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CARBON STORAGE NEWSLETTER

JUNE 2020

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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DOE/NETL HIGHLIGHTS

NETL Software Helps Estimate CO₂ Storage Potential.

A new iteration of a National Energy Technology Laboratory (NETL) software application enables researchers to more accurately estimate carbon dioxide (CO₂) storage potential. The *CO₂-SCREEN* (Storage prospective Resource Estimation Excel aNalysis) tool applies methods and equations for estimating prospective CO₂ storage resources in residual oil zones (ROZs), which can be used for large-scale carbon capture, utilization, and storage (CCUS) projects. ROZs have the potential to boost economic activity through energy production while also storing CO₂. From *NETL Press Release*, May 2020.

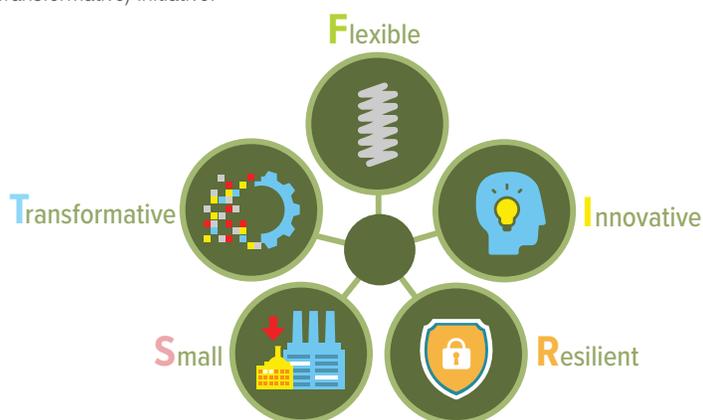
ANNOUNCEMENTS

Document Highlights DOE's CCS R&D.

A document released by the U.S. Department of Energy (DOE)/NETL highlights 20 years of its carbon capture and storage (CCS) research and development (R&D). The document, titled "*Safe Geologic Storage of Captured Carbon Dioxide: Two Decades of DOE's Carbon Storage R&D Program in Review*," details the role played by DOE's *Regional Carbon Sequestration Partnership (RCSP) Initiative*.

DOE Announces Intent to Commit Funding for Coal FIRST Initiative.

DOE's Office of Fossil Energy announced its intention to commit federal funding for cost-shared R&D projects through the release of the draft Funding Opportunity Announcement (FOA), *Design Development and System Integration Design Studies for Coal FIRST Concepts*. (The draft FOA was issued to make interested parties aware of DOE's intention to issue the finalized FOA later this summer.) Projects resulting from the finalized FOA will support DOE's Coal FIRST (Flexible, Innovative, Resilient, Small, Transformative) Initiative.



National Carbon Capture Center Expands Testing.



The National Carbon Capture Center (NCCC) announced expanded testing in its future scope of work for DOE/NETL. NCCC is now expected to include testing of CO₂ utilization and direct air capture technologies. In addition, NCCC will broaden its testing and evaluation of CO₂ capture technologies for natural gas power generation through a new addition to the center.

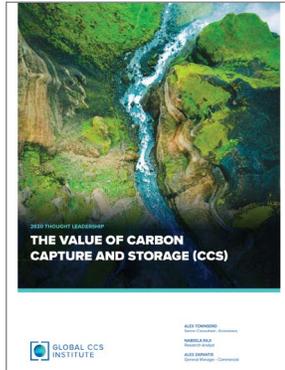
ANNOUNCEMENTS *(cont.)*

CCUS Finance Workshop Report Available.

CMC Research Institutes released a summary report of a workshop exploring CCUS investment opportunities. Workshop attendees discussed challenges that technology developers, industry, and investors may face and potential solutions that may be realized while advancing CCUS technologies from early-stage research to commercialization.

Report Assesses Value, Benefits of CCS.

The Global CCS Institute released a report analyzing the benefits of large-scale investment and deployment of CCS. *The report discusses* the evidence related to the value of CCS under two themes: CCS as an essential technology to economically meet long-term goals, and CCS as a driver of economic growth and employment.



UK CCC Pens Letter in Support of CCS.

