Carbon Sequestration Newsletter

April 2011

What's Inside?

Introduction

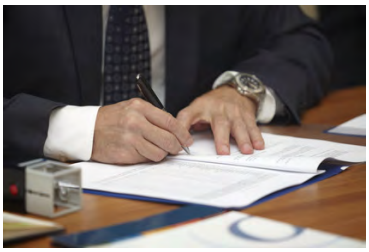
This Newsletter is created by the National Energy Technology Laboratory and represents a summary of carbon sequestration news covering the past month. Readers are referred to the actual article(s) for complete information. It is produced by the National Energy Technology Laboratory to provide information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

Highlights

***Fossil Energy Techline*, "Carbon Capture and Storage Initiative Aims to Bring Technologies to Market Faster."**

The Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL) is beginning research with numerous national laboratories, universities, and industry under the Carbon Capture and Simulation Initiative (CCSI) to develop state-of-the-art computational modeling and simulation tools to accelerate the commercialization of carbon capture and storage (CCS) technologies. CCSI will utilize a software infrastructure to accelerate the development and deployment of new, cost-effective CCS technologies. This will be achieved by identifying promising concepts through rapid computational screening of devices and processes; reducing the time and expense to design and troubleshoot new devices and processes through science-based optimal designs; quantifying the technical risk in taking technology from laboratory- to commercial-scale; and quantifying deployment costs more quickly by replacing some of the tests with power plant simulations. Led by NETL, CCSI leverages the core strengths of the U.S. Department of Energy's (DOE) national laboratories in modeling and simulation and unites the best capabilities at NETL, Los Alamos National Laboratory (LANL), Lawrence Berkeley National Laboratory (LBNL), Lawrence Livermore National Laboratory (LLNL), and Pacific Northwest National Laboratory (PNNL). For more information on DOE's Carbon Sequestration Research Program, visit: http://www.fossil.energy.gov/programs/sequestration/index.html. March 16, 2011, http://www.fossil.energy.gov/news/techlines/2011/11018-CCS_Initiative_Begins_Research.html.

***Fossil Energy Techline*, "Licensing Agreement Moves Two NETL-Patented Carbon Capture Sorbents Closer to Commercialization."**



A licensing agreement between NETL and ADA Environmental Solutions (ADA-ES) has moved two new patented sorbents used for CO_2 capture from coal-fired power plants closer to commercialization. The first patent involves treating a solid substrate with an acid or a base and a substituted amine salt, eliminating the need for organic solvents and polymeric materials for the preparation of CO_2 capture systems. The second patent involves treating an amine to increase the number of secondary amine groups and impregnating the amine in a porous solid support. The method increases the CO_2 capture capacity and decreases the cost of utilizing an amine-enriched solid sorbent in CO_2 capture systems. The commercial license for these sorbents allows NETL to control the right to make, use, and sell the products and services claimed in the patent, ensuring strategic commercialization throughout the coal-fired power plant industry. March 23, 2011, http://www.fossil.energy.gov/news/techlines/2011/11019-CO2_Capture_Sorbents_Move_Closer_t.html.

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Sequestration in the News

***Chaparral Energy News Release*, "Chaparral Energy Agrees to a CO_2 Purchase and Sale Agreement with CVR Energy for Capture of CO_2 for Enhanced Oil Recovery."**

Subsidiaries of Chaparral Energy and CVR Energy reached a CO_2 purchase and sale agreement to capture CO_2 from CVR's nitrogen fertilizer plant in Coffeyville, Kansas. The agreement provides for the purchase of CO_2 for Chaparral's initiation of enhanced oil recovery (EOR) operations in its North Burbank Unit in northeastern Oklahoma. Coffeyville Resources Nitrogen Fertilizers, LLC (CVR Energy's subsidiary) owns and operates a nitrogen fertilizer facility that produces approximately 850,000 tons of CO_2 per year. As part of the new agreement, most of the fertilizer plant's CO_2 will be captured by Chaparral, who will construct a CO_2 compression facility at the plant site and install approximately 70 miles of pipeline to deliver it to its North Burbank Unit in Osage County. The injection is expected to begin no later than July 2013. March 23, 2011, http://www.chaparralenergy.com/index.php?page=chaparral-energy-agrees-to-a-co2-purchase-and-sale-agreement-with-cvr-energy-for-capture-of-co2-for-enhanced-oil-recovery.

***Denbury News Release*, "Denbury Enters Into Two Industrial CO_2 Purchase Contracts."**

Denbury Resources announced it has entered into two contracts to purchase CO_2 from anthropogenic sources in the Gulf Coast and Rocky Mountain regions. In the first contract, Denbury will purchase CO_2 captured from the DKRW Advanced Fuels LLC's Medicine Bow Fuel and Power LLC (MBFP) coal-to-transport fuels project in Wyoming. MBFP will capture CO_2 produced from its project and clean, compress, and deliver the CO_2 to Denbury for EOR in their Rocky Mountain region oil fields; deliveries are expected to begin in late 2014 or early 2015. In the second contract, Denbury will purchase 70 percent of the CO_2 captured from Mississippi Power Company's Kemper County integrated gasification combined cycle (IGCC) project in Mississippi. Mississippi Power will capture, clean, compress, and deliver CO_2 from its recently initiated 582-megawatt (MW) IGCC power plant to Denbury's Heidelberg Field; deliveries are expected to begin in 2014. March 16, 2010, http://phx.corporate-ir.net/phoenix.zhtml?c=72374&p=irol-newsArticle&ID=1539782&highlight.

