THE CARBON SEQUESTRATION NEWSLETTER

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Sequestration in the News

***Scientific American,* "Can We Bury Global Warming?"** In the cover story of the July issue of *Scientific American,* Robert H. Socolow of Princeton University maintains that "pumping carbon dioxide underground to avoid warming the atmosphere is feasible, but only if several key challenges can be met." Socolow presents an excellent overview of the science and economics of CO_2 capture and storage, providing insight into the current state of the technology and the challenges to be overcome. July 2005, http://www.sciam.com/article.cfm?chanID=sa006&colID=1&articleID=0001D260-6966-12B9-9A2C83414B7F0000 (subscription required)

***Forbes,* BP and Partners Plan "Carbon-Free" electricity from hydrogen.** BP and its partners ConocoPhillips, Shell Transport & Trading Co., and Scottish and Southern Energy announced they plan to build a clean energy plant near Peterhead in Scotland at a cost of $600 million. The plant, which could come online in 2009, would convert natural gas to hydrogen and carbon dioxide gases, then use the hydrogen gas as fuel for a 350MW power station. The carbon dioxide would be exported through existing pipelines to the mature BP-operated Miller oilfield. The field is due to cease production in 2006/7 but the injection of carbon dioxide could increase oil recovery by up to 40 million barrels and extend the field's life by 15-20 years, BP said. Initial engineering feasibility studies have been completed and the partners will now begin detailed design work to make sure the project is economically viable. June 30, 2005, http://www.forbes.com/associatedpress/feeds/ap/2005/06/30/ap2118078.html

***San Francisco Chronicle*, "Funds granted to test underground storage near Rio Vista."** Article highlights the West Coast Regional Carbon Sequestration Partnership (Westcarb), which received a $14.3 million DOE grant. The partnership has already spent two years looking for underground locations that could safely store the gas. In the next phase of testing, Westcarb researchers will inject 4,000 tons of carbon dioxide – bought from a commercial source, such as a refinery – into a depleted natural gas reservoir and a brine formation near Rio Vista, California. The group, led by the California Energy Commission, also will study how much carbon dioxide can be removed from the atmosphere by replanting or better managing forests. Westcarb's tests will focus on monitoring the gas once it's underground, said Larry Myer, the partnership's technical director. June 10, 2005, http://sfgate.com/cgi-bin/article.cgi?file=/c/a/2005/06/10/BUG2VD67EC1.DTL

***Reuters*, "Record European CO_2 Prices Seen Going Higher Still."** European CO_2 prices on June 17 reached a new high of 20.85 euros a tonne, up 35 cents from the previous day. Prices for CO_2, which have tripled since the start of the year, have yet to reach the point at which utilities will switch from coal-fired to gas-fired stations, industry and trade sources say. June 20, 2005, http://www.planetark.com/dailynewsstory.cfm/newsid/31312/story.htm. According to Point Carbon, European carbon prices broke through another significant barrier in trading on June 29, with forwards for 2005 delivery reaching as high as 25.00 euros (approximately $30) in the OTC market, and December 2005 futures peaking at 25.05 euros on the ECX.

***The Christian Science Monitor*, SaskPower to Build a "CO_2 Capture Ready" PC Power Plant.** Article discusses "capture ready" coal-fired power plants and highlights a proposed plant in Saskatchewan, Canada. The plant, slated to go on-line in 2013, located about 110 miles south of Regina, will sport a few million dollars of extras – everything from extra ductwork and bigger boilers to extra open space right next to key areas of the plant – to become one of the world's first "capture ready" plants. "We're building a plant that will last for a number of decades, so it seems prudent to recognize that at some point during that time, carbon will have to be managed," says Rick Patrick, SaskPower's vice president of planning, environment, and regulatory affairs. "We think a capture-ready design will give us maximum flexibility for whatever comes at us." The article questions the benefits of adding capture ready technology to conventional coal-fired power plants. "An escape valve for greenhouse gas," June 2, 2005, http://www.csmonitor.com/2005/0602/p14s02-sten.html

***The Springfield News-Leader*, Possibility of Carbon Taxes Factors into Power Plant Investment Decision.** American Electric Cooperative (AEC), which is planning to build a pulverized coal power plant in Missouri by 2011 has looked at the impact of possible carbon taxes on the plant economics. "A tax of $10 per ton of carbon dioxide emissions still leaves coal as the least-costly option. But if the tax were set at $12.30 per ton, "suddenly nuclear power becomes the cheapest baseload source," said Jim Jura, general manager of AEC. "We think baseload coal is still the way to go, but if something were to happen to carbon dioxide rules in the next two or three years, we'd still have enough flexibility to move to an IGCC plant," said Jura." "Nuclear one day may be cheapest," June 21, 2005, http://www.news-leader.com/apps/pbcs.dll/article?AID=/20050621/NEWS04/506210383/1095

***Cascadia Scorecard Weblog*, "Capturing Carbon."** The Cascadia Scorecard Weblog has an entry dealing with carbon capture and sequestration, which includes comments from readers. The blog is published by Northwest Environment Watch (NEW), a Seattle research and communication center that monitors progress toward sustainability in the Northwest. June 15, 2005, http://cascadiascorecard.typepad.com/blog/2005/06/capturing_carbo.html

***BBC News*, "Funds for greenhouse gas storage."** The UK government announced £25m of funding for a plan to capture greenhouse gases and store them under the North Sea. Carbon storage could be up and running within a decade, said the government. The money is part of a £40m package to tackle climate change that covers not only carbon sequestration, but projects for cleaner electricity generation from coal and gas, as well as for hydrogen and fuel cell technology. "We've consulted the industry closely and it's clear that the long-term benefits of capture and storage, which could reduce emissions from power plants by up to 85 percent, merit significant investment now," said energy minister Malcolm Wicks. June 14, 2005, http://news.bbc.co.uk/go/pr/fr/-/2/hi/science/nature/4089538.stm. For background information, visit "Ministers back carbon dumping," *Guardian Unlimited*, June 15, 2005, http://politics.guardian.co.uk/green/story/0,9061,1506620,00.html. Also see, "Britain Tries to Capture Greenhouse Gases," *Discovery Channel*, June 15, 2005, http://dsc.discovery.com/news/afp/20050613/carboncapture.html and "Gov't supports greenhouse gas storage projects," *Reuters*, June 14, 2005, http://today.reuters.co.uk/news/newsArticle.aspx?type=topNews&storyID=2005-06-14T145414Z_01_MCC453530_RTRUKOC_0_BRITAIN-ENVIRONMENT-CO2.xml

