



Office of Fossil Energy

Carbon Sequestration Newsletter

MAY 2012

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America contains at least 500 years of geologic storage resource for CO₂ emissions that result from either industrial sources or power plants. In addition to estimating storage resource for North American oil and gas fields, unmineable coal, and saline formations, NACSA also documents the location of approximately 2,250 large stationary CO₂ sources, which, along with documenting the locations of storage potential of various geological sites, helps quantify the benefits and opportunities for potential carbon capture, utilization, and storage (CCUS) projects. Created through the North American Carbon Atlas Partnership (NACAP) and developed by DOE, Natural Resources Canada, and the Mexican Ministry of Energy, NACSA also includes work from DOE's Regional Carbon Sequestration Partnerships (RCSPs), whose 400 organizations provide input to DOE's National Energy Technology Laboratory's (NETL) National Carbon Sequestration Database and Geographic Information System. To view the atlas, go to: http://www.netl.doe.gov/technologies/carbon_seq/refsshelf/NACSA2012.pdf. For more information on NACAP, visit: <http://www.nacsap.org/>. The NACSA Interactive Viewer is available at: <http://gis.netl.doe.gov/NACAP/>. May 2, 2012, http://www.netl.doe.gov/publications/press/2012/120502_energy_department_announces.html.

Fossil Energy Techline, "NETL Shares Computing Speed, Efficiency to Tackle Technology Barriers."

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

NETL News Release, "Energy Department Announces New Mapping Initiative to Advance North American Carbon Storage Efforts."

The U.S. Department of Energy (DOE), with partners from Canada and Mexico, released the North American Carbon Storage Atlas (NACSA), the first-ever atlas mapping the potential carbon dioxide (CO₂) storage resource in North America. According to NACSA, North

One of the world's fastest supercomputers will be installed this summer at the Office of Fossil Energy's (FE) National Energy Technology Laboratory's (NETL) Simulation-Based Engineering User Center to help develop solutions to carbon capture, utilization, and storage (CCUS) technology barriers. The energy-efficient, high-performance supercomputer will be used to develop and deploy advanced simulation tools that are needed to quickly and reliably overcome energy technology challenges. Researchers from partnering organizations, such as the members of the NETL-Regional University Alliance (NETL-RUA), will be able to access the supercomputer via NETL's user centers in Albany, Oregon; Morgantown, West Virginia; and Pittsburgh, Pennsylvania, which will also provide advanced visualization hardware and software. For more information on the five universities that are part of the NETL-RUA, go to: <http://www.netl.doe.gov/rua/index.html>. March 29, 2012, http://www.fossil.energy.gov/news/techlines/2012/12009-NETL_Shares_Computing_Speed.html.



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SEQUESTRATION IN THE NEWS

Fossil Energy Techline, "DOE-Sponsored IGCC Project Could Lead to Lower-Cost Carbon Capture Technologies."

New research from a DOE-sponsored project at their National Carbon Capture Center (NCCC) has shown that changes in operating conditions, coupled with changes in commercially manufactured catalysts, can produce both power generation increases and significant cost savings at integrated gasification combined cycle (IGCC) power plants. The project's results have the potential to eventually lead to lower-cost carbon capture technologies and help to provide affordable, reliable, and clean energy from the Nation's domestic coal resources. The test results are being provided to manufacturers to assist them in specifying future water-gas shift (WGS) systems for IGCC plants that incorporate carbon capture, and the findings are also being implemented at a commercial IGCC plant now under construction in Kemper County, Mississippi. Further tests are being planned with other commercially available, newly formulated WGS catalysts. May 9, 2012, http://www.fossil.energy.gov/news/techlines/2012/12019-Catalyst_Tests_Successful.html.

Reuters, "Norway Opens Major Facility to Test Carbon Capture,"

Norway has launched a \$1-billion, government-funded center to develop CCS technology. The facility, the Technology Center Mongstad (TCM), will test two post-combustion carbon capture technologies that have the potential to be upscaled to industrial-scale use. The center will be capable of testing exhaust gases from two nearby sources – a 280-megawatt (MW) combined heat and power plant, and the 10 million ton-per-year Mongstad refinery; the two sources produce flue gases with different CO₂ contents (approximately 3.5 percent and 13 percent, respectively). According to TCM's technology manager, the center has two carbon capture plants with a combined capacity to process 100,000 tons of CO₂ per year. May 7, 2012, <http://www.reuters.com/article/2012/05/07/us-norway-carboncapture-idUSBRE8460SE20120507>.

Carbon Capture Journal, "Imperial College London Opens [~\$3.16 Million] Carbon Capture Pilot Plant."

Imperial College London has opened a carbon capture plant that demonstrates how CO₂ emissions can be captured by a power plant, providing hands-on education in a controlled environment to undergraduate engineers. In addition to teaching students the principles that can be applied in a range of industrial settings, the plant will also perform several other roles, such as hosting a summer school for engineering students from around the world and acting as a laboratory for Imperial academics who are improving technology to capture CO₂ emissions. It is expected that approximately 8,000 undergraduates will be trained during the plant's predicted 25-year lifespan. April 21, 2012, <http://www.carboncapturejournal.com/displaynews.php?NewsID=928&PHPSESSID=181cig4coo7bptbebtcc8j84e2>.

