

CSN

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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:

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CARBON STORAGE PROGRAM
DOCUMENTS and
REFERENCE MATERIALS

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- ▷ Peer Review
- ▷ Best Practices Manuals
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DOE/NETL HIGHLIGHTS

DOE Invests in Large-Scale Fossil Fuel Pilot Projects.

The U.S. Department of Energy's (DOE) Office of Fossil Energy (FE) selected six projects to receive federal funding to support future design and construction of the next generation of coal-fired power plants that are flexible, resilient, economical, and emit near-zero emissions, including carbon dioxide (CO₂). The projects were selected under Phase II of the "*Fossil Fuel Large-Scale Pilots*" Funding Opportunity Announcement (FOA), which was issued in August 2017 and includes three phases, with competitive down-selections made between each phase. All of the selected projects will be managed by the National Energy Technology Laboratory (NETL). From *energy.gov* on July 9, 2019.

ANNOUNCEMENTS

DOE Director Testifies Before US Senate Energy and Natural Resources Committee.

NETL Director Brian Anderson, Ph.D., appeared before the U.S. Senate Energy and Natural Resources Committee to discuss how NETL effectively develops innovative energy technologies that promote economic growth and competitiveness. To highlight the technology advances, the Director submitted *NETL's 2018 Science and Technology Accomplishments publication* for the hearing record. An archived webcast of the hearing *is available online*.

*DOE/NETL's Carbon Capture, Utilization, Storage, and Oil and Natural Gas Programs Annual Meeting.*

Registration is open and an updated agenda is available for DOE/NETL's "Addressing the Nation's Energy Needs Through Technology Innovation – 2019 Carbon Capture, Utilization, Storage, and Oil and Gas Technologies Integrated Review Meeting," to be held August 26–30, 2019, at the David L. Lawrence Convention Center in Pittsburgh, Pennsylvania, USA. Registration refunds will not be offered after August 16, 2019. Please note the Machine Learning Meeting scheduled for Friday August 30, 2019, has been postponed.

*Report Summarizes Subsurface Workshop.*

A team led by NETL and Carnegie Mellon University's Wilton E. Scott Institute for Energy Innovation released a report summarizing the "*Real-Time Decision-Making for the Subsurface*" workshop held in July 2018 in Pittsburgh, Pennsylvania, USA. The two-day workshop was attended by technical experts from DOE, industry, universities, and national laboratories discussing the current state of technology capable of enabling autonomous monitoring and subsurface control for unconventional oil and gas recovery and carbon storage.

ANNOUNCEMENTS *(cont.)*

Paper Looks to Inspire Strategies for Early-Stage CCS.

Pale Blue Dot Energy released a paper outlining research findings of its *ACT Acorn carbon capture and storage (CCS) project* in northeast Scotland. The paper, *published in the Journal of Cleaner Production*, follows recent funding from the United Kingdom government's carbon capture, utilization, and storage (CCUS) Innovation fund to carry out a detailed design and move the project closer to realization by 2023. The paper assesses Acorn's publicly available outputs to identify strategies that could enhance the viability of early-stage CCS projects.



Partnership to Develop Business Case for CCUS.

Dutch energy transition firm DAREL and Carbon Clean Solutions are partnering to enable development of a value chain for cost-effective carbon management for large industrial emitters. The partnership will seek to develop a business case for CCUS for large-scale decarbonization.

UCSB Grant Program Funds Carbon Storage Study.

A program at University of California Santa Barbara (UCSB) *awarded a grant* for a carbon storage study project at its North Campus Open Space. The project will assess the potential of carbon storage and provide hands-on research experience in "carbon farming."

Conference Notes Importance of CCS.

The Westminster Energy, Environment, and Transport Forum held a policy conference titled "The UK Gas Network: Infrastructure, Decarbonization and Energy Security." During the event, leaders stated that large-scale CCS would be needed to reach net-zero goals.

Database to Monitor CO₂ Emissions.

The *World Input-Output Database*, launched by the Joint Research Center, will monitor the industrial and energy use of residents in more than 40 countries, as well as their corresponding CO₂ emissions, from 2000 through 2016. Primarily targeting policy makers and researchers, the database covers global energy consumption, efficiency, energy splits and trends, and CO₂ emissions generated.

PROJECT and BUSINESS DEVELOPMENTS

China Energy to Build New CCS Plant.

