THE CARBON SEQUESTRATION NEWSLETTER

February 2003

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Sequestration News

Abstract deadline approaching: NETL's Second National Conference on Carbon Sequestration.

"Developing and Validating the Technology Base to Reduce Carbon Intensity" will be held May 5-8, 2003 in Alexandria, VA. You are invited to submit a paper proposal that builds on what was presented at the 2001 Conference, or breaks new ground. Conference organizers will look for breakthroughs, innovative concepts, and progress reports on the development of carbon sequestration strategies that will contribute to the goals of the President's Global Climate Change Initiative. Submit a 100 word abstract via email to carbonsq@exchangemonitor.com, by Feb. 7, 2003.

A Wall Street Journal feature article. In early January, an article with the sub-heading "Potential solution to global warming lies two miles deep, both underground and in the ocean" covered: the Weyburn-Dakota EOR project, AEP's early exploration beneath the Ohio River Valley, the challenges and potential of ocean storage, and the current costs of capture technology. "In the Pipeline: A Pollution Solution: Bury It," *The Wall Street Journal*, January 8, 2003, (Subscription required).

Chicago Tribune stopgap solution to global warming. The Illinois Basin's deep saline aquifers, depleted oil wells, and coal seams were mentioned for long-term storage of several billion tons of CO₂. "Earth a solution to air pollution? Scientists seriously consider injecting gases in ground," Chicago Tribune, January 27, 2003.

Capture

Exergetic and environmental life cycle assessments were performed for three CO₂ low-emission power cycles: a semi-closed gas turbine combined cycle, an IGCC, and an O2/CO₂ innovative cycle, which burns methane in oxygen. The gas turbine combined cycle and IGCC both utilize amine absorption methods for CO₂ capture while the excess CO₂ from the innovative cycle is removed in liquid phase. "Life cycle assessment comparison of technical solutions for CO₂ emissions reduction in power generation," *Energy Conversion and Management Journal*, Volume 44 (1), January 2003.

Three methods to capture CO₂ from natural gas-fired combined gas/steam turbine power plants are evaluated and compared: (A) CO₂ separation by amine absorption, (B) Gas turbine combined cycle (CC) using a semi-closed gas turbine with near to stoichiometric combustion using oxygen, and, (C) Decarbonization via an autothermal reforming reactor with catalytic partial oxidation of gas natural gas. Total fuel-to-electricity conversion efficiencies, including CO₂ compression, were reported at: (A) 49.6%; (B) 47.2%; and (C) 45.3%, as compared to a 58% efficiency with no CO₂ capture. "A novel methodology for comparing CO₂ capture options for natural gas-fired combined cycle plants," *Advances in Environmental Research*, in press.

Use of CO₂ to maintain pressure in natural gas wells. Natural gas storage—the process of keeping natural gas underground and under pressure to provide a smooth supply—requires the use of a "cushion gas" to provide pressure support. It is common for the leftover methane to be used, but preliminary simulations demonstrate that 30% more methane can be stored when using CO₂. Research at Lawrence Berkeley National Laboratory investigates whether carbon sequestration tax credits could make the use of CO₂ as a cushion gas economically feasible. Critical issues include limiting the CO₂/natural gas mixing, and gas prices. "Carbon dioxide as cushion gas for natural gas storage," *Energy Fuels*, 17 (1), January 15, 2003.

Flue Gas CO₂ capture by gas-phase ammonia carbonation. CO₂ capture by ammonia carbonation, typically performed by bubbling flue gas through an aqueous ammonia solution, is prohibitively expensive for the power industry, so researchers at Oak Ridge National Laboratory are investigating a gas-phase reaction which captures up to 50% of the CO₂. The reaction produces a solid common fertilizer, ammonium bicarbonate (NH4HCO3). Higher removal efficiencies are expected with optimization of reactor geometry and operating conditions. "Removal of carbon dioxide from flue gas by ammonia carbonation in the gas phase," *Energy Fuels*, 17 (1), January 15, 2003.