EPA News Release, "EPA Proposes First Carbon Pollution Standard for Future Power Plants."

On March 27, the U.S. Environmental Protection Agency (EPA) proposed the first Clean Air Act (CAA) standard for carbon emissions

SEQUESTRATION IN THE NEWS (CONTINUED)

from new power plants. EPA's rule creates a path forward for new technologies to be deployed at future facilities that will allow companies to burn coal while emitting less carbon. The rulemaking proposed concerns new generating units that will be built in the future, and does

not apply to existing units already operating or units that will start construction over the next 12 months. For more information, visit: <http://epa.gov/carbonpollutionstandard/>. The proposed rule can be viewed at: <http://epa.gov/carbonpollutionstandard/pdfs/20120327proposal.pdf>. March 27, 2012, <http://yosemite.epa.gov/opa/admpress.nsf/bd4379a92ceeeac8525735900400c27/9b4e8033d7e641d9852579ce005ae957!OpenDocument>.

ANNOUNCEMENTS

DOE Releases Funding Opportunity Announcement.

DOE released DE-FOA-0000732: Novel Sensing and Monitoring Technologies for Subsurface Detection of CO₂, the objective of which is to competitively solicit projects in novel technologies under the Crosscutting Research Program Area to support DOE Strategic Coals. This Funding Opportunity Announcement (FOA) targets advancements in subsurface monitoring technologies that will facilitate the injection and storage of CO₂, thus contributing to the emission reduction of CO₂ from fossil fuel-based electric industrial sources. Proposals are due June 18, 2012. To view the FOA, visit: <http://www.netl.doe.gov/business/solicitations/index.html#0000732>.

2012 NETL CO₂ Capture Technology Meeting.

NETL's 2012 CO₂ Capture Technology Meeting will be held at the Sheraton Station Square Hotel in Pittsburgh, Pennsylvania, on July 9-12, 2012. This year's meeting will provide a public forum to present CO₂ capture technology development status and accomplishments made under NETL's Innovations for Existing Plants (IEP), Carbon Storage, and Demonstration Programs, as well as highlight DOE's Advanced Research Projects Agency-Energy (ARPA-E) CO₂ capture portfolio. In addition to covering post-, oxy-, and pre-combustion technologies, the meeting will also cover solvent, membrane, chemical looping, and compression technologies. To learn more, go to: <http://netldev.netl.doe.gov/events/2012-co2-capture>.

2012 NETL Carbon Storage R&D Project Review Meeting.

The DOE Carbon Storage R&D Project Review Meeting will be held at the Sheraton Station Square Hotel in Pittsburgh, Pennsylvania, on August 21-23, 2012. More than 120 DOE-sponsored projects will be presented, covering DOE's carbon storage infrastructure and Core R&D projects. In addition, DOE's Regional Carbon Sequestration Partnerships (RCSPs) Initiative and the American Recovery and Reinvestment Act (ARRA) Site Characterization projects will be featured. Presentations will focus on regulatory issues, government-industry collaborations, and large-scale international storage efforts. An interactive reception/poster session will also be held to highlight related work being performed by ARRA-supported Regional Carbon Sequestration Training Centers, DOE National Laboratories, RCSP subcontractors, and other organizations directly participating in geologic carbon storage and characterization projects in the United States and internationally. More information is available at: <http://netldev.netl.doe.gov/events/carbon-storage-project-review>.

2012 MGSC Annual Meeting and Workshop.

The Midwest Geological Sequestration Consortium (MGSC) Annual Meeting and Workshop will be held September 17-19, 2012, at the I Hotel and Conference Center in Champaign, Illinois. The agenda includes a full day of presentations on the Illinois Basin Decatur Project (IBDP), covering all aspects of MGSC Phase II research activities; a Sequestration Training and Education Program (STEP)-sponsored workshop; and an optional tour of the IBDP site. For more information, visit the MGSC website at: <http://www.sequestration.org/>.

WRI Launches New CCS Regulatory Matrix.

The World Resources Institute (WRI) launched a new online tool that compares CCS regulations, standards, and best practice guidelines. The CCS Regulatory Matrix is designed to enable decision-makers to quickly see how different frameworks deal with key issues, such as site selection/characterization requirements and long-term liability. To access CCS Regulatory Comparison Matrix 2.0, click: <http://www.wri.org/project/carbon-dioxide-capture-storage/proposal-matrix>.

Global CCS Institute to Facilitate CCS Knowledge Sharing in Europe.

The Global CCS Institute won a tender to provide secretariat and knowledge dissemination services for the European Commission's CCS Demonstration Project Network. The services, which began in March 2012 and will last four years, include coordination of network secretariat, communications activities, aggregation and dissemination of data, and meeting facilitation. For more information, visit: <http://www.carboncapturejournal.com/displaynews.php?NewsID=937>.

