

# C S N

SEPTEMBER 2016

# CARBON STORAGE NEWSLETTER

This newsletter is compiled by the National Energy Technology Laboratory to provide information on recent activities and publications related to carbon storage. It covers domestic, international, public sector, and private sector news in the following areas:

- ▷ DOE/NETL HIGHLIGHTS
- ▷ ANNOUNCEMENTS
- ▷ PROJECT and BUSINESS DEVELOPMENTS
- ▷ LEGISLATION and POLICY
- ▷ EMISSIONS TRADING
- ▷ CLIMATE and SCIENCE NEWS
- ▷ JOURNAL ARTICLES
- ▷ REPORTS and PUBLICATIONS

## CARBON STORAGE PROGRAM DOCUMENTS and REFERENCE MATERIALS

- ▷ Carbon Storage Educational Resources
- ▷ Program Reports, Plans, and Roadmaps
- ▷ Conference Proceedings
- ▷ Carbon Storage Portfolio
- ▷ Systems Analysis
- ▷ Peer Review
- ▷ Best Practices Manuals
- ▷ Fossil Energy Techlines



## DOE/NETL HIGHLIGHTS

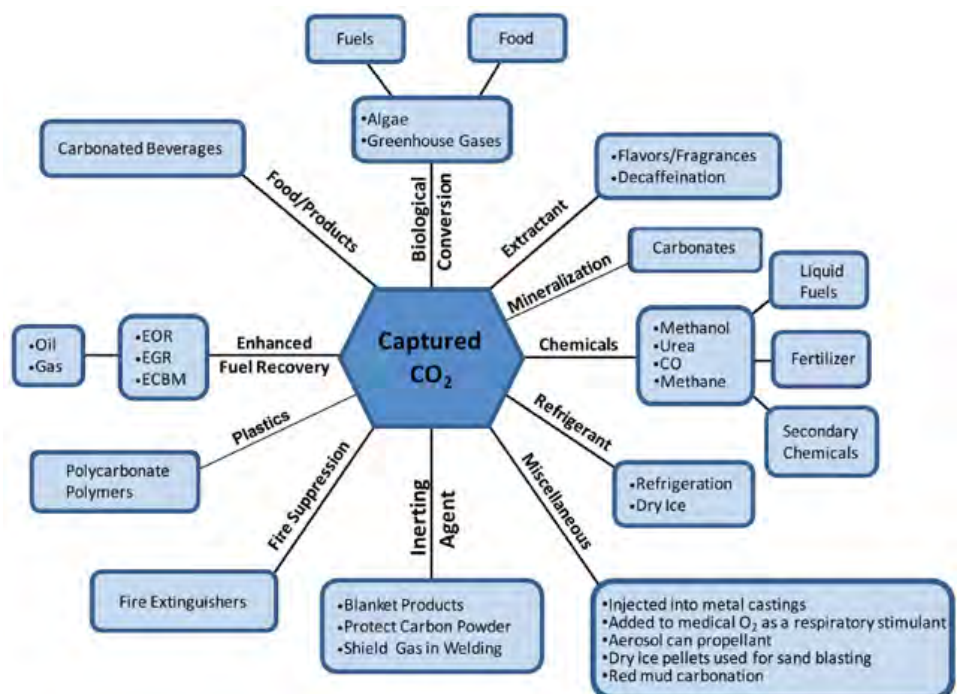
*“DOE’s Carbon Storage Advances Featured in Special Issue of International Journal of Greenhouse Gas Control.”*

Carbon storage research conducted under the U.S. Department of Energy’s (DOE) *National Risk Assessment Partnership (NRAP)* was highlighted in a special August 2016 issue of the *International Journal of Greenhouse Gas Control*, which is comprised of a compendium of research generated by the NRAP team over six years of collaboration. This is the first special issue focused on results from a research team, and the articles detail advancements in scientific understanding, risk assessment methodology, and computational tool development related to full geologic carbon dioxide (CO<sub>2</sub>) storage system performance. Release of the special issue coincides with the completion of NRAP’s first phase of research, which resulted in the generation of first-of-kind scientific data, methodologies, and simulation tools to support quantitative assessment of environmental risks associated with industrial-scale geologic CO<sub>2</sub> storage. NRAP is now transitioning into a second phase, in which the risk-assessment methodologies and tools developed during Phase I will be applied to real-world CO<sub>2</sub> storage sites, and new tools and findings will be generated to help effectively manage carbon storage operations. From *energy.gov* on August 18, 2016.