Sequestration in the News, Cont'd

Terrestrial

High levels of CO₂ reduce forest isoprene emissions. University of Colorado at Boulder researchers found that two pollutants – CO₂ and hydrocarbons emitted from agricultural forest trees — offset each other somewhat in mitigating air quality problems. Growth of a poplar plantation under increased CO₂ (800 ppmv and 1,200 ppmv) reduced ecosystem isoprene (a GHG) production by 21% and 41%, while above-ground biomass accumulation was enhanced by 60% and 82%, respectively. Results show that negative air-quality effects of proliferating agriforests may be offset by increases in CO₂. "Increased CO₂ uncouples growth from isoprene emission in an agriforest ecosystem," *Nature* 421, January 5, 2003.

Japan's forests to contribute to GHG reductions. Japan plans to plant trees and implement other forest development steps in 17.5 million hectares of forests, about 70 pct of Japan's overall woodlands, according to this article. The government increased its afforestation expenditures by 1 percent in the fiscal 2003 budget. "Japan to develop forests to achieve Kyoto Protocol target," *Jiji Press*, December 26, 2002.

Wheat, CO₂ and SO₂. Wheat grown with 600 ppm CO₂ and 0.06 ppm SO₂ singly and in combination showed that individual SO2 treatment reduced protein and starch contents, and increased respiration rate, total soluble sugars and total phenolics. Combination treatments increased concentrations of total soluble sugars, starch and total phenolics. Individual CO₂ treatment stimulated photosynthesis and reduced stomatal conductance and transpiration rate. "Physiological and biochemical responses of two cultivars of wheat to elevated levels of CO₂ and SO₂, singly and in combination," *Environmental Pollution*, February 2003.

Bio-indications of fossil carbon sequestration in plants. By measuring the ratio of carbon-13 and carbon-12 contained in plants scientists are able to determine how much of the CO₂ absorbed by the plant came from the natural carbon cycle and how much came for CO₂ emissions. Plants growing in fossil-fuel-CO₂-contaminated areas, such as major cities, assimilate a mixture of global atmospheric CO₂ and of fossil fuel CO₂ with different ratios of C13. Calculation based on contaminated and non-contaminated grass shows that urban grasses assimilate up to 29.1% of fossil-fuel-CO₂-derived carbon in their tissues. "13C Values of Grasses as a Novel Indicator of Pollution by Fossil-Fuel-Derived Greenhouse Gas CO₂ in Urban Areas," *Environ. Sci. Technol.*, 37 (1), January 2003.

Forest management with a carbon sequestration goal. This paper reveals the difficulty of obtaining good harvest schedules compatible with high levels of carbon captured, from an economic and forestry viewpoint. Theoretical aspects are applied to a Spanish forest. "Forest management optimisation models when carbon captured is considered: a goal programming approach," Forest Ecology and Management, Vol 174 (1-3), February 17, 2003.

Saskatchewan's forest carbon. The first forest carbon sequestration project formally approved under the Canadian Greenhouse Gas Emission Trading (GERT) Pilot is a 50-year (2000-2050) project in which Saskatchewan Environment sells an expected net 1.6 Mt carbon sequestered in white spruce plantations and forest protection to the electrical utility Saskatchewan Power Corporation. "Saskatchewan forest carbon sequestration project," *Forestry chronicle* 78 (6), December 2002.

Canadian environmental projects. Fifty-three environmental projects in communities across Canada will be funded through Environment Canada's EcoAction Community Funding Program. Among the projects are climate mitigation projects, such as an urban forest preservation project in Montreal. "Environment Minister David Anderson announces \$1.9 million for community environmental projects," Environment Canada, January 7, 2003.

Ocean

Marine life and CO₂. An adjunct professor of oceanography and coastal sciences at LSU, along with colleagues, is testing the effect of CO₂ on ocean floor creatures. Does the exposure to CO₂ influence biodiversity? Are some species more susceptible than others? "Deep water clean air: Project explores ways to store CO₂ on the ocean floor," *Sunday Advocate* Baton Rouge, LA, January 19, 2003.

Technology solidifies CO₂ in seawater. Kaken Co., an R&D firm, uses electrolytic reactions to create insoluble calcium carbonate (CaCO3) from seawater. The CaCO3 particles precipitate to the seabed, and seawater then absorbs atmospheric CO₂. At a cost of \$2-3 billion to build an electrolytic cell equipped with power facilities and installed in the sea, the electrolytic reaction also recovers hydrogen gas in the process. "Method developed to solidify carbon dioxide for seabed burial," *The Nikkei Weekly*, January 6, 2003.

