

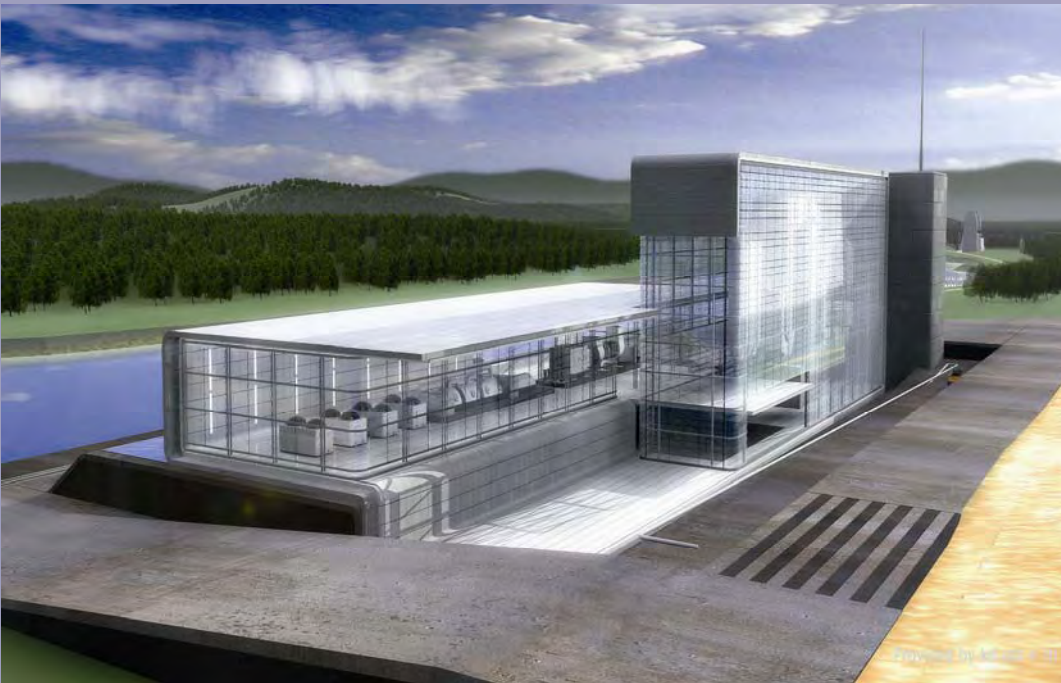
# THE CARBON SEQUESTRATION NEWSLETTER

[http://www.netl.doe.gov/publications/carbon\\_seq/subscribe.html](http://www.netl.doe.gov/publications/carbon_seq/subscribe.html)

May 2007

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## HIGHLIGHTS



**Artist Rendition of the FutureGen Plant (Source: US Department of Energy)**

**Fossil Energy Techline, “DOE Signs FutureGen Cooperative Agreement.”** On April 10, The US Department of Energy (DOE) and the FutureGen Alliance agreed to terms of the next phase of the FutureGen project, valued at \$42.5 million. FutureGen is a first-of-its-kind, near-zero emissions coal-fueled power plant that will integrate carbon dioxide capture and storage technology to reduce greenhouse gas emissions. The cooperative agreement outlines the inclusions in the current project phase and updates to overall cost estimates for the project. Cur-

rent funding will pay for a detailed summary of the project’s conceptual designs, final site selection, negotiation of a site agreement, and release of required National Environmental Policy Act (NEPA) documentation. By 2016, the total cost for FutureGen is projected to increase from \$950 million to \$1.7 billion, due to the increased cost of materials and labor in heavy construction. An expected \$300 million in power revenue will help to offset the more than \$1 billion and \$400 million to be funded by DOE and the FutureGen Alliance, respectively. Both parties will continue to monitor expenses for future phases of the project. To read the FutureGen Alliance press release on this development, see: [http://www.futuregenalliance.org/news/releases/pr\\_04-13-07.pdf](http://www.futuregenalliance.org/news/releases/pr_04-13-07.pdf). For a link to the FutureGen Alliance website, click on: <http://www.futuregenalliance.org/>. For a link to DOE’s FutureGen Initiative webpage, go to: <http://www.fossil.energy.gov/programs/powersystems/futuregen/index.html>. April 10, 2007, [http://www.fossil.energy.gov/news/techlines/2007/07019-DOE\\_Signs\\_FutureGen\\_Agreement.html](http://www.fossil.energy.gov/news/techlines/2007/07019-DOE_Signs_FutureGen_Agreement.html).

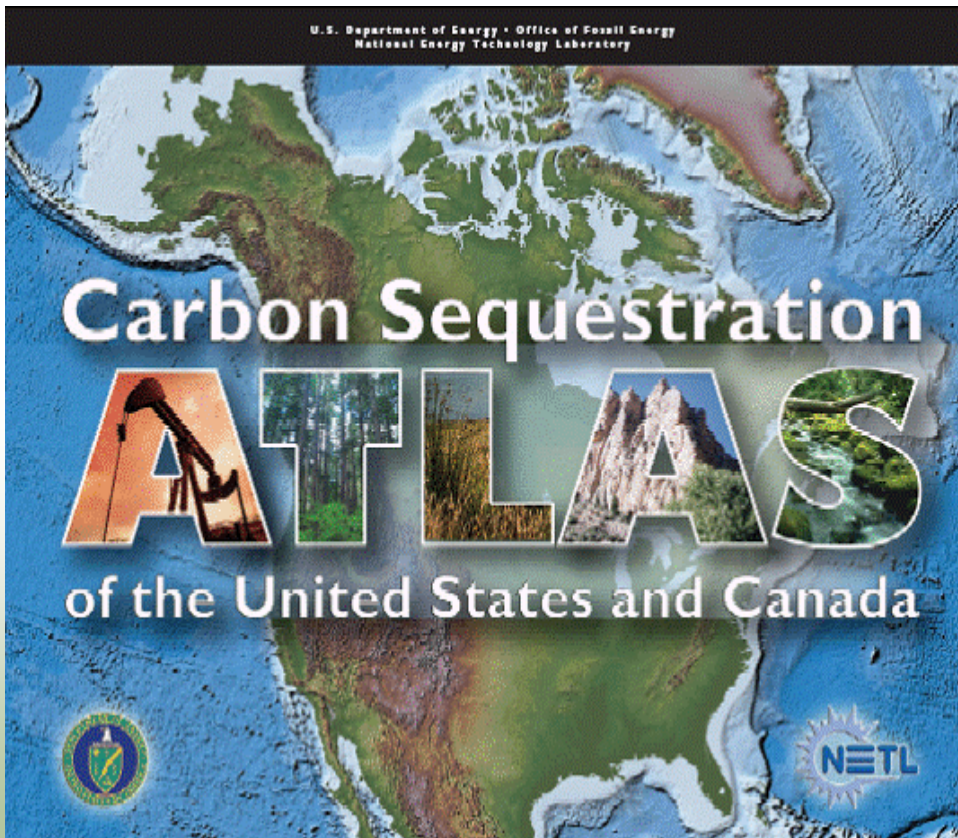
## Highlights (continued)

