



# Carbon Sequestration Newsletter



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**FEBRUARY 2011**



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(NETL), the manual, titled, “Site Screening, Site Selection, and Initial Characterization for Storage of CO<sub>2</sub> in Deep Geologic Formations,” will be used as a resource by future project developers and CO<sub>2</sub> producers and transporters. In addition, the BPM will be used to inform government agencies of the best practices for exploring potential CO<sub>2</sub> geologic storage sites and educate the public about the analyses being conducted. This is the fourth BPM released by DOE, and it provides a framework for reporting resources calculated using methods developed by DOE, the Carbon Sequestration Leadership Forum (CSLF), and others. This BPM focuses on the exploration phase of the site characterization process and communicates analyses and guidelines for narrowing potential sub-regions into qualified sites for CO<sub>2</sub> geologic storage. Development of the geologic storage system proposed in this BPM will be instrumental in establishing consistent, industry-standard terminology and guidelines for communicating storage resources and storage capacity estimates, as well as project risks, to stakeholders. (See **Recent Publications** section for the **Executive Summary** and a link to the “Site Screening, Site Selection, and Initial Characterization for Storage of CO<sub>2</sub> in Deep Geologic Formations” BPM.) January 5, 2011, [http://www.fossil.energy.gov/news/techlines/2011/11002-Best\\_Practices\\_Manual\\_Released.html](http://www.fossil.energy.gov/news/techlines/2011/11002-Best_Practices_Manual_Released.html).

*Fossil Energy Techline, “New Roadmap Updates Status of DOE Carbon Capture and Storage RD&D Efforts.”*

## INTRODUCTION

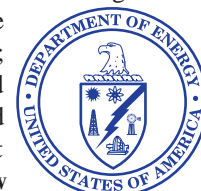
This Newsletter is created by the National Energy Technology Laboratory and represents a summary of carbon sequestration news covering the past month. Readers are referred to the actual article(s) for complete information. It is produced by the National Energy Technology Laboratory to provide information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

## HIGHLIGHTS

*Fossil Energy Techline, “DOE ‘Best Practices’ Manual Focuses on Site Selection for CO<sub>2</sub> Storage.”*

The U.S. Department of Energy (DOE) released its latest carbon capture and storage (CCS) best practices manual (BPM), which focuses on the most promising methods for assessing potential carbon dioxide (CO<sub>2</sub>) geologic storage sites. Developed by the Office of Fossil Energy’s (FE) National Energy Technology Laboratory

DOE published a new roadmap that provides an overview of research, development, and demonstration (RD&D) efforts to supply cost-effective, advanced CCS technologies for coal-based power systems. The “DOE/NETL Carbon Dioxide Capture and Storage RD&D Roadmap” outlines the efforts to develop advanced CCS technology, as well as several technologies being pursued to mitigate risks inherent to RD&D efforts. DOE anticipates that an array of advanced CCS technologies will be ready for large-scale demonstration by 2020, providing safe, cost-effective carbon management to meet national goals for reducing greenhouse gas (GHG) emissions. Research success will enable CCS technologies to overcome a wide range of challenges, such as successful integration of CO<sub>2</sub> capture, compression, transport, and storage technologies with power generation systems; effective CO<sub>2</sub> monitoring, verification, and accounting (MVA); permanence of underground CO<sub>2</sub> storage; and public acceptance. (See **Recent Publications** section for a portion of the Overview



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## HIGHLIGHTS (CONTINUED)

and a link to the “DOE/NETL Carbon Dioxide Capture and Storage RD&D Roadmap.”) For more information on DOE's Carbon Sequestration Research Program, visit: <http://www.fossil.energy.gov/programs/sequestration/index.html>. January 11, 2011, [http://www.fossil.energy.gov/news/techlines/2011/11003-New\\_CCS\\_Roadmap\\_Released.html](http://www.fossil.energy.gov/news/techlines/2011/11003-New_CCS_Roadmap_Released.html).

### *Fossil Energy Techline, “DOE Manual Studies Terrestrial Carbon Sequestration.”*

According to a BPM released by DOE, entitled, “Best Practices for Terrestrial Sequestration of Carbon Dioxide,” there is considerable opportunity and growing technical sophistication to make terrestrial carbon storage both practical and effective. The BPM details the most suitable operational approaches and techniques for terrestrial CO<sub>2</sub> storage, which uses photosynthesis to create organic matter that is stored in vegetation and soils; this is different from CO<sub>2</sub> mitigation technologies that focus on capturing and permanently storing anthropogenic CO<sub>2</sub> emissions. NETL used data from the seven Regional Carbon Sequestration Partnerships (RCSPs) to prepare the BPM, which also discusses the analytical techniques necessary to monitor, verify, and account for terrestrially stored carbon. In addition, results from the RCSPs' terrestrial field projects are presented. The best practices outlined in this BPM will help those interested in pursuing terrestrial storage projects, as well as those interested in regulating them, to optimize their efforts. (See **Recent Publications section for the Introduction and a link to the “Best Practices for Terrestrial Carbon Sequestration” BPM.**) January 18, 2011, [http://www.fossil.energy.gov/news/techlines/2011/11005-DOE\\_Publishes\\_Best\\_Practices\\_Manua.html](http://www.fossil.energy.gov/news/techlines/2011/11005-DOE_Publishes_Best_Practices_Manua.html).

