Carbon Sequestration Newsletter

DECEMBER 2009

A Call for Papers
see page 3

WHAT'S INSIDE?

INTRODUCTION

This Newsletter is created by the National Energy Technology Laboratory and represents a summary of carbon sequestration news covering the past month. Readers are referred to the actual article(s) for complete information. It is produced by the National Energy Technology Laboratory to provide information on recent activities and publications related to carbon sequestration. It covers domestic, international, public sector, and private sector news.

HIGHLIGHTS

***Fossil Energy Techline*, "DOE-Sponsored Mississippi Project Hits 1-Million-Ton Milestone for Injected CO_2."**

A large-scale carbon dioxide (CO_2) storage project led by the Southeast Regional Carbon Sequestration Partnership (SECARB) has injected more than 1 million tons to date at the Cranfield site in Southwestern Mississippi, becoming the fifth project worldwide to achieve that milestone. The Cranfield project combines the use of CO_2 injection with enhanced oil recovery (EOR), followed by CO_2 injection into deeper and larger-volume saline formations. Researchers at Cranfield have been monitoring the injected CO_2 with instrumentation installed nearly two miles beneath the surface to ensure the safe and permanent storage in the Lower Tuscaloosa Formations. The Cranfield project also has been successful in the deployment of pressure-response monitoring techniques in the injection zone ("in-zone") and above the injection zone ("above zone"). Real-time data collected since July 2008 has demonstrated that these techniques are cost-effective methods for monitoring, verification, and accounting (MVA) programs across the United States. SECARB is one of seven members of the Regional Carbon Sequestration Partnership (RCSP) Program managed by the Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL). The project, sponsored by the U.S. Department of Energy's (DOE) FE, is helping to move forward on Group of Eight (G-8) recommendations for launching 20 similar international projects by 2010. For more information on SECARB, click: http://secarbon.org/. To learn more about DOE's RCSP Program, go to: http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html. November 5, 2009, http://www.fossil.energy.gov/news/techlines/2009/09076-DOE_Project_Hits_Million_Ton_Miles.html.

***Fossil Energy Techline*, "DOE Signs Cooperative Agreement for New Hydrogen Power Plant."**

DOE signed a cooperative agreement with Hydrogen Energy California LLC (HECA) to build and demonstrate a hydrogen-powered, electric generating facility with carbon capture and storage (CCS) capabilities in Kern County, California. HECA also plans to construct an advanced Integrated Gasification Combined Cycle (IGCC) plant that will produce power by converting fuel into hydrogen and CO_2. Approximately 2 million tons of the CO_2 produced from the gasification process (around 90 percent) will be transported less than four miles by pipeline to the Elk Hills oilfield where it will be stored in underground geologic formations. Other benefits of the new plant include maximizing the use of non-potable water for the plant's power production, using EOR to increase oil production, and creating 1,500 construction jobs and 100 permanent operational positions. The project, which is estimated to cost approximately $2.3 billion with the Federal cost-share limited to $308 million (less than 11 percent), consists of three phases: project definition (Phase I), design and construction (Phase II), and demonstration (Phase III). The storage of 2 million tons of CO_2 per year is anticipated to begin by 2016. The project will be administered by DOE's FE and NETL and is part of the Clean Coal Power Initiative (CCPI), a cost-shared collaboration between the Federal government and private

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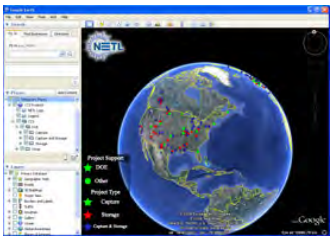
Highlights (Continued)

industry. November 6, 2009, http://www.fossil.energy.gov/news/techlines/2009/09077-DOE_Signs_Cooperative_Agreement.html.

***Fossil Energy Techline*, "DOE Targets Rural Indiana Geologic Formation for CO_2 Storage Field Test."**

The Midwest Geological Sequestration Consortium (MGSC) has initiated the injection of 8,000 tons of CO_2 to evaluate the carbon storage potential and test the EOR potential of abandoned oil wells in the Mississippian-aged Clore Formation in Posey County, Indiana. The injection is expected to last six to eight months and the field test will assess the most promising strategies for deploying CCS in the Illinois Basin. DOE researchers believe EOR programs can improve the efficiency and economics of using the technology in a variety of geologic applications. The three member project team, which is composed of the Illinois State Geological Survey at the University of Illinois, the Indiana Geological Survey, and Gallagher Drilling Inc., is injecting CO_2 into the Mumford Hills oilfield at an approximate depth of 1,900 feet. An MVA effort is currently underway to monitor air and groundwater quality; measure the amount of produced oil, gas, and water; monitor CO_2 injection composition, volumes, and rates; and monitor injection pressure and temperature. The project is expected to support more than 120 full-time jobs over the life of the project. For more information on MGSC, visit: http://www.sequestration.org/. November 12, 2009, http://www.fossil.energy.gov/news/techlines/2009/09078-Indiana_CO2_Injection_Begins.html.

