for operation in accordance with the evolution and needs of RGGI. The current schedules for RGGI call for a first compliance period from 2009 through 2012. March 14, 2006, http://www.chicagoclimatex.com/news/press/release_20060314_NYCX.html

May 2006

Reuters, "Chicago Climate Mart To Try CO₂ Link With EU." The Chicago Climate Exchange (CCX) has announced that it is opening its voluntary carbon dioxide (CO₂) market to European Union (EU) traders that have Emissions Trading Scheme allowances. The CCX will allow EU CO₂ emission allowances to be used in compliance with CCX commitments for calendar year 2005, creating a linkage between North America's only reduction and trading system and the European Union Emissions Trading Scheme. CCX has set up "demonstration transfers," through which trade can be carried out between markets. "Batches of 100 tons of EU allowances would be transferred by a CCX member from its EU allowance account into an account CCX has established in an EU registry," CCX said in a statement. "The EU allowances would then be retired, and CCX would issue 100 metric tons of CO₂ into that member's CCX registry account." April 5, 2006, http://today.reuters.co.uk/news/newsArticle.aspx?type=scienceNews&storyID=2006-04-05T004141Z_01_N04191089_RTRIDST_0_SCIENCE-ENERGY-EMISSIONS-CHICAGOCLIMATE-DC.XML.

Reuters, "EU CO₂ Emission Prices Hit New Record High." European carbon dioxide emissions prices jumped to a new record high of 31 euros (\$38.28) per tonne (December 2007 carbon quotas) on April 12, although they closed at 30.25 euros (\$37.35) per tonne. The boost was caused by surging oil prices and strong German power markets. CO₂ prices have risen five fold since the launch of the European Union trading scheme last year. Dry weather in Europe is prompting generators, especially in Spain, to burn fossil fuel due to lack of hydropower. Deutsche Bank is forecasting that CO₂ emission prices could rise toward 40 euros (\$49.39) over the coming year. April 12, 2006, <http://today.reuters.com/business/newsarticle.aspx?type=tnBusinessNews&storyID=nL12586863>.

Reuters, "CO₂ Market on Brink as Price Continues to Slide," Carbon credits for December 2006 delivery fell as low as 14 euros (\$17) in early Thursday trading on the European Climate Exchange. The price recovered to around 17 euros (\$21) by 10:00 Greenwich Mean Time. Carbon credits had hit a high of 31 euros (\$39) on April 12. "From a market perspective it's terrible news," said James Emanuel, Head of Carbon Trading at brokers CO₂e.com. "If there's a (net carbon credit) surplus there's no incentive to reduce emissions and the (carbon) price collapses. It won't go to 0, it would effectively go down to the administrative cost of the scheme... it could be 1 euro, who knows?" Power prices in Europe have declined due to the falling CO₂ prices. British Energy was down 1.8 percent, International Power 1.2 percent, RWE 2 percent, EON 2.1 percent and EDF 3.1 percent. April 26, 2006, <http://www.planetark.com/dailynewsstory.cfm/newsid/36175/story.htm>.

Globe and Mail, "Legal Teams Clean Up On Emissions Trading." Emissions trading can require legal expertise in securities, the environment and tax law. Large law firms are being drawn into corporate legal work to assist business in preparing for compliance as each country sets emissions targets for their industries. Law firms working in this area include: Chicago-based Baker & McKenzie, London-based Clifford Chance LLP, Amsterdam-based De Brauw Blackstone Westbroek, Canadian Based Fasken

Martineau DuMoulin LLP, McCarthy Tétrault LLP, and Calgary-based Bennett Jones, Macleod Dixon LLP and Thackray Burgess. Boston-based Brown Rudnick Berlack Israels LLP announced on March 20 the formation of a Climate & Energy Group to work on renewable energy project development, emissions reduction schemes and alternative energy sources for clients. March 29, 2006, <http://www.theglobeandmail.com/servlet/story/LAC.20060329.RLAWYERS29/TPStory/Business>.

June 2006

The New York Times, “Data Leaks Shake Up Carbon Trade.” On May 12, an online database accidentally listed a complete set of the carbon emissions data from the European Commission, three days before it was to be officially released. As a result, the carbon trading prices for the European Union Emissions Trading Scheme (EU ETS) sank to 8.60 euros (\$11) per metric ton, down from a high of 31 euros (\$40) in mid-April. **(EU ETS market values are listed monthly in the Trading section’s Carbon Market Update in this newsletter.)** Critics question whether governments and industry overestimated their carbon emissions when originally allocating the credits, causing companies to sell large amounts of their extra credits, resulting in the drop in trading value. The EU ETS is now facing criticism from both traders and environmentalists; those trading on the ETS are now asking the commission to release ETS data quarterly instead of annually, and environmentalists are asking for tougher limits for phase two of the scheme (2008-2012). Traders are also asking to have the same oversight that any securities or bond market would, along with the same warnings and fines for leaking information. The EU ETS is thinly traded with only about 30 or 40 companies trading on the market on a given day, resulting in a more volatile market. Despite the upheaval, many are still optimistic about the carbon market. Said Louis Redshaw, head of environmental products at Barclays Capital, “Trading is the only way to reduce emissions economically and efficiently. I am confident this market will be around in 5 or 10 years.” May 16, 2006, <http://www.nytimes.com/2006/05/16/business/16place.html>. (Subscription required.)

AP, “EU Carbon Dioxide Emissions Below Limit”, and EU Press Release, “EU Emissions Trading Scheme Delivers First Verified Emissions Data for Installations.” The carbon emissions data which appeared on the European Commission website was intended to be posted on May 15, but was accidentally posted on May 12. The emissions quotas are part of the European Union Emissions Trading Scheme, and covers more than 9,400 installations. Carbon dioxide (CO₂) emissions in 21 European Union countries were 44.1 million metric tons (2.4 percent) below the limit allocated to the region during the first year of trading. Germany had the largest surplus of credits, after emitting 21.4 million tons (4.3 percent) below its allowable limit. The 21 countries have a maximum of 1.83 billion tons of emissions (2005-2007), with approximately 9,400 industries permitted to sell any of their excess allowances. France, the Czech Republic, and Finland also did not exceed their limits after emitting 19.3 million tons, 14.5 million tons, and 11.5 million tons, respectively. For a summary table of the emission and allocations, see: http://ec.europa.eu/environment/climat/pdf/citl_pr.pdf. Member State reports can be downloaded from the Commission's Climate Change website at: http://ec.europa.eu/environment/climat/emission/citl_en.htm. The searchable database on verified emissions and surrendered allowances (the Community Independent Transaction Log) can be found at: <http://ec.europa.eu/comm/environment/ets/>. [To view the data, click <http://www.ec.europa.eu/comm/environment/ets/welcome.do> to access the EU's community transaction log Web site. Click on the allocation/compliance search icon on the left-hand menu. Choose a nation in the “registry” box. Click the search box and, then, click the “export” box and choose a format for the download.] For information on the Commission's infringement action against Member States without an active registry see: <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/06/469&format=HTML&aged=0&language=EN&guiLanguage=en>. For general information of the EU emission trading scheme see: <http://europa.eu.int/comm/environment/climat/emission.htm>. May 15, 2006, <http://msnbc.msn.com/id/12800327/from/RL.3/>, and May 15, 2006, http://ec.europa.eu/environment/climat/pdf/citl_pr.pdf.

CCX Press Release, "Chicago Climate Exchange Announces Fourth Consecutive Record Trading Month." Chicago Climate Exchange (CCX) had its highest trading volume for the CCX Carbon Financial Instrument contracts for the first half of May (1-15) at 2,435,400 metric tons carbon dioxide (CO₂), double the volume of April 2006. The total volume of trades in April 2006 was 1,069,400 metric tons of CO₂. May 15, 2006, http://www.chicagoclimateexchange.com/news/press/release_20060515_MayRecord.pdf.

July 2006

Voice of America, "Carbon Trading: How the Chicago Climate Exchange Works." Voice of America Broadcasting service covered the basic concepts of the Chicago Climate Exchange in their Special English Agriculture Report. To read the report or download the audio files to listen to the May 30, 2006 broadcast, see: <http://www.voanews.com/specialenglish/2006-05-30-voa2.cfm>.

Greenwire, "Farmers Find New Cash Crop in Emissions Trading." Some US farmers engaged in no-till farming practices have signed up with Chicago Climate Exchange (CCX) to receive compensation for the carbon sequestration value of their soils. CCX allows no-till farming to be listed among the available credits for members that cannot meet their emission targets. According to a 1997 inventory by United States Department of Agriculture's Natural Resource and Conservation Service (NRCS), sixteen percent of 382 million total US farmland acres were in continuous no-till operations. Rataan Lal, a soil scientist at The Ohio State University, said the number of no-till farms has not risen much since that study. He said that the conversion of all US farmland to continuous and permanent no-till, along with other improved farming practices, would offset about 300 million metric tons of carbon per year, or more than 4 percent of the nation's annual emissions. Lal said global carbon storage potential for all soils through no-till and other land practices is between 600 million and 1.2 billion tons of carbon per year would be enough to offset between 5 and 15 percent, respectively, of global greenhouse emissions. No till will not work in every type of soil or with any crop. Keith Paustian, a professor at Colorado State University, said soils with the highest potential for carbon sequestration stretch from southern Minnesota across the Midwestern Corn Belt -- Iowa, Illinois, Indiana, southern Michigan and western Ohio. June 22, 2006, <http://www.eenews.net/Greenwire/2006/06/22/#1/>. (Subscription may be required.)

International Herald Tribune (from The New York Times), " 'Carbon Leaders' and 'Carbon Dogs' Join Gauges for Climate Investment." Investment research firms such as Sanford C. Bernstein and Innovest Strategic Value Advisers are setting up carbon-tilted rating scales for companies on that are traded on the stock exchange. Innovest, in partnership with UBS, has created a "carbon beta" basket—a fund that will consist of 50 stocks in five industries. The fund managers will monitor global warming regulations, and buy and sell stocks based on how the companies would be affected by the regulations. Each grouping of industry stocks would include an equal number of 'carbon leaders' and 'carbon dogs,' " as an Innovest analyst Doug Morrow calls the ratings. Innovest and Sanford Bernstein are anticipating that the US Government will eventually set up a system for trading carbon credits. Once companies under the carbon credit system would start buying and selling carbon credits, the buyers would be "carbon dogs" and the sellers "carbon leaders." May 24, 2006, <http://www.ihrt.com/articles/2006/05/24/business/green.php>.

August 2006

Environmental Finance, Single EU-wide Emissions Cap Proposed for Post-2012." At Environmental Finance Publication's European Emissions Trading 2006 conference in Brussels, Belgium, Peter Zapfel, European Union (EU) European Emissions Trading Scheme (ETS) coordinator at the European Commission said the Commission's policy paper on the trading scheme beyond 2013 will be published in the next few weeks. One idea he discussed regarding Phase Three of the ETS, which begins in 2013, is that a single cap on carbon dioxide emissions could be set for all of the EU instead of

setting country-by-country targets. "Harmonized allocation" has been discussed in the debate, and the current "burden sharing agreement" by which the EU accepted a single Kyoto Protocol target, to which member states made differing contributions, only lasts up to 2012. July 13, 2006, <http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MTk2NzU>.

The New York Times, "New German Rule Could Increase Greenhouse Gas Emissions." The German cabinet has decided to exclude the German coal industry from the European Trading System scheme. German Chancellor Angela Merkel has set the reduction target for 2008 to 2012, to 3.4 percent. Critics feel that this reduction is ineffectual if the German coal industry is excluded, and that it may encourage other European Union member states to loosen their emissions targets. The European Commission stated June 30 that it needed to study Germany's plan before commenting on it. June 28, 2006, <http://www.nytimes.com/2006/06/29/business/worldbusiness/29green.html>. (Subscription required.)