***Enel Press Release*, "Inauguration of Italy's First CCS Pilot Plant in Brindisi."**

Enel inaugurated a pilot plant for capturing and storing CO_2 at its Federico II power plant in Brindisi, the first of its kind in Italy. The pilot plant will be capable of separating 2.5 metric tons of CO_2 per hour (up to a maximum of 8,000 metric tons per year) from the Federico II coal-fired power plant. The CO_2 will be transported to Cortemaggiore, where it will be injected and permanently stored underground. The design stage has been completed and existing CO_2 levels are being

Sequestration in the News (Continued)

assessed. The plant, which is expected to be operational by 2012, will treat 810,000 m^3 of emissions per hour, separating up to 1 million metric tons of CO_2 per year for storage below the Adriatic Sea. The development of the project is part of a combined Enel and ENI project aimed at testing the first integrated Italian pilot plant. March 1, 2011, http://www.enel.com/en-GB/media/press_releases/release.aspx?iddoc=1641325.

Announcements

Documents Now Available on the NETL Reference Shelf.

The following documents are available for download on the NETL Carbon Sequestration Reference Shelf: the "Carbon Sequestration Atlas of the United States and Canada – Third Edition (Atlas III)"; the "DOE/NETL Carbon Dioxide Capture and Storage RD&D Roadmap"; "Carbon Sequestration Program FY2008-2009 Accomplishments"; the "Site Screening, Site Selection, and Initial Characterization for Storage of CO_2 in Deep Geologic Formations" BPM; and "Best Practices for Terrestrial Sequestration of Carbon Dioxide." To view these documents, go to: http://www.netl.doe.gov/technologies/carbon_seq/refshelf/refshelf.html.

DOE Program Offers Participants Unique Opportunity to Gain CCS Knowledge.

DOE's Research Experience in Carbon Sequestration (RECS) program, scheduled for June 5-15, 2011, in Birmingham, Alabama, is accepting applications for graduate students and early career professionals interested in gaining knowledge in CCS. RECS 2011 is a science-based program that combines classroom activities with visits to geologic storage test sites, power plants, and the National Carbon Capture Center (NCCC). For application information, visit: http://www.recsco2.org/11app.html.

Well Integrity Management Workshop.

This workshop, scheduled for June 7-9, 2011, at Renaissance Polat Istanbul Hotel, in Istanbul, Turkey, will provide an opportunity for participants to learn the importance of managing well integrity from well design through construction to the production and maintenance phases. The forum will also focus on the latest well integrity technology projects, case studies, challenges, and solutions. For more information, go to: http://www.spe.org/events/11ash2/index.php.

New Movie on CCS.

BIGCCS, established by the Norwegian Research Center, has published a movie illustrating the basic elements of CCS technology and explaining how CCS can contribute to reaching global CO_2 emission reduction targets. For more information, visit: http://www.bellona.org/news/news_2011/1300716787.59; to view the movie, go to: http://www.youtube.com/watch?v=eTBnuU8BSew.

Science

***The Guardian*, "Moray Firth Rocks 'Could Store 15 Years of Carbon Emissions,'"** and ***The Press and Journal*, "Study Reveals Rocks Under Firth can Store CO_2 Emissions."**

According to a report sponsored by the Scottish Carbon Capture and Storage (SCCS) consortium, sandstone rocks under the North Sea have the potential to store at least 15 years worth of CO_2 emissions from power plants in Scotland with the help of CCS technologies. The study, titled, "Progressing Scotland's CO_2 storage opportunities," estimates that the rock formation, known as Captain sandstone and buried more than half a mile beneath the Moray Firth, could eventually store up to 100 years' worth of CO_2 emissions and, by 2020, create at least 13,000 jobs. Three Scottish power firms are competing for funding for CCS demonstration projects. According to the SCCS research, which was funded by the Scottish Government and businesses in the energy sector, the development of CCS technologies could generate more than $16.2 billion a year for the United Kingdom by 2025. (See Recent Publications section for a portion of the Executive Summary and a link to "Progressing Scotland's CO_2 storage opportunities.") For more information on SCCS, visit: http://www.geos.ed.ac.uk/research/sccs/. March 14, 2011, http://www.guardian.co.uk/environment/2011/mar/14/moray-firth-carbon-capture-storage and March 14, 2011, http://www.pressandjournal.co.uk/Article.aspx/2177573?UserKey=.