***Fossil Energy Techline*, "Worldwide Carbon Capture and Storage Projects on the Increase."**



According to a new DOE online database, worldwide efforts to fund and establish CCS projects have accelerated, indicating ongoing momentum toward achieving the G-8 goal for launching 20 CCS demonstrations by 2010. A project of FE and NETL, the CCS Database reveals 192 proposed and active CCS projects worldwide (38 capture, 46 storage, and 108 capture and storage). The database also provides information about the efforts of various industries, public groups, and governments to develop and deploy CCS technology; lists technologies being developed for capture, testing sites for CO_2 storage, and estimations of costs and anticipated project completion dates; and uses Google Earth to illustrate the location of projects and provide links for further information in a user friendly application. The database will be updated as more information becomes available. To view the NETL CCS Database, visit: http://www.netl.doe.gov/technologies/carbon_seq/database/index.html. November 13, 2009, http://www.fossil.energy.gov/news/techlines/2009/09079-DOE_Unveils_CCS_Database.html.

Sequestration in the News

***Reuters*, "U.S. Coal Plant Captures and Stores Carbon,"** and ***Carbon Capture Journal*, "Alstom and AEP Commission Mountaineer CCS Demonstration."**

American Electric Power (AEP) and Alstom have teamed together to demonstrate technology that captures and stores CO_2 emissions at AEP's 1,300-megawatt (MW) Mountaineer Power Plant in West Virginia. The project diverts flue gas from the plant's smokestack to a structure that traps the CO_2 using a chilled ammonia solution. The CO_2 is compressed into a liquid-like state, transported approximately 1,300 feet by pipeline to two separate sites, and injected into saline formations 8,000 feet underground. The Mountaineer CCS demonstration project, which is designed to capture at least 100,000 metric tonnes of CO_2 annually and cost approximately $73 million, began capturing and storing CO_2 in September and October 2009, respectively. If successful, AEP plans to install a $670 million, 235-MW, commercial-scale CCS project at the same plant. November 17, 2009, http://www.reuters.com/article/companyNews/idUSN0926278820091118, and October 30, 2009, http://www.carboncapturejournal.com/displaynews.php?NewsID=475&PHPSESSID=1oktiartr07lsnu1m2227hvb14.

***Renewable Energy Magazine*, "GE to Power World's Largest Carbon Sequestration Plant."**

According to a recent announcement, a CCS project under Barrow Island off Australia's west coast will be powered with compression equipment supplied by GE Oil & Gas. The project is part of the Gorgon Project, which involves extracting natural gas from the Gorgon natural gas field in Australia and delivering it by pipeline(s) to gas treatment and liquefaction facilities on Barrow Island. Carbon dioxide will be stripped from the natural gas before it is liquefied and the captured CO_2 will be injected into depleted natural gas wells 1,300 meters below the surface. The Gorgon Project, Australia's biggest single resource project, is projected to generate 10,000 jobs and cost approximately $39.4 billion for the first phase of development and $45.8 billion overall. Gorgon is one of the first major greenhouse gas (GHG) storage projects to be launched following the G-8's 2008 recommendation to implement 20 large-scale CCS demonstration projects by 2020. The partners of the project are proposing to capture and store more than 3.4 million metric tonnes of CO_2 per year, or 120 million tonnes over the life of the project. October 30, 2009, http://www.renewableenergymagazine.com/paginas/Contenidosecciones.asp?ID=14&Cod=4333&Tipo=&Nombre=Latest%20news.

***U.S. News & World Report*, "Dutch Government Pushes Forward on CO_2 Storage."**

The Dutch Government has approved a pilot project that will inject approximately 800,000 tons of CO_2 into depleted gas fields more than one mile beneath Barendrecht, a suburb 12 miles from Rotterdam. According to estimates by the Dutch Government, there is a storage capacity of approximately 10 million tons of CO_2 in two underground depleted oil fields at this location. The project researchers will closely monitor the use of the first field before considering the use of the second field. While a number of similar projects to store CO_2 underground are currently underway across Europe, this project is the first of its kind in the Netherlands. If successful, the project will also help the European Union (EU) achieve its goal of significantly reducing GHG emissions by 2050. November 18, 2009, http://www.usnews.com/science/articles/2009/11/18/dutch-government-pushes-forward-co2-storage.html.

Announcements

PCOR Releases Documentary.

The Plains CO_2 Reduction (PCOR) Partnership has released a series of 30-minute documentaries, including its most recent release, titled, "Managing Carbon Dioxide: The Geologic Solution." This video discusses the history of geologic CO_2 sequestration. To view the documentary, visit the PCOR website at: http://www.undeerc.org/PCOR/documentary/default.aspx.

Call for Papers.

The 9th Annual Carbon Capture and Sequestration Conference, scheduled for May 10-13, 2010, at the Hilton Pittsburgh in Pittsburgh, Pennsylvania, is currently accepting papers and poster presentations. Abstracts must be submitted online by February 16, 2010. For more information on the requirements and guidelines, visit: http://www.carbonsq.com/pdf/2010/call%20for%20papers.pdf.

U.S.-China Clean Energy Announcements.

