THE CARBON SEQUESTRATION NEWSLETTER

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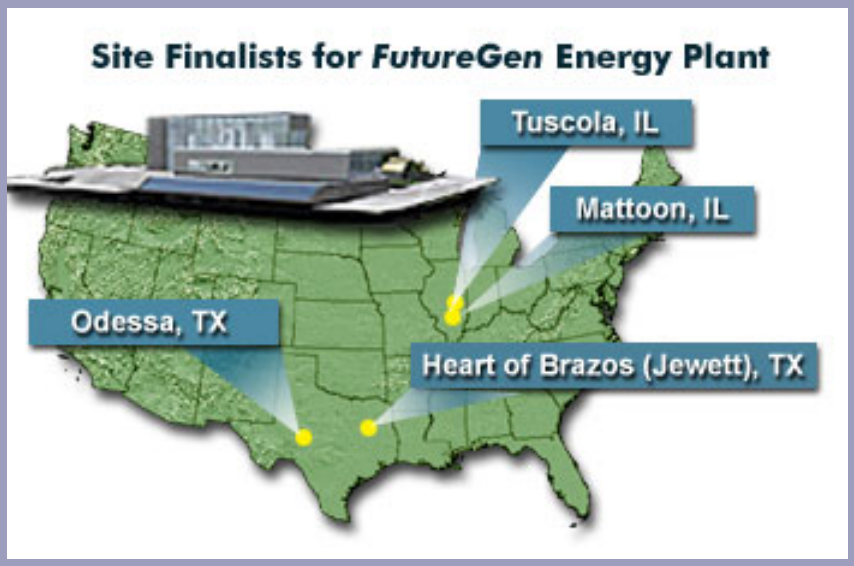

***DOE Fossil Energy Techline,* "FutureGen Alliance Announces Final Candidate Host Sites."** The FutureGen Alliance announced its short list of candidate sites on July 25 for the FutureGen near-zero emissions coal-fueled power plant. Following an extensive technical review of the 12 competing site proposals 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 CO_2 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 (CO_2) 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 CO_2 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 CO_2. The Bush administration rejected the reasoning, and now must convince the Supreme Court that it has no legal obligation to regulate greenhouse gases, including CO_2. The EPA successfully defended its position to the US Court of Appeals for the DC Circuit in 2005, and has issued a state-

ment 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.nwsource.com/html/nationworld/2003087868_scotus27.html, and June 27, 2006, http://www.eenews.net/EEDaily/print/2006/06/27/1.

Sequestration in the News

***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 (CO_2) 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 CO_2. July 18, 2006, http://www.webwire.com/ViewPressRel.asp?aId=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.gnn.gov.uk/Content/Detail.asp?ReleaseID=212415&NewsAreaID=2.

Science

***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

Announcements

Job Announcement. NETL has announced an opening for a position as a Focus Area Lead, Geological and Environmental Sciences, EJ-801/1301-V. The incumbent of this position is responsible for leading the development and conduct of scientific and applied research in geological, chemical, microbiological, and engineering processes important to the extraction, production, and utilization of fossil energy resources, such as improved exploration and production (E&P) of natural gas and oil from unconventional domestic resources, use of oil shale and oil/tar sands, and the conversion and storage of carbon dioxide and other greenhouse gases in forms that will not exacerbate global climate change. Closing date for this position is September 7, 2006. For more information, see: http://jobsearch.usajobs.opm.gov/getjob.asp?JobID=46032852.

Call for Papers. Abstracts are now being accepted online for presentations at the 10th Annual Electric Utilities Environmental Conference (EUEC 2007) Conference & Expo which will be held January 21 through 24, 2007. Presentation track C contains session topics including: carbon sequestration, carbon trading, climate change, and monitoring / verification. Deadline for papers and PowerPoint presentations is December 1, 2006. http://www.euec.com/abstract/abstract.html.

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 CO_2 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 CO_2 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 CO_2 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

***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 CO_2 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

"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 CO_2-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, http://www.sciencedirect.com/science/article/B6V8C-4K7NHDW-1/2/73e862d796900964a5790f7c35daf0ce. (Subscription may be required.)

