

## CSN

CARBON STORAGE  
NEWSLETTER

JANUARY 2019

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:

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## DOE/NETL HIGHLIGHTS

*DOE Issues Notice of Intent for Carbon Storage Funding.*

The U.S. Department of Energy (DOE) *issued a Notice of Intent (NOI)* to provide federal funding for research and development (R&D) projects that contribute to the development of transformational sensing capabilities for monitoring parameters associated with subsurface carbon dioxide (CO<sub>2</sub>) storage. The National Energy Technology Laboratory (NETL) will manage the projects selected under the Funding Opportunity Announcement (FOA), "Transformational Sensing Capabilities for Monitoring the Subsurface," which will be issued in fiscal year (FY) 2019. The objective of the FOA is to competitively solicit and award R&D projects that improve existing technologies to reduce uncertainty and enable real-time decision-making associated with subsurface CO<sub>2</sub> storage. From *energy.gov* on January 3, 2019.

## ANNOUNCEMENTS

*DOE Issues NOI for Crosscutting Technologies.*

NETL issued an NOI for an FOA for cost-shared R&D projects to enhance the performance and economics of the existing and future coal fleet. The objective of the FOA is to competitively solicit and award R&D projects to develop innovative technologies that can improve operational performance, reduce costs at existing coal power plants, and enhance future facilities. "*Crosscutting Research for Coal-Fueled Power Plants*" is expected to be available in FY 2019.

*NARUC Publishes Study of CCUS Technology and Policy.*

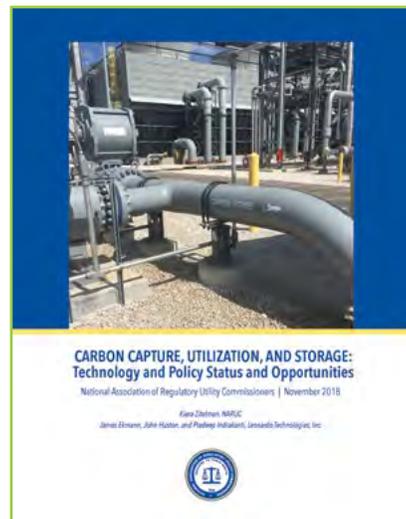
NETL contributed to a report from the National Association of Regulatory Utility Commissioners (NARUC) that examines the state of national carbon issues. The report, titled "*Carbon Capture, Utilization, and Storage: Technology and Policy Status and Opportunities*," assists state regulators in their understanding of current carbon capture, utilization, and storage (CCUS) policy and technology. Developed by NARUC's Center for Partnerships and Innovation, the report is part of the NARUC/DOE Carbon Capture, Storage, and Utilization Partnership.

*NASA Instrument Maps Carbon Storage in 3D.*

Led by the University of Maryland in collaboration with the National Aeronautics and Space Administration's (NASA) Goddard Space Flight Center, the Global Ecosystem Dynamics Investigation (GEDI) telescope will provide a three-dimensional map of forest canopies and carbon storage. The instrument is capable of revealing the makeup of remote forest ecosystems around the world.

*Award Launched for Best CO<sub>2</sub> Utilization.*

Innovative technologies and products in the carbon capture and utilization area will be eligible to win a new award for "Best CO<sub>2</sub> Utilization." The award will allow innovators to market their CO<sub>2</sub> capture or conversion technology, CO<sub>2</sub>-based material, or a corresponding product launched to the market in 2018 or 2019. The award will be presented at the "*7<sup>th</sup> Conference on Carbon Dioxide as Feedstock for Fuels, Chemistry, and Polymers*," which will take place March 20-21, 2019, in Cologne, Germany.



## ANNOUNCEMENTS *(cont.)*

### *Report on CCS Released.*

The Global CCS Institute released a report, titled “*Global Status of CCS: 2018*,” at the United Nation’s (UN) 24<sup>th</sup> Conference of the Parties (COP24) in Katowice, Poland. The report depicts the importance of deploying carbon capture and storage (CCS) technologies.