ANNOUNCEMENTS (CONTINUED)

33rd IEAEOR Symposium.

Hosted by the Petroleum Technology Research Center (PTRC), the International Energy Association Enhanced Oil Recovery (IEA-EOR) Research Program's 33rd Annual Symposium and Workshop will be held in Regina, Saskatchewan, on August 26-30, 2012. In addition to two days of conference activities, a one-day workshop focused on CO₂-EOR is included. The conference concludes with a field trip to SaskPower's Boundary Dam Power Plant and Cenovus Energy's Weyburn field CO₂ injection facility. For more information, visit the conference website at: <http://www.iea-eor2012.com/>.

SCIENCE

***Phys.Org*, "Global Change Puts Plankton Under Threat."**

According to a study published in the journal "Nature Climate Change," changes in seawater pH levels, due to carbon acid formed as a result of increased CO₂ emissions, could lead to poor growth or the eventual death of marine plankton. The research claims that approximately half of human-generated CO₂ emissions dissolves in the ocean, forming carbon acid and leading to a decrease in seawater pH levels. Coupled with potential climate change, researchers believe the ocean acidification-induced changes could pose a concern to the survival of plankton. The research team used mathematical modeling and cellular physiology to reveal that marine plankton will eventually experience a more acidic environment than previously thought. The research will be further developed on key Australian phytoplankton species. May 4, 2012, <http://phys.org/news/2012-05-global-plankton-threat.html>.

***Reuters*, "New Antarctic Ice Shelf Threatened by Warming."**

According to new research from the Alfred Wegener Institute for Polar and Marine Research, the Filchner-Ronne Ice Shelf, which borders the Weddell Sea on the eastern side of Antarctica, may melt by the end of the century due to potential climate change and accelerate rising sea levels. The 450,000-km² ice shelf acts as a buffer against warming waters, eroding the base of the larger glaciers currently located on land. Researchers predict that the melting of the Filchner-Ronne shelf could add up to 4.4 mm per year to rising global sea levels. According to the latest estimates based on remote sensing data, and in addition to the estimated 1.7-mm annual rise due to the expansion of the oceans as the water warmed, melting glaciers and ice shelves contributed 1.5 mm a year to rising global sea levels from 2003 to 2010. Research for this study was funded by the European Union's (EU) "Ice2sea" Program, which was set in the wake of the 2007 Intergovernmental Panel on Climate Change (IPCC) report highlighting ice sheets as a remaining uncertainty in rising sea level projections. May 9, 2012, <http://www.reuters.com/article/2012/05/09/us-antarctica-global-warming-idUSBRE84811E20120509>.



POLICY

***Reuters*, "Mexican Senate Clears Way for Climate Bill," and *AFP*, "Mexico's Senate Passes Climate Change Bill."**

Mexico's Senate unanimously passed a climate change bill encouraging a voluntary carbon emissions trading market that would reduce carbon emissions by 50 percent by 2050. The measure, which still needs signed by the Mexican President to become a law, would promote policies and incentives to reduce carbon emissions, decrease the use of fossil fuels, and make renewable power more competitive. The legislature sets out that participants in the future emissions market can trade CO₂ permits with partner countries. In addition, a centralized agency, called the National Institute of Ecology and Climate Change, would be created, coordinating efforts from various ministries. April 19, 2012, <http://www.reuters.com/article/2012/04/19/us-mexico-carbon-idUSBRE8311N020120419>, and April 20, 2012, <http://www.google.com/hostednews/afp/article/ALeqM5iybWYXT1WghY2tz3TR15eGoXSyQ?docId=CNG.ee083f962ddb1d71cc981938aad89d5.431>.

***Bloomberg*, "U.K. Pledges \$97 Million for Carbon Capture in Emerging Markets," and *The Guardian*, "U.K. to Give [\$97 Million] to Developing Countries to Build CCS Plants."**

At a meeting in London among energy ministers from 23 countries, the United Kingdom (U.K.) agreed to provide as much as ~\$97 million to encourage the development of CCS technology in emerging markets. The money, which will be drawn from the previously announced International Climate Financing funding, will be used to boost projects and develop new partnerships. According to the Carbon Capture, Use, and Storage Action Group, the U.K. funds will contribute to the \$200 million that should be allocated globally to speed up the deployment of CCS technology. In addition, the meeting also resulted in the energy ministers forming a partnership to foster collaboration between the public and private sectors in 16 countries. April 25, 2012, <http://www.bloomberg.com/news/2012-04-25/u-k-pledges-97-million-for-carbon-capture-in-emerging-markets.html>, and April 26, 2012, <http://www.guardian.co.uk/environment/2012/apr/26/carbon-capture-storage-developing-countries?newsfeed=true>.

POLICY (CONTINUED)

Reuters, “Peru is Latest Developing Nation to Adopt Climate Change Initiative.”