*“DOE Seeks Projects to Advance Carbon Dioxide Utilization from Coal-Fired Power Plants.”*

DOE released a Funding Opportunity Announcement (FOA) focused on securing applications for projects that will develop CO<sub>2</sub>-utilization technologies that produce useful products, without generating additional greenhouse gas (GHG) emissions, at a lower cost than currently available technologies. The FOA has three areas of interest: (1) biological-based concepts for beneficial use of CO<sub>2</sub>, (2) mineralization concepts utilizing CO<sub>2</sub> with industrial wastes, and (3) novel physical and chemical processes for beneficial use of carbon. More information on the FOA, titled *“Applications for Technologies Directed at Utilizing Carbon Dioxide from Coal-Fired Power Plants,”* is available via FedConnect. The projects will be a part of DOE’s Carbon Storage Program. From *energy.gov* on August 25, 2016.



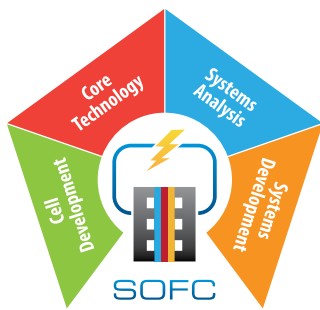
*Schematic Illustrating the Uses of CO<sub>2</sub>*

## ANNOUNCEMENTS

### NETL's 2016 Carbon Storage and Oil and Natural Gas Technologies Review Meeting Materials Available Online.

Proceedings of the 2016 Carbon Storage and Oil and Natural Gas Technologies Review Meeting, held August 16-18, 2016, in Pittsburgh, Pennsylvania, USA, are available. Plenary sessions included an international offshore carbon storage panel discussion and updates on Regional Carbon Sequestration Partnership (RCSP) projects. Poster presentations are also available for download.

### DOE Announces Funding to Advance Cleaner Fossil Fuel-Based Power Generation.



DOE selected 14 research and development (R&D) projects to advance energy systems that will enable cost-competitive, fossil fuel-based power generation with near-zero emissions. The National Energy Technology Laboratory (NETL)-managed projects will accelerate the scale-up of coal-based advanced combustion power systems; advance coal gasification processes; and improve the cost, reliability, and endurance of solid oxide fuel cells (SOFCs). DOE's *Office of Fossil Energy (FE)* will fund the projects.

### NETL Technologies Named Finalists for Awards.

The *Carbon Capture Simulation Initiative (CCSI)* Toolset was one of four NETL-developed technologies named finalists for this year's R&D 100 Awards, presented annually by R&D Magazine in recognition of the top technologies and services across multiple categories. The CCSI Toolset is a suite of computational tools and models tailored to help maximize learning and reduce potential risk during scale-up of carbon capture technologies.

### NETL Releases CCS Education Videos.

NETL released two educational videos on the safe and permanent storage of CO<sub>2</sub>. The *first video* describes NRAP, an NETL-led initiative within DOE's FE that applies science-based prediction for engineered-natural systems to the long-term storage of CO<sub>2</sub>. The *second video* discusses NETL's advances and innovation in cost-effective and safe carbon capture and storage (CCS) strategies.

### DOE Announces Funding to Advance Safe and Permanent Storage of CO<sub>2</sub>.

DOE announced funding for cost-shared R&D projects focused on the safe and permanent storage of CO<sub>2</sub> during CCS operations. The Carbon Storage Assurance and Facility Enterprise (CarbonSAFE) initiative is intended to develop integrated CCS storage complexes, which will be constructed and permitted for operation in the 2025 timeframe following a series of developmental phases.

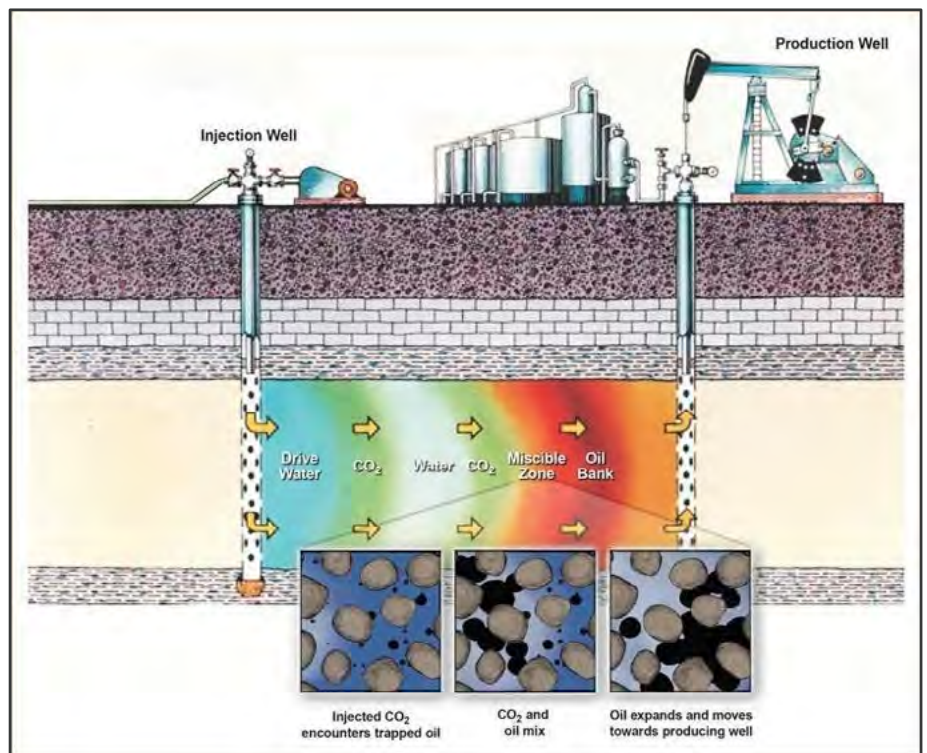
### DOE Investing in Advanced Geologic Carbon Storage and Geothermal Exploration.



