

CSN

FEBRUARY 2019

CARBON STORAGE
NEWSLETTER

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

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

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 (CO₂) 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 CO₂ storage. From *energy.gov* on January 3, 2019.

ANNOUNCEMENTS

DOE Issues Notice of Intent.

DOE's Office of Fossil Energy (FE) issued an NOI for an FOA with the objective of competitively soliciting and awarding R&D projects for front-end engineering and design (FEED) studies to retrofit a domestic coal-fired power plant and for a coal or natural gas plant that generates CO₂ suitable for utilization or storage. The FOA, titled "Front-End Engineering and Design Studies for Carbon Capture Systems on Coal and Natural Gas Power Plants," will support FE's *Carbon Capture Program*.

*DOE Announces Federal Funding.*

DOE's FE announced federal funding for cost-shared R&D under an FOA, titled "Maximizing the Coal Value Chain," to develop innovative uses of domestic coal to create new market opportunities. These projects will support FE's *Advanced Energy System Program*. DOE also *made available federal funding* for cost-shared R&D projects, under the FOA "Improving Efficiency, Reliability, and Flexibility of Existing Coal-Based Power Plants," that will enhance technologies that improve overall performance, reliability, and flexibility of the nation's existing coal-fired power plant. Projects will support DOE's *Transformative Power Generation Program* and *Crosscutting Research Program*.

*Nordic Countries Commit to Further Develop CCS.*

Finland, Sweden, Norway, Denmark, and Iceland signed a declaration committing to work towards carbon neutrality, including further developing and deploying carbon capture and storage (CCS) and bioenergy with CCS (BECCS) technologies. In the "Declaration on Nordic Carbon Neutrality," the countries also agreed to enhance their Nationally Determined Contributions (NDCs), which represent a country's efforts to reduce national emissions.

"Ideal" CCS Transport Site Named.

A report has named Peterhead Port as the "ideal" hub across the United Kingdom (UK) to facilitate CCS in the north of Scotland. The Acorn CCS project study highlighted 16 UK plots deemed "suitable" for CCS, singling out Peterhead's deepwater water port as the key location for the transfer of 15 million metric tons of CO₂ due to its proximity to existing North Sea pipelines and infrastructure.

Company Commits to Reduce CO₂ Emissions, Achieve Net Zero by 2050.

Baker Hughes, a GE Company (BHGE), announced its commitment to reduce its CO₂ equivalent (CO₂e) emissions by 2030, achieving net-zero CO₂e emissions by 2050. BHGE also launched a Carbon Management Practice that offers quantitative assessment of carbon intensity, evaluation of carbon solutions, and the accreditation of emission reductions.

PROJECT and BUSINESS DEVELOPMENTS

Large-Scale CO₂ Storage Field Trials Planned.

Very Large Scale Decarbonization Partners (VLS Decarb) is planning field trials in several U.S. shale basins, with the potential to further develop the trials into fully functioning CO₂ storage facilities. VLS Decarb is in the process of securing Precedent Agreements for long-term carbon storage contracts. From *Carbon Capture Journal* on February 4, 2019.

Permit Awarded for Carbon Storage Project.

The government of Norway awarded a permit for a CO₂ storage project on the Norwegian Continental Shelf (NCS). Oil firm Equinor was awarded the permit for its "Northern Lights" project, which aligns with the government of Norway's goal to develop and export new technologies for CCS. First announced in July 2018, the Equinor project is currently performing FEED studies, which will provide cost estimates. From *The Maritime Executive* on January 11, 2019.

Technology Development May Lead to EOR Operations.

The development of Carbon Engineering's "Air to Fuels" technology may enable captured CO₂ to be used for enhanced oil recovery (EOR) operations. Direct air capture (DAC) plants are not location-dependent, meaning they could be sited near an oil field to enable the CO₂ to be used for EOR operations. Carbon Engineering has been capturing 1 ton/day of atmospheric CO₂ at a pilot plant in Squamish, British Columbia (Canada), since 2015. The "Air to Fuels" technology produces synthetic fuel by combining the captured CO₂ with hydrogen generated from electrolysis using renewable energy. From *The Chemical Engineer* on January 15, 2019.

DOE Collaboration May Help Identify, Design New CCS Materials.