Reuters, "EU's Dimas Says CO₂ Cap Tighter for Second Phase." Environment Commissioner Stavros Dimas said that the carbon dioxide (CO₂) emissions cap will be tighter in the second phase (2008-2012) of the European Union's (EU's) emissions trading scheme (ETS). The ETS has been trying to reestablish its credibility as an effective way to fight climate change since it was shown in May 2006 that the May 2005 data showed a surplus of carbon dioxide (CO₂) credits. The ETS was further undermined when nearly all of the EU states missed the June 30 deadline to set caps for the second trading period. The EU's 15 "old" member states are required under the Kyoto Protocol to reduce their carbon emissions by 8 percent compared to 1990 levels by the end of the 2008-2012 phase. Dimas is determined for the reduction to be met, and feels that the ETS is the most economic and cost efficient instrument through which to meet the targets. Dimas expects to have all of the EU's National Allocation Plans within July 2006. July 17, 2006, <http://www.planetark.org/dailynewsstory.cfm?newsid=37283&newsdate=17-Jul-2006>. (Subscription may be required.)

Chicago Climate Exchange Press Release, "The Montréal Climate Exchange is Established." The Montréal Exchange (MX) and the Chicago Climate Exchange (CCX) announced on July 12 the establishment of the Montréal Climate Exchange (MCeX), the first environmental products market in Canada. The Montréal Climate Exchange will allow for companies to trade CO₂ emissions credits. Other environmentally related products will be developed in the future. The two exchanges have finalized the preliminary agreement that was announced in Montréal on December 7, 2005, during meeting of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC, MOP-1). July 12, 2006, http://www.chicagoclimateexchange.com/news/press/release_20060712_Montreal_establish.html.

Recent Publications

September 2005

"Norway study finds CO₂ EOR too expensive, risky." Article highlights an April 2005 Norwegian Petroleum Directorate (NPD) study concluding that carbon dioxide injection currently is not a commercial alternative for enhancing oil recovery off Norway. The study – reported in the May 2005 *Carbon Sequestration Newsletter* – found several impediments for injecting CO₂, even though it determined that the technology was feasible and could substantially increase oil recovery. The main impediments were the expense for building a network for delivering CO₂ to the fields and the high estimated \$30-33/bbl cost for oil recovery. *Oil & Gas Journal*, August 8, 2005, <http://ogj.pennnet.com/> (subscription required)

"A New Global Warming Strategy." According to a report issued by environmental group EarthSave International, cars and power plants will not be a major cause of global warming in our lifetime. Rather, the most significant source of climate change over the next half-century is likely animal agriculture. The

report's data analysis, based on the work of leading climate scientists, shows that methane sources - not carbon dioxide sources - are the biggest cause of global warming today, and will continue to be for the next 50 years. "This reveals an untapped opportunity to make serious and rapid progress in reducing dangerous global warming trends," said Noam Mohr, author of the report. *World-Wire*, August 29, 2005, <http://www.world-wire.com/news/0829050001.html>

For an online copy of the report visit <http://www.earthsave.org/globalwarming.htm>.

"CO₂ will probably not help to save Venice from the sea." This paper explores the use of CO₂ injection into an aquifer to raise the city of Venice. The paper finds that because of the prevailing ambient conditions in the aquifer phase change of CO₂ cannot be avoided. The ensuing change of specific volume and compressibility will inhibit a uniform uplift pattern which is needed to avoid cracks in historical buildings. This prevents the use of CO₂ in the proposed conditions. *Mechanics Research Communications*, Volume 32, Issue 6, November-December 2005, Pages 617-627, <http://www.sciencedirect.com/science/journal/00936413> (subscription required)

"The impact of carbon sequestration on the production cost of electricity and hydrogen from coal and natural-gas technologies in Europe in the medium term." The economic assessment provided in this study shows that the introduction of carbon sequestration technologies in Europe in 2020, will result in an increase in the production cost of electricity by coal and natural gas technologies of 30–55 percent depending on the electricity-generation technology used; gas turbines will remain the most competitive option for generating electricity; and integrated gasification combined cycle technology will become competitive. When carbon sequestration is coupled with natural-gas steam reforming or coal gasification for hydrogen production, the production cost of hydrogen will increase by 14–16 percent. Furthermore, natural-gas steam reforming with carbon sequestration is far more economically competitive than coal gasification. *Energy*, Volume 30, Issue 14, November 2005, Pages 2672-2689, <http://www.sciencedirect.com/science/journal/03605442> (subscription required)

October 2005

"Spending on environment yields big returns-report." A U.N.-backed report on the social returns of investing in the environment suggests that forests may be more valuable when left standing rather than being cleared for crops because trees can absorb the heat-trapping gases widely blamed for global warming. "The carbon storage or 'sequestration' potential of forests ranges between \$360 and \$2,200 per hectare which makes them worth far more than if they are converted to grazing or cropland," UNEP said. And the study said that it becomes far more cost effective to conserve forests than to clear them once carbon prices exceed \$30 a tonne. *Reuters*, September 14, 2005, <http://www.alertnet.org/thenews/newsdesk/L14643761.htm>

"Integrated climate-change strategies of industrialized countries." This paper provides an overview of the evolving climate-change strategies put in place by industrialized countries to combat climate change and to comply with their quantitative commitments under the Kyoto Protocol. It presents the emerging new and integrated method of climate-policy formulation and implementation based on a portfolio approach, where a mix of policies and measures are selected to help achieve the required emissions reduction. *Energy*, Volume 30, Issue 14, Pages 2523-2758 (November 2005), <http://www.sciencedirect.com/science/journal/03605442> (subscription required)

"Carbon Capture and Storage – Market Opportunities 2005." This report, produced for Scottish Enterprise and the DTI, says Scottish businesses in particular can capitalize on the opportunities presented by the growing need to tackle rising CO₂ emissions from the combustion of fossil fuels. It was commissioned to assess the market opportunities arising from carbon capture and storage in depleted oil and gas fields in the North Sea. *Scottish Enterprise*, September 2005, http://www.scottish-enterprise.com/sedotcom_home/sig/sig-energy/energy-oilandgas/energy-oilandgas-help/energy-oilandgas-research.htm#carbon_capture

November 2005

“CO₂ Price Dynamics: The Implications of EU Emissions Trading for the Price of Electricity.” This study concludes that free allocation of emission allowances is a highly questionable policy option for a variety of reasons and suggests that auctioning is better. *Energy research Centre of the Netherlands (ECN)*, September 2005, <http://www.ecn.nl/docs/library/report/2005/c05081.pdf>

Verification of Tracking System Design for the Regional Greenhouse Gas Initiative. The Environmental Resources Trust released a report on “Verification System Design for RGGR and RGGI.” The Northeast States and several Mid-Atlantic States are currently developing a Regional Greenhouse Gas Registry (RGGR), a policy and accounting framework capable of quantifying and registering greenhouse gas emissions and project-related emission reductions or “offsets.” The goal of the verification system recommended and outlined in this white paper is to provide a high level of data quality assurance to all mandatory, voluntary, and RGGI programs—that will be useful to current and future regulatory efforts—while minimizing both public and private costs. For the full report, visit <http://www.ert.net/pubs.html>

“Multi-gas emission pathways to meet climate targets.” A new study on multi-gas emissions pathways has been accepted by the Journal *Climatic Change* for publication. A free software tool to generate emissions pathways that meet specific climate targets (like 2°C, 400ppm CO₂ equivalence etc.) accompanies this study. To download the paper, visit http://www.up.umnw.ethz.ch/~mmalte/simcap/publications/Meinshausen_etal_Multigas_pathways_rf.pdf. The manual and software tool are available at <http://www.simcap.org> (click on “Models”)

“Transaction and abatement costs of carbon-sink projects in developing countries.” Concerns have been expressed that participation in carbon-sink projects may be constrained by high costs; particularly for projects involving smallholders in developing countries. This paper addresses these issues by reviewing the implications of transaction and abatement costs in carbon-sequestration projects. An approach to estimating abatement costs is demonstrated through four case studies of agroforestry systems located in Sumatra, Indonesia. The paper concludes with recommendations to reduce the disadvantages that smallholders may face in capturing the opportunities offered by carbon markets. *Environment and Development Economics* 10: 597–614, October 2005, <http://journals.cambridge.org/action/displayIssue?jid=EDE&volumeld=10&issueld=05> (subscription required)

“Degassing Lakes Nyos and Monoun: Defusing certain disaster.” Based on 12 years of limnological measurements the authors developed a model of future removal rates and CO₂ inventory, which predicts that in Monoun the current pipe will remove approximately 30 percent of the CO₂ remaining before the natural gas recharge balances the removal rate. In Nyos the single pipe will remove approximately 25 percent of the gas remaining by 2015; this slow removal extends the present risk to local populations. More pipes and continued vigilance are required to reduce the risk of repeat disasters. The model indicates that 75-99 percent of the gas remaining would be removed by 2010 with two pipes in Monoun and five pipes in Nyos, substantially reducing the risks. *PNAS*, October 4, 2005, vol. 102, no. 40, 14185-14190, <http://www.pnas.org/cgi/content/abstract/102/40/14185> (subscription required)

“Secondary forests as temporary carbon sinks? The economic impact of accounting methods on reforestation projects in the tropics.” The authors found that secondary forest becomes economically attractive, if the price of permanent credits is above \$4.5/tCO₂, whereas forest plantations require permanent CER prices of \$7.0/tCO₂. *Ecological Economics*, Volume 55, Issue 3, November 15, 2005, Pages 380-394, <http://www.sciencedirect.com/science/journal/09218009> (subscription required)

“Tillage impacts on soil aggregation and carbon and nitrogen sequestration under wheat cropping sequences.” An experiment conducted in south-central Texas showed that the use of no till farming significantly improved soil aggregation and the sequestration of soil organic carbon and soil organic nitrogen in surface soil, but not subsurface soils. *Soil and Tillage Research*, Volume 84, Issue 1, November 2005, Pages 67-75, <http://www.sciencedirect.com/science/journal/01671987> (subscription required)

December 2005

Special Edition of *Environmental Science & Policy*. The December 2005 issue of the journal *Environmental Science & Policy* focuses on Mitigation and Adaptation Strategies for Climate Change. Articles of interest include: Misdefining “climate change”: consequences for science and action, Defining response capacity to enhance climate change policy, Integrating mitigation and adaptation into climate and development policy, and others. Volume 8, Issue 6, Pages 537-654 (December 2005), <http://www.sciencedirect.com/science/journal/14629011> (subscription required)

“Target 2020: Policies and measures to reduce greenhouse gas emissions in the EU.” According to a new report by the Wuppertal Institute in Germany, the European Union can cut a third of its greenhouse gas emissions by 2020 through energy efficiency and renewable energies, as well as through a strong emissions trading system. The report highlights the concrete steps that the EU should take to cut CO₂ emissions by 33 percent by 2020, even with a moratorium on nuclear energy. The full report and the summary can be downloaded from http://www.panda.org/news_facts/publications/index.cfm?uNewsID=24155

“Key GHG Data.” In this publication the United Nations Climate Change secretariat confirms that developed countries, taken as a group, have achieved sizable emission reductions. Compared to the 1990 levels, overall greenhouse gas emissions of these countries were down 5.9% in 2003. But the secretariat warns that further efforts are required to sustain these reductions and to cut the emissions further. However, Richard Kinley, acting head of the secretariat of the UNFCCC, emphasizes that a large part of these reductions was achieved in the early 1990s in countries of Eastern and Central Europe undergoing transition to a market economy. The report is the first UNFCCC publication covering all GHG data officially submitted by developed and developing countries under the Climate Change Convention. The publication includes data on greenhouse gas emissions from 40 developed and 121 developing countries. For additional information and a link to the full report visit http://unfccc.int/essential_background/background_publications_htmlpdf/items/3604.php

“Evidence and Implications of Recent Climate Change in Northern Alaska and Other Arctic Regions.” This study reviews a broad array of evidence that illustrates the Arctic is undergoing a system-wide response to an altered climatic state. According to the study, new extreme and seasonal surface climatic conditions are being experienced, a range of biophysical states and processes influenced by the threshold and phase change of freezing point are being altered, hydrological and biogeochemical cycles are shifting, and more regularly human sub-systems are being affected. *Climatic Change* (October 2005) Volume 72, Number 3, <http://www.springerlink.com/openurl.asp?genre=article&id=doi:10.1007/s10584-005-5352-2> (subscription required)