***Indiana University News Release*, "Rising CO_2 is Causing Plants to Release Less Water to the Atmosphere, Researchers Say."**

Coinciding with rising CO_2 levels over the last 150 years, the density of pores that allow plants to breathe has shrunk by 34 percent, restricting the amount of water vapor released to the atmosphere, according to researchers. In reports published in the *Proceedings of the National Academy of Sciences*, scientists from Indiana University Bloomington and Utrecht University in the Netherlands analyzed data gathered from a diversity of plant species in Florida ranging from 100 to 150 years in age. According to their predictions, more than doubling today's CO_2 levels from 390 parts per million (ppm) to 800 ppm will further reduce the amount of water released by the plants. March 3, 2011, http://newsinfo.iu.edu/news/page/normal/17577.html.

Policy

***Carbon Capture Journal*, "International Experts to Guide CCS Regulatory Review in Alberta."**

A panel of international experts will help guide a CCS Regulatory Framework Assessment that will examine the environmental, safety, and assurance CCS processes that exist in the Canadian province of Alberta. In addition, the assessment will determine if any new processes need to be implemented for commercial-scale deployment. The six-member panel will review Alberta's existing regulatory regime and CCS frameworks from other jurisdictions, and also focus on areas including regulatory, environmental, geological, and technical considerations, as well as [monitoring, verification, and accounting (MVA)] requirements. A steering committee will oversee the process and guide the scope of the review, and working groups will develop recommendations for the steering committee's consideration. March 11, 2011, http://www.carboncapturejournal.com/displaynews.php?NewsID=755.

"Assessing the risk for CO_2 transportation within CCS projects, CFD [modeling]."

The following is the Abstract of this article: "Surface transportation of [CO_2] will be a critical issue in the developing field of CCS. A [release] from a high-pressure transportation facility can result in damage to the environment and hazard to people, depending on the total amount of [CO_2] released to the atmosphere and the concentrations achieved in the proximity of the [release]. Generic Risk Assessments for CO_2 transportation to date have relied on various assumptions about the behavior of [CO_2] after a severe pressure drop. In this study, simulations by two classes of atmospheric dispersion model (Gaussian and computational fluid dynamics, CFD) have been compared, taking representative input parameters concerning high-pressure CO_2 releases from the literature. The CFD model was used to simulate a high-speed release with specified velocities with the aim of evaluating the effect of initial gas dispersion on the downwind length reached by toxic concentrations of the pollutant. Results of this investigation depict a lowering of the Risk involved in the transportation of CO_2 by up to one order of magnitude, when modeling the same releases with a CFD tool, compared to the more widespread Gaussian models. The EU used results from Gaussian modeling for drawing up an Impact Assessment on the CO_2 transportation within CCS. In this paper, suggestions for future preparation of CCS Risk Assessments are presented." **Alberto Mazzoldi, Tim Hill, Jeremy J. Colls**, *International Journal of Greenhouse Gas Control*, Available online February 1, 2011, doi:10.1016/j.ijggc.2011.01.001, http://www.sciencedirect.com/science/article/B83WP-522Y7XF-1/2/e730734ac18832a042720bd726fb0605. (Subscription may be required.)

"The social and political complexities of learning in CCS demonstration projects."

The following is the Abstract of this article: "Demonstration of a fully integrated power plant with CCS at scale has not yet been achieved, despite growing international political interest in the potential of the technology to contribute to climate change mitigation and calls from multiple constituents for more demonstration projects. Acknowledging the scale of learning that still must occur for the technology to advance towards deployment, multiple CCS demonstration projects of various scales are emerging globally. Current plans for learning and knowledge sharing associated with demonstration projects, however, seem to be limited and narrowly conceived, raising questions about whether the projects will deliver on the expectations raised. Through a comparison of the structure, framing and socio-political context of three different CCS demonstration projects in different places and contexts, this paper explores the complexity of social learning associated with demonstration projects. Variety in expectations of the demonstration projects' objectives, learning processes, information sharing mechanisms, public engagement initiatives, financing and collaborative partnerships are highlighted. The comparison shows that multiple factors including the process of building support for the project, the governance context and the framing of the project matter for the learning in demonstration projects. This analysis supports a broader conceptualization of learning than that currently found in CCS demonstration plans – a result with implications for both future research and practice." **Nils Markusson, Atsushi Ishii, and Jennie C. Stephens**, *Global Environmental Change*, Available online February 26, 2011, doi:10.1016/j.gloenvcha.2011.01.010, http://www.sciencedirect.com/science/article/B6VFV-5288NV3-1/2/a501e17f05e69c12e500091832968c0d. (Subscription may be required.)

"Characterizing the international carbon capture and storage community."