***UKOOA Press Release*, "Carbon Storage under North Sea feasible but challenging."** According to the UK Offshore Operators Association (UKOOA) – the industry body representing oil and gas producers in the North Sea – capturing CO_2 from an onshore location and transporting it offshore for reinjection through existing oil and gas pipelines and installations is an entirely different and much more costly matter than any of the commercial projects currently under way. In the North Sea it would require significant investment in new infrastructure both on and offshore, including substantial retrofitting of the offshore installations, where there are weight and space limitations. A further hurdle is the legality of transferring carbon dioxide, officially designated a "waste" product, from one location to another for disposal offshore, which is not allowed under current international law (OSPAR and the London Convention). June 14, 2005, http://www.politics.co.uk/campaignsite/uk-offshore-operators-association-(ukooa)-$1588030$3.htm

***Technology Review*, "Carbon Dioxide for Sale."** Article chronicles the Dakota Gasification Company from its conception during the energy shortages of the 1970s, through the turbulent period of natural gas deregulation in the mid-1980s, to an industrial beast that operates a 300-kilometer CO_2 pipeline, which supplies CO_2 for EOR projects in Saskatchewan, in addition to converting 18,000 tons of lignite coal into 170 million cubic feet of synthetic natural gas per day (enough to heat 2,500 homes for a year). According to the article, "Dakota survived by becoming a recycler: the by-products of its waste streams bring in more than $150,000 a day. And its most lucrative by-product – the one that finally secured its future – is carbon dioxide." July 2005, http://www.technologyreview.com/articles/05/07/issue/brief_carbon.asp

***The Guardian* (London), "How will carbon capture and storage work?"** According to this article, capturing carbon dioxide from power plants is more technically demanding than storage. Article addresses the negative aspects associated with capture, including cost and parasitic load. Mentions gasification technology and oxyfuel plants like Vattenfall as alternatives to post-combustion capture, but argues that both processes are in their infancy. On the storage side, the article uses Statoil's Sleipner project to illustrate the maturity of storage technology, but adds that the issues here are long-term safety and short-term legality. June 16, 2005, http://www.sustain-online.org/plugins/DocSearch/details.asp?MenuId=1&ClickMenu=&doOpen=1&type=DocDet&ObjectId=MTU1MTE

***Financial Times* (London), "The day of reckoning nears for energy markets."** Article contends that high oil and natural gas prices signify a fundamental shift in world energy markets, led by cultural and social changes in developing countries that make acquiring motor vehicles and appliances more desirable and acceptable. To ease tight markets the author suggests: building more nuclear power capacity; re-examining the regulatory constraints on exploration in areas that hold vast reserves of oil and natural gas; enhancing international energy partnerships (especially with Canada, Mexico, and Australia); and increasing international investments in clean coal, carbon sequestration, renewables, and hydrogen technology. "The best chance America has to lessen its dependence on energy imports and increase supply is to ensure that coal remains an integral and environmentally safe part of its energy mix and to introduce new sources - from wind and solar to hydrogen fuel cells," says the article. June 3, 2005, http://www.wbcsd.org/includes/getTarget.asp?type=DocDet&id=15082

***News & Star*, Wind and Carbon Sequestration Crucial in Cutting CO_2 Emissions, Friends of the Earth.** In an article focusing on a proposed 27 turbine wind farm near Tebay in the UK, Friends of the Earth's executive director, Tony Juniper says, "Some objectors have questioned the reality of climate change, but future generations will not thank them for this blinkered view. Wind energy will have a crucial role in cutting carbon dioxide emissions in the next few years. The Government must also help the development of emerging technologies, such as wave energy, tidal power and carbon sequestration, so we can develop a low carbon economy…The nuclear lobby is doing its best to push nuclear energy, but this would be a dangerous and expensive diversion in the fight against climate change." June 7, 2005, http://www.newsandstar.co.uk/news/viewarticle.aspx?id=251215

***Petroleum Economist*, "Canada: EOR schemes offer CO_2-sequestration opportunities."** According to this article, the drive to coax as much oil as possible from Western Canada's ageing fields is also yielding environmental benefits – now that producers have developed ways to inject carbon dioxide to rebuild reservoir pressures and, as the CO_2 mixes with oil, allow the oil to flow more easily to the surface. The article highlights the following CO_2 sequestration projects: the EnCana-led Weyburn project; Apache Canada's plans to recover 45m barrels of oil and store up to 8.75m tonnes of CO_2 in the Midale field, near Weyburn; a Penn West Petroleum project in central Alberta, injecting 3m cf/d of CO_2 to generate 700 barrels a day of light oil and gain 15 percent incremental recovery; and an Anadarko Petroleum pilot EOR project in central Alberta. In addition, the article also looks at the incentives offered by the governments of Saskatchewan and Alberta. June 2005, http://www.petroleum-economist.com/default.asp?Page=5&ISS=16209 (subscription required)

Sequestration in the News, Cont'd

***Pocatello Idaho State Journal*, "Official likes idea to pipe out proposed plant's CO_2."** Article discusses the prospects of geologic carbon sequestration in Idaho, and mentions a proposed coal gasification facility at a former FMC site outside of Pocatello. Article cites a Department of Agriculture report that states, "The potential for carbon dioxide sequestration is high, but not well documented." Questions about the feasibility of geologic sequestration in Pocatello are raised, and the author suggests an alternative scenario where carbon dioxide is put into a pipeline that runs through southeast Wyoming. June 10, 2005, http://www.journalnet.com/articles/2005/06/10/news/local/news05.txt