On November 17, 2009, the United States and China announced a package of measures to strengthen cooperation on clean energy between the two countries. Among the six fact sheets released, the two countries announced the establishment of the U.S.-China Clean Energy Research Center, the U.S.-China Energy Efficiency Action Plan, and the U.S.-China Renewable Energy Partnership. To learn more, view the White House Press Release at: http://www.whitehouse.gov/the-press-office/us-china-clean-energy-announcements.

Announcements - Continued

United Nations Climate Change Conference (COP 15) in Copenhagen.
World leaders will discuss a comprehensive and ambitious climate change deal at the United Nations Climate Change Conference (COP 15) at the Bella Center in Copenhagen, Denmark, on December 7-18, 2009. For more information, including a detailed overview of the event, go to: http://unfccc.int/meetings/items/4749.php.

10th International Conference on Greenhouse Gas Control Technologies.
The 10th International Conference on Greenhouse Gas Control Technologies (GHGT-10) will be held in Amsterdam, Netherlands, on September 19-23, 2010. This conference will provide a platform for discussions on overcoming barriers involved in the implementation of GHG mitigation technologies. For more information, visit the conference website at: http://www.ghgt.info/ghgt10.html.

EOR as CCS: Removing the Obstacles to Permanently Storing Carbon Dioxide.
Electric Utility Consultants, Inc. (EUCI) is presenting this web conference on January 13, 2009, from noon to 1:30 PM Eastern Time. Among the topics to be discussed include a session focusing on the injection of CO_2 for EOR projects. To download a brochure, go to the conference website at: https://www.euci.com/web_conferences/0110-eor/.

Science

***Canada.com*, "Global Warming a Growing Threat to Arctic Reindeer."**

Climate change is affecting the reindeer population in Norway as rising temperatures hit food stocks and industry growth moves into grazing lands. As winter temperatures rise, lichen, a fungus that grows on rocks or tree trunks and serves as the main food source of reindeer in Norway, has become more difficult to find. In the past, snow has fallen on dry ground, but recently snow has fallen on previously melted snow, creating ice that covers the ground and lichen and affects the reindeers' ability to digest the food. Adding to the threat, grazing land is also disappearing as buildings, pipelines, roads, and other infrastructure are developed in the region. To alleviate the effects, reindeer herders are forced to move the animals to drier grounds. Studies show that the Arctic tends to warm three times faster than elsewhere in the Northern Hemisphere. November 15, 2009, http://www.canada.com/technology/Global+warming+growing+threat+Arctic+reindeer/2220423/story.html.

***The New York Times*, "Seas Grow Less Effective at Absorbing Emissions."**

According to new research published in the journal Nature, the Earth's oceans have grown less efficient at absorbing CO_2 emissions. Scientists claim the oceans' intake of CO_2 from the burning of fossil fuels has declined since the 1980s, with a larger decrease since 2000. According to the research, the diminishing absorption rate results from a gradual change in the oceans' chemistry. Scientists arrived at this conclusion by creating a mathematical model using measurements of seawater, such as temperature and salinity, collected over the past 20 years. The data was then worked backward to create a formula that established the accumulation of human-generated CO_2 from the beginning of the industrial era to present day. The results showed that even as human-generated emissions of CO_2 increased, the oceans' uptake rate growth dropped by 10 percent from 2000 to 2007. November 18, 2009, http://www.nytimes.com/2009/11/19/science/earth/19oceans.html?_r=3. (Subscription may be required.)

***Science Daily*, "Warmer Means Windier on World's Biggest Lake."**

Rising water temperatures are resulting in more powerful winds on Lake Superior, with the potential to affect currents and biological cycles. Surface water temperatures measured by lake buoys have climbed 1.2 degrees per decade since 1985, approximately 15 percent faster than the air above the lake and twice as fast as warming over nearby land. Winds generally remain calm over cold water as a result of the wide temperature differential between water and air. However, as the water warms, the temperature gap is shrinking, causing the atmosphere to become more turbulent. Scientists and researchers used more than 20 years of temperature and wind data collected by three lake buoys and Earth-observing satellites to model Lake Superior's water and wind system in three dimensions. November 15, 2009, http://www.sciencedaily.com/releases/2009/11/091115134132.htm.

Policy

***Internal Revenue Bulletin: 2009-44*, "Credit for Carbon Dioxide Sequestration Under Section 45Q."**

On November 2, 2009, the Internal Revenue Service (IRS) issued guidance for taxpayers to claim tax credits for capturing qualified CO_2 from a qualified facility and safely storing the CO_2 in a geologic

