NETL the ENERGY lab

Carbon Storage CSN Newsletter

November 2014

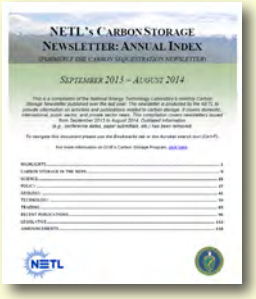
What's Inside?

Highlights

"NETL Collaborations Advance Carbon Management Strategies."

The Carbon Capture Simulation Initiative (CCSI) and the National Risk Assessment Partnership (NRAP) are using predictive computational modeling to help the U.S. Department of Energy (DOE) meet its goal of having carbon capture and storage (CCS) technologies ready for demonstration in the 2020 to 2025 timeframe. Meeting this goal requires the development of new approaches to reduce the 20 to 30 years typically required for commercial deployment of new technology concepts. Led by the Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL), the two collaborative efforts use computational modeling, which involves developing mathematical equations and computer code to simulate the real-life behavior of engineered and natural systems. The use of these models allows for more efficient, timely, and cost-effective technology development and deployment. For more information, visit DOE's national lab webpage. From *NETL News Release* on August 27, 2014.

Announcements



Carbon Storage Newsletter Annual Index 2014 Available.

This document is a compilation of NETL's Carbon Storage Newsletter published over the September 2013 to August 2014 timeframe. Outdated information (e.g., conference dates, paper submittals) has been removed.

Call for Papers: 2015 CCUS Conference: Abstracts Now Being Accepted.

The Call for Papers for the 14th Annual Conference on Carbon Capture, Utilization, and Storage has been released, and abstracts are being accepted through January 23, 2015. The theme of this year's conference, scheduled for April 28 through May 1, 2015, in Pittsburgh, Pennsylvania, USA, is "Advancing CO_2 Emission Reduction Systems to Achieve Global Reduction Goals, Meet Electricity Needs, and Utilize Domestic Resources."

CSU Launches Degree in GHG Management and Accounting.

Colorado State University (CSU) launched a new Master's of Greenhouse Gas Management and Accounting (MGMA) degree that combines environmental knowledge with quantitative and technical skills. The MGMA program is offered by CSU's Department of Ecosystem Science and Sustainability and enables students from a wide variety of backgrounds, such

Announcements (Continued)

as environmental studies, business, engineering, and agriculture, to develop skills needed for greenhouse gas (GHG) management and accounting. The MGMA program will start in Fall 2015 and applications are being accepted through February 2015.

University of Strathclyde Joins SCCS Partnership.

Scientists from the University of Strathclyde have joined the Scottish Carbon Capture & Storage (SCCS) partnership, which includes the British Geological Survey, Heriot-Watt University, the University of Aberdeen, and the University of Edinburgh. The University of Strathclyde offers expertise in areas such as CO_2 transport and environmental impact analysis.

PSE Releases gCCS – Whole Cain CCS Systems Modeling.

The "gCCS" is a system modeling tool for design and operating decisions across the CCS chain. The system contains steady-state and dynamic models of all major CCS operations, from power generation through capture, compression, transmission, and injection. Details on model application, major features, and scope are available via the link.

Texas A&M Establishes New CO_2-EOR Center.

The Chaparral-Fischer CO_2 Enhanced Oil Recovery (EOR) Center will be used to study and improve the use of CO_2-EOR in both conventional and unconventional reservoirs. Researchers will investigate the potential to increase oil recovery and identify the recovery mechanisms and their impact in unconventional reservoirs. In conventional reservoirs, researchers will focus on understanding sweep efficiency issues related to CO_2 flooding in heterogeneous and fractured rocks, in addition to studying continuous CO_2 injection, water-alternating-gas (WAG), chemically aided WAG, direct CO_2 thickening, and the use of nanoparticles.

Knowledge Pipeline Webinar Series.

The Center for Petroleum and Geosystems Engineering (CPGE) at the University of Texas at Austin is offering a series of webinars to share perspectives from a variety of scientists, engineers, and technologists who are researching economical energy resources and environmental impact.

Carbon Storage in the News

"Wood Group Kenny Awarded Subsea Pipeline FEED Contract for Carbon Capture and Storage Project."

Wood Group Kenny was awarded a contract for the front end engineering design (FEED) of the subsea and pipeline element of the Peterhead CCS project in Aberdeenshire, Scotland, United Kingdom (UK). A total of 80 engineers will support the project from Wood Group Kenny offices in Aberdeen and London. The contract includes developing a landfall solution at the Peterhead Power Station; design of a CO_2 pipeline from Peterhead Power Station to a subsea tie-in with the existing Goldeneye pipeline; and a new subsea intervention valve, including controls system and tie-in spools. The project is being developed by Shell, with support from Scottish and Southern Energy. The Peterhead CCS project is part of the UK's CCS roadmap. From *OilVoice* on October 16, 2014.