January 2006

“The United States Department of Energy's Regional Carbon Sequestration Partnerships program: A collaborative approach to carbon management” This paper reviews the Regional Carbon Sequestration Partnerships (RCSPs) concept, which is a first attempt to bring the US Department of Energy's (DOE) carbon sequestration program activities into the “real world” by using a

geographically-disposed-system type approach for the US Each regional partnership is unique and covers a unique section of the US and is tasked with determining how the research and development activities of DOE's carbon sequestration program can best be implemented in their region of the country. Cost effective capture and separation technology must be developed, tested, and demonstrated; a database of potential sequestration sites must be established; and techniques must be developed to measure, monitor, and verify the sequestered CO₂. Geographical differences in fossil fuel use, the industries present, and potential sequestration sinks across the US dictate the use of a regional approach to address the sequestration of CO₂. To accommodate these differences, the DOE has created a nationwide network of seven RCSPs to help determine and implement the carbon sequestration technologies, infrastructure, and regulations most appropriate to promote CO₂ sequestration in different regions of the Nation. These partnerships currently represent 40 states, three Indian Nations, four Canadian Provinces, and over 200 organizations, including academic institutions, research institutions, coal companies, utilities, equipment manufacturers, forestry and agricultural representatives, state and local governments, non-governmental organizations, and national laboratories. These partnerships are dedicated to developing the necessary infrastructure and validating the carbon sequestration technologies that have emerged from DOE's core R&D and other programs to mitigate emissions of CO₂. The partnerships provide a critical link to DOE's plans for FutureGen, a highly efficient and technologically sophisticated coal-fired power plant that will produce both hydrogen and electricity with near-zero emissions. Though limited to the situation in the US, the paper describes for the international scientific community the approach being taken by the US to prepare for carbon sequestration, should that become necessary. *Environment International*, Volume 32, Issue 1, January 2006, <http://www.sciencedirect.com/science/article/B6V7X-4GRH73K-1/2/484284ed4d6288ebc68ebc05f327f1ab> (subscription may be required)

Energy Information Administration's "Annual Energy Outlook 2006 (Early Release)"

The Annual Energy Outlook 2006 (AEO 2006) presents a midterm forecast and analysis of US energy supply, demand, and prices through 2030. The projections are based on results from the Energy Information Administration's National Energy Modeling System. The AEO 2006 Early Release includes the reference case. The full publication, to be released in early 2006, will include complete documentation and additional cases examining energy markets. December 2005. View this document at: <http://www.eia.doe.gov/oiaf/aeo/carbon.html>

February 2006

"Technological Development and Economic Growth," In conjunction with the Inaugural Ministerial Meeting of the Asia Pacific Partnership on Clean Development and Climate between Australia, China, India, Japan, the Republic of Korea and the United States held January 11-12, the independent government economic research agency the Australian Bureau of Agricultural and Resource Economics (ABARE), published the above-named report. The purpose of the report is to assess the potential economic, environmental and energy consumption effects of possible action on the development and deployment of clean technologies under the Asia Pacific Partnership on Clean Development and Climate. In this report, medium and long-term drivers and projections of energy demand and emissions in the six partnership economies are discussed. The environmental and economic impacts of three alternative scenarios, reflecting enhanced technological development and transfer under the partnership agreement, are considered using ABARE's global trade and environment model (GTEM). The results of the study indicate that potential use of such technologies in the electricity, transport and industry sectors could provide substantial opportunities to curb greenhouse gas emissions in the medium to long term, without hindering the development aspirations of developing countries. *ABARE research report (06.1)*, January 2006, http://www.abare.gov.au/publications/2006/RR06_1_ClimateAsiaPacific.pdf.

March 2006

"Carbon Management Working Group Report for the Advanced Coal Task Force, Western Governors' Association,"

In light of concerns about the potential impacts of anthropogenic greenhouse gas emissions on climate change, the Carbon Management Working Group was established to provide guidance to the Western Governors' Association (WGA). Numerous carbon management opportunities are available to the states included in the WGA. This report discusses methods to store – or “sequester” – carbon captured from power plant emissions, options for advancing the management of captured carbon, and options to offset these emissions. Carbon sequestration has emerged as a key technology pathway to achieve substantial reductions in greenhouse gas emissions at relatively low cost while continuing use of fossil fuel energy supplies. The analysis focuses on the physical, economic and policy requirements necessary to enable carbon sequestration as a carbon management option in the western states. The report looks at the 2005-2020 timeframe and recommends implementation of specific projects along a timeline that would significantly advance carbon sequestration in WGA states. Western states have enormous potential to sequester carbon dioxide; a variety of policy options can better position the West to achieve this potential in the future. Included in the list of contributors are three National Energy Technology Laboratory contributors including: Scott Klara, Sean Plasynski, and Rameshwar Srivastava. January 10, 2006. <http://www.westgov.org/wga/initiatives/cdeac/index.htm>. To view the complete report see: <http://www.westgov.org/wga/initiatives/cdeac/Coal-carbon.pdf>. For Policy recommendations of the Task Force see: <http://www.westgov.org/wga/initiatives/cdeac/Coal-policy.pdf>. For technology options presented by the task force see:

<http://www.westgov.org/wga/initiatives/cdeac/Coal-technology.pdf>.

To download reference documents see: <http://www.westgov.org/wga/initiatives/cdeac/Coal-technology-2015.xls>, <http://www.westgov.org/wga/initiatives/cdeac/Coal-technology-2025.xls>, and <http://www.westgov.org/wga/initiatives/cdeac/Coal-technology-cost.xls>.

“Annual Energy Outlook 2006 (AEO 2006), Full Report,” The Energy Information Administration (EIA) released the *Annual Energy Outlook 2006 (AEO2006)* full report on its website on February 14, 2006. In preparing projections for the *AEO2006*, EIA evaluated a wide range of trends and issues that could have major implications for US energy markets between now and 2030. View the report at: <http://www.eia.doe.gov/oiaf/aeo/index.html>. The AEO Supplemental tables were generated for the reference case of the AEO2006 using the National Energy Modeling System, a computer-based model which produces annual projections of energy markets for 2003 to 2030. Link to the one hundred seventeen Supplemental Tables through: <http://www.eia.doe.gov/oiaf/aeo/supplement/index.html>.

“Agenda for Climate Action.” The Pew Center for Global Climate Change has issued a report that takes a comprehensive look at a suite of climate, energy, and technology policies that could provide reductions in greenhouse gases in the US. The report identifies both broad and specific policies, combining recommendations on economy-wide mandatory emissions cuts, technology development, scientific research, energy supply, and adaptation with critical steps that can be taken in key sectors. Fifteen specific recommendations are given in 6 areas: (1) science and technology, (2) market-based programs, (3) sectoral emissions, (4) energy production and use, (5) adaptation, and (6) international engagement. Geologic carbon sequestration, separation and capture technologies, emissions trading, agricultural sequestration, and other areas are specifically mentioned. February 2006.

Download a brochure listing the recommendations at:

<http://www.pewclimate.org/docUploads/Agenda%5FBrochure%5F2%2E08%2Epdf>.

For the full report see:

http://www.pewclimate.org/global-warming-in-depth/all_reports/agenda_for_climate_action/index.cfm.

“Draft Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2004 (February 2006),” The US Environmental Protection Agency (EPA) released the draft report of US greenhouse gas emissions, summarizing and presenting annual emissions by source category and sector. In 2004, greenhouse gas emissions in the US increased by 1.7 percent from the previous year. Total emissions were equivalent to 7,075 million metric tons for carbon dioxide. The largest source of emissions was fossil fuel combustion, accounting for 80 percent of the total. The report also includes estimates of carbon sequestration in U.S.

forests. See announcements section of this newsletter for information on Public Comments Being Accepted. February 23, 2006. See pdf and html of the draft report at:

<http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>.

“The GHG Protocol for Project Accounting,” World Resources Institute and the World Business Council for Sustainable Development released this protocol in December 2005. The protocol is a tool for determining the greenhouse gas emission reduction benefits of climate mitigation projects. It aims at developing accounting and reporting standards and/or general guidance for both emission reduction and land use, land-use change and forestry (LULUCF) projects. Download at:

<http://www.ghgprotocol.org/plugins/GHGDOC/details.asp?type=DocDet&ObjectId=MTc0MTg>. Also see the Corporate GHG Accounting and Reporting Standard at:

<http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=ODQ5>.

Greenwire, “New Zealand, Sweden, Finland Atop Performance Index,” The pilot 2006 Environmental Performance Index (EPI) was released January 26, 2006. The EPI is a study developed by Yale University and Columbia University in collaboration with the World Economic Forum and the Joint Research Centre of the European Commission. The study ranks 133 countries on 16 indicators tracked in six established policy categories. Within the Sustainable Energy policy category, annual carbon dioxide emissions, measured as metric tons per \$1 million of gross domestic product, average around 363 tons. North Korea, Turkmenistan, Ukraine, Uzbekistan and Mongolia rank at the bottom of the scale, with North Korea at 4,859 tons. Nations with rapid economic expansion, such as China (731 tons) and India (621 tons), emit more than double the world average. The US ranks at 171 tons: behind other major industrial powers such as France (56 tons), Japan (57 tons), Germany (80 tons), Britain (118 tons); closely matching Canada (168 tons); and ahead of Australia (209 tons) and Russia (914 tons). See the full API study and supporting data and documents at <http://www.yale.edu/epi/>. January 30, 2006, http://www.eenews.net/Greenwire/searcharchive/test_search-display.cgi?q=%22Carbon%22&file=%2FGreenwire%2Fsearcharchive%2FNewsline%2F2006%2FJanuary23%2F01230603.htm.

April 2006

“Undeveloped Domestic Oil Resources Provide Foundation For Increasing US Oil Supply.” This Department of Energy, Office of Fossil Energy report provides an estimate of total undeveloped and future technically recoverable domestic oil resources in the US. Undeveloped domestic oil resources still in the ground total more than one trillion barrels. The resource includes undiscovered oil, "stranded" light oil amenable to carbon dioxide enhanced oil recovery (CO₂-EOR) technologies, unconventional oil and new petroleum concepts. This assessment originally examined the resource potential for applying state-of-the-art CO₂-EOR technologies in only six basins/areas of the United States. It did not include the additional resource potential outlined in the ten basin-oriented assessments, or the recoverable resources from residual oil zones, as discussed in related reports issued by the Department of Energy in February 2006. February 2006,

http://www.fossil.energy.gov/programs/oilgas/eor/Undeveloped_Domestic_Oil_Resources_Provi.html.

“Stranded Oil in the Residual Oil Zone.” Five reports on Stranded Oil in the Residual Oil Zone introduce one of the most exciting new, unconventional oil resources that can be added to the US domestic oil resource base. This is "stranded (or residual) oil" in the transition zone below the traditional oil-water contact that exists in many domestic oil reservoirs. This resource has not previously been included in any official domestic oil resource databases. Work was undertaken in three U.S. oil basins—the Permian, Williston and Big Horn—to more rigorously define the size and potential of this new resource, and how much may be recoverable using carbon dioxide enhanced oil recovery techniques.

February 2006,

http://www.fossil.energy.gov/programs/oilgas/eor/Stranded_Oil_in_the_Residual_Oil_Zone.html.

“Game Changer Improvements Could Dramatically Increase Domestic Oil Resource Recovery.”

This report illustrates that the wide-scale implementation of "next generation" carbon dioxide enhanced oil recovery (CO₂-EOR) technology advances have the potential to increase domestic oil recovery efficiency from about one-third to over 60 percent, doubling the technically recoverable resources in six domestic oil basins/areas studied to date. Application of next generation CO₂-EOR technologies extrapolated to other U.S. oil basins and regions could bring about truly "game changing" advances in oil recovery efficiency and domestic oil production. February 2006,

http://www.fossil.energy.gov/programs/oilgas/eor/Game_Changer_Oil_Recovery_Efficiency.html.

“Voluntary Reporting of Greenhouse Gases 2003 – Summary.”

The Energy Information Administration has released the report for the 2003 reporting year under the Voluntary Reporting of Greenhouse Gases Program, required by Section 1605(b) of the Energy Policy Act of 1992. Two hundred thirty-four U.S. companies and other organizations reported 2,188 projects to reduce or sequester greenhouse gases with reductions of: 268 million metric tons carbon dioxide equivalent of direct reductions, 81 million metric tons of indirect reductions, 7 million metric tons of reductions from carbon sequestration, and 16 million metric tons of unspecified reductions. Total US greenhouse gas emissions in 2003 are estimated at 6,936 million metric tons carbon dioxide equivalent. March 2006. Download pdf or html files at: <http://www.eia.doe.gov/oiaf/1605/vrrpt/summary/index.html>.