**Fossil Energy Techline, “DOE Regional Partnerships Find More Than 3,500 Billion Tons of Possible Carbon Dioxide Storage Capacity.”** The “Carbon Sequestration Atlas of the United States and Canada,” made available online on March 27, describes in great detail the stationary sources of carbon dioxide (CO<sub>2</sub>) emissions in the two countries, suitable geologic storage formations for CO<sub>2</sub>, as well as the capacity estimates for CO<sub>2</sub> in these formations. By first identifying the sources of the greenhouse gas CO<sub>2</sub>, efforts can be initiated to greatly reduce the amount of the gas emitted into the atmosphere by capturing and safely sequestering it in geologic formations. Power plants and other stationary sources of CO<sub>2</sub> account for more than 3.8 billion tons of CO<sub>2</sub> emissions per year in the US and Canada. The Atlas was created by researchers at the National Energy Technology Laboratory (NETL) in cooperation with the seven Regional Carbon Sequestration Partnerships and the National Carbon Sequestration Database and Geographical Information System (NATCARB). Altogether, the Partnerships comprise more than 400 organizations, including 40 states, four Canadian provinces, and three Indian nations. The main objectives of the Atlas are to: (1) provide an overview of the lifecycle of CO<sub>2</sub> through the capture and sequestration processes;

(2) summarize the Energy Department’s activities in sequestration research and development; and, (3) present information about the Regional Carbon Sequestration Partnerships’ activities. The Atlas is currently available in both static and interactive versions. The printed version will be available in May 2007. To download the Carbon Sequestration Atlas from the NETL website, go to: [http://www.netl.doe.gov/publications/carbon\\_seq/atlas/index.html](http://www.netl.doe.gov/publications/carbon_seq/atlas/index.html). To access the link to the frequently updated, interactive version of the Atlas from the NATCARB website, see: <http://www.natcarb.org/>. March 27, 2007, [http://www.fossil.energy.gov/news/techlines/2007/07016-Carbon\\_Sequestration\\_Atlas\\_Publish.html](http://www.fossil.energy.gov/news/techlines/2007/07016-Carbon_Sequestration_Atlas_Publish.html).

## Sequestration in the News

**Fossil Energy Techline, “First Utility-Scale Carbon Dioxide Deployment Shows Value of Private-Public Joint Ventures.”** The first commercial carbon sequestration project will begin at American Electric Power (AEP), following a combined ten-year effort between AEP and the US Department of Energy’s (DOE) National Energy Technology Laboratory (NETL). Carl Bauer, NETL’s Director, was commended for his efforts in the success of the joint venture between DOE and AEP. DOE contributed \$7.2 million and \$1.4 million came from industry partners to fund the three initial phases of the project leading up to the deployment of the carbon dioxide (CO<sub>2</sub>) capture phase. AEP will begin demonstration of the capture technology using chilled ammonia, followed by sequestration of 100,000 tons of CO<sub>2</sub> at its Mountaineer Plant in West Virginia. The captured CO<sub>2</sub> will be pumped into a saline formation located below the site. Success of this demonstration will be followed by a 1.5 million ton capture project at AEP’s 450 megawatt plant in Oklahoma, which will be used for enhanced oil recovery efforts in 2011. To read more about the Office of Fossil Energy’s Carbon Sequestration Program, go to: <http://www.fossil.energy.gov/programs/sequestration/index.html>. March 20, 2007, [http://www.fossil.energy.gov/news/techlines/2007/07014-DOE\\_Commends\\_AEP\\_Project.html](http://www.fossil.energy.gov/news/techlines/2007/07014-DOE_Commends_AEP_Project.html).





## Announcements

### **“Keynote Speakers Announced for Sixth Annual Conference on Carbon Capture and Storage.”**

Acting Assistant Secretary for Fossil Energy Thomas Shope and the Natural Resources Defense Council's Climate Center Director David Hawkins will provide keynote remarks at the conference. The Honorable Luke Ravenstahl, Mayor of Pittsburgh, and Carl Bauer, Director of the National Energy Technology Laboratory, will give the opening remarks. Click here for the latest agenda for the May 7-10 conference: <http://www.carbonsq.com/pdf/2007/07agenda.pdf>.

**The US Department of Energy to Host the First “Carbon Sequestration Leadership Task Force on Capacity Building in Emerging Economies.”** This capacity building workshop will be held in conjunction with the Sixth Annual Conference on Carbon Capture and Storage in Pittsburgh, Pennsylvania. Member countries attending the workshop will include Brazil, China, Columbia, India, Mexico, and South Africa. Attendance to the workshop, scheduled to convene on May 7 and May 10, is by invitation only. Information about the Carbon Sequestration Leadership Forum can be found at: <http://www.cslforum.org/index.htm>.

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

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

**Intergovernmental Panel on Climate Change (IPCC) Meetings Scheduled.** The following IPCC meetings are scheduled to take place at the United Nations Conference Centre in Bangkok, Thailand: the 9<sup>th</sup> Session of IPCC Working Group III on April 30-May 3, 2007 and the 26<sup>th</sup> Session of the IPCC on May 4, 2007. The focus of the 26<sup>th</sup> Session meeting will be on acceptance of the actions by the sessions of IPCC Working Groups I, II and III; review of the IPCC terms of reference; future work on emissions scenarios; and future work program of the Task Force on National Greenhouse Gas Inventories. Information for invited participants can be found by going to: <http://www.ipcc.ch/meet/session26.htm>.