China Energy Group announced plans to launch a CCS project in northwest China in 2020. Officials also announced that the company would add more than 6 gigawatts (GW) of ultra-low emission, coal-fired capacity, as well as build another 5 GW of low-emissions capacity in 2020. From *Reuters* on July 18, 2019.

Work Starts at CCS Research Facility.

Work has begun at CO2CRC's Otway National CCS Research Facility—located at Nirranda South in southwest Victoria (Canada)—with the drilling of four monitoring wells, equipped with fiber-optic sensing and subsurface gauges, approximately 1 mile underground. Part of CO2CRC's Otway Stage 3 Project, the effort will develop subsurface carbon storage technologies that reduce the cost and carbon footprint of long-term CO₂ storage monitoring for CCS projects. From *CO2CRC News* on July 17, 2019.



Project Stores CO₂ in Mine Waste.

Technology developed by the University of British Columbia (UBC) will be used to store CO₂ in two Canadian mines. The project, a collaboration among UBC, the University of Alberta, Trent University, INRS (a Canadian university focused on fundamental and applied research), and three mining companies, will store the CO₂ in mine tailings, which is the waste left over from ore mining. The project received funding from Natural Resources Canada's *Clean Growth Program*. From *UCB News* on July 23, 2019.



LEGISLATION and POLICY

Energy Research Legislation Reintroduced.

A bill that reauthorizes DOE FE research activities and sets priorities for the next generation of clean energy technologies passed through the Committee on Science, Space, and Technology's Subcommittee on Energy. The Fossil Energy Research and Development Act of 2019 is expected to be considered by the full committee next. The reintroduced legislation focuses on CCUS and CO₂ removal, among other areas. From *U.S. Congressman Marc Veasey Press Release* on July 10, 2019.

EU Clarifies Intent to Support CCS Technology.

The European Commission clarified its intent to support CCS. According to officials, future European Union (EU) funding for CCS will likely focus on transport infrastructure, such as CO₂ pipelines. While the prior focus was on CCS demonstration plants, the Commission will now concentrate on supporting carbon storage and utilization value chains. From *EURACTIVE* on July 10, 2019.

EMISSIONS TRADING

RGGI Releases Notice and Materials for Auction 45.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the Auction Notice and application materials for the 45th quarterly CO₂ allowance auction, scheduled for September 4, 2019. The [Auction Notice for CO₂ Allowance Auction 45](#) provides the information needed to submit a [Qualification Application](#) for Auction 45, in which the RGGI states will offer 13,116,447 CO₂ allowances for sale at a minimum reserve price of \$2.26. A 10 million CO₂ allowance cost containment reserve (CCR) will also be made available (the CCR will be accessed if the interim clearing price exceeds the CCR trigger price of \$10.51). From [RGGI News Release](#) on July 9, 2019.



Carbon Trading Initiative Launched.

An initiative to trade carbon credits from mangrove conservation and restoration on the Kenyan coast was launched. Under the Vanga Blue Forests Project, the Kenya Forest Service and the Community Forest Association will co-manage the mangroves while the Kenya Marine and Fisheries Research Institute will provide technical support to the community. The United Nations (UN) Environment Program also helped to develop the management plan, which includes the sale of carbon credits on the voluntary carbon market, verified by the [Plan Vivo carbon trading standard](#). From [UN Environment Program](#) on July 24, 2019.



United Nations
Environment Programme

SCIENCE NEWS

Scientists Engineering Plants to Store CO₂.

Researchers at Salk Institute's Harnessing Plants Initiative (USA) discovered a gene with the potential to optimize a plant's natural ability to capture and store CO₂. The deeper a plant's root system, the better the plant's ability to store CO₂; the gene discovered by Salk researchers, called EXOCYST70A3, has the ability to determine how deep a plant's roots grow in soil. According to the study, [published in the journal Cell](#), the EXOCYST70A3 gene can be altered, enabling the plant's root system to grow more deeply. From [Science Alert](#) on July 15, 2019.

Forest Elephant Extinction Linked to Carbon Storage.

Biologists from Saint Louis University (USA) conducted a study of the effect of potential elephant extinction on forest composition. According to their findings, forest elephants prefer to browse on fast-growing trees, enabling slow-growing trees, which are capable of storing more CO₂, to be more dominant. Therefore, the extinction of forest elephants, [according to the study published in the journal Nature Geoscience](#), could potentially cause an increase in the fast-growing trees at the expense of the slow-growing trees, thus reducing the forest's ability to store CO₂. From [Newswise](#) on July 24, 2019.

