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# CARBON STORAGE NEWSLETTER

JULY 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:

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

### *NETL Signs Partnership with ExxonMobil and NREL.*

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) signed a research and development (R&D) partnership with ExxonMobil and the *National Renewable Energy Laboratory (NREL)*. Per the *cooperative research and development agreement (CRADA)*, ExxonMobil is investing up to \$100 million over 10 years for the R&D of advanced lower-emissions technologies. The agreement will support research and collaboration in bringing biofuels and carbon capture and storage (CCS) to commercial scale. In addition to developing technologies related to energy efficiency and greenhouse gas (GHG) mitigation, the joint research will focus on reducing emissions from fuel and petrochemicals production; stimulate collaborative projects among ExxonMobil, NREL, and NETL; and facilitate work with other national laboratories, such as the Idaho National Laboratory. From *National Energy Technology Laboratory* on May 8, 2019.



## ANNOUNCEMENTS

### *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.



### *NETL Participates in Conference on Coal Technologies.*

NETL participated in the 2019 *Clearwater Clean Energy Conference*, which provided an overview of emerging, evolving, innovative technologies, fuels, and/or equipment in the power generation industry. The agenda included an NETL-led technical session focused on carbon dioxide (CO<sub>2</sub>) capture, storage, and reuse.



## ANNOUNCEMENTS *(cont.)*

### *NETL Infographics Highlight Carbon Capture Work.*

NETL is releasing a series of eight infographics that explain the structure of its *Carbon Capture Program*, illustrating its impact and highlighting achievements and notable projects. *Infographics that have been released to date are currently available online*, with the rest scheduled for release at a later date.



### *World Bank Releases Report on Carbon Pricing.*

The World Bank released the annual "State and Trends of Carbon Pricing" report, which presents the latest worldwide developments regarding carbon pricing. According to the report, 57 carbon pricing initiatives have been implemented or are scheduled for implementation globally (up from 51 in April 2018).

## PROJECT and BUSINESS DEVELOPMENTS

### *Equinor to Publish Offshore Carbon Storage Data.*

*Equinor and its partners will publish a dataset* from the Sleipner CCS project located in the North Sea region of Norway. The Sleipner field has been used for CCS since 1996, and Equinor has been sharing data with the research community for the past 15 years. The data will now be made openly available, published via the DOE-supported and SINTEF-led CO<sub>2</sub> Data Share Consortium, which is an open international network for data and knowledge exchange. The digital platform for the data sharing is scheduled to be online in 2019. From *The Maritime Executive* on June 12, 2019.

### *Third Phase of CCS Project Announced.*

Australian CCS research organization CO<sub>2</sub>CRC announced a \$31.3 million investment for the third phase of the Otway CCS project located in southwest Victoria. The third phase (Otway Stage 3 Monitoring and Verification Project) follows the finalization of all project-related technical and scientific work programs, operational arrangements, regulatory approvals, and funding. According to CO<sub>2</sub>CRC officials, this phase of the project will be to develop subsurface storage technologies for long-term CO<sub>2</sub> storage monitoring. From *Gas World* on June 12, 2019.

## LEGISLATION and POLICY

### *Bill Seeks CO<sub>2</sub> Reduction Through CCS Projects.*

A bill reintroduced in the U.S. Senate would allow businesses to use governmental private activity bonds for CCS projects. If the *Carbon Capture Improvement Act* is passed, a project could be financed entirely if more than 65% of the CO<sub>2</sub> emissions at the facility are captured and stored underground (projects that achieve lower percentages could be permitted on a pro-rated basis). From *Daily Energy Insider* on June 13, 2019.

### *EERC Established as Energy Research Center of North Dakota.*

The North Dakota State House of Representatives approved a bill to establish the Energy & Environmental Research Center at the University of North Dakota (EERC) as the state's energy research center. The Energy Research Center of North Dakota will focus on areas related to the state's energy industry as well as pipeline safety and increasing oil recovery.

### *Personal CO<sub>2</sub> Subscription Service Launched.*

Climeworks launched a new program allowing individuals to purchase a CO<sub>2</sub> removal service to offset their emissions. Once captured, the CO<sub>2</sub> is stored underground in Iceland via *Climeworks' CarbFix process*.