***Global Issues*, United States Backs Efforts to Develop Methane as Energy Source.** Article discusses the importance of methane both as a major component of natural gas and as a greenhouse gas, identifies potential methane reduction opportunities, and describes the Methane to Markets Partnership. "Methane to Markets" appears in the June 2005 issue of the U.S. State Department's electronic journal, *Global Issues*. The entire issue, "Protecting the Environment: Thirty Years of U.S. Progress," can be viewed at http://usinfo.state.gov/journals/itgic/0605/ijge/ijge0605.htm

***La Société*, "Shell selected for major new coal gasification opportunity in Australia."** An IGCC project with carbon dioxide sequestration is under study in Australia. Stanwell Corp., owned by the Queensland government, named Shell Gas & Power the preferred coal gasification technology provider for the project. It would be the world's first IGCC power generation plant to geo-sequester nearly all the produced CO_2. June 17, 2005, http://www.edubourse.com/finance/actualites.php?idActus=22034. Also see, "IGCC plant with CO_2 sequestration studied." *Oil & Gas Journal*, June 21, 2005, http://ogj.pennnet.com/articles/article_display.cfm?Section=ONART&C=GenIn&ARTICLE_ID=230617&p=7 (subscription required)

Announcements

"Secretary Bodman Announces $100 Million to Move Carbon Sequestration Technology 'From the Lab to the Field'." Secretary of Energy Samuel Bodman announced that DOE will provide $100 million to further develop carbon sequestration technologies used to capture and permanently store greenhouse gases. The grants are being made to the same seven regional carbon sequestration partnerships that received awards in 2003. Over the next four years, the partnerships will field test and validate carbon sequestration technologies that are best suited to their respective regions. They will also evaluate the most promising regional repositories for carbon dioxide. As part of this effort, the partnerships will also conduct public outreach, satisfy permitting requirements, and identify best-management practices for future deployment. Each partnership will receive between $2 million and $4 million per year in DOE funding. The total value of the seven projects exceeds $145 million over four years. *DOE/FE techline*, June 9, 2005, http://www.netl.doe.gov/publications/press/2005/tl_climate_tech.html

Final Call for Papers: OGEL Special Issue on Coal. Oil, Gas & Energy Law Intelligence (OGEL) is seeking prospective authors to contribute previously published or unpublished articles in a forthcoming Special Issue dedicated to exploring the role of coal in future energy demands. Examples of relevant topics include, but are not limited to, clean coal technologies, green technologies, geological and/or carbon sequestration, clean development mechanisms, or emissions trading. **Deadline to Submit is July 20, 2005**. Please contact Veronica Brieno Rankin, special issue editor, at: vjbrieno@mtu.edu or MycoGeo@aol.com

"UND's EERC gets $14 million to lead regional carbon dioxide reduction project." The Energy and Environmental Research Center at the University of North Dakota has been awarded a $14.3 million grant to serve as the lead in a $21.4 million federal research project focused on carbon dioxide reduction. "This is precisely what we mean when we talk about the benefits of our campuses partnering with business and government to create opportunities for North Dakota," Governor John Hoeven said in a news release. The award to EERC will be combined with a local share of nearly $7.2 million for the project, called the Plains CO_2 Reduction Partnership. The project centers around field trials involving storage of carbon dioxide; comprehensive monitoring; and mitigation in depleted oil and gas reservoirs, unmineable coal seams, and restoration of wetlands. *Grand Forks Herald*, June 9, 2005, http://www.grandforks.com/mld/grandforks/11854018.htm

"DOE to Establish National Center for Hydrogen Technology." The U.S. Department of Energy announced the award of $2.7 million to the University of North Dakota to establish a National Center for Hydrogen Technology. The new center will focus on obtaining hydrogen from coal, and will test a range of technologies from hydrogen production to transportation to utilization. Research conducted at the center will advance President Bush's Hydrogen Fuel Initiative, which calls for developing the technology needed for commercially viable hydrogen-powered fuel cells, and FutureGen. Initial projects will address coal refining, hydrogen carriers, end-of-pipe reforming, and strategic studies to identify the research areas most likely to overcome barriers to the deployment of hydrogen-from-coal technologies. *DOE/FE Techline*, June 24, 2005, http://www.fossil.energy.gov/news/techlines/2005/tl_undeerc_hydrogen.html

"Climate Trust Issues $4.3M Request for Carbon Offset Project Proposals." The Climate Trust announced the release of its 2005 Request for Carbon Offset Projects (RFP). The Trust encourages project developers with high-quality carbon offset projects to submit a project application. The Trust is interested in offsets from most project sectors. For information on how to apply, please visit http://www.climatetrust.org/solicitations_2005_RFP.php. Initial proposals are due August 24, 2005.

Australian program offsets GHG emissions from transport. Greenfleet is a not for profit organization that provides a simple way to reduce your car's impact on the environment. For $40, Greenfleet will plant 17 native trees on your behalf. These trees will help to create a forest, and as they grow will absorb the greenhouse gases that your car produces in one year. Since 1997 Greenfleet has planted more than 2 million trees on behalf of Australian motorists and fleets. These forests will not be harvested and will create an investment in rural Australia for future generations. For additional information, visit http://www.greenfleet.com.au/. For information on how to offset your vehicles emissions in the U.S., visit the TerraPass website at http://www.terrapass.com

Science

"Earth's Energy Imbalance: Confirmation and Implications." A NASA Goddard Institute climate model – driven mainly by increasing human-made greenhouse gases and aerosols, among other forcings – calculates that Earth is now absorbing 0.85 ± 0.15 watts per square meter more energy from the Sun than it is emitting to space. This imbalance is confirmed by precise measurements of increasing ocean heat content over the past 10 years. Implications include: the expectation of additional global warming of about 0.6-C without further change of atmospheric composition; the confirmation of the climate system's lag in responding to forcings, implying the need for anticipatory actions to avoid any specified level of climate change; and the likelihood of acceleration of ice sheet disintegration and sea level rise. *Science,* June 3, 2005, http://www.sciencemag.org/content/vol308/issue5727/index.shtml (subscription required)