DOE selected eight R&D projects to receive federal funding under its *Subsurface Technology and Engineering Research, Development, and Demonstration (SubTER)* Crosscut initiative. The projects will be funded by FE's Carbon Storage Program and the *Office of Energy Efficiency and Renewable Energy's (EERE)* Geothermal Technologies Office (GTO).

### Texas CO<sub>2</sub> Capture Demonstration Project Hits Milestone.

A CCS project sponsored by DOE and managed by NETL successfully captured and transported 3 million metric tons of CO<sub>2</sub> via pipeline. The project demonstrates the implementation of Air Products and Chemicals, Inc.'s *vacuum swing adsorption technology* into a hydrogen production facility, and verifies the effective use of CO<sub>2</sub> enhanced oil recovery (EOR) for permanently storing CO<sub>2</sub>. The project is supported through DOE's *Industrial Carbon Capture and Storage (ICCS) Program*.



Enhanced Oil Recovery Process

## PROJECT and BUSINESS DEVELOPMENTS

### *“Red Tail Energy, EERC Win Funding to Support CCS Study.”*

Red Tail Energy, LLC, (RTE) and the University of North Dakota's Energy and Environmental Research Center (UNDEERC) have been awarded funding by the North Dakota Industrial Commission's Renewable Energy Program to examine CCS integration. The funding will be used to examine the integration of CCS by determining the technical and economic parameters of installing and operating a commercial CCS system at RTE's ethanol manufacturing facility in North Dakota, USA. The Broom Creek Formation, found below the RTE facility, has been identified as the location for potential geologic CO<sub>2</sub> storage. From *Ethanol Producer Magazine* on August 10, 2016.

### *“[CCS Demonstration Project in Japan Starts Up].”*

Commissioned by the Japan Ministry of Economy, Trade, and Industry (METI), Japan CCS (JCCS) is finalizing the commercialization of its CO<sub>2</sub> separation, capture, transportation, and storage technology and has constructed a demonstration plant in Tomakomai, Hokkaido. JCCS is conducting the METI scheme Tomakomai CCS Large-Scale Demonstration Project over a nine-year period, which began in 2012. JCCS completed preparatory work for the plant during its first four years of operation (2012 through 2015). METI initiated pressure injection and CO<sub>2</sub> monitoring in April 2016. Over the course of the demonstration project (a three-year period), more than 100,000 metric tons of CO<sub>2</sub> will be injected each year, stored at two different depths, and monitored. From *gasworld* on August 11, 2016.

## LEGISLATION and POLICY

### *“Canada Advances Mission Innovation with Establishment of Clean Energy Innovation Program.”*

Natural Resources Canada (NRC) announced the Canadian government is seeking proposals for projects as part of the Clean Energy Innovation Program, the goal of which is to advance the commercialization of clean energy technologies. In addition, the initiative will aid Canada in meeting its *Mission Innovation* goal of doubling its 2014 through 2015 funding for clean energy and clean technology R&D by 2020. Mission Innovation is a global initiative of 20 countries focused on accelerating clean energy development. From *Natural Resources Canada News Release* on August 18, 2016.

### *“California Legislature Passes Climate Change Bills.”*

The California Senate voted to extend the state's climate change efforts, setting a target of reducing emissions 40 percent below 1990 levels by 2030. California is currently on track to meet its 2020 goal of reducing emissions to 1990 levels. The bill, which extends the current efforts through 2030, was passed following a linked bill that increases legislative oversight of the climate change programs managed by the California Air Resources Board. From *Reuters* on August 24, 2016.

## EMISSIONS TRADING

### *“Mexico Announces Launch of Cap-and-Trade Pilot Program.”*

Mexican officials announced the launch of a cap-and-trade simulation program as a test run for a national carbon market expected to launch in 2018. The pilot program, which will commence in November 2016, will provide up to 60 voluntary companies the opportunity to adapt to a forthcoming carbon credit system. As part of the Paris climate agreement, Mexico expects to implement measures to reduce GHG emissions by 22 percent by 2030. From *Reuters* on August 15, 2016.