"UAE's Carbon Capture Project to Remove 800,000 [Metric Tons] of Carbon Dioxide per Year."

A CCS project in the iron and steel sector in Abu Dhabi will capture 800,000 [metric tons] of CO_2 emissions annually. The project will start capturing CO_2 and injecting it into oil fields for EOR in 2016. The joint venture between Abu Dhabi National Oil Company (Adnoc) and Masdar will capture CO_2 at Emirates Steel, one of United Arab Emirates' (UAE) largest steelmaking facilities. The Global CCS Institute (GCCSI) published the information in its "Global Status of CCS: 2014" report, which found that there are currently 22 carbon capture projects in construction or operation worldwide. The report highlights nine CCS projects currently under construction, with eight expected to be operational by 2016. The report also states that there are 14 CCS projects in the advanced planning stage, including nine in the power sector. A summary of the "Global Status of CCS: 2014" report is available in the "Recent Publications" section of this newsletter. From *gulfnews.com* on November 7, 2014.

"Skyonic Opens World's First Commercial-Scale Carbon Capture and Utilization Facility."

Skyonic Corporation opened Capitol SkyMine, a commercial-scale carbon capture and utilization facility at Capitol Aggregates' existing cement plant in San Antonio, Texas, USA. According to officials, the Capitol SkyMine will have a total carbon impact of 300,000 tons annually by capturing CO_2 and transforming it into functional products, like baking soda, bleach, and hydrochloric acid, through the use of Skyonic's SkyMine® technology. The process allows industrial facilities or fossil-fuel-fired power plants to capture up to 90 percent of CO_2 emissions from flue gas and transform them into solid products that can be sold. From *Skyonic Press Release* on October 20, 2014.

Science

"Climate Change Alters Cast of Winter Birds."

According to biologists from the University of Wisconsin-Madison, wintering bird species that were once rare in the American Northeast have become more common. The research, which was published in the journal "Global Change Biology," used more than two decades of data on 38 species of birds. The data showed that birds typically found in more southerly regions are pushing north and changing the communities of birds that spend their winters in northern latitudes. The researchers found that the shifts in the mix of overwintering bird species is occurring in areas of milder winters with less snow, more variable and strong precipitation events, and a shorter snow season. From *Science Daily* on October 17, 2014.

"Fish Moving Poleward at Rate of 26 Kilometers [~16.2 Miles] per Decade."

According to a University of British Columbia study examining the impacts of potential climate change on fish stocks, large numbers of fish could disappear from the tropics by 2050 as changing temperatures may drive them into Arctic and Antarctic waters. The study, which appears in the "ICES Journal of Marine Science," used modeling to predict how 802 commercially important species of fish and invertebrates react to warming water temperatures, other changing ocean properties, and new habitats opening up at the poles. Using an Intergovernmental Panel on Climate Change (IPCC) scenario that has the Earth's oceans warming by 3°C by 2100, the researchers found that fish could potentially move away from their current habitats at a rate of approximately 16 miles per decade. Under another IPCC scenario that has the Earth's oceans warming by 1°C by 2100, the fish would move approximately 9 miles per decade. From *Science Daily* on October 10, 2014.

"Penguins Use Their Personalities to Prepare for Climate Change."

A researcher from the Institute of Veterinary, Animal, and Biomedical Sciences at Massey University in New Zealand suggests a bird's individual personality may be a factor in improving its chances of coping with environmental stressors. Studying the differences in the level of a stress hormone called corticosterone that native little penguins secreted when exposed to stressful stimulus, the study found a variation in corticosterone responses, which was determined by personality. The study found that "[b]irds with low corticosterone responses and proactive personalities are likely to be more successful (have greater fitness) in constant or predictable conditions, while birds with reactive personalities and high corticosterone responses will be more successful in changing or unpredictable conditions." From *Science Daily* on October 8, 2014.

Policy

"U.S.-China Joint Announcement on Climate Change."