"Space Measurements of Carbon Offer Clearer View of Earth's Climate Future." Article summarizes the proceedings of the "Carbon from Space" workshop held in Italy during the first week of June. "Direct satellite measurements of carbon dioxide will have as dramatic an impact as the Hubble Space Telescope within the Earth science field," said Philippe Ciais of the Laboratory for Climate Sciences and the Environment (LSCE) in Gif-sur-Yvette, France. "It should give us a completely new picture of something more or less completely unknown, showing us the carbon flux across tropical areas such as South America and Africa, where we basically have no data available right now." In the near future, the capacity to measure CO_2 from space will increase, because the Japan Aerospace Exploration Agency (JAXA) is gearing up for the launch of its Greenhouse gases Observing Satellite (GOSAT) in 2008, while NASA prepares its own CO_2-detecting mission called the Orbiting Carbon Observatory (OCO) for 2007. *ScienceDaily*, June 13, 2005, http://www.sciencedaily.com/releases/2005/06/050612111201.htm

Policy

"The debate's over: Globe is warming." Article cites recent events – GE's Ecomagination campaign, Governor Schwarzenegger's call for reduced GHG emissions in California, and pressure from religious groups – that have shifted the debate over whether the planet is heating, to what to do about it. *USA Today*, June 12, 2005, http://www.usatoday.com/news/world/2005-06-12-global-warming-cover_x.htm?POE=NEWISVA

"China to Watch Others on Climate Change Action." China will watch how other countries meet their commitments under phase I of the Kyoto Protocol before deciding whether to sign up to its own mandatory cuts, said Xie Zhenhua, Chinese environment minister. *Reuters*, June 15, 2005, http://www.planetark.com/dailynewsstory.cfm/newsid/31247/story.htm

"Scientists pile on pressure over climate change." The Royal Society, the U.S. National Academies of Science, along with the science academies of France, Russia, Germany, Japan, Italy, Canada, Brazil, China, and India signed a joint statement calling on G8 nations to reduce greenhouse gas emissions. The statement says, "There is now strong evidence that significant global warming is occurring. It is likely that most of the warming in recent decades can be attributed to human activities…It is vital that all nations identify cost-effective steps that they can take now, to contribute to substantial and long-term reduction in net global greenhouse gas emissions." *The Guardian*, June 8, 2005, http://www.guardian.co.uk/climatechange/story/0,12374,1501659,00.html. The statement can be downloaded at http://nationalacademies.org/onpi/06072005.pdf

U.S. is "doing more than people give them credit for." In an interview with the Guardian ahead of the British-chaired G8 summit in July, which seeks to promote climate change and Africa as the great challenges of the decade, Tony Blair's environment secretary says that the U.S. is "doing more than people give them credit for in terms of new technology investment such as carbon sequestration…But the question is, 'is that enough?' And the general feeling in the world community is that no, it is not doing enough." In this article Margaret Beckett urges the Bush administration to accept that the "incontrovertible" weight of scientific evidence on the dangers of global warming is stimulating an urgent worldwide dialogue that the U.S. must seriously engage with - or risk being left out. *The Guardian*, May 28, 2005, http://politics.guardian.co.uk/green/story/0,9061,1494310,00.html

"Climate and energy: what the United States needs." Article argues that America can meet the global warming challenge by modernizing its energy policy to catch up with and then lead the world. The author cites five paths to the future: cost-effective clean alternatives to gasoline (ethanol and hydrogen), modernization of the electric power grid, modernization of the U.S. auto industry, expanding renewable energy resources, and modernizing the coal industry. With regard to advanced combined cycle power plants with carbon sequestration the author says, "The Bush administration has a small program for this, but it is not nearly big enough." *OpenDemocracy*, May 26, 2005, http://www.opendemocracy.net/globalization-climate_change_debate/USclimate_2547.jsp

Southern Company Chairman Addresses Energy Policy Issues. Southern Company Chairman, President and CEO David Ratcliffe said that the company is working hard to achieve a "delicate balance" of providing more affordable electricity to a growing region while continuing to lower emissions from its power plants. "As we look to the future, here's what we know: There is a 250-year supply of coal in the United States, compared with about 50 years of a known supply of natural gas," Ratcliffe explained. "Coal is here. It is not in a foreign land. As compared to the fact that more than 95 percent of the world's known natural gas reserves lay outside the United States. We must continue to use coal, although we must use it more efficiently and cleanly." Southern Company believes technology is the answer to address energy policy and energy demand, said Ratcliffe. "We must develop a smart, sensible energy policy, driven by technology that assures electricity is affordable and reliable for everyone." *PRNewswire-FirstCall*, June 13, 2005, http://biz.yahoo.com/prnews/050613/clm053.html?.v=9

Geology

"An experimental study on seismic monitoring of a CO_2 flooding in two sandstones." Laboratory experiments indicated a 6 percent reduction in compressional wave velocities during CO_2 flooding. *Energy* 30 (August-September 2005) 2352-2359, http://www.sciencedirect.com/science/journal/03605442 (subscription required)

"Effect of supercritical CO_2 on cap rock sealing performance." Cap Rock samples from the Nagaoka CO_2 injection site in Japan were exposed to CO_2 and the effects measured. Porosity increased slightly. Permeability measurements were not taken but identified as important. *Energy* 30 (August-September 2005) 2344-2351, http://www.sciencedirect.com/science/journal/03605442 (subscription required)

"Geology of coalbed methane reservoirs in the Southeast Qinshui Basin of China." Article characterizes coal seams in the Southeast Qinshui Basin of China. Also discusses location of coalbed methane zones and permeability of the coalbed methane reservoir. *International Journal of Coal Geology* 62 (22 June 2005) 197-210, http://www.sciencedirect.com/science/journal/01665162 (subscription required)

"Near-future perspective of CO_2 aquifer storage in Japan: Site selection and capacity." Japan has started a 5-year national R&D project titled "Underground Storage of Carbon Dioxide" to reduce CO_2 emissions into the atmosphere. One of the targets of the project is to select a few preferred storage sites as candidates for large-scale demonstration tests and for commercial use in the near future. This paper ranks the sites in terms of capacity potential and CO_2 supply potential, both of which significantly affect the storage economics. In total, 69 sites on land and offshore and 113 fossil fuel fired power plants are being considered. *Energy* 30 (August-September 2005) 2023-2382, http://www.sciencedirect.com/science/journal/03605442 (subscription required)