### *“CO<sub>2</sub> Solutions [Finalizes] Commercial Agreement to Deploy CCS Unit in Canada.”*

Fibrex General Partnership, CO<sub>2</sub> Solutions, and Serres Toundra, Inc. finalized an agreement to deploy a CCS unit at a pulp mill in Québec, Canada. The unit will be designed and constructed by CO<sub>2</sub> Solutions and is expected to capture approximately 30 metric tons of CO<sub>2</sub> per day from a pulp mill in Saint-Félicien, Québec, Canada; the CO<sub>2</sub> will then be transported for reuse in Serres Toundra's neighboring vegetable greenhouse. After a successful six-month demonstration period, Serres Toundra will purchase the captured CO<sub>2</sub> for the next 10 years. The site is expected to be commissioned by the end of 2017. From *gasworld* on August 19, 2016.

### *“[Australia Invests in CCS R&D].”*

The Australian CCS Research Development and Demonstration (RD&D) Fund, which provides funding for CCS projects with an emphasis on CO<sub>2</sub> transport and storage, awarded funding to seven applicants. In addition to supporting the Australian government's focus on reducing technical and commercial barriers to the deployment of large-scale CCS projects, the projects selected for funding are also expected to encourage industry investment in further deployment of CCS technologies. Details of the selected applicants, which include both industry- and institution-led projects, are [available online](#). From *Carbon Capture Journal* on August 29, 2016.

### *“Ontario, Québec Sign Climate Policy Deal with Mexico.”*

The governments of Ontario and Québec, Canada, signed an agreement with the Mexican government to jointly develop carbon markets, allowing companies in the two Canadian provinces to purchase Mexican greenhouse gas (GHG) reduction credits. The memorandum was reached during the Climate Summit of the Americas in Guadalajara, Mexico, in August 2016. Under the agreement, Mexico plans to join the *Western Climate Initiative (WCI)*, a non-profit corporation formed to support the implementation of state and provincial GHG emissions trading programs. Ontario and Québec are currently represented in WCI. From *The Globe and Mail* on August 31, 2016.

### *“CO<sub>2</sub> Allowances Sold for \$4.54 in 33rd RGGI Auction.”*

The Northeastern and Mid-Atlantic states participating in the Regional Greenhouse Gas Initiative (RGGI) announced the results of their 33rd auction, in which 14,911,315 CO<sub>2</sub> allowances were sold at a clearing price of \$4.54. None of the 10 million cost containment reserve (CCR) allowances available were sold; the CCR is a fixed additional supply of allowances offered only if CO<sub>2</sub> allowance prices exceed certain price levels (\$8.00 in 2016). The third auction of 2016, Auction 33 generated \$67.7 million for reinvestment in strategic programs, such as energy efficiency, renewable energy, and GHG abatement. To date, total proceeds from all RGGI CO<sub>2</sub> allowance auctions exceeds \$2.58 billion. From *RGGI News Release* on September 9, 2016.