### *CCUS Lessons-Learned Workshop Held.*

Emissions Reduction Alberta (ERA) held a CCUS lessons-learned workshop in Calgary, Canada. Technology developers, industry insiders, investors, government employees, and regulatory officials attended the workshop, at which topics covered included the business case for carbon capture and use, the market potential of current and future technologies, knowledge sharing of the operation of commercial facilities, and implementing CCUS projects.

## PROJECT and BUSINESS DEVELOPMENTS

### *CCS Test Started at Japanese Cement Plant.*

In conjunction with the government of Japan’s Ministry of Environment, Taiheiyo Cement started a CCS test at its Fujiwara plant in Inabe, Japan. The company is testing a chemical absorption method, with further installations on the project planned in early 2019. From *Global Cement* on January 2, 2019.

### *CCS License Awarded.*

## Pale Blue Dot.

The Oil and Gas Authority (OGA), the licensing authority of offshore CO<sub>2</sub> storage in the United Kingdom (UK), awarded a CO<sub>2</sub> appraisal and storage license to Pale Blue Dot Energy for the Acorn CCS project, which seeks to reuse existing oil and gas infrastructure for transporting and storing CO<sub>2</sub>. In addition, the Acorn CCS project will also repurpose or rebuild an existing CO<sub>2</sub> capture facility based at the St. Fergus Gas Terminal, located on the Aberdeenshire coast. Together with the *lease option awarded by Crown Estate Scotland*, these documents allow Pale Blue Dot to undertake the characterization work required for a full lease and storage permit to permanently store CO<sub>2</sub> at the Acorn CO<sub>2</sub> storage site. From *Oil and Gas Authority* on December 6, 2018.

### *Zero-Emission Cement Plant Takes Shape in Norway.*

A *cement plant in Brevik, Norway*, is moving towards becoming carbon free. According to officials at the Norcem plant, the first stage of CCS installation is expected to capture approximately half of the plant’s CO<sub>2</sub> emissions. A final feasibility study will be published in August 2019 in order to inform a Norwegian government proposal to invest in building the full-scale CCS facility. According to officials, if the proposal is approved by Parliament, the project will enter a three-year construction phase. From *EURACTIV.com* on December 17, 2018.

### *CCS Projects Selected for EU Funding.*

Twelve near-zero emissions projects were awarded European Union (EU) Horizon 2020 funding under the *Competitive Low-Carbon Energy* calls for proposals. *The selected projects* are expected to develop technologies for capturing, storing, and converting CO<sub>2</sub>. Project areas include advanced CO<sub>2</sub> capture technologies, conversion of captured CO<sub>2</sub>, strategic planning for CCUS development, and modeling in support of the transition to a low-carbon energy system in Europe. The projects are expected to be launched in spring 2019. From *Carbon Capture Journal* on December 21, 2018.

## LEGISLATION and POLICY

### *Carbon Tax Legislation Introduced.*

Two U.S. Senators introduced carbon tax legislation that would place a price on CO<sub>2</sub> and other greenhouse gas (GHG) emissions. S. 3791, “*The Energy Innovation and Carbon Dividend Act*,” is designed to address potential climate change and encourage market-driven innovation in clean energy technologies. A one-pager on the bill is *available online*. From *U.S. Senator Jeff Flake Press Release* on December 20, 2018.

### *Canada Carbon Pricing Act Takes Effect.*

Canada’s *Greenhouse Gas Polluting Pricing Act* went into effect on January 1, 2019, instituting a fee on carbon emissions beyond a certain threshold for larger industrial facilities. The act is reserved for the provinces that did not adopt the carbon pricing system or did not develop their own plan. From *Kitchener Today* on January 1, 2019.