A computational modeling method may help to fast-track the identification and design of new CCS materials for use by coal-fired power plants. Developed at the University of Pittsburgh's Swanson School of Engineering, in collaboration with DOE/NETL scientists, the hypothetical mixed matrix membranes would provide an economical solution, with a predicted cost of less than \$50/ton of CO₂ removed. The research findings were published in the *Royal Society of Chemistry journal Energy & Environmental Science*. From *University of Pittsburgh's Swanson School of Engineering* on January 8, 2019.

LEGISLATION and POLICY

Draft Carbon Emissions Bill Released in Oregon.

A draft bill set to reduce CO₂ emissions in Oregon (USA) has been released. The measure would establish a Carbon Policy Office and modify greenhouse gas (GHG) emissions reduction goals and market-based mechanisms for covered entities to demonstrate compliance. From *The Register-Guard* on February 1, 2019.

California CCS Protocol Takes Effect.

The California Air Resources Board's (CARB) decision to include a CCS protocol in its Low-Carbon Fuel Standard (LCFS) has taken effect. The protocol allows transportation fuels whose lifecycle emissions have been reduced through CCS to become eligible for credits under the LCFS. Credits are *currently trading at approximately \$180 per ton*, and can be combined with the federal tax credit (45Q) for CCS projects; 45Q provides \$50 per ton for CO₂ stored geologically and \$35 per ton for CO₂ stored permanently via EOR. From *Carbon Capture Journal* on January 20, 2019.

Carbon Legislation Introduced.

Legislation to help reduce U.S. CO₂ emissions by up to 45 percent by 2030, with a more than 90 percent reduction target by 2050 (compared to 2016 levels), was introduced in the U.S. House of Representatives. *The Energy Innovation and Carbon Dividend Act (EICDA)* will price CO₂ at \$15 per metric ton of CO₂e and increasing the price by \$10 every year. From *U.S. Congressman Ted Deutch Press Release* on January 24, 2019.

Massachusetts Carbon Tax Analyzed.

According to analysis by researchers from the Harvard T.H. Chan School of Public Health (USA), a carbon tax based on several proposals in the Massachusetts legislature has the potential to reduce CO₂ emissions by 33 million metric tons. Published in the journal *Environmental Research Letters (ERL)*, the findings were based on models of how a potential carbon fee-and-rebate bill would affect CO₂ emissions in the 2017 through 2040 timeframe. From *Physics World* on January 24, 2019.



EMISSIONS TRADING

RGGI States Initiate Auction Process for Auction 43.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the Auction Notice and application materials for their 43rd quarterly CO₂ allowance auction, to be held on March 13, 2019. The Auction Notice provides potential participants with the information needed to submit a Qualification Application and indicate their intent to bid. Auction 43 will offer for sale 12,883,436 CO₂ allowances 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 January 15, 2019.



Report Analyzes Value of Global CO₂ Markets.

The value of traded global markets for CO₂ allowances rose 250 percent in 2018, according to a new report. According to analysts at Refinitiv, a global provider of financial markets and infrastructure, the overall value of traded global markets in 2018 was \$164 billion (144 billion euros). A total of 9 billion carbon permits were traded globally in 2018, up 45 percent from 2017. The European market accounted for 90 percent of the total value of globally traded carbon permits, with North American trading schemes making up 9 percent. From *Reuters* on January 16, 2019.

CLIMATE and SCIENCE NEWS

Pair of Studies Detail Accelerated Antarctica Ice Melt.

According to a pair of studies, Antarctica's ice sheet has been melting at an accelerated rate over the past four decades, potentially due to elevated levels of CO₂. Published in the *Proceedings of the National Academy of Sciences*, [a new study](#) led by the University of California at Irvine (USA) found that the rate of ice loss in Antarctica has increased from 40 gigatons per year from 1979 through 1990 to 252 gigatons per year from 2009 through 2017 (a six-fold increase). [Another study](#), published in the journal *Nature Geoscience* and led by New Zealand's GNS Science, Victoria University of Wellington, and the University of Wisconsin-Madison, found that elevated atmospheric CO₂ levels could be playing a role in the instability of the Antarctica ice sheet. From *CNN* on January 14, 2019.

Research Team Finds Potential CCS Opportunities.

Japanese scientists found a way to separate carbon monoxide (CO) and CO₂, allowing for potential CCS opportunities. The study, conducted by Kanazawa University, used a hollow, spherical cluster of vanadate molecules to separate the molecules. The results found that vanadium in V12 form has the potential to be an ideal solution in CO₂ capture and CO₂ storage. From *Kanazawa University* on January 7, 2019.

