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CARBON STORAGE NEWSLETTER

OCTOBER 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

- ▷ Carbon Storage Educational Resources
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DOE/NETL HIGHLIGHTS

DOE/NETL 2020 Virtual Integrated Project Review Meeting Underway.

A series of free virtual sessions organized by the U.S. Department of Energy (DOE) and the National Energy Technology Laboratory (NETL) commenced in August 2020 with sessions on carbon capture, utilization, and storage (CCUS). In September 2020, the virtual meeting featured four days of carbon storage topics, including an overview of the Regional Initiatives, updates on *Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative* Phase II projects, and results from recent efforts of *DOE's Regional Carbon Sequestration Partnerships (RCSPs)*. In addition, the virtual meeting included discussions on carbon storage technologies, wellbore integrity, plume detection, intelligent monitoring systems, and offshore opportunities. The 2020 Virtual Integrated Project Review Meeting, which will run into November 2020, features sessions focused on how DOE/Office of Fossil Energy (FE)-sponsored research and development (R&D) activities advance transformative science and technologies to support efficient and environmentally sound use of fossil fuels. A comprehensive schedule of the virtual meeting is [available online](#). From *NETL News Releases*. August and September 2020.



2020 INTEGRATED PROJECT REVIEW MEETING

ANNOUNCEMENTS

Wyoming Granted Primacy to Regulate CO₂ Storage Wells.

The U.S. Environmental Protection Agency (EPA) granted the Wyoming Department of Environmental Quality primacy to monitor underground injection wells used to store carbon dioxide (CO₂). In addition, Wyoming state regulators will have the authority to craft and enforce regulations to protect drinking water sources during construction and use of the wells, as required under the *Safe Drinking Water Act*. Wyoming joins North Dakota as U.S. states permitted to implement their own regulations on *Class VI injection wells*.

DOE/NETL Launches Carbon Capture Newsletter.

DOE/NETL announced the launch of a Carbon Capture Newsletter. The monthly newsletter provides information on recent activities and publications related to carbon capture and *NETL's Carbon Capture Program*. Sections include Interagency News and Updates, Upcoming U.S. and International Conferences, Business and Industry News, and Publications. [Click here for subscription information.](#)



ANNOUNCEMENTS *(cont.)*

DOE Offers Prize to Design Subsurface Visualization Tool.

DOE/FE will award up to \$1.5 million to winning innovators in a prize challenge to support their SMART (Science-informed Machine Learning to Accelerate Real-Time Decisions in the Subsurface) Initiative. The SMART Visualization Platform (VP) Challenge prize competition seeks competitors with software development expertise to create a new visualization platform that will assist in making subsurface insights accessible to a wider range of users and stakeholders. *SMART* leverages the expertise of seven national laboratories, as well as industry partners, universities, unconventional field laboratories, and carbon storage regional initiatives, to realize breakthroughs in understanding the subsurface environment through machine learning. Registration information can be found on the [SMART VP Challenge website](#). The registration deadline is January 22, 2021.



NETL Releases ROZ Appraisals Featuring FE/NETL Onshore CO₂-EOR Cost Model.

NETL released CO₂-enhanced oil recovery (EOR) appraisal reports for two regions of the San Andres residual oil zone (ROZ) fairway in the Permian Basin (USA). The two reports (*An Eight-County Appraisal of the San Andres Residual Oil Zone (ROZ) "Fairway" of the Permian Basin* and *A Four-County Appraisal of the San Andres Residual Oil Zone (ROZ) "Fairway" of the Permian Basin*) use reservoir simulator outputs and economic viability considerations to estimate the oil that can be produced and the CO₂ that can be stored in these fairway regions. The FE/NETL CO₂ Prophet Model and the *FE/NETL Onshore CO₂-EOR Cost Model* were used to determine results of these studies. The reports, cost model, and other relevant documents can be found on NETL's [Search Energy Analysis](#) website by searching under the Collection Names "Eight-County San Andres ROZ Appraisal," "Four-County San Andres ROZ Appraisal," and "FE/NETL Onshore CO₂-EOR Cost Model."

NETL Releases Offshore Oil Field Case Studies.

NETL released three case studies on offshore CO₂-EOR. The studies (*Horn Mountain Oil Field Case Study*, *Cognac Offshore Oil Field Case Study*, and *Petronius Offshore Oil Field Case Study*) provide perspective into the challenges of evaluating offshore CO₂-EOR and CO₂ storage potential, and demonstrate the performance of the CO₂ Prophet Model EOR reservoir simulator. These studies, as well as other relevant documents, can be found on NETL's [Search Energy Analysis website](#) by searching "offshore EOR."



DOE Invests in Carbon Capture Technologies.

DOE announced federal funding to support the development and advancement of CO₂ capture technologies under two Funding Opportunity Announcements (FOAs). The funding will support nine projects for coal and natural gas power and industrial sources and 18 projects that remove CO₂ through direct air capture (DAC) technology. Descriptions of the projects are [available on the NETL website](#).

NETL Releases 2020 Compendium of Carbon Capture Technology.