Australian and U.S. researchers monitored ocean tracers, in this case chlorofluorocarbons (CFCs), to find that less anthropogenic CO₂ is absorbed by the world's oceans than previously estimated by models. Their findings were published in the January 10, 2003, issue of *Science*. "Oceans' uptake of carbon dioxide is increasing, but slower than forecast," NewsRx. com, January 30, 2003.

Sequestration in the News, Cont'd

Ocean productivity. An ocean fertilization section in the January 9th journal *Nature* explores work in understanding the correlation between ocean productivity (thus a carbon sink) and iron-containing dust from the continents. "New era of ocean stewardship unveiled by Planktos Foundation," Planktos, January 12, 2003.

Trading and Policy

New York considers GHG tailpipe standards. In his State Of The State address, Governor Pataki announced that New York may adopt the GHG tailpipe standards recently passed in California. The New York State Energy Plan website, and the 2003 New York State of the State, January 8, 2003.

Attorneys general of Maine, Massachusetts and Connecticut intend to sue the Environmental Protection Agency for failure to regulate CO₂ under the Clean Air Act. "Three Attorneys General Plan to Sue EPA," *The Guardian,* January 31, 2003.

Voluntary partnership with members of the transport sector. The U.S. Environmental Protection Agency launched "SmartWay" to reduce air pollution and GHG emissions from ground freight carriers. Charter partners, Canon USA, Coca-Cola, CSX, Federal Express, H-E-B Grocery, IKEA, Interface, Nike, Norm Thompson Outfitters, Roadway Corporation, Schneider National, UPS, and Yellow Transportation, will develop performance measures to improve air quality, and reduce GHG emissions. As much as 18 million metric tons of carbon equivalent will be reduced annually by 2012. "EPA announces new initiative to reduce greenhouse gas emissions and improve air quality," EPA, January 10, 2003. See also "Air pollution a priority, Whitman says Administration effort to press curbs may lead to clash with Senate GOP leaders," *The Washington Post*, January 10, 2003.

Voluntary industry agreements. Industry groups representing hundreds of companies have agreed to a Bush administration appeal to voluntarily reduce GHG emissions. The administration and industry leaders plan to unveil a broad array of pledges at the White House on Feb. 6. "U.S. is pressuring industries to cut greenhouse gases," *The New York Times*, January 20 2003.

Chicago Climate Exchange prepares for start-up. Fourteen organizations entered a legally binding agreement under the Chicago Climate Exchange to cut GHG emissions by 4 percent within 4 years based on 1998-2001 levels. Trading will begin this spring. The 14 entities are: American Electric Power; Baxter International Inc.; the City of Chicago; DuPont; Equity Office Properties Trust; Ford Motor Company; International Paper; Manitoba Hydro; MeadWestvaco Corp; Motorola, Inc.; STMicroelectronics; Stora Enso North America; Temple-Inland Inc.; and Waste Management, Inc. "14 Organizations to Cut Greenhouse Gases 4 Percent by 2006," CCX, January 16, 2003.

Five utilities face shareholder resolutions. American Electric Power, Southern Company, Xcel Energy Inc., TXU Corp. and Cinergy Corp, responsible for nearly 25 percent of total U.S. CO₂ emissions, are being pressured by a coalition including the State of Connecticut Plans and Trust Fund to the Interfaith Center on Corporate Responsibility and the Presbyterian Church, USA, to disclose future financial and environmental risks which may result from GHG emissions. "Utility shareholders demand liability disclosure," *New York Times*, January 17, 2003.

Dupont initiates GHG trading in the U.S. DuPont's involvement in carbon management has its roots in chlorofluorocarbons (CFCs). DuPont developed a CFC alternative, HFCs, then threw its support behind the Montreal Protocol. In 1990, DuPont announced that by 2000 it would slash GHG emissions 40% from the 1990 level (86 million tons CO₂ equivalent) and hold global energy use flat. About 20% of GHG emissions were CO₂ emissions, 20% HFCs, and roughly 60% nitrous oxide. To cut nitrous-oxide emissions, DuPont spent \$10 to \$20 million at each adipic-acid factory. In late 2002 DuPont and Entergy traded 125,000 tons of CO₂ equivalent, at \$1-\$5 per ton. "Changing Climate: New Market Shows Industry Moving On Global Warming --- Even as Bush Opposes Kyoto, Firms Are Trading Rights To Emit Greenhouse Gases --- DuPont Tries to Get Out Front," *The Wall Street Journal*, January 16, 2003.