Small Trees Impact on CO₂ Storage.

According to a study led by the Royal Museum for Central Africa, small trees can store CO₂ for a longer period of time compared to larger trees due to smaller trees growing slower and living longer. The research, [published in the online journal Nature Plants](#), found that small trees have the potential to store CO₂ for an average of 74 years, whereas larger trees can store it for an average of 54 to 57 years. From *Phys.Org* on January 29, 2019.

Consortium Receives Grant to Research CO₂ Storage.

A consortium led by the University of California, Davis, and the UC Working Lands Innovation Center (USA) [received a grant](#) from California's Strategic Growth Council to research scalable methods of using soil amendments



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to store GHGs such as CO₂. The consortium will oversee 29 treatment and control sites across California to find out if adding pulverized rock, compost, and biochar to different types of crops and rangelands can store CO₂. The studies are expected to assess whether soil amendments can bring additional co-benefits, such as improved crop and rangeland productivity and soil health, to California growers and ranchers across diverse regions. After three years, the consortium plans to deliver the most promising soil amendment strategies. From *UC Davis News* on January 16, 2019.

JOURNAL ARTICLES

Tracking CO₂ Plumes in Clay-Rich Rock by Distributed Fiber Optic Strain Sensing (DFOSS): A Laboratory Demonstration.

The following is the Abstract of this article: "Monitoring the migration of pore pressure, deformation, and saturation plumes with effective tools is important for the storage and utilization of fluids in underground reservoirs, such as geological stores of CO₂ and natural gas. Such tools would also verify the security of the fluid contained reservoir-caprock system. Utilizing the swelling strain attributed to pressure buildup and the adsorption of supercritical CO₂ on clay minerals, [the authors] tracked the fluid plume in a natural clay-rich Tako sandstone at the laboratory core scale. The strain was measured by a high-resolution distributed fiber optic strain sensing (DFOSS) tool. The strain changes induced by CO₂ adsorptions on clay minerals were significantly greater than those caused by pore pressure alone. The distribution of the swelling strain signals effectively captured the dynamic breakthrough of the CO₂ plume from the high- to low-permeability regions in the Tako sandstone. Besides revealing the in situ deformation state, the measured strain changes can track the movement of the CO₂ plume as it enters the clay-rich critical regions in the reservoir-caprock system. The present findings and potential future applications of DFOSS in the field are expected to enhance the monitoring and management of underground fluid reservoirs." **Yi Zhang, Ziqiu Xue, Hyuck Park, Ji-Quan Shi, Tamotsu Kiyama, Xinglin Lei, Yankun Sun, and Yunfeng Liang**, *Water Resources Research*. (Subscription may be required.)

The U.S. power sector decarbonization: Investigating technology options with MARKAL nine-region model.

The following is the Abstract of this article: "The U.S. economy decarbonization over the next 35 years requires a large transformation of the energy system. The main finding of this study is that it is technically feasible to achieve 80% GHG emissions reduction below the 2005 levels by 2050 through deployment of existing or near-commercially available technologies. GHG reductions are primarily achieved through high levels of electricity sector decarbonization, electrification of end uses, and exchange of the remaining end-uses to

lower carbon fuels such as natural gas. However, deep decarbonization by 2050 triggers very high marginal CO₂ reduction costs, unless significant cost reductions of zero and near-zero carbon technologies occur. The results show that CO₂ reduction policies accelerate the deployment of renewables and CCS only in the scenarios where the decarbonization policies are more stringent than those in the Clean Power Plan (CPP). Electricity generation mixes in the reference scenarios are largely dependent on the price of natural gas, but also show significant sensitivity to cost reductions in CCS. When increased CCS learning rates are incorporated into the model runs, more CCS is optimal in the medium-term and long-term future in the scenarios with CO₂ constraints. An 80% reduction scenario also prompts electrification in end-use demand sectors, creating even more dependence on CO₂ management in the electricity generation sector." **Nadejda Victor, Christopher Nichols, and Charles Zelek**, *Energy Economics*. (Subscription may be required.)

Econometric supply-and-demand models to analyze carbon pricing policies.