## SEQUESTRATION IN THE NEWS

### *Kansas Geological Survey News Release, “Kansas Geological Survey Receives Grant to Test Tool for Predicting CO<sub>2</sub> Storage Potential.”*

The Kansas Geological Survey will use a \$1.5 million DOE grant to test a tool that can predict the CO<sub>2</sub> storage potential in the deep subsurface of parts of Kansas. The new tool, called volumetric curvature, will be used by researchers to analyze data from seismic reflection – a technique that creates images of underground rocks without having to drill. The target for the test (a deep saline formation located in the south-central and southwestern parts of Kansas) is a porous rock formation more than 3,500 feet deep, up to 1,000 feet thick, and covered by caprocks. The tool will be operated from the surface to analyze seismic data collected at the study area. If successful, the seismic data analysis tool would provide a cost-effective way to assess geologic CO<sub>2</sub> storage capacity and lead to a better understanding of the underground movement of CO<sub>2</sub> in saline formations. December 30, 2010, <http://www.kgs.ku.edu/General/News/2010/arbuckle.html>.

# SEQUESTRATION IN THE NEWS (CONTINUED)

*Providence Resources News Release*, “Ulysses Gas Storage Project Update,” and *Carbon Capture Journal*, “Ulysses Storage Project Completes First Phase.”

A new study carried out by Providence Resources, on behalf of AMEC, has confirmed that the construction of an offshore natural gas salt cavern storage facility at the Undersea Large-Scale Saline Sequestration and Enhanced

Storage (ULYSSES) location is economically and technically feasible. The ULYSSES Project will store CO<sub>2</sub> in the Kish Bank Basin in offshore Dublin, Ireland. The initial development phase of the study includes planning, capacity modeling, infrastructural integration, and gas sourcing. The ULYSSES Project, which began in 2008, will also be advanced by the detailed technical data relating to the subsurface geology. January 10, 2011, <http://www.providenceresources.com/uploads/ulyssesgasstorageprojectupdate-january2011-10-1-11.pdf>, and January 10, 2011, <http://www.carboncapturejournal.com/displaynews.php?NewsID=710&PHPSESSID=4ndsvm4kbbkuviahlsrbe72q844>.

## ANNOUNCEMENTS

### **NETL Releases Accomplishments Document.**

The U.S. Department of Energy’s National Energy Technology Laboratory (DOE/NETL) has released a new document, titled, “Carbon Sequestration Program FY2008-2009 Accomplishments,” which highlights the accomplishments of the Carbon Sequestration Program during the 2008 and 2009 fiscal years (FY). The new publication shows that the program has achieved numerous accomplishments through the growth, expansion, and introduction of new concepts and opportunities as a result of an adapting effort that incorporates novel activities to resolve issues uncovered by research and development (R&D) activities and social demands. The document is available on the NETL website at: [http://www.netl.doe.gov/technologies/carbon\\_seq/refshelf/CS\\_AR2008-2009.pdf](http://www.netl.doe.gov/technologies/carbon_seq/refshelf/CS_AR2008-2009.pdf).

### **Third Carbon Sequestration Atlas Estimates Up to 5,700 Years of CO<sub>2</sub> Storage Potential in U.S. and Portions of Canada.**

DOE released the “Carbon Sequestration Atlas of the United States and Canada – Third Edition (Atlas III),” which documents 1,800 billion to more than 20,000 billion metric tons of CO<sub>2</sub> storage resource potential in saline formations, oil and gas reservoirs, and unmineable coal areas in the United States and portions of Canada. This suggests a potential 500 to 5,700 years of CO<sub>2</sub> storage resources in assessed geologic formations. In addition to documenting CO<sub>2</sub> storage resource potential, Atlas III also provides updates on RCSP activities, DOE’s Carbon Sequestration Program, international CCS collaborations, worldwide CCS projects, CCS regulatory issues, and CO<sub>2</sub> stationary source emissions. To view an interactive version, go to: <http://www.natcarb.org>; a print version is available at: [http://www.netl.doe.gov/technologies/carbon\\_seq/refshelf/atlasIII/](http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasIII/).

### **Call for Papers for 10<sup>th</sup> Annual CCS Conference.**

The 10<sup>th</sup> Annual CCS Conference, held at the David L. Lawrence Convention Center in Pittsburgh, Pennsylvania, on May 2-5, 2011, is accepting papers/posters for peer review. Topics include: RCSP large-scale field testing, U.S.-Canadian CCS collaboration, and American Recovery and Reinvestment Act of 2009 (Recovery Act) investments. Abstracts are due February 18, 2011; full papers are due April 18, 2011. For more information, including a complete list of topics, visit: <http://www.carbonsq.com/callforpapersccs2011.pdf>.

### **IEA GHG Summer School.**

Applications are now being accepted for the 2011 International Energy Agency Greenhouse Gas (IEA GHG) Summer School in Champaign, Illinois. This event is open to Ph.D. students and post docs; selected students will receive travel and training expenses for five days of class work and a site visit to the Midwest Geological Sequestration Consortium’s (MGSC) Decatur, Illinois, site to view an operational CCS facility. To submit an application or view additional information, go to:

<http://www.ieaghg.org/index.php?/20110121240/summer-school-2011-test.html>.

### **First Issue of Fossil Energy Today Now Available.**

DOE’s FE has launched a new digital newsletter, titled, “Fossil Energy Today.” The quarterly newsletter will provide readers with updates on important activities, progress, and other developments within Fossil Energy in an easily accessible format. For more information, as well as a link to the first issue, go to: <http://www.fossil.energy.gov/news/energytoday.html>.