The United Kingdom (UK) Committee on Climate Change (CCC) wrote letters to *the UK* and *Scottish governments* providing advice on (1) strengthening the economy through actions such as redeploying workforces in low-carbon industries, including CCS, and (2) targeted funding for science and innovation in low-carbon technologies.

Podcast Discusses Carbon Cycle, Carbon Storage.

The “No-Till Farmer Influencers & Innovators” podcast released an episode discussing the carbon cycle and why it is more complicated than the common perception of carbon storage. In addition, the episode covered the role carbon cycling can play in today’s carbon credits program.

PROJECT and BUSINESS DEVELOPMENTS

Technology Approved for Full-Scale Demo Project.

DNV GL, an international accredited registrar and classification society headquartered in Høvik, Norway, has approved technology for a full-scale demonstration project to remove CO₂ emissions from a cement plant in Norway. The project, which was initiated by Gassnova (the Norwegian state’s agency for implementation of CCS projects), will apply carbon capture technology developed by Aker Solutions at Norcem’s Brevik, Norway, cement plant. The plant is part of Europe’s industrial demonstration of CCUS; the captured CO₂ is expected to be transported to and injected into a CO₂ storage site offshore of Norway. From *DNV GL News Release*. April 2020.

Feasibility Study to Assess CCS Options.

KBR was awarded a feasibility study to assess options for CCS in South East Asia. As part of the study, awarded by JX Nippon Oil & Gas Corporation, KBR will provide technical consultancy services for developing concepts and technology recommendations for CO₂ capture and reinjection. KBR is a global provider of professional services and technologies within the government, technology, and energy solution sectors. From *KBR Press Release*. May 2020.

Investment in CCS Project Announced.

Equinor, Shell, and Total announced their intent to establish a joint venture company to invest in Norway’s Northern Lights project, part of the Norwegian full-scale CCS project. The investment decision concludes the study phase of the project during which the companies conducted engineering studies and project planning, drilled a confirmation well, and developed the necessary agreements. Phase I of the project includes capacity to transport, inject, and store up to 1.5 million metric tons of CO₂ per year. If approved by the Norwegian government, Phase I is expected to be operational in 2024. From *Total News Release*. May 2020.

Partnership to Capture, Store CO₂.

LafargeHolcim, a Swiss building material company, is partnering with Solidia Technologies, a U.S.-based cement and concrete technology company, to reduce CO₂ across its value chain. Combined, the two companies’ solutions capture and store CO₂ and emit up to 30% less CO₂ during cement production, leading to 70% reduced-carbon concrete. From *World Cement*. May 2020.

LEGISLATION and POLICY

Policy Design to Finance CCUS Projects in US.

Columbia University’s Center on Global Energy Policy released a report on CCUS policy configurations. The report found that additional policies would benefit and incentivize the deployment of CCUS in the commercial power market. The authors analyzed which policy configurations would incentivize the widespread deployment of CCUS in the U.S. electric generation industry. The results focused on the effect of ownership structure, the 45Q tax credit, capital cost incentives, and revenue enhancement incentives. More information, including the full report, a presentation, and a data-sharing portal, is *available online*. From *Carbon Capture Journal*. April 2020.

Roadmap Examines CO₂ Emissions Reductions Through Technologies.

CEMBUREAU (the European Cement Association) *published its Carbon Neutrality Roadmap (CNR)*, examining how the European cement industry can reach net-zero CO₂ emissions by 2050 and align with the European Green Deal. *According to the roadmap*, achieving net-zero emissions by 2050 will require the deployment of existing and new technologies, such as CCUS. The CNR also details the role these technologies could play in reducing CO₂ emissions at each stage of the cement and concrete value chain and provides both technical and policy recommendations. From *CemNet.com*. May 2020.



LEGISLATION and POLICY (cont.)

[Australia's Technology Investment Roadmap Considers CCS Technologies.](#)

Australia's federal government released its technology investment roadmap for reducing CO₂ emissions over the next 30 years. CCS was among the technologies under consideration to meet the nation's emissions goals, for which the Australian government recommended long-term investment. From *ABC.net*. May 2020.