**International Summer School on Carbon Capture and Storage.** The IEA Greenhouse Gas Programme (IEA GHG) and Forschungszentrum Jülich are pleased to announce a new international initiative to develop an annual summer school on Carbon Capture and Storage (CCS). The first of these summer schools will be held at Kloster Seeon, near Munich, Bavaria, Germany on August 19-24, 2007. It is planned that future summer schools will be held annually and will rotate around the world. The next summer school in 2008 is planned to be held in Canada. The target groups for the summer school are young scientists, such as doctoral and postdoctoral students with backgrounds in engineering, geotechnologies, socio-economics. Some 50 students from both developed and developing countries will be invited to attend. For complete details, see: <http://www.ieagreen.org.uk/summerschool/index.html>.

**Fossil Energy Techline, “DOE-Funded Research at Maryland Marsh Aids Climate Change Solutions.”**

Members of the Midwest Regional Carbon Sequestration Partnership (MRCSP), one of the seven Regional Carbon Sequestration Partnerships formed by the US Department of Energy (DOE), met at the Blackwater National Wildlife Refuge to evaluate the progress made to date to reclaim the marshland for carbon sequestration purposes. By maintaining and restoring the wetlands and tidal marshes, it will be possible to successfully demonstrate terrestrial carbon sequestration and avoid the negative impact on the Blackwater site caused by rising sea waters. The DOE’s National Energy Technology Laboratory and the State of Maryland are working to preserve the estuary by replenishing the 150-400 acres per year lost to sea level rise, sinking,



erosion, salt water intrusion, and plant-eating invasive species such as nutria (rodents) and Canadian geese. Clean dredged material, which needs to be disposed of in order to keep the Port of Baltimore channels open, is transferred to the Blackwater Refuge and then planted with grasses to restore the marsh. Researchers from

the University of Maryland, an MRCSP partner, also hope to identify specific types of wetlands best suited for storing carbon. Twenty-seven acres of the marsh have been restored to date, with the goal to rebuild up to 20,000 acres. March 22, 2007, [http://www.fossil.energy.gov/news/techlines/2007/07015-Marsh\\_Restoration\\_Aids\\_Climate.html](http://www.fossil.energy.gov/news/techlines/2007/07015-Marsh_Restoration_Aids_Climate.html).

**Jackson Hole Star Tribune, “State Has Vast Capacity for Carbon Dioxide Sequestration.”**

Wyoming could play an important role in combating the harmful effects of carbon dioxide (CO<sub>2</sub>) emissions because of the potential to store large amounts of CO<sub>2</sub> in coal seams and oil reservoirs across the state. Sequestering CO<sub>2</sub> in coal seams has the added benefit of producing methane gas that otherwise might be left behind; additionally, sequestering CO<sub>2</sub> in depleted oil fields can be used for enhanced oil recovery methods. An estimated 4.15 billion barrels of oil and 19.6 trillion cubic feet of methane could be recovered using sequestration technologies. Carl Bauer, Director of the National Energy Technology Laboratory (NETL), delivered the keynote address at the Western Research Institute-sponsored symposium held at the University of Wyoming’s School of Energy Resources, “CO<sub>2</sub> Sequestration: Opportunities for Wyoming.” There he addressed the importance of Wyoming’s sequestration opportunities in fighting global warming. The Big Sky Regional Carbon Sequestration Partnership, directed by Susan Capalbo, is involved in sequestration projects in the state of Wyoming. April 5, 2007, [http://www.jacksonholestartrib.com/articles/2007/04/05/news/top\\_story/7ae7cfcede80d12e872572b400037b89.prt](http://www.jacksonholestartrib.com/articles/2007/04/05/news/top_story/7ae7cfcede80d12e872572b400037b89.prt).

**Reuters, “US Sees Ample Room to Bury Carbon Dioxide But Costs Unknown.”**

Underground storage capacity for carbon dioxide (CO<sub>2</sub>) emissions is abundant in the United States and Canada, with widespread storage sites capable of storing more than 3,500 billion tons of CO<sub>2</sub> in underground saline formations alone. Carbon burial costs have yet to be determined, but underground storage of CO<sub>2</sub> is an emerging technology that could help slow the effects of global warming. Emissions of the gas could be captured from power plants that burn fossil fuels, including coal, the largest source of CO<sub>2</sub> emissions. Dawn Deel, Carbon Sequestration Project Manager at the US Department of Energy’s National Energy Technology Laboratory, contributed to the release of the first *Carbon Sequestration Atlas of the United States and Canada*, a comprehensive assessment of carbon capture and storage potential in the United States and portions of Canada. Included in the docu-



ment is an analysis of stationary CO<sub>2</sub> sources, including 4,000 power plants, to determine whether they lay above potential CO<sub>2</sub> storage sites. It was determined that the majority of power plants have the underground storage capacity at the site or are within close proximity. Currently, the US has not implemented a mandatory emissions reduction policy, but leading Presidential contenders from both parties are expressing support for such legislation. **(See the Publications section of this newsletter for detailed information about the Carbon Sequestration Atlas.)** March 29, 2007, <http://www.alertnet.org/thenews/newsdesk/N29192907.htm>.

## Science

**ABC News, “Panel: Global Warming a Threat to Earth.”** On April 6, the Intergovernmental Panel on Climate Change (IPCC) released the second of four reports from the IPCC this year. The February report laid out the scientific case for how global warming is happening. This report, drawn up by the IPCC Working Group II, assesses the latest scientific knowledge on the current impacts of climate change and what the effects of global warming will be. It also presents a breakdown according to regions as to how climate change will affect billions of people. Representatives from more than 120 nations attended the meeting. Disagreement on final editing occurred between the climate scientists who wrote the report and government negotiators. Several scientists disputed with government delegates attempting to tone down the language of the report and diminish the evidence of already apparent climate changes. At the end of the negotiating, the final 21-page Summary for Policyholders was approved, which drew on information from the full 1,500-page technical document. The summary will be presented at the G8 Summit in June 2007, and it is expected that the European Union will again urge the United States to set

mandatory regulations to control greenhouse gas emissions. **(See the Recent Publications section of this newsletter, “Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, ‘Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability’,” for a reference and link to download the report.)** April 10, 2007, <http://abcnews.go.com/Technology/wireStory?id=3014590>.