## **ANNOUNCEMENTS (CONTINUED)**

### **CO<sub>2</sub> Flooding Training Course.**

The Society of Petroleum Engineers (SPE) is conducting a training course, titled, "Practical Aspects of CO<sub>2</sub> Flooding," on April 6, 2011, at the Houston Training Center in Houston, Texas. The course, based on SPE Monograph Volume 22, "Practical Aspects of CO<sub>2</sub> Flooding," will cover the practical aspects and economics of CO<sub>2</sub> flooding, CO<sub>2</sub> geosequestration, and hydrocarbon gas flooding, among other topics. To learn more, visit: [http://www.aboutoilandgas.com/career/educ\\_training/tc/PAC.php](http://www.aboutoilandgas.com/career/educ_training/tc/PAC.php).

### **Carbon Dioxide Regulation Webinar.**

A webinar, titled, "Carbon Dioxide Regulation Under the Clean Air Act: Where Are We Now, and Where Are We Going," will be held on February 11, 2011. Topics include an overview of past and pending GHG litigation and regulatory action, Clean Air Act regulations and discussion, the Mandatory Reporting Rule (MRR), air permit requirements, and implications of GHG permitting and reduction. More information is available at: [http://www.euci.com/web\\_conferences/0211-regs/agenda.php?ci=1256](http://www.euci.com/web_conferences/0211-regs/agenda.php?ci=1256).

## **SCIENCE**

### ***The Guardian*, "Glacier Shrinkage will Hit European Alps Hardest, Study Claims."**

According to a new study published in the journal *Nature: Geoscience*, glaciers in the European Alps could shrink by 75 percent by the end of the century due to potential climate change. In the study, researchers conclude that mountain glaciers and ice caps around the world are projected to lose 15 to 27 percent of their volume by 2100. Researchers also believe that this projected decrease in volume will lead to "substantial impacts" on regional water availability, as well as a rise in sea levels (the study predicts melting glaciers and ice caps will result in increases in sea levels by as much as 16.1 cm by 2100). Data was gathered by simulating the response of 2,638 ice caps and 120,229 mountain glaciers worldwide to the 10 state-of-the-art projected climate change models developed for the last Intergovernmental Panel for Climate Change (IPCC) report. It was found that while melting mountain glaciers and ice caps have contributed less than one percent of all water on Earth, their retreat has caused half of the sea level rises over the past 50 years. January 9, 2011, <http://www.guardian.co.uk/environment/2011/jan/09/global-warming-glaciers-sea-levels>.

### ***ScienceDaily*, "Warming Climate Means Red Deer Rutting Season Arrives Early."**

The annual rutting season of wild red deer on the Isle of Rum could be changing due to warming spring and summer temperatures, according to scientists. A new study shows that the rutting and calving seasons are occurring two weeks earlier, on average, compared to 30 years ago. Scientists came to this conclusion by using annual records of breeding success in more than 3,000 individually recognizable deer as part of a 38-year study of the ecology of red deer on the Isle of Rum. The long-term research was conducted by scientists at the Universities of Cambridge and Edinburgh, who believe the data provides evidence that warming temperatures are affecting the behavior of British mammals. January 16, 2011, <http://www.sciencedaily.com/releases/2011/01/110114100948.htm>.

## **POLICY**

### ***Journal of Accountancy*, "International Greenhouse Gas Assurance Standard Proposed."**

The International Auditing and Assurance Standards Board (IAASB), an independent standard-setting board operated by the International Federation of Accountants (IFAC), released a proposed standard to provide assurance on GHG emissions reported by companies. The International Standard on Assurance Engagements (ISAE) 3410, Assurance Engagements on Greenhouse Gas Statements, addresses responsibilities in identifying, assessing, and responding to risks of misstatements. It also contains assurance reports on GHG statements. Comments on the draft are due by June 10, 2011. To view ISAE 3410, Assurance Engagement on Greenhouse Gas Statements, click: <http://www.ifac.org/Guidance/EXD-Details.php?EDID=0152>. January 13, 2011, <http://www.journalofaccountancy.com/Web/20113739.htm>.

### **"Drivers and barriers towards large scale Carbon Capture and Storage (CCS) deployment and possible government responses."**

The following is the Introduction of this article: "Large scale CCS is seen as an important technology to substantially reduce global CO<sub>2</sub> emissions. However, CCS is not a mature technology yet. Value drivers behind (large scale) CCS deployment are currently not sufficient to overcome the current (not only economic) hurdles on the road towards (large scale) CCS projects. Main aim of this paper is to provide an answer to the question 'What government role or response is most appropriate to tackle the main obstacles towards large scale CCS deployment?' In order to answer this question, a number of sub questions is formulated. The first section of this paper will deal with the question: *What are the main drivers for large scale CCS deployment?* The drivers will be differentiated among the various parts in the CCS value chain (capture, transport and storage). The second section will address the following research question: *What are the main barriers towards large scale CCS deployment?* Based on a recently undertaken CCS stakeholder consultation, a number of regulatory-, financial-, technical-, organizational- and policy issues towards large scale CCS deployment is identified. The

## POLICY (CONTINUED)

third part deals with the question: *What are possible government roles/ responses to stimulate and enable CCS?* On the basis of the answers to the previous research questions, this section will identify which measures and/or other government actions are needed in which part of the CCS chain, to reinforce current drivers and to remove the barriers towards large scale CCS in the Netherlands. In the final section, conclusions will be presented in terms of the most appropriate government role and response needed, in order to realize large scale CCS. The research questions will be answered from a theoretical perspective together with the insights gathered from interviews with almost all CCS stakeholders represented in the Netherlands.” **Marten Slagter and Edmund Wellenstein.** Presented at the 10<sup>th</sup> International Conference on Greenhouse Gas Control Technologies (GHGT-10), held September 19-23, 2010, at RAI in Amsterdam, The Netherlands, <https://www4.eventsinteractive.com/iea/viewpdf.esp?id=270025&file=%5C%5CDCFILE01%5CEP11%24%5CEventwin%5CPool%5Coffice27%5Cdocs%5Cpdf%5Cghgt10Final00883%2Epdf>.