[UK Draft Accord Sets Path for Future UK-EU CO₂ Trading.](#)

In a draft technical energy accord released on its website, the UK set out the basis for potentially linking UK-European Union (EU) CO₂ emissions trading systems (ETSs). The carbon pricing section of the draft accord states that the UK is open to linking to the EU ETS, which could potentially include enabling CO₂ allowances from either entity to be used in either system. From *S&P Global*. May 2020.

EMISSIONS TRADING

[Regional Greenhouse Gas Initiative Reports Made Available.](#)

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released two reports. The [Annual Report on the Market for RGGI CO₂](#)



[Allowances: 2019](#) evaluates market activity for RGGI CO₂ allowances, focusing on allowance prices, trading and acquisition of allowances in the auctions and secondary market, participation in the market by individual firms, and market monitoring. More details on 2019 allowance prices, holdings, and market participation are available on RGGI's [Market Monitor Reports webpage](#). In addition, the [Report on the Secondary Market for RGGI CO₂ Allowances: First Quarter 2020](#) addresses the period from January through March 2020 and contains information on the secondary market for RGGI CO₂ allowances, including future prices, market activity, and allowance holdings. From *RGGI News Releases*. May 2020.

[EU, Swiss Carbon Trading Link Postponed.](#)

The EU Commission announced that it had postponed the launch of a provisional mechanism for transferring carbon permits between Switzerland and the EU ETS. The EU and Switzerland linking agreement entered into force in January 2020; however, for the linking to happen, a provisional mechanism for the transfer of permits had to be in place by May 2020. The EU Commission said this transfer has been postponed until September 2020 due to the COVID-19 outbreak. From *Today Online*. May 2020.

[Europe Carbon Trading Volumes Rise.](#)

According to Germany's emissions trading authority (DEHSt), trading volumes in Europe's carbon trading market rose in the first quarter of 2020 by 8% year-on-year. More than 1 billion allowances were traded in March 2020, which was the largest volume in a single month since October 2018. From *Montel News*. May 2020.

[German Bank Forecasts Global Carbon Offset Market.](#)

The value of the global market for CO₂ emissions offsets could increase from \$0.6 billion (2019) to \$200 billion by 2050, according to the German bank Berenberg. The bank states that as countries hit the limits of decarbonization, they will have to rely on offsetting projects to balance carbon emissions. Carbon offsets can include land-use projects that absorb CO₂ (such as forest and marshland development programs) or changes to cleaner energy of industrial technologies that would otherwise be uneconomical. From *S&P Global*. May 2020.

SCIENCE NEWS

[Research Examines Water Sustainability During CCS Implementation.](#)

Research conducted by scientists from University of California, Berkeley (USA) examined how CCS technology can be sustainably implemented without compromising water resources. The study, [published in the online journal Nature Sustainability](#), also examined how emerging CCS technologies could mitigate the demand current CCS practices place on water consumption. From *University of California, Berkeley, News Release*. May 2020.

[Scientists Develop Artificial Photosynthesis for Carbon Storage.](#)

New developments may allow scientists to recreate and control artificial photosynthesis for carbon storage. Using spinach membranes and oil droplets filled with enzymes, European researchers were able to mimic natural plant pathways and transform CO₂ into useful compounds. According to the study, [published in the journal Science](#), this artificial photosynthesis may be more efficient than its natural counterpart in the future since the researchers are able to carefully control how photosynthesis takes place. From *Inverse*. May 2020.

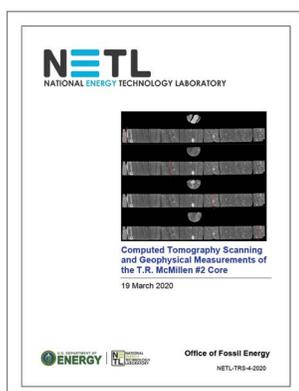
[Scientists Develop CO₂-Separating Membrane.](#)

Newcastle University (UK) scientists developed a self-assembling silver membrane with the potential to capture CO₂ emissions and possibly be utilized in certain CCS applications. According to the researchers, silver could be an effective material for some CCS applications. In the study, [published in the journal Energy & Environmental Science](#), the research team found a way to gain the benefits of using silver in the CO₂ separation process without needing a lot of the element itself. From *ScienceAlert*. May 2020.