The United States of America and the People's Republic of China announced bilateral cooperation on climate change and will collaborate with other countries to adopt a protocol, another legal instrument, or an agreed outcome at the United Nations (UN) Climate Conference in Paris, France, in 2015. Under the agreement, the United States would cut its 2005 level of carbon emissions by 26 to 28 percent before the year 2025. China would peak its carbon emissions by 2030 and will also aim to increase the share of non-fossil fuels in primary energy consumption to approximately 20 percent by 2030. Both sides intend to work toward higher targets over time. The United States and China believe that technological innovation is essential for reducing the cost of current mitigation technologies. Energy technology cooperation between the two nations is shown from past efforts, such as establishing the U.S.-China Climate Change Working Group (CCWG), agreeing to work together towards the global phase down of hydrofluorocarbons (HFCs), creating the U.S.-China Clean Energy Research Center (CERC), and agreeing on a joint peer review of inefficient fossil fuel subsidies under the G-20. Finally, the United States and China announced additional measures to strengthen and expand their cooperation by using the existing entities such as the CCWG, the CERC, and the U.S.-China Strategic and Economic Dialogue. The measures include expanding joint clean energy research and development (R&D); advancing major carbon capture, utilization, and storage demonstrations; enhancing cooperation on HFCs; launching a climate-smart/low-carbon cities initiative; promoting trade in green goods; and demonstrating clean energy. From *White House Press Release* on November 11, 2014.

"EU Strikes Compromise to Set New Climate Target" and **"European Leaders Agree on Targets to Fight Climate Change."**

European Union (EU) leaders agreed to a new overall target to reduce EU CO_2 emissions in 2030 by at least 40 percent from levels in the benchmark year of 1990. The EU has nearly achieved an existing goal of a 20 percent cut by 2020. The agreement makes the EU the first global emitter to reach agreement ahead of a UN climate summit scheduled for December 2015 in Paris, France. According to officials, the EU pledge to cut emissions by 40 percent would eventually require legally binding targets for each of the EU's member countries to meet the target in a reasonable manner. From *Reuters* on October 23, 2014, and from *New York Times* on October 23, 2014.

"Siting Is a Constraint to Realize Environmental Benefits from Carbon Capture and Storage."

The following is the Abstract of this article: "CCS for coal power plants reduces onsite [CO_2] emissions, but affects other air emissions on and offsite. This research assesses the net societal benefits and costs of Monoethanolamine (MEA) CCS, valuing changes in emissions of CO_2, [sulfur dioxide (SO_2), nitrogen oxide (NO_X), ammonia (NH_3)] and particulate matter (PM), including those in the supply chain. Geographical variability and stochastic uncertainty for 407 coal power plant locations in the U.S. are analyzed. The results show that the net environmental benefits and costs of MEA CCS depend critically on location.

Policy (Continued)

For a few favorable sites of both power plant and upstream processes, CCS realizes a net benefit (benefit–cost ratio >1) if the social cost of carbon exceeds $51/ton. For much of the U.S. however, the social cost of carbon must be much higher to realize net benefits from CCS, up to a maximum of $910/ton. While the social costs of carbon are uncertain, typical estimates are in the range of $32-220 per ton, much lower than the breakeven value for many potential CCS locations. Increased impacts upstream from the power plant can dramatically change the social acceptability of CCS and needs further consideration and analysis." **Ashok Sekar, Eric Williams, and Mikhail Chester**, *Environ. Sci. Technol*. (Subscription may be required.)

"Communication science and technology while engaging the public at the Illinois Basin – Decatur Project."

The following is the Abstract of this article: "The Midwest Geological Sequestration Consortium communication initiative at the Illinois Basin – Decatur Project (IBDP) draws on multiple CCS best practices, guidelines, and international project experiences to be both proactive and responsive toward the engagement of multiple stakeholders. The IBDP communications strategy was developed early in the project to actively reduce associated risks by creating and implementing a communication plan, training communicators, and providing a structure for the communications team. Formalized approaches to knowledge sharing and capacity building have generated additional opportunities to further outreach and impact from IBDP experiences. The initial challenge for the communications team was to provide easy-to-understand, scientifically accurate, and consistent information for stakeholders to carry throughout the project. Consistent, factual information was developed and incorporated into project planning, and provides the basis of public communications through the alignment of goals across communications, risk mitigation, and project management. The refinement of the communication strategy and plan is ongoing due to the changing communication needs that are encountered throughout the lifetime of the project." **Sallie E. Greenberg and Lori M. Gauvreau**, *Greenhouse Gases: Science and Technology*. (Subscription may be required.)

Geology

"CO_2 geological storage: hydro-chemo-mechanical analyses and implications."

The following is the Abstract of this article: "The injectivity of CO_2 and the integrity of the reservoir-caprock system are affected by CO_2 invasion, water-CO_2-mineral reactions, and ensuing mineral dissolution and precipitation. [The authors] identify different zones around an injection well and investigate the effects of these hydro-chemo-mechanical interactions. Geochemical analyses combine a comprehensive mass balance formulation with chemical calculations using published equations and PHREEQC. This analysis framework is used to assess near-well, pool, and far-field conditions, and to determine species concentrations, pH, changes in brine density, and changes in mineral and fluid volume in the reservoir. Results show that the brine density may increase by as much as 1.2 [percent] and can sustain convective flow of CO_2 dissolved brine; the characteristic time scale for convection can be as short as a few years in some permeable formations currently being considered for storage. The precipitation of secondary minerals near the injection well increases the mineral volume by a maximum of [five percent], yet, only a minor decrease in CO_2 permeability is anticipated. Dissolution may result in unsupported caprock (the span should not exceed 20 [percent] of the caprock thickness to prevent failure), and may cause compaction-driven shear failure of the reservoir. Finally, the analysis of lateral capillary trapping shows that the CO_2 pool is only a few meters thick in leveled caprock interfaces and in the absence of geometric traps." **Seunghee Kim and J. Carlos Santamarina**, *Greenhouse Gases: Science and Technology*. (Subscription may be required.)