**“A study on roles of public survey and focus groups to assess public opinions for CCS implementation.”**

The following is the Abstract of this article: “The authors conducted a set of focus groups and a public survey to assess awareness and potential acceptability of CCS in the context of national policy formulation in 2009-2010. In 2010, the authors also conducted focus groups to assess awareness of CCS and to identify information needs to form local opinion for CCS demonstration project in the context of local implementation in a potential project site. By comparing the results of those assessments, roles of focus groups and public survey are clarified. In national policy context, focus group assessment helps to design a public survey as well as provides an example of the public’s thought on CCS, and shows some processes of opinion formulation through group dynamics. In local context, qualitative assessments through focus groups and other methodology such as interviews and local meeting would play important role to understand local public opinion. Meanwhile, the cautions that focus group would not provide comprehensive assessments on public opinion and might pick exaggerated opinions are drawn in using focus group data.” **Kenshi Itaoka, Aya Saito, and Makoto Akai.** Presented at GHGT-10, held September 19-23, 2010, at RAI in Amsterdam, The Netherlands, <https://www4.eventsinteractive.com/iea/viewpdf.esp?id=270025&file=%5C%5CDCFILE01%5CEP11%24%5CEventwin%5CPool%5Coffice27%5Cdocs%5Cpdf%5Cghgt10Final00961%2Epdf>.

## GEOLOGY

**“CO<sub>2</sub>-porewater-rock reactions - Large-scale column experiment.”**

The following is the Abstract of this article: “This study focused on the reactions between CO<sub>2</sub>, porewater and host rock during geological CO<sub>2</sub> storage in deep reservoirs. The aim of this work was to provide a well-constrained laboratory experiment reacting known quantities of minerals with CO<sub>2</sub>-rich fluids, to simulate situations where CO<sub>2</sub> is being injected into lithologies deep underground. The

experiment was undertaken using a Ti-column, 100 cm long, held within a large pressure vessel. The column was packed with a simplified mineral assemblage. The reactant fluid was equilibrated with CO<sub>2</sub> at a temperature of 130°C and a pressure of 300 bar, before being pumped into the column held under the same conditions. Fluid was passed along the column at a constant flow rate for approximately 3.5 months. Fluids collected from the outlet end of the column were analyzed to provide data on the fate of the dissolved species. On completion of the experiment, the column was then examined for mineralogical changes. The experimental results can be used as a test case for predictive geochemical computer modelling. Such models will help improve [the] ability to predict the long-term fate of CO<sub>2</sub> stored underground.” **Keith Bateman, Christopher Rochelle, Alicja Lacinska, and Doris Wagner.** Presented at GHGT-10, held September 19-23, 2010, at RAI in Amsterdam, The Netherlands, <https://www4.eventsinteractive.com/iea/viewpdf.esp?id=270025&file=%5C%5CDCFILE01%5CEP11%24%5CEventwin%5CPool%5Coffice27%5Cdocs%5Cpdf%5Cghgt10Final00149%2Epdf>.

**“Effect of time on the carbonation reaction of saline aquifers with controlled pH.”**

The following is the Abstract of this article: “This work investigated the effect of time on the carbonation reaction in synthetic saline solution, under mild conditions and with a controlled pH, aiming the mineral trapping of CO<sub>2</sub> on saline aquifers. The experiments were performed in a glass reactor at 40°C, [six] hours and atmospheric pressure. The saline solution and solid phase were characterized by Flame Atomic Absorption Spectroscopy (FAAS), Scanning Electron Microscopy (SEM) and Fourier Transform Infrared Spectroscopy (FTIR). This work demonstrated that the saline solution pH lowers to approximately 7-8 in the first hour of reaction (initial pH of approximately 10), remaining constant until the end of the reaction. Through the analysis by AAS, it was found that the concentration of [calcium (Ca)] ions in the brine decreases with time. A greatest reduction in the Ca ions concentration occurs within the first two hours of reaction, remaining constant in the others hours. The [magnesium (Mg)] concentration showed the trend of the final concentration remains close to initial concentration, even with the carbonates precipitation. SEM analysis indicated that the precipitates obtained had morphology similar to that found for various forms of calcium carbonate (i.e. calcite and aragonite). FTIR analysis shows characteristic bands of carbonates, which agrees with the results of the analysis by SEM.” **Marta Kerber Schütz, Natália Lopes, Angélica Cenci, Rosane Ligabue, Jeane Dullius, Sandra Einloft, and João Marcelo Ketzer.** Presented at GHGT-10, held September 19-23, 2010, at RAI in Amsterdam, The Netherlands, <https://www4.eventsinteractive.com/iea/viewpdf.esp?id=270025&file=%5C%5CDCFILE01%5CEP11%24%5CEventwin%5CPool%5Coffice27%5Cdocs%5Cpdf%5Cghgt10Final01199%2Epdf>.