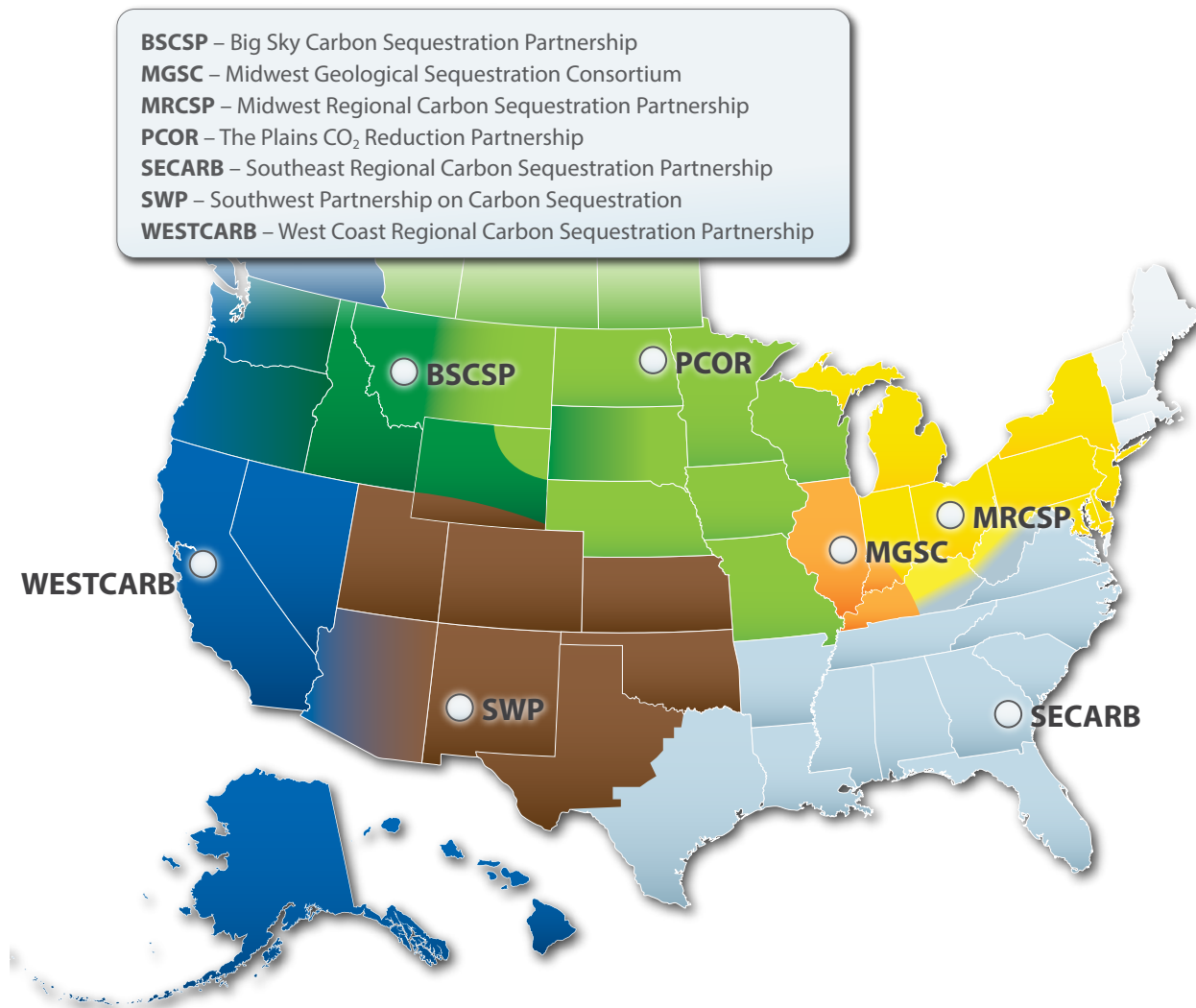
## CLIMATE and SCIENCE NEWS

### “Blowing Bubbles to Catch Carbon Dioxide.”

Researchers from Sandia National Laboratory and the University of New Mexico developed a technology capable of capturing CO<sub>2</sub> from coal- and gas-fired electricity plants. The bubble-like membrane technology, called CO<sub>2</sub> Memzyme, is approximately 10 times thinner than a soap bubble and produces 99-percent pure CO<sub>2</sub>. A video on CO<sub>2</sub> Memzyme, which has been tested successfully at the laboratory scale, is [available online](#). From *Sandia National Laboratories News Release* on September 1, 2016.

### “USGS Studies Groundwater Sampling for CO<sub>2</sub>.”

Scientists at the U.S. Geological Survey (USGS), Electric Power Research Institute (EPRI), and Lawrence Berkeley National Laboratory (LBNL) completed a comparison study of deep-groundwater sampling techniques to provide guidance on the methods available to accurately reflect CO<sub>2</sub> storage effectiveness. The study, titled “*Comparison of geochemical data obtained using four brine sampling methods at the SECARB Phase III Anthropogenic Test CO<sub>2</sub> injection site, Citronelle Oil Field, Alabama,*” was published in the *International Journal of Coal Geology* and included four sampling methods: gas lift, electric submersible pump, a down-hole vacuum sampler, and a U-tube. The research was carried out at the Citronelle injection site in Alabama, USA, which is part of the Southeast Regional Carbon Sequestration Partnership (SECARB) Anthropogenic Test project. SECARB is one of [seven DOE RCSPs](#). From *Carbon Capture Journal* on September 1, 2016.



Map depicting location of the seven RCSP Regions

## JOURNAL ARTICLES

***“Reducing costs of carbon capture and storage by shared reuse of existing pipeline—Case study of a CO<sub>2</sub> capture cluster for industry and power in Scotland.”***

The following is the Abstract of this article: “The deployment of CCS is [recognized] as critical to delivering deep decarbonisation of energy and industrial processes. CCS clusters, where multiple CO<sub>2</sub> emitting sources share CO<sub>2</sub> transport and storage infrastructures, offer cost savings and enable smaller sources to undertake CCS, which are unlikely to be capable of justifying a stand-alone transport and storage system. Scotland has a legacy of onshore and offshore pipelines, which transported methane from producing regions. These can be re-used to connect CO<sub>2</sub> emitters to storage. Approximately 80 [percent] of large [stationary]-source CO<sub>2</sub> emissions in Scotland are within 40 km of the Feeder 10 pipeline. Thirteen selected emitters are evaluated for potential CO<sub>2</sub> capture volume, estimated capture project cost and cost of connection. Scenarios for sequential deployment show that Feeder 10 has capacity through known expansion potential for developments allowing capture volumes rising from 2 to 8 Mt yr<sup>-1</sup> CO<sub>2</sub>.” **Peter A. Brownsort, Vivian Scott, and R. Stuart Haszeldine**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