The following is the Abstract of this article: "CCS is a climate change mitigation technology that has been receiving increased public and private investment over the past decade in several countries. During this time, a diverse international network of professionals focused on the advancement of CCS technology has emerged. Within this international CCS community, a shared perception of the value of advancing CCS technology is generally assumed, and this community has been influential in lobbying for increased support for the development of CCS in many countries and at the international level. The phenomenon of an apparently shared perspective within a specific community relates to Haas' (1992a) description of the evolution of an epistemic community, or a knowledge-based network of recognized experts who 'not only hold in common a set of principled and causal beliefs but also have shared notions of validity and a shared policy enterprise.' Understanding the extent to which a given community can be characterized as an epistemic community can provide insights about the effectiveness of its policy intervention, its association with the broader public, and the success of communicating the messages that it wants to convey. The goal of this research is to begin to explore the nature of the CCS community; to provide a preliminary characterization of the community, and to consider whether and in what ways the community might be considered to be an epistemic community or a compilation of multiple different epistemic communities. This characterization suggests that although the CCS community may be influencing decision-makers and successfully garnering political support for advancing CCS technology, a potential disconnect with the concerns of a broader public is deserving of more attention and social science research." **Jennie C. Stephens, Anders Hansson, Yue Liu, Heleen de Coninck, and Shalini Vajjhala**, *Global Environmental Change*, Available online February 18, 2011, doi:10.1016/j.gloenvcha.2011.01.008, http://www.sciencedirect.com/science/article/B6VFV-526KFDC-1/2/b418228459d108ebdcbe246bd9f13c07. (Subscription may be required.)

Geology

"Swelling of moist coal in carbon dioxide and methane."

The following is the Abstract of this article: "Determining the feasibility of injecting CO_2 into coal seams for enhanced coalbed methane (ECBM) recovery as well as providing long-term carbon sequestration is an active area of research. It is now well known that coal swells in the presence of water and gases, which in turn may affect its in-seam permeability. If the swelling of the coal matrix by each component can be quantified, it may be possible to make better predictions about the suitability of particular seams for ECBM and carbon sequestration. Despite numerous studies where coal swelling has been measured in gases or water, there is relatively little information relating to how swelling of coals by gases is affected by water. In this paper [the authors] report on the gas-induced swelling behavior of four moist Australian coals. Blocks of coal, nominally 30 × 9 × 9 mm, were cut parallel and perpendicular to the bedding plane from larger lumps. Samples were moisture-equilibrated at 97 [percent] relative humidity before being exposed to CO_2 or [methane (CH_4)] at pressures up to 16 MPa and a temperature of 55°C. Swelling of each sample was measured directly using digital cameras to monitor the change in length of the block as a function of pressure. Results show that swelling was greater in CO_2 than CH_4, with lower rank coals swelling more than high rank material. The presence of moisture significantly reduced the amount of additional swelling by the gas compared to dry coals; however, the degree to which the swelling of the coals was affected by moisture depended on the rank of the coal. It was also found that, proportionally, CH_4-induced swelling was more affected by the presence of moisture than CO_2-induced swelling. Although moist coals swelled less in CO_2 or CH_4 than dry coals, if the swelling due to moisture is included, the total swelling is more than that induced by the corresponding gas in the dry coal." **Stuart Day, Robyn Fry, and Richard Sakurovs**, *International Journal of Coal Geology*, Available online February 2, 2011, doi:10.1016/j.coal.2011.01.008, http://www.sciencedirect.com/science/article/B6V8C-5236R4F-1/2/c33e38bfe1b68e5a4c0dc9fa78cf1439. (Subscription may be required.)

"Some implications of cold CO_2 injection into deep saline [formations]."

The following is the Abstract of this article: "When CO_2 is injected down a well, the temperature at the bottom of the well depends on surface conditions, heat exchange with the wall of the well and pressure work within the well. Typically, the temperature of the CO_2 at the bottom of the well is lower than the local geothermal temperature. As this relatively cold CO_2 flows into the porous matrix, local thermal equilibrium manifests a thermal front, behind which the porous matrix and CO_2 adjust to the cold injection temperature. As the temperature of the injected CO_2 increases across the thermal front, the CO_2 becomes less viscous and less dense. In relatively high permeability rock, as the flow spreads from the well, it becomes buoyancy-driven, and so at the thermal front, the flow adjusts from a deep, slow flow to a relatively shallow, fast flow. The increased depth in the near source cold region has two significant implications. First, it increases the near source storage potential as more rock is flooded with CO_2, but it may also enhance the [release] into the seal rock which occurs in regions where the current is sufficiently deep for the pressure to exceed the capillary entry pressure." **W. J. Rayward-Smith and Andrew W. Woods,** *Geophysical Research Letters*, Available online March 23, 2011, doi:10.1029/2010GL046412, http://www.agu.org/pubs/crossref/2011/2010GL046412.shtml. (Subscription may be required.)

Technology

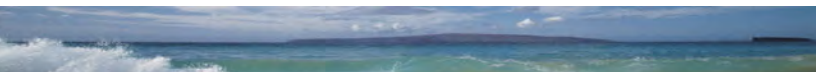
"Safe storage of CO_2 together with improved oil recovery by CO_2-enriched water injection."