## TECHNOLOGY

**“Geological investigations for CO<sub>2</sub> storage: from seismic and well data to 3D modeling.”**

## TECHNOLOGY (CONTINUED)

The following is the Abstract of this article: “This work is part of the CPER Artenay project that aims at quantifying the environmental benefits and the technico-economic feasibility of storing CO<sub>2</sub> issued from a bio-ethanol distillery into a deep saline aquifer in the Paris Basin, France. This communication focuses on the geological investigations that ultimately lead to defining an optimal location for an injection site in CCS project. This paper presents a new approach for the pre-site characterization going from seismic and well data analyses to storage design. First, the general context of the area has been set follow by seismic interpretation. Those investigations leads to a geological surfaces modeling taking into account the basin border location of the project. The next step is the properties modeling made using sequence stratigraphy surfaces and Petrel software. This work will conduct to choose the optimal injection location regarding this geological investigation and the environmental constrains.” **F. Chapuis, H. Bauer, S. Grataloup, A. Leynet, B. Bourguine, C. Castagnac, S. Fillacier, A. Lecomte, Y. Le Gallo, and D. Bonijoly.** Presented at GHGT-10, held September 19-23, at RAI in Amsterdam, The Netherlands, <https://www4.eventsinteractive.com/iea/viewpdf.esp?id=270025&file=%5C%5CDCCFILE01%5CEP11%24%5CEventwin%5CPOOL%5Coffice27%5Cdocs%5Cpdf%5Cghgt10Final00351%2Epdf>.

**“Coupled reactive flow and transport modeling of CO<sub>2</sub> sequestration in the Mt. Simon sandstone formation, Midwest U.S.A.”**

The following is the Abstract of this article: “Multi-phase reactive flow and transport modeling is an effective tool for [MVA] of CO<sub>2</sub> sequestration in deep geological formations. In the current study, modeling is performed to simulate large scale CO<sub>2</sub> injection (a million tons per year for 100 years) into Mt. Simon sandstone, a major candidate saline reservoir in the Midwest of USA. The long term fate of CO<sub>2</sub> was simulated by extending the modeling period to 10,000 years. The results indicate that most of the injected CO<sub>2</sub> remains within a radius of 3300 m lateral distribution. Four major trapping mechanisms and their spatial and temporal variations are evaluated in [the authors’] simulations: hydrodynamic, solubility, residual, and mineral trapping. A strongly acidified zone (pH 3–5) forms in the areas affected by the injected CO<sub>2</sub> (0–3300 m), and consequently causes extensive mineral precipitation and dissolution. The predicted long-term fate of CO<sub>2</sub> is closely linked to the geochemical reactions conceptualized in the models. In [the authors’] model, the replenishing upstream water continues to dissolve CO<sub>2</sub> long after the injection, which results in total dissolution of hydrodynamically trapped CO<sub>2</sub> at the end of 10,000 years. In contrast, most previous models neglected the regional flow after injection and hence artificially limited the extent of geochemical reactions as if in a batch system. Consequently, a supercritical CO<sub>2</sub> plume (hydrodynamic trapping) would persist after 10,000 years. The continued supply of acidified water from interaction between replenishing water and CO<sub>2</sub> also results in extensive dissolution of feldspars and precipitation of secondary clay minerals, to a much more extent than what predicted in models without including regional flow. However, the prediction of complete dissolution of feldspars in 10,000 years can also result from the artifact that the linear rate laws are used in [the authors’] model (as

well as all previous work), which overestimates the rates of feldspar dissolution near equilibrium. Nevertheless, [the authors’] simulations indicate the prolonged existence of an acidic brine plume, which suggests long-term risk assessment should transfer from the primary risk of CO<sub>2</sub> leakage to secondary risk of acidic plume leakage after all CO<sub>2</sub> is dissolved.” **Faye Liu, Peng Lu, Chen Zhu, and Yitian Xiao,** *International Journal of Greenhouse Gas Control*, Available online September 23, 2010, doi:10.1016/j.ijggc.2010.08.008, <http://www.sciencedirect.com/science/article/B83WP-5132XXW-1/2/755c4975b7db2d5311e326a738f8c81f>. (Subscription may be required.)



## TERRESTRIAL

**“A comparison of carbon assessment methods for optimizing timber production and carbon sequestration in Scots pine stands.”**

The following is the Abstract of this article: “Projected changes in forest carbon stocks and carbon balance differ according to the choice of estimation methods and the carbon pools considered. Here, [the authors] compared three carbon assessment methods for optimizing timber production and carbon sequestration in six example Scots pine (*Pinus sylvestris* L.) stands in Finland. The forest carbon stock was assessed, with three methods: stem carbon, biomass expansion factors (BEFs), and a process-based model. Given a carbon price of [\$54] t<sup>-1</sup> and a [three percent] discount rate, the highest average carbon stock and mean annual increment (MAI) were obtained with the BEF method. Increasing the carbon price from [\$0 to \$272] t<sup>-1</sup> resulted in longer optimal rotations and higher MAI, and increased the average carbon stock, especially when carbon was assessed by the BEF method. Comparison of these carbon assessment methods, using economic sensitivity analyses, indicated that optimal thinning regimes and average carbon stocks are strongly dependent on the assessment method. The process-based method led to less frequent thinnings and shorter rotations than the BEF method, due to different predictions of biomass production. As a cost-effective option, optimal thinning regimes play a very important role in timber production and carbon sequestration.” **Tianjian Cao, Lauri Valsta, and Annikki Mäkelä,** *Forest Ecology and Management*, Available online September 21, 2010, doi:10.1016/j.foreco.2010.07.053, <http://www.sciencedirect.com/science/article/B6T6X-512KGJT-1/2/28768cd40eec9c7f6ebcd59bad67aa35>. (Subscription may be required.)