NETL's 2020 Compendium of Carbon Capture Technology, which is now [available on the NETL website](#), provides stakeholders with a summary of NETL's Carbon Capture Program. The document contains CO₂ capture technology R&D descriptions for more than 130 active and completed projects.



Field Hearing Held on CCS.

The U.S. Senate Committee on Environment and Public Works held a field hearing on carbon capture and storage (CCS) near the Dry Fork Station power plant in Wyoming, USA. The hearing was held at the [Integrated Test Center \(ITC\)](#), a utility-scale carbon capture laboratory attached directly to a coal facility.

CCS Facility Announces Monthly Totals.

The CCS facility located at SaskPower's Boundary Dam Power Station captured more than 75,000 metric tons of CO₂ in July 2020, marking the facility's highest single month total since July 2019. More than 390,000 metric tons of CO₂ have been captured through CCS at the facility in 2020; nearly 3.48 million metric tons of CO₂ have been captured since the facility went online in 2014.

Report Reviews CO₂ Storage Regulations.

The CO₂ Capture Project published a report reviewing global CCS regulations. The "[Survey of CO₂ Storage Regulations](#)" report (subscription may be required to view) analyzes recent developments in CO₂ storage project regulations worldwide, emphasizing key developments, outstanding issues, and gaps that may impact the commercial success of CCS.

White Paper Outlines Case for CO₂ Storage.

The American Forest Foundation released a white paper outlining the case for how family-owned forests can store CO₂. "[Family-owned Forests: How to Unlock the Carbon Potential in America's Backyard](#)" details financial mechanisms that could enable family landowners to overcome cost barriers for implementing practices that would increase the health and CO₂ storage ability of their trees.

PROJECT and BUSINESS DEVELOPMENTS

CCS Study Moves to Geophysical Survey Stage.

The University of Wyoming, Basin Electric Power Cooperative, and other partners are working to develop a site capable of storing more than 50 million metric tons of CO₂ underground as part of a DOE CarbonSAFE Initiative project. A geophysical survey has begun, covering approximately nine square miles around the Dry Fork Station power plant in Gillette, Wyoming (USA). Over the next three years, the project partners will conduct commercial-scale surface and subsurface testing, data assessment, and modeling; prepare and file construction permits with Wyoming's Department of Environmental Quality; integrate the project with a separate CO₂ capture study; and conduct the required National Environmental Policy Act analyses. From *University of Wyoming*. August 2020.

CCS Feasibility Study Set to Begin.

A study to determine the feasibility of constructing a full-scale CCS facility project at a cement plant in Edmonton, Canada, is set to begin. The study will focus on the feasibility of capturing the majority (90 to 95%) of CO₂ from the flue gas of the Lehigh cement plant. The International CCS Knowledge Centre is a partner on the project. From *Journal of Commerce*. August 2020.

Agreement Reached on Scaled-Up CO₂ Removal, Storage.

Climeworks, ON Power, and CarbFix will collaborate to build facilities to capture CO₂ using DAC technology and store the CO₂ via natural underground mineralization. The facilities will be built within ON Power's Geothermal Park in Iceland, and the CO₂ will be stored in basalt formations. From *Carbon Capture Journal*. September 2020.

LEGISLATION and POLICY

Reports Highlight Carbon Pricing, CCUS.

A pair of reports released in September 2020 discuss the potential policies that could impact energy transition scenarios. In an Energy Outlook released by the United Kingdom (UK)-based BP, the role of future carbon prices was highlighted. In addition, a report titled "Delivering on America's Pledge," released by the U.S.-based sustainability research organization Rocky Mountain Institute, discussed the role of CCUS in power generation. From *S&P Global*. September 2020.

UK Publishes CCUS Policy Documents.

The UK's Department of Business, Energy and Industrial Strategy (BEIS) published new policy documents that focus on CCUS. The policy documents are BEIS's follow-up to previous consultation on CCUS and hydrogen policy. The documents establish "Expert Working Groups" and discuss topics such as preferred business models; the future of CCUS clusters supported by a CCS Infrastructure Fund and a consumer-funded, gas-fired CCS power station; decarbonization; CCUS chain links; and export opportunities within CO₂ storage. From *Lexology* (subscription may be required). September 2020.

EMISSIONS TRADING

RGGI Release Results of Auction 49.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) announced results of their 49th auction of CO₂ allowances, during which 16,192,785 CO₂ allowances were sold at a clearing price of \$6.82. None of the 11.8 million cost containment reserve (CCR) allowances made available were sold; CCR is a fixed supply of allowances made available if prices exceed certain levels (\$10.77 in 2020). The auction generated \$110.4 million for reinvestment in strategic programs such as energy efficiency, renewable energy, and greenhouse gas (GHG) abatement programs. Additional information on RGGI auctions is [available online](#). From *RGGI Press Release*. September 2020.

RGGI Inc.



Funding Awarded to CO₂ Storage Project.

