



MAY 2013

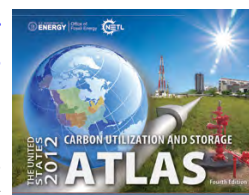
Carbon Storage Newsletter

WHAT'S INSIDE?

- Announcements
- Carbon Storage in the News
- Science
- Policy
- Geology
- Technology
- Terrestrial
- Trading
- Recent Publications
- Legislative Activity
- Subscription Information

Monitoring, verification, and accounting (MVA) activities are underway to ensure the injected CO₂ remains in the geologic formation. The first plant has been capturing CO₂ since December 2012, while the second plant completed construction in February and began carbon capture operations in March. Both units are now operating at full capacity. More than 222,000 tons of CO₂ have been captured and provided for storage as of early May. The two retrofitted Air Products and Chemicals plants produce commercial bulk hydrogen primarily for use at the nearby Valero refinery. To learn more about carbon capture and storage (CCS), watch this [short video](#). From *NETL News Release* on May 10, 2013.

“Carbon Storage Atlas, Employee Newsletter Earn International Communications Awards.”



DOE’s Office of Fossil Energy (FE) and its National Energy Technology Laboratory (NETL) won two prestigious 2013 Blue Pencil & Gold Screen Awards presented by the National Association of Government Communicators (NAGC). NETL earned first place honors in the “Technical or Statistical Report” category for the United States 2012 Carbon Utilization and Storage Atlas (Atlas IV). NETL also won the top award last year for the previous version of the Atlas. Since its first edition in 2007, NETL has updated the Atlas every two years to reflect the current state of CCS technology. Atlas IV highlights the potential of CCS and estimates hundreds of years’ worth of CO₂ storage resource potential. [Atlas IV](#) is available for download via the Carbon Storage Reference Shelf. An interactive version of the data used in Atlas IV is available via the [National Carbon Sequestration Database and Geographic Information System \(NATCARB\) Viewer](#). More about Atlas IV is available in an [informational video](#) on YouTube. FE’s internal employee newsletter, *inTouch*, was also recognized for communications excellence. The NAGC Blue Pencil & Gold Screen Awards program is an international competition that recognizes exceptional government communication products across more than 40 categories. This year’s competition drew more than 300 entries. From *NETL News Release* on May 7, 2013.

HIGHLIGHTS

“Breakthrough Industrial Carbon Capture, Utilization and Storage Project Begins Full-Scale Operations.”



Port Arthur 1 & 2 Hydrogen Production Plants

The Air Products and Chemicals hydrogen production facilities in Port Arthur, Texas, have successfully begun capturing carbon dioxide (CO₂) and using it for enhanced oil recovery (EOR). At full-scale operation, more than 90 percent of the CO₂ from the product stream of two methane steam reformers (approximately 1 million metric tons of CO₂ per year) will be delivered for storage and EOR, leading to an estimated annual increase in oil production of 1.6 to 3.1 million barrels from the West Hastings oil field. The approximately \$431 million project, supported by \$284 million from the U.S. Department of Energy (DOE), included retrofitting the plants with an innovative system that separates CO₂ from the steam reformer product gas during hydrogen production, followed by compression and drying processes. The DOE investment also helped construct a 13.1-mile-long feeder that connects the two plants to Denbury’s 325-mile, 24-inch Green Pipeline, which begins in Louisiana and ends at the West Hastings field.

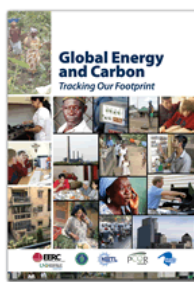
“Regional Partnership Documentary Wins ‘Best of Show’ Aurora Award.”

A documentary co-produced by Prairie Public Broadcasting and the Plains CO₂ Reduction (PCOR) Partnership, with support from DOE, won a 2012 Platinum Best of Show Aurora Award in the nature/environment documentary category. The documentary, titled, [“Global Energy and Carbon:](#)



HIGHLIGHTS (CONTINUED)

[Tracking Our Footprint](#),” demonstrates global energy use by average families in industrialized, emerging, and developing economies. In addition, it explores carbon management options that ensure adequate energy access for the world’s



growing population. The 30-minute documentary represents an important outreach tool for keeping the public informed of DOE’s efforts to mitigate greenhouse gases (GHGs) in the atmosphere. The fifth in a series of documentaries produced by the PCOR Partnership and Prairie Public Broadcasting, the documentary premiered on Prairie Public Television in October 2010, and has since been broadcasted more than 100 times in 30 different states. The PCOR Partnership is one of seven partnerships in the NETL-managed [Regional Carbon Sequestration Partnership Initiative](#). From *NETL Press Release* on April 30, 2013.