“Energy Market Impacts of Alternative Greenhouse Gas Intensity Reduction Goals.” The Energy Information Administration (EIA) released this report in response a request from Senator Ken Salazar that the EIA analyze the impacts of implementing alternative variants of an emissions cap-and-trade program for greenhouse gases. March 8, 2006,

[http://www.eia.doe.gov/oiaf/servicept/agq/pdf/sroiaf\(2006\)01.pdf](http://www.eia.doe.gov/oiaf/servicept/agq/pdf/sroiaf(2006)01.pdf).

May 2006

“Coal: America’s Energy Future, Volume I, The National Coal Council, March 2006.” US Secretary of Energy Samuel W. Bodman requested the National Coal Council to conduct a study and assemble a report identifying the challenges and opportunities of more fully exploring US coal resources to meet the national’s future energy needs. Included in the report are information and overviews of near-zero emissions power generation technology, FutureGen, carbon capture and storage, enhanced oil and gas recovery, carbon dioxide pipelines, the Carbon Sequestration Regional Partnerships, and global carbon sequestration programs. March 2006, <http://nationalcoalcouncil.org/report/NCCReportVol1.pdf>.

“Voluntary Reporting of Greenhouse Gases 2004.” The Voluntary Reporting of Greenhouse Gases Program, required by Section 1605(b) of the Energy Policy Act of 1992, records the results of voluntary measures to reduce, avoid, or sequester greenhouse gas emissions. For the 2004 reporting year, 226 US companies and other organizations reported to the Energy Information Administration (EIA) that they had undertaken 2,154 projects to reduce or sequester greenhouse gases in 2004. The reported greenhouse gas emission reductions for the projects reported included 277 million metric tons carbon dioxide equivalent (million MTCO₂e) of direct reductions, 92 million MTCO₂e of indirect reductions, 7 million MTCO₂e of reductions from carbon sequestration, and 14 million MTCO₂e of unspecified reductions. Total U.S. greenhouse gas emissions in 2004 are estimated at 7,122 million MTCO₂e. [http://www.eia.doe.gov/oiaf/1605/vrrpt/pdf/0608\(04\).pdf](http://www.eia.doe.gov/oiaf/1605/vrrpt/pdf/0608(04).pdf).

“Seismic Imaging for Site Selection and Monitoring of Carbon Dioxide Sequestration Part 2—Laboratory Studies.”

This is the second in a two part series from *GasTips*, a publication of Gas Technology Institute, the US Department of Energy and Hart Energy Publishing which covers technology developments in natural gas exploration, production and processing. The Gas Technology Institute, with

support from the Illinois Clean Coal Institute and cooperation of the Illinois State Geological Survey, designed and implemented a comprehensive research project aimed at determining the viability of seismic techniques for site selection and monitoring of carbon dioxide sequestration in Illinois coal seams. Read details of the studies starting on page 2 of the pdf file of the Winter 2006 *GasTips*, which is available at: <http://www.netl.doe.gov/technologies/oil-gas/publications/GasTIPS/GasTIPS-Winter2006.pdf>.

"Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2004. April 2006." After gathering comments from a broad range of stakeholders around the country, the US Environmental Protection Agency has published the "Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2004." The report analyzes the sources of greenhouse gas emissions. It shows that both methane and nitrous oxide emissions have decreased from 1990 levels by 10 percent and two percent, respectively. Overall, greenhouse gas emissions during 2004 increased by 1.7 percent from the previous year. This increase, which occurred during a period of economic expansion, was due primarily to an increase in carbon dioxide emissions associated with fuel and electricity consumption. Fossil fuel combustion was the largest source of emissions, accounting for 80 percent of the total. While the US economy expanded by 51 percent from 1990 to 2004, emissions have grown by only 15.8 percent over the same period. This report is the latest in an annual set of reports that the US submits to the Secretariat of the United Nations Framework Convention on Climate Change, which sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. Read a press release at: <http://yosemite.epa.gov/opa/admpress.nsf/68b5f2d54f3eefd28525701500517bf/7510b703526bc37b85257153006e5add!OpenDocument>. April 2006. Download a pdf file of the complete report, or sections of the report at: <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2006.html>.

"The Climate Action Team Report to Governor Schwarzenegger and the Legislature." The California Climate Action Team (CAT) has released a report that recommends a wide range of measures to reduce greenhouse gas emissions in California by approximately 30% by 2020. The final report was released on April 3. The CAT Report recommends 46 specific strategies to reduce greenhouse gas emissions in California, including implementation of the California Solar Initiative, development of alternative fuels, forest conservation measures, and intelligent transportation systems. Combined with emission reduction efforts already underway, these new strategies would help the state meet the Governor's targets in 2010 (approximately 60 million tons CO₂ equivalent in emission reductions) and 2020 (approximately 175 million tons CO₂ equivalent in emission reductions). To view the final 2006 Climate Action Team Report to Governor Schwarzenegger and the Legislature, and other supporting documents, see: http://www.climatechange.ca.gov/climate_action_team/reports/index.html.

Greenwire, "Draft World Bank Report Emphasizes Technology to Curb Emissions."

The World Bank has released their draft report "Clean Energy and Development: Towards an Investment Framework," intended to assist developing nations in accessing sustainable energy sources to fuel economic growth and reduce poverty. The report, which was requested by G8 leaders at their meeting in Scotland in 2005, will be discussed at the development committee forum of the World Bank and International Monetary Fund meeting on April 23 in Washington, DC. The report says that the development and use of new energy technologies are key to mitigating global warming. The draft recommends integrated gasification combined cycle (IGCC) with carbon capture and storage (CCS), afforestation, and a decrease in deforestation, among other measures. The draft also states that research, development and demonstration are needed to further improve technologies in certain areas including IGCC with CCS. The draft also calls for detailed financing plans on clean energy projects and climate mitigation, and to be prepared quickly for the World Bank's September 2006 annual meeting. Some experts say that the draft does not go far enough in recommending new ways to address climate change, and that the report recommends technologies that are too expensive for developing nations. The World Bank spokesperson declined to comment on the draft, saying only that the final version will be

available the week of April 17. Download the draft April 5, 2006 report as a pdf file here:

[http://siteresources.worldbank.org/DEVCOMMINT/Documentation/20890696/DC2006-0002\(E\)-CleanEnergy.pdf](http://siteresources.worldbank.org/DEVCOMMINT/Documentation/20890696/DC2006-0002(E)-CleanEnergy.pdf).

April 14, 2006, <http://www.eenews.net/Greenwire/2006/04/14/#10>. (Subscription may be required to access news story.)

“Benchmarking Air Emissions of the 100 Largest Electric Power Producers in the United States – 2004. April 2006.” The 2006 Benchmarking report is the fifth collaborative effort among Ceres, the Natural Resources Defense Council (NRDC) and Public Service Enterprise Group (PSEG) highlighting environmental performance and progress in the nation’s electric power sector. The Benchmarking series began in 1997 and uses publicly reported data to compare the emissions performance of the 100 largest power producers (producers) in the United States. The current report is based on 2004 generation and emissions data. These producers include public and private entities that own nearly 2,000 power plants and account for 88 percent of reported electric generation and 89 percent of the industry’s reported emissions. The report focuses on four power plant pollutants for which public emissions data are available: sulfur dioxide (SO₂), oxides of nitrogen (NO_x), mercury (Hg), and carbon dioxide (CO₂). Since 1990, power plant emissions of SO₂ and NO_x have decreased and CO₂ emissions have increased. CO₂ emissions are not regulated at the federal level. In 2004, power plant CO₂ emissions were 27 percent higher than they were in 1990. The report predicts a bigger increase in the years ahead due to an unprecedented surge of new US coal-plant proposals that would emit substantially more CO₂ than other sources generating the same amount of power. There are currently more than 130 new coal plants proposed across the US, and the Energy Information Administration (EIA) projects a 66 percent increase in coal-based power production and a 43 percent increase in CO₂ emissions by 2030. The EIA projection assumes no controls on CO₂ emissions at the power plants. To download the report, see: http://www.ceres.org/pub/docs/Ceres_bnmrkng_electric_2004_0406_full.pdf. Also see <http://www.nrdc.org/air/pollution/benchmarking/default.asp> to download supporting data tables.

“Carbon Capture and Storage: A Consultation on Barriers to Commercial Deployment.” The United Kingdom HM Treasury has released a consultation report on carbon capture and storage (CCS) that invites answers to questions that aim to establish the extent to which there are barriers to commercial deployment and whether and how these could be addressed. Specifically, the consultation aims to build understanding on: the current state and future development of CCS technologies and the likely costs attached to deploying them commercially; the potential carbon savings available from CCS; the barriers which currently exist to further development and commercial deployment; and whether there is a case for government intervention and, if called for, the forms this might take. Responses to the document are accepted until May 11, 2006. March 2006, http://www.hm-treasury.gov.uk/budget/budget_06/other_documents/bud_bud06_odcarbodb.cfm.

June 2006

“Carbon Sequestration Project Portfolio 2006.” 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 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 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_portfolio3/table_contents.pdf.

“Canada’s CO₂ Capture & Storage Technology Roadmap (CCSTRM).” Natural Resources Canada has released Canada’s Carbon Dioxide (CO₂) Capture & Storage Technology Roadmap. The CCSTRM

seeks to establish a robust architecture for addressing the technical risks and economic costs, with scientific understanding of geological, geotechnical, reservoir management, and engineering aspects of CO₂ capture and storage. The CCSTRM (March 2006) is available for download at:
http://www.nrcan.gc.ca/es/etb/cetc/combustion/co2trm/htmldocs/co2trm_e.html.

“Carbon Dioxide Capture and Geologic Storage: A Core Element of a Global Energy Technology Strategy to Address Climate Change.” The findings presented in this report stem from more than ten years of research at Battelle’s Joint Global Change Research Institute (JGCRI) to better understand the significant potential of carbon dioxide capture and storage (CCS) technologies in addressing climate change. A significant portion of the research was supported by the National Energy Technology Laboratory. A central focus of this report is on actions that will allow CCS technologies to transition from their current status as potential solutions to climate change to the point where these systems are deployed widely and have become safe, effective, and trusted cornerstones of the global energy system. This report was presented by the lead author of the report and Senior Scientist at JGCRI, James J. Dooley, at the Fifth Annual Conference on Carbon Capture and Sequestration in Alexandria, Virginia, held May 8-11, 2006. To read the full report, see:
http://www.battelle.org/news/06/CCS_Climate_Change06.pdf. To obtain a hard copy of the report, contact Jim Dooley via email at: dooleyj@battell.org. To read the May 10, 2006 press release regarding key points of the report see: <http://www.battelle.org/news/06/05-10-06ClimateChange.stm>.

“Los Alamos Energy Security, Los Alamos National Laboratory, The Carbon Sequestration Issue, Winter, 2006, Vol. 2. No. 1.” *Los Alamos Energy Security*, produced by Los Alamos National Laboratory’s Office of Energy and Environmental Initiatives, presents energy issues of critical national and global importance and highlights the Laboratory’s energy security research and development. The Winter 2006 issue covered various Carbon Sequestration projects, technologies, publications, events, and websites. To download a pdf of the publication see:
http://www.lanl.gov/energy/energysecurity/LANL_energysecurity2_1_hi.pdf.

July 2006

“Annual European Community Greenhouse Gas Inventory 1990-2004 and Inventory Report 2006.” This report is the annual submission of the greenhouse gas inventory of the European Community to the United Nations Framework Convention on Climate Change. It presents greenhouse gas emissions between 1990 and 2004 by individual Member State and by economic sector. The report shows that, between 2003 and 2004, emissions in the 15 pre-2004 Member States increased by 11.5 million tons, or 0.3% and total EU emissions increased by 0.4%. (Technical Report number 6/2006.) To view the abstract, or link to the tab with the content of the report and all annexes, see:
http://reports.eea.europa.eu/technical_report_2006_6/en.