### *Workshop Discusses CCS.*

Representatives from industry, government, academia, and the private sector convened at the Global CCS Institute's workshop at the Innovate4Climate Conference to discuss CCS technologies. Held in Singapore in June 2019, the workshop covered topics such as the significance of CCS as an emissions reduction technology; the cost of CCS technology; and opportunities for carbon capture, utilization, and storage (CCUS) technologies present for the South East Asia region.

### *Study Launched on Decarbonizing Europe.*

Industry, regional experts, academics, and European Union (EU) officials held a public meeting of the research study group "Infrastructure needs of an EU industrial transformation towards deep decarbonization." The workshop highlighted the potential of individual regions specializing more in CCS.

### *CCUS Pilot Project Unveiled.*

Drax and Deep Branch Biotechnology are collaborating on a CCUS pilot project to be executed within the CCUS Incubation Area at Drax's power station in Yorkshire, United Kingdom (U.K.). *According to officials*, the objective of the project is to explore how captured CO<sub>2</sub> can be used to make sustainable animal feed. The pilot project, expected to begin later this year, will capture CO<sub>2</sub> from the energy generation process and feed it to microbes, which will use it to make single-cell proteins that could replace soy and fishmeal in fish and livestock feeds. From *BusinessGreen* on June 18, 2019.



### *Canada Unveils CO<sub>2</sub> Reduction Plan.*

Canadian officials unveiled a CO<sub>2</sub> reduction plan that encourages companies to make emissions reduction part of their business models. Under the plan, companies that release GHG emissions above set standards would be required to pay into a fund for investment in government-certified clean tech companies. According to officials, the plan has the potential to lower Canada's baseline emissions by as much as 101 metric megatons by 2030. From *CBC News* on June 19, 2019.

## EMISSIONS TRADING

### [New Jersey Finalizes CO<sub>2</sub> Regulation, Joins RGGI.](#)

New Jersey (USA) [finalized a regulation](#) to establish a market-based program to reduce GHG emissions and, as a result, will join the Regional Greenhouse Gas Initiative (RGGI) as a participating state starting on January 1, 2020. The decision was made after an extensive public process, as well as an RGGI ruling that New Jersey's starting CO<sub>2</sub> allowance budget and emissions reduction trajectory demonstrates a stringency comparable to the existing RGGI program. From [RGGI News Release](#) on June 17, 2019.



### [RGGI Releases Results of 44<sup>th</sup> Auction of CO<sub>2</sub> Allowances.](#)

The RGGI-participating states released the results of their 44<sup>th</sup> auction of CO<sub>2</sub> allowances. Auction 44 saw 13,221,453 CO<sub>2</sub> allowances sold at a clearing price of \$5.62, with bids ranging from \$2.26 to \$10.01 per allowance. None of the 10 million cost containment reserve (CCR) allowances made available were sold (CCR is a fixed additional supply of allowances only available for sale if CO<sub>2</sub> allowance prices exceed certain price levels [\$10.51 in 2019]). More information is available in the [Market Monitor Report for Auction 44](#). From [RGGI News Release](#) on June 7, 2019.

### [Emissions Trading Scheme Unveiled in India.](#)

Government officials in Gujarat, the western-most Indian state, announced the launch of an emissions trading scheme (ETS). Under the ETS, an environmental governing body would set a limit on the amount of emissions that can be released with or without permits. From [Business Standard](#) on June 4, 2019.

### [Carbon Trading Market Launched.](#)

Universal Solar Technology announced a joint venture to launch the Entrex Carbon Market, which utilized a blockchain-enabled technology platform to trade carbon credits and carbon offsets. The platform allows credits, offsets, and other products to be found, researched, tracked, managed, and traded via regulated entities through a compliant platform. From [Yahoo! Finance](#) on June 17, 2019.

## SCIENCE NEWS

### [Researchers Study Ice Age CO<sub>2</sub> Levels.](#)

New research conducted by scientists at Oregon State University claims that the lower atmospheric CO<sub>2</sub> levels during the ice age could be attributed in part to seawater temperature variation. According to the study, which was [published in the journal Science Advances](#), the difference in ocean surface temperatures between the high latitudes and the mid latitudes was significant during the warm phases of the ice age. As the warmer water moved toward Antarctica and began to cool, the lost heat went into the atmosphere, increasing the ocean's potential to store CO<sub>2</sub>. From [Oregon State University Press Release](#) on June 12, 2019.