The U.S. - China Working Group on Climate Change agreed to cooperate on climate change science and technology activities including non-CO₂ gases, carbon capture and sequestration, and measurement and verification. The fourth meeting of the multi-agency international group will take place in the U.S. in May 2003. "U.S. Delegation Details New Scientific Cooperation with China," U.S. Department of State," January 16, 2003.

The U.S. and Russia cooperate on climate information. The U.S. and the Russian Federation will discuss climate change policy and related scientific, technological, and legal issues. "Joint Statement of the U.S.-Russian Inter-Ministerial Climate Change Policy Dialogue," U.S. Department of State, January 17, 2003.

The Tokyo Stock Exchange to incorporate GHGs. TSE plans to set up a market for trading GHG emission credits under the Kyoto Protocol to begin in 2005. "TSE to create market for greenhouse gas trading," *Japan Today*, January 1, 2003.

Events and Announcements, Cont'd

Ocean Carbon Sequestration Solicitation. The U.S. Department of Energy requests proposals for basic research projects on the purposeful enhancement of carbon sequestration in the oceans. Final applications are due 3/20/03. Contact Anna Palmisano, DOE, at (301) 903-9963 or refer to Program Notice 03-15 on the Office of Science Grants and Contracts website.

Two DOE Solicitations. The Department of Energy Small Business Innovation Research will select 200 Phase I grant applications for up to \$100,000 over a period of six to nine months. The DOE Office of Science will make approximately \$400 million available for grants in basic energy, biological and environmental sciences in FY 2003. Small Business Innovation Research and *Office of Science Financial Assistance Program --Notice 03-01*.

NETL workshop on non-liquid CO₂ separation and capture scrubbing technologies. A workshop to assess non-liquid capture technologies and provide a tour of a new flexible Modular CO₂ Capture Facility (MCCF), will be offered February 25 and 26 at the Pittsburgh NETL facility. NETL is soliciting potential partners to have in-development non-liquid capture technologies for flue gas, fuel gas or other gas streams, evaluated at the NETL MCCF. If interested, please contact Curt White, curt.white@netl.doe.gov, before February 4, 2003.

Emissions trading and project-based mechanisms: Synergies between emerging regimes. The workshop will be held in Budapest, Hungary, February 7 and 8 and will cover such issues as: the role of project-based activities in trading regimes, ensuring coherent accounting and institution building, and linking different domestic, regional and international trading regimes. FIELD, UNEP, and CEU.

Carbon Sequestration AAAS Meetings. NETL has organized two meetings within the "Dealing with Global Climate Change" Symposia at the American Association for the Advancement of Science annual meeting, February 13-18, 2003, in Denver, Colorado: "Comparative Assessment: Carbon Sequestration as a Greenhouse Gas Mitigation Strategy" and "Climate Change Mitigation Strategy: Technical Challenges for Carbon Sequestration," February 17, 2003.

Introduction to Emissions Trading. The Emissions Marketing Association will arrange several introductory conferences on emissions trading during 2003. February 3: NY, NY, prior to the "Carbon Finance" Conference; March 2: Brussels, Belgium, prior to the EMA Greenhouse Gas Conference; May 4: Phoenix, Arizona, prior to the EMA 7th Annual Spring Meeting. ET101.

Call for papers for the joint CarboEurope / Global Carbon Project conference. The conference will cover the terrestrial continental carbon budget (Europe / Siberia / Amazon); process understanding; carbon management in forest and non-forest ecosystems; verification and carbon monitoring. It will be held in Lisbon, 19-21 March, 2003. Dr. Annette Freibauer email: afreib@bgc-jena.mpg.de, 3rd CarboEurope Meeting.

The Earth Technologies Forum: the Conference on Climate Change and Ozone Protection will be held April 22-24, 2003 in Washington, DC.

Climate change for business. Climate change: science, impacts and responses will be held in London March 31 – April 4. Arranged by Imperial College in collaboration with The Tyndall Centre for Climate Change Research and others, it will cover underlying science and business responses.