The following is the Abstract of this article: "The 2007 [International Energy Agency's (IEA)] World Energy Outlook report predicts that the world's energy needs will grow by 55 [percent] between 2005 and 2030, with fossil fuels accounting for 84 [percent] of this massive projected increase in energy demand. An undesired side effect of burning fossil fuels is CO_2 emission which is now widely believed to be responsible for the problem of global warming. Various strategies are being considered for addressing the increase in demand for energy and at the same time developing technologies to make energy greener by reducing CO_2 emissions. One of these strategies is to 'capture' produced CO_2 instead of releasing it into the atmosphere. Capturing CO_2 and its injection in oil reservoirs can lead to improved oil recovery as well as CO_2 retention and storage in these reservoirs. The technology is referred to as CCS. Large point sources of CO_2 (e.g., coal-fired power plants) are particularly good candidates for capturing large volumes of CO_2. However, CO_2 capture from power plants is currently expensive. In addition to high costs of CO_2 capture, the low pressure of the flue gas (1 atm) and its low CO_2 content (typically 10–15 [percent]) contribute to the high cost of CO_2 capture from power plants and the subsequent compression. This makes conventional CO_2 flooding (which requires large volumes of CO_2) uneconomical in many oil reservoirs around the world which would otherwise be suitable candidates for CO_2 injection. Alternative strategies are therefore needed to utilize smaller sources of CO_2 that are usually available around oil and gas fields and can be captured at lower costs (due to their higher pressure and higher CO_2 concentration). [The authors] investigate the potential of carbonated (CO_2-enriched) water injection (CWI) as an injection strategy for improving recovery from oil reservoirs with the added benefit of safe storage of CO_2. The performance of CWI was investigated by conducting high-pressure flow visualization as well as coreflood experiments at reservoir conditions. The results show that CWI significantly improves oil recovery from water flooded porous media. A relatively large fraction of the injected CO_2 was retained (stored) in the porous medium in the form of dissolved CO_2 in water and oil. The results clearly demonstrate the huge potential of CWI as a productive way of utilizing CO_2 for improving oil recovery and safe storage of potentially large cumulative quantities of CO_2." **Mehran Sohrabi, Nor Idah Kechut, Masoud Riazi, Mahmoud Jamiolahmady, Shaun Ireland, and Graeme Robertson**, *Chemical Engineering Research and Design*, Available online February 5, 2011, doi:10.1016/j.cherd.2011.01.027, http://www.sciencedirect.com/science/article/B8JGF-523V3NP-3/2/908ab65aa70abf2068a0192a95725056. (Subscription may be required.)

Technology (Continued)

"Brine flow up a well caused by pressure perturbation from geologic carbon sequestration: Static and dynamic evaluations."

The following is the Abstract of this article: "Industrial-scale storage of CO_2 in saline sedimentary basins will cause zones of elevated pressure, larger than the CO_2 plume itself. If permeable conduits exist between the injection reservoir and overlying shallow [formations], brine could be pushed upwards along these conduits and mix with groundwater resources. This paper discusses the potential for such brine [release] to occur in temperature- and salinity-stratified systems. Using static mass-balance calculations as well as dynamic well flow simulations, [the authors] evaluate the minimum reservoir pressure that would generate continuous migration of brine up a wellbore into a freshwater [formation]. Since the brine invading the well is denser than the initial fluid in the wellbore, continuous flow only occurs if the pressure perturbation in the reservoir is large enough to overcome the increased fluid column weight after full invasion of brine into the well. If the threshold pressure is exceeded, brine flow rates are dependent on various hydraulic (and other) properties, in particular the effective permeability of the wellbore and the magnitude of pressure increase. If brine flow occurs outside of the well casing, e.g., in a permeable fracture zone between the well cement and the formation, the fluid/solute transfer between the migrating fluid and the surrounding rock units can strongly retard brine flow. At the same time, the threshold pressure for continuous flow to occur decreases compared to a case with no fluid/solute transfer." **Jens T. Birkholzer, Jean Philippe Nicot, Curtis M. Oldenburg, Quanlin Zhou, Stephen Kraemer, and Karl Bandilla**, *International Journal of Greenhouse Gas Control*, Available online February 17, 2011, doi:10.1016/j.ijggc.2011.01.003, http://www.sciencedirect.com/science/article/B83WP-526CXS6-1/2/e26214df56490818f3f6dfdf22dc92cf. (Subscription may be required.)



Terrestrial

"Standing biomass and carbon storage of above-ground structures in dominant mangrove trees in the Sundarbans."

The following is the Abstract of this article: "[The authors] evaluated carbon stocks in the above-ground biomass (AGB) of three dominant mangrove species (*Sonneratia apetala, Avicennia alba and Excoecaria agallocha*) in the Indian Sundarbans. [The authors] examined whether these carbon stocks vary with spatial locations (western region vs. central region) and with seasons (pre-monsoon, monsoon and post-monsoon). Among the three studied species, *S. apetala* showed the maximum above-ground carbon storage (t ha^{-1}) followed by *A. alba* (t ha^{-1}) and *E. agallocha* (t ha^{-1}). The AGB varied significantly with spatial locations ($p < 0.05$) but not with seasons ($p < 0.05$). The variation may be attributed to different environmental conditions to which these areas are exposed to such as higher siltation and salinity in central region compared to western region. The relatively higher salinity in central region caused subsequent lowering of biomass and stored carbon of the selected species." **Abhijit Mitra, Kasturi Sengupta, and Kakoli Banerjee**, *Forest Ecology and Management*, Available online February 4, 2011, doi: 10.1016/j.foreco.2011.01.012, http://www.sciencedirect.com/science/article/B6T6X-523KH7F-4/2/0203418bf1f6d107cab9bbd9269ff343. (Subscription may be required.)