### [Company Launches Initiative to Capture, Store CO<sub>2</sub>.](#)

A Boston, Massachusetts (USA) company launched an initiative to accelerate carbon storage. According to Indigo Agriculture officials, [the Terraton Initiative](#) seeks to utilize the potential of agricultural soils to remove 1 trillion tons of atmospheric CO<sub>2</sub>. From [Indigo Agriculture Press Release](#) on June 12, 2019.

### [Researchers Develop Organisms to Convert CO<sub>2</sub>.](#)

Researchers from the University of Colorado Boulder's Department of Chemical and Biological Engineering developed organisms capable of using CO<sub>2</sub> to produce a variety of plastics and fuels. By using light-activated quantum dots to fire particular enzymes within microbial cells, the researchers were able to create nanobio-hybrid organisms that "eat" CO<sub>2</sub> and convert it into useful products such as biodegradable plastic, gasoline, ammonia, and biodiesel. Findings of the study, which were published in the [Journal of the American Chemical Society](#), are expected to help researchers develop low-cost carbon storage. From [University of Colorado Boulder](#) on June 11, 2019.

### [Tropical Soil Disturbance Could Be Source of CO<sub>2</sub>.](#)

According to a new study, CO<sub>2</sub> that had previously been stored in the Earth for millennia could now be re-entering the carbon cycle. Researchers from Florida State University studied 19 sites in the eastern Democratic Republic of the Congo and discovered that thousand-year-old tropical soil unearthed by deforestation and agriculture land use could be releasing CO<sub>2</sub> into the atmosphere. The study was [published in the journal Nature Geoscience](#). From [Phys.org](#) on June 24, 2019.

### [Researchers Convert CO<sub>2</sub> into Liquefiable Fuels.](#)

Researchers from the University of Illinois developed an artificial photosynthesis process that converts CO<sub>2</sub> into fuels. In the study, [published in the journal Nature Communications](#), the researchers developed a process that uses the same green light portion of the visible light spectrum during natural photosynthesis to convert CO<sub>2</sub> and water into fuel, in conjunction with electron-rich gold nanoparticles that serve as a catalyst. From [University of Illinois News Bureau](#) on June 24, 2019.

## JOURNAL ARTICLES

### *High-resolution 3D marine seismic acquisition in the overburden at the Tomakomai CO<sub>2</sub> storage project, offshore Hokkaido, Japan.*

The following is the Abstract of this article: "Monitoring injected CO<sub>2</sub> is an important part of assuring permanence of long term storage to mitigate atmospheric emissions. Three-dimensional (3D) seismic has been shown to be an effective technology for visualizing and quantifying subsurface geology and fluids. In this study, [the authors] demonstrate the successful acquisition, processing, and initial interpretation of a first-of-its-kind high-resolution 3D (HR3D) marine seismic survey above an active CO<sub>2</sub> injection site offshore Tomakomai, Japan. An initial sensitivity study indicated generally favorable subsurface conditions for imaging subsurface pore fluid changes. A unique processing workflow incorporating multiple data processing software packages has been tailored to the short-offset and low-fold HR3D acquisition. The final 3D volume shows generally flat and laterally-continuous stratigraphy in the overburden above the injection zone without identifiable faults, indicating coherent overburden above the CO<sub>2</sub> injection site and low associated risk of vertical CO<sub>2</sub> migration. The successful deployment of this novel marine seismic monitoring technology in the overburden at a small-scale (100 kt/yr) demonstration project suggests HR3D will also be a useful characterization and monitoring tool for larger demonstration and commercial-scale (10 MT) offshore CCS sites." **T.A. Meckel, Y.E. Feng, R.H. Treviño, and D. Sava**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