ANNOUNCEMENTS

[New Fossil Energy Website.](#)

DOE’s FE website has been updated and moved to the Energy.gov platform. It is now accessible by clicking [here](#). Feedback can be provided through [email](#), [Facebook](#), or [Twitter](#).

[2013 CO₂ Capture Technology Meeting.](#)

This meeting, scheduled for July 8-11, 2013, in Pittsburgh, Pennsylvania, features more than 50 DOE-sponsored CO₂ capture technology projects. The projects included span three primary technology pathways (post-combustion, pre-combustion, and oxy-combustion) and various stages of development (lab-scale, bench-scale, and small pilot-scale). Presentations of solvent, sorbent, membrane, oxy-combustion, chemical looping, and compression technologies, as well as systems studies and modeling, will be included.

[Korea Carbon Capture and Sequestration R&D Center Request for Proposal.](#)

The Korea Carbon Capture and Sequestration R&D Center (KCRC), an institution supported by the Ministry of Science, ICT, and Future Planning (MSIP) in South Korea, is seeking proposals for the implementation of the “Korea CCS 2020 Project” and to develop CCS technologies.

[GHG Reporting Database Launched.](#)

The Climate Registry launched the GHG Reporting Database, a free online tool that compares Federal, regional, and state GHG reporting requirements. The database is designed to help organizations navigate GHG regulations, which include the Federal Greenhouse Gas Reporting Program (GHGRP), California’s Mandatory Reporting Regulation (MRR), and Regional Greenhouse Gas Initiative (RGGI) requirements. The database allows users to search by keyword, conduct side-by-side program comparisons, and search for variation in requirements between specific reporting programs or U.S. Environmental Protection Agency (EPA) sub-part.

[2013 Midwest Carbon Sequestration Science Conference.](#)

The Midwest Geological Sequestration Consortium (MGSC) annual Project Advisory Meeting is scheduled for October 7, 2013, at the I Hotel and Conference Center in Champaign, Illinois. This conference will include a full day of Illinois Basin Decatur Project (IBDP) research presentations covering the MGSC Phase III research activities. The conference will also include a Sequestration Training and Education Program (STEP)-sponsored workshop and an optional tour of the IBDP site. Full meeting details will be distributed in June, with registration opening in July.

[12th International Conference on Greenhouse Gas Control Technologies.](#)

GHGT-12 will be held on October 5-9, 2014, in Austin, Texas, USA. This will be the first visit by the conference series to Austin and more than 1,600 participants are expected to attend. The event will be hosted by the University of Texas at Austin and the IEA Greenhouse Gas R&D Programme (IEAGHG).

[NETL’s Carbon Capture, Utilization, and Storage Database – Version 4.](#)

NETL has released the fourth version of the CCS Database, which includes active, proposed, canceled, and terminated CCS projects worldwide. As of November 2012, the database contained 268 CCS projects worldwide. The 268 projects include 68 capture, 61 storage, and 139 for capture and storage in more than 30 countries across 6 continents. Users can download the CCS Database as a [Google Earth layer](#) or download a copy in [Microsoft Excel](#) file format.

ANNOUNCEMENTS (CONTINUED)

Energy Innovation Projects Announced across Canada.

Canada announced 55 new projects aimed at producing and using energy in a cleaner, more efficient manner. Fifteen projects will be pre-commercialization demonstration projects to test the feasibility of various technologies and 40 projects will be research and development (R&D) projects to address knowledge gaps and bring technologies from the conceptual stage to the ready-to-be-tested stage of development. The projects will be focus on research in the following areas: energy efficiency, clean electricity and renewables, bioenergy, electrification of transportation, and unconventional oil and gas.

CARBON STORAGE IN THE NEWS

“Lithium Discovery Could Be New Industry for Wyoming.”

While working on a CO₂ storage site project, researchers at the University of Wyoming Carbon Management Institute (CMI) discovered a new lithium resource that could potentially offset the cost of creating the project’s underground CO₂ storage space. According to early analyses of fluid samples collected from a well drilled on the Rock Springs Uplift, the reservoir brines from a 25-mi² nearby area could contain approximately 228,000 tons of lithium, which is a key component of “greener technologies,” as lithium-ion batteries are employed by wind, solar, and smart-grid technologies. The high levels of lithium were originally found in formation waters last year while CMI researchers were working on the drill site, located east of Rock Springs and slightly north of Point of Rocks. The waters were sampled again in November 2012 with the same results. In order to offset costs, the production of the lithium would have to be integrated with the carbon storage work to utilize the deep wells drilled for CO₂. From *The Billings Gazette* on April 24, 2013.

“Ottawa Funds \$4.5m in Geological Research for Sydney Area.”