"Transport of Organic Contaminants Mobilized from Coal through Sandstone Overlying a Geological Sequestration Reservoir."

The following is the Abstract of this article: "Column experiments were conducted using a wetted sandstone rock installed in a tri-axial core holder to study the flow and transport of organic compounds mobilized by $scCO_2$ under simulated geologic carbon storage (GCS) conditions. The sandstone rock was collected from a formation overlying a deep saline reservoir at a GCS demonstration site. Rock core effluent pressures were set at 0, 500, or 1000 [pounds per square inch (psig)] and the core temperature was set at 20 or 50°C to simulate the transport to different subsurface depths. The concentrations of the organic compounds in the column effluent and their distribution within the sandstone core were monitored. Results indicate that the mobility though the core sample was much higher for [benzene, toluene, ethylbenzene, and xylenes (BTEX)] compounds than for naphthalene. Retention of organic compounds from the vapor phase to the core appeared to be primarily controlled by partitioning from the vapor phase to the aqueous phase. Adsorption to the surfaces of the wetted sandstone was also significant for naphthalene. Reduced temperature and elevated pressure resulted in greater partitioning of the mobilized organic contaminants into the water phase." **Zhong L, KJ Cantrell, DH Bacon, and JL Shewell**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

"Mineral Carbonation of Red Gypsum for CO_2 Sequestration."

The following is the Abstract of this article: "Reduction of CO_2 emissions into the atmosphere is a key challenge to mitigate the anthropogenic greenhouse effect. [Carbon dioxide] emissions cause lots of problems for the health of humans and increase [climate change], in which CO_2 uptake decreases these environmental issues. The mineral carbonation process is an alternative method during which industrial wastes rich in calcium (Ca) or magnesium (Mg) react with CO_2 to form a stable carbonate mineral. In this research, the feasibility of CO_2 mineral carbonation by the use of red gypsum, as a Ca-rich source, was evaluated using an autoclave mini reactor. Wide-range conditions of procedure variables, such as reaction temperature, reaction time, CO_2 pressure, and liquid/solid ratio, on the rate of mineral carbonation were studied. The results showed that the maximum conversion of Ca (98.8 [percent]) is obtained at the condition that has an optimum amount of these variables. Moreover, the results confirmed that red gypsum has high

Geology (Continued)

potential to form calcium carbonate ($CaCO_3$) during the process of CO_2 mineral carbonation. It was concluded that the mineral carbonation process using red gypsum can be considered to be an interesting, applicable, and low-cost method in industry to mitigate a considerable amount of CO_2 from the atmosphere, which is the main issue in the current and coming years." **Omeid Rahmani, Radzuan Junin, Mark Tyrer, and Rahmat Mohsin**, *Energy Fuels*. (Subscription may be required.)

Technology

"Conceptual Process Design of CO_2 Recovery Plants for Enhanced Oil Recovery Applications."

The following is the Abstract of this article: "Processes for recovering CO_2 from CO_2-rich gas are important in the CO_2 EOR field. From an environmental point of view EOR through the injection of CO_2 is very beneficial because it allows for the storage of part of the CO_2 injected while increasing oil recovery. To make this process even more environmentally friendly, the fraction of CO_2 which exits (is produced from) the oil well can be captured and recycled for reinjection giving a more efficient CO_2 storage strategy. The mixture of gases produced from an oil well contains light hydrocarbons, heavy hydrocarbons, water, and CO_2. Dehydration units and numerous other separation units for separating CO_2 and hydrocarbons can be used to recover CO_2, so various potential configurations should be investigated to find the one which is most appropriate. In this study, the TEG (triethylene glycol) and adsorption dehydration processes are used for gas dehydration and a combination of amine, Selexol and distillation processes are used for CO_2 separation. Unisim is used to simulate the processes and they are evaluated economically in terms of plant installation costs and energy consumption. A case study is presented to demonstrate the feasibility of various design configurations." **Dong-Hun Kwak, Donghyun Yun, Michael Binns, Yeong-Koo Yeo, and Jin-Kuk Kim**, *Ind. Eng. Chem. Res*. (Subscription may be required.)