## EMISSIONS TRADING



### *RGGI Releases 2016 Annual Electricity Monitoring Report.*

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the “*CO<sub>2</sub> Emissions from Electricity Generation and Imports in the Regional Greenhouse Gas Initiative: 2016 Monitoring Report*.” The eighth in a *series of annual monitoring reports*, this report summarized data for the period from 2005 through 2016 for electricity generation, net electricity imports, and related CO<sub>2</sub> emissions for the states participating in RGGI’s third control period. From *RGGI News Release* on December 13, 2018.

### *RGGI Releases Statement, Revision.*

The RGGI-participating states *released a statement* on the New Jersey Department of Environmental Protection’s *draft proposed regulation* to reduce GHG emissions (which will be open for public comment through February 15, 2019). In addition, the RGGI-participating states also *issued a revision* to the *2017 Model Rule*, which was developed to provide guidance to states as they implement the RGGI program. From *RGGI News Releases* on December 14 and 17, 2018.

## CLIMATE and SCIENCE NEWS

### *Scientists Identify New Minerals for Carbon Capture and Storage.*

University of Alberta (Canada) geologists have identified new minerals that are capturing and storing CO<sub>2</sub>. Members of the hydrotalcite group, the minerals are the first outside of the carbonate family to naturally capture CO<sub>2</sub> in mine waste. The research, which was [published in the International Journal of Greenhouse Gas Control](#), highlights the potential for improving carbon capture one to two meters beneath the surface of mining wastes, where most carbon storage usually occurs. According to researchers, findings of the study, which was conducted at the Woodsreef Asbestos Mine in New South Wales, Australia, point to the potential of mineral waste from mines to more effectively store CO<sub>2</sub>. From *ScienceDaily* on December 12, 2018.

### *New Soil Management Portal Helps Track Carbon Storage.*

An Agri-Tech company has launched a Nutrient Management System that has the potential to quantify carbon storage in soil, according to company officials. Farmeye's NMP Portal is an online, map-based system for soil nutrient management and a tool to help manage and monitor fertilizer usage on farms. From *Agri-Land* on December 31, 2018.

## JOURNAL ARTICLES

### *CO<sub>2</sub>-SCREEN tool: Application to the Oriskany sandstone to estimate prospective CO<sub>2</sub> storage resource.*

The following is the Abstract of this article: "The ability to accurately predict the CO<sub>2</sub> storage resource in saline formations is important to make high-level, energy-related government policy and business decisions. CO<sub>2</sub>-SCREEN (Storage prospective Resource Estimation Excel aNalysis) is a tool developed by DOE-NETL to screen saline formations for prospective CO<sub>2</sub> storage resources. CO<sub>2</sub>-SCREEN uses DOE methods and equations to serve as a consistent mechanism for calculating prospective CO<sub>2</sub> storage resources. CO<sub>2</sub>-SCREEN is comprised of two files: an Excel file used for inputs and outputs and a GoldSim Player file used to run Monte Carlo simulations. CO<sub>2</sub>-SCREEN requires input of physical geologic parameters (i.e. thickness, porosity) as well as efficiency factor ranges (i.e. net-to-gross thickness) to calculate a mass storage estimate. An application of CO<sub>2</sub>-SCREEN is demonstrated here using well log data from the Oriskany Sandstone portion in Pennsylvania. The Oriskany Sandstone is divided into 20 km x 20 km grid cells in which 151 cells contain well log data. CO<sub>2</sub>-SCREEN calculates prospective CO<sub>2</sub> storage resource for each grid cell based on the well log data and uses lithology and depositional environment information for efficiency factor ranges. The Oriskany Sandstone CO<sub>2</sub> storage resource estimate for Pennsylvania, calculated by CO<sub>2</sub>-SCREEN, ranges from 0.07 to 1.28 gigatons (Gt) with a P50 value of 0.32 Gt. This resource assessment analysis is done to demonstrate the use of CO<sub>2</sub>-SCREEN and results are comparable to previous studies which encourages the application of CO<sub>2</sub>-SCREEN to other saline formations and warrants exploring the expansion of this tool to assess the CO<sub>2</sub> storage resource in other formations such as shale and depleted oil and gas reservoirs." **Sean Sanguinito, Angela L. Goodman, and James I. Sams III**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)



### *Immediate and long-run impacts of a forest carbon policy—A market-level assessment with heterogeneous forest owners.*

The following is the Abstract of this article: "Sequestering carbon in forests and wood products is an inexpensive way to reduce the atmospheric carbon concentration. However, its full potential is not utilized in present climate policies. Optimizing sequestration, while continuing to harvest wood for materials and energy, could reduce the economic burden of mitigation efforts.