Trading

***RGGI News Release*, "RGGI Auction Yields $83.4 Million for Investment in Energy Efficiency, Job Creation."**

The Regional Greenhouse Gas Initiative's (RGGI) 11th quarterly auction of CO_2 allowances, held March 9, 2011, yielded $83,425,588 for states to invest in programs that enable energy consumers to control their energy budgets. All of the 41,995,813 current control period CO_2 allowances (2009-2011) offered in the auction, as well as all of the 2,144,710 CO_2 allowances for a future control period (2012-2014) offered, sold at a price of $1.89 per allowance. A total of 36 entities submitted bids to purchase 1.1 times the available supply of current control period allowances, with electric generators and their corporate affiliates purchasing 85 percent. Seven entities submitted bids to purchase 1.4 times the available supply of future control period allowances, with electric generators and their corporate affiliates purchasing 56 percent. The 10 Northeast and Mid-Atlantic states that participate in RGGI invest proceeds from the auctions, which now totals more than $860.9 million, in programs aimed at saving energy consumers money, creating jobs, and making business more competitive. The next RGGI auction is scheduled for June 8, 2011. March 11, 2011, http://www.rggi.org/docs/Auction_11_Release_Report.pdf.

***Reuters*, "EU to Auction 120 Million CO_2 Permits in 2012."**

The European Commission has added to its auctioning regulation by proposing that 120 million Phase 3 EU carbon permits be auctioned in early 2012. Under the EU Emissions Trading Scheme (EU ETS), emissions from approximately 11,000 factories and power plants are capped. A corresponding number of permits (EU Allowances [EUAs]) are distributed accordingly; if more CO_2 is emitted than EUAs allocated, more can be purchased. In Phase 3 of EU ETS, which runs from 2013 to 2020, most EUAs will be allocated through auctions as opposed to being distributed for free. The 120 million EUAs to be auctioned in 2012 will be in addition to 300 million EUAs that the European Investment Bank intends to monetize by the end of 2012 to raise low-carbon technology funds. March 15, 2011, http://www.reuters.com/article/2011/03/15/us-eu-carbon-auctions-idUSTRE72E2I220110315.

"Carbon capture and storage as a corporate technology strategy challenge."

The following is the Abstract of this article: "Latest estimates suggest that widespread deployment of CCS could account for up to one-fifth of the needed global reduction in CO_2 emissions by 2050. Governments are attempting to stimulate investments in CCS technology both directly through subsidizing demonstration projects, and indirectly through developing price incentives in carbon markets. Yet, corporate

Trading (Continued)

decision-makers are finding CCS investments challenging. Common explanations for delay in corporate CCS investments include operational concerns such as the high cost of capture technologies, technological uncertainties in integrated CCS systems and underdeveloped regulatory and liability regimes. In this paper, [the authors] place corporate CCS adoption decisions within a technology strategy perspective. [The authors] diagnose four underlying characteristics of the strategic CCS technology adoption decision that present unusual challenges for decision-makers: such investments are precautionary, sustaining, cumulative and situated. Understanding CCS as a corporate technology strategy challenge can help move beyond the usual list of operational barriers to CCS and make public policy recommendations to help overcome them." **Frances Bowen**, *Energy Policy*, Available online March 3, 2011, doi:10.1016/j.enpol.2011.01.016, http://www.sciencedirect.com/science/article/B6V2W-529C3TM-2/2/06f31d2e212f48e3fc10d80a978016fb. (Subscription may be required.)

Recent Publications

"The Global Status of CCS: 2010."

The following is from the Executive Summary of this document: "The concentration of CO_2 in the atmosphere continues to increase, rising to 390 [ppm] by the end of 2010. At the same time, 2010 was the warmest year on record, ranking equally with 2005 and 1998. Efficiently and effectively managing the risks of climate change requires reducing greenhouse gas [(GHG)] emissions, particularly CO_2… In response, governments have increased research, development and demonstration efforts for a range of renewable and low emission energy technologies, including CCS. Carbon capture technologies have been deployed commercially in the gas processing and chemical industries for some time. However, the same capture technologies are considered to be immature and in need of demonstration when applied to the power generation, iron and steel or cement industries. In terms of storage applications, while CO_2 use in EOR has a long history, it requires enhancements in the measurement, monitoring and verification of CO_2 injected. The use of deep saline formations is much more recent and is only in operation at large-scale in a few projects. This report, an annual global review of project developments and the drivers behind them, serves as a reference point for the broader CCS community in understanding the 'state of play' in the development of CCS activities and projects globally." This Global CCS Institute (GCCSI) report is available at: http://www.globalccsinstitute.com/sites/default/files/global-status-css-final_0.pdf.

"Progressing Scotland's CO_2 storage opportunities."