The Carbon Capture and Storage Research Consortium of Nova Scotia announced that they received \$4.5 million through the ecoEnergy Innovation Initiative for geological research in Nova Scotia. Earlier research identified that the Sydney sub-basin has the largest theoretical capacity to permanently store captured CO₂ underground. Field research and community consultation will start this spring and a report will be released to the public by the winter of 2015. The information will be shared with the community. From *The Chronicle Herald* on May 3, 2013.

“Svalbard Prepares the Ground for CO₂ Storage.”

Researchers at the Svalbard University Center (UNIS) have found CO₂ storage capacity in a major underground reservoir in Adventsdalen, near Longyearbyen at Svalbard (Norway), following several years of study. A total of six wells with depths varying from 190 to 970 meters have been drilled in Adventsdalen and water injection tests indicate that the reservoir is ideal for CO₂ storage. Researchers also believe the reservoir has a sufficient caprock. The reservoir capacity estimation is still uncertain and plans call for the injection of smaller amounts of CO₂ in the wells to make more precise estimations of the capacity. The project plans to inject up to 200,000 tons of CO₂ in the reservoir over a period of 10 years. The Lab, a project under the UNIS,

has been engaged in the study of the reservoir since 2007 and partners include ConocoPhillips, Statoil, Store Norske, Gassnova, Statkraft, and Lundin Norway. From *Barents Observer* on May 13, 2013.

SCIENCE

“Climate Change Compounds Rising Threats to Koala.”

According to the Australian Koala Foundation (AKF), the koala population has dropped approximately 40 percent in Queensland and approximately 33 percent in New South Wales due to a shrinking of their habitat from potential climate change. According to AKF estimates, there are 45,000 to 90,000 koalas left in the wild. Native only to Australia, the koalas derive much of their moisture needs from eucalyptus leaves. Climate scientists warn that forecasts of longer dry periods, rises in temperature, and severe droughts could pose a risk to the creature’s habitat and could affect the “nutrition quality and moisture content” of leaves. From *Guardian Environment Network* on April 30, 2013.



“Earth’s Greenhouse Gas Levels Approach 400-ppm Milestone.”

According to the Scripps Institution of Oceanography at UC San Diego, the ratio of CO₂ in Earth’s atmosphere is approaching 400 parts per million (ppm), which would be the highest level in 2.5 million to 5 million years. A Keeling curve update launched by Scripps in late April showed measurements from Mauna Loa, Hawaii, that could soon breach the 400-ppm level. Measurements from Mauna Loa, which is far from major emission sources, are considered the most reliable indicators of Earth’s atmospheric content, according to Scripps. Over the previous 800,000 years, CO₂ levels have not exceeded 300 ppm; the CO₂ level was approximately 280 ppm during the Industrial Revolution. According to Scripps, there is no known geologic period in which rates of increase have been so apparent. From *Los Angeles Times* on May 1, 2013.

“NASA Study Projects Warming-Driven Changes in Global Rainfall.”

A modeling study conducted by NASA has discovered new evidence that potential climate change may increase the risk for extreme rainfall and drought, showing for the first time that a rise in CO₂ concentrations could affect rainfall types on Earth. The study analyzed 14 climate model

SCIENCE (CONTINUED)

computer simulations that indicated wet regions of the world would see increases in heavy precipitation, and many land areas outside the tropics could become drier, due to the potential warming of the climate from projected increases in CO₂ levels. For every degree Fahrenheit of CO₂-induced warming, the models project heavy rainfall to increase by 3.9 percent, light rain to increase by one percent, and the length of periods without rain to increase by 2.6 percent (all globally). According to the study, which was accepted for publication in the American Geophysical Union journal “Geophysical Research Letter,” areas projected to see an increase in heavy rainfall are in the tropical zones around the equator; areas most likely to be affected by drought include the deserts and arid regions. From *NASA News Release* on May 3, 2013.

POLICY

“Strategic climate policy with offsets and incomplete abatement: Carbon taxes versus cap-and-trade.”

The following is the Abstract of this article: “This paper provides a first analysis of a ‘policy bloc’ of fossil fuel importers which implements an optimal climate policy, faces a (non-policy) fringe of other fuel importers, and an exporter bloc, and purchases offset from the fringe. [The authors] compare a carbon tax and a cap-and-trade scheme for the policy bloc, in either case accompanied by an efficient offset mechanism for reducing emissions in the fringe. The policy bloc is shown to prefer a tax over a cap, since only a tax reduces the fuel export price and by more when the policy bloc is larger. Offsets are also more favorable to the policy bloc under a tax than under a cap. The optimal offset price under a carbon tax is below the tax rate, while under a cap and free quota trading the offset price must equal the quota price. The domestic carbon and offset prices are both higher under a tax than under a cap when the policy bloc is small. When the policy bloc is larger, the offset price can be higher under a cap. Fringe countries gain by mitigation in the policy bloc, more under a carbon tax since the fuel import price is lower.” **Jon Strand**, *Journal of Environmental Economics and Management*. (Subscription may be required to view article.)