Peru has adopted a resolution to lower carbon emissions. The long-term climate change initiative aims to include more renewable fuels in Peru’s energy matrix, switch to a low-carbon economy, and curb illegal logging in the Amazon rain forest. Peru emits approximately .4 percent of the world’s greenhouse gas (GHG) emissions. In last year’s U.N. talks in Durban, South Africa, Peru backed a goal for an international climate change deal by 2015 that would come into force by 2020. April 26, 2012, <http://www.reuters.com/article/2012/04/26/us-peru-climate-idUSBRE83P1H820120426>.

SouthAfrica.info, “South Africa Approves CO₂ Capture Plan.”

South Africa’s Cabinet announced the approval of a plan to capture and store CO₂ in deep geologic formations. According to the Performance Monitoring and Evaluation Minister, South Africa voluntarily committed to reduce its CO₂ emissions by 34 percent by 2020 and by 45 percent by 2025, on the condition that the necessary technological and financial support was provided. Potential areas for CCS in South Africa were identified in a recently released Geological Storage Atlas; the next step will be a test injection of CO₂ into a suitable geologic formation to determine if the CO₂ can be stored safely. May 7, 2012, <http://www.southafrica.info/news/business/1968687.htm>.

“Assessment of strategies for CO₂ abatement in the European petroleum refining industry.”

The following is the Abstract of this article: “Petroleum oil refineries account for almost [eight percent] of the total CO₂ emissions from industry in the EU. In this paper, the European petroleum refining industry is investigated and the prospects for future CO₂ abatement in relation to associated infrastructure are assessed. A more efficient use of

the adjacent infrastructure, e.g., district heating networks, natural gas grids, [neighboring] industries, and CO₂ transport and storage systems, could provide opportunities for additional CO₂ emissions reduction. It is shown that access to infrastructures that can facilitate CO₂ abatement varies significantly across countries and between individual refineries. The assessment shows that short-term mitigation options, i.e., fuel substitution and energy efficiency measures, could reduce CO₂ emissions by 9-40 MtCO₂/year (6-26 [percent] of the total refinery emissions). It is further shown that [CCS] offers the greatest potential for more significant emission reductions in the longer term. However, the potential for CO₂ capture varies significantly depending on the choice of technology, CO₂ source, and scope of implementation (5-80 [percent] of the total refinery emissions).” **Daniella Johansson, Johan Rootzén, Thore Berntsson, and Filip Johnsson**, *Energy*, Available online April 19, 2012, doi:10.1016/j.energy.2012.03.039, <http://www.sciencedirect.com/science/article/pii/S0360544212002307>. (Subscription may be required.)



GEOLOGY

“Variations in the mechanical behavior of Illinois bituminous coals.”

The following is the Abstract of this article: “Unmineable coalbeds are being considered as one of the geological [storage] options for storing CO₂. The storage mechanisms and potential risks associated with the effects of CO₂ on the coal structure are not yet understood and must be evaluated. The mechanical properties of the coal are expected to play an important role in the coal seams’ stability, especially under external perturbations. Typically, the mechanical characteristics of coal are investigated as a bulk material, which averages the effects of various structural in homogeneities as well as of face and butt cleat fractures present in the coal. In this paper, [the authors] attempt to establish baseline mechanical characteristics of Illinois bituminous coals while minimizing the fracture effects. Rectangular coal strips (length <20 mm), which showed no visible macro-defects, from two different Illinois bituminous coal seams, were subjected to three-point bending tests. [The authors’] results suggest there are significant variations in the flexural modulus (ranging from 0.7 GPa to 3.4 GPa) of the coal samples even though the coal rectangular strips originated from the same coal chunk. Vibrational spectroscopic analysis on the samples, which underwent mechanical testing, indicates a correlation between the flexural strength and modulus with the intensity of aliphatic groups. However, the mineral content of the coal seems not to influence the mechanical behavior of Illinois bituminous coals.” **Richard D. West, Gediminas Markevicius, Vivak M. Malhotra, and Stephen Hofer**, *Fuel*, Available online April 5, 2012, doi:10.1016/j.fuel.2012.03.042, <http://www.sciencedirect.com/science/article/pii/S0016236112002517>. (Subscription may be required.)

“CO₂ [storage] into the Wyodak coal seam of Powder River Basin – Preliminary reservoir characterization and simulation.”

The following is the Abstract of his article: “Injection of [CO₂] captured from flue gas into coalbeds is regarded as one of the value-added options of CO₂ [storage] as the cost of injection can be partially or fully offset by the revenue generated through release of additional methane. The Powder River Basin is one of the major coalbed methane producing areas in the world. The paper presents findings of a preliminary reservoir simulation study on the feasibility of CO₂ [storage] over a nine-section area (4.8 km × 4.8 km) of the Powder River Basin into the thick Wyodak coal seam, one of the two major coal seams in the highly productive Fort Union formation. The reservoir model was built on the basis of information available in the public domain. Gamma ray logs from 60 wells were utilized for developing a 3-D geological model of the coal seam and overlying rocks in the area by employing geostatistical techniques. Considerable variability in gas and water production was observed in the 65 wells. This variability was utilized for capturing the reservoir heterogeneity by Gaussian geostatistical simulation, which produced realizations of fracture porosity and permeability distribution throughout the reservoir. Results of fluid flow simulation indicated that it would not be feasible to place more than one injector per 1.6 km × 1.6 km (1 mile × 1 mile) section of the area due to geomechanical constraint. As a preliminary estimate, it may be feasible to inject 0.658 million tons of CO₂ through such injector over a period of 20 years. [Twelve percent] more CO₂ can be injected over the same period by