### *Application of the Aquifer Impact Model to support decisions at a CO<sub>2</sub> sequestration site.*

The following is the abstract of this article: "The National Risk Assessment Partnership (NRAP) has developed a suite of tools to assess and manage risk at CO<sub>2</sub> sequestration sites. The NRAP tool suite includes the Aquifer Impact Model (AIM), which evaluates the potential for groundwater impacts from leaks of CO<sub>2</sub> and brine through abandoned wellbores. There are two aquifer reduced-order models (ROMs) included with the AIM tool, a confined alluvium aquifer, and an unconfined carbonate aquifer. The models accept aquifer parameters as a range of variable inputs so they may have broad applicability. The generic aquifer models may be used at the early stages of site selection, when site-specific data is not available. Guidelines have been developed for determining when the generic ROMs might be applicable to a new site. This paper considers the application of the AIM to predicting the impact of CO<sub>2</sub> or brine leakage were it to occur at the Illinois Basin Decatur Project (IBDP). Results of the model sensitivity analysis can help guide characterization efforts; the hydraulic parameters and leakage source term magnitude are more sensitive than clay fraction or cation exchange capacity. Sand permeability was the only hydraulic parameter measured at the IBDP site. More information on the other hydraulic parameters could reduce uncertainty in risk estimates. Some non-adjustable parameters are significantly different for the ROM than for the observations at the IBDP site. The generic ROMs could be made more useful to a wider range of sites if the initial conditions and no-impact threshold values were adjustable parameters." **Diana Holford Bacon, Randall A. Locke II, Elizabeth Keating, Susan Carroll, Abbas Iranmanesh, Kayyum Mansoor, Bracken Wimmer, Liange Zheng, Hongbo Shao, and Sallie E. Greenberg**, *Greenhouse Gases: Science and Technology*. (Subscription may be required.)

### *Researching candidate sites for a carbon storage complex in the Central Appalachian Basin, USA.*

The following is the abstract of this article: "The purpose of the Central Appalachian Basin-Carbon Storage Assurance Facility Enterprise Integrated Prefeasibility Project was to identify candidate sites in eastern Ohio for a storage complex capable of storing 50 million [metric tons]. Carbon capture and storage (CCS) will be essential in the Appalachian Basin, which includes coal-fired power plants, natural gas processing, refineries, chemical plants, and natural gas power. The project team investigated Cambrian-Ordovician Age sandstones and carbonates collocated near depleted oilfields, where enhanced oil recovery could provide a stepping stone for developing a storage hub. Feasible routes for linking sources to sinks via regional pipelines were assessed. The sub-basinal analysis demonstrated significant potential storage capacity in both deep saline reservoirs and depleted oil and gas fields. The project definition analysis revealed the project footprint would be reasonable and only two wells would be needed for injection of CO<sub>2</sub>. Project economics illustrated a need for both government and private investment in the absence of a regulatory mandate. Ohio also lacks a comprehensive policy for long-term liability and subsurface storage rights, which could be addressed during pilot testing. Developing qualified sites within two selected areas for large-scale deployment of CCS appears feasible and the study helped to define future research needs." **Lydia Cumming, Jared Hawkins, Joel Sminchak, Manoj Valluri, and Neeraj Gupta**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

### *Carbon pricing, technology transition, and skill-based development.*

The following is the abstract of this article: "[The authors] analyze the impact of carbon prices on human capital accumulation, sectoral change, and economic growth. In [the authors'] framework output is produced with dirty and/or clean technologies using skilled and unskilled labor as inputs. Carbon policy affects technology selection which transmits incentives for human capital formation. [The authors] show that a temporary policy may be sufficient for a transition to a clean economy and that such a policy also stimulates economic growth. Moreover, in the presence of inter-country knowledge spillovers, a carbon policy in the North helps human capital formation in the South and induces South's transition to the clean steady state." **Kirill Borissov, Alexandra Brausmann, and Lucas Bretschger**, *European Economic Review*. (Subscription may be required.)

### *On the role of spatially correlated heterogeneity in determining mudrock sealing capacity for CO<sub>2</sub> sequestration.*

The following is the abstract of this article: "Storing CO<sub>2</sub> in depleted hydrocarbon reservoirs is a common practice world-wide. Mudrocks often serve as seals above these reservoirs due to their small pore throats and low permeability, but they can fail if the buoyant pressure of the trapped fluid overcomes the threshold pressure of the seal. Mudrocks are primarily made of silt-sized and clay-sized particles, and sufficiently high silt concentrations can create situations where the silt grains create a connected stress chain through the rock matrix, which preserves the large pore throats under compaction. This phenomenon, termed silt bridging, can reduce the threshold pressure of the mudrock, causing seal failure. [The authors] used grain-scale modeling to create computer-generated grain packs with and without the effect of gravity to understand the effects of deposition and compaction on the petrophysical properties like capillary pressure, tortuosity, permeability, capillary drainage curves, and spatial correlation of heterogeneities. [The authors] found that, when the fraction of silt-sized grains exceeded 40%, the percolation length (the length of the first path of the non-wetting fluid through a medium) and the tortuosity suddenly decreased. This was supported by the results from the throat size variograms, where the same type of correlations between throats were observed at greater lag distances, signifying increased intergranular distances. [The authors'] work provides an insight into the role of different grain sizes, concentrations and spatial distributions on the flow properties and sealing capacity of mudrocks." **Abhishek Bihani and Hugh Daigle**, *Marine and Petroleum Geology*. (Subscription may be required.)