“International Energy Outlook 2006.” The International Energy Outlook 2006 (IEO2006) presents an assessment by the US’s Energy Information Administration (EIA) of the outlook for international energy markets through 2030. US projections appearing in IEO2006 are consistent with those published in EIA’s Annual Energy Outlook 2006 (AEO2006), which was prepared using the National Energy Modeling System (NEMS). The report also provides projections of energy-related carbon dioxide emissions by country, region, and fuel type. World carbon dioxide emissions continue to increase steadily in the IEO2006 reference case, from 25.0 billion metric tons in 2003 to 33.7 billion metric tons in 2015, and 43.7 billion metric tons in 2030. June 20, 2006. To view the webpage where the report or chapters of the report, including chapter 7: “Energy-Related Carbon Dioxide Emissions,” can be downloaded, see:
<http://www.eia.doe.gov/oiaf/ieo/index.html>.

“Advice on a Long-term Strategy on Energy and Climate Change.” Canada’s National Round Table on the Environment and the Economy has released a report of key findings derived from an examination of a 2050 scenario developed by energy consultants ICF International. The June 2006 document

addresses opportunities and challenges facing Canada in relation to its long-term energy and climate change future. Specifically, it deals with how to, by 2050: 1.) meet the energy needs of a growing economy, 2.) achieve substantial reductions in carbon emissions, and 3.) improve the quality of Canada's air. Carbon capture and sequestration in the oil and gas sector is one of the strategic priorities named in the report. To read the report in html format, see: http://www.nrtee-trnee.ca/eng/programs/Current_Programs/Energy-Climate-Change/EEC-Wedge-Advisory-Note/ECC-Wedge-advisory-note_Section-1_e.htm. To download the pdf format of the report, click: http://www.nrtee-trnee.ca/eng/programs/Current_Programs/Energy-Climate-Change/EEC-Wedge-Advisory-Note/final_advisory%20note%20energy%20and%20climate%20change%20strategy-15-June-2006_e.pdf.

“The Carbon Boom: National and State Trends in Carbon Dioxide Emissions Since 1960.” Twenty-eight states more than doubled their carbon dioxide (CO₂) emissions between 1960 and 2001, according to a new analysis of government data released by the watchdog group US Public Interest Research Group (US PIRG). They state that increased combustion of oil to fuel cars and light trucks, and coal for electricity drove the steep rise in emissions. Using data compiled by the US Department of Energy's Oak Ridge National Laboratory, their report examines trends in carbon dioxide emissions and fossil fuel combustion nationally, regionally, and by state between 1960 and 2001, the most recent year for which state-by-state data are available. To download the pdf file of the June 2006 report, or view the news release or report summary, see: <http://uspirg.org/uspirnnewsroom.asp?id2=24976>.

“Clean Energy, a Strong Economy and a Healthy Environment.” In this report, the Western Governors' Association's Clean and Diversified Energy Advisory Committee reported its recommendations to the Governors (June 21, 2006). The Governors adopted a policy resolution that incorporated many of the recommendations aimed at bringing on-line 30,000 Megawatts of clean energy by 2015, increasing energy efficiency 20 percent by 2020 and providing adequate transmission for the region. (See this newsletter's Legislative Activity section for the related article: **Western Governor's Association Press Release, “Western Governors Adopt Policies on Clean, Diversified Energy, Global Climate Change and Transportation Fuels.”**) To download the report, go to: <http://www.westgov.org/wga/initiatives/cdeac/CDEAC06.pdf>.

“Surface Temperature Reconstructions for the Last 2,000 Years (2006).” In response to a request from Congress, this National Academy of Science (NAS) report assesses the state of scientific efforts to reconstruct surface temperature records for the Earth over approximately the last 2,000 years and the implications of these efforts for our understanding of global climate change. Because widespread, reliable temperature records are only available for the last 150 years or so, scientists estimate temperatures in the more distant past by analyzing "proxy evidence," which includes tree rings, corals, ocean and lake sediments, cave deposits, ice cores, boreholes, and glaciers. Starting in the late 1990s, scientists began using sophisticated methods to combine proxy evidence from many different locations in an effort to estimate surface temperature changes during the last few hundred to few thousand years. This report concludes that large-scale surface temperature reconstructions are important tools in our understanding of global climate change that allows the NAS to state, with a high level of confidence, that global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding four centuries. The report says less confidence can be placed in large-scale surface temperature reconstructions for the period from A.D. 900 to 1600, although available proxy evidence indicates that temperatures at many, but not all, individual locations were higher during the past 25 years than during any period of comparable length since A.D. 900. It also concludes that very little confidence can be assigned to statements concerning the hemispheric mean or global mean surface temperature prior to about A.D. 900, primarily because of the scarcity of precisely dated proxy evidence. To view this report or sections of it online, go to: <http://www.nap.edu/catalog/11676.html>. To download a shorter briefing, go to: http://dels.nas.edu/dels/rpt_briefs/Surface_Temps_final.pdf. (Also see this newsletter's Science section for a related item: *Greenwire*, “National Academy of Science Finds ‘Hockey Stick’ Graph's Conclusion

'Plausible' ” and *The National Academies Press Release*, “ ‘High Confidence’ That Planet Is Warmest in 400 Years; Less Confidence in Temperature Reconstructions Prior to 1600.”)

August 2006

Senator Jeffords Press Release, “Jeffords Introduces Landmark Legislation to Reduce Greenhouse Gas Pollution” and the text of Bill S 3698. On July 20, US Senator Jim Jeffords (Independent-VT) and ranking member of the Senate Environment and Public Works Committee, introduced the Global Warming Pollution Reduction Act (Bill S 3698). Senator Barbara Boxer (D-CA) is the bill's lead co-sponsor. The Act would require a reduction of CO₂ emissions levels in the US to 1990 levels, between 2010 and 2020. By 2030, the US must reduce its emissions by one-third of 80 percent below 1990 levels, by 2040 by two-thirds of 80 percent below 1990 levels, and by 2050, to 80 percent below 1990 levels. The reductions are required by power plants, automobiles and carbon intensive businesses. The Environmental Protection Agency (EPA) will be the administrator of the Act. Additional reductions may be required if global atmospheric concentrations exceed 450 parts per million or the average global temperatures increase above 3.6 degrees Fahrenheit above the pre-industrial average. Section 707 of the act outlines vehicle-specific heightened emissions standards beginning in model year 2016. Section 709 of the Act requires establishment of a low-carbon generation trading project for electric energy owner and operators. Section 710 outlines aspects of a geological carbon dioxide sequestration project competitive grant program. Section 711 would allow for the EPA to conduct research and development in conjunction with other agencies (NOAA, NASA and DOE) on global climate change standards to: help develop measurements, standards, and procedures for reducing CO₂, to monitor CO₂, to establish baseline measurement, and to assist in developing improved industrial processes to reduce global warming pollution. The National Academy of Sciences would report to EPA and the Congress to determine whether the goals of the Act have been met. Section 714 of the Act also states that the Secretary of Agriculture is to set up provisions for above-ground and below ground biological carbon sequestration. To view a copy of the bill, and more of its provisions, see: http://jeffords.senate.gov/climate_bill_final.pdf. To view Senator Jeffords' Congressional Record statement on the bill, see: <http://jeffords.senate.gov/climaterecordsstatement.pdf>. For a brief description of some of the bill's provisions, see: http://jeffords.senate.gov/climate_bill_summary.pdf. For a summary of the bill, see: http://jeffords.senate.gov/climate_bill_provisions.pdf. July 20, 2006, <http://jeffords.senate.gov/~jeffords/press/06/07/072006climatebill.html>.

“Ohio Climate Roadmap-Part 2. June 2006.” The Ohio Environmental Council, an Ohio environmental conservation group, issued a 65-point action plan for how Ohio can combat global warming, yet strengthen its industries of agriculture, coal, and manufacturing. The report emphasizes that Ohio industry is well positioned to be a major supplier of the technology necessary to reduce greenhouse gas emissions. Carbon dioxide (CO₂) reduction efforts recommended include: converting crop farms from conventional to conservation tillage (no till) and maintaining Ohio's existing forest coverage (estimated reduction of CO₂: 39 million tons per year, through 2030); and phasing in the replacement of Ohio's conventional coal-burning power plants with coal-gasification power plants that capture and store carbon emissions (estimated reduction of CO₂ from year 2000 emission levels: up to 104 million tons per year). To read more, see: http://www.theoec.org/hottopics_pressroom.html or download the report in full at: http://www.theoec.org/pdfs/pressrelease/hottopics_pr_roadmap2.pdf.

“US Carbon Dioxide Emissions from Energy Sources 2005 Flash Estimate.” US carbon dioxide emissions from burning fossil fuels increased by 0.1 percent in 2005, from 5,903 million metric tons of carbon dioxide (MMTCO₂) in 2004 to 5,909 MMTCO₂ in 2005, according to preliminary estimates released by the Energy Information Administration (EIA). The 2005 emissions increase was the third smallest during the 1990 to 2005 period, exceeding only the emissions declines recorded in 1991 and 2001. Total US energy-related carbon dioxide emissions have grown by 18.4 percent between 1990 and 2005. Energy-related carbon dioxide emissions account for over 80 percent of US greenhouse gas emissions. This flash estimate data is based on data published in the Energy Information

Administration's Monthly Energy Review (May 2006). These estimates are considered to be preliminary. More detailed estimates of Greenhouse Gas Emissions from all sources, energy and non-energy, will appear in the report Emissions of Greenhouse Gases in the United States, 2005, which is scheduled to be released in November 2006. To read the press release, see:
<http://www.eia.doe.gov/neic/press/press272.html>. June 28, 2006,
<http://www.eia.doe.gov/oiaf/1605/flash/flash.html>.

Legislative Activity

September 2005

Bush Signs Energy Bill. At a bill-signing ceremony at the Energy Department's Sandia National Laboratories on August 8th, President Bush signed the energy bill into law. Bush said the new energy policy will go a long way toward weaning Americans off imported oil by encouraging the domestic production of oil and natural gas and greater use of cleaner-burning, domestic energy sources, including cleaner burning coal. "Bush Signs Energy Bill, Cheers Steps Toward Self-Sufficiency," *Washington Post*, August 9, 2005, <http://www.washingtonpost.com/wp-dyn/content/article/2005/08/08/AR2005080800124.html>

"New Rules Could Allow Power Plants to Pollute More." The Bush administration has drafted regulations that would fundamentally alter the limits placed on air emissions from older, less efficient coal-fired power plants. The draft rules, obtained by the Washington Post, take the position that decisions on whether a plant complies with the regulations after modernization should be based on how much pollution it could potentially emit per hour, rather than the current standard of how much it pollutes annually. *Washington Post*, August 31, 2005, <http://www.washingtonpost.com/wp-dyn/content/article/2005/08/30/AR2005083001949.html>

October 2005

U.S. Senate Energy Committee Holds Climate Hearing. On September 20, the Senate Committee on Energy and Natural Resources held a full committee hearing titled "Climate Change Science and Economics." Chairman Pete Domenici (R-NM) said, "I am pleased that the committee is continuing its discussion on climate change. It is clear that something is happening with the Earth's climate. I am aware that many in the scientific community are warning us that something needs to be done. I am also aware that there are equally qualified members of the scientific community who do not share those views. Nevertheless, I believe that it is prudent to heed the warnings we are hearing and begin to find ways of alleviating the human contribution to climate change. With this hearing, we will continue the search for meaningful, economically feasible answers that will produce real reductions in greenhouse gas emissions." To read the witness testimonies, visit the U.S. Senate Energy Committee website at http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Hearing&Hearing_ID=1496

November 2005

"House Climate Stewardship Act of 2005 Cosponsorship Now at 106." As of October 20, the number of cosponsors of the House Climate Stewardship Act of 2005 (HR 759), introduced by Rep. Wayne Gilchrest (R-MD) on February 10, 2005, has risen from the original 25 to 106. The eight cosponsors signing on after the August Congressional recess are Representatives Brady (D-PA), Payne (D-NJ), Capuano (D-MA), Velazquez (D-NY), Meehan (D-MA), Cleaver (D-MO), Sherman (D-CA), and Schwartz (D-PA), with Rep. Schwartz being the most recent cosponsor. The purpose of the bill is to provide for a program of scientific research on abrupt climate change, to accelerate the reduction of greenhouse gas emissions in the United States by establishing a market-driven system of GHG tradable,

reduce dependence upon foreign oil, and ensure benefits to consumers from the trading in such allowances. *EESI – Climate Change News*, October 21, 2005, <http://www.eesi.org/publications/Newsletters/CCNews/10.21.05%20CCNews.htm>