GEOLOGY (CONTINUED)

using a horizontal well but the loss of injectivity may be substantial due to reduction of permeability by coal matrix swelling. The loss of permeability can partially be overcome by intermittent injection for [six] months followed by a similar soak period. Placing one vertical injector each into all the nine sections would result in a scaled-up volume of 5.5 million tons of CO₂ injection. However, the nature of overlying rock could play a vital role in retention of injected CO₂ and up to 20 [percent] of the gas may migrate up by buoyancy.” **Pratik Dutta and Mark D. Zoback**, *International Journal of Greenhouse Gas Control*, Available online April 21, 2012, doi:10.1016/j.ijggc.2012.03.004, <http://www.sciencedirect.com/science/article/pii/S175058361200062X>. (Subscription may be required.)

“Relationships between the sorption [behavior] of methane, carbon dioxide, nitrogen and ethane on coals.”

The following is the Abstract of this article: “[Storage] of [CO₂] in coal seams can reduce emissions of [CO₂] to the atmosphere. If such [storage] simultaneously results in enhanced coal bed methane (ECBM) production, some of the [storage] costs can be recovered by the value of the methane produced. This requires knowledge of both the [CO₂] and methane sorption [behavior] of coal at high pressures. In order to elucidate the connection between them, [the authors] investigated the sorption of [CO₂], methane, ethane and nitrogen at 55°C at pressures up to 20 MPa for a number of coals. Sorption isotherms were fitted by a modified Dubinin-Radushkevich model. The maximum sorption capacities of the coals for the different gases were found to be highly correlated. The relationship between maximum sorption capacity of a coal for a gas and its critical temperature was approximately proportional. The relationship between methane and nitrogen maximum sorption capacity was particularly close: on a volume basis, the maximum sorption capacity of all coals examined for methane was twice that of nitrogen. The ratio of maximum sorption capacity of [CO₂] and methane decreased linearly with increasing carbon content. The ethane/methane sorption ratio also tended to decrease with increasing rank though to a smaller extent, indicating that the proportionally greater sorption at low rank coals is not unique to [CO₂]. The heat of sorption tends to increase with increasing vitrinite reflectance; this may reflect the greater polarizability of higher rank coals (which also determines their reflectance).” **Richard Sakurovs, Stuart Day, and Steve Weir**, *Fuel*, Available online March 20, 2012, doi:10.1016/j.fuel.2012.03.014, <http://www.sciencedirect.com/science/article/pii/S0016236112002232>. (Subscription may be required.)

TECHNOLOGY

“Modeling and Upscaling of Binary Gas Coal Interactions in CO₂ Enhanced Coalbed Methane Recovery.”

The following is the Abstract of this article: “When CO₂ injected into the unmineable coal seam, complicated binary gas [methane (CH₄)]-CO₂ coal interactions affect coal porosity and permeability, which is one of

the bottleneck scientific issues faced in enhancing production of coalbed methane and the geological [storage] of [CO₂]. The issue is addressed through the development and application of a novel fully coupled coal deformation, gas transport and gas adsorption/desorption finite element (FE) model with COMSOL Multiphysics. The COMSOL FE model considers the combined net effects on coal permeability among the coal matrix swelling/shrinking due to gas displacement, pore pressure and in-situ stress. These combined effects are quantified through solving a set of coupled field equations which govern the coal deformation, prescribe the transport and interaction of gas flow in a similar way to poroelastic theory, and define CH₄-CO₂ counter diffusion and flow in a coal seam. Numerical models were verified with the experiment data. The established COMSOL FE simulator was applied to simulate the CO₂ injection performance in Qinshui Basin field under in-situ size and conditions, to address in-situ spatial-temporal evolutions of coal deformation and permeability. Simulation results suggest that net change of coal permeability accompanying binary gas dispersion is controlled competitively by the influence of effective stresses and differential swelling of coal. 1.75 × 10⁴t CO₂ can be [stored] in 300×300 m² area of Qinshui Basin within 10 years. During the simulation, coalbed methane recovery was promoted by 1.44 times.” **Lai Zhou, Qiyang Feng, Zhongwei Chen, and Jishan Liu**, *Procedia Environmental Sciences*, Available online April 6, 2012, doi:10.1016/j.proenv.2012.01.368, <http://www.sciencedirect.com/science/article/pii/S1878029612003696>. (Subscription may be required.)

“Modeling and analysis of selected carbon dioxide capture methods in IGCC systems.”