## JOURNAL ARTICLES *(cont.)*

### *Carbon capture and storage (CCS) experts' attitudes to and experience with public engagement.*

The following is from the abstract of this article: "...Public engagement with CCS is important for a range of reasons, but previous work has not explored the perceived rationales for, or benefits of, public engagement amongst CCS experts (including those who engage the public themselves). Here, [the authors] present mixed-methods research (comprising expert interviews and an online survey) to elucidate these rationales, and expose CCS expert views of public engagement. [The authors'] findings indicate some differences in perceptions of public engagement with CCS (and of the risks and benefits of CCS) between those who engage directly with the public and those who do not: the former tend to have a more nuanced view of engagement, and are also more enthusiastic about the benefits of CCS, than the latter. Overall, CCS experts recognise the importance of public engagement for the roll-out of CCS for both substantive and instrumental rationales, and are largely aware of the range of factors (knowledge, values, trust, etc.) influencing public engagement. Nevertheless, the relatively low salience of early and substantive engagement amongst CCS experts suggests there is room for improving the flow of learning from the public engagement research literature to those charged with delivering it." **Dimitrios Xenias and Lorraine Whitmarsh**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

### *Can a carbon emission trading scheme generate the Porter effect? Evidence from pilot areas in China.*

The following is the abstract of this article: "...Since 2013 China implemented carbon emission trading scheme (ETS) in seven provinces or cities. The purpose of this paper is to investigate whether the implementation of ETS can result in the Porter effect. Based on the Porter hypothesis theory, this study employs the difference-in-difference (DID) method and the improved DEA model to analyze whether ETS can bring economic dividend and environmental dividend. The empirical results specify that in the short term, ETS can significantly reduce carbon emissions in the pilot provinces, but fail to increase GDP. Therefore, ETS does not realize the Porter effect in the short term. Nevertheless, in terms of the empirical results [the authors] can find ETS plays a significant role in emission reduction. In the long term, ETS can stimulate sustainable economic dividend and environmental dividend, and achieve the Porter effect. From the test results, [the authors] can find ETS has good economic and emission reduction functions. ETS achieves the Porter effect in the long term but not in the short term. In order to achieve the Porter effect from ETS successfully, a sound carbon emission trading scheme must be established to ensure efficient carbon emission trading market." **Feng Dong, Yuanju Dai, Shengnan Zhang, Xiaoyun, Zhang, and Ruyin Long**, *Science of The Total Environment*. (Subscription may be required.)

### *China's roadmap to low-carbon electricity and water: Disentangling greenhouse gas (GHG) emissions from electricity-water nexus via renewable wind and solar power generation, and carbon capture and storage.*

The following is from the abstract of this article: "Electricity and water form an intricate nexus, in that water is crucial for power generation, and electricity (or other primary forms of energy) is the key enabler for water purification and waste-water treatment. Nonetheless, both energy conversion and water purification result in substantial amounts of greenhouse gas (GHG) emissions. These negative interactions with potential 'snowball' effect, can be decoupled via the deployment of renewable power generation, and carbon capture from fossil-[fueled] technologies. However, such retrofits pose new challenges as wind and solar energy exhibit intermittent generation patterns. In addition, integrating thermal power plants with carbon capture and storage (CCS) imposes energy penalties and increases water requirements. In the present research, an optimization framework is developed which enables systematic decision-making for the retrofit of existing power and water infrastructure as well as investment in renewable and green technologies. A key aspect of the applied framework is the simultaneous optimization of design and operational decisions in the presence of uncertainties in the water demand, electricity demand, as well as wind and solar power availability. The proposed methodology is demonstrated for the case of the water-electricity nexus in China, and provides in-depth insights into regional characteristics of low carbon electricity generation, and their implications for water purification and wastewater treatment, demonstrating a roadmap towards sustainable energy and electricity." **Mahdi Sharifzadeh, Raymond Khoo Teck Hien, and Nilay Shah**, *Applied Energy*. (Subscription may be required.)