Policy (Continued)

formation in the United States. Under Section 45Q, which was added to the IRS code by the Energy Improvement and Extension Act of 2008, a taxpayer who stores CO_2 under the predetermined conditions may qualify for the tax credit if: (1) the taxpayer owns an industrial facility where carbon capture equipment is in service; (2) the taxpayer captures at least 500,000 metric tons of qualified CO_2 at the industrial facility during the taxable year; and (3) the qualified CO_2 is securely stored in a geologic formation (this requirement applies only for CO_2 captured after February 17, 2009, if the CO_2 is used in an EOR project). If the qualified CO_2 is not used in an EOR project, the tax credit totals $20 per metric ton of qualified CO_2; if the qualified CO_2 is used in an EOR project, the tax credit totals $10 per metric ton of qualified CO_2. The taxpayer will be responsible for maintaining records for inspection by the IRS, including: (1) methodology, inputs, and equations used to measure the amount of CO_2 at the source of capture and verify the amount of CO_2 injected (CO_2 recycled or re-injected as part of EOR operations are not included in the credit); (2) evidence of secure geological storage, such as certificates issued by a Federal or state government; (3) methodology, inputs, and equations used to calculate the amount of CO_2; and (4) all contracts entered into by the taxpayer and any contracting party that ensure the use of the CO_2 for EOR or secure geological storage. The tax credit amount will be adjusted for inflation for any taxable year beginning in a calendar year after 2009. The complete IRS Bulletin: 2009-44, which contains Notice 2009-83, is available at: http://www.irs.gov/pub/irs-irbs/irb09-44.pdf. November 2, 2009, http://www.irs.gov/irb/2009-44_IRB/ar11.html#d0e1860.

"Design considerations for financing a national trust to advance the deployment of geologic CO_2 storage and motivate best practices."

The following is the Abstract of this article: "This paper explores how the widely held public policy view of the evolution of the risk profile associated with geologic CO_2 storage profoundly influences the public policy dialogue about how to best address the long-term risk profile for geologic storage. Evidence emerging from research and pilot scale field demonstrations of CO_2 storage demonstrates that, with proper site characterization and sound operating practices, retention of stored CO_2 will increase with time thus invalidating the premise of an ever growing risk. The authors focus on key issues of fit, interplay, and scalability associated with the ability of a trust fund funded by a hypothetical $1 per ton CO_2 tipping fee for each ton of CO_2 stored in the United States under WRE450 and WRE550 climate policies to manage such risks in an economically efficient and environmentally effective manner. The authors conclude there is no intrinsic value – in terms of risk management or risk reduction – in creating a trust fund predicated solely on collecting a universally applied tipping fee that does not take into account site-specific risk profiles. If left to grow unchecked, a trust fund that is predicated on a constant stream of payments unrelated to each contributing site's risk profile could result in the accumulation of hundreds of billions to more than a trillion dollars contributing to significant opportunity cost of capital. Further, rather than mitigating the financial consequences of long-term CCS risks, this analysis suggests a blanket $1 per ton CO_2 tipping fee, if combined with a concomitant limitation of liability may increase the probability and frequency of long-term risk by eliminating financial incentives for sound operating behavior and site selection criteria—contribute to moral hazard. At a minimum, effective use of a trust fund requires: (1) strong oversight regarding site selection and fund management, and (2) a clear process by which the fund is periodically valued and funds collected are mapped to the risk profile of the pool of covered CCS sites. Without appropriate checks and balances, there is no *a priori* reason to believe that the amount of funds held in trust will map to the actual amount of funds needed to address long-term care expenses and delimited compensatory damages. For this reason, the authors conclude that financing a trust fund or other risk management instrument should be based on a site delimited estimate of potential future expected financial consequences rather than on the random adoption of a fixed funding stream, e.g., a blanket $1 per ton, because it 'sounds' reasonable." **James J. Dooley, Chiara Trabucchi, and Lindene Patton**, *International Journal of Greenhouse Gas Control*, Available online October 15, 2009, doi: 10.1016/j.ijggc.2009.09.009, http://www.sciencedirect.com/science/article/B83WP-4XFXXB2-1/2/be52e71c0b2a3e6f61ec0e8147a0d02f. (Subscription may be required.)

"Stakeholder attitudes on Carbon Capture and Storage – An International Comparison."

The following is the Abstract of this article: "This paper presents results from a survey of stakeholder attitudes towards CCS. The survey is the first to make a global comparison across three major regions: North America, Japan, and Europe. It is based on a 30-question survey which targeted individuals working at stakeholder organizations that seek to shape, and will need to respond to, policy on CCS, including electric utilities, oil and gas companies, CO_2-intensive industries and non-governmental organizations (NGOs). The paper reports results from the original survey carried out in 2006 and from a recent follow up on key CCS questions (April 2009). The results show generally small differences across the regions and between the different groups of stakeholders. All believed that the challenge of significant reductions in emissions using only current technologies was severe. There was a widespread belief that CCS as well as renewable technologies such as solar power will achieve major market entry into the electricity sector within the next 10-20 years, whereas there is more [skepticism] about the role of hydrogen and especially nuclear fusion in the next 50 years. All groups were generally positive towards renewable energy. Yet, there were some notable areas of disagreement in the responses, for example, as expected, NGOs considered the threat of climate change to be more serious than the other groups. North American respondents were more likely to downplay the threat compared to those of the other regions. The Japanese were more concerned about the burden that would be placed on industry in the coming decade as a result of emissions constraints and NGOs were more likely to believe that the burden imposed would be light. NGO respondents also believed CCS to be far more attractive than nuclear power (fission) but much less than renewables. As expected, the risk for leakage from reservoirs was ranked number one of the risk options given. The follow-up study generally confirmed the results of the original study with a few notable differences. As expected, the results of the follow-up shows that respondents consider CCS to play an increased role in the national climate debate. In Japan, there was an increased fraction of respondents who claimed that their organization has a clear position on CCS." **Filip Johnsson, David Reiner, Kenshi Itaoka, and Howard Herzog**, *International Journal of Greenhouse Gas Control*, Available