The following is the Abstract of this article: “Carbon dioxide capture from energy systems will likely become a necessity as the European Union regulations are becoming increasingly more stringent. The greatest disadvantage of the existing methods of CO₂ separation is the high energy intensity. In the Integrated Gasification Combined Cycle (IGCC) system, the [CO₂] capture process is conducted before combustion, which facilitates the separation. In this paper, two methods of CO₂ capture are compared. The first is the most frequently considered, known as chemical absorption. The second is membrane CO₂ separation, which is not as commonly deployed but has the potential to be an even more efficient process. The models of CO₂ capture installations were built in Aspen software. The two processes used in the analyses were primarily compared with respect to the energy intensity of each method. The results of the analysis show that the use of membranes allows for a significant decrease in the energy intensity of the capture process compared with the absorption process. However, the purity of the separated CO₂ significantly depends on the type and surface of the membrane and on the process parameters. Nevertheless, it is clear that the development of membrane techniques will enable the most competitive CO₂ capture solutions, in terms of effectiveness and cost, compared with other methods.” **Anna Skorek-Osikowska, Katarzyna Janusz-Szymańska, and Janusz Kotowicz**, *Energy*, Available online March 3, 2012, doi:10.1016/j.energy.2012.02.002, <http://www.sciencedirect.com/science/article/pii/S0360544212000953>. (Subscription may be required.)



TERRESTRIAL

“Mineral Carbonation as the Core of an Industrial Symbiosis for Energy-Intensive Minerals Conversion.”

The following is the Summary of this article: “The longer term sustainability of the minerals sector may hinge, in large part, on finding innovative solutions to the challenges of energy intensity and CO₂ management. This article outlines the need for large-scale ‘carbon solutions’ that might be shared by several colocated energy-intensive and carbon-intensive industries. In particular, it explores the potential for siting a mineral carbonation plant as a carbon [formation] at the heart of a minerals and energy complex to form an industrial symbiosis. Several resource-intensive industries can be integrated synergistically in this way, to enable a complex that produces energy and mineral products with low net CO₂ emissions. An illustrative hypothetical case study of such a system within New South Wales, Australia, has been constructed, on the basis of material and energy flows derived from Aspen modeling of a serpentine carbonation process. The synergies and added value created have the potential to significantly offset the energy and emission penalties and direct costs of CO₂ capture and storage. This suggests that greenfield minerals beneficiation and metals refining plants should consider closer integration with the power production and energy provision plants on which they depend, together with a carbon solution, such as mineral carbonation, as a critical element of such integration. Other sustainability considerations are highlighted.” **Geoffrey F. Brent, Daniel J. Allen, Brent R. Eichler, James G. Petrie, Jason P. Mann, and Brian S. Haynes**, *Journal of Industrial Ecology*, Available online February 2012, doi:10.1111/j.1530-9290.2011.00368.x, <http://onlinelibrary.wiley.com/doi/10.1111/j.1530-9290.2011.00368.x/abstract;jsessionid=C5891EB4F3AFF606F61C46D3D3C5C5D4.d01t04>. (Subscription may be required.)

TRADING

Bloomberg Businessweek, “South Korea Parliament Approves Carbon Trading System.”

The National Assembly of South Korea approved a cap-and-trade system to cut GHGs. The bill will establish a market-based program requiring companies that exceed their emission quotas to purchase permits from companies that emit below their respective quotas. Under the bill, which calls for emissions trading to begin in 2015, companies emitting more than 125,000 metric tons of CO₂ annually will be subject to Korea’s cap-and-trade system, as will factories, buildings, and livestock farms that annually produce more than 25,000 metric tons. Rules governing compliance are expected to be released within the next six months. May 3, 2012, <http://www.businessweek.com/news/2012-05-02/south-korean-parliament-approves-carbon-trading-system#p2>.

RGGI News Release, “2011 Annual Market Monitor Report: RGGI CO₂ Allowance Market Remains Competitive.”

Potomac Economics, the independent market monitor, released the 2011 “Annual Report on the Market for RGGI CO₂ Allowances.” In evaluating the activity in the market for Regional Greenhouse Gas Initiative (RGGI) CO₂ allowances in 2011, the report focused on allowance prices, trading and acquisition of allowances in the auctions and secondary market, participation in the market by individual firms, and market monitoring. According to the report, the majority of CO₂ allowances offered in each auction in 2011 was acquired by compliance entities; they purchased 91 percent of the allowances sold for the first control period, and 69 percent of the allowances sold for the second control period. For more information on the report, go to: http://www.rggi.org/docs/MM_2011_Annual_Report.pdf. May 4, 2012, http://www.rggi.org/docs/PR050412_2011-Annual-Market-Monitor-Report.pdf.

“The impact of the EU ETS on the corporate value of European electricity corporations.”