PUBLICATIONS

Computed Tomography Scanning and Geophysical Measurements of the T.R. McMillen #2 Core.

The following is from the abstract of this DOE/NETL document: "The computed tomography (CT) facilities and the Multi-Sensor Core Logger (MSCL) at the National Energy Technology Laboratory (NETL) in Morgantown, West Virginia were used to characterize core from the Carbon Safe Christian County project, T.R. McMillen #2 well (API 1202125650). The primary impetus of this work is a collaboration between the U.S. Department of Energy (DOE) and the Illinois State Geologic Survey at the University of Illinois, Urbana-Champaign. The resultant datasets are presented in this report, and can be accessed from NETL's Energy Data eXchange (EDX) online system using the following link: <https://edx.netl.doe.gov/dataset/carbonsafe-tr-mcmillen-2>. [...] Imaging with the NETL medical CT scanner was performed on the entire core. Qualitative analysis of the medical CT images, coupled with X-ray fluorescence (XRF), P-wave, and magnetic susceptibility measurements from the MSCL were useful in identifying zones of interest for more detailed analysis. The ability to quickly identify key areas for more detailed study with higher resolution will save time and resources in future studies. The combination of methods used provides a multi-scale analysis of the core; the resulting macro and micro descriptions are relevant to many subsurface energy related examinations traditionally performed at NETL."

***U.S. DOE/NETL large pilot-scale testing of advanced carbon capture technologies.***

The following is from the abstract of this article: "The mission of the United States (U.S.) Department of Energy/National Energy Technology Laboratory (DOE/NETL) Carbon Capture Program is to develop the next generation of advanced CO₂ capture concepts for the power-generation sector. The Carbon Capture Program employs a down-selection process that graduates technologies from a large portfolio of laboratory/bench-scale projects to a smaller set of small-scale pilot projects and eventually to an even smaller group of large-scale pilot projects. At every scale, computer simulation plays a significant role in guiding experimental efforts and accelerating the overall pace of technology development. This down-selection process serves to de-risk industrial investment, given that there is insufficient information generated at the laboratory/bench scale to confidently predict eventual commercial success. The Carbon Capture Program is currently engaged in efforts to advance the next generation of capture technologies to large pilot scale. Three capture technologies have been awarded Phase I projects in a competition to build large-scale pilots for advanced energy and post combustion capture systems. In addition, six capture technologies are working toward large-scale pilot testing at Technology Center Mongstad in Norway. Advances along three innovation pathways—materials, processes, and equipment—have been critical in preparing these technologies for large pilot-scale testing. This paper describes the approach that is being followed by the Carbon Capture Program to advance the technologies and provides brief descriptions of the technical innovations that have prepared individual technologies for large pilot-scale testing." **Lynn Brickett, Ron Munson, and John Litynski, *Fuel*.** (Subscription may be required.)

A comparison of carbon dioxide storage resource estimate methodologies for a regional assessment of the Northern Niagaran Pinnacle Reef Trend in the Michigan Basin.

The following is from the abstract of this article: "The Northern Niagaran Pinnacle Reef Trend has more than 800 identified Silurian-aged pinnacle reefs in the Michigan Basin. The reefs have a long history of oil and gas production, gas storage, and more recently successful CO₂-enhanced oil recovery (EOR) operations. These fields provide an excellent opportunity to evaluate the geologic variability in complex carbonate reservoirs and its impact on carbon capture, utilization, and storage feasibility. A comprehensive database was built that identifies reefs and links key reservoir attributes to each field. Novel methodologies and techniques were developed to analyze hundreds of fields for CO₂ storage and EOR options. This included a regional static earth model to compute volumetric-based resource estimates, fluid substitution to estimate storage resources from oil and gas production, and proximity analysis-based weighting of reefs to predict reservoir performance metrics and estimate EOR. Lastly, an enhanced storage scenario of maximizing a reef's storage potential at the end of a CO₂-EOR life cycle was evaluated." **Autumn Haagsma, Joel Main, Ashwin Pasumarti, Manoj Valluri, Mackenzie Scharenberg, Glenn Larsen, Wayne Goodman, Amber Conner, Zachary Cotter, Laura Keister, William Harrison, Srikanta Mishra, Rick Pardini, and Neeraj Gupta, *Environmental Geosciences*.** (Subscription may be required.)