### *Global-Scale Evaluation of Role of Soil Minerals in Carbon Storage.*

Scientists from University of California, Santa Barbara, and Washington State University (USA) have found that minerals in soil can store a significant amount of atmospheric CO<sub>2</sub>. The researchers conducted a global-scale evaluation of the role soil plays in producing dissolved organic matter and storing it in minerals by consulting soil profiles from the National Ecological Observatory Network (NEON). The results showed that wetter climates are more conducive to the formation of minerals that are more effective at storing CO<sub>2</sub>, while more arid climates store less CO<sub>2</sub>, thus suggesting that a change in water balance could drive carbon storage. From *ScienceDaily* on January 2, 2019.

### *Study Shows Organic Particles Effect on Carbon Cycling.*

A *new study* analyzed how carbon degraded in different aquatic habitats in Sweden's boreal forests, where CO<sub>2</sub> is often stored in conifers. Conducting the study to better understand carbon transformation and the role of particulate organic carbon (POC) in boreal waters, the researchers found that across all aquatic ecosystems, the degradation rates of POC were approximately 15 times higher than those of dissolved organic carbon (DOC). According to researchers, the results imply that particulate organic matter may play a role in aquatic CO<sub>2</sub> emissions. From *Eos.org* on January 2, 2019.

Optimal sequestration can be incentivized by subsidizing carbon storage according to its social value. [The authors] analyze the dynamic market-level impacts of implementing a forest carbon policy by using the Finnish Forest and Energy Policy model (FinFEP). [The authors] find that sizeable and immediate increases in carbon sinks can be obtained, even with low carbon prices. High carbon payments strongly increase the carbon sink in the short run, but this impact diminishes over time. Low payments have a milder but longer-lasting impact. Forest owners' valuations of forest amenities also affect the magnitude and dynamics of harvest and carbon sequestration results. Thus, a realistic description of forest owner behavior is needed to assess the impacts of forest carbon policies. Moreover, [the authors] show that a market-level model is necessary for assessing the regional carbon sequestration impacts and costs. Relying on stand-level models with fixed timber prices may yield overly optimistic results." **Johanna Pohjola, Jani Laturi, Jussi Lintunen, and Jussi Uusivuori**, *Journal of Forest Economics*. (Subscription may be required.)

### *A dynamic assessment of instrument interaction and timing alternatives in the EU low-carbon policy mix design.*

The following is the Abstract of this article: "The European Union low-carbon strategy includes a range of complementary policies. Potential interactions between instruments and different timing of their implementation can influence the cost and likelihood of achieving the targets. [The authors] test the interactions between the three main pillars of the European Union strategy through a dynamic Computable General Equilibrium model (GDynEP) with a time horizon of 2050. Main results are: i) going for the unilateral European Union carbon mitigation target without any complementary technological policy will produce large economic losses; ii) by investing in clean energy technologies (energy efficiency and renewable energy) with a carbon tax revenue recycling mechanism, these losses will decrease substantially; iii) when complementary clean energy technology policies are implemented, the optimal timing of binding targets changes; iv) the higher the public support to clean energy technologies, the larger the economic gains in early adoption of challenging abatement targets." **Massimiliano Corradini, Valeria Costantini, Anil Markandya, Elena Paglialunga, and Giorgia Sforna**, *Energy Policy*. (Subscription may be required.)