The following is the Abstract of this article: “In this research, the impact of the European Emission Trading Scheme (EU ETS) on the corporate value of European electricity corporations has been measured, and a comparison study of the impact between phase I and phase II of the EU ETS has been performed. To achieve this, a modified multifactor market model has been used to investigate how the development of EU emission allowance (EUA) prices has influenced corporate value. The results indicate that the impact of these has changed much from phase I to phase II. EUA price developments have affected corporate value in opposite directions: in phase I, the increase in EUA prices tended to cause corporate value appreciation, while during phase II, it was more likely to induce depreciation. Second, the corporate value development has been much more sensitive to changes in EUA prices in phase II than in phase I. The causes of the impact change have also been analyzed. The conclusion reached has been that the changes have resulted mainly from the adjustment of the EUA allocation policy between phases I and II. Moreover, the effects of corporate efforts to reduce CO₂ emissions on corporate value did not emerge until phase II, when the EUA allocation became more rigorous.” **Jian-Lei Mo, Lei Zhu, and Ying Fan**, *Energy*, Available online March 22, 2012, doi:10.1016/j.energy.2012.02.037, <http://www.sciencedirect.com/science/article/pii/S0360544212001326>. (Subscription may be required.)

RECENT PUBLICATIONS

“Tracking Progress in Carbon Capture and Storage.”

The following is a summary of this document: “At the second Clean Energy Ministerial in Abu Dhabi, April 2011 (CEM 2), the Carbon Capture, Use and Storage Action Group (CCUS AG) presented seven substantive recommendations to Energy Ministers on concrete, near-term actions to accelerate global CCS deployment. Twelve CCUS AG governments agreed to advance progress against the 2011 recommendations by the third Clean Energy Ministerial (London, 25-26 April 2012) (CEM 3). Following CEM 2, the CCUS AG requested the [International Energy Agency (IEA)] and the Global CCS Institute to report on progress made against the 2011 recommendations at CEM 3. 'Tracking Progress in Carbon Capture and Storage: International Energy Agency/Global CCS Institute report to the third Clean Energy Ministerial' responds to that request. The report considers a number of key questions. Taken as a whole, what advancements have committed CCUS AG governments made against the 2011 recommendations since CEM 2? How can Energy Ministers continue to drive progress to enable CCS to fully contribute to climate change mitigation? While urgent further action is required in all areas, are there particular areas that are currently receiving less policy attention than others, where efforts could be redoubled? The report concludes that, despite developments in some areas, significant further work is required. CCS financing and industrial applications continue to represent a particularly serious challenge.” The full IEA publication is available for download at: <http://iea.org/publications/freepublications/publication/name,26622,en.html>.

“Carbon Capture and Storage: [Realizing] the potential?”

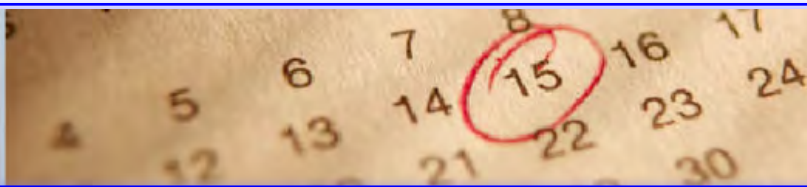
The following is from the Executive Summary of this document: “The aim of the research is to assess the technical, economic, financial and social uncertainties facing CCS technologies, and to [analyze] the potential role they could play in the UK power sector between now and 2030. CCS technologies are often highlighted as a crucial component of future low carbon energy systems – in the UK and internationally. However, it is unclear when these technologies will be technically proven at full scale, and whether their costs will be competitive with other low carbon options. The important contribution that CCS technologies could make to reducing global carbon emissions has been [recognized] by the UK government for several years. There has been a plan to build at least one full scale demonstration project since 2006. But, at the time of writing, this has not yet resulted in a firm agreement to fund a specific project. Last autumn, the planned Scottish Power demonstration at the Longannet power plant became the latest CCS project to be cancelled. Despite continuing public commitments to CCS from Ministers, policy, economic and financial uncertainties remain a particular concern for investors in the UK – and in many other countries where CCS demonstrations are planned. The re-launch of the [~\$1.5 billion] fund for CCS demonstration projects in April 2012, alongside a roadmap for the [commercialization] of CCS technologies, may signal a decisive turning point in UK policy. However, it remains to be seen whether the measures within the roadmap, and the generous package of financial support that is now available, will be sufficient to make CCS a commercial reality. Against this policy background, this report systematically examines the uncertainties facing CCS technologies in the UK. It uses historical evidence to explore these uncertainties, and the conditions under which they can be at least partly resolved. The historical evidence base comprises nine case studies, each of which focuses on a technology that is partly analogous to CCS. The report draws on this evidence to develop potential pathways for CCS in the UK to 2030, and uses this analysis to draw conclusions for current policies and strategies.” To view the entire UK Energy Research Center (UKERC) document, go to: http://www.ukerc.ac.uk/support/tiki-download_file.php?fileId=2386.

LEGISLATIVE ACTIVITY

Lexology, “Carbon Sequestration Bill Advances in California Legislature,” and *California Current*, “Senate Panel Keep Carbon Capture and Sequestration Bill Alive.”