Development and application of a machine learning based multi-objective optimization workflow for CO₂-EOR projects.

The following is from the abstract of this article: "Carbon dioxide-Enhanced Oil Recovery (CO₂-EOR) is known as one of techniques for hydrocarbon production improvement as well as an important candidate to reduce greenhouse gas emissions. Thus, an ideal development strategy for a CO₂-EOR project would consider multiple objectives including to maximize oil recovery, CO₂ storage volume and project economic outcomes. This work proposes a robust computational framework that couples artificial neural network (ANN) and multi-objective optimizers to optimize the aforementioned objectives in CO₂-EOR processes simultaneously. Expert ANN systems are trained and employed as surrogate models of the high-fidelity compositional simulator in the optimization workflow. The robustness of the development optimization protocol is confirmed via a synthetic injection-pattern-base case study. Afterward a field implementation to Morrow-B formation to optimize the tertiary recovery stage of the field development is discussed. This work compares the optimum solution found using an aggregate objective function and the solution repository (Pareto front) generated by the multi-objective optimization process. The comparison indicates the existence of potential multi-solutions satisfying certain criteria in a CO₂-EOR project designing, which cannot be found using traditional weighted sum method. The optimization results provide significant insight into the decision-making process of CO₂-EOR project when multiple objective functions are considered." **Junyu You, William Ampomah, and Qian Sun, *Fuel*.** (Subscription may be required.)

PUBLICATIONS (cont.)

Application of bioelectrochemical systems for carbon dioxide sequestration and concomitant valuable recovery: A review.

The following is from the abstract of this article: "The rise in global atmospheric temperature due to increase in the atmospheric carbon dioxide concentration needs to be tackled immediately before it reaches the point of no return. The application of innovative technologies based on the concepts of bioelectrochemical systems (BESs) can contribute in this direction by simultaneously sequestering CO₂ and producing value-added products in the process. Wastewater treatment with simultaneous bioenergy and biofuel recovery is also one of the added [advantages] of employing BESs for CO₂ fixation. This review focuses on the potential of employing BES-based technologies like microbial carbon capture, plant-microbial fuel cell and microbial electrosynthesis cell for the concomitant production of valuables and CO₂ sequestration. Also, various parameters affecting performance of BES that need to be optimized for the proper field-scale demonstration of these technologies are discussed." **Sovik Das, Swati Das, Indrasis Das, and M.M. Ghangrekar**, *Materials Science for Energy Technologies*. (Subscription may be required.)

Mitigation of carbon dioxide by accelerated sequestration in concrete debris.

The following is from the abstract of this article: "Carbon capture and storage is becoming increasingly feasible. This study provides a novel quantitative analysis of the global CO₂ mitigation potential through accelerated carbon sequestration in concrete debris separated from construction and demolition waste. [The authors] consider the economic and environmental tradeoff. Based on data collection from 14 large regions and countries, [the authors] created a method to estimate and project the generation of concrete debris, recycling and carbonation rates, and cost. The overall concrete debris generation was more than 3.0 (0.6) billion tonnes (Bt) in 2017 worldwide, mainly from emerging countries such as China and India. This debris has the potential to mitigate 62.5 (8.9) million tonnes (Mt) CO₂ under optimal carbonation conditions determined by pressure, temperature, humidity, time, CO₂ concentration, and debris size. [The authors'] scenario analysis reveals that the global cumulative carbonation of concrete debris could be as high as 3.0 Bt CO₂ between 2018 and 2035, which equals approximately one third of the total CO₂ emissions from fuel combustion of China in 2016. In our scenarios, the economic benefits of storing CO₂ by concrete debris are mainly from recycled concrete aggregate rather than carbon sequestration, but also consider the current carbon price in major carbon markets. These findings highlight an effective and practical approach to reuse concrete debris as well as enhancing economic benefits. This approach could be helpful to better manage the fast-growing concrete debris and need for carbon mitigation as well as bridging the gap of CO₂ sequestration by concrete debris between research and application." **Ning Zhang, Huabo Duan, Travis R. Miller, Vivian W.Y. Tam, Gang Liu, and Jian Zuo**, *Renewable and Sustainable Energy Reviews*. (Subscription may be required.)