The following is from the Executive Summary of this document: "CCS is a rapidly growing industry that offers both environmental benefits and substantial business, employment and research opportunities for Scotland and the UK. In 2009 the report Opportunities for CO_2 storage around Scotland identified the size of these opportunities and key initiatives that need to be acted upon to move CCS forward in Scotland. Government, industry and stakeholder organizations joined with SCCS researchers in this Scottish Carbon Capture and Storage Development Study to progress some of the actions needed to inform the deployment of the entire CCS chain in Scotland and the UK. The study presents new insights on: a path to CCS, defining the activities and timescales to meet national and international ambitions for deployment of CCS and reduction of [GHG] emissions; Scotland's CO_2 storage assets, refining the estimated large-scale CO_2 storage capacity in North Sea sandstones; skills and capacity needs for the future global CCS industry and how to realize opportunities it presents for UK economic development; [and] public communication and engagement on CCS." The complete SCCS report is available at: http://www.sccs.org.uk/progress-to-co2-storage-scotland/ProgressingScotlandCO2Opps.pdf.

"Cost and Performance of Carbon Dioxide Capture from Power Generation."

The following is from the Executive Summary of this document: "Energy scenarios developed by IEA suggest that CCS from power plants might contribute by 2050 to around 10 [percent] of the energy-related CO_2 emission reduction required to stabilize global warming. Since CO_2 capture from power generation is an emerging technology that has not been demonstrated on a commercial scale, related cost and performance information is based on feasibility studies and pilot projects and is still uncertain. This paper analyses techno-economic data for CO_2 capture from power generation, including CO_2 conditioning and compression, in order to support energy scenario modeling and policy making. Cost and performance trends are shown based on estimates published over the last five years in major engineering studies for about 50 CO_2 capture installations at power plants. Capital cost and levelized cost of electricity (LCOE) are re-evaluated and updated to 2010 cost levels to allow for a consistent comparison. Presented data account for CO_2 capture but not transportation and storage of CO_2. They are estimates for generic, early commercial plants based on feasibility studies, which have an accuracy of on average ±30 [percent]. The data do not reflect project-specific cost or cost for first large-scale demonstration plants, which are likely higher. For coal-fired power generation, no single CO_2 capture technology outperforms available alternative capture processes in terms of cost and performance. Average net efficiency penalties for post- and oxy-combustion capture are 10 percentage points relative to a pulverized coal plant without capture, and eight percentage points for pre-combustion capture compared to an [IGCC]. Overnight costs of power plants with CO_2 capture in regions of the OECD are about [$3,800/kW] across capture

Recent Publications (Continued)

routes, which is 74 [percent] higher than the reference costs without capture. Cost figures vary substantially depending on the type of power plant type and fuel used. The relative increase in overnight costs compared to a reference plant without CO_2 capture is a comparably stable metric across studies. It is thus recommended for estimating cost is limited data are available. Projected LCOE is on average [$105 per megawatt hour]. Average costs of CO_2 avoided are [$55 per tonne of CO_2] if a pulverized coal power plant without CO_2 capture is used as a reference." To read the IEA paper, click: http://www.iea.org/papers/2011/costperf_ccs_powergen.pdf.

"A Roadmap for moving to a competitive low carbon economy in 2050."

The following is from the document: "The EU provides its Member States with a long-term framework for dealing with the issue of sustainability and the cross-border effects of phenomena that cannot be dealt with at the national level alone. Climate change has long been recognized as one such long-term shaping factor where coherent EU action is needed, both inside the EU and internationally. The Commission recently proposed the Europe 2020 flagship initiative for a resource-efficient Europe and within this framework it is now putting forward a series of long-term policy plans in areas such as transport, energy and climate change. This Communication sets out key elements that should shape the EU's climate action helping the EU become a competitive low carbon economy by 2050. The approach is based on the view that innovative solutions are required to mobilize investments in energy, transport, industry and information and communication technologies, and that more focus is needed on energy efficiency policies." This European Commission-adopted Roadmap is available at: http://ec.europa.eu/clima/documentation/roadmap/docs/com_2011_112_en.pdf.

Legislative Activity

***WDAQ.com*, "Gov. Barbour Signs Energy Bill."**

Governor Haley Barbour signed a bill that sets up a regulatory structure that grants the Mississippi Department of Environmental Quality (MDEQ) and Mississippi Oil and Gas Board the authority to oversee and monitor long-term underground CO_2 storage. Under the "Mississippi Geologic Sequestration of Carbon Dioxide Act," MDEQ and the Oil and Gas Board will work out an agreement to store CO_2 in oil and gas fields for EOR. Companies will be able to apply for permits from MDEQ and the Oil and Gas Board to build storage facilities in the state. To view Senate Bill No. 2723, click: http://index.ls.state.ms.us/isysnative/UzpcRG9jdW1lbnRzXDIwMTFccGRmXHNiXDI3MDAtMjc5OVxzYjI3MjNpbi5wZGY=/sb2723in.pdf#xml=http://10.240.72.35/isysquery/irl8748/1/hilite. March 24, 2011, http://www.wdam.com/Global/story.asp?S=14313203.