The 6th workshop on international climate policy will be held at the Vienna University of Business Administration in Vienna, Austria April 25 and 26. Email: c.ploechl@ic-vienna.at for more information.

Petroleum Geologist Convention. The next annual convention of the American Association of Petroleum Geologists (AAPG), entitled "Energy: Our Monumental Task" will be in Salt Lake City, Utah, on May 11-14, 2003. A special session on "Geological Sequestration of CO₂" has been arranged. Click on session O-22.

The Global Warming International Center is sponsoring the 14th Global Warming Conference on May 27-30, 2003, in Boston, Massachusetts. Topics include energy and transportation, industry emissions, agricultural and forestry resources management, and the carbon budget.

The Greening of Industry Network and the EPA are sponsoring the Greening of Industry Network Conference: Innovating for Sustainability on October 12-15, 2003, in San Francisco, California. The conference will focus on overcoming barriers to sustainable development by addressing issues, including climate change.

The 12th International Conference on Coal Science at the Cairns Convention Centre, Australia, November 2nd – 6th 2003 will cover topics including global warming, GHG emissions, CO₂ mitigation and sequestration. The Australian Institute of Energy, the International Energy Agency & IEA Clean Coal Centre.

Recent Publications

An overview of CO₂ capture technologies. A primary goal of the NETL Carbon Sequestration Program is to dramatically lower the cost of eliminating CO₂ from flue gas and other streams by either pre- or post-combustion processes. Scott Klara, Product Manager, addresses the status of research efforts related to promising pathways and potential technological breakthroughs of CO₂ capture for utilization and/or sequestration. Membranes, improved CO₂ sorbents, advanced scrubbing, oxyfuel combustors, formation of CO₂ hydrates, and economic assessments are part of the research portfolio. "U.S. DOE Integrated Collaborative Technology Development Program for CO₂ Separation and Capture," *Environmental Progress*, Vol. 21, No. 4, The American Institute of Chemical Engineers, December 2002.

A report by the Climate Change Science Program and The Subcommittee on Global Change Research as a supplement to the President's Fiscal Year 2003 budget. (1.7MB PDF file) "Our Changing Planet: The Fiscal Year 2003 U.S. Global Change Research Program and Climate Change Research Initiative," USGCRP, January 2003.

The European sequestration program. A six page brochure describes the science and technology of carbon capture and sequestration, and provides examples of European research and involvement. Sixth Framework Program, European Commission on Community Research, January 2003.

NETL carbon sequestration presentations. Two new presentations have been posted on the NETL Carbon Sequestration website Reference Shelf: "US DOE's Geologic Carbon Sequestration Program," and "An Overview: The U. S. DOE Carbon Sequestration Program," January 2003.

IGCC regulatory and environmental information. A reference resource for gasification-based power generation technologies examines environmental performance and regulatory topics affecting the siting and operation of commercial plants. Comparison of CO₂ generation, capture, emissions, parasitic power loss, capital cost and effect on electricity price is also examined. "Major environmental aspects of gasification-based power generation technologies, Final Report," NETL, December 2002.

Carbon and the WTO. Various climate change mitigation measures are up and running at the national, sub-national and international levels. An issue relevant to carbon sequestration is whether firms' projects and/or governments' policies for particular agricultural subsidies for carbon sequestration could be restricted by the WTO agriculture agreement. The answer is yes, they could be, unless they fulfill certain criteria. "The Kyoto Protocol and the WTO: Institutional evolution and adaptation," Policy Brief No. 28, Centre for European Policy Studies.

Climate change Congressional briefing summaries. The Environmental and Energy Study Institute provides summaries of a Congressional briefing: "Global Climate Change: An Overview of the Science and NOAA's Priorities," EESI, July 23, 2002.

Western oil and gas resources. A new national inventory of U.S. oil and gas resources beneath federal lands evaluates five major geologic basins in the interior West: the Paradox/San Juan Basins; the Uinta/Piceance Basins; the Greater Green River Basin; the Powder River Basin; and the Montana Thrust Belt. An estimated 57 percent of oil and 63 percent of gas are available under standard stipulations. "Scientific Inventory of Onshore Federal Lands Oil and Gas Resources and Reserves and the Extent and Nature of Restrictions or Impediments to Their Development," US Departments of Interior, Agriculture and Energy, January, 2003.