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

## Policy

**Reuters, “Japan, China to Take Part in Post-Kyoto Talks,”** and **Reuters, “China to Unveil Climate Plan Next Month.”** Following a summit meeting held on April 11 between Chinese Premier Wen Jiabao and Japanese Prime Minister Shinzo Abe, the two leaders pledged their willingness to take part in post-Kyoto negotiations to limit global warming in their countries. The Kyoto Protocol, set to expire in 2012, is supported by thirty-five developed nations, but participation by the highest polluters, such as China and the United States, has not ensued. According to Gao Guangsheng, head of the Chinese Office of the National Coordination Committee for Climate Change, China will define what policies for reducing emissions should be developed and in



which areas the country plans to reduce greenhouse gas emissions, but declined China's commitment to reveal an overall national target or establishment of an emissions trading exchange. China and Japan also agreed to other bilateral environmental initiatives during the summit, including technical assistance by Japan on desulphurization of Chinese coal-fired thermal power plants. April 11, 2007, <http://www.alertnet.org/thenews/newsdesk/T231974.htm>, and March 30, 2007, <http://www.planetark.com/avantgo/dailynewsstory.cfm?newsid=41173>.



**“Regulatory challenges to the implementation of carbon capture and geological storage within the European Union under EU and international law.”**

Carbon dioxide capture and storage (CCS) is a relatively new technology in the context of climate change mitigation strategies, and its legal and regulatory implications are not yet broadly understood. This paper takes a brief look at international environmental law principles relevant to CCS, identifies key environmental and safety risks associated with the technology, and highlights significant legal frameworks that pose challenges to the implementation of CCS within the European Union (EU) under EU and international law. It then notes continuing regulatory gaps that will need to be addressed for large-scale CCS to take place. The paper concludes that the clear inclusion or exclusion of CCS activities from the range of relevant legal frameworks will increase transparency, provide regulatory certainty and ultimately facilitate CCS in appropriate contexts.

**M.J. Mace, Chris Hendriks and Rogier Coenraads,** *International Journal of Greenhouse Gas Control*, Available online March 30, 2007. [doi:10.1016/S1750-5836\(07\)00028-X](https://doi.org/10.1016/S1750-5836(07)00028-X), <http://www.sciencedirect.com/science/article/B83WP-4NCKK7W-1/2/422f865f315b3e8985e23296b8787795>. (Subscription may be required.)

## Geology

**“CO<sub>2</sub> storage capacity estimation: Issues and development of standards.”** Associated with the endeavors of geoscientists to pursue the promise that geological storage of carbon dioxide (CO<sub>2</sub>) has of potentially making deep cuts into greenhouse gas emissions, Governments around the world are dependent on reliable estimates of CO<sub>2</sub> storage capacity and insightful indications of the viability of geological storage in their respective jurisdictions. Similarly, industry needs reliable estimates for business decisions regarding site selection and development. If such estimates are unreliable, and decisions are made based on poor advice, then valuable resources and time could be wasted. Policies that have been put in place to address CO<sub>2</sub> emissions could be jeopardized. Estimates need to clearly state the limitations that existed (data, time, knowledge) at the time of making the assessment and indicate the purpose and future use to which the estimates should be applied. A set of guidelines for estimation of storage capacity will greatly assist future deliberations by government and industry on the appropriateness of geological storage of CO<sub>2</sub> in different geological settings and political jurisdictions. This work has been initiated under the auspices of the Carbon Sequestration Leadership Forum ([www.cslforum.org](http://www.cslforum.org)), and it is intended that it will be an ongoing taskforce to further examine issues associated with storage capacity estimation.

**John Bradshaw, Stefan Bachu, Didier Bonijoly, Robert Burruss, Sam Holloway, Niels Peter Christensen and Odd Magne Mathiassen,** *International Journal of Greenhouse Gas Control*, Available online March 26, 2007, [doi:10.1016/S1750-5836\(07\)00027-8](https://doi.org/10.1016/S1750-5836(07)00027-8), <http://www.sciencedirect.com/science/article/B83WP-4NBRG1R-1/2/8e64629160f1a76f9c3353b047a207a9>. (Subscription may be required.)

**“Permitting issues for CO<sub>2</sub> capture, transport and geological storage: A review of Europe, USA, Canada and Australia.”** The paper reviews the environmental, health and safety permitting/regulatory issues presented by carbon capture and storage (CCS) operations across the full project cycle, and reviews existing regulations in the European Union, North America and Australia to assess their applicability to CCS, and identify regulatory gaps. **Paul Zakkour and Mike Haines,** *International Journal of Greenhouse Gas Control*, Available online January 30, 2007, [doi:10.1016/S1750-5836\(06\)00008-9](https://doi.org/10.1016/S1750-5836(06)00008-9), <http://www.sciencedirect.com/>



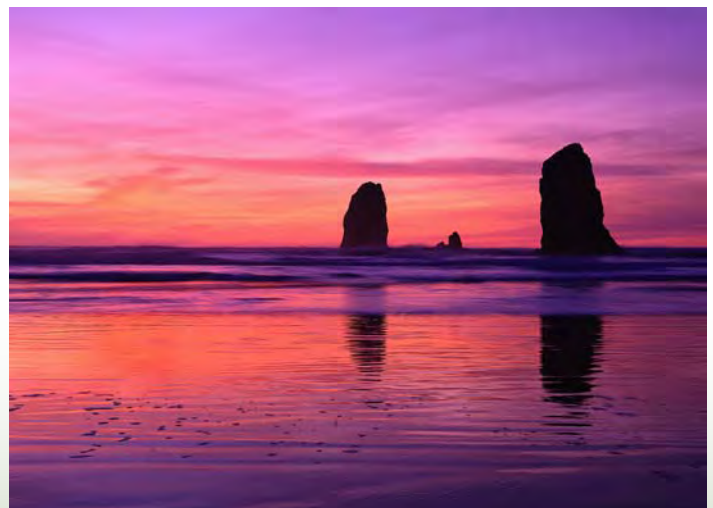
[science/article/B83WP-4MY11CV-1/2/223c2999e3c747374981c8b15a89169a](http://www.sciencedirect.com/science/article/B83WP-4MY11CV-1/2/223c2999e3c747374981c8b15a89169a).  
(Subscription may be required.)