## TRADING

**“RGGI News Release, “RGGI States Issue Notice for March 2011 CO<sub>2</sub> Allowance Auction.”**

The 10 Northeast and Mid-Atlantic states participating in the Regional Greenhouse Gas Initiative (RGGI) released the Auction Notice and application materials for the first quarterly CO<sub>2</sub> allowance auction of 2011. A total of 41,995,813 CO<sub>2</sub> allowances

## TRADING (CONTINUED)

for the current control period (2009 to 2011) and 2,144,710 CO<sub>2</sub> allowances for the future control period (2012 to 2014) will be offered for sale in CO<sub>2</sub> Allowance Auction 11; states will use the reserve price of \$1.89 (the reserve price is adjusted at the beginning of each calendar year for the U.S. Department of Labor, Bureau of Labor Statistics Consumer Price Index). The released application materials provide potential auction participants with the information needed to submit a Qualification Application and indicate their intent to bid on the allowances. Since the debut of the RGGI auctions on September 25, 2008, more than 318 million CO<sub>2</sub> allowances have been auctioned by the states participating in nine total auctions. For more information on the application process, visit: [http://www.rggi.org/market/co2\\_auctions/information](http://www.rggi.org/market/co2_auctions/information). January 11, 2011, [http://www.rggi.org/docs/Auction\\_11\\_Notice\\_News\\_Release.pdf](http://www.rggi.org/docs/Auction_11_Notice_News_Release.pdf).

### “Deployment of CCS Technologies across the Load Curve for a Competitive Electricity Market as a Function of CO<sub>2</sub> Emissions Permit Prices.”

The following is the Abstract of this article: “Consistent with other published studies, the modelling presented here reveals that baseload power plants are the first aspects of the electricity sector to decarbonize and are essentially decarbonized once CO<sub>2</sub> permit prices exceed a certain threshold (\$90/ton CO<sub>2</sub> in this study). The decarbonization of baseload electricity is met by significant expansions of nuclear

power and renewable energy generation technologies as well as the application of CCS technologies applied to both coal and natural gas fired power plants. Relatively little attention has been paid thus far to whether intermediate and peaking units would respond the same way to a climate policy given the very different operational and economic context that these kinds of electricity generation units operate under. In this paper, the authors discuss key aspects of the load segmentation methodology used to imbed a varying electricity demand within the GCAM (a state-of-the-art Integrated Assessment Model) energy and economic modelling framework and present key results on the role CCS technologies could play in decarbonizing subpeak and peak generation (encompassing only the top 10 [percent] of the load) and under what conditions. To do this, the authors have modelled two hypothetical climate policies that require 50 [percent] and 80 [percent] reductions in U.S. emissions from business as usual by the middle of this century. Intermediate electricity generation is virtually decarbonized once carbon prices exceed approximately \$150/tonCO<sub>2</sub>. When CO<sub>2</sub> permit prices exceed \$160/ton CO<sub>2</sub>, natural gas power plants with CCS have roughly the same market share as conventional gas plants in serving subpeak loads. The penetration of CCS into peak load (upper [six percent] here) is minimal under the scenarios modeled here suggesting that CO<sub>2</sub> emissions from this aspect of the U.S. electricity sector would persist well into the future even with stringent CO<sub>2</sub> emission control policies in place.” **P Luckow, MA Wise, and JJ Dooley**. Presented at GHGT-10, held September 19-23, at RAI in Amsterdam, The Netherlands, <https://www4.eventsinteractive.com/iea/viewpdf.esp?id=270025&file=%5C%5DCDCFILE01%5CEP11%24%5CEventwin%5CPool%5Coffice27%5Cdocs%5Cpdf%5Cghgt10Final00515%2Epdf>.

## RECENT PUBLICATIONS

### “Site Screening, Site Selection, and Initial Characterization for Storage of CO<sub>2</sub> in Deep Geologic Formations.”

The following is from the Executive Summary of this document: “The contribution of [GHGs] to global warming continues to be a growing concern. One of the most common [GHGs] is CO<sub>2</sub>. A number of methods to lower CO<sub>2</sub> emissions are under investigation. One of the promising technologies for near- to medium-term CO<sub>2</sub> emissions reduction is geologic storage of CO<sub>2</sub> (CO<sub>2</sub> GS) in deep geologic formations. It is estimated that the storage potential for assessed U.S. and Canadian geologic formations is sufficient to store CO<sub>2</sub> equivalent in the amount that would be emitted to the atmosphere from large stationary sources in these two countries for several hundred years. The purpose of this document is to establish a framework and methodology for Site Screening, Site Selection, and Initial Characterization of CO<sub>2</sub> GS sites that: [(1)] Provide stakeholders with a compilation of best practices for Site Screening, Site Selection, and Initial Characterization; [(2)] Communicate the experience gained through RCSP Initiative through the Characterization and Validation Phases; [and (3)] Develop a consistent industry-standard framework, terminology, and set of guidelines for communicating project related storage resources and risk estimates associated with the project. The primary audience for this manual is future storage project developers, CO<sub>2</sub> producers, and transporters. It will also be of use in informing local, regional, state, and national governmental agencies regarding best practices in exploration for CO<sub>2</sub> GS sites. Furthermore, it will inform the general public on the rigorous analyses conducted for potential CO<sub>2</sub> GS sites.” To read the full BPM, visit: [http://www.netl.doe.gov/technologies/carbon\\_seq/refshelf/BPM-SiteScreening.pdf](http://www.netl.doe.gov/technologies/carbon_seq/refshelf/BPM-SiteScreening.pdf).