"In Situ ^{13}C and ^{23}Na Magic Angle Spinning NMR Investigation of Supercritical CO_2 Incorporation in Smectite-Natural Organic Matter Composites."

The following is the Abstract of this article: "This paper presents an in situ NMR study of clay-natural organic polymer systems (a hectoritehumic acid [HA] composite) under CO_2 storage reservoir conditions (90 bars CO_2 pressure, 50°C). The ^{13}C and ^{23}Na NMR data show that supercritical CO_2 interacts more strongly with the composite than with the base clay and does not react to form other C-containing species over several days at elevated CO_2. With and without organic matter, the data suggest that CO_2 enters the interlayer space of Na-hectorite equilibrated at 43 [percent] relative humidity. The presence of supercritical CO_2 also leads to increased ^{23}Na signal intensity, reduced line width at half height, increased basal width, more rapid ^{23}Na T_1 relaxation rates, and a shift to more positive resonance frequencies. Larger changes are observed for the hectorite-HA composite than for the base clay. In light of recently reported MD simulations of other polymer-Na-smectite composites, [the authors] interpret the observed changes as an increase in the rate of Na^+ site hopping in the presence of supercritical CO_2, the presence of potential new Na^+ sorption sites when the humic acid is present, and perhaps an accompanying increase in the number of Na^+ ions actively involved in site hopping. The results suggest that the presence of organic material either in clay interlayers or on external particle surfaces can significantly affect the behavior of supercritical CO_2 and the mobility of metal ions in reservoir rocks." **Bowers GM, DW Hoyt, SD Burton, BO Ferguson, T Varga, and RJ Kirkpatrick**, *Journal of Physical Chemistry*. (Subscription may be required.)

"CO_2 Deserts: Implications of Existing CO_2 Supply Limitations for Carbon Management."

The following is the Abstract of this article: "Efforts to mitigate the impacts of climate change will require deep reductions in anthropogenic CO_2 emissions on the scale of Gigatons per year. [Carbon dioxide] capture and utilization and/or storage technologies are a class of approaches that can substantially reduce CO_2 emissions. Even though examples of this approach, such as CO_2-EOR, are already being practiced on a scale >0.05 Gt/year, little attention has been focused on the supply of CO_2 for these projects. Here, facility-scale data newly collected by the U.S. Environmental Protection Agency was processed to produce the first comprehensive map of CO_2 sources from industrial sectors currently supplying CO_2 in the United States. Collectively these sources produce 0.16 Gt/year, but the data reveal the presence of large areas without access to CO_2 at an industrially relevant scale (>25 kt/year). Even though some facilities with the capability to capture CO_2 are not doing so and in some regions pipeline networks are being built to link CO_2 sources and [storage formations], much of the country exists in 'CO_2 deserts'. A life cycle analysis of the sources reveals that the predominant source of CO_2, dedicated wells, has the largest carbon footprint further confounding prospects for rational carbon management strategies." **Richard S. Middleton, Andres F. Clarens, Xiaowei Liu, Jeffrey M. Bielicki, and Jonathan S. Levine**, *Environ. Sci. Technol*. (Subscription may be required.)

"Exploring the effects of data quality, data worth, and redundancy of CO_2 gas pressure and saturation data on reservoir characterization through PEST Inversion."

The following is the Abstract of this article: "This study examined the impacts of reservoir properties on CO_2 migration after subsurface injection and evaluated the possibility of characterizing reservoir properties using CO_2 monitoring data such as saturation distribution. The injection reservoir was assumed to be located 1,400-1,500 m below the ground surface such that CO_2 remained in the supercritical state. The reservoir was assumed to contain layers with alternating conductive and resistive properties, which is analogous to actual geological formations such as the Mount Simon Sandstone unit. The CO_2 injection simulation used a cylindrical grid setting in which the injection well was situated at the center of the domain, which extended up to 8,000 m from the injection well. The CO_2 migration was simulated using the [Pacific Northwest National Laboratory (PNNL)]-developed simulator STOMP-CO_2e (the water-salt-CO_2 module). [The authors] adopted a nonlinear parameter estimation and

Technology (Continued)

optimization modeling software package, PEST, for automated reservoir parameter estimation. [The authors] explored the effects of data quality, data worth, and data redundancy on the detectability of reservoir parameters using CO_2 saturation monitoring data, by comparing PEST inversion results using data with different levels of noises, various numbers of monitoring wells and locations, and different data collection spacing and temporal sampling intervals. This study yielded insight into the use of CO_2 saturation monitoring data for reservoir characterization and how to design the monitoring system to optimize data worth and reduce data redundancy." **Z Fang, Z Hou, G Lin, DW Engel, Y Fang, and PW Eslinger**, *Environmental Earth Sciences*. (Subscription may be required.)