Policy (Continued)

online October 16, 2009, doi: 10.1016/j.ijggc.2009.09.006, http://www.sciencedirect.com/science/article/B83WP-4XG3DJ7-1/2/54db359fb6dd0f6335fb878bb61caa4a. (Subscription may be required.)

Geology

"Changes in reservoir properties from injection of supercritical CO_2 into coal seams – A laboratory study."

The following is the Abstract of this article: "Two Australian Permian coals of similar rank but different texture, one predominantly dull and the other predominantly bright, were investigated in laboratory experiments to assess changes in reservoir properties following exposure to supercritical CO_2 ($SCCO_2$) and water. Both powdered coal (0.180-0.220 mm) and small cubes (15 mm to a side) were tested in a high-pressure (HP) batch reactor for up to 120 hrs. Two reaction fluids were used, each on separate sister coal samples: de-ionized water (DH_2O) only, and a $SCCO_2$ and DH_2O mixture. Properties were measured before and after treatment with: high-pressure CO_2 adsorption isotherms (storage capacity); helium pycnometry, mercury porosimetry and low-pressure (LP) CO_2 adsorption (density, porosity and PSD effects); leachate chemical analysis for dissolved mineral matter; and water and CO_2 permeabilities at in situ conditions during core flood experiments on an 80 mm cube. Micro and meso porosities for both coals showed significant increases after reactions with the $SCCO_2$ and DH_2O mixture. The macro porosity decreased significantly for the dull coal, but increased marginally for the bright coal. Total accessible porosity for dull coal showed virtually no change (0.5 [percent]); the bright coal exhibited 3.4 [percent] increase from a pretreatment total porosity of 11.0 [percent]. On powdered samples reacted with the mixture, 80 [percent]+ increases in internal surface areas, measured using LP CO_2 sorption at 0°C, were noted for both coals. The HP CO_2 excess adsorption isotherms on both coals increased after treatment, varying with pressure level, coal type and coal texture. The core flood tests indicated the permeability to CO_2, after a waterflood stage, increased significantly. The second stage waterflood exhibited an over 600 [percent] increase on the pre-CO_2 first stage waterflood permeability. These combined results indicate that mineral matter in Permian coals is dissolved and mobilized by the carbonic acid formed during CO_2 dissolution in water, leading to increased porosity, permeability and HP CO_2 excess adsorption." **P. Massarotto, S.D. Golding, J.-S. Bae, R. Iyer, and V. Rudolph**, *International Journal of Coal Geology*, Available online November 11, 2009, doi: 10.1016/j.coal.2009.11.002, http://www.sciencedirect.com/science/article/B6V8C-4XNN5B9-1/2/f315ed125c98cec799200670306288fc. (Subscription may be required.)

"Role and impact of CO_2-rock interactions during CO_2 storage in sedimentary rocks."

The following is the Abstract of this article: "Before implementing CO_2 storage on a large scale its viability regarding injectivity, containmentand long-term safety for both humans and environment is crucial. Assessing CO_2-rock interactions is an important part of that as these potentially affect physical properties through highly coupled processes. Increased understanding of the physical impact of injected CO_2 during recent years including buoyancy driven two-phase flow and convective mixing elucidated potential CO_2 pathways and indicated where and when CO_2-rock interactions are potentially occurring. Several areas of interactions can be defined: (1) interactions during the injection phase and in the near well environment, (2) long-term reservoir and caprock interactions, (3) CO_2-rock interactions along leakage pathways (well, caprock and fault), (4) CO_2-rock interactions causing potable aquifer contamination as a consequence of leakage, (5) water-rock interactions caused by aquifer contamination through the CO_2 induced displacement of brines and finally engineered CO_2-rock interactions (6). The driving processes of CO_2-rock interactions are discussed as well as their potential impact in terms of changing physical parameters. This includes dissolution of CO_2 in brines, acid induced reactions, reactions due to brine concentration, clay desiccation, pure CO_2-rock interactions and reactions induced by other gases than CO_2. Based on each interaction environment the main aspects that are possibly affecting the safety and/or feasibility of the CO_2 storage scheme are reviewed and identified. Then the methodologies for assessing CO_2-rock interactions are discussed. High priority research topics include the impact of other gaseous compounds in the CO_2 stream on rock and cement materials, the reactivity of dry CO_2 in the absence of water, how CO_2 induced precipitation reactions affect the pore space evolution and thus the physical properties and the need for the development of coupled flow, geochemical and geomechanical models." **Irina Gaus**, *International Journal of Greenhouse Gas Control*, Available online November 2, 2009, doi: 10.1016/j.ijggc.2009.09.015, http://www.sciencedirect.com/science/article/B83WP-4XKSY3T-1/2/1607d6daddb03048627d59695f95f2e5. (Subscription may be required.)