Climate Policy Journal. The following articles are of interest: "The future of the intergovernmental panel on climate change," "Economic consequences of the US withdrawal from the Kyoto/Bonn Protocol;" "An evaluation of the level of ambition and implications of the Bush Climate Change Initiative;" "Comparing developing countries under potential carbon allocation schemes;" "Biomass strategies for climate policies?"; "Forest certification eligibility as a screen for CDM sinks projects;" and "Carbon sequestration in agroforestry systems." Climate policy 2 (4), December 2002.

DOE's Voluntary Greenhouse Gas Reporting (1605b) Program workshops' records. The records include transcripts, participant lists, audio recordings, slides presented and submitted documents. Additional comments may still be sent to ghgregistry.comments@hq.doe.gov. DOE's Energy Information Administration also intends to solicit public comment on revised reporting forms later in 2003. Revised guidelines and forms will be finalized by January 2004. DOE, January 2003.

Recent Publications con't

Presentations from EPA's Fifth State and Local Climate Change Partners' Conference, Annapolis, Maryland, November 20-22, 2002 are available.

Policy issues associated with stabilization of GHGs. Appropriate global targets; implications of stabilizing atmospheric concentrations of GHG emissions at different levels; alternatives to defining long-term goals; action timetables; economic and environmental implications of early versus delayed action; equity issues; and possible frameworks for a future global agreement are discussed in this report. "Kyoto and Beyond: Issues and Options in the Global Response to Climate Change," the Swedish Environmental Protection Agency, January 2003.

Energy Policy Journal. The newest issue contains "The costs of the Kyoto Protocol in the European Union;" "The natural and social properties of CO₂ emission intensity," and "International greenhouse gas trading programs: a discussion of measurement and accounting issues," *Energy Policy*, April 2003.

Legislative Activity

The 108th Congress opened session January 7th, 2003. Three Senate proposals concerning climate and GHG reductions have been referred to the Committee on Environment and Public Works. There are two renewable fuel proposals in the House of Representatives.

The Climate Stewardship Act of 2003. Introduced by Senators McCain and Lieberman, S.139 is a cap-and trade bill that contains the following language on sequestration: for the years 2010 through 2015, 15 percent of total allowance submission requirements may be satisfied by international trading, and sequestration, and after 2015, only 10%. Definitions: The term "sequestration" means the capture, long-term separation, isolation, or removal of GHGs from the atmosphere. The term includes agricultural and conservation practices; reforestation; and forest preservation; and any other appropriate method of capture, long-term separation, isolation, or removal of GHGs from the atmosphere, as determined by the Administrator. It does not include any conversion of, or negative impact on, a native ecosystem; any introduction of non-native species or genetically modified organisms; or forest monocultures. The draft of McCain and Lieberman's Climate Stewardship Act of 2003. See also "New players on global warming," New York Times, January 15, 2003.

The National Greenhouse Gas Emissions Inventory and Registry Act of 2003, S.194, was introduced January 17th by Corzine, Lieberman and Jeffords. It establishes an inventory, registry, and information system.

The Global Climate Security Act of 2003. Daschle introduced S.17 on January 7th, which establishes a National Greenhouse Gas Emissions Information System and requires a National Assessment of Climate Change Impacts; establishes a 1990 GHG emissions level goal by 2013 for Federal government; requires a report on the most cost-effective policy options to reduce net Federal Government GHG emissions to zero by 2025; establishes grants to states or local governments for operating GHG data collection, inventory, or trading systems; implementing GHG emission reduction or sequestration projects; and conducting research intended to reduce net GHG emissions in the U.S. through sustainable economic development.

Energy R&D. Committee on Science Chairman Sherwood Boehlert (R/NY) and Representative Ralph Hall (D/TX) have introduced H.R. 238, an energy bill that provides \$2.5 billion in renewable energy program funding and \$3.5 billion for energy efficiency programs for FY 2003 through 2007. It includes a clean coal tax incentive.

This newsletter is produced by the National Energy Technology Laboratory and presents summaries of significant events related to carbon sequestration that have taken place over the past month.

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Contact: Scott Klara, klara@netl.doe.gov, or visit the website at www.netl.doe.gov/coalpower/sequestration/.