***“The impact of verified emissions announcements on the European Union emissions trading scheme: A bilaterally modified dummy variable modelling analysis.”***

The following is the Abstract of this article: “Carbon trading scheme is easily subject to the shocks from vital information announcements or regulations modification due to its vulnerability as a man-made market. This paper investigates the impact of verified emissions announcements, which are released annually by the European Commission and span three phases (2006–2013), on carbon price returns and volatility in the European Union emissions trading scheme (EU ETS), by constructing econometric model with bilaterally modified dummy variables of high adaptability. The results show that on average, verified emissions announcements have significant impact on carbon expected returns but show a week effect on price volatility; the separate examination for each announcement event indicates heterogeneous ex-ante and ex-post impacts over time in different market contexts, but the ex-post impact dominates obviously. The verified emissions announcement remarkably causes shocks to the market and the risk of prior information leakage although it facilitates the price discovery. Meanwhile, there is an obvious asymmetry between ex-ante and ex-post impacts that is triggered by market characteristics, and it generally takes more than seven days to absorb the ex-post impacts due to the intrinsic characteristics of the EU ETS. These findings could provide reference for market traders and regulators to make robust allowance management strategy and system design.” **Jun-Jun Jia, Jin-Hua Xu, and Ying Fan**, *Applied Energy*. (Subscription may be required.)

***“Pore-scale supercritical CO<sub>2</sub> dissolution and mass transfer under imbibition conditions.”***

The following is the Abstract of this article: “In modeling of geological carbon storage, dissolution of supercritical CO<sub>2</sub> (scCO<sub>2</sub>) is often assumed to be instantaneous with equilibrium phase partitioning. In contrast, recent core-scale imbibition experiments have shown a prolonged depletion of residual scCO<sub>2</sub> by dissolution, implying a non-equilibrium mechanism. In this study, eight pore-scale scCO<sub>2</sub> dissolution experiments in a 2D heterogeneous, sandstone-analog micromodel were conducted at supercritical conditions (9 MPa and 40°C). The micromodel was first saturated with deionized (DI) water and drained by injecting scCO<sub>2</sub> to establish a stable scCO<sub>2</sub> saturation. DI water was then injected at constant flow rates after scCO<sub>2</sub> drainage was completed. High resolution time-lapse images of scCO<sub>2</sub> and water distributions were obtained during imbibition and dissolution, aided by a scCO<sub>2</sub>-soluble fluorescent dye introduced with scCO<sub>2</sub> during drainage. These images were used to estimate scCO<sub>2</sub> saturations and scCO<sub>2</sub> depletion rates. Experimental results show that (1) a time-independent, varying number of water-flow channels are created during imbibition and later dominant dissolution by the random nature of water flow at the micromodel inlet, and (2) a time-dependent number of water-flow channels are created by coupled imbibition and dissolution following completion of dominant imbibition. The number of water-flow paths, constant or transient in nature, greatly affects the overall depletion rate of scCO<sub>2</sub> by dissolution. The average mass fraction of dissolved CO<sub>2</sub> (dsCO<sub>2</sub>) in water effluent varies from 0.38 [percent] to 2.72 [percent] of CO<sub>2</sub> solubility, indicating non-equilibrium scCO<sub>2</sub> dissolution in the millimeter-scale pore network. In general, the transient depletion rate decreases as trapped, discontinuous scCO<sub>2</sub> bubbles and clusters within water-flow paths dissolve, then remains low with dissolution of large bypassed scCO<sub>2</sub> clusters at their interfaces with longitudinal water flow, and finally increases with coupled transverse water flow and enhanced dissolution of large scCO<sub>2</sub> clusters. The three stages of scCO<sub>2</sub> depletion, common to experiments with time-independent water-flow paths, are revealed by zoom-in image analysis of individual scCO<sub>2</sub> bubbles and clusters. The measured relative permeability of water, affected by scCO<sub>2</sub> dissolution and bi-modal permeability, shows a non-monotonic dependence on saturation. The results for experiments with different injection rates imply that the non-equilibrium nature of scCO<sub>2</sub> dissolution becomes less important when water flow is relatively low and the time scale for dissolution is large, and more pronounced when heterogeneity is strong.” **Chun Chang, Quanlin Zhou, Timothy J. Kneafsey, Mart Oostrom, Thomas W. Wietsma, and Qingchun Yu**, *Advances in Water Resources*. (Subscription may be required.)