Kucinich Demands White House Documents On Climate Change. In the wake of a devastating hurricane season, Congressman Dennis J. Kucinich (D-OH) introduced a Resolution of Inquiry (H. Res. 515) demanding that the White House submit to Congress all documents in their possession relating to the anticipated effects of climate change on the coastal regions of the United States. The Kucinich Resolution is co-sponsored by 150 Members of Congress. A Resolution of Inquiry is a rare House procedure used to obtain documents from the Executive Branch. Under House rules, Kucinich's resolution is referred to committee, and action must be taken in committee within 14 legislative days. October 27, 2005, Rep. Kucinich, <http://kucinich.house.gov/News/DocumentSingle.aspx?DocumentID=36282>

December 2005

“Lugar-Biden Initiative Calls For American Leadership on Climate Change.” On November 11th U.S. Senator Joe Biden (D-DE) joined with Dick Lugar (R-IN) to introduce a Senate Resolution calling for the United States to return to international negotiations on climate change. The Lugar-Biden Climate Change Resolution also proposes an official Senate Observer Group to ensure bipartisan Senate support for any new agreements. If adopted, this resolution will replace the last major statement of the Senate's position on international climate change which was made back in 1997, prior to the Kyoto Protocol. *Press Release*, November 15, 2005, <http://biden.senate.gov/newsroom/details.cfm?id=248835&&>

“Committee Defeats Resolution of Inquiry.” On November 9, the House Science Committee defeated a resolution of inquiry that would have required the Administration to provide to Congress, within 14 day of enactment, all documents related to “the effects of climate change on the coastal regions of the United States” produced by the National Aeronautics and Space Administration, National Weather Service, National Science Foundation, National Oceanic and Atmospheric Administration, National Assessment Synthesis Team, and the U.S. Geological Survey. The resolution, which was introduced by Representative Dennis Kucinich (D-OH), was defeated 11 to 16 and, by voice vote, was reported from Committee adversely. It will not be brought before the full House. *House Committee on Science*, November 9, 2005, <http://www.house.gov/science/press/109/109-159.htm>

January 2006

Commonwealth of Massachusetts Press Release, “Romney Announces Strict New Clean Air Regulations to Take Effect January 1,” Massachusetts Governor Mitt Romney announced that strict state limitations on carbon dioxide (CO₂) emissions will take effect on January 1, 2006. Massachusetts is the first and only state to set CO₂ emissions limits on power plants, doing so in 2001. The limits, which target the six largest and oldest power plants in the state, are designed to lower emissions of nitrogen oxides, sulfur dioxide and mercury from power plant smokestacks. The draft regulations were announced December 7, and reaffirm the existing CO₂ limits. The press release states that the limits contain protections against excessive price increases for businesses and consumers. Power generation companies can implement CO₂ reductions at their own facilities, or fund other reduction project off-site through a greenhouse gas offset and credits program. The new regulations propose a two-tiered system of “triggers and safety valves.” Plants will be able to do offset project in the Northeast region, to keep technology development and environmental benefits closer to home. If the price of available offsets reaches \$6.50/ton of emissions for 12 months, firms would then be able to shop for offsets anywhere in the world. If offsets rise to \$10.00/ton, firms are allowed to meet their emissions obligations by paying into the state's Greenhouse Gas Expendable Trust, used by the state to purchase new offsets or invest

in GHG reduction technology. December 7, 2005,

http://www.mass.gov/portal/site/massgovportal/menuitem.b6302844a78a31c14db4a11030468a0c/?pageID=pressreleases&agId=Agov2&prModName=gov2pressrelease&prFile=gov_pr_051207_7_29_regs.xml

February 2006

Washington Post, "States Adopt California's Greenhouse Gas Limits," On December 30th, Massachusetts joined Oregon, Connecticut and five other states that adopted California's tough greenhouse gas rules, limiting the amount of carbon dioxide and other gases that can be emitted from vehicle tailpipes. The new rules supplement federal exhaust standards already in place. States which have adopted the rules are: Vermont (Nov. 7), Maine (Dec. 1), Connecticut (Dec. 20), New Jersey (Dec. 20), Rhode Island (Dec. 22), New York (Dec. 22), Oregon (Dec. 22, temporarily adopted with 180 days for Oregon Environmental Quality Commission to approve permanently), and Massachusetts (Dec. 30). Every major automaker is suing to have the rules overturned. Automakers feel that the carbon dioxide regulations are so strict that they would cause extensive design changes in new vehicles that will increase prices, affecting new car sales. The California rule, which was approved by a state environmental board in 2004, and with approval by the federal government, would take effect for model year 2009. It requires a 30 percent reduction in greenhouse gases by 2016. Automakers are countering with a proposed 10 percent reduction in carbon dioxide emitted in vehicle production by 2012, and are not supporting restrictions on emissions from vehicle tailpipes. Some state regulators also fear that the forthcoming study by the National Resource Council, due out this month, may be used by Congress to limit states' ability to join the California program. In a statement the EPA said it favors other methods of lower carbon dioxide besides regulating tailpipe emissions. It stated, "The only way to cut [carbon dioxide] emissions is through drastic increase in fuel economy—which in the past has led to smaller, lighter, and less-safe vehicles." EPA must issue a waiver before any of California's greenhouse gas regulations can go into effect. If California is permitted to impose new regulations, the Clean Air Act allows other states with poor air quality to adopt California's rules after Agency approval. January 3, 2006, <http://www.washingtonpost.com/wp-dyn/content/article/2006/01/02/AR2006010201467.html>

Boston Globe, "Big Gaps in State's Plans for Emissions," Governor Mitt Romney is advocating for changes to Massachusetts' plan to limit greenhouse gas emissions from power plants in the state, which went into effect January 1, 2006. The governor's proposed changes would allow for offsets to be purchased by power plants from anywhere worldwide, compensating for excess emissions from their facilities. State officials do not have a blueprint for administration of the complex program, including penalties. Environmental critics say that language Romney is advocating for creates a loophole. Instead of requiring projects to be "enforceable" and "permanent", Romney wants them to be "enforceable as a practical matter," and "permanent to the maximum extent enforceable." The governor announced his proposed changes in December 2005, just days before the state pulled out of the Regional Greenhouse Gas Initiative (RGGI). State officials will accept public comments until early March 2006. The state's plan applies to the state's six oldest power plants, which account for 70 percent of the greenhouse gases emitted by all 32 plants in the state. According to the plan, limits are being phased in, with the caps that began in January 2006. Tighter restrictions begin in 2008, though plants could exceed limits if they purchase offsets. Robert W. Gollidge Jr., the state Department of Environmental Protection commissioner said that the plan will cost over \$750,000 each year to run, and require two full time employees, with verifying and monitoring off-sets to be contracted out to private companies. Under Romney's proposal, plants would have to keep offset projects in the northeastern United States until the price to offset a ton of carbon dioxide emissions reached \$6.50 for more than 12 months. If the price of offsets continued to rise to \$10 a ton for 12 months, companies could opt out of buying offsets and instead pay the amount into a fund that would also go toward efforts to reduce CO₂. Romney said this "safety valve" is needed to keep energy costs from rising too high. January 17, 2006, http://www.boston.com/news/local/massachusetts/articles/2006/01/17/big_gaps_in_states_plans_for_emissions/

Greenwire, State-led Coalition Urges Appellate Court to Overturn GHG 'Nuisance' Opinion, A coalition of eight states, New York City and environmental groups are in the process of reviving litigation aimed at forcing five of the largest electric power companies to adopt greenhouse gas limits. The group, consisting of California, Connecticut, Iowa, New Jersey, New York, Rhode Island, Vermont, Wisconsin, New York City and the Open Spaces Coalition, lost a lawsuit this past summer in federal district court. The group argues that CO₂ emissions create a public nuisance covered under common law, and are bringing a case against power plants owned and operated by American Electric Power Co., Southern Co., Tennessee Valley Authority, Xcel Energy Inc. and Cinergy Corp. US District Court Judge Loretta Preska dismissed the case in August of 2005, on the grounds that the claims raised broad "political questions" that can only be addressed by Congress or the executive branch. The group filed a brief on December 15, 2005 with the 2nd US Circuit Court of Appeals (2nd Circuit) in New York City, citing precedents set by both the Supreme Court and 2nd Circuit that do not set such restrictive limits on a lawsuit when politics also surround an issue. Environmentalists, led by the Natural Resources Defense Council, also filed a separate eighty-page petition. In both briefs, the coalition maintains that they have standing to bring the case, and that the court can order the utilities to lower their emissions of greenhouse gases. Lawyers for the electric utility have until January 30, 2006 to respond to the group's arguments, and a panel of three judges will be named to hear the case. (To see the states' brief go to: <http://www.eenews.net/Greenwire/Backissues/images/010406gwr1.pdf> For US District Court Judge Loretta Preska's opinion go to: <http://www.eenews.net/Greenwire/Backissues/images/091505gwr2.pdf> For the environmentalist's brief go to: <http://www.eenews.net/Greenwire/Backissues/images/010406gwr5.pdf>.) January 4, 2006, http://www.eenews.net/Greenwire/searcharchive/test_search_display.cgi?q=carbon&file=%2FGreenwire%2Fsearcharchive%2FNewsline%2F2006%2FJanuary4%2F01040606.htm (subscription may be required)

March 2006

White House Press Release, "State of the Union: The Advanced Energy Initiative," In his State of the Union Address, President Bush outlined the Advanced Energy Initiative, which provides for a 22% increase in clean-energy research at the Department of Energy (DOE). The President stated that the best way to break the addiction to foreign oil is through new technologies, including advanced energy technologies. The Initiative will accelerate technology in two vital areas: how the US powers homes and businesses, and how it powers its automobiles. Within the Advanced Energy Initiative is the Coal Research Initiative. As part of the National Energy Policy, the President committed \$2 billion over 10 years to increase the pace of research in the use of clean coal technologies to generate electricity while meeting environmental regulations at low cost. The 2007 Budget includes \$281 million for development of clean coal technologies. Also included in the budget is \$54 Million for the FutureGen Initiative. January 31, 2006, <http://www.whitehouse.gov/news/releases/2006/01/20060131-6.html>.

Department of Energy Press Release, "Department of Energy Requests \$23.6 Billion for FY 2007," US Secretary of Energy Samuel Bodman announced the Fiscal Year (FY) 2007 proposed budget for the US Department of Energy, requesting \$23.6 billion, a \$124 million increase over the FY 2006 request. These funds are to directly advance the goals of the American Competitiveness Initiative and the Advanced Energy Initiative. Within the budget, \$648.9 million is requested for the Office of Fossil Energy, a \$192.8 million (23 percent) reduction from FY 2006 appropriation. Within the Office of Fossil Energy budget, \$54 million would support the FutureGen initiative in FY 2007, a \$36.2 million increase from FY 2006 with \$203 million planned for FY 2008; and the Carbon Sequestration initiative is requesting \$73.9 million, a \$7.6 million increase from FY 2006. See detailed budget documents at: <http://www.energy.gov/news/3150.htm>. February 6, 2006, <http://www.energy.gov/news/3150.htm>.

Greenwire, "Domenici, Bingaman Pinpoint Obstacles to Global Warming Bill," The Senate Energy and Natural Resources Committee's top Republican Pete Domenici (R-NM), and top Democrat Jeff Bingaman (D-NM) have released a white paper outlining their view on the issues that need to be

considered in formulating a greenhouse gas bill for consideration in Congress. The paper "Design Elements of a Mandatory Market-Based Greenhouse Gas Regulatory System" outlines the key questions and design elements of a national greenhouse gas program assuming a "mandatory market-based system." Domenici feels that there will be a greenhouse gas regime in effect in the US at some time in the future. Bingham's goal is to present a bill by 2007. Public comments are to be received and a conference to be held in March to bring together two dozen experts on the issue.

Download the white paper at: <http://energy.senate.gov/public/files/ClimateChangeWhitePaper.doc>

February 3, 2006, <http://www.eenews.net/EEDaily/include/print.php?single=02030601>. . (Subscription may be required.)