"Behavior of supercritical CO_2 injected into porous media containing water." Authors used a magnetic resonance imaging (MRI) technique to directly visualize the distribution of supercritical CO_2 injected into a packed bed of glass beads containing water. At high CO_2 saturations, a stable layer flow occurred. The effect of capillary contraction along the flow direction was also simulated. *Energy* 30 (August-September 2005) 2370–2382, http://www.sciencedirect.com/science/journal/03605442 (subscription required)

"CO_2 separation during hydrocarbon gasification." Hydrogen production by removal of carbon oxides during hydrocarbon gasification with CaO and other metal oxides was examined theoretically and experimentally. Because the chemical energy contained in CaO can be released during hydrocarbon gasification, H_2 production efficiency as high as 70–80 percent can be expected. *Energy* 30 (August-September 2005) 2186-2193, http://www.sciencedirect.com/science/journal/03605442 (subscription required)

"Injection and boiling of liquid CO_2 with a hydrate coating." Authors found that the hydrate film on a CO_2 droplet promotes the boiling of liquid CO_2 when the pressure decreases. Thus, when the drops rise above 500-m in the ocean, boiling due to decompression should occur. *Energy* 30 (August-September 2005) 2275-2283, http://www.sciencedirect.com/science/journal/03605442 (subscription required)

Terrestrial

"Researchers unlocking switchgrass secrets." Article highlights the potential for switchgrass to store carbon and produce ethanol. Besides its significant above-ground biomass for bioenergy production, the crop has an abundant and deep root system. The roots can extend more than 8 feet into the soil and account for more than 80 percent of the plant's biomass, says Mark Liebig, a soil scientist at USDA's Agricultural Research Service laboratory in Mandan, North Dakota. At 1 to 2 feet deep, the soil organic carbon difference between switchgrass and other crops – such as wheat and corn – could be 3.5 tons per acre. At 2- to 3-foot depths, the difference could be 2 tons per acre. Over a 4-foot depth, it then averaged 6.9 tons per acre more soil organic carbon than a cultivated crop. *Grand Forks Herald*, May 30, 2005, http://www.grandforks.com/mld/grandforks/business/11772006.htm

"Range That's a Home to Forage Research" Article highlights the USDA Agricultural Research Service's (ARS) Southern Plains Range Research Station (SPRRS) in Woodward, Oklahoma. According to the article, current Southern Plains Experimental Range (SPER) projects have potential to affect the Southern Plains – and the world – far into the future, and even beyond agriculture. "We're examining ways for growers to sequester carbon and, perhaps, one day earn money from doing so. We're also evaluating systems that complement both forage and livestock, improving cropland and pasture restoration techniques, and examining the importance of plant diversity for sustainable management of restored grasslands," says research leader Phillip Sims. ARS is working to develop a national estimate of how much carbon U.S. farm and grazing land soils are currently storing in what is, in effect, a net carbon bank. *Agricultural Research* magazine, June 2005, http://www.ars.usda.gov/is/AR/archive/jun05/range0605.htm

"The Relationship between Carbon Input, Aggregation, and Soil Organic Carbon Stabilization in Sustainable Cropping Systems." The objectives of this study were to evaluate the long-term role of C input in soil organic carbon (SOC) sequestration and to identify underlying mechanisms of C stabilization in soils. Ten Mediterranean cropping systems were studied, with annual soil C sequestration rates ranging from –0.35 to 0.56 Mg C ha–1 yr–1. The authors found a strong linear relationship between SOC sequestration and cumulative C input, with a residue-C conversion to SOC rate of 7.6 percent. This linear relationship suggests that these soils have not reached an upper limit of C sequestration (i.e., not C saturated). *Soil Science Society of America Journal*, 69:1078-1085 (2005), published online: June 2, 2005, http://soil.scijournals.org/cgi/content/abstract/69/4/1078 (subscription required)

"C-Lock: A System for Estimating and Certifying Carbon Emission Reduction Credits for the Sequestration of Soil Carbon on Agricultural Land." The C-Lock system was developed to address the need for an improved method of quantifying and certifying project-level carbon emission reduction credits (CERC). It was designed to enable individual landowners to efficiently quantify, certify, pool, market, and trade CERCs generated by agricultural management practices. This article provides a general overview of the C-Lock system as it has been implemented for the USA State of South Dakota. *Mitigation and Adaptation Strategies for Global Change* (2005) 10: 307–331, http://www.ingentaconnect.com/content/klu/miti/2005/00000010/00000002/00000643 (subscription required)

"The Ecological and Economic Potential of Carbon Sequestration in Forests: Examples from South America." This study quantifies carbon sequestration in above-ground biomass and soils of plantation forests and secondary forests in two countries in South America – Ecuador and Argentina – and calculates the cost of temporary carbon sequestration. Costs per temporary certified emission reduction unit vary between 0.1 and 2.7 USD per Mg CO_2 (1 Mg = 1 tonne) and mainly depend on opportunity costs, site suitability, discount rates, and certification costs. In Ecuador, secondary forests are a feasible and cost-efficient alternative, whereas in Argentina reforestation on highly suitable land is relatively cheap. The results can be used to design cost-effective sink projects and to negotiate fair carbon prices for landowners. *Ambio,* Vol. 34, No. 3, May 2005, http://www.ambio.kva.se/2005/Nr%203_05/May05_8.shtml (subscription required)