## REPORTS and OTHER PUBLICATIONS

### *The Potential for CCS and CCU in Europe.*

The following is from the Executive Summary of this International Association of Oil & Gas Producers (IOGP) document: "...Estimates have shown that the sum of European jobs linked directly and indirectly to the emergence of a market for CCS may approach 150,000 in 2050. There are 18 commercial projects in operation globally today with a total capture capacity of some 40 Mtpa CO<sub>2</sub>. In Europe, CCS technologies and projects are currently more advanced than CCU projects, with Norway in particular having deployed CCS at Sleipner since 1996 and at Snøhvit since 2007. CCU covers a range of technologies at differing levels of maturity, cost and market size. Ultimately CCS and CCU are mutually supportive solutions, since both require access to capture facilities and to gas infrastructure and transportation services. They should both be seen as technology options to cost-effectively meet the EU's climate targets for 2030 and 2050. Europe is well placed to benefit from CCS and CCU due to its extensive pipeline infrastructure which can be used to transport CO<sub>2</sub>, hydrogen and synthetic methane, and other renewable and decarbonised gases. Europe also has extensive geological CO<sub>2</sub> storage capacity and subsea expertise, with countries such as Norway and the UK willing to enable shared access to their offshore storage facilities for CO<sub>2</sub> from EU industry. Today, the largest CCS facilities are in the United States where Enhanced Oil Recovery (EOR) has been an important economic driver. In Europe, EOR applications are more limited and the current ETS price does not sufficiently support the CCS or CCU business case. Appropriate and timely policies coupled with regulatory and financial support are needed for CCS and CCU, as in many cases infrastructure must be put in place in advance of a mature market for decarbonised products and services. Support for CO<sub>2</sub> transportation and storage infrastructure will in particular be important, to help de-risk the early development of the CCS and CCU value chains. Large source emission clusters in Europe provide good opportunities to create economies of scale, by establishing shared CO<sub>2</sub> transportation infrastructure with third party access and efficient use of this infrastructure by multiple parties. Existing EU and national funding schemes should continue to apply to CCS and CCU, and these technologies should be recognised in the national energy and climate plans..."

### *Global Carbon Capture and Storage (CCS) Market Size, Status and Forecast 2019-2025.*

The following is from a description of this document: "Carbon capture and storage (CCS) (or carbon capture and sequestration or carbon control and sequestration) is the process of capturing waste carbon dioxide (CO<sub>2</sub>) from large point sources, such as fossil fuel power plants, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally an underground geological formation. The aim is to prevent the release of large quantities of CO<sub>2</sub> into the atmosphere (from fossil fuel use in power generation and other industries)... Although CO<sub>2</sub> has been injected into geological formations for several decades for various purposes, including enhanced oil recovery, the long term storage of CO<sub>2</sub> is a relatively new concept. In the coming years there is an increasing demand for [CCS] in the regions of United States and Europe that is expected to drive the market for more advanced Carbon Capture and Storage. Growth in government budgets in the principal countries, increasing of power generation fields expenditures, more-intense competition, launches in introducing new products, retrofitting and renovation of old technology, increasing adoption of [CCS] will drive growth in United States and Europe markets. In 2018, the global [CCS] market size was [\$3,300 million] and it is expected to reach [\$4,980 million] by the end of 2025, with a [compound annual growth rate (CAGR)] of 6.1% during 2019-2025. This report focuses on the global [CCS] status, future forecast, growth opportunity, key market and key players. The study objectives are to present the [CCS] development in United States, Europe and China."

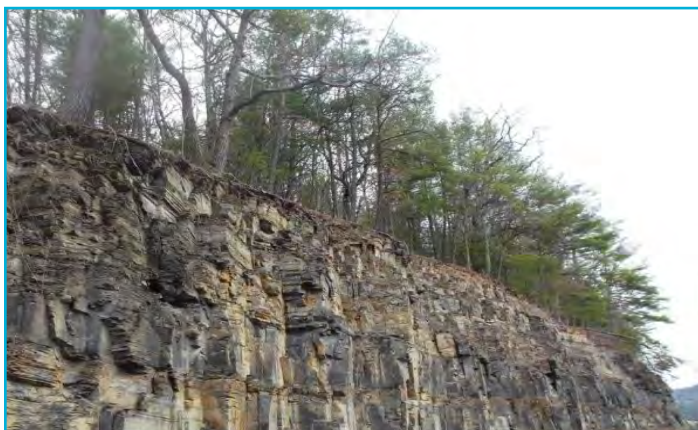
## ABOUT DOE'S CARBON STORAGE PROGRAM

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 (note that all links were active at the time of publication).

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