JOURNAL ARTICLES

Modeling of time-lapse seismic monitoring using CO₂ leakage simulations for a model CO₂ storage site with realistic geology: Application in assessment of early leak-detection capabilities.

The following is from the abstract of this article: "Time-lapse surface seismic surveys have been widely used at carbon sequestration sites for site characterization, monitoring subsurface CO₂ plume migration, and detecting potential CO₂ leakage from a storage reservoir. Monitoring in the first permeable unit directly above the primary seal is important for early detection of CO₂ leakage. Forward modeling of time-lapse seismic data can be used to assess the utility of the seismic method for CO₂ leakage detection. [The authors] develop a workflow for forward modeling of time-lapse seismic data, including constructing seismic velocity models using flow simulation outputs, modeling of pre-stack and post-stack synthetic seismic data following seismic data processing sequence and analysis of processed synthetic time-lapse seismic data. [The authors] apply the forward modeling and analysis workflow to assessing the detectability and the earliest detection time of seismic monitoring using the hypothetical CO₂ leakage scenarios for a model geologic storage site with realistic geology. [The authors] derive the detection thresholds using the simulated normalized root-mean-square (NRMS) differences for the no-leakage case at a range of signal-to-noise ratios, representing the background noise levels in seismic data. [The authors] then compare NRMS differences triggered by the CO₂ leakage to the detection thresholds at each time step to quantify the detectability and the earliest detection time of seismic monitoring. [The authors] analyze the effects of the acquisition parameters and elastic parameters on the produced synthetic seismic data and earliest detection time. [The authors'] modeling results indicate that high signal-to-noise ratio is needed to detect the CO₂ leakage at the model site. Minimizing the background noise in seismic data is crucial for improving the detectability of the seismic

method. Increasing the shot density or increasing the dominant frequency of the source wavelet is likely to increase the possibility of the leakage detection and reduce the time needed for the detection. The elastic parameters used in the rock physics modeling have significant effects on the resultant seismic velocity models and synthetic seismic data, highlighting their critical roles in understanding and interpreting time-lapse seismic reflection data associated with CO₂ monitoring, verification and accounting activities." **Zan Wang, William P. Harbert, Robert M. Dilmore, and Lianjie Huang**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Boundary Dam or Petra Nova – Which is a better model for CCS energy supply?

The following is from the abstract of this article: "SaskPower's Boundary Dam plant (Canada) and NRG's Petra Nova plant (USA) are the only two commercial-scale coal-fired power plants currently operational in the world that use CCS technology. While both CCS installations are retrofit projects that employ a post-combustion CO₂ capture system using advanced amines, the two plants differ significantly in their approach to providing the steam and electrical energy requirements of the capture system. This paper presents a comparative techno-economic evaluation of pulverized coal (PC) power plants equipped with the different CCS system configurations used in these two demonstration plants, as well as two additional design configurations that may be of interest. The results presented in this paper illustrate the conditions which favor one approach over the other, and thus provide insights for planning new large-scale CCS projects." **Hari C. Mantripragada, Haibo Zhai, and Edward S. Rubin**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

Efficient pathways to reduce carbon emissions in the electric sector.

The following is from the abstract of this article: "The study develops a 2-dimensional map of the feasible design space for an electric generation system. Cost and CO₂ emissions contours are plotted across the map. The principles of constrained optimization are used to identify the efficient pathways eliminating emissions and the technology drivers that determine them. The CO₂ intensity of the baseload is shown to be the primary driver. Further, the need for large, seasonal storage depends strongly on the level of baseload deployed." **Alan D. Lamont**, *The Electricity Journal*. (Subscription may be required.)

Impacts of a carbon tax across US household income groups: What are the equity-efficiency trade-offs?

The following is from the abstract of this article: "This paper assesses the impacts across U.S. household income groups of carbon taxes of various designs. [The authors] consider both the source-side impacts (reflecting how policies affect wage, capital, and transfer incomes) as well as the use-side impacts (reflecting how policies alter the prices of goods and services purchased by households). [The authors] apply an integrated general equilibrium framework with extended measures of the source- and use-side impacts that add up to the overall welfare impact. [The authors'] results indicate that the distributional impacts depend importantly on the nature of revenue-recycling and the treatment of transfer income. In the absence of targeted compensation to achieve distributional objectives, the use-side impacts tend to be regressive while the source-side impacts are progressive, and the progressive source-side impacts tend to offset fully the regressive use-side impacts. Both impacts are considerably larger when one employs the more comprehensive welfare measures introduced in this study. The efficiency costs of targeted compensation to achieve distributional objectives depend critically on the recycling method and compensation target. These costs are an order of magnitude higher when the remaining revenues after compensation are used for corporate income tax cuts, compared with costs when remaining revenues are used other ways. Efficiency costs also rise dramatically when targeted compensation extends beyond the lowest income quintiles." **Lawrence H. Goulder, Marc A.C. Hafstead, GyuRim Kim, and Xianling Long**, *Journal of Public Economics*. (Subscription may be required.)