Ocean

"British Scientists Say Carbon Dioxide Is Turning the Oceans Acidic." A new report by Britain's Royal Society says that carbon dioxide is turning the oceans acidic, and the growing acidity is very likely to harm coral reefs and other marine life by the end of the century. The burning of fossil fuels releases more than 25 billion metric tons of carbon dioxide into the air each year. Roughly a third of that is absorbed by the oceans, where the gas undergoes chemical reactions that produce carbonic acid, which is corrosive to shells. Depending on the rate of fossil fuel burning, the pH of ocean water near the surface is expected to drop to 7.7 to 7.9 by 2100, lower than any time in the last 420,000 years, the Royal Society report said. Ocean water today is somewhat alkaline, at 8.1. *New York Times*, July 1, 2005, http://www.nytimes.com/2005/07/01/international/europe/01ocean.html?adxnnl=1&adxnnlx=1120224701-VL0ilgLJRI9wZ9E+Qm/WUA. The report, "Ocean acidification due to increasing atmospheric carbon dioxide," can be downloaded at http://www.royalsoc.ac.uk/document.asp?id=3249

"Sea helps in global warming prevention." Japanese researchers have found that a subtropical area in the western Pacific absorbs about 60 million tons of carbon dioxide a year. Since 1981, Japan's Meteorological Agency has dispatched a marine meteorological observation vessel to the area around the Marshall Islands six times a year. After analyzing data in the subtropical area, researchers found interrelations between the temperature of the sea water and the amount of carbon dioxide the sea water absorbs and concluded that the sea in the area absorbs some 60 million tons of carbon dioxide a year. *ScienceDaily*, June 6, 2005, http://www.sciencedaily.com/upi/index.php?feed=Science&article=UPI-1-20050606-06051400-bc-japan-carbondioxide.xml

"Correlations among the design factors of the CO_2 ocean sequestration system, GLAD." An ocean sequestration method to dispose of a large amount of CO_2 gas has been developed to mitigate global warming. This system is called the gas lift advanced dissolution (GLAD) system. This paper describes a mathematical model of GLAD's internal flow, which was derived to optimize the system specifications, and the correlations among the design factors of GLAD system derived by using this mathematical model. *Energy* 30 (August-September 2005) 2308-2317, http://www.sciencedirect.com/science/journal/03605442 (subscription required)

Trading

"Optimal intensity targets for emissions trading under uncertainty." This study assess how well intensity targets – where countries' permit allocations are indexed to future realized GDP – can cope with uncertainties in a post-Kyoto international greenhouse emissions trading scheme. The authors present some empirical foundations for intensity targets and derive a simple rule for the optimal degree of indexation to GDP. Using an 18-region simulation model of a 2020 global cap-and-trade treaty under multiple uncertainties and endogenous commitments, optimal intensity targets could achieve global abatement as much as 20 percent higher than under absolute targets. *The Australian National University*, Economics and Environment Network Working Paper EEN0504, June 21, 2005, http://een.anu.edu.au/download_files/een0504.pdf

"The dynamics of carbon sequestration and alternative carbon accounting, with an application to the upper Mississippi River Basin." Carbon sequestration is a temporal process in which carbon is continuously being stored/released over a period of time. Different methods of carbon accounting can be used to account for this temporal nature including annual average carbon, annualized carbon, and ton-year carbon. In this paper, starting by exposing the underlying connections among these methods, the authors examine how the comparisons of sequestration projects in the Upper Mississippi River Basin are affected by these methods and the major factors affecting them. *Ecological Economics* 54 (2005) 23– 35, http://www.sciencedirect.com/science/journal/09218009 (subscription required)

Events

July 13, 2005, **What's New in Energy & Environmental Hedge Funds**, New York, NY. Topics will include: Energy commodity hedge funds, new ways of playing the energy trading & investment space, what's in store for 2006 for energy & environmental hedge funds, and the new emerging investment model for green hedge funds. Please direct inquiries to Ms. Carmen Cook, Seminar Director of the Energy Hedge Fund Center at 212-222-2775 or info@global-change.com. For additional information, visit http://www.energyhedgefunds.com

July 17-29, 2005, **Research Experience in Carbon Sequestration (RECS).** RECS is a first of-its-kind, high-level summer research program on carbon sequestration. It is designed to engage undergraduates, graduates and early career professionals in carbon sequestration science through hands-on field work and data analysis with leading U.S. scientists. For additional information, visit http://recs.lanl.gov

August 2-11, 2005, **IAMAS 2005 Conference: Carbon Cycle and Climate Symposium**, Beijing, China. The aim of this session is to encourage multiple-disciplinary approach in studying carbon cycles and its interactions with climate. Topics of relevance include: regional and national carbon inventories, CO_2 emissions from land use change and fires, measurements or modeling of net CO_2 exchange of terrestrial ecosystems, land surface models including carbon dynamics in global climate models, interactions between carbon cycle and climate in the past, present and future and applications of model-data fusion in regional and global carbon cycle studies. Conference website: http://www.iamas2005.com Contact: Ying Ping Wang – Yingping.wang@csiro.au

September 15-16, 2005, **Reduction of Emissions and Geological Storage of CO_2: Innovation and Industrial Stakes**, Paris, France. The symposium intends to bring together researchers, industrialists, economists, and financiers to examine the role the geological storage of CO_2 can play in reducing emissions of greenhouse gases, and the means to be used to finance such operations. For additional information visit http://www.CO2symposium.com

September 26-30, 2005, **7th International CO_2 Conference,** Broomfield, CO. The purpose of this conference is to bring together scientists from different disciplines to communicate the most recent results pertinent to the global carbon cycle, with an emphasis on the contemporary increase of atmospheric carbon dioxide. Topics will include atmospheric and oceanic measurements and monitoring networks, terrestrial ecosystems and land use change, carbon cycle process models, source/sink inverse models, the ice core record, new observational techniques, long-term potentials and vulnerabilities of carbon sequestration, and more generally, the human impact on the carbon cycle. For more information: http://www.cmdl.noaa.gov/info/icdc7/

October 9-14, 2005, **2005 International Conference on Coal Science and Technology (ICCS&T)**, Okinawa, Japan. The conference will cover the latest aspects of coal including, combustion, conversion, co-use with biomass and waste, reduction/elimination of environmental load from coal use, and clean coal technologies. For more information regarding the conference please visit the conference website at http://unit.aist.go.jp/energy/iccst