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

## Technology

**“Capture-ready coal plants--Options, technologies and economics.”** This paper summarizes the spectrum of options that can be employed during the initial design and construction of pulverized coal (PC), and integrated gasification and combined cycle (IGCC) plants to reduce

the capital costs and energy losses associated with retrofitting for carbon dioxide (CO<sub>2</sub>) capture at some later time in the future. It also estimates lifetime (40 year) net present value (NPV) costs of plants with differing levels of pre-investment for CO<sub>2</sub> capture under a wide range of CO<sub>2</sub> price scenarios. Three scenarios are evaluated—a baseline supercritical PC plant, a baseline IGCC plant and an IGCC plant with pre-investment for capture. This analysis evaluates each technology option under a range of CO<sub>2</sub> price scenarios and determines the optimum year of retrofit, if any. The results of the analysis show that a baseline PC plant is the most economical choice under low CO<sub>2</sub> prices, and IGCC plants are preferable at higher CO<sub>2</sub> prices (e.g., an initial price of about \$22/ton CO<sub>2</sub> starting in 2015 and growing at 2 percent per year). Little difference is seen in the lifetime NPV costs between the IGCC plants with and without pre-investment for CO<sub>2</sub> capture. This paper also examines the impact of technology choice on lifetime CO<sub>2</sub> emissions. The difference in lifetime emissions becomes significant only under mid-estimate CO<sub>2</sub> price scenarios (roughly between \$20 and 40/ton CO<sub>2</sub>) where IGCC plants will retrofit sooner than a PC plant. **Mark C. Bohm, Howard J. Herzog, John E. Parsons and Ram C. Sekar**, *International Journal of Greenhouse Gas Control*, Available online March 23, 2007, [doi:10.1016/S1750-5836\(07\)00033-3](http://www.sciencedirect.com/science/article/B83WP-4NB38PW-1/2/0f9786693be185b20c0f97df15232f80), <http://www.sciencedirect.com/science/article/B83WP-4NB38PW-1/2/0f9786693be185b20c0f97df15232f80>.  
(Subscription may be required.)



**“Use of experience curves to estimate the future cost of power plants with CO<sub>2</sub> capture.”** Given the dominance of power plant emissions of greenhouse gases, and the growing worldwide interest in carbon dioxide (CO<sub>2</sub>) capture and storage (CCS) as

a potential climate change mitigation option, the expected future cost of power plants with CO<sub>2</sub> capture is of significant interest. Reductions in the cost of technologies as a result of learning-by-doing, R&D investments and other factors have been observed over many decades. This study uses historical experience curves as the basis for estimating future cost trends for four types of electric power plants equipped with CO<sub>2</sub> capture systems: pulverized coal (PC) and natural gas combined cycle (NGCC) plants with post-combustion CO<sub>2</sub> capture; coal-based integrated gasification combined cycle (IGCC) plants with pre-combustion capture; and coal-fired oxyfuel combustion for new PC plants. [The authors] first assess the rates of cost reductions achieved by other energy and environmental process technologies in the past. Then, by analogy with leading capture plant designs, [the authors] estimate future cost reductions that might be achieved by power plants employing CO<sub>2</sub> capture. Effects of uncertainties in key parameters on projected cost reductions



also are evaluated via sensitivity analysis. **Edward S. Rubin, Sonia Yeh, Matt Antes, Michael Berkenpas and John Davison**, Available online February 26, 2007, *International Journal of Greenhouse Gas Control*, doi:10.1016/S1750-5836(07)00016-3, <http://www.sciencedirect.com/science/article/B83WP-4N4S69V-1/2/0a29f2daa919c8f774445b761eef6404>. (Subscription may be required.)

**“Modeling the impacts of climate policy on the deployment of carbon dioxide capture and geologic storage across electric power regions in the United States.”** This paper summarizes the results of a first-of-its-kind holistic, integrated economic analysis of the potential role of carbon dioxide (CO<sub>2</sub>) capture and storage (CCS) technologies across the regional segments of the United States (US) electric power sector, over the time frame 2005–2045, in response to two hypothetical emissions control policies analyzed against two potential energy supply futures

that include updated and substantially higher projected prices for natural gas. This paper's detailed analysis is made possible by combining two specialized models developed at Battelle: the *Battelle CO<sub>2</sub>-GIS* to determine the regional capacity and cost of CO<sub>2</sub> transport and geologic storage; and the *Battelle Carbon Management Electricity Model*, an electric system optimal capacity expansion and dispatch model, to examine the investment and operation of electric power technologies with CCS against the background of other options. A key feature of this paper's analysis is an attempt to explicitly model the inherent heterogeneities that exist in both the nation's current and future electricity generation infrastructure and in its candidate deep geologic CO<sub>2</sub> storage formations. Overall, between 180 and 580 gigawatts (GW) of coal-fired integrated gasification combined cycle with CCS (IGCC + CCS) capacity is built by 2045 in these four scenarios, requiring between 12 and 41 gigatonnes of CO<sub>2</sub> storage in regional deep geologic res-

ervoirs across the US. Nearly all of this CO<sub>2</sub> is from new IGCC + CCS systems, which start to deploy after 2025. Relatively little IGCC + CCS capacity is built before that time, primarily under unique niche opportunities. For the most part, CO<sub>2</sub> emissions prices will likely need to be sustained at over \$20/tonne CO<sub>2</sub> before CCS begins to deploy on a large scale within the electric power sector. Within these broad national trends, a highly nuanced picture of CCS deployment across the US emerges. Across the four scenarios studied here, power plant builders and operators within some North American Electric Reliability Council (NERC) regions do not employ any CCS while other regions build more than 100 GW of CCS-enabled generation capacity. One region sees as much as 50 percent of its geologic CO<sub>2</sub> storage reservoirs' total theoretical capacity consumed by 2045, while most of the regions still have more than 90 percent of their potential storage capacity