The following is the Abstract of this article: "In this paper, the introduction of a carbon pricing policy in air transport industry is investigated. The impact on ticket prices, airlines' market shares and resulting network-wide carbon emissions is studied via a methodology which includes a supply and demand model and a method for estimating carbon emissions costs by airline and itinerary. The application of the carbon pricing policy at the U.S. domestic aviation network revealed that the policy could have some significant effects on ticket prices, air travel demand and resulting CO₂ emissions for high carbon price. But, to achieve the aviation industry ambitious goal to reduce net aviation CO₂ emissions by 50% until 2050, this paper suggests that airlines and policy makers need to adopt a multi-faceted approach with carbon pricing policies, technological, operational and infrastructure improvements to ensure economic and environmental sustainability." **Ioanna Pagoni and Paraskevi Psarakaki-Kalouptsi**, *International Journal of Transportation Science and Technology*. (Subscription may be required.)

JOURNAL ARTICLES (cont.)

Exploring the impacts of a low-carbon policy instrument: A case of carbon tax on transportation in China.

The following is the Abstract of this article: "The rapid growth of energy consumption and CO₂ emission in transportation has brought great challenges to China's energy demand and environmental issues. Carbon tax, considered as an efficient low-carbon policy instrument, can effectively reduce the use of fossil fuels and improve energy efficiency. This study aims to explore the impacts of a transportation carbon tax on transport sectors, macroeconomy and social welfare by developing a computable general equilibrium (CGE) model. Meanwhile, to achieve fiscal revenue neutrality, two schemes are employed for revenue recycling. One is that all of the carbon tax revenue is recycled to subsidize households through lump-sum transfer; the other one is that carbon tax revenue is used to reduce the income tax of households and enterprises. The simulation results show that the appropriate carbon tax rate is 50 Chinese Yuan (RMB)/ton-CO₂. At this level of taxation, energy demand and carbon reduction have fewer negative impacts on the macro-economy and transport sectors. [The authors] also find that the appropriate carbon tax rates among different transport sectors and different energy categories are different. The appropriate carbon tax rates for airlines, railway, urban transport and water transport are same (50 RMB/ton-CO₂), while the appropriate carbon tax rate for road transport sector is 60 RMB/ton-CO₂. The recycling of carbon tax revenue to households and enterprises should be implemented to realize the 'weak double dividend' effect of the carbon tax." **Yinxiang Zhou, Wenshi Fang, Mengjuan Li, and Weili Liu**, *Resources, Conservation and Recycling*. (Subscription may be required.)

Optimum storage depths for structural CO₂ trapping.

The following is the Abstract of this article: "Structural trapping is the primary CO₂ geo-storage mechanism, and it has historically been quantified by CO₂ column heights, which can be permanently immobilized beneath a caprock, using a buoyancy force-capillary force balance. However, the high dependence of CO₂-wettability (a key parameter in the above analysis) on pressure and temperature – and thus storage depth – has not been taken into account. Importantly, rock can be CO₂-wet at high pressure, and this wettability reversal results in zero structural trapping below a certain storage depth (~2400m maximum caprock depth for a most likely scenario is estimated here). Furthermore, more relevant than the CO₂ column height is the actual mass of CO₂ which can be stored by structural trapping (mCO₂). This aspect has now been quantified here, and importantly, mCO₂ goes through a maximum at ~1300m depth, thus there exists an optimal storage depth at around 1300m depth." **Stefan Iglauer**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Postcombustion CO₂ Capture from Wet Flue Gas by Temperature Swing Adsorption.

The following is the Abstract of this article: "[The authors] present an analysis of a novel temperature swing adsorption (TSA) process with condensers capable of treating wet flue gas reaching 90% CO₂ recovery and 95% purity (on a dry basis). In the first part, the characterization of the binary CO₂/water vapor adsorption equilibrium on zeolite 13X is presented, quantifying residual CO₂ adsorption at different levels of water adsorption. On this basis, [the authors] propose an empirical and analytical isotherm model able to capture the competition between CO₂ and water vapor. In the second part, the isotherm model is used in a process simulator to assess the performance of the proposed TSA process in detail. The strict specifications on the CO₂ product could be reached by employing a layered-bed configuration, where a portion of the zeolite 13X bed is replaced by activated alumina. Further, the process is optimized by parametric analysis with respect to productivity and energy consumption while using the specifications as constraints. It is shown that reasonable performance can be obtained, comparable to the scenario where a drying step precedes the cyclic adsorption process but achieving this in a single process step. Moreover, the critical effect of the significant mass transfer resistance of water vapor on zeolite 13X is quantified. Due to a

spread of reported mass transfer coefficients of water vapor on zeolite 13X, the process is assessed for three representative values, showing that comparable performance can be obtained for all cases considered by varying the length of the guard layer. The robustness of the process is further underlined by the reasonable performance for varying concentrations of water vapor in the feed." **Max Hefti and Marco Mazzotti**, *Industrial & Engineering Chemistry Research*. (Subscription may be required.)