## JOURNAL ARTICLES *(cont.)*

### *Economic [optimization] of European supply chains for CO<sub>2</sub> capture, transport and sequestration, including societal risk analysis and risk mitigation measures.*

The following is the Abstract of this article: "European large stationary sources are currently emitting more than 1.4 Gt of CO<sub>2</sub> every year. A significant decrease in [GHG] emissions cannot be achieved without CCS technologies. However, although being practiced for over 30 years, CO<sub>2</sub> transportation is intrinsically [characterized] by the risk of leakage. This study proposes to assess and tackle this issue within the CCS design problem, by proposing a spatially explicit mixed integer linear programming approach for the economic [optimization] of a European supply chain for carbon capture, transport and geological storage, where societal risk assessment is formally incorporated within the modelling framework. Post-combustion, oxy-fuel combustion and pre-combustion are considered as technological options for CO<sub>2</sub> capture, whereas both pipelines (inshore and offshore) and ships are taken into account as transport means. Both inland-inshore and offshore injection options are available for carbon geological sequestration. Risk mitigation measures are considered in the design of the transport network. The overall supply chain is economically [optimized] for different minimum carbon reduction scenarios. Results demonstrate that accounting for societal risk may impact the overall carbon sequestration capacity, and that the proposed approach may represent a valuable tool to support policy makers in their strategic decisions." **Federico d'Amore, Paolo Mocellin, Chiara Vianello, Giuseppe Maschio, and Fabrizio Bezzo**, *Applied Energy*. (Subscription may be required.)

### *Carbon Capture and Sustainable Utilization by Algal Polyacrylonitrile Fiber Production: Process Design, Techno-Economic Analysis, and Climate Related Aspects.*

The following is the Abstract of this Article: "Carbon capture and sustainable utilization (CCU) is essential to accomplishing the targets of 2015's Paris Agreement. A promising option consists of algal based CO<sub>2</sub> conversion into lipid rich biomass with further processing into polyacrylonitrile (PAN) fiber, the major precursor for carbon fiber production. A first feasibility analysis was carried out under multiple constraints for price, byproduct yield, and consumption of land, CO<sub>2</sub>, and energy. Several process-route alternatives were composed, modeled, and compared in terms of mass and energy flows, resource needs, and cost. To quantify risks from market and modeling uncertainties, [the authors] conducted a primary techno-economic analysis (TEA) with variable process pathways in a dynamic economic model of a related project company (SPV), embedded in a Monte Carlo simulation. First results indicate that process combinations with algal biodiesel-production and biomass-liquefaction (BtL) components come close to meeting the multiple constraints and justify progressing to extended research and development activities." **Uwe Arnold, Thomas Brück, Andreas De Palmenaer, and Kolja Kuse**, *Industrial & Engineering Chemistry Research*. (Subscription may be required.)

### *Practical deployment of pipelines for the CCS network in critical conditions using MINLP modelling and optimization: A case study of South Korea.*

The following is the Abstract of this article: "In applying CCS technology, pipelines are an economic choice for transporting CO<sub>2</sub>. However, it is difficult to plan the pipeline network in detail since various factors, such as mountain regions and high population density increase the cost of pipeline installation. Also, uncertainty of the reservoir capacity and national policies is important factors in practical pipeline deployment, especially in critical conditions mentioned above. In this study, the development of an optimal CCS pipeline network in critical conditions, and the effect of practical design conditions on the network, are studied using mixed-integer nonlinear programming (MINLP)

modeling and optimization. South Korea is selected as a case study and optimal CCS networks are obtained according to four scenarios developed with regard to reservoir capacity and policy options. A rigorous cost model was developed, and subdivided penalty factors were applied to consider the drastic change in geographical conditions. The four scenarios were evaluated and the effect of the considered factors on the timely development of the CCS network was analyzed." **Changsoo Kim, Kyeongsu Kim, Jeongnam Kim, Usama Ahmed, and Chonghun Han**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