***“Comparison of geochemical data obtained using four brine sampling methods at the SECARB Phase III Anthropogenic Test CO<sub>2</sub> injection site, Citronelle Oil Field, Alabama.”***

The following is the Abstract of this article: “The chemical composition of formation water and associated gases from the lower Cretaceous Paluxy Formation was determined using four different sampling methods at a characterization well in the Citronelle Oil Field, Alabama, as part of the SECARB Phase III Anthropogenic Test, which is an integrated [CCS] project. In this study, formation water and gas samples were obtained from well D-9-8 #2 at Citronelle using gas lift, electric submersible pump, U-tube, and a downhole vacuum sampler (VS) and subjected to both field and laboratory analyses. Field chemical analyses included electrical conductivity, dissolved sulfide concentration, alkalinity, and pH; laboratory analyses included major, minor and trace elements, dissolved carbon, volatile fatty acids, free and dissolved gas species. The formation water obtained from this well is a Na–Ca–Cl-type brine with a salinity of about 200,000 mg/L total dissolved solids. Differences were evident between sampling methodologies, particularly in pH, Fe and alkalinity. There was little gas in samples, and gas composition results were strongly influenced by sampling methods. The results of the comparison demonstrate the difficulty and importance of preserving volatile analytes in samples, with the VS and U-tube system performing most favorably in this aspect.” **Christopher H. Conaway, James J. Thordsen, Michael A. Manning, Paul J. Cook, Robert C. Trautz, Burt Thomas, and Yousif K. Kharaka**, *International Journal of Coal Geology*. (Subscription may be required.)

## JOURNAL ARTICLES *(cont.)*

### *“Stakeholder and public perceptions of CO<sub>2</sub>-EOR in the context of CCS – Results from UK focus groups and implications for policy.”*

The following is the Abstract of this article: “Interest is growing in CO<sub>2</sub>-EOR as an additional economic incentive for CO<sub>2</sub> injection and demonstration of storage feasibility. However, given increasing societal concern over fossil fuel energy, could CO<sub>2</sub>-EOR unintentionally hinder conventional CCS by reducing support from neutral or cautiously supportive voices? This paper assesses how stakeholders and citizens respond to four scenarios for CCS with CO<sub>2</sub>-EOR in the North Sea, and draws societal implications for deployment in other mature basins. Based on focus group data from Aberdeen, Edinburgh and London, [the authors] argue that scenarios [emphasizing maximizing] oil recovery may be met with [skepticism] or even opposition, and that there is an expectation for national governments to lead and ensure CO<sub>2</sub>-EOR (and CCS more generally) are undertaken in the public interest. Nonetheless, [the authors’] data also suggest a certain degree of pragmatism as to the embeddedness of fossil fuels in society, and thus that there may be qualified support for CCS with CO<sub>2</sub>-EOR as making best use of existing fields whilst [decarbonizing] the power and industrial sectors. However, for this support to emerge there is an imperative for coherent and credible policy that positions CO<sub>2</sub>-EOR firmly within a managed transition towards a low-carbon economy.” **Leslie Mabon and Chris Littlecott**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

### *“Seismic monitoring of CO<sub>2</sub> [geostorage]: CO2CRC Otway case study using full 4D FDTD approach.”*

The following is the Abstract of this article: “Stage 2C of the Otway project by CO2CRC Limited was designed as a feasibility study of seismic monitoring to detect and [characterize] small-scale [release] of CO<sub>2</sub>-rich gas into a saline [formation]. Design of the monitoring program is based on a series of simulations conducted in 2007–2014. The gas plume is likely to be small in size and the contrast in elastic properties is also predicted to be relatively low. To [maximize] the chances of detecting the low-amplitude time-lapse signal [the authors optimize] the current time-lapse processing workflow using synthetic datasets for the entire baseline and monitor surveys. The datasets were obtained by an elastic 3D FDTD modelling approach for the actual field acquisition geometry and the most realistic model of the subsurface and distribution of elastic properties in the gas plume. To this end [the authors] built a full-earth static geological model of the Otway site with resolution typical for reservoirs in petroleum exploration. Distributions of the seismic properties were obtained from geostatistical interpolation between wells within the static model. The analysis of the synthetic datasets gives an estimate of the magnitude of the time-lapse signal and illustrates effects of the conventional processing procedures on the signal in the presence of the band limited random noise. [The authors] have found that the anticipated intensity of the time-lapse signal is comparable to the average intensity of the reflections observed within the target interval, and hence should be sufficient for the detection of the signal. [The authors] believe that the proposed modelling workflow is of methodological value since it provides a reliable basis for seismic feasibility studies and development of modelling-driven processing workflows.” **Stas Glubokovskikh, Roman Pevzner, Tess Dance, Eva Caspari, Dmitry Popik, Valeriya Shulakova, and Boris Gurevich**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

## REPORTS and PUBLICATIONS

### *“CCS Forum Report.”*

The following is from the Executive Summary of this document: “The three-day CCS Forum, held in London, hosted delegates from academia, industry, and government to discuss the future of CCS and, in particular, to identify the key research challenges to be addressed in the near-to-medium term. In all sectors pertaining to CCS, it was agreed that translating major research findings to the market often takes many years and that developing a systematic procedure for the acceleration of the transition of academic research to pilot- and demonstration-scales is essential. Over the course of the three days, the applications of CO<sub>2</sub> capture technologies to the power and industrial sectors were discussed in detail, as was the subsequent geological storage of the CO<sub>2</sub>. In addition to the [utilization] of the CO<sub>2</sub> in enhanced hydrocarbon recovery, the mineral carbonation of industrial wastes and also the potential for the further conversion of CO<sub>2</sub> into chemicals was discussed. Furthermore, the role of policy measures to enable the deployment of CO<sub>2</sub> to the power and industry sectors was discussed. The critical needs identified have been summarized in the Executive Summary and the detailed insights are included in each section throughout the remainder of the document.”