The impact on electric power industry under the implementation of national carbon trading market in China: A dynamic CGE analysis.

The following is the Abstract of this article: "As the largest carbon emissions source sector, electric power industry is undoubtedly a principal part of the carbon trading market in China. Aimed at researching the impact on power industry beyond establishing the national carbon trading market, a dynamic computable general equilibrium (CGE) model embedded with carbon trading block is introduced in this paper. Subsequently, [the authors] design 8 scenarios of which illustrate corresponding industry carbon emissions baselines and free quotas ratios. The main simulation results are as follows. The implementation of carbon emissions trading would bring a certain negative impact on the overall economy. Real GDP will be reduced by about 0.08%–0.52% in 2030. Though low free quotas ratio will cause a relatively high loss of GDP, this negative impact would be eliminated in the long run. In addition, carbon emissions trading would also promote the clean production of electricity. Indeed, the electric power industry would reach carbon emissions peak around 2020. Relative to scenarios without carbon trading, carbon emissions would reduce more than 1000 million tons in 2030 when industry carbon emissions baseline declines at an annual rate of 2%. Consequently, the carbon market can achieve a more significant reduction in carbon emissions with the influencing of quotas fully auctioned scenario." **Wei Li, Yan-Wu Zhang, and Can Lu**, *Journal of Cleaner Production*. (Subscription may be required.)

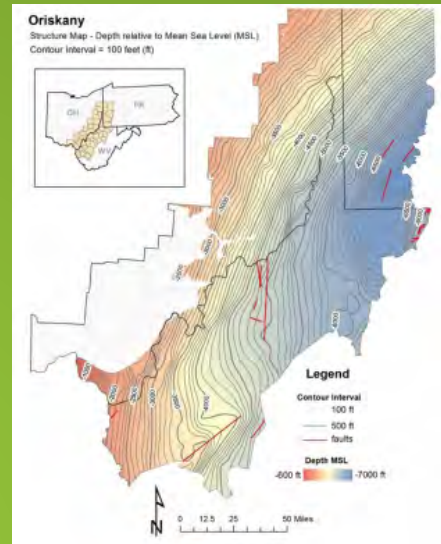
Impact of carbon allowance allocation on power industry in China's carbon trading market: Computable general equilibrium based analysis.

The following is the Abstract of this article: "Global warming has necessitated the quest for CO₂ mitigation globally. Emission Trading Scheme (ETS) is a market-oriented strategy which may be effective for CO₂ mitigation. This study establishes a Computable General Equilibrium (CGE) model to analyze the impact of different ETS quota allocation scheme on the electricity industry and determine the best choice of quota allocation scheme for the electricity industry in China. The research on China's carbon trading market may provide an important case for the global carbon trading market. The results show that different quota allocation schemes have impacts on electricity price, and there are some spillover effects to other industries. Higher Annual Decline Factor (ADF) will reduce carbon rights than lower ones. Changes in the quota allocation schemes of a single industry (electricity) can hardly affect aggregate GDP and CO₂ emissions. Moreover, ETS quota allocation scheme in the electricity sector based on historical emission intensity could have better performance in commodity price, electricity supply, ETS price, GDP and social welfare. Thus, this paper suggests that the best choice of ETS quota allocation scheme in the electricity sector is the scheme that is based on historical emission intensity which ADF is 0." **Lirong Zhang, Yakun Li, and Zhijie Jia**, *Applied Energy*. (Subscription may be required.)

REPORTS and OTHER PUBLICATIONS

History, Sampling, Porosity and Permeability Testing of Salem Limestone, Oriskany Sandstone and Marcellus Shale.