“Human health risk assessment of CO₂ [release] into overlying [formations] using a stochastic, geochemical reactive transport approach.”

The following is the Abstract of this article: “Increased human health risk associated with groundwater contamination from potential CO₂ [release] into a potable [formation] is predicted by conducting a joint uncertainty and variability (JUV) risk assessment. The approach presented here explicitly incorporates heterogeneous flow and geochemical reactive transport in an efficient manner and is used to evaluate how differences in representation of subsurface physical heterogeneity and geochemical reactions change the calculated risk for the same hypothetical [formation] scenario where a CO₂ [release] induces increased Pb²⁺ concentrations through dissolution of galena (PbS). A nested Monte Carlo approach was used to take Pb²⁺ concentrations at a well from an ensemble of numerical reactive transport simulations (uncertainty) and sample within

a population of potentially exposed individuals (variability) to calculate risk as a function of both uncertainty and variability. Pb²⁺ concentrations at the well were determined with numerical reactive transport simulation ensembles using a streamline technique in a heterogeneous 3D [formation]. Three ensembles with variances of log hydraulic conductivity ($\sigma_{2\ln K}$) of 1, 3.61, and 16 were simulated. Under the conditions simulated, calculated risk is shown to be a function of the strength of subsurface heterogeneity, $\sigma_{2\ln K}$ and the choice between calculating Pb²⁺ concentrations in groundwater using equilibrium with galena and kinetic mineral reaction rates. Calculated risk increased with an increase in $\sigma_{2\ln K}$ of 1 to 3.61, but decreased when $\sigma_{2\ln K}$ was increased from 3.61 to 16 for all but the highest percentiles of uncertainty. Using a Pb²⁺ concentration in equilibrium with galena under CO₂ [release] conditions (PCO₂ = 30 bar) resulted in lower estimated risk than the simulations where Pb²⁺ concentrations were calculated using kinetic mass transfer reaction rates for galena dissolution and precipitation. This study highlights the importance of understanding both hydrologic and geochemical conditions when numerical simulations are used to perform quantitative risk calculations.”

Adam L Atchley, Reed Maxwell, and Alexis Navarre-Sitchler, *Environ. Sci. Technol.* (Subscription may be required to view article.)

GEOLOGY

“Reduction of lateral pressure propagation due to dissipation into ambient mudrocks during geological carbon dioxide storage.”

The following is the Abstract of this article: “CO₂ storage in deep geological formations can lead to significant reductions in anthropogenic CO₂ emissions if large amounts of CO₂ can be stored. Estimates of the storage capacity are therefore essential to the evaluation of individual storage sites as well as the feasibility of the technology. One important limitation on the storage capacity is the radius of review, the lateral extent of the pressure perturbation, of the storage project. [The authors] show that pressure dissipation into ambient mudrocks retards lateral pressure propagation significantly and therefore increases the storage capacity. For a three-layer model of a reservoir surrounded by thick mudrocks, the far-field pressure is approximated well by a single-phase model... The combination of large uncertainty in mudrock properties and the sigmoid shape leads to wide and strongly skewed probability distributions for the predicted radius of review and storage capacity. Therefore, if the lateral extent of the pressure front limits the storage capacity, the determination of the mudrock properties is an important component of the site characterization.”

Kyung Won Chang, Marc A. Hesse, and Jean-Philippe Nicot, *Water Resources Research*. (Subscription may be required to view article.)

“Use of Reactive Species in Water for CO₂ Mineralization.”

The following is the Abstract of this article: “Various CCS technologies have been developed to address the issues concerning climate changes associated with anthropogenic CO₂ emissions. In the present work, possibilities of mineralizing CO₂ with the reactive species such as Mg²⁺ ions present in nature such as sea water and produced water have been explored. Laboratory tests conducted with solutions containing 1,400 ppm Mg²⁺ ions showed that

GEOLOGY (CONTINUED)

nesquehonite ($\text{Mg}(\text{OH})(\text{HCO}_3)_2 \cdot 2\text{H}_2\text{O}$) is formed upon CO_2 injection to the solution at an atmospheric pressure. The results showed that for the mineralization to occur, the pH should be raised above 6.8 as predicted from thermodynamics. Kinetic studies conducted at different temperatures showed that the nesquehonite formation involves an activation energy of 66.7 kJ/mol, which can be overcome by increasing the mass and heat transfer efficiency, as well as the operative temperature. Based on the kinetics data obtained at a low agitation speed, the number and volume of the mineralization reactors required to capture the CO_2 emitted from a [600-MW] coal power plant have been determined. In addition, the amounts of alkalis needed to raise the pH for precipitation and subsequently to the natural pH of sea water have been estimated.” **Juan Ma and Roe-Hoan Yoon**, *Energy Fuels*. (Subscription may be required to view article.)