Technology

"Making carbon dioxide sequestration feasible: Toward federal regulation on CO_2 sequestration pipelines."

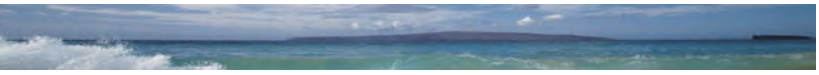
The following is the Abstract of this article: "As the United States moves closer to a national climate change policy, it will have to focus on a variety of factors affecting the manner in which the country moves toward a future with a substantially lower carbon footprint. In addition to encouraging renewable energy, smart grid, clean fuels and other technologies, the United States will need to make substantial infrastructure investments in a variety of industries. Among the significant contributors to the current carbon footprint in the United States is the use of coal as a major fuel for the generation of electricity. One of the most important technologies that the United States can employ to reduce its carbon footprint is to sequester the CO_2 from coal-fired power plants. This article focuses on the legal and policy issues surrounding a critical piece of the necessary sequestration infrastructure: CO_2 pipelines that will carry CO_2 from where it is removed from fuel or waste

Technology (Continued)

gas streams to where it will be sequestered. Ultimately, this article recommends developing a federally regulated CO_2 pipeline program to foster the implementation of carbon sequestration technology." **Joel Mack and Buck Endemann**, *Energy Policy*, Available online October 28, 2009, doi: 10.1016/j.enpol.2009.10.018, http://www.sciencedirect.com/science/article/B6V2W-4XJN4X4-4/2/b23168f0c51c94939fdbdc34b1f5fe79. (Subscription may be required.)

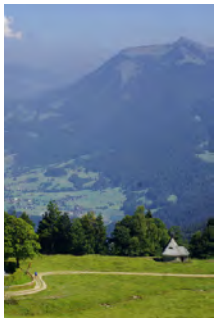
"CO_2 sequestration from coal fired power plants."

The following is the Abstract of this article: "The paper takes into consideration a new approach for CO_2 capture and transport, based on the formation of solid CO_2 hydrates. Carbon dioxide sequestration from power plants can take advantage of the properties of gas hydrates. The formation and decomposition of hydrates from various N_2-CO_2 mixtures has been studied experimentally in a 2 l reactor, to determine the CO_2 separation in terms of hydrate composition and residual CO_2 content in the reacted gas. Carbon dioxide acts as a co-former for the production of hydrates containing nitrogen, besides CO_2. The mixed hydrates that are obtained are less stable than simple CO_2 hydrates. When CO_2 content in the flue gas is higher than 30 [percent] by volume, the hydrates formed at 5 MPa are sufficiently concentrated (about 70 [percent] CO_2) and [CO_2] reduction in the reacted gas is acceptable. The application of a process based on hydrate formation could be especially interesting (for CO_2 capture and transport) when connected to an oxy-coal combustion process; in this case the CO_2 content in the flue gas is very high and the hydrate formation is greatly facilitated." **Carlo Giavarini, Filippo Maccioni, and Maria Laura Santarelli**, *Fuel*, Available online October 14, 2009, doi: 10.1016/j.fuel.2009.09.035, http://www.sciencedirect.com/science/article/B6V3B-4XFN8DC-3/2/b1a8fb38a632d453b57432adaa457790. (Subscription may be required.)



Terrestrial

"IA-SDSS: A GIS-based land use decision support system with consideration of carbon sequestration."



The following is the Abstract of this article: "Land use, land use change and forestry (LULUCF) can play a positive role in mitigating global warming by sequestering carbon from the atmosphere into vegetation and soils. Local entities (e.g. local government, community, stockholders) have been making great efforts in enhancing carbon sequestration (CS) of local forests for mitigating global climate change and participating in international carbon-trade promoted by the Kyoto Protocol. Approaches and tools are needed to assess the enhancement of CS through land use changes and proper policy decisions. This paper presents an integrated assessment framework and a spatial decision support system (IA-SDSS) as a tool to support land-use planning and local forestry development with consideration of CS. The IA-SDSS integrates two process-based carbon models, a spatial decision (EMDS) module, a spatial cost-benefit analysis (CBA) module, and the analytic hierarchy process (AHP) module. It can provide spatially explicit CS information as well as CS-induced economic benefits under various scenarios of the carbon credit market. A case study conducted in Liping County, Guizhou Province, China demonstrated that the IA-SDSS developed in this study is applicable in supporting decision-making on 'where' and 'how' to adopt forestry land use options in favor of CS." **Jun Wang, Jingming Chen, Weimin Ju, and Manchun Li**, *Environmental Modelling & Software*, Available online November 7, 2009, doi: 10.1016/j.envsoft.2009.09.010, http://www.sciencedirect.com/science/article/B6VHC-4XMTFRC-3/2/331c1a97dc5641efcd03dc487b151bc0. (Subscription may be required.)