Greenwire, "California Task Force Unlikely to Recommend Emissions Cap," The Climate Action Team set up by California Governor Arnold Schwarzenegger (R-CA) is unlikely to recommend a strict cap on carbon emissions when it reports to the legislature this month. It is also unlikely to propose a specifically defined market-based cap-and-trade program; rather it is expected to allow the state lawmakers and governor to initiate proposals. Governor Schwarzenegger signed Executive Order # S-3-05 on June 1, 2005, establishing greenhouse gas reduction targets, the first of which is for the state to reduce to 2000 emission levels by 2010. To meet the targets, the Governor directed the state environmental agency to set up the action team to recommend how to implement the policy. The task force is more likely to focus on intermediate steps in its upcoming report to legislature including proposals which would require legislative action: mandatory emissions reporting got the climate registry, "the foundation for a cap-and-trade program," establishing a "public goods" transportation fee to lower dependence on petroleum, and early-action credits towards a future carbon market. February 2, 2006, http://www.eenews.net/Greenwire/searcharchive/test_search-display.cgi?q=sequestration&file=%2FGreenwire%2Fsearcharchive%2FNewsline%2F2006%2FFebruary2%2F02020613.htm. (Subscription may be required.)

Contra Costa Times (CA), "Tackling Utilities' Emissions," California regulators voted on February 16 to cap power plant emissions of carbon dioxide despite objections from utilities. The Public Utilities Commission president Mike Peevey said that the commission acted in order to do their part in meeting the greenhouse gas (GHG) goals articulated last year by California Governor Schwarzenegger. Analysts from the California Air Resources Board recently estimated that the costs to meet the GHG reductions of 1990 levels by 2020 is \$8 billion, but that the costs would be offset by savings resulting from more energy efficient use and economic growth. February 17, 2006, <http://www.contracostatimes.com/mld/cctimes/news/local/states/california/13895486.htm>

Greenwire, "California GHG Plan Won't Harm Economy, Think Tank Says," The Center For Clean Air Policy, an independent think tank, reports in its study released January 19, 2006, that California can reach the governor's greenhouse gas emissions targets with a zero net cost to the consumer. The targets are 2000 levels by 2010 (59 million tons reduction), and 1990 levels by 2020 (145 million tons reduction), with a further reduction to 80% below 1990 levels by 2050. The analysis was funded by private foundations and the California Energy Commission. The cost-effectiveness and reduction potential for greenhouse gas mitigation options were analyzed in the transportation, agriculture, forestry, cement and high tech sectors, thus the inclusion of refining and power generation could potentially lead to more cuts. Read the report entitled "Cost Effective GHG Measures for California" at: <http://www.ccap.org/domestic/Summary%20Report-Final%201-19-06.pdf>. January 19, 2006, <http://www.eenews.net/eenewspm/2006/01/19/archive/4/?terms=GHG>. (Subscription may be required.)

April 2006

Environment News Service, "States Ask Supreme Court Review of Global Warming Car Emissions Case." A coalition of 12 US states, three cities, an island government, and several environmental groups has appealed to the US Supreme Court a case to force the US government to regulate carbon dioxide emissions from cars and trucks. A lower court had ruled in July 2005 to uphold

the ruling that the Environmental Protection Agency did not have to regulate carbon dioxide and some other greenhouse gasses. March 6, 2006, <http://www.ens-newswire.com/ens/mar2006/2006-03-06-05.asp>.

Greenwire, "Senate Global Warming Summit Set for April 4." The Senate Energy and Natural Resources Committee is holding a public summit on April 4, 2006 to address the responses received from the broad call for proposals made in March regarding creating a market-based greenhouse gas regulatory system. Participants to the meeting will be selected from the responses that were received from the various stakeholders, though the meeting itself will be open to the public and the media. The submittals to be discussed at the meeting are posted at: http://energy.senate.gov/public/index.cfm?FuseAction=Conferences.Detail&Event_id=4&Month=4&Year=2006. To view some comments covered by Greenwire, go to the subscriber website at: <http://www.eenews.net/Greenwire/2006/03/15/#11>. February 23, 2006, <http://www.eenews.net/EEDaily/2006/02/23/#4>. (Subscription may be required.)

Greenwire, "Senator Feinstein Unveils Mandatory Cap-And-Trade Bill." Senator Diane Feinstein (D-California) has outlined a draft bill outlining a mandatory cap-and-trade system that would reduce company greenhouse gas (GHG) emissions by 7.25 percent from this year's levels. Caps would be implemented for GHG emissions at current levels from 2006 to 2010. In 2011, each company would have to reduce emission by 0.5 percent until 2015, and by just under 1 percent from 2015 to 2020. Reductions could be made by installing controls at the plants, implementing new practices, or purchasing credits. The Feinstein bill differs from the McCain-Lieberman bill in not placing limits on domestic agricultural sequestration, where McCain-Lieberman place a 15 percent cap on the number of credits that can be purchased from farmers domestically. This bill would also allow up to 25 percent of the credits to be purchased from international sources, with McCain-Lieberman's limit at 15 percent. Feinstein is releasing her bill ahead of the Senate Energy and Natural Resources Committee April 4 climate conference (mentioned in the previous article in this newsletter, "**Senate Global Warming Summit Set for April 4**"). For additional information see: http://www.yubanet.com/artman/publish/article_33120.shtml. March 20, 2006, <http://www.eenews.net/Greenwire/print/2006/03/20/10>. (Subscription may be required.)

Greenwire, "New Power Plants, Industrial Boilers See Stricter Controls with Final EPA Rule." The Environmental Protection Agency (EPA) has issued its final "new source performance standard" (NSPS) rule: "Standards of Performance for Electric Utility Steam Generating Units, Industrial– Commercial– Institutional Steam Generating Units, and Small Industrial–Commercial–Institutional Steam Generating Units; Final Rule," Federal Register, Volume 71, Number 38, Pages 9866-9886, February 27, 2006. This new rule sets limits for emissions of nitrogen oxides, sulfur dioxide, and particulate matter (from certain coal, oil and natural gas utilities, and certain large scale boilers), but does not regulate carbon dioxide. Though it was urged to consider new limits on greenhouse gas emissions from power plants, the EPA has concluded that it does not presently have the authority to set NSPS to regulate CO₂ or other greenhouse gases that contribute to global climate change. The EPA's statement agrees with previous Bush administration directives that CO₂ is not legally considered an air pollutant under the Clean Air Act. See comments and response on greenhouse gases on page 9869 of the rule: <http://www.smartpdf.com/register/2006/Feb/27/9866A.pdf>. February 27, 2006, <http://www.eenews.net/eenewspm/2006/02/27/#1>. (Subscription may be required.)

May 2006

Reuters, "California Aims to Limit Emissions of Gases." April 3, 2006, California state assembly members drafted a bill that could make California the first state to set a limit on emissions of greenhouse gases. The bill was drafted by Democrat Speaker Fabian Núñez and Democrat Assemblywoman Fran Pavley, and would cut emission levels by 25% or 145 million tons, to 1990 levels by 2020. Also, on April 3, a report was released by California's "Climate Action Team" that presented emissions cutting

strategies to the Governor and the legislature. (See **Recent Publications** section of this newsletter for a link to the final 2006 **"Climate Action Team Report to Governor Schwarzenegger and the Legislature."**) The report recommends that the emissions reduction target for 2020 (approximately 175 million tons CO₂ equivalent in emission reductions) be the basis for an emissions cap that was recommended to be extended beyond California's borders to other Western states. Mandatory reporting of emission levels by oil and gas exploration and production, oil refining, electric power, cement manufacturing, and solid waste landfills were also recommended. The environmental advisors who contributed to the report also said that a market-based program should be developed for California to include trading, emissions credits, auction and offsets, and that such a program should be presented to the governor by January 1, 2008. April 3, 2006, <http://go.reuters.com/newsArticle.jhtml?type=scienceNews&storyID=11737539>.

Greenwire, "Governor Schwarzenegger Vows 'Sensible and Deliberate' Effort On Emissions." At the first "Climate Action Summit" held by California, Governor Arnold Schwarzenegger stated that California should establish a carbon emissions inventory and then proceed in a "sensible and deliberate way" to meet goals established a year ago to reduce total carbon output to 1990 levels by 2020, and 80 percent below that by 2050. His comments were in response to the Climate Action Team Report issued by the Climate Action Team on April 3. (See **Recent Publications** section of this newsletter for a link to the final 2006 **"Climate Action Team Report to Governor Schwarzenegger and the Legislature."**) The Governor also stated that California should work toward the goals without caps, since caps could impact the business community. A debate followed with comments made by the invited panelists regarding aspects of the Climate Action Team Report. Much of the discussion centered on California's historic leadership in pioneering regulations that are eventually accepted by other states or the federal government; for example, its early efforts to reduce vehicle pollution led to development of the catalytic converter technology. April 12, 2006, <http://www.eenews.net/Greenwire/2006/04/12/#1>. (Subscription may be required.)

Yahoo News, "Maryland joins states breaking with Bush on CO₂." On April 6, 2006, Governor Robert Ehrlich, a Republican, signed an act requiring Maryland to join the Regional Greenhouse Gas Initiative (RGGI) agreement. Maryland joins seven states in the RGGI agreement, New York, Connecticut, New Jersey, Vermont, Maine, New Hampshire, and Delaware, whose aim is to cap carbon dioxide (CO₂) emissions from power plants at 1990 levels starting in 2009, and cut emissions by 10 percent below 2018 levels. Of the eight states, Maryland's "CO₂ emissions per person" in 2000 ranked second, as did their CO₂ emissions, according to Environment Northeast. April 7, 2005, http://news.yahoo.com/s/nm/20060407/pl_nm/energy_rggi_maryland_dc_1.

Energy and Environment Daily, "Bipartisan House Plan Aims to Cap GHG Emissions." Representatives Tom Udall (D-NM), and Tom Petri (R-WI) have sponsored the "Keep America Compleitive Global Warming Policy Act of 2006" aimed at capping emissions through a market-based trading system. The legislation does not include emissions limits but requires the US EPA to set up a pollution cap three years after the bill becomes law. The bill would establish a system of allowances for the cap-and-trade program, and allocate 25 percent of those allowances to a new Department of Energy research program, 10 percent to the State Department for investment in developing countries' low-carbon and no-carbon projects/policies, and 35 percent to the US EPA for those who may be adversely impacted due to the legislation. An unlimited number of "safety value" allowances will be available at \$25 per metric ton of carbon. This bill would regulate emissions from "upstream" sources, including oil importers; natural gas processors and pipelines; oil refineries; and coal producers and importers. To view the bill go to: <http://www.govtrack.us/data/us/bills.text/109/h5049.pdf>, or <http://thomas.loc.gov/cgi-bin/query/z?c109:h5049>. March 29, 2006, http://www.eenews.net/EEDaily/sr_climate_change/2006/03/29/6/. (Subscription may be required.)

Forbes, "US Industries Plead for Cleaner Air." The Senate Committee on Energy & Natural Resources Climate Conference was held April 4 at which business, government and non-profit groups

and “think-tank” organizations responded to the questions raised in the white paper entitled “Design Elements of a Mandatory Market-Based Greenhouse Gas Regulatory System” released in February 2006 by Senator Pete V. Domenici, (R-NM) and Senator Jeff Bingaman (D-NM). The white paper outlines the key questions and design elements of a national greenhouse gas program assuming a “mandatory market-based system,” and serves to help formulate a bill to be presented to Congress by Senator Bingaman. A consensus is growing in business to set up a cap-and-trade emissions system modeled after Europe’s system. Businesses long opposed to mandatory emissions caps are seeing the laws that are being created in the US to cap emissions on a statewide or regional basis, and are giving input towards a nationwide system, which many companies see as inevitable. To read the responses by the various participants in the conference see:

http://energy.senate.gov/public/index.cfm?FuseAction=Conferences.Detail&Event_id=4&Month=4&Year=2006. April 5, 2006, http://www.forbes.com/business/2006/04/04/greenhouse-emissions-environment-cx_jh_0405green.html.

June 2006

Burlington Free Press (Vermont), “Governor Signs Bill to Reduce Greenhouse Gas Emissions.”