Technology

"Hybrid Membranes for Selective Carbon Dioxide Separation from Fuel Gas." The potential of hybrid membranes as a carbon dioxide (CO_2) capture technology for integrated gasification combined cycle applications was evaluated. Commercial gamma-alumnia (γ-alumina) supports were modified with a variety of trichlorosilanes intended to enhance the surface adsorption of CO_2. 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 CO_2. 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 CO_2/He selectivity. Membranes modified with 2-acetoxyethyl, 2-carbomethoxyethyl, and 3-aminopropyl groups exhibited CO_2 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 CO_2 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 CO_2. **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 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, O^{2-}. 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 (H_2 + 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 CO_2. Extraction of hydrogen from water-gas shift reactors through dense hydrogen transport membranes, while retaining CO_2 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 CO_2 at high pressure and high concentration, which is ideal for efficient sequestration of CO_2. 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 CO_2 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 CO_2. 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 CO_2 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 CO_2 capture and storage." In this study, the authors estimate and analyze the carbon dioxide (CO_2) mitigation costs of large-scale biomass-fired cogeneration technologies with CO_2 capture and storage. The CO_2 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 CO_2) is captured from biomass-fired energy systems, the systems could in principle be negative CO_2 emitting energy systems. CO_2 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 CO_2 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 CO_2 mitigation cost. In the first method, the cogenerated power was credited based on avoided power production in standalone plants and in the second method the same reference output was produced from all systems. Biomass-fired CHP-BIGCC with CO_2 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, http://www.sciencedirect.com/science/article/B6V4S-4K4PSKR-1/2/89bfff4c65cda3a64e2ad7244b8cd461. (Subscription may be required.)

Terrestrial/Ocean

"Food for Thought: Lower-Than-Expected Crop Yield Stimulation with Rising CO_2 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 ($[CO_2]$) 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 $[CO_2]$ under fully open-air field conditions. In those trials, elevated $[CO_2]$ enhanced yield by approximately 50 percent less than in enclosure studies. This casts serious doubt on projections that rising $[CO_2]$ will fully offset losses due to climate change. **Stephen P. Long, Elizabeth A. Ainsworth, Andrew D. B. Leakey, Josef Nösberger, Donald R. Ort, Science,** *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. (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 CO_2 losses stimulated by N and P fertilization suggest that knowledge of such patterns and their effects on soil CO_2 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. Bricklemyer, 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

Carbon Market Update, July 19, 2006	
CCX-CFI 2006 ($/tCO2) **$4.50 (Vintage 2006)**	EU ETS-EUA DEC 2006 ($/tCO2) **$ 20.68** **(Converted from € to US$)**

***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 CO_2 Cap Tighter for Second Phase."** Environment Commissioner Stavros Dimas said that the carbon dioxide (CO_2) 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 (CO_2) 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 in-

strument 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 CO_2 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

"Results of Site Offeror Proposal Evaluation." FutureGen is a government-industry cost-shared project to design, build, and operate a first-of-a- kind coal-fueled, near-zero emission power plant. The FutureGen power plant will produce electricity and hydrogen from coal while capturing and permanently storing carbon dioxide (CO_2) in a deep geologic formation. The nominal 275-megawatt prototype plant will operate as a production plant, generating commercially significant levels of electric power. It will also provide a large-scale engineering laboratory for testing new and clean power generation, CO2 capture, and coal-to-hydrogen technologies, and will include process slip-stream access for testing and developing new technologies. The FutureGen program intends to build and operate the cleanest coal-fueled power plant in the world. On December 2, 2005, the U.S. Department of Energy (DOE) entered into a cooperative agreement with the FutureGen Industrial Alliance, Inc. (Alliance) to begin the site selection process and prepare a conceptual design for the facility. This report details the process developed and implemented by the Alliance to identify candidate sites for the proposed FutureGen facility. This process involved developing siting criteria, issuing a Request for Proposals (RFP), and evaluating proposals received, including a visit to each proposed site. This site identification process has resulted in the creation of a Candidate Site List. This list, and supporting rationale, is being submitted to DOE for inclusion, as DOE deems appropriate, into the agency's National Environmental Policy Act (NEPA) compliance process. July 21, 2006, http://www.fossil.energy.gov/programs/powersystems/futuregen/fg_proposal_evaluation_report.pdf.