The economic effects of carbon tax on China's provinces.

The following is from the abstract of this article: "The responsibility for carbon emissions tends to be different under different emission accounting principles. By applying the latest 2012 Chinese multi-regional input-output table, this study evaluated the impacts of carbon tax on tax burdens and sectoral competitiveness in Chinese provinces when considering either production-based or consumption-based emissions. [The authors'] results indicated that, in the scenario of cutting production tax for carbon tax, the developed provinces, such as Beijing, Shanghai, Zhejiang, and Jiangsu, who are much bigger payers of production tax, are net beneficiaries of carbon tax. In contrast, recycling the tax revenues to low-income households makes the less-developed provinces in the central and western China become net revenue receivers. Furthermore, for competitiveness effects, the emission intensive sectors, such as Electricity and hot water production and supply, Petroleum and gas, and Metal products, are impacted vitally under both accounting principles in all provinces. Nevertheless, compared with the production-based principle, a consumption-based carbon tax could reduce the unfavorable competitiveness effects of most affected sectors in the less-developed provinces, while slightly increasing those effects in the developed provinces. [The authors'] results provide new information on the regional impacts of carbon tax based two different accounting principles with different tax revenue recycling scenarios." **Kun Zhang, Mei-Mei Xue, Kuishuang Feng, and Qiao-Mei Liang**, *Journal of Policy Modeling*. (Subscription may be required.)

Recovery in soil carbon stock but reduction in carbon stabilization after 56-year forest restoration in degraded tropical lands.

The following is from the abstract of this article: "Afforestation is considered as an effective method for alleviating the rising of atmospheric CO₂ concentration through the accumulation and long-term storage of carbon (C) in the vegetation and soil. However, it is still unknown whether soil C accumulation in the restored forests could eventually recover to the equivalent level of the undisturbed forests and much less is known about how afforestation will affect C stabilization. Here [the authors] conducted a field study in degraded tropical forests of south China. The aim was to evaluate the recovery of soil C stock following afforestation by comparing different C fractions in soils (0–10 cm and 10–20 cm) in two reforested forests [a restored secondary forest (RSF) and a managed *Eucalyptus* plantation (MEP)] to those in a bare land (BL) and a nearby undisturbed forest (UF). Results showed that after 56-year afforestation at the bare lands, C stocks in both soil layers were significantly increased with an increase greater in the RSF than the MEP, while C recalcitrant indices (RI) were reduced. Soil C stock in the RSF recovered to a similar level to the UF, but soil RI in the RSF was still lower than the UF particularly in the 10–20 cm layer. The calculated capacity of soil C sequestration with the product of soil C stock and its RI followed the order of UF > RSF > MEP > BL. [The authors'] results demonstrate that afforestation on degraded tropical lands could recover soil C stock within a few decades, but C stabilization would be reduced." **Huiling Zhang, Qi Deng, Dafeng Hui, Jianping Wu, Xin Xiong, Jianqi Zhao, Mengdi Zhao, Guowei Chu, Guoyi Zhou, and Deqiang Zhang**, *Forest Ecology and Management*. (Subscription may be required.)

The initial three years of carbon dioxide exchange between the atmosphere and a reclaimed oil sand wetland.