***NASDAQ*, "Australia's Swan to Introduce Carbon Price Legislation in Spring."**

Australian officials announced plans to introduce legislation for a carbon tax in the spring session of parliament, which begins August 16, 2011. In order for the legislation to pass, the Labor government needs to negotiate majorities in both the upper and lower houses. According to officials, the full details of the carbon price package will be announced prior to the introduction of the legislation. March 24, 2011, http://www.nasdaq.com/aspx/stock-market-news-story.aspx?storyid=201103222230dowjonesdjonline000448&title=australias-swan-to-introduce-carbon-price-legislation-in-spring.

Events

May 2-5, 2011, **10th Annual Conference on Carbon Capture and Sequestration**, *David L. Lawrence Convention Center, Pittsburgh, Pennsylvania, USA*. This annual, DOE-hosted 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/index.htm.

Events (Continued)

May 16-18, 2011, **World Coal Gen Conference**, *Hotel TBA, Beijing, China*. This conference brings together representatives from the world coal generation industry to discuss combustion technologies, coal gasification, ultrasupercritical steam condition technologies, flue gas treatment, water management, and new materials to optimize plant performance. Detailed information can be viewed at: http://www.worldcoalgen.org/index.htm.

July 19-21, 2011, **SPE Enhanced Oil Recovery Conference**, *InterContinental Kuala Lumpur, Kuala Lumpur, Malaysia*. With continued oil demand, more countries and companies are evaluating and applying EOR techniques to realize the full potential of producing assets. This conference brings together global experts to share successes and lessons learned in evaluating and implementing the full range of EOR techniques. More information on the Technical Program is available at: http://www.spe.org/events/eorc/pages/schedule/tues_technical_programme.php.

June 19-22, 2011, **Carbon Capture and Sequestration**, *Novotel Twin Waters Resort, Brisbane, Queensland, Australia*. This workshop will review scientific, technical, and stakeholder issues associated with CCS. Among the topics to be discussed are: advances in carbon capture technologies; existing and planned CO_2 storage projects; status and predictions of GHG emissions regulations; industrial efforts in combating CO_2 emissions; advanced technologies for monitoring CO_2 injection and retention; issues regarding long-term liability; and funding of CCS projects. To learn more, visit: http://www.spe.org/events/10adel/index.php.

July 11-14, 2011, **Global Conference on Global Warming 2011**, *Calouste Gulbenkian Congress Center, Lisbon, Portugal*. This international conference discusses potential solutions to climate change issues and provides a forum for the exchange of the latest developments and technical information. To view a complete list of conference-related topics, click: http://www.gcgw.org/gcgw11/documents/poster_GCGW11.pdf.

July 18-20, 2011, **Carbon Capture and Storage: Science, Technology, and Policy**, *MIT, Cambridge, Massachusetts, USA*. This energy short course covers the science, technology, and policy aspects of CCS, focusing on the role of CCS in the climate change mitigation portfolio; the technical approaches to CO_2 capture; the science behind geologic storage, site selection, and risk evaluation; and the role of policy in establishing a market and business opportunities for CCS. For more information, visit the course website at: http://web.mit.edu/professional/short-programs/courses/carbon_capture_storage.html.

July 21-22, 2011, **Third International Conference on Climate Change**, *JW Marriot, Rio De Janeiro, Brazil*. This conference will examine, among other topics, natural and human-generated causes of potential climate change, as well as CCS technological responses and carbon and taxes offsets. In addition, the conference will explore other social, ethical, and political responses to potential climate change. To learn more, visit: http://on-climate.com/conference-2011/.

August 17-19, 2011, **COAL-GEN**, *Greater Columbus Convention Center, Columbus, Ohio, USA*. Covering the latest topics affecting the design, development, upgrading, operation, and maintenance of coal-fired power plants, COAL-GEN is the industry's largest event focused on the present and future of coal-fired generation. Visit the conference website at: http://www.coal-gen.com/index.html.

August 22-26, 2011, **NETL CO_2 Capture Technology Meeting**, *Sheraton Station Square Hotel, Pittsburgh, Pennsylvania, USA*. This DOE-hosted conference will present CO_2 capture technology development status and accomplishments made under NETL's Innovations for Existing Plants (IEP), Carbon Sequestration, and Demonstration Programs. Topics to be discussed include post-, oxy-, and pre-combustion carbon capture, as well as chemical looping and CO_2 compression technologies. For more information, click: http://www.netl.doe.gov/events/11conferences/co2capture/.

EVENTS (CONTINUED)

October 9-11, 2011, **Reservoir Characterization and Simulation Conference and Exhibition**, *Beach Rotana Hotel, Abu Dhabi, UAE*. The Society of Petroleum Engineers (SPE) is hosting the third edition of the Reservoir Characterization and Simulation Conference and Exhibition (RCSC). The conference focuses on reservoir applications and different technologies for characterizing, modeling, and simulating reservoir characteristics. To learn more, visit: http://www.spe.org/events/rcsc/2011/.

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To learn more about DOE's Carbon Sequestration Program, please contact John Litynski at john.litynski@netl.doe.gov, or Dawn Deel at dawn.deel@netl.doe.gov.