### “DOE/NETL Carbon Dioxide Capture and Storage RD&D Roadmap.”

The following is from the Overview of this document: “The combustion of fossil fuels for electricity generation plays an integral role in the energy security and global economic competitiveness of the United States. According to Energy Information Administration (EIA) estimates, fossil fuels accounted for approximately 71 percent of total U.S. electricity generation in 2008. However, fossil fuel combustion results in the emission of large quantities of CO<sub>2</sub> such that the U.S. power generation sector produced more than 40 percent of total U.S. anthropogenic CO<sub>2</sub> emissions in 2008. It now appears likely that Federal legislation and/or regulation could soon be enacted that would limit CO<sub>2</sub> emissions from the U.S. power generation sector in order to stabilize atmospheric concentrations of CO<sub>2</sub> and address concerns that anthropogenic emission of GHG, including CO<sub>2</sub>, is contributing to global climate change. While it is not clear what specific rules,

## RECENT PUBLICATIONS (CONTINUED)

regulations, or targets may be put in place, it is highly probable that emissions of CO<sub>2</sub> from these power plants will be targeted for reduction. The majority of current U.S. power generation sector CO<sub>2</sub> emissions result from the combustion of coal. According to EIA estimates, more than 1 billion tons of coal were consumed by the U.S. power generation sector in 2008 and accounted for almost 50 percent of total U.S. electricity generation. The resulting 1.9 billion metric tons of CO<sub>2</sub> emissions comprised more than 80 percent from the power generation sector and almost 34 percent of the 5.8 billion metric tons of total U.S. anthropogenic CO<sub>2</sub> emissions in 2008. Moreover, EIA estimates that almost 95 percent of the coal-based CO<sub>2</sub> emissions projected to be released from today through 2030 will originate from existing coal-based power plants. Therefore, both existing and new coal-based power plants would likely be targeted for reduction should Federal legislation and/or regulation be enacted to reduce CO<sub>2</sub> emissions from the power sector.” To view the 2010 CCS Roadmap, go to: [http://www.netl.doe.gov/technologies/carbon\\_seq/refshelf/CCSRoadmap.pdf](http://www.netl.doe.gov/technologies/carbon_seq/refshelf/CCSRoadmap.pdf).

### “Best Practices for Terrestrial Sequestration of Carbon Dioxide.”

The following is from the Introduction of this document: “Carbon (C) is an essential element for sustaining life. It can be found naturally in organic and inorganic forms with a small exchange rate between them. At about 18 percent (about 50 percent on a dry basis), the concentration of C in living matter is almost 100 times greater than the average concentration in the earth (0.19 percent). Thus, for life to continue, carbon must be recycled. This is accomplished primarily by photoautotrophs that use light energy from the sun to convert CO<sub>2</sub> in the atmosphere to organic matter by photosynthesis. This carbon is returned to the atmosphere as CO<sub>2</sub> by respiration, combustion, and decay. For thousands of years, this cycle remained in balance, and the CO<sub>2</sub> concentration in the atmosphere remained fairly constant. However, in the last 100 years or so, combustion of fossil fuels, deforestation, changes in tillage practices, and other factors have perturbed this balance, resulting in an increase in atmospheric CO<sub>2</sub>. There is growing concern that increasing levels of GHGs in the atmosphere, particularly CO<sub>2</sub>, are contributing to global climate change. Atmospheric levels of CO<sub>2</sub> have risen significantly from preindustrial levels of 280 parts per million (ppm) to present levels of 384 ppm. Evidence suggests that elevated atmospheric CO<sub>2</sub> concentrations are the result of a combination expanded use of fossil fuels for energy production and transportation, land use conversion (deforestation), and soil cultivation. Predictions of increased global fossil energy use imply a continued increase in carbon emissions and a corresponding rise in the CO<sub>2</sub> level in the atmosphere unless a major change is made in the way energy is produced and used – in particular, how carbon is managed.” The full BPM is available at: [http://www.netl.doe.gov/technologies/carbon\\_seq/refshelf/BPM\\_Terrestrial.pdf](http://www.netl.doe.gov/technologies/carbon_seq/refshelf/BPM_Terrestrial.pdf).