Terrestrial

"Laboratory Investigations of Weathering of Soils from Mammoth Mountain, CA, a Naturally CO_2-Impacted Field Site."

The following is the Abstract of this article: "The potential impacts of CO_2 [release] from a natural subsurface reservoir on soil and water quality were studied. Field measurements of soil pore CO_2 concentrations and visual inspection of plants at Mammoth Mountain, CA, allowed the demarcation of tree-kill and non-tree-kill zones, with CO_2 concentrations >100,000 ppm and ~1,000 ppm, respectively. Soils collected from six sites along a transect stretching from the center of the tree-kill zone to an equidistant point into the non-tree-kill zone were analyzed for surface area and organic carbon content. Batch and column leaching tests were conducted to determine the extent of weathering induced by the presence of CO_2 in the aqueous solution. Soils deep into the tree-kill area exhibited significantly higher surface areas (10.67 m^2/g vs 2.53 m^2/g) and lower organic carbon content (9,550 mg/kg vs 35,550 mg/kg). Batch results indicated that lower pH values (~2) released higher concentrations of Mg, Si, Fe, and As, while, for soils in the tree-kill zone, longer-term batch results indicated higher releases at the higher pH of 5.5. Column experiments were used to compare the effects of pH adjusted using HCl vs CO_2. For pore volumes (PV) < 100, CO_2 enhanced trace element release. For 100 < PV < 10,000 concentrations of elements in the two systems were equivalent and steady. At PV > 10,000, after a drop in pH in the CO_2 system, larger amounts of Fe and As were released, suggesting a CO_2-induced dissolution of Fe-silicates/clays and/or reductive dissolution of Fe^{3+} that releases Fe-bound arsenic. The specific role of pore water-dissolved CO_2 on the release of trace elements is hitherto unknown. However, interactions of pore-water CO_2 and the minerals in the Mammoth Mountain soils can cause the release of environmental pollutants." **Helen Sanchez, Gustavo Menezes, Andre Ellis, Claudia Espinosa-Villegas, and Crist Khachikian**, *Environ. Sci. Technol*. (Subscription may be required.)

Trading

"Columbia to Launch Voluntary Carbon Credit Trading."

Fundacion Natura, a Columbian environmental charity, announced it will launch a carbon trading platform in 2015 to companies seeking to offset carbon emissions. The platform is being developed by the Bolsa Mercantil de Colombia (BMC), a commodities exchange used by physical producers and consumers of farm produce. Columbia does not currently have any legally binding GHG emission limits. From *Reuters* on October 31, 2013.

"On the empirical content of carbon leakage criteria in the EU Emissions Trading Scheme."

The following is the Abstract of this article: "The EU Emissions Trading Scheme continues to exempt industries deemed at risk of carbon [release] from permit auctions. Carbon [release] risk is established based on the carbon intensity and trade exposure of each [four]-digit industry. Using a novel measure of carbon [release] risk obtained in interviews with almost 400 managers at regulated firms in six countries, [the authors] show that carbon intensity is strongly correlated with [release] risk whereas overall trade exposure is not. In spite of this, most exemptions from auctioning are granted to industries with high trade exposure to developed and less developed countries. [The authors'] analysis suggests two ways of tightening the exemption criteria without increasing relocation risk among non-exempt industries. The first one is to exempt trade exposed industries only if they are also carbon intensive. The second one is to consider exposure to trade only with less developed countries. By modifying the carbon [release] criteria along these lines, European governments could raise additional revenue from permit auctions of up to €3 billion per year [approximately $3.73 billion], based on a permit price of €30 [approximately $37]." **Ralf Martin, Mirabelle Muûls, Laure B. de Preux, and Ulrich J. Wagner**, *Ecological Economics*. (Subscription may be required.)

"Endogenous market power in an emissions trading scheme with auctioning."

The following is the Abstract of this article: "This paper contributes to the literature on market power in emissions permits markets, modeling an emissions trading scheme in which [emitters] differ with respect to their marginal abatement costs at the business-as-usual emissions. The [emitters] play a two-stage static complete information game in which their market power arises endogenously from their characteristics. In the first stage all [emitters] bid in an auction for the distribution of the fixed supply of permits issued by the regulator, and in the second stage they trade these permits in a secondary market. For compliance, they can also engage in abatement activity at a quadratic cost. Under the assumptions of the model, in equilibrium all [emitters] are successful in the auction. In the secondary market the low-cost emitters are net sellers and the high-cost emitters are net buyers. Moreover, the high-cost emitters are worse off as a result of the strategic behavior. In addition, the secondary market price is unambiguously above the auction clearing price. [The author finds] that the aggregate compliance cost when [emitters] act strategically increases in the heterogeneity of their marginal abatement costs at the business-as-usual emissions, but there

Trading (Continued)

exists a threshold of the fixed supply of permits above which strategic behavior is compliance cost-saving for the [emitters]. Finally, for a low enough variance of the marginal abatement cost at the business-as-usual emissions, strategic behavior is compliance cost-saving for the [emitters], regardless of the level of the available supply of permits." **Corina Haita**, *Resource and Energy Economics*. (Subscription may be required.)