When Is Blockchain Worth It? A Case Study of Carbon Trading.

The following is from the abstract of this article: "Blockchain, as an emerging technology and a disruptive innovation, has attracted attention from both academia and industry. However, there are many potential risks associated with it, such as the technical risk, the legal risk and the privacy risk. A comprehensive risk analysis is crucial for cost-effective deployment of blockchain technology. Important adoption decisions, including when to deploy blockchain, how to plan the investment, how to transfer current businesses onto blockchain, and how to price the blockchain service depend on this risk analysis. Yet very little study exists concerning the blockchain adoption planning with risks analysis. This research presents a cost-and-risk analysis framework and an adoption planning method for the case of blockchain application in carbon trading. Design requirements implied by the analysis are inferred and the architecture of a novel hybrid blockchain system is proposed. The system leverages the advantages of blockchain technology and incorporates institutional risk control framework. The optimal adoption strategy of this system is derived through modelling of users' and the organizer's behavior." **Fangyuan Zhao and Wai Kin (Victor) Chan**, *Energies*. (Subscription may be required.)

Evaluating the efficiency of carbon emissions policies in a large emitting developing country.

The following is from the abstract of this article: "Using the energy-environmental version of the Global Trade Analysis Project, this study compares the effects of three carbon emissions mitigation strategies – a carbon tax, a fuel tax and an emissions trading scheme (ETS) to combat the intended emissions target for Indonesia, a large emitting developing country. Although the fuel tax was found to raise economic growth by 0.29% in 2030, the carbon tax and ETS which reduce economic growth by about 0.11% have less adverse effects on inflation, welfare loss, wage decline, and employment loss. Unlike the fuel tax, the carbon tax and ETS are also likely to promote substitution towards renewable energy given the massive increase in the price of coal of over 100% due to the carbon tax and ETS. To meet Indonesia's emissions target, a carbon tax of US\$36/ton of CO₂ is needed. The carbon tax which is simpler and more swiftly implementable is the more practical choice compared to the ETS in the short to medium term for developing countries with political economy constraints in their energy and transportation sectors." **Sumali Dissanayake, Renuka Mahadevan, John Asafu-Adjaye**, *Energy Policy*. (Subscription may be required.)

Pricing decisions in a socially responsible supply chain under carbon cap-and-trade regulation.

The following is from the abstract of this article: "This article investigates a socially responsible supply chain under the cap-and-trade mechanism. Stylized centralized and decentralized models are established to characterize corporate social responsibility (CSR) in this supply chain. Analytical results reveal that the centralized case always achieves a higher socially responsible channel profit than the two decentralized models, but whether the centralized case achieves a higher pure channel profit than the decentralized scenarios depends on how heavier the weight is placed on CSR: when the weight is modest, the centralized model attains a higher pure channel profit, while a heavier weight on CSR leads to a higher pure channel profit for the two decentralized cases. [The authors] further examine how the CSR concern level and a government-set carbon cap-and-trade policy affect the operations of this socially responsible supply chain." **Zhi-chao Zhang, Kevin W. Li, Zhi Liu, and Jun Huang**, *IFAC-PapersOnLine*. (Subscription may be required.)

Carbon Taxes and CO₂ Emissions: Sweden as a Case Study.

The following is from the abstract of this article: "This quasi-experimental study is the first to find a significant causal effect of carbon taxes on emissions, empirically analyzing the implementation of a carbon tax and a value-added tax on transport fuel in Sweden. After implementation, carbon dioxide emissions from transport declined almost 11 percent, with the largest share due to the carbon tax alone, relative to a synthetic control unit constructed from a comparable group of OECD countries. Furthermore, the carbon tax elasticity of demand for gasoline is three times larger than the price elasticity. Policy evaluations of carbon taxes, using price elasticities to simulate emission reductions, may thus significantly underestimate their true effect." **Julius J. Andersson**, *American Economic Journal: Economic Policy*. (Subscription may be required.)

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](#).



Rig drilling a site characterization well at the Craig Power Station in Colorado, USA. Photo Source: Schlumberger Carbon Services

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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