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

## Terrestrial/Ocean

**“Combined climate and carbon-cycle effects of large-scale deforestation.”** The prevention of deforestation and promotion of afforestation have often been cited as strategies to slow global warming. Deforestation releases carbon dioxide (CO<sub>2</sub>) to the atmosphere, which exerts a warming influence on Earth's climate. However, biophysical effects of deforestation, which include changes in land surface albedo, evapotranspiration, and cloud cover also affect climate. Here [the authors] present results from several large-scale deforestation experiments performed with a three-dimensional coupled global carbon-cycle and climate model. These simulations were performed by using a fully three-dimensional model representing physical and biogeochemical interactions among land, atmosphere, and ocean. [The authors] find that global-scale deforestation has a net cooling influence on Earth's climate, because the warming carbon-cycle effects of deforestation are overwhelmed by the net cooling associated with changes in albedo and evapotranspiration. Latitude-specific deforestation experiments indicate that afforestation projects in the tropics would be clearly beneficial in mitigating global-scale warming, but would be counterproductive if implemented at high latitudes and would offer only marginal benefits in temperate regions. Although these results question the efficacy of mid- and high-latitude afforestation projects for climate mitigation, forests remain environmentally valuable resources for many reasons unrelated to climate. (See Science section of this newsletter, **“Tree Planting May Add to Warming, Says DOE-Funded Study,”** for an article referencing this journal abstract.) **G. Bala, K. Caldeira, M. Wickett, T. J. Phillips, D. B. Lobell, C. Delire, and A. Mirin**, *Proceedings of the National Academy of Sciences*, Published online April 9, 2007, <http://www.pnas.org/cgi/content/abstract/0608998104v1>. (Subscription required.)

**“The GEFSOC soil carbon modeling system: A tool for conducting regional-scale soil carbon inventories and assessing the impacts of land use change on soil carbon.”** The GEFSOC soil carbon modeling system was built to provide interdisciplinary teams of scientists, natural resource managers and policy analysts (who have the appropriate computing skills) with the necessary tools to conduct regional-scale soil carbon (C) inventories. It allows users to assess the effects of land use change on soil organic carbon (SOC) stocks, soil fertility and the potential for soil carbon sequestration. The tool was developed in conjunction with case-studies of land use and management impacts on SOC in Brazil, Jordan, Kenya and India, which represent a diversity of land use and land management patterns and are countries where sustaining soil organic matter and fertility for food security is an on-going problem. The tool was designed to run using two common desktop computers, connected via a local area network. It utilizes open-source software that is freely available. All new software and user interfaces developed for the tool are available in an open source environment allowing users to examine system details, suggest improvements or write additional modules to interface with the sys-



tem. The tool incorporates three widely used models for estimating soil carbon dynamics: (1) the Century ecosystem model; (2) the RothC soil carbon decomposition model; and (3) the Intergovernmental Panel on Climate Change (IPCC) method for assessing soil C at regional scales. The tool interacts with a Soil and Terrain Digital Database (SOTER) built for the specific country or region the user intends to model. A demonstration of the tool and results from an assessment of land use change in a sample region of North America are presented. **M. Easter, K. Paustian, K. Killian, S. Williams, T. Feng, R. Al-Adamat, N.H. Batjes, M. Bernoux, T. Bhattacharyya, C.C. Cerri, C.E.P. Cerri, K. Coleman, P. Falloon, C. Feller, P. Gicheru, P. Kamoni, E. Milne, D.K. Pal, D.S. Powlson, Z. Rawajfih, M. Sessay and S. Wokabi**, *Agriculture, Ecosystems & Environment*, Available online February 15, 2007, [doi:10.1016/j.agee.2007.01.004](https://doi.org/10.1016/j.agee.2007.01.004), <http://www.sciencedirect.com/science/article/B6T3Y-4N2DRBJ-1/2/7f151403695b84df48ef38bf63b97b62>. (Subscription may be required.)

[environment/energy-giant-embraces-carbon-trading/2007/03/19/1174152972167.html#](http://environment/energy-giant-embraces-carbon-trading/2007/03/19/1174152972167.html#).

## Recent Publications

**“Carbon Sequestration Atlas of the United States and Canada.”** The US Department of Energy’s (DOE) National Energy Technology Laboratory (NETL) is proud to release the first “Carbon Sequestration Atlas of the United States and Canada.” Production of this Atlas is the result of cooperation and coordination among carbon sequestration experts from local, state, and government agencies, as well as industry and academia. This Atlas presents the first coordinated assessment of carbon capture and storage (CCS) potential across the majority of the US and portions of western Canada. The Atlas also provides an introduction to the carbon storage (sequestration) process, summarizes the DOE’s Carbon Sequestration Program, and gives information about the CCS contributions from each Regional Carbon Sequestration Partnership (RCSP) to date. One of the key questions concerning CCS is: how much potential is there to effectively help address global climate change? As shown in this Atlas, CCS holds great promise as part of a portfolio of technologies that enables the US and the rest of the world to address climate change while meeting the energy demands of an ever increasing global population. The Atlas includes the most current and best available estimates of potential carbon dioxide (CO<sub>2</sub>) sequestration capacities determined by a methodology applied consistently across all of the RCSPs. All data were collected before December 2006. “The Carbon Sequestration Atlas of the United States and Canada” contains three main sections: (1) Introduction, (2) National Perspectives, and (3) Regional Perspectives. The Introduction section contains an overview of CCS technologies, a summary of the DOE’s efforts in the CCS area, a brief description of the RCSP Program, and information on the National Carbon Sequestration Database and Geographic Information System (NATCARB). The National Perspectives section provides maps showing the number, location, and magnitude of all CO<sub>2</sub> sources in the US and portions of Canada, as well as the areal extent and capacity of geologic CO<sub>2</sub> sequestration sites evaluated within the RCSP Regions. The National Perspectives section also contains a summary of the methodologies and assumptions employed to calculate the estimated CO<sub>2</sub> sequestration capacities of various geologic formations.