“Regional capacity estimates for CO_2 geological storage in deep saline [formations] – Upper Miocene sandstones in the SW part of the Pannonian basin.”

The following is the Abstract of this article: “Deep saline [formations] are regarded as the most suitable sites or options for CO_2 geological storage, mainly due to their large storage capacity and extensive spatial distribution in most sedimentary basins. The estimation of the storage capacity in this type of sinks presents a problem due to the lack of subsurface data. A significant step from regional towards local capacity estimation is redefinition of regional storage capacity by applying modified methodology for integrated studies of hydrocarbon reservoirs. The suggested procedure was investigated by detailed mapping of the Sava West [formation] in the Croatian part of the Pannonian basin. First, the cap rock was chosen based on its depth, thickness and lateral continuity, and then the target reservoir – Upper Miocene Poljana sandstone layers underlying the regional cap rock. Their depth and effective thickness, as well as the subsurface pressure, temperature and resulting density of CO_2 were mapped based on the well data. The [formation] body was then divided into square elements and the storage capacity was calculated for each of them. Mapping of specific storage capacity in this way enables identification of the areas of greater potential for geological storage that should be further investigated for detailed definition of the potential storage objects.” **Iva Kolenković, Bruno Saftić, and Dario Perešin**, *International Journal of Greenhouse Gas Control*. (Subscription may be required to view article.)

TECHNOLOGY

“Experimental study of potential wellbore cement carbonation by various phases of carbon dioxide during geologic carbon [storage].”

The following is the Abstract of this article: “Hydrated Portland cement was reacted with CO_2 in supercritical, gaseous and aqueous phases to understand the potential cement alteration processes along the length of a wellbore, extending from a deep CO_2 storage reservoir to the shallow subsurface during geologic C [storage]. The 3-D X-ray microtomography (XMT) images showed that the cement alteration

was significantly more extensive with CO_2 -saturated synthetic groundwater than dry or wet supercritical CO_2 at high P (10 MPa)-T (50°C) conditions. Scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS) analysis also exhibited a systematic Ca depletion and C enrichment in cement matrix exposed to CO_2 -saturated groundwater. Integrated XMT, XRD and SEM-EDS analyses identified the formation of an extensive carbonated zone filled with $\text{CaCO}_3(\text{s})$, as well as a porous degradation front and an outermost silica-rich zone in cement after exposure to CO_2 -saturated groundwater. Cement alteration by CO_2 -saturated groundwater for [two to eight] months overall decreased the porosity from 31 [percent] to 22 [percent] and the permeability by an order of magnitude. Cement alteration by dry or wet supercritical CO_2 was slow and minor compared to CO_2 -saturated groundwater. A thin single carbonation zone was formed in cement after exposure to wet supercritical CO_2 for [eight] months or dry supercritical CO_2 for 15 months. An extensive calcite coating was formed on the outside surface of a cement sample after exposure to wet gaseous CO_2 for [one to three] months. The chemical-physical characterization of hydrated Portland cement after exposure to various phases of CO_2 indicates that the extent of cement carbonation can be significantly heterogeneous depending on the CO_2 phase present in the wellbore environment. Both experimental and geochemical modeling results suggest that wellbore cement exposure to supercritical, gaseous and aqueous phases of CO_2 during geologic C [storage] is unlikely to damage the wellbore integrity because cement alteration by all phases of CO_2 is dominated by carbonation reactions. This is consistent with previous field studies of wellbore cement with extensive carbonation after exposure to CO_2 for [three] decades. However, XMT imaging indicates that preferential cement alteration by supercritical CO_2 or CO_2 -saturated groundwater can occur along the cement-steel or cement-rock interfaces. This highlights the importance of further investigation of cement degradation along the interfaces of wellbore materials to ensure permanent geologic C storage.” (Subscription may be required to view article.)

“Modeling the investment in carbon capture retrofits of pulverized coal-fired plants.”