### *Shelf space allocation problem under carbon tax and emission trading policies.*

The following is the Abstract of this article: "This study formulates a mixed integer nonlinear programming (MINLP) model for the shelf space allocation problem (SSAP) under two common environmental policies: the Carbon Tax System and the Emission Trading System. For each system, the impact on profitability and the opportunities for emission cuts are presented. Via numerical experiments [the authors] specifically explore the impact of a fixed carbon tax, emission allowances, and emission price on two of the most important in-store management decisions in retail: shelf space capacity and product allocation decisions. Real-life retail data of four product categories are tested and solved to optimality using COUENNE. Then, [the authors] analyze optimal solutions to gain important insights for the benefit of both retailers and governmental decision makers." **Vincent F. Yu, Renan Maglasang, and Yu-Chung Tsao**, *Journal of Cleaner Production*. (Subscription may be required.)

### *Regional impacts of launching national carbon emissions trading market: A case study of Shanghai.*

The following is the Abstract of this article: "This study investigates the impacts of launching a national carbon trade market through the IMEDICGE (Integrated Model of Energy, Environment and Economy for Sustainable Development/Computable General Equilibrium) model, between Shanghai and the Rest of China (ROC). Five scenarios are established by considering China's Nationally Determined Contributions (NDC) targets, including a baseline scenario (BaJ scenario), a carbon cap on ETS participating sectors scenario (CAPsec scenario), a carbon cap on Shanghai and ROC regions scenario (CAPreg scenario), a carbon cap scenario with local carbon emissions trading among ETS participating sectors (ETsec scenario) and a carbon cap scenario with inter-regional carbon emissions trading (ETreg scenario). The results under the ETreg scenario predict a carbon price of 164.64 USD/tCO<sub>2</sub> and a total carbon trade volume of 189.91 Mt by 2030. The metal smelting sector will be the largest seller of emissions quotas in Shanghai, whereas the power generation sector will be the largest buyer. Due to its higher carbon mitigation cost and increasing autonomous carbon intensity, the aviation sector will face more challenges to reduce emissions among ETS participating sectors in Shanghai. The results indicate that launching a national carbon trade market could generate both economic and environmental benefits and help China achieve its NDC targets." **Zhiqing Liu, Yong Geng, Hancheng Dai, Jeffrey Wilson, Yang Xie, Rui Wu, We You, and Zhongjue Yu**, *Applied Energy*. (Subscription may be required.)

## REPORTS and OTHER PUBLICATIONS

***Experimental and Numerical Modeling Approach to Elucidating Damage Mechanisms in Cement-Well Casing-Host Rock Settings for Underground Storage of CO<sub>2</sub>.***

The following is from the Abstract of this NETL document: "This research project was completed during an ambitious 12-month period encompassing both experimental and modeling efforts to elucidate the potential for damage mechanisms in Class H Portland cement exposed to high temperature, pressure and supercritical CO<sub>2</sub> or carbon dioxide-oxygen cycle (CO<sub>2</sub>-O<sub>2</sub>). One key goal of this work was to decouple the effects of these three influences to determine which, if any, had the most profound impact on integrity of Class H cement. Experimental work was completed at both Oregon State University (OSU) and NETL-Albany. Modeling work was done at OSU. The results of the experimental work showed that mechanical properties, specifically compressive strength and modulus of rupture were most affected (decreased over the control) at high temperatures (85°C), high pressure (4,200 psi) and in the presence of supercritical CO<sub>2</sub> or CO<sub>2</sub>-O<sub>2</sub>. The influence of low (23°C) or intermediate temperature (50°C) as well as exposure to a synthetic brine or saturated limewater had negligible effects on mechanical properties. Cement exposed to supercritical CO<sub>2</sub> and CO<sub>2</sub>-O<sub>2</sub> were shown to alter the cement specimens from the exterior of paste samples inward as the carbonation front lead to distinct zones of amorphous silica, calcite deposited, calcium depleted, and finally the unaltered cement closer inward toward the center of the sample. While total alteration depths were similar between both sets of exposed samples (CO<sub>2</sub> or CO<sub>2</sub>-O<sub>2</sub>) the amount of alteration within the altered zone varied between the different exposures, qualitatively. Pore solution analysis reflected the alteration process showing that the concentrations of alkalis (from the Portland cement) reduced over time as the concentration of calcium increased. Inversely, aqueous calcium decreased in the bulk solution. It was also found that sulfate was drawn preferentially at high temperature (85°C). Perhaps the most important finding was verification that the introduction of O<sub>2</sub> into the gas stream resulted in rapid corrosion of the Alloy-20 metal on the interior of the autoclaves used for high pressure, temperature and gas exposure experiments. This represents a significant concern for the long-term sequestration of co-sequestration of CO<sub>2</sub> once oxygen is introduced into the system. The wellbore casing, being made of stainless steel, is subject to deterioration and this could represent a potential leakage pathway. A reactive-transport finite element model was developed for the numerical investigation of the deterioration of Class H cement that was exposed to brines with different compositions and sequestration scenarios (e.g. CO<sub>2</sub> and CO<sub>2</sub>-O<sub>2</sub> exposures) at wellbore temperatures and pressures. The modeling study also included the simulation of the hydration processes of cement. The high temperature/pressure conditions required the modeling of a two-phase flow problem due to the presence of supercritical CO<sub>2</sub>. The modeling framework involved the integration of reactive-transport processes (modeled using a commercial finite element modeling software) with thermodynamic processes of species in cement and brine (modeled using a geochemical modeling open source software)."