"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 (CO_2) reduction efforts recommended include: converting crop farms from conventional to conservation tillage (no till) and maintaining Ohio's existing forest coverage (estimated reduction of CO_2: 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 CO_2 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 ($MMTCO_2$) in 2004 to 5,909 $MMTCO_2$ 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://

Artist Concept of FutureGen Power Plant

www.eia.doe.gov/neic/press/press272.html. June 28, 2006, http://www.eia.doe.gov/oiaf/1605/flash/flash.html.

Legislative Activity

***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 CO_2 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 CO_2, to monitor CO_2, 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.

***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.html.

***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 plantiffs 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.)

Events

August 22- 23, 2006, **G8 Workshop: Short Term Opportunities for CO_2 Capture and Storage in the Fossil Fuel Sector,** *San Francisco, CA.* The workshop's goal is to foster introduction of carbon dioxide (CO_2) capture and storage (CCS) technologies to the market. Its objectives include investigations and promotion of early opportunities for CCS, such as separation of CO_2 from natural gas and CO_2 enhanced oil recovery. The workshop will gather professionals working in these areas and serve as a platform for information exchange and as a preparatory event for a bigger dissemination and popularization workshop to be organized in 2007. Organizers of the conference are IEA, Chevron, USEA, IEA Greenhouse Gas R&D Programme, IEA EOR IA. Contact Jacek Podkanski, jacek.podkanski@iea.org, for more information.

August 16-18, 2006, **CoalGen 2006,** *Duke Energy Center, Cincinnati, OH.* In their sixth year, the COAL-GEN 2006 conference will cover the latest topics affecting the design, development, upgrading, operation and maintenance of coal-fueled power plants. Included in the event is a session on polygeneration & carbon dioxide capture which consists of presentations on polygeneration from IGCC facilities and CO_2 capture from gasified coal plants. http://cg06.events.pennnet.com/fl//content.cfm?NavId=3535&Language=Engl.

September 5-7, 2006, **Sixth European Conference on Coal Research and its Applications,** *University of Kent, Kent, UK.* The purpose of this conference is to bring together researchers at universities with participants from industry who also conduct research or who are interested in the application of this research in industry. Papers are invited on many topics that describe applications in coal technology, including carbon dioxide removal and storage technology. Email Dr. A. W. Thompson for information: alan.thompson@nottingham.ac.uk, or see: http://www.coalresearchforum.org/.

September 18-19, 2006, **2006 Global CO_2 Cap-and-Trade Forum,** *Westin Embassy Row, Washington, DC.* The Forum will include keynotes, case studies, panels, and presentations by experts from the public and private sector who will discuss: the global carbon trading commodities market overview; carbon reduction mandates; voluntary carbon reduction initiatives; carbon offsets; financing carbon reducing projects; and more. For further information about participating in or attending the event, please contact Jim Turner at 646-546-5230 or jturner@srinstitute.com. Also see: http://www.srinstitute.com/conf_page.cfm?instance_id=25&web_id=863&pid=470.

September 24-27, 2006, **Society of Professional Engineers Annual Technical Conference and Exhibition (ATCE 2006),** *Henry B. Gonzalez Convention Center, San Antonio, TX.* SPE's Annual Technical Conference and Exhibition (ATCE) is perhaps the most significant annual gathering of petroleum professionals anywhere in the world. Among the presentation scheduled, there will be 2 presentation sessions on the topic of CO_2 sequestration. See: http://www.spe.org/atce/2006/technical/tuesday_am.html and http://www.spe.org/atce/2006/technical/wednesday_am.html for the listing of the topics. Register through August 25 to receive a discounted rate. For complete information, visit the 2006 ATCE website at http://www.spe.org/atce/2006/index.html.

September 24-27, 2006, **Energy in a World of Changing Costs and Technologies,** *Ypsilanti Marriott at Eagle Crest, Ann Arbor, MI.* The conference will take science and technology policies as a point of departure for an in depth look at energy challenges in a world of changing costs and technologies. Among the many topics are: science & technology policy, basic research and commercialization strategies for vehicle technologies, electricity generation, and carbon sequestration. For information see: http://www.usaee.org/usaee2006/. Download the conference brochure at: http://www.usaee.org/usaee2006/documents/USAEE_2006_PrintProg1_WEB.pdf.