The following is from the abstract of this article: "Northern peatlands contain up to 20% of the ~3000 Pg of global soil organic carbon. Carbon-rich peatlands cover upwards of 65% of the landscape in northern Canada where resource extraction activities disturb both the carbon pools and the future carbon sequestration capacity of the landscape. Previous estimates of the carbon losses from this disturbance predict a complete loss of the region's peatland carbon pool. Mining industries operating in these sensitive environments have recently begun constructing closure landscapes which are intended to develop carbon cycle processes similar to undisturbed northern peatlands. This study investigates eddy covariance fluxes of CO₂ at one of Canada's first fully constructed boreal plains watersheds, the Sandhill Fen Watershed. During the first three years since inception, only the lowland region had an annual net ecosystem exchange of CO₂ (NEE) indicative of increasing CO₂ sink potential. The lowland region was characterized by saturated salvaged peat soils, standing water, thriving communities of *Typha* and *Carex* spp. and was a net CO₂ sink of 77gCm⁻² in the third year. At the same time the upland and the midland regions characterized by moist salvaged peat soils and a mix of herbaceous, shrub and planted *Picea glauca* and *Pinus banksiana* remained net sources of CO₂. Despite similar rates of gross primary production, ecosystem and plot-level respiration rates in the lowland were significantly lower than in the midland region, likely due to very low reduction potentials within the lowland's saturated soils. With no other significant outflows of carbon, the lowland of the Sandhill Fen Watershed may be in the early stages of organic matter accumulation. Due to limited oxidation of the salvaged peat substrate in the lowland region, wetland reclamation employing these techniques may reduce the disturbance loss of the carbon pool in the boreal plains." **M. Graham Clark, Elyn Humphreys, and Sean K. Carey**, *Ecological Engineering*. (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

Carbon and nitrogen storage of constructed and natural freshwater wetlands in Southern California.

The following is from the abstract of this article: "Artificial wetlands are often constructed to replace degraded natural wetlands; however, it is unclear whether constructed wetlands can become functionally equivalent to natural wetlands. [The authors] used measurements of soil and plant nitrogen (N) and carbon (C) storage as indicators of initial function in an artificial wetland in southern California, and compared them to the C and N stocks of local naturally occurring wetlands. [The authors] hypothesized that C and N stocks would be significantly lower in the constructed wetland. Soil and vegetation C and N stocks of the constructed wetland increased rapidly but plateaued after 6 years, and soil C and N stocks of the constructed wetland were higher than, or comparable to, local natural wetlands. Limited comparisons between constructed and natural freshwater wetlands reported in the literature illustrated high variability in ecosystem C and N storage, but soil C and N stocks in artificial wetlands were significantly lower than in natural wetlands. Southern California wetlands had lower soil C and N storage compared to other temperate zone wetlands, which may be due to the highly variable rainfall and flow regimes of semi-arid wetlands in southern California." **Jacob Maziarz, George L. Vourlitis, and William Kristan**, *Ecological Engineering*. (Subscription may be required.)

Feasibility study for carbon capture utilization and storage (CCUS) in the Danish North Sea.

The following is from the abstract of this article: "An innovative addition to the conventional oil and gas extraction by introducing enhanced oil recovery (EOR) techniques in the Danish North Sea is something which has been sought for long time. Combining the offshore EOR technology with the CCS is considered to be a possibly attractive solution as the associated benefit is twofold: (1) increased oil recovery through miscible displacement via CO₂ pushing the hydrocarbons out of the reservoir and (2) the disposal of a greenhouse gas such as the CO₂. A feasibility study for implementing a CCUS project is presented in the scope of this study, in a North Sea Chalk Field which is the oldest and one of the largest oilfields in the Danish sector, both for the technical and the economic merit, by means of using a commercial reservoir simulation package. The capital (CAPEX) and operational (OPEX) expenditures associated with such a long term development project is estimated. Results suggest that around 100 million barrels of additional oil reserves can be unlocked via CO₂ injection, while 40 million [metric tons] of CO₂ is being trapped in the reservoir." **Vural Sander Suicmez**, *Journal of Natural Gas Science and Engineering*. (Subscription may be required.)

REPORTS and OTHER PUBLICATIONS

Computed Tomography Scanning and Geophysical Measurements of the FutureGen FGA-1 Core.