### *“Carbon Capture and Storage (CCS) Market Analysis: By Technology (Post Combustion, Pre Combustion, Oxy Fuel Technology); By Storage (Geological, Ocean and Mineral); By End User (Chemical, Fertilizer, Iron and Steel, Oil & Gas) – Forecast (2016 – 2021).”*

The following is a description of this report: “CCS technology has emerged as critical technical component in the combined efforts of various nations to combat climate change. [CCS] refers to the capturing of [CO<sub>2</sub>] from different sources of emission, separating it from other gases and transporting to a suitable location for storage. Considering the cumulative commitment of disparate industrial stakeholders in curbing CO<sub>2</sub> emissions coupled with ongoing dominant role of fossil fuels in energy generation, the [CCS] technology is being adopted and employed across the globe. The report explains that global [CCS] market is segmented on the basis of type of capture technology, storage technology and geography. Based on capture technology, market is classified into: [Post Combustion Capture, Pre Combustion Capture, Oxy Fuel Technology and Others.] Also, based on the storage methods, the market has been categorized into: [Geological Storage, Mineral Storage, Ocean Storage and Others. CCS] technology finds its applications into a variety of end user industries which include: [Chemical Production, Fertilizer Production, Iron and Steel, Oil & Gas, Power generation and Others.] Each of these segments is further broken down to give an in-depth analysis of the market. The [CCS] market report analyses the applications in disparate end user industries coupled with market demand from across the regions. The growth in [CCS] market is driven from Non Organization for Economic Corporation and Development (OECD) countries with a strong economic growth and industrialization. The increase of energy consumption is projected from renewable energy and nuclear power, presently contributing 2.5 [percent] growth to the market per year. Policies and regulations governing usage of fossil fuels and [CO<sub>2</sub>] emissions fuel are set to increase the market growth. The increase in usage of biofuels resulted in the increase of energy consumption.”

### *“A need unsatisfied: Blueprint for enabling investment in CO<sub>2</sub> storage.”*

The following is the Executive Summary of this Deloitte LLP document: “The Crown Estate commissioned Deloitte LLP to project manage and participate in a collaborative study that investigated the risks of offshore CO<sub>2</sub> storage development and identified potential commercial models for public and private investment in CO<sub>2</sub> transport and offshore storage infrastructure. Storage rights on the UK continental shelf are owned by The Crown Estate. . . The conclusions and recommendation in this report are intended to: move forward discussion between policy makers and industry participants form full-chain CCS projects [and] provide a suitable framework that enable CO<sub>2</sub> storage projects to be developed and which can serve the needs of both power stations and industrial emitters.”

## ABOUT DOE'S CARBON STORAGE PROGRAM

The **Carbon Storage Program** advances the development and validation of technologies that enable safe, cost-effective, permanent geologic storage of CO<sub>2</sub>. The Carbon Storage Program also supports the development of best practices for CCS that will benefit projects implementing CCS at a commercial scale, such as those being performed under NETL's Clean Coal Power Initiative and Industrial Carbon Capture and Storage Programs. The technologies being developed and the small- and large-scale injection projects conducted through this program will be used to benefit the existing and future fleet of fossil fuel power-generating facilities by developing tools to increase our understanding of the behavior of CO<sub>2</sub> in the subsurface and identifying the geologic reservoirs appropriate for CO<sub>2</sub> storage.

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 [National Energy Technology Laboratory's CCS Database](#) includes active, proposed, and terminated CCS projects worldwide. The information is taken from publically available sources to provide convenient access to information regarding efforts by various industries, public groups, and governments towards development and eventual deployment of CCS technology. NETL's CCS Database is available as a Microsoft Excel spreadsheet and also as a customizable layer in Google Earth.

Newsletters, program fact sheets, best practices manuals, roadmaps, educational resources, presentations, and more are available via the [Carbon Storage Program Publications webpage](#).

Get answers to your carbon capture and storage questions at NETL's [Frequently Asked Questions webpage](#).

## 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

The [National Energy Technology Laboratory \(NETL\)](#), part of DOE's national laboratory system, is owned and operated by the U.S. Department of Energy (DOE). NETL supports DOE's mission to advance the national, economic, and energy security of the United States.

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### Get Social with Us

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



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