## Trading

Carbon Market Update, April 16, 2007	
CCX-CFI 2007 (\$/tCO <sub>2</sub> ) <b>\$3.65 (Vintage 2007)</b>	EU ETS-EUA DEC 2007 (\$/tCO <sub>2</sub> ) <b>\$.99</b>  <b>(Converted from € to US\$)</b>

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



(Appendix A contains the complete “Methodology for Development of Carbon Sequestration Capacity Estimates” document.) The Regional Perspectives section includes a detailed presentation of CO<sub>2</sub> sequestration capacity assessments for each RCSP based on these methodologies and assumptions. (See article in this month’s Highlights section, “DOE Regional Partnerships Find More Than 3,500 Billion Tons of Possible Carbon Dioxide Storage Capacity,” and News section for the article, “US Sees Ample Room to Bury Carbon Dioxide but Costs Unknown,” which reference the Atlas.) To download the Atlas or sections of the Atlas see: [http://www.netl.doe.gov/publications/carbon\\_seq/atlas/index.html](http://www.netl.doe.gov/publications/carbon_seq/atlas/index.html).

**Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, “Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability.”** This Summary sets out the key policy-relevant findings of the Fourth Assessment of Working Group II of the Intergovernmental Panel on Climate Change (IPCC). The Assessment is of current scientific understanding of impacts of climate change on natural, managed and human systems, the capacity of these systems to adapt and their vulnerability. It builds upon past IPCC assessments and incorporates new knowledge gained since the Third Assessment. To download the Summary for Policymakers which was released on April 6, 2007 in Brussels, go to: <http://www.ipcc.ch/SPM6avr07.pdf>.

To listen to the audio webcast of the press conference in Brussels, go to: <http://scic.cec.eu.int/streaming/archives/ipcc2007/audio.asx>. (See article entitled, “Panel: Global Warming a Threat to Earth,” in the Science section of this newsletter, which references this report.)

**“Scotland’s Climate Change Programme: Annual Report 2007.”** “Scotland’s Climate Change Programme, Changing our Ways,” sets out how the Scottish Executive is responding to the urgent social, economic and environmental challenge of climate change. It quantifies Scotland’s equitable contribution to UK climate change commitments in carbon terms – the Scottish Share - and has set an ambitious Target to exceed this by one million tons of carbon savings in 2010. The Programme sets out actions to reduce all greenhouse gases but most measures focus upon carbon dioxide which makes up the greatest proportion of greenhouse gases. The Scottish Share and Target are therefore expressed in terms of tons of carbon. Scotland’s Climate Change Programme is work in progress towards a goal in 2010 and this is the first in a series of annual reports. “Scotland’s Climate Change Programme, Changing our Ways” can be found online at: <http://www.scotland.gov.uk/Publications/2006/03/30091039/0>. The pdf of the subject

annual report, which was laid before the Scottish Parliament by the Scottish Ministers in March 2007 can be found at: <http://www.scotland.gov.uk/Resource/Doc/169305/0047159.pdf>.



## Legislative Activity

**Greenwire, “Supreme Court Orders EPA to Consider Regulating Greenhouse Gases.”** On April 2, the Supreme Court ruled in favor of 11 states and 13 environmental groups that the US Environmental Protection Agency (EPA) must take action to regulate carbon dioxide (CO<sub>2</sub>) emissions from new cars and trucks. The first of its kind ruling, *Massachusetts v. EPA* rejects the notion that the EPA does not have the authority to set emissions standards or somehow regulate greenhouse gases in relation to global warming. Justice Paul Stevens, writing for the majority, also dismissed EPA’s standing that a federal rule would have little or no effect on climate change in Massachusetts or other states, because US automobile emissions account for only seven percent of global fossil fuel emissions and only a third of the country’s overall emissions. The consensus among environmentalists about the ruling is that it will now be up to Congress to move forward and institute legislation to regulate greenhouse gases. To read the Supreme Court opinion, go to: [http://www.eenews.net/features/documents/2007/04/02/document\\_gw\\_03.pdf](http://www.eenews.net/features/documents/2007/04/02/document_gw_03.pdf). To read a transcript of the oral arguments, see: [http://www.eenews.net/features/documents/2006/11/29/document\\_pm\\_01.pdf](http://www.eenews.net/features/documents/2006/11/29/document_pm_01.pdf).

April 2, 2007, [http://www.eenews.net/Greenwire/2007/04/02/archive/1/?terms="CLIMATE"](http://www.eenews.net/Greenwire/2007/04/02/archive/1/?terms=). (Subscription may be required.)

**Greenwire, "EPA to Issue Decision on California Emissions Waiver" and The Associated Press/Time, "EPA Revives California Emissions Rule."**

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

**Great Falls Tribune, "Tester Bill Aims to Put \$315 Million into Clean-Coal Technology."**

United States Senator Jon Tester (D-Montana) is co-sponsoring a bill totaling \$315 million which he would like to use to fund carbon capture and storage projects throughout the United States. The proposed legislation has the support of the Senate Energy and Natural Resources Committee chairman and the ranking member. The funding, to be allocated from 2008 through 2010, would be divided among the seven US Department of Energy (DOE)-sponsored Regional Partnerships, formed by DOE in 2004 to study the feasibility and safety of capture, injection and long-term storage of carbon dioxide (CO<sub>2</sub>). Tester's state of Montana is home to the Big Sky Regional Partnership, made up of researchers in Montana, Wyoming, Idaho, Washington, and Oregon. The partnership is based at Montana State University. Big Sky is currently hoping to initiate geologic sequestration pilot studies, which would involve small scale CO<sub>2</sub> injection studies at sites previously determined in their initial phase of re-

search. Success of these tests would be followed by large-scale injections. April 8, 2007, <http://www.greatfallstribune.com/apps/pbcs.dll/article?AID=/20070408/NEWS01/704080305&template=printart>.





## Events

May 7-10, 2007, **Sixth Annual Conference on Carbon Capture and Sequestration**, *Sheraton at Station Square, Pittsburgh, PA*. This conference will bring together the experts directly involved in developing, demonstrating and deploying carbon capture, separation and sequestration technologies as part of the Administration's Climate Change Technology Program. In addition, this year the Carbon Sequestration Leadership Forum Task Force on Capacity Building in Emerging Economies will sponsor a Workshop in conjunction with the conference devoted to possible approaches that can be undertaken to build capacity in the governmental and industrial sector to facilitate the development, deployment and public acceptance of carbon capture and sequestration. For conference and registration information, see: <http://www.carbonsq.com/>.