Carbon Market Update, November 16, 2009	
CCX-CFI 2009 ($/tCO$_2$)	EU ETS-EUA DEC 2009
$0.15 (Vintage 2009)	($/tCO$_2$) $20.37
	(Converted from € to US$)

Trading

***European Environment Agency Press Release*, "Non-Industrial Emissions Key for Meeting Kyoto Targets."**

On November 12, 2009, the European Environment Agency (EEA) released a report that shows the majority of EU member states are on track to meet their Kyoto Protocol commitments to reduce GHG emissions. The Kyoto Protocol requires the EU member states to reduce their average emissions during 2008 through 2012 to eight percent below 1990 levels; however, recent projections indicate that the member states are on pace to exceed the number, reaching a total reduction of more than 13 percent below the base year. According to the EEA report, reductions during the period will be achieved through a combination of existing and additional policies, the purchase of credits from emission-reducing projects outside the EU, the trading of emission allowances by participants in the EU emission trading scheme (EU ETS), and forestry activities that absorb CO_2 from the atmosphere. To view the EEA report, titled, "Greenhouse gas emission trends and projections in Europe 2009," click: http://www.eea.europa.eu/publications/eea_report_2009_9. November 12, 2009, http://www.eea.europa.eu/pressroom/newsreleases/non-industrial-emissions-key-for-meeting-kyoto-targets.

Recent Publications

Carbon Dioxide Capture for Storage in Deep Geologic Formations – Results from the CO_2 Capture Project.

The following is from the Preface of this document: "The CO_2 Capture Project (CCP) is a collaborative partnership of eight of the world's leading energy companies and three government organizations. The initiative undertakes research and develops technologies to help make CCS a practical reality for reducing global CO_2 emissions and tackling climate change – one of the great international challenges of [this] time. Since 2000, CCP has been at the very forefront of advancing CCS; a process that involves capturing the CO_2 emitted from industrial and energy-related sources and then securely storing the CO_2 deep underground in geological formations. Phase 1 of CCP identified next generation capture technologies that had the potential to deliver performance and efficiency improvements resulting in close to a 50 [percent] reduction in the cost of CO_2 capture. It also pioneered a risk-based approach for geological site selection, operation and abandonment; and developed new CO_2 monitoring tools and the science behind CO_2 geological storage. In Phase 2, CCP has continued to build on achievements in capture and storage. The culmination of this five year study is found in this book." To view the rest of this document, visit: http://www.co2captureproject.org/ccp_results3.html.

An Ideal Portfolio of CCS Projects and Rationale for Supporting Projects.

The following is from the Executive Summary of this document: "The potential impact from climate change brought about by increasing atmospheric concentrations of [GHGs] is widely acknowledged as a global problem that requires urgent global action. CCS will need to play an important role within the portfolio of approaches required to achieve a material reduction in [CO_2] for two reasons, namely: (1) the continued importance of fossil fuels to future energy supply; and (2) the scale of CO_2 emissions from industries where there are limited other abatement options. Accordingly, the [G-8] supports the launch of 20 large-scale projects by 2010 that will help to bring about broad scale deployment of CCS by 2020. The Global CCS Institute was launched by the Australian Government in April 2009. The objective of the Global CCS Institute is to accelerate the broad-based commercial deployment of CCS technologies, so that CCS forms an integral part of the portfolio of technologies required to make significant reductions in the level of CO_2 emissions. In June 2009, L.E.K. Consulting (L.E.K.) was commissioned by the Global CCS Institute to characterize an Ideal Portfolio of CCS project types and develop a Rationale for Supporting Projects." To view the full document, click: http://www.globalccsinstitute.com/downloads/FP_Global_CCS_Portfolio_Final%20Report_2009OCT16_v2.pdf.

Near Zero Emissions Coal (NZEC) Initiative.

The following is from the Executive Summary of this document: "The China-UK Near Zero Emissions Coal (NZEC) Initiative has examined the merits of various options for CCS in China, including the potential for the development of CCS technology and its deployment in the future. It was developed under the wider 2005 EU-China NZEC Agreement which aims to demonstrate CCS in China and the EU. Reconciling the potential for economic growth in China with the global need to reduce CO_2 emissions, as well as making best use of national resources of coal, is a complicated issue. A range of measures is being put in place in China to tackle [GHG] emissions, including energy efficiency improvements as well as the introduction of significant amounts of energy from nuclear, wind, solar and other renewable sources. For the power generation and energy intensive industrial sectors, such as iron/steel and cement, all of which remain heavily dependent on coal, CCS is the only option that can ensure a significant reduction in CO_2 emissions." To view the entire report, click: http://www.nzec.info/en/assets/Reports/China-UK-NZEC-English-031109.pdf.