Governor Jim Douglas signed a bill on May 2, 2006 that formally commits Vermont to the Regional Greenhouse Gas Initiative (RGGI) agreement, joining New Hampshire, Maine, Connecticut, New York, New Jersey and Delaware. RGGI will develop a cap on carbon dioxide emissions from power plants for member states, and create a trading market within the region. Vermont is scheduled to receive its allowances in 2009. May 5, 2006.

<http://www.burlingtonfreepress.com/apps/pbcs.dll/article?AID=/20060502/NEWS/60502015>.

Reuters, “Ten States, DC Sue EPA Over Power Plant Emissions.” Ten states (New York, California, Connecticut, Maine, Massachusetts, New Mexico, Oregon, Rhode Island, Vermont and Wisconsin) plus New York City and Washington, DC filed a lawsuit against the US Environmental Protection Agency (EPA) on April 27, claiming that newly adopted emissions standards do not do enough to regulate carbon dioxide emissions from power plants. The states said that the EPA is refusing to regulate carbon dioxide emissions under the Clean Air Act, despite what they feel is clear evidence that the emissions contribute to global warming, thereby harming “public health and welfare.” The suit was filed in the federal appellate court for Washington, DC, and is being handled by the office of New York Attorney General Eliot Spitzer. EPA officials defended their emissions policy saying in a statement that they “will review all options and make an informed decision on how to proceed.” “EPA’s climate protection programs continue to exceed the agency’s greenhouse gas emissions goals and are on target to meet the President’s 18 percent goal to reduce greenhouse gas intensity by 2012,” a spokeswoman stated.

To view the states and cities petition for review see:

http://www.eenews.net/features/documents/2006/04/27/document_gw_01.pdf, and for the environmental group’s petition for review see:

http://www.eenews.net/features/documents/2006/04/27/document_gw_02.pdf

(Subscription may be required to view petitions.)

April 28, 2006, <http://www.planetark.com/dailynewsstory.cfm/newsid/36170/story.htm>.

Greenwire, “Senator Carper Picks Up Fresh Support for GHG Emissions Bill.” Senator Tom Carper’s bill (D-DE), the Clean Air Planning Act, is to be co-sponsored by Senator Dianne Feinstein (D-CA), Lamar Alexander (R-TN), Lincoln Chafee (R-RI) and Judd Gregg (R-NH). The bill would require a cap on greenhouse gases emitted from power plants, including carbon dioxide (CO₂) emissions. Senator John McCain, who has introduced a bill regarding greenhouse gas limits across the US economy as opposed to just focusing on power plants, said he was inclined to support the Carper bill while maintaining leadership on his own bill. Senator Feinstein felt the Carper bill would “dovetail” with her upcoming legislation for control of greenhouse gas emissions across the US economy. Senator Jim Jeffords (I-VT), the ranking member of the Senate Environment and Public Works Committee, said he

supported Carper's bill but is still going to unveil his own plan to more aggressively limit CO₂ emissions. May 3, 2006, <http://www.eenews.net/eenewspm/print/2006/05/03/2>. (Subscription may be required.)

July 2006

Greenwire, "Representative Waxman Unveils Emission-Reduction Bill." On June 20, Representative Henry Waxman (Democrat-CA), and other house members introduced the "Safe Climate Act," a bill aimed to reduce emissions of greenhouse gases at more stringent levels than any previous Capitol Hill proposal. The bill would require the US Environmental Protection Agency (EPA) in 2010 to freeze total US greenhouse gas emissions at the 2009 level. In 2011, emissions would be cut by approximately 2 percent per year (to reflect 1990 emissions levels by 2020). Then in 2021, emissions levels would be cut by 5 percent per year, to a level reflecting 1990 emissions levels by 2050. The EPA would also be tasked to set up a cap and trade system with allowances auctioned/allocated by the President of the US. The EPA would also set motor vehicle emissions standards as least as stringent as California's standards and tighten the standards in 2014. The National Academy of Sciences and the National Research Council would review the process every five years and recommend adjustments needed nationally and internationally. To view an overall and section by section summary of the bill, and/or download a pdf of the bill, see: <http://www.waxman.house.gov/waxman/safeclimate/index.htm>. June 20, 2006, <http://www.eenews.net/Greenwire/2006/06/20/#11>. (Subscription may be required.)

Western Governor's Association Press Release, "Western Governors Adopt Policies on Clean, Diversified Energy, Global Climate Change and Transportation Fuels." On June 11, the first day of the Western Governors' Association (WGA) Annual Meeting, the governors (representing 19 states and 3 US Flag Pacific Islands) backed a broad set of proposals for meeting future electricity needs. The policy resolution they adopted was based on the recommendations developed over the past 18 months by more than 250 stakeholders, outlined in the WGA report entitled, "Clean Energy, a Strong Economy and a Healthy Environment." (See **Recent Publications** section of this Newsletter for the link to the report: "**Clean Energy, a Strong Economy and a Healthy Environment.**" To read the policy resolution see: <http://www.westgov.org/wga/policy/06/clean-energy.pdf>.) The goals outlined in the report are to develop an additional 30,000 megawatts of clean energy by 2015; increase energy efficiency 20 percent by 2020; and ensure secure, reliable transmission for the next 25 years. Governor Mike Rounds of South Dakota said that the governors will consider measures most appropriate for their states by encouraging regulators, policymakers, utilities, transmission operators and other stakeholders to eliminate barriers to greater utilization of clean energy resources. Several federal level policies and legislation were identified by the governors as being needed to work toward their efforts including extending the federal tax credit for Integrated Gas Combined Cycle facilities for five years and providing a tax credit program for carbon capture and sequestration for at least five years. June 11, 2006, <http://www.westgov.org/wga/press/plenary1-pr.htm>.

August 2006

Senator Jeffords Press Release, "Jeffords Introduces Landmark Legislation to Reduce Greenhouse Gas Pollution" and the text of Bill S 3698. On July 20, US Senator Jim Jeffords (Independent-VT) and ranking member of the Senate Environment and Public Works Committee, introduced the Global Warming Pollution Reduction Act (Bill S 3698). Senator Barbara Boxer (D-CA) is the bill's lead co-sponsor. The Act would require a reduction of CO₂ emissions levels in the US to 1990 levels, between 2010 and 2020. By 2030, the US must reduce its emissions by one-third of 80 percent below 1990 levels, by 2040 by two-thirds of 80 percent below 1990 levels, and by 2050, to 80 percent below 1990 levels. The reductions are required by power plants, automobiles and carbon intensive businesses. The Environmental Protection Agency (EPA) will be the administrator of the Act. Additional reductions may be required if global atmospheric concentrations exceed 450 parts per million or the average global temperatures increase above 3.6 degrees Fahrenheit above the pre-industrial average. Section 707 of

the act outlines vehicle-specific heightened emissions standards beginning in model year 2016. Section 709 of the Act requires establishment of a low-carbon generation trading project for electric energy owner and operators. Section 710 outlines aspects of a geological carbon dioxide sequestration project competitive grant program. Section 711 would allow for the EPA to conduct research and development in conjunction with other agencies (NOAA, NASA and DOE) on global climate change standards to: help develop measurements, standards, and procedures for reducing CO₂, to monitor CO₂, to establish baseline measurement, and to assist in developing improved industrial processes to reduce global warming pollution. The National Academy of Sciences would report to EPA and the Congress to determine whether the goals of the Act have been met. Section 714 of the Act also states that the Secretary of Agriculture is to set up provisions for above-ground and below ground biological carbon sequestration. To view a copy of the bill, and more of its provisions, see:

http://jeffords.senate.gov/climate_bill_final.pdf. To view Senator Jeffords' Congressional Record statement on the bill, see: <http://jeffords.senate.gov/climate/recordsstatement.pdf>. For a brief description of some of the bill's provisions, see: http://jeffords.senate.gov/climate_bill_summary.pdf. For a summary of the bill, see: http://jeffords.senate.gov/climate_bill_provisions.pdf. July 20, 2006, <http://jeffords.senate.gov/~jeffords/press/06/07/072006climatebill.html>.

Energy and Environment Daily, "House Science Panel Clears \$3.7B Energy Package" and Chemical and Engineering News, "House Panel Approves Alternative Energy R&D." The House Science Committee approved legislation on June 27 to boost research in alternate energy technologies including the FutureGen initiative, but did not endorse a proposal to create to establish an Advanced Research Projects Agency-Energy (ARPA-E) within the Department of Energy. The "Energy Research, Development, Demonstration and Commercial Application Act of 2006," H.R. 5656, is a compendium of smaller bills introduced by committee members over the last few months which authorizes \$3.7 billion over six years for various research initiatives. The provisions for FutureGen are contained in Section 3 of the bill which specifies the emissions reduction criteria for the project, and the appropriations by the year. According to the bill, FutureGen is required to be designed to ensure that sulfur dioxide, nitrogen oxide and particulates be near zero emissions, and carbon dioxide and mercury be reduced by at least 90 percent. Also specified is that "the project demonstrates the feasibility of electricity generation from coal using advanced clean coal technology with carbon capture and geological sequestration at a cost not greater than 10 percent higher than the average of all commercial integrated coal gasification combined cycle electric generating plants operating in the United States as of the date of enactment of this Act." Commercially available advanced clean coal technology is also to be utilized to the extent practicable. The bill specifies that the plant be operating by 2012. The appropriations for FutureGen are \$54,000,000 for fiscal year (FY) 2007; \$112,000,000 for FY 2008; \$130,000,000 for FY 2009; \$95,000,000 for FY 2010; \$75,000,000 for FY 2011; and \$71,000,000 for FY 2012. The National Academy of Sciences (NAS) recommended the creation of ARPA-E in their report to Congress last October. ARPA-E is modeled after the Department of Defense's Advanced Research Projects Agency (DARPA). The bill does contain language directing the NAS to further study its proposal for ARPA-E which would support high-risk, high pay-off research to accelerate traditional and alternative energy sources and energy efficiency. (To link to the bill itself, see: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_bills&docid=f:h5656ih.txt.pdf.) June 28, 2006, <http://www.eenews.net/EEDaily/print/2006/06/28/4>, (Subscription may be required), and June 28, 2006, <http://pubs.acs.org/cen/news/84/i27/8427energy.htm>.

Greenwire, "Senate Panel Funds Asia-Pacific Partnership." The Senate Appropriations Committee has appropriated funding for the Asia-Pacific Partnership, and has also endorsed other US climate change work with Australia, China, India, Japan and South Korea. The appropriations are contained in three separate Fiscal year 2007 appropriations bills. The State Department received \$26 million for the efforts, while the US Environmental Protection Agency was given \$1 million of the \$5 million requested. The bill provides no new funding for the US Department of Energy request, but it specifically permits DOE to get the \$15 million that was requested from existing accounts. There is also a \$6 million?? request for

potential funding for the APP, to be marked up by an Appropriations Subcommittee on July 13. June 29, 2006, <http://www.eenews.net/Greenwire/print/2006/06/29/5>. (Subscription may be required.)

Greenwire, "California Rebuffed in Bid to Postpone GHG Trial." On July 19, US Magistrate Judge Lawrence O'Neill rejected California's request to wait for the Supreme Court's ruling on *Massachusetts v. EPA* before hearing the auto industry's lawsuit to overturn the state's greenhouse gas limits for new cars, light-duty trucks and sports utility vehicles. (For new on *Massachusetts v. EPA*, see this newsletter **The Seattle Times**, "**Supreme Court To Rule on Regulating Carbon Dioxide**," and **Energy and Environment Daily**, "**Supreme Court Mixes Up Global Warming Debate**.") Judge O'Neill stated that the "defendants have not argued that they will be prejudiced from proceeding in this case while *Massachusetts v. EPA* is pending." O'Neill also explained that it did not make sense to wait when the Supreme Court may only resolve one or two of the automakers' five overall claims against the California regulations. The plaintiffs include 13 new motor vehicle dealers in the Southern San Joaquin Valley, the Association of Automobile Manufacturers, DaimlerChrysler Corp., General Motors Corp. and the Tulare County Farm Bureau. The trial will begin January 30th, 2007. The case is *Central Valley Chrysler-Jeep Inc. v. Catherine Witherspoon*, No. 04-6663. Click here for Judge O'Neill's order: http://www.eenews.net/features/documents/2006/07/19/document_gw_01.pdf July 19, 2006, <http://www.eenews.net/Greenwire/print/2006/07/19/11>. (Subscription may be required.)

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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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