The following is the Abstract of this article: “This paper focuses on the investment decision to retrofit an existing supercritical pulverized coal (SCPC) unit with CCS technology. [The authors] establish a valuation model with discrete sequential investment decision-making based on real options theory, and [the authors] consider the following uncertainty factors: electricity price, carbon price, CCS investment cost and CO_2 additional [operation and maintenance (O&M)] cost. [The authors] also take CCS operation flexibility into account. [The authors] solve the model using the least squares Monte Carlo (LSM) method. [The authors] employ four indicators—cost saving value, investment risk, emission abatement amount and average capture rate—to evaluate the investment decision to retrofit China’s existing SCPC unit with CCS. The results illustrate the following: (1) CO_2 capture (additional O&M) cost can be the most significant factor that will affect CCS retrofit investment; (2) the existing level of CCS technology and policy framework cannot support the plant owner to retrofit the existing SCPC unit with CCS; and (3) the carbon price or capture subsidy must be at a high level to control the CCS retrofit investment risk such that it is less than [five percent]. [The authors’] proposed model is most suitable for plant owners’ CCS retrofit decisions.” **Lei Zhu and Ying Fan**, *Energy*. (Subscription may be required to view article.)

TECHNOLOGY (CONTINUED)

“Planning of carbon capture and storage with pinch analysis techniques.”

The following is the Abstract of this article: “CCS is a means for reducing CO₂ emissions from fossil fuel combustion in power generation and industrial processes. It involves the capture of CO₂ for subsequent storage in various geological formations. The selection and matching of the power plants and storage sites are often an issue of optimization due to various constraints, i.e., time of availability, injection rate, and storage capacity limits. In this work, a novel graphical targeting tool based on pinch analysis is proposed to address the planning problem of the storage of captured CO₂ from power generating plants into corresponding reservoirs. The main consideration for the problem is the time of availability of the latter, since reservoirs need to be developed prior to CO₂ storage. The time limitation is addressed by the graphical technique where time is taken as the governing element in solving the problem. Hypothetical examples are used to elucidate the proposed approach.” **Raymond E.H. Ooi, Dominic C.Y. Foo, Denny K.S. Ng, and Raymond R. Tan**, *Chemical Engineering Research and Design*. (Subscription may be required to view article.)

TERRESTRIAL

“Tracking the fate of microbially [stored] carbon dioxide in soil organic matter.”

The following is the Abstract of this article: “The microbial contribution to soil organic matter (SOM) has recently been shown to be much larger than previously thought and thus its role in carbon [storage] may also be underestimated. In this study [the authors] employ ¹³C (13CO₂) to assess the potential CO₂ [storage] capacity of soil chemoautotrophic bacteria and combine Nuclear Magnetic Resonance (NMR) with Stable Isotope Probing (SIP); techniques that independently make use of the isotopic enrichment of soil microbial biomass. In this way molecular information generated from NMR is linked with identification of microbes responsible for carbon capture. A mathematical model is developed to determine real-time CO₂ flux so that net [storage] can be calculated. [Twenty-eight] groups of bacteria showing close homologies with existing species were identified. Surprisingly, *Ralstonia eutropha* was the dominant group. Through NMR [the authors] observed the formation of lipids, carbohydrates and proteins produced directly from CO₂ [utilized] by microbial biomass. The component of SOM, directly associated with CO₂ capture, was calculated at 2.86 mg C (89.21 mg kg⁻¹) after 48 hours. This approach can differentiate between SOM derived through microbial uptake of CO₂ and other SOM constituents and represents a first step in tracking the fate and dynamics of microbial biomass in soil.” **Kris M Hart, Anna L Kulakova, Chris Allen, Andre J Simpson, Seth F Oppenheimer, Hussain Masoom, Denis Courtier-Murias, Ronald Soong, Leonid A Kulakov, Brian T Murphy, and Brian P. Kelleher**, *Environ. Sci. Technol.* (Subscription may be required to view article.)

TRADING

“Emission trading and international competition: The impact of labor market rigidity on technology adoption and output.”

The following is the Abstract of this article: “Emission trading systems have been proposed in different regions to reduce polluting emissions and are in use in the European Union for [CO₂] emissions. One of the objectives of these systems is to encourage firms to adopt advanced abatement technologies. However, permits also create an incentive to reduce output, which may be seen as negative by policy makers. [The authors] analyze the impact of a rigid [labor] market on these two outcomes, showing the conditions necessary to avoid reductions in production while keeping the incentives to improve abatement technologies. The analysis is done for oligopolistic firms engaged in international rivalry.” **Alejandro Caparrós, Jean-Christophe Péreau, and Tarik Tazdail**, *Energy Policy*. (Subscription may be required to view article.)

“A modified GHG intensity indicator: Toward a sustainable global economy based on a carbon border tax and emissions trading.”