### “CO<sub>2</sub> Storage – Is it safe? Towards large-scale implementation of CCS.”

The following is from the Summary of this document: “[Carbon dioxide] geologic storage (CGS) technology is by no means fail-proof or risk-free, but carefully selected and qualified storage sites that are operated according to effective regulatory supervision should be safe. The key will be to apply fit-for-purpose risk management throughout the lifecycle of the storage sites, starting from screening, and continuing through site selection, qualification, injection operations, and, finally, closure. CGS is a mature technology that has been used at industrial scale at several large sites both onshore and offshore. CGS technology can be applied immediately, at a much larger scale, at tens to hundreds of sites globally. The main evidence for this is empirical, collected through relevant analogue subsurface industrial experiences and at large-scale demonstrations of CGS at several sites. This includes almost 100 years of natural gas storage at hundreds of sites in North America and Europe, 35+ years of experience with CO<sub>2</sub> enhanced oil recovery (EOR) in North America, 15+ years experience with acid gas (mixtures of [hydrogen sulfide (H<sub>2</sub>S)] and CO<sub>2</sub>) injection in western Canada, and 14+ years experience at dedicated CGS projects in the North Sea and Algeria. Moreover, there are currently a handful of research-focused pilot CGS projects on [five] continents. The current state of CO<sub>2</sub> injection technology can best be summarized by the conclusions reached by the Massachusetts Institute of Technology in their Environmental Assessment of Geological Storage of CO<sub>2</sub>, namely that: *‘The technologies and practices associated with geological CO<sub>2</sub> storage are all in current commercial operation, and have been so for a decade to several decades... No major “breakthrough” technological innovations appear to be required for large scale CO<sub>2</sub> transportation and storage.’*” To view this document, click: [http://www.dnv.com/binaries/Position%20paper%20-%20Is%20CO2%20storage%20safe\\_tcm4-442340.pdf](http://www.dnv.com/binaries/Position%20paper%20-%20Is%20CO2%20storage%20safe_tcm4-442340.pdf).

## LEGISLATIVE ACTIVITY

### *New York Times*, “Massachusetts Sets Targets to Slash Carbon Emissions.”

Massachusetts officials have announced a plan that will reduce statewide GHG emissions by 25 percent below 1990 levels in the next 10 years. The emissions targets are the highest allowed under Massachusetts state

climate legislation and are believed to be the most stringent in the Nation. The plan, which will rely on existing programs to reach the reduced levels – such as renewable-energy mandates, energy-efficiency standards, and efforts in the electricity sector that are already in place under RGGI – is expected to result in a net increase in jobs across the state. Massachusetts is one of 10 states participating in RGGI, a cap-and-trade system for electric utilities. December 29, 2010, [http://www.nytimes.com/2010/12/30/science/earth/30climate.html?\\_r=2](http://www.nytimes.com/2010/12/30/science/earth/30climate.html?_r=2).





## EVENTS

February 17-18, 2011, **5<sup>th</sup> Annual European Carbon Capture and Storage**, *Grange St. Paul's Hotel, London, United Kingdom*. Sponsored by Platts, this conference provides an overview of the European CCS industry and its development. Topics to be discussed include the latest in policy developments; deployment challenges, such as finance, public awareness, and storage liability; and project case studies. For the full agenda, visit: <http://www.platts.com/ConferenceDetail/2011/pc165/index>.

February 21-24, 2011, **Coal Power Generation 2011**, *Mandarin Orchard, Singapore*. This two-day event focuses on the building of coal-fired power plants in Asia. Among the topics to be discussed are the commercial competitiveness of CCS, costs and risks of CCS, and how CCS can make coal power generation more socially acceptable. For more information, visit the conference website at: <http://www.coalpowergeneration.com/>.

February 23-24, 2011, **Carbon Management for Oil and Gas**, *Prince Hotel and Residence, Kuala Lumpur, Malaysia*. This summit brings together carbon experts to share their experiences in implementing successful CCS and EOR technologies. Effective methods of CO<sub>2</sub> transportation will be examined, as will geologic storage options in Southeast Asia. Other key topics to be covered include the economics, legal issues, and public perceptions of CCS. For more information, visit: <http://summit-carbonmanagement.com/Event.aspx?id=394956>.

March 1-3, 2011, **Carbon Market Insights 2011**, *Amsterdam RAI, Amsterdam, The Netherlands*. This conference will focus on international negotiations and domestic legislation in the carbon market. The program will also focus on the trading and market dynamics of carbon as an emerging commodity. To view the conference website, which includes a downloadable program, click: <http://www.pointcarbon.com/events/conferences/cmi2011/>.

April 4-8, 2011, **Greenhouse 2011**, *Cairns Convention Centre, Queensland, Australia*. Attendees of this conference will be presented with the latest information in climate change science from scientists and industry representatives. The program also covers topics such as climate modeling, climate change projections, and policy and economics. For a detailed program, visit the conference website at: <http://www.greenhouse2011.com/page.aspx>.

April 12, 2011, **Carbon Capture and Storage Business Forum**, *Calgary TELUS Convention Centre, Calgary, Alberta, Canada*. This one-day conference examines the latest developments and solutions to CCS deployment challenges by examining the latest business developments and leading edge technology updates from those active in current CCS projects. Visit the conference website, which includes a downloadable agenda, at: <http://www.conferenceboard.ca/conf/11-0073/default.aspx>.

April 12-14, 2011, **Energy Efficiency Global Forum**, *SQUARE Brussels Meeting Centre, Brussels, Belgium*. This three-day conference brings together members of the worldwide energy efficiency community to discuss the clean-energy economy. In its fourth year, the Energy Efficiency Global Forum (EE Global) also includes technology sessions focused on global energy policy, technology, and delivery. For more information, go to: <http://eeglobalforum.org/index.html>.

April 13-15, 2011, **3<sup>rd</sup> Annual China Clean Coal Summit 2011**, *Qingdao, Shandong, China*. In addition to providing updates in China's clean coal technology, coal-to-liquids (CTLs), CCS, and future integrated gasification combined cycle (IGCC) technology, this summit will offer case studies, future project information, site tours, and an international forum to help progress towards a successful and cleaner future. For more information, click: <http://chinacleancoalsummit.com/index.asp>.

May 2-5, 2011, **10<sup>th</sup> 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)

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](http://www.gcgw.org/gcgw11/documents/poster_GCGW11.pdf).

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