"An emissions trading scheme design for power industries facing price regulation."

The following is the Abstract of this article: "The electricity market, monopolistic in nature, with government price regulation, poses a serious challenge for policy makers with respect to the cost-effectiveness of emissions trading, particularly in Asian countries. This paper argues that a cap-and-trade regulatory system for indirect emissions combined with a rate-based allocation system for direct emissions can achieve market efficiency even in the presence of price and quantity controls in the electricity market. This particular policy mix could provide appropriate incentives for industries to reduce their electricity consumption while inducing power producers to reduce their direct carbon emissions cost-effectively in conditions where there is strict government control of electricity prices. Another advantage of the suggested policy mix is that it allows carbon [release] in cross-border power trades to be effectively eliminated." **Yong-Gun Kim and Jong-Soo Lim**, *Energy Policy*. (Subscription may be required.)

Recent Publications

"Acid Gas Interactions with Pozzolan-Amended Wellbore Cement Under Geologic Storage Conditions."

The following is from the Research Objectives section of this National Risk Assessment Partnership (NRAP) report: "The overall goal of the research was to improve the understanding of the permeability change in pozzolan-amended wellbore cement induced by CO_2 and H_2S attack under co-storage conditions and to develop a model to predict these changes over the lifetime of a typical geologic carbon storage site. Information about the permeability change of pozzolan-amended wellbore cement under geologic carbon storage conditions can be incorporated into integrated risk assessment models. Pozzolan-amended wellbore cement was chosen for this study, because pozzolan amended Portland cement is one of the most common types of cement systems used for well sealing in oil and gas fields. Among the many types of available pozzolanic materials, type F fly ash, the most common pozzolan used in well cement (minimum 70 wt% of SiO_2, Al_2O_3 and Fe_2O_3 and maximum 20 wt% of CaO), was chosen as the pozzolanic material used in Kutchko et al. The overall goal was achieved by addressing the following three objectives: (1) understand the response of pozzolan-amended wellbore cement to CO_2 and H_2S attack; (2) quantify CO_2 and H_2S alteration rates of pozzolan-amended cement with different pozzolan contents; and (3) develop a process-based, reactive transport model capable of describing the interactions of a CO_2-H_2S-brine mixture with pozzolan-amended wellbore cement and predicting changes in effective permeability of wellbore cement over time."

"Characterization of Experimental Fracture Alteration and Fluid Flow in Fractured Natural Seals."

The following is from the Executive Summary of this NRAP report: "This report describes a series of experiments designed to examine the effects and flow of CO_2 saturated brine moving through samples from rock formations that are seals for geologic storage of CO_2. The samples were obtained from three sites being considered or used for CCS pilot studies within the continental United States. All samples contain small fractures (some natural, others induced) that make the samples suitable for examining the effects on seal integrity of seepage through small fractures. Experiments were performed over multiple weeks by injecting CO_2-saturated brine through fractured samples while the samples were scanned with a computed tomography (CT) scanner at regular intervals during the course of the experiment. Representative reservoir pressures were maintained on the samples during the experiments. The goal was to evaluate the change in the fracture flow that would result from a CO_2 [release] so that accurate relationships can be described in reduced-order models (ROMs) currently under development in the NRAP project. Of the three formations studied, only one formation had a reaction that was significant. Reactions within the Tuscaloosa claystone sample appeared to reduce the transmissivity of the fracture slightly during the 39-day experiment. A change in the geometry of the fracture was not observable with the medical CT images that were captured during the experiment. All other tests showed minimal changes in the fractures and fracture flow properties. These results indicate that geochemical reactions may not be significant within fractured seal formations that contain the types of shale rock matrices used here, and accounting for these reactions should not be needed in the ROMs being developed for the NRAP project. If a rock matrix contains minerals that are more reactive than the three samples studied, this conclusion may not apply."

"The Global Status of CCS: 2014."

The following provides a highlight of this report: "The report provides a detailed overview of the current status of large-scale CCS projects worldwide, finding that 2014 has been a pivotal year for CCS, which is now a reality in the power industry. For the first time, the report introduces and provides links to project descriptions for around 40 lesser scale 'notable' CCS projects. The 2014 report focuses on a number of 'notable' projects in Japan. The Global Status of CCS: 2014 report provides a comprehensive overview of global

Recent Publications (Continued)

and regional developments in CCS and what is required to support global climate mitigation efforts. Providing a number of key recommendations for decision makers, the report is an important reference guide for industry, government, research bodies and the broader community." A Supplementary Information presentation package and Summary Report are also available from GCCSI.