The following is the Abstract of this article: “It will be difficult to gain the agreement of all the actors on any proposal for climate change management, if universality and fairness are not considered. In this work, a universal measure of emissions to be applied at the international level is proposed, based on a modification of the Greenhouse Gas Intensity (GHG-INT) measure. It is hoped that the generality and low administrative cost of this measure, which [the authors] call the Modified Greenhouse Gas Intensity measure (MGHG-INT), will eliminate any need to classify nations. The core of the MGHG-INT is what [the authors] call the IHDI-adjusted Gross Domestic Product (IDHIGDP), based on the Inequality-adjusted Human Development Index (IHDI). The IDHIGDP makes it possible to propose universal measures, such as MGHG-INT. [The authors] also propose a carbon border tax applicable at national borders, based on MGHG-INT and IDHIGDP. This carbon tax is supported by a proposed global Emissions Trading System (ETS). The proposed carbon tax is analyzed in a short-term scenario, where it is shown that it can result in a significant reduction in global emissions while keeping the economy growing at a positive rate. In addition to annual GHG emissions, cumulative GHG emissions over two decades are considered with almost the same results.” **Reza Farrahi Moghaddam, Fereydoun Farrahi Moghaddam, and Mohamed Cheriet**, *Energy Policy*. (Subscription may be required to view article.)

RECENT PUBLICATIONS

“Quantification of Risk Profiles for Atmosphere and Groundwater.”

The following is the Executive Summary of this document: “This report summarizes National Risk Assessment Partnership (NRAP) efforts to develop an approach to quantify risk profiles for atmospheres and [formations] at a CO₂ storage site. [The authors] have used a science-based prediction approach for computation of time-dependent profiles for [release] risks at a CO₂ storage site. The approach requires prediction of a storage site performance over long time. [The authors] used an Integrated Assessment Model (IAM) in order to implement a system modeling approach for predicting long term site behavior. The systems modeling approach treats a storage site as a system made up of sub-systems such as storage reservoir, overlying seal, wellbores, faults or other transport pathways, and shallow permeable zones including groundwater systems, etc. The behavior of each of the components in the storage-site system is predicted using reduced-order models (ROMs) based on detailed process-level simulations. Different approaches were used to develop ROMs. A look-up table approach, which directly incorporated reservoir simulation results, was used for the storage reservoir; a high-resolution look-up table developed using Lawrence Livermore National Laboratory’s (LLNL) PSUADE (Problem Solving environment for Uncertainty Analysis and Design Exploration) package and based on Los Alamos National Laboratory’s (LANL) FEHM (Finite Element Heat and Mass transport code) simulation results was used for [release] through cemented wellbores; a look-up table, which directly incorporated simulation results performed using Lawrence Berkeley National Laboratory’s (LBNL) TOUGH2 (Transport Of Unsaturated Groundwater and Heat simulator) was used for [release] through open wellbores; high-order polynomial ROMs developed using LLNL’s PSUADE package and based on detailed numerical simulations using LANL’s FEHM code and Pacific Northwest National Laboratory’s (PNNL) STOMP (Subsurface Transport Over Multiple Phases) code were used for shallow [formations]. The IAM was used for first-generation risk profile calculation was built using LANL’s CO₂-PENS (CO₂-Predicting Engineered Natural Systems) system model.”

“CO₂ Capture Project Annual Report 2012.”

The following is from the Introduction of this document: “There has been intense activity in 2012 across all [CO₂ Capture Project (CCP)] Teams – Capture, Storage, Policy & Incentives and Communications. The Capture Team continues to work to develop a suite of economically viable next generation technologies – focusing on oil refinery, oil production and power generation scenarios. Last year saw the CCP hold an oxy-firing test at a pilot-scale Fluid Catalytic Cracking (FCC) unit at a Petrobras research facility in Parana state, Brazil. This demonstration has indicated the technical viability of retrofitting an FCC unit to enable CO₂ capture through oxy-firing. It has underlined oxy-firing technology as the preferred route for FCC CO₂ capture and is a crucial achievement for the CCP and its member companies, who have closely collaborated to bring this to fruition. The team also made progress in developing a range of other capture technology tests and studies that will be delivered in 2013, while greater clarity was achieved around the baseline cost implications of the three main capture technologies. It has also been an important year for the Storage Team, which has continued its work on addressing key issues for industry and regulators through a mix of experiment, analysis, modeling and field trials. The team guided a number of important monitoring field trials to completion with the successful deployment of innovative Modular Borehole Monitoring technology at Citronelle Dome in the [United States], and further results from a satellite monitoring program at Decatur, Illinois. The team’s work on contingencies, contributing to the understanding of detection and remediation of unexpected CO₂ or brine migration has also progressed well. This work has the potential to be a key input to help assure stakeholders that storage can be performed safely and securely. The Policy & Incentives Team has continued to further contribute to an understanding of government and institutional policies influencing the development of CCS. Its 2012 CCS Regulatory Study has given valuable insight into the evolution of legal frameworks in key jurisdictions and into how project managers and regulators are finding pathways for regulatory approvals.”