Legislative Activity

***U.S. Senator John Barrasso Press Release*, "Barrasso, Bingaman Introduce Bill to Address Global Warming."**

U.S. Senators John Barrasso and Jeff Bingaman introduced a bill that encourages the development of clean air technology that removes CO_2 from the atmosphere and permanently stores it. The Carbon Dioxide Capture Technology Act (S.2744), which will create an award system for scientists and researchers, states a program would be established by a Federal commission under DOE. Members of the commission would include climate scientists, physicists, chemists, engineers, business managers, and economists. Awards will go to the public and private entities that design technology to remove and permanently store CO_2 directly from the atmosphere. Once the technology is developed, the property rights would be shared by the United States and the inventor. To view the "Carbon Dioxide Capture Technology Act" (S.2744), click: http://www.govtrack.us/congress/bill.xpd?bill=s111-2744. November 12, 2009, http://barrasso.senate.gov/public/index.cfm?FuseAction=PressOffice.PressReleases&ContentRecord_id=e98e0891-081e-ddac-1ae4-15c3905ebef0&Region_id=&Issue_id=.

EVENTS

December 8-10, 2009, **Power-Gen International**, *Las Vegas Convention Center, Las Vegas, Nevada, USA*. This conference will cover environmental issues, fossil technologies, renewable energies, and plant performance related to the power industry. Included in the agenda are sessions focused on carbon capture plant design and pre- and post-combustion CO_2 reduction technologies. To download the full agenda, click: http://www.power-gen.com/etc/medialib/power-gen-international/documents.Par.59930.File.dat/PGI%2009%20Conference%20Grid3.pdf.

December 11-12, 2009, **Carbon Credit International Conference**, *New Delhi, India*. Attendees of this conference will develop knowledge of the Clean Development Mechanism (CDM) through the trading of carbon credits. In addition, attendees will be provided with carbon financing opportunities and have the chance to network with individuals working in the CDM market. To learn more, visit the conference website at: http://www.onlinecarbonfinance.com/.

December 14-18, 2009, **AGU 2009 Fall Meeting**, *Moscone Convention Center, San Francisco, California, USA*. This meeting provides an opportunity for researchers, teachers, students, and consultants to discuss the latest topics in Earth and space sciences. Included are presentations covering climate change projections and impacts in the United States. To learn more, visit the conference website at: http://www.agu.org/meetings/fm09/index.php.

January 21-22, 2010, **3rd Annual Carbon Trading: Opportunities and Risks in a National Cap-and-Trade System**, *Sheraton Suites Hotel, Houston, Texas, USA*. This event offers in-depth information on new and potential carbon regulations in the United States and how they can affect business decisions. Among the topics to be discussed are carbon liabilities, carbon regulations, and forest and natural resource projects. For more information, visit the conference website at: http://www.platts.com/ConferenceDetail.aspx?xmlpath=2010/pc003/index.xml.

January 26-27, 2010, **4th Annual Carbon Capture and Storage Conference**, *Calgary Telus Convention Centre, Calgary, Alberta*. This conference will focus on the long-term viability and execution of CCS. Designed to address the vital issues concerning the commercial success of CCS, the agenda also includes discussions on the risks of carbon storage, optimal conditions to transport CO_2, and reliable CO_2 capture technologies. To view the full agenda, visit the conference website at: http://www.canadianinstitute.com/CCS.htm.

February 17-18, 2010, **Carbon and Climate Change**, *AT&T Conference Center - Hotel at the University of Texas, Austin, Texas, USA*. This two-day conference covers topics such as U.S. climate policies and regulations, carbon taxes, and the economics of carbon capture and mitigation, as well as a presentation by DOE about the need to reduce GHGs. To view the entire program, go to: http://www.utcle.org/conference_overview.php?conferenceid=840#Travel.

February 23-24, 2010, **4th Annual European Carbon Capture and Storage**, *Hilton Park Lane, London, UK*. This event will provide an update on Europe's developing CCS market, funding allocation, policy changes, lessons learned from European and international case studies, and practical solutions to the challenges of commercialization. For more information, visit the conference website at: http://www.platts.com/ConferenceDetail.aspx?xmlpath=2010/pc065/index.xml.

March 5-6, 2010, **2010 MIT Energy Conference**, *Sheraton Boston Hotel, Boston, Massachusetts, USA*. This student-run conference brings together leaders in the fields of technology, policy, industry, and finance to develop solutions for the world's energy challenges. Fundamental changes in the way energy is produced and consumed will be explored and technology and policy pathways that have potential to make a significant impact on energy solutions across the global energy landscape will be presented. To learn more, visit the conference website at: http://www.mitenergyconference.com/index.php.

Events (Continued)

May 10-13, 2009, **9th Annual Conference on Carbon Capture & Sequestration**, *Hilton Pittsburgh, Pittsburgh, Pennsylvania, USA.* Following in the footsteps of the previous eight events, this annual conference will focus on the potential of present and future CCS technologies deployed in the United States and North America. Members from the U.S. and international scientific and engineering communities will be present to share experiences on such technologies and systems. For more information, visit the conference website at: http://www.carbonsq.com/.

For subscription details...

Please visit http://listserv.netl.doe.gov/mailman/listinfo/sequestration, enter your email address, and create a password. This will enable you to receive a pdf version of the Carbon Sequestration Newsletter at no cost.
To view an archive with past issues of the newsletter, see: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/subscribe.html.

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