"6th International Energy Agency (IEA) International CCS Regulatory Network Meeting: Workshop Report."

The following is from the Executive Summary of this report: "The IEA International CCS Regulatory Network held its 6th meeting in Paris, France on 27 and 28 May 2014. The first day of the meeting was a survey of progress in developing and implementing legal and regulatory frameworks in the jurisdictions represented. The second day was focused thematically, exploring a range of issues which have emerged in the development of legal and regulatory frameworks. A number of governments have now implemented CCS legal and regulatory frameworks, particularly to ensure the safe and effective storage of CO_2 underground. Many of these leading jurisdictions are now waiting for the regulations to be tested by early large scale CCS projects. Existing projects in these jurisdictions have often been developed under either existing energy or environmental frameworks or under special frameworks crafted for demonstration projects or R&D, and are now being integrated into new CCS specific regulation. Other governments are in the earlier stages of developing CCS legal and regulatory frameworks. A common first step in these jurisdictions is to survey the application of existing legislation to CCS projects. This review and assessment highlights the gaps in existing legislation and helps to identify legislative vehicles for CCS specific regulation. A number of common themes emerged experiences of governments in developing CCS legal and regulatory frameworks as relayed in the meeting. Legal frameworks are not developed in isolation but rather build on and adapt existing law. Furthermore, the nature of regulation will be greatly impacted by the regulatory context in a given jurisdictions. For both of these reasons, CCS legal and regulatory frameworks will differ greatly between jurisdictions and therefore, there is no 'one size fits all' solution. The meeting also discussed the important balance between flexibility and certainty in regulation. Best practice regulation and standard setting now encourages goal setting, rather than prescriptive requirements in order to remain flexible to technological developments and emergent risks. This is an area where standards can complement regulation, as they are regularly updated to reflect best practice. Counterbalancing this need for flexibility is the regulatory certainty required for projects to secure investment."

Legislative Activity

"Malta Proposes Climate Change Law."

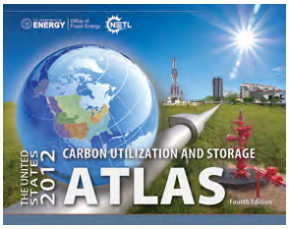
Malta has proposed a new climate bill that would create a legal obligation to meet emission-reduction targets. The bill will require the government to create national strategies for low-carbon development and adaptation to climate change impacts. In addition, the bill also establishes an independent Climate Action Fund that would be used to finance domestic climate action and provide donations to developing countries. As a member of the EU, Malta is bound to the regional carbon reduction target of 40 percent by 2030 (see Policy section of this newsletter for more information). Under the EU's current targets, Malta's emissions can increase five percent from 2005 levels by 2020. According to the Malta's latest submission to the UN, emissions increased from 2005 to 2011. The bill is currently in the consultation phase and the government plans to discuss the bill in December 2014. From *The Independent* on November 3, 2014.

About DOE's Carbon Storage Program

The Carbon Storage Program is implemented by the U.S. Department of Energy's Office of Fossil Energy and managed by the National Energy Technology Laboratory. The program is developing technologies to capture, separate, and store CO_2 in order to reduce greenhouse gas emissions without adversely influencing energy use or hindering economic growth. NETL envisions having a technology portfolio of safe, cost-effective, carbon dioxide capture, transport, and storage technologies that will be available for commercial deployment.

The Carbon Storage Program Overview webpage provides detailed information of the program's structure as well as links to the webpages that summarize the program's key elements.

Carbon Storage Program Resources



The U.S. Department of Energy's 2012 United States Carbon Utilization and Storage Atlas (Atlas IV) shows that the United States has at least 2,400 billion metric tons of potential carbon dioxide storage resource in saline formations, oil and gas reservoirs, and unmineable coal. Data from Atlas IV is available via the National Carbon Sequestration Database and Geographic Information System (NATCARB), which is a geographic information system-based tool developed to provide a view of carbon capture and storage potential.

Newsletters, program fact sheets, best practices manuals, roadmaps, educational resources, presentations, and more are available via the Carbon Storage Reference Shelf.

Get answers to your carbon capture and storage questions at NETL's Frequently Asked Questions webpage.

There are several ways to join the conversation and connect with NETL's Carbon Storage Program:

NETL RSS Feed

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About NETL's Carbon Storage Newsletter

Compiled by the National Energy Technology Laboratory, this newsletter is a monthly summary of public and private sector carbon storage news from around the world. The article titles are links to the full text for those who would like to read more.

National Energy Technology Laboratory

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