“Making the case for funding carbon capture and storage in developing countries.”

The following is a summary of this document: “This report was developed for the Fourth Clean Energy Ministerial [(CEM)] meeting held in New Delhi [April 17-18, 2013]. It provides an update on recommendations made to Ministers in the preceding report ‘Funding Carbon Capture and Storage in Developing Countries’ tabled at the 2012 CEM in London. It includes a ‘Template Business Case’ that identifies the links between funding for CCS and development impacts, which may be a useful reference document for donor countries considering funding CCS in developing countries.”

“European chemistry for growth: Unlocking a competitive, low carbon and energy efficient future.”

The following is the Introduction of this document: “The European chemical industry is an essential industry manufacturing products used in the majority of everyday goods. The industry adds value to the economy and creates direct employment for 1.2 million people. Looking towards 2050, the European chemical industry has the potential to continue as an innovative industry contributing to new and currently unknown solutions to [fulfill] human needs. The chemical industry uses fossil and renewable resources both as feedstock to make products and as a source of energy to generate heat, steam and electricity. It accounts for roughly one third of the combined energy and feedstock use of the European industry. Its energy and feedstock basis is largely fossil fuel based and as such contributes to the increasing level of [GHGs] in the atmosphere and to climate change. At the same time, the European chemical industry is a vital solution provider to create a more

RECENT PUBLICATIONS (CONTINUED)

energy efficient and low carbon economy. It contributes to energy efficient solutions in almost all sectors of the economy, and the demand for products of the chemical industry will continue to grow. The challenge for the European chemical industry is to satisfy the demand growth for chemical products with highly efficient European production while reducing CO₂ and other GHG emissions. For this to happen, the European chemical industry needs to be competitive in a global market place, which is challenging due to differences in feedstock and energy prices as well as climate policies and their ambition levels across the world. Globally, energy use continues to increase and to limit the most harmful impacts of climate change on society, global action is required to improve energy efficiency and to transform the energy system towards a lower GHG emissions intensity. Currently, the debate in Europe is focused on how to develop its energy and climate policies in the coming decades given the current absence of a global agreement on GHG emissions reduction and the uncertain outlook on reaching such an agreement in the years to come.”

“Looking at the Potential of Carbon Sequestration.”

The following is from the description of this document: “This report envisages on the key issue of making carbon [storage] an economically competent and financially viable strategy which links the community in the long run by incentivizing sustained socio-economic activity in conjunction with the environment. The report looks at carbon [storage] projects as a means of promoting sustainable forestry practices as well as conserving the interest of the land stakeholders in implementation of these projects... The report uses the Bolivia – Noelle Kempff Climate Action model and several other projects as case studies of a large scale carbon project at work in a developing country. The efforts of some countries and the innovative initiative taken by them in achieving carbon [storage] ahead of the world order and also ensuring the goal of weaving the community in economic activity with the environment thereby removing one of the most basic reasons for degradation of forest cover. The report is a complete guide to understanding and identifying the true potential of Carbon [Storage] for a clean sustainable future for mankind.” (Subscription may be required to view document.)

LEGISLATIVE ACTIVITY

“New Bill Would Expand Tax Benefits to CCS, Clean Energy Projects.”

On April 24, 2013, a group of lawmakers reintroduced the “Master Limited Partnership Parity Act” that would provide access to a corporate tax structure, which is traditionally reserved for fossil fuel products, to CCS and other clean energy projects. An expanded version of a measure introduced to the Senate in 2012, the legislation was brought forward to both chambers of the U.S. Congress to spur new private investment. The goal is for the bill to widen the scope of eligible energy technologies to include CCS and other clean energy technologies. According to the legislation, CCS and coal gasification projects that store at least 75 percent of their CO₂ emissions would be eligible for the tax structure. From *GHG Monitor* on April 26, 2013.

“Shaheen-Portman Energy Efficiency Bill Passes Senate Energy Committee with Strong Support.”

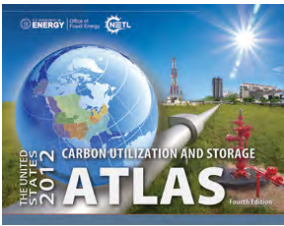
The energy efficiency and job creation strategy proposed by two U.S. Senators passed the U.S. Senate Committee on Energy and Natural Resources by a vote of 19-3. The legislation offers a framework to promote the transition to a more energy-efficient economy, while increasing economic growth and private sector job creation. The bill uses a variety of tools to reduce barriers for private sector energy users and drive adoption of efficiency technologies by energy consumers. From *U.S. Senator Jeanne Shaheen Press Release* on May 8, 2013.

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 CO₂ 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:



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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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