September 25-27, 2006, **The 4th NCUT/WRI Conference on the Upgrading and Refining of Heavy Oil, Bitumen and Synthetic Crude Oil,** *Westin Hotel, Edmonton, Alberta, Canada.* This triennial meeting is co-sponsored with Canada's National Centre for Upgrading Technology (Western Research Institute) through a Base Research Program with NETL. It brings together experts from the public and private sectors to discuss new developments and challenges in improving the economics and environmental performance of the heavy oil and bitumen industry. A few talks will include issues of Carbon Capture & Sequestration and Enhanced Oil Recovery. For details, see: http://www.ncut.com/acrobats/2006%20Conference.pdf.

Events cont...

September 25-28, 2006, **The 23rd International Pittsburgh Coal Conference,** *David L. Lawrence Convention Center, Pittsburgh, PA.* The Twenty-Third Annual International Pittsburgh Coal Conference will focus on environmental emissions issues and technologies surrounding the continued use of coal and the development of future coal-based energy plants to achieve near-zero emissions of pollutants, reduced costs, and high thermal efficiency while producing a suite of products to meet future energy market requirements. A proposed topic area of "Global Climate Change: Science, Sequestration, and Utilization" includes possible subtopics of: Kyoto protocol and policy issues; carbon dioxide capture technologies; sequestration in geological sinks; enhancing natural sinks; modeling and assessments; non-carbon dioxide greenhouse gas capture and storage; multi-pollutant capture and storage; and CO_2 utilization. Pay before July 16, 2006 for a discount. For more information, see: http://www.engr.pitt.edu/pcc/2006%20Conference.htm.

September 26-27, 2006, **Sixth Annual Workshop of Greenhouse Gas Emission Trading,** *IEA Headquarters, Paris, France.* This workshop, organized jointly between the IEA, IETA, and EPRI, will provide an opportunity for government, industry, brokers, finance, and non-governmental organization delegates to discuss some of the key issues relating to emissions trading for climate policy. The workshop will combine presentations of recent research with discussion sessions on the following topics: 1. country roundtable: highlights of regulatory developments; 2. market news; 3. exploring the implications of design options (price caps, intensity targets, etc.) on the carbon dioxide market; 4. linking: technical issues; and 5. green investment schemes and Joint Implementation. *Please note: participation is by invitation only.* Email etworkshop@iea.org for more information. http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=231.

September 28-30, 2006, **CO_2 EXPO 2006 - 2nd International Exhibition on the Carbon Market,** *New Fair of Rome, Rome, Italy*. This conference and exhibition will focus on carbon markets and trading as they relate to the Emissions Trading Scheme, with a focus on Italian interests. Artenergy, publisher of the Italian climate change magazine *Clima,* is promoting the event. For more information and email updates on the event see: http://www.co2expo.com/en/.

November 8-9, 2006, **Coal-Seq V Forum,** *Hilton Houston NASA Clear Lake, Houston, TX.* Experts from around the world will present the latest results from field projects and other technology development efforts, and discuss the unique technical and non-technical issues associated with carbon dioxide, Enhanced Coalbed Methane (CO_2 ECBM)/sequestration in coal seams. Go to www.coal-seq.com under "Upcoming Events" for a Registration Form. For further information about participating in or attending this event, please contact Susan Pershall at (713) 780-0815 or spershall@adv-res-hou.com.

For Subscription Details....

Please visit http://listserv.netl.doe.gov/mailman/listinfo/sequestration, enter your email address, and create a password to receive the Newsletter at no cost, both as text and in pdf format. (If you prefer not to receive the pdf file in your email, choose "yes" for the daily digest option. Otherwise leave the default value at "no.") To view the archive of newsletters, see: http://www.netl.doe.gov/publications/carbon_seq/subscribe.html.

To learn more about DOE's Carbon Sequestration Program, please contact Sean Plasynski sean.plasynski@netl.doe.gov, or Dawn Deel at dawn.deel@netl.doe.gov.