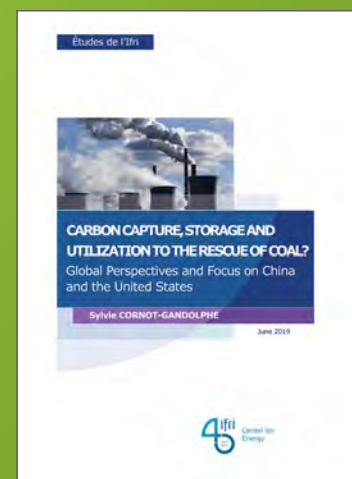
The following is from the abstract of this DOE/NETL document: "The computed tomography (CT) facilities at the NETL Morgantown, West Virginia site were used to characterize multiple cores collected during the FutureGen project. The core from the FutureGen Industrial Alliance, Inc., Battelle, FGA-1 well was drilled through 4,813 ft (1,467 m) of the Eau Claire (Lombard and Elmhurst members), the Mount Simon (Upper and Lower), and the basement. Core from the FGA-1 was collected in four sections to obtain samples from these formations: Eau Claire (3,772 to 3,919.5 ft), Eau Claire to Mount Simon transition (3,924 to 3,954 ft), lower Mount Simon (4,400 to 4,426 ft), and the basement (4,434 to 4,442 ft). The primary impetus of this work is to further characterize the FutureGen 2.0 core currently stored in the NETL core repository. As part of this effort, bulk scans of core were obtained from the FGA-1 well. This report, and the associated scans, provide detailed datasets not typically available for analysis. The resultant datasets are presented in this report and can be accessed from NETL's Energy Data eXchange (EDX) online system. All equipment and techniques used were non-destructive, enabling future examinations to be performed on these cores. Low resolution CT imagery with the NETL medical CT scanner was performed on the entire core. Qualitative analysis of the medical CT images, coupled with dual energy density scans and X-ray fluorescence (XRF) were useful in identifying zones of interest for more detailed analysis. The ability to quickly identify key areas for more detailed study at higher resolution will save time and resources in future studies. The combination of methods used provided a multi-scale analysis of this core and provides both a macro and micro description of the core that is relevant for many subsurface energy-related examinations that have traditionally been performed at NETL."

Foamed Cement: Correlation of Foam Quality with Mechanical and Physical Properties.

The following is from the abstract of this DOE/NETL document: "The primary functions of oil well cement include providing casing support and zonal isolation for the life of a well. Foam cement systems are often used to achieve these objectives. Industry standards and practices require careful assessment of various cement properties to ensure the integrity of the primary cement job. This report presents a series of studies focused on the mechanical (compressive strength, Young's modulus, and Poisson's ratio) and physical (density, permeability, and porosity) properties of foamed cement typically used for cementing deep offshore wells in the Gulf of Mexico. Cements with various amounts of entrained air were prepared in the lab according to American Petroleum Institute, API RP 10B- 4 using Class H cement and industry standard foaming agents. Permeability, porosity, compressive strength, Young's modulus, and Poisson's ratio were measured across a range of foam qualities and compared to 'baseline' or 'control sample' of a neat cement system. Additional studies include cement evolution with curing time and the effect of temperature variations on this evolution. Bubble sizes and interconnection in the foamed cement systems were also briefly discussed. All the cements investigated in this study were produced at atmospheric pressure, which is the current industry practice for testing foam cement systems. Nevertheless, there is some caution to the end users, as the curing pressures in this document differ from the 'bottomhole' conditions. The data obtained in this study are useful for comparative purposes and may serve as a baseline for future evaluation of foam cement systems under representative 'bottomhole' conditions. These data are also complementary to the CT image analysis of foamed cements performed at NETL."

Carbon Capture, Storage and Utilization to the Rescue of Coal? Global Perspectives and Focus on China and the United States.

The following is from the Executive Summary of this document: "...There is increasing policy support for CCS projects around the world. This renewed interest comes with different focuses than policies at the beginning of the 2000s, which had coal power plants as a focal point. Today, there is a growing focus on CCS in industrial and manufacturing applications. There is also a growing interest in hydrogen production combined with CCS in several countries. The focus is not only on capture and storage but also on utilization of the carbon (CCUS) for applications like increasing output from oil wells (enhanced oil recovery or EOR) or as an input for creating useful products. However, outside EOR, the uses of CO₂ are limited... Currently, there are 23 large-scale CCS/CCUS [projects] in operation and construction in the world, with a capture capacity of 40 million tons per annum (Mtpa) of CO₂. Most of these projects come from processes with highly concentrated CO₂ streams, such as natural gas processing and chemical production facilities, and 70% of the capture capacity is in North America. Only two coal power units in the world have been retrofitted with carbon capture, one in Canada and one in the United States (US). In addition, among the 20 projects under development in the world, six projects (4 in China and 2 in South Korea) involve coal power plants. There is also one project under feasibility study in Canada. Altogether, CCS/CCUS projects based on coal power plants have a CO₂ capture capacity of 12.4 Mtpa and involve some 4 GW of coal capacity. The challenge to scale up the technology is enormous..."



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 CO₂, 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 CO₂ emissions. The program also serves to increase the understanding of the effectiveness of advanced technologies in different geologic reservoirs appropriate for CO₂ 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 CO₂ behaves in the subsurface. These objectives are key to increasing confidence in safe, effective, and permanent geologic CO₂ 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 (note that all links were active at the time of publication).

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