November 13-17, 2005, **Greenhouse 2005: Action on Climate Control,** Melbourne, Australia. There is a clear need for industry, scientists, and government at all levels to work closely together to tackle this significant environmental issue. Demand is strong for the latest information on the science, the likely impacts of climate change, adaptation strategies, and approaches to reducing atmospheric greenhouse gas concentrations. The Conference will cover these themes as well as international issues, policy development, communication and education. For more information: http://www.greenhouse2005.com Contact: Paul Holper - paul.holper@csiro.au

Recent Publications

"CMU study: New coal technology could help reduce emissions." Increased investment in coal gasification technology by electric utilities could dramatically reduce carbon dioxide emissions without damaging the economy, according to a new Carnegie Mellon University study. The 75-page report, commissioned by the Pew Center on Global Climate Change, says such technology combined with carbon capture and sequestration could all but eliminate carbon dioxide emissions in 50 years as new power plants are phased in. Granger Morgan, a co-author of the report and head of CMU's Department of Engineering and Public Policy and co-director of the Electric Industry Center, said that the $250 billion electric utility industry should be required to invest 1 percent of its revenues – more than triple what they do now – to further develop such advanced technologies. *Pittsburgh Post-Gazette*, June 16, 2005, http://www.post-gazette.com/pg/05167/522393.stm. The report, "U.S. Electric Power Sector and Climate Change Mitigation," is available at http://www.pewclimate.org/global-warming-in-depth/all_reports/electricity/index.cfm

"The public perception of carbon dioxide capture and storage in the UK: results from focus groups and a survey." A series of meetings of two "Citizen Panels" were held to explore public perceptions of off-shore carbon dioxide capture and storage (CCS). In addition, a face-to-face survey of 212 randomly selected individuals was conducted. The study found that, on the first hearing about CCS in the absence of any information on its purpose, the majority of people either do not have an opinion at all or have a somewhat negative perspective. However, when (even limited) information is provided on the role of CO_2 storage in reducing CO_2 emissions to the atmosphere, opinion shifts towards expressing slight support for the concept. *Climate policy* 4 (4, 2005): 377-398, http://www.earthscan.co.uk/news/article/mps/uan/382/v/6/sp/ (subscription required)

"Sequestration rental policies and price path of carbon." Carbon rental has been suggested as a way of providing incentives to sequester carbon in biomass in the context of emissions trading systems for GHG emissions. A rental system works by issuing a credit for sequestered carbon that must be repaid after some fixed term. Rental systems avoid many of the difficulties of ensuring the permanence of sequestered carbon that exist in other institutional arrangements. This article adapts the results of Herzog et al. (2003) to argue that a rental system requires that carbon prices rise more slowly than the value of alternative investments in order to provide adequate incentives, and that there are good reasons to believe that this may not happen. *Climate policy* 4 (4, 2005): 419-425, http://www.earthscan.co.uk/news/article/mps/uan/382/v/6/sp/ (subscription required)

"Can geological carbon storage be competitive?" A working paper from CICERO reviews the literature on the costs and benefits of geological carbon storage and finds that in the near-term Carbon Capture and Storage (CCS) is likely to be an economically viable option only in a small set of circumstances, particularly enhanced oil recovery. In the medium and longer term, with improvements in CCS technology and the likelihood of increased greenhouse gas permit prices, CCS is likely to become an economically viable option under a wider range of circumstances. The paper can be downloaded at http://www.cicero.uio.no/publications/detail.asp?publication_id=2735&lang=en

New case studies on International Energy Technology Collaboration and Climate Change Mitigation. The case study, "Clean Coal Technologies," reviews recent experience and identifies lessons in international collaboration with regard to clean coal technologies. It presents information on efficient coal technologies, with a focus on fuel combustion and power generation, and on clean coal technology and equipment transfer to China. The paper can be downloaded from http://www.oecd.org/dataoecd/22/38/34878689.pdf

"Top 100 U.K. Carbon Emitters Named as Warning to Investors." A new report, "The Carbon 100," evaluates the total carbon emissions of the FTSE 100. It shows that just five sectors – oil and gas, electricity, mining, steel, and leisure – generate 85 percent of direct carbon emissions despite accounting for only 29 percent of market capitalization. Shell has been named as the biggest emitter of greenhouse gases in the U.K. The oil company is responsible for 23 percent of all emissions from FTSE 100 companies, closely followed by BP and Scottish Power who account for 17 percent each. The report calls for improved disclosure from companies about their emissions so that investors can make more informed decisions. At present less than half of the FTSE 100 disclose their carbon emissions. *Edie News*, June 20, 2005, http://www.greenbiz.com/news/news_third.cfm?NewsID=28272. The report can be downloaded in PDF format online at http://www.trucost.com/Trucost_The_Carbon_100.pdf

"Emission and Atmospheric CO_2 Stabilization: Long Term Limits and Paths." The objective of stabilization of greenhouse gas concentrations is often envisioned as a monotonic approach to higher constant concentrations. For CO_2 to approach a constant concentration over a finite time, CO_2 emissions must peak and then gradually approach zero over 1,000+ years, regardless of the concentration level. While this intellectual architecture has proved useful, the authors suggest consideration of a broader range of scenarios, including ones in which net emissions decline to zero over a finite period of time resulting in a maximum CO_2 concentration followed by a long-term decline to a lower level. Carbon cycle model results illustrate these scenarios. *Mitigation and Adaptation Strategies for Global Change* (2005) 10: 213–220, http://www.ingentaconnect.com/content/klu/miti/2005/00000010/00000002/00003783 (subscription required)