The following is the Abstract of this NETL document: "This report describes measurements of the fluid storage and transmission properties of Salem Limestone, Oriskany Sandstone, and Marcellus Shale. Test results are assessed in the context of confining stress applied to the sample and sample preparation procedures. For perspective, a general geologic description is provided for each rock type. The current regional stress state was also considered in terms of the test specimens' propensity for preferential fracturing. As part of the test program, two different methods for sample testing were used depending on rock type. Combined permeability and porosity tests were performed on small, cylindrical plug samples one inch (2.54 cm) in diameter by at least two inches (5 cm) in length. Helium gas was used in testing for both the Salem Limestone and Oriskany Sandstone, whereas nitrogen gas was used for Marcellus Shale. Porosity to gas and high-pressure, pulse-decay gas permeability were evaluated on all samples at four net confining pressure steps: 500 psi (3.4 MPa), 1,000 psi (6.9 MPa), 1,500 psi (10.3 MPa), and 2,000 psi (13.8 MPa). Test results for each rock type were generally uniform. Under conditions of increasing net confining pressure, the average matrix porosity of the Salem Limestone ranges from 7.62% to 7.83%, and matrix permeability ranges from 1.81 to 1.87 mD. The Oriskany Sandstone's average matrix porosity ranges from 6.05% to 6.43% and matrix permeability ranges from 4.8 to 9.1 μ D. The Marcellus Shale plug samples were cut in two different directions; in one group the cylinder axis was cut perpendicular to the bedding plane and the other group was cut parallel to the bedding plane. Porosity measured in the group of perpendicular samples ranges from 4.34% to 7.72% and permeability ranges from null to 0.5 μ D. Porosity of the parallel sample group ranges from 0.54% to 1.32% and permeability readings from 0.02 to 1.12 μ D. Interpretation of the results concluded that porosity and permeability are relatively insensitive to the sample preparation methods used in this study, and the recorded values are reasonable when compared with published data or other representative samples."

*Industrial Carbon Capture Business Models.*

The following is the Executive Summary of this UK Department of Business, Energy, and Industrial Strategy (BEIS) document: "Deep [decarbonization] of all sectors of energy use is required to meet the UK's long-term emissions reductions goals. Whilst progress has been made in the power sector, energy intensive industry (EII) presents a particular challenge, both technically due to lack of alternative processes, and economically, due to the internationally traded nature of many products. Carbon Capture [Utilization] and Storage (CCUS) has been [recognized], both internationally and in the UK, as a key technology in reducing CO₂ emissions in industry. In the last 15 years, the annual global CO₂ storage rate doubled to a 2017 value of around 37 MtCO₂/year, with most operational projects being industrial CCUS. Importantly, [Industrial carbon capture (ICC)] presents many opportunities for the UK, including protecting existing industry from exposure to climate regulations (e.g. CO₂ pricing), attracting foreign direct investment in UK manufacturing and supporting [decarbonization] of the heat sector. The International Energy Agency estimates there will be a global CCUS market worth over £100 bn, and even a modest share of this could increase UK [gross value added (GVA)] by between £5 bn and £9 bn per year by 2030. To unlock the potential for CCUS deployment at scale in the UK during the 2030s, BEIS committed in the Clean Growth Strategy (CGS) to review viable delivery and investment models. As the previous full-chain CCS projects in the UK involved complex risk sharing arrangements, it is important to explore whether 'part chain' business models for ICC are more investable. Element Energy and its partners were commissioned by BEIS to identify the range of business models that could [incentivize] cost-effective deployment and operation of ICC technology in the UK. Consideration is given to the key barriers currently hindering the deployment of ICC as well as business models used in other sectors and countries that have potential to address these challenges and drive cost reductions."



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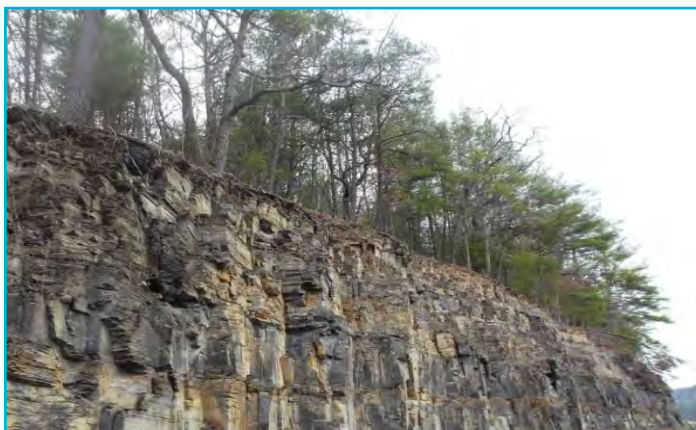
ABOUT DOE'S CARBON STORAGE PROGRAM

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.

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