May 1, 2007, **Emissions Trading and the Road Transport Sector**, *Energy Institute, London, England*. This one-day event will present and discuss the latest thinking on the potential for introducing a carbon emissions trading system for the road transport sector. This event is a collaboration between the Low Carbon Vehicle Partnership and the Energy Institute. To visit the conference website and download a registration form, click on: <http://www.energyinst.org.uk/index.cfm?PageID=57>.

May 1-3, 2007, **Electric Power 2007**, *Donald E. Stephens Convention Center, Chicago, Illinois*. The Electric Power Conference is programmed by the power industry--for the power industry. Electric Power brings the industry a conference program that meets the needs of the power plant owner/operator companies and project developers. Sessions include "Coal Power Plants – Upgrades and New Capacity," "Integrated Gasification Combined Cycle (IGCC), Advanced Combustion and CO<sub>2</sub> Capture Technologies," and "Environmental Regulatory Issues, Strategies and Technologies." For complete conference and registration information, see: <http://www.electricpowerexpo.com/index.asp>.

May 2-4, 2007, **Carbon Expo**, *Koelnmesse, Cologne, Germany*. Carbon Expo is the global carbon market event that combines the up-to-date content of a high-level conference with the advantages of a trade fair. Participants will be able to interact with real market players representing supply and demand in the carbon market. For conference details, see: <http://www.carbonexpo.com/wEnglisch/carbonexpo2/index.htm>.

May 15-17, 2007, **Third International Conference on Clean Coal Technologies for our Future**, *T Hotel and Conference Centre, Cagliari and Sotacarbo Coal Research Centre, Carbonia, Sardinia, Italy*. The ability to use coal in an environmentally acceptable and sustainable manner is an important issue to consider. This conference will allow participants to share in the debate and formulate the important decisions that the individuals involved in the coal industry must make for the future. For further information and to visit the conference website, see: <http://www.cct2007.it/>.

May 23-24, 2007, **All-Energy '07 Exhibition and Conference**, *Aberdeen Exhibition and Conference Centre (AECC), Aberdeen, Scotland*. The All-Energy Exhibition and Conference is the United Kingdom's largest event devoted to renewable energy and is the seventh in the annual series. Admission to the exhibition and conference is free of charge to all with a professional interest in renewable/sustainable energy. A session devoted to carbon capture and storage is part of the conference agenda. Attendees can participate in a "cutting your organization's carbon footprint" clinic, and the conference website details how participants can use carbon offsetting for their air travel to the conference. For complete event information, go to: <http://www.all-energy.co.uk/Home.html>.

## Events (continued)

May 24-25, 2007, **Russia and the Kyoto Protocol**, *St. Petersburg National Mining Institute, St. Petersburg, Russia*. Designated as the largest carbon market conference in Russia, this event will bring together Russian authorities, project owners and developers, emission reduction buyers, potential project hosts, technology providers, carbon investors, and analysts. The conference will include presentations and discussions on Russia's share of the global carbon market, with specific focus on Assigned Amount Units (AAU) trading and investing in Joint Investment projects in Russia. For online registration and to view the conference program, go to: <http://www.pointcarbon.com/Events/Other%20Point%20Carbon%20events/article20697-406.html>.

May 29-31, 2007, **Corporate Climate Response**, *CBI Conference Centre, London, England*. Through a series of corporate case studies and expert panels this conference will highlight and benchmark how leading companies are responding to the challenges and opportunities of climate change. Issues to be covered include: Implications of the Energy Performance Commitment, offsetting, renewables, benchmarking, strategy and senior management. For event details, go to: [http://www.greenpowerconferences.com/corporateclimateresponse/ccr\\_london07.html](http://www.greenpowerconferences.com/corporateclimateresponse/ccr_london07.html).

June 4-5, 2007, **European Carbon Capture and Storage Conference**, *Amsterdam, Netherlands*. Carbon capture and storage appears as a highly attractive idea. It offers to resolve the contradiction between limiting carbon dioxide emissions and meeting growing energy demand. Moreover, it promises to do so without a radical change in energy sources, thereby avoiding the tremendous challenges posed by transitioning to a nonhydrocarbon based energy economy. Even on a small scale, it would provide a valuable wedge in the gradual transition to more sustainable energy systems. This conference will bring together key leaders from across Europe to share the challenges of development, manage the risks and ensure viability. For details about the event or to request a brochure, see: <http://www.platts.com/Events/pc773/>.

June 10-15, 2007, **The 32<sup>nd</sup> International Technical Conference on Coal Utilization and Fuel Systems**, *Sheraton Sand Key, Clearwater, Florida*. Conference attendees will share their knowledge and expertise on coal technologies. The issues on the front burners of the electric utility industry will be spotlighted. All in attendance will have a firm grasp on the major issues facing the industry today and tomorrow. Sessions of interest include: "Update on FutureGen," "Panel: Update on the Regional Carbon Sequestration Partnership," "Effective Carbon Management," and "The Future of Coal; Options for a Carbon Constrained World-Review of the MIT Coal Study." To read the complete conference brochure and for registration details, see: <http://www.coaltechnologies.com/Program%20Announcement%202007.pdf>.

June 14-15, 2007, **Carbon Markets Asia**, *Orchard Hotel Singapore, Singapore*. Asia is fast becoming one of the world's most exciting carbon markets. In the seven months since last year's Carbon Markets Asia 2006 event over 140 new Clean Development Mechanism (CDM) projects have been listed across the region, and the pace does not appear to be slowing down. This event will bring together the key players in this vibrant market in a forum of debate, analysis and learning. For event details and an agenda overview, visit: <http://www.greenpowerconferences.com/carbonmarkets/>



## Events (continued)

June 26-28, 2007, **Power-Gen Europe 2007**, *Feria de Madrid, Madrid, Spain*. Join the European power generation industry at the one place that both leading product suppliers and leading technical and strategic decision-makers gather. Power-Gen Europe 2007 promises even more, being co-located alongside two new industry gatherings, Renewable Energy Europe and Powergrid Europe, thereby bringing together three key elements of power production and delivery today – conventional power generation, renewable power generation, and transmission and distribution. For complete conference details, go to: <http://pge07.events.pennnet.com/fl/content.cfm?NavId=4701&Language=Engl>.

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