Legislative Activity

"Senate Overwhelmingly Passes Energy Bill." In a final vote of 85 to 12 – with 49 Republicans, 35 Democrats, and one independent voting in support of the measure - the Senate on June 28 approved a broad-based energy bill that would provide tax breaks and incentives to encourage domestic oil and natural gas production but billions more to boost renewable energy sources, nuclear power and conservation. The bill will now enter into conference with the House. The Senate passed two amendments to the energy bill to curb carbon emissions and address climate change (an amendment introduced by Sen. Chuck Hagel and a "Sense of the Senate on Climate Change" amendment). Two climate amendments to the Senate Energy Bill did not pass (the "Climate Stewardship and Innovation Act of 2005" and an amendment proposed by Sen. John Kerry). *Washington Post*, June 29, 2005, http://www.washingtonpost.com/wp-dyn/content/article/2005/06/28/AR2005062800398.html.
Also see, "Senate Passes Bill That Strives to Balance Oil and Alternatives," *New York Times*, June 29, 2005, http://www.nytimes.com/2005/06/29/politics/29energy.html.
For information concerning the upcoming conference with the House to reconcile the different energy bills, see "Senate OKs Energy Bill; House Fight Looms," *Washington Post*, June 29, 2005, http://www.washingtonpost.com/wp-dyn/content/article/2005/06/29/AR2005062900492.html

The energy legislation debate in the Senate produced numerous articles in June. The following articles represent a small sample of the energy legislation news:

"Senate approves weaker, voluntary climate plan." Discusses the Senate's approval of a plan by Nebraska Republican Chuck Hagel that would offer tax credits and guaranteed government repayment of loans for projects such as coal gasification, carbon sequestration, and energy efficiency improvements that reduce heat-trapping emissions. *Reuters*, June 21, 2005, http://www.enn.com/today.html?id=8040

"Senators address global warming." Ten senators, half of them Republicans, for the first time supported a resolution calling for mandatory limits on greenhouse gas emissions that cause global warming. The resolution came on the heels of the 60-38 defeat of the McCain-Lieberman Climate Stewardship and Innovation Act. The "Sense of the Senate on Climate Change" resolution says, "It is the sense of the Senate that, before the end of the first session of the 109th Congress, Congress should enact a comprehensive and effective national program of mandatory, market-based limits on emissions of greenhouse gases that slow, stop, and reverse the growth of such emissions at a rate and in a manner that will not significantly harm the United States economy; and will encourage comparable action by other nations that are major trading partners and key contributors to global emissions." *Lynchburg News and Advance*, June 25, 2005, http://www.newsadvance.com/servlet/Satellite?pagename=LNA%2FMGArticle%2FLNA_BasicArticle&c=MGArticle&cid=1031783495103&path=!news!archive

"Senate Rejects Greenhouse Gas Limits." Voting 60 to 38, lawmakers rejected an amendment sponsored by Sens. John McCain and Joseph I. Lieberman, calling for mandatory limits on emissions linked to global warming. *Washington Post*, June 23, 2005, http://www.washingtonpost.com/wp-dyn/content/article/2005/06/22/AR2005062200465.html

"Global Warming Gains Higher Profile in Senate." Discusses the three plans proposed this month to address global warming. Sponsors included Sen. Jeff Bingaman, Sens. John McCain and Joe Lieberman, and Sen. Chuck Hagel. *LA Times*, June 19, 2005, http://www.centredaily.com/mld/dailytimes/2005/06/21/news/nation/11936987.htm

"GOP Warms Up to Emissions Cuts." Highlights shifting views of Republican Senators who have historically dismissed calls for federal action on global warming and are now seeing a political benefit to embracing curbs on GHGs. *Washington Post*, June 12, 2005, http://www.washingtonpost.com/wp-dyn/content/article/2005/06/11/AR2005061100557.html

"House Democrats Introduce New Apollo Energy Act." On June 9 U.S. Representative Jay Inslee (D-WA) and fourteen other House Democrats introduced the New Apollo Energy Act (H.R.2828) as a clean energy policy alternative to the current House Energy Bill (H.R.6). Referring to H.R.6, Inslee said, "This energy bill is truly a "Jurassic" piece of legislation that relies on a limited energy source derived from creatures and plants that died millions of years ago. In fact, 93 percent of the $8 billion in tax incentives in the bill go to oil, gas, and other traditional energy industries." Some of the key features of the New Apollo Energy Act include: incentives to increase fuel efficiency; $49 billion in government loan guarantees for the construction of clean-energy generation facilities that will produce power from wind, solar, geothermal, biomass, oceans, coal with carbon-sequestration technology, and other sources; reductions in daily domestic oil consumption; a cap on US emissions of GHGs; research into advanced clean technologies; a Renewable Portfolio Standard; and improving energy transmission and reliability. *Green Car Congress*, June 9, 2005, http://www.greencarcongress.com/2005/06/house_democrats.html

"US House Approves Funding For FutureGen." U.S. Congressman Jerry Costello (D-IL) announced at the end of May that the FutureGen clean coal power plant project has received $18 million in the House Energy & Water Development Appropriations bill for fiscal year 2006. In addition, another $257 million in clean coal funds is set aside exclusively for FutureGen in following years. "This is an important step that gives FutureGen increased momentum," said Costello. "Having the full House of Representatives make the commitment to set aside this substantial amount of money in future years is a significant step forward for the program." The bill must still be considered by the Senate. *Sun Times News*, May 26, 2005, http://www.suntimesnews.com/2/news_archive/may_05/0526us.htm

"State panel debates climate change." According to this article, for the first time a Pennsylvania state committee has debated global warming, with an eye toward implementing a plan to reduce greenhouse gas emissions. Montgomery County earlier this month became the first in Pennsylvania to take action by agreeing to create an inventory of greenhouse gas emissions. That inventory would let county officials know where local sources of greenhouse gases are coming from, such as farms and traffic pollution, to help inform open space and smart growth policies, said Montgomery County Commissioner Thomas Jay Ellis. "We can set an example. We can be the laboratory for the nation," Ellis said. According to some estimates, Pennsylvania produces 1 percent of the world's greenhouse gas emissions. *The Intelligencer*, June 22, 2005, http://www.phillyburbs.com/pb-dyn/news/113-06222005-505695.html

This newsletter is produced by the National Energy Technology Laboratory and presents summaries of significant recent events related to carbon sequestration. If you'd like to join the e-mail distribution list, email majordomo@list-manager.netl.doe.gov with "subscribe sequestration" in the body of the message. We encourage you to pass this along to interested persons. Contacts: Sean Plasynski, sean.plasynski@netl.doe.gov or Sarah Forbes, sarah.forbes@netl.doe.gov.