***Estimating Carbon Storage Resources in Offshore Geologic Environments.***

The following is from the Executive Summary of this NETL document: "Long-term carbon storage in geologic reservoirs is a leading technique for removing excess CO<sub>2</sub> that would otherwise be emitted to the atmosphere as a result of anthropogenic activities. Effective carbon storage requires both safety and permanence. One underutilized national storage scenario involves carbon storage in offshore geologic formations, similar to those that hold oil, gas, or brine. This scenario has been tested in other countries on a small-scale, but is yet unproven in the United States. A major advantage of offshore storage is that the risk of CO<sub>2</sub> leakage into fresh groundwater resources is decreased, and the effect of that leakage on human population centers is minimized. However, as with onshore storage scenarios, there are many uncertainties surrounding offshore storage. These include issues related to both safety and permanence. After an extensive literature review of the current storage methodologies for onshore carbon storage in saline formations, comparing and contrasting the offshore and onshore characteristics of reservoirs, this study makes recommendations about future work to support offshore storage estimates and research. This report concludes with the suggestion that despite important differences between onshore and offshore systems, carbon can be stored safely and permanently in offshore saline geologic formations. This research proposes using DOE, NETL saline storage methodology with an integration of spatial-statistical tools to adjust for uncertainties."

## ABOUT DOE'S CARBON STORAGE PROGRAM

The **Carbon Storage Program** at the National Energy Technology Laboratory (NETL) is focused on developing and advancing technologies to enable safe, cost-effective, permanent geologic storage of CO<sub>2</sub>, both onshore and offshore, in different depositional environments. The technologies being developed will benefit both industrial and power sector facilities that will need to mitigate future CO<sub>2</sub> emissions. The program also serves to increase the understanding of the effectiveness of advanced technologies in different geologic reservoirs appropriate for CO<sub>2</sub> storage—including saline formations, oil reservoirs, natural gas reservoirs, unmineable coal, basalt formations, and organic-rich shale basins—and to improve the understanding of how CO<sub>2</sub> behaves in the subsurface. These objectives are key to increasing confidence in safe, effective, and permanent geologic 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

Newsletters, program fact sheets, best practices manuals, roadmaps, educational resources, presentations, and more information related to the Carbon Storage Program is available on [DOE's Energy Data eXchange \(EDX\) website](#).



Parallel, vertical, orthogonal natural fracture faces (joint sets) in an outcrop of organic-rich Millboro Shale (Marcellus equivalent), Clover Creek, VA. Photo by Dan Soeder, 2014.

## 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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