The California Senate’s Committee on Environmental Quality unanimously approved SB 1139 (Carbon Capture and Storage Act of 2012) aimed at establishing a regulatory system for CCS plants in California by closing gaps in current state law. As drafted, the measure assigned three different agencies to develop regulations for various aspects of CCS: (1) the Fire Marshal would be in charge of pipelines carrying captured CO₂ from power plants to geological storage sites; (2) the Division of Oil, Gas, and Geothermal Resources would be in charge of regulating the underground injection of CO₂ when in conjunction with EOR; and (3) the California Air Resources Board would be responsible for developing methodology for determining how much emissions reduction credit should be granted for CCS operations. Under an Environmental

Quality Committee amendment, the methodology would be due by January 1, 2015. To view SB 1139, go to: http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_1101-1150/sb_1139_cfa_20120413_121218_sen_comm.html. April 18, 2012, <http://www.lexology.com/library/detail.aspx?g=ae932c3-a1c5-48fc-9dd7-6643446a3dd6>, and April 20, 2012, <http://www.cacurrent.com/storyDisplay.php?sid=6063>.



EVENTS

June 4-8, 2012, **7th Asia Clean Energy Forum**, *ADB Headquarters, Mandaluyong City, Philippines*. Participants of this forum will discuss successful strategies and mechanisms for accelerating access to affordable, low-carbon energy. The Pre-Forum, held the first two days of the event, includes a Regional Workshop on Greenhouse Gas Inventories and Accounting. The Main Forum, held the last three days of the event, will be made up of 32 plenary and breakout sessions. A full agenda has yet to be developed. To learn more, go to: <http://www.asiacleanenergyforum.org/>.

June 11-14, 2012, **CSLF Technical Meeting**, *Radisson Blu Royal Hotel, Bergen, Norway*. The Carbon Sequestration Leadership Forum (CSLF) will review the progress of their CCS projects, discuss further research areas, and coordinate with the international research community to advance CCS technology and policy. For more information, including the Task Force schedule, the Technical Group Meeting agenda, and the CO₂ Capture Workshop agenda, click: <http://www.cslforum.org/meetings/bergen2012/premeeting.html>.

June 13-14, 2012, **CO₂ Capture and Storage – Regional Awareness-Raising Workshop**, *Middle East Technical University, Ankara, Turkey*. The aim of this workshop, in its second year, is to provide a basic overview and status of CCS in Europe, the Middle East, and Turkey. Topics to be discussed include EU and Turkish policy and legislation on CCS, carbon capture technologies, CO₂ storage technologies, CO₂-EOR, and examples and experiences from CCS projects. For more information, visit: <http://www.cgseurope.net/NewsData.aspx?IdNews=70&ViewType=Actual&IdType=478>.

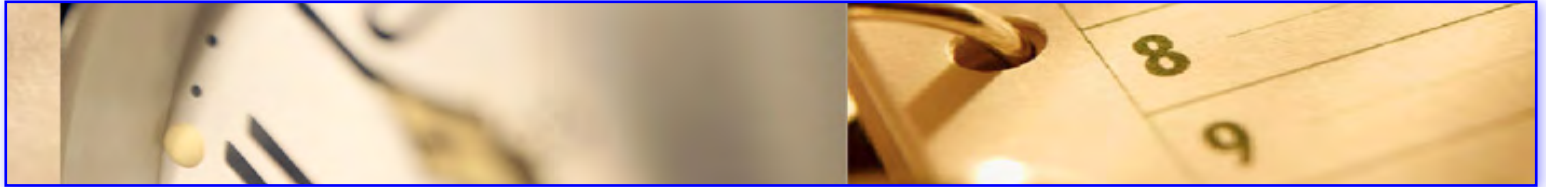
June 14-15, 2012, **World Climate 2012**, *Vienna University of Technology, Vienna, Austria*. This conference focuses on potential climate change, bringing together academic scientists, engineers, industry researchers, politicians, activists, and scholars to exchange research results. For more information, visit the conference website at: <http://www.vienna-conference.com/worldclimate/index.html>.

July 12-13, 2012, **4th International Conference on Climate Change: Impact and Responses**, *The University of Washington, Washington, USA*. This conference will address a range of themes relating to potential climate change, such as natural and human causes; ecosystem and human impacts; and technological, social, ethical, and political responses. The conference program will consist of a mix of plenary and parallel sessions. More information is available at: <http://on-climate.com/conference-2012/>.

July 23-25, 2012, **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 CO₂ 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.

September 4-6, 2012, **Carbon Capture & Storage: A Field-Based Masterclass**, *Springfield County Hotel, Stoborough, Wareham, Dorset, UK*. This three-day course follows the path of CO₂ from extraction from ancient rocks in the subsurface, through its use, to the capture and safe storage back into the rocks. The training experience will combine classroom sessions, case studies, and field visits. For more information, download the course flyer at: http://www.cstlm.com/content_189_.

November 18-22, 2012, **International Conference on Greenhouse Gas Technologies 11 (GHGT-11)**, *Kyoto International Conference Center, Japan*. This will be the second visit to Kyoto by the GHGT conference series, with more than 1,600 delegates expected to attend. A formal agenda has not yet been developed; however, planning for GHGT-11 is underway. The call for papers has expired. Visit: <http://www.ghgt.info/index.php/Content-GHGT11/ghgt-11-overview.html> for more details.



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