MIT Energy Initiative's Carbon Capture, Utilization, and Storage Center awarded funding to a research project seeking to expand understanding of new processes for storing CO₂ in basalt formations by converting it from an aqueous solution into carbonate minerals. The plan for the project, titled "High-fidelity monitoring for carbon sequestration: integrated geophysical and geochemical investigation of field and laboratory data," is to conduct a comprehensive study to better understand the coupled chemo-mechanical processes that accompany CO₂ storage in basalt formations. From *MIT News*. August 2020.



Marine-Based CO₂ Capture System Has EOR Potential.



Mitsubishi Heavy Industries and partners will conduct test operations and measurements of a small-scale, ship-based CO₂ capture demonstration plant to verify the plant equipment's use as a marine-based CO₂ capture system. Carbon dioxide captured as a result of the "Carbon Capture on the Ocean" (CC-Ocean) project has the potential to be recycled for use in EOR operations. The project is expected to last two years; following further operational tests, the plant is expected to be installed onboard a coal carrier. From *Mitsubishi Heavy Industries*. August 2020.

European Commission to Propose CO₂ Emissions Reduction.

The European Commission (EC) will propose updated 2030 European Union (EU) CO₂ reduction targets, with the goal of making the EU climate-neutral by 2050, according to officials. The current reduction target, agreed upon in 2018, was to reduce CO₂ emissions to 40% of 1990 levels. The new target will be proposed as an amendment to the EC's draft EU climate law proposed earlier in 2020. From *S&P Global*. September 2020.

New Zealand Risk Reporting for Financial Institutions.

New Zealand officials announced new legislation mandating climate risk reporting for large financial institutions. Under the legislation, the financial institutions would be required to report annually on governance, risk management, and mitigation strategies for potential climate change. The disclosure requirements, which are based on the Task Force on Climate-Related Disclosure framework, would apply to approximately 200 institutions throughout New Zealand. From *Financial Review* (subscription may be required). September 2020.

EC to Adjust EU ETS Regulations.

According to EU executives, the EC will adjust the EU emission trading system (ETS) to be included in the bloc's carbon border adjustment mechanism. The new carbon border tax is expected to provide an alternative to providing free CO₂ allowances. From *Euractiv*. September 2020.

SCIENCE NEWS

Monitoring System to Track CO₂ Storage in Soil.

A monitoring system designed to track soil carbon storage on dairy farms is being developed in the Netherlands. Researchers from Wageningen University and Research (WUR) and FrieslandCampina, a Dutch dairy company, partnered to develop the monitoring system to better inform farmers on how soil carbon storage affects their dairy farms. For example, an increase in soil organic matter could lead to improved soil carbon storage, thus lowering a farms' "carbon footprint." The research, titled "Possibilities for Monitoring CO₂ Sequestration & Decomposition of Soil Organic Matter on Dairy Farms," is [available on the WUR website](#).

Researchers Study Ability of Forests to Store CO₂.

University of Leeds (UK) researchers conducted a study on the long-term CO₂ storage capacity of forests. The study, [published in the journal Nature Communications](#), analyzed the relationship between tree growth and tree lifespan by examining more than 200,000 tree-ring records from 82 tree species from sites across the world. The results showed that accelerated tree growth results in shorter tree lifespans, thus leading researchers to question the previously assumed future net carbon uptake of forests this century. From *University of Leeds*. September 2020.

PUBLICATIONS

Review of Federal, State, and Regional Tax Strategies and Opportunities for CO₂-EOR-Storage and the CCUS Value Chain.

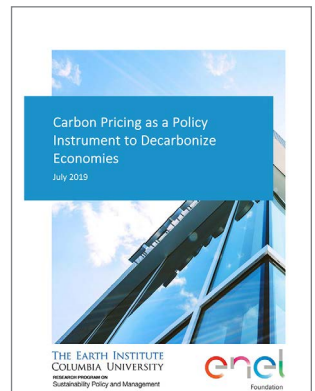
The following is from the Introduction of this document: "In 2018, the United States emitted 6.7 billion metric tons of GHG emissions. Almost half of these emissions (49 percent) came from the power and industrial sectors. . . . GHG emissions in the power sector have decreased by 28 percent since 2005 due to fuel mix changes and the penetration of renewables. GHG reductions in other sectors, however, have remained stagnant. CCUS presents an opportunity to lessen the tension between meeting the nation's energy needs and reducing its greenhouse gas emissions. It can help reduce GHG emissions not only in the power sector but also in the industrial sector through direct capture and utilization and in the transportation sector at ethanol facilities and through EOR, for example. CCUS is a demonstrated, commercially proven technology path for making deep GHG reductions. In North America, the most recent CCUS examples in the power sector include the 110-MW coal-fired retrofit of Boundary Dam Unit 3 in Saskatchewan, Canada, and the 240 MW retrofit of W.A. Parish Unit 8 in Texas ('Petra Nova') that is used for enhanced oil recovery. Both the Boundary Dam and Petra Nova projects are post-combustion capture projects where CO₂ is removed after combustion in the boiler stack. Pre-combustion capture through hydrogen production (e.g., coal gasification) and oxyfuel combustion where a fossil fuel is combusted with pure oxygen are other forms of carbon capture for power generation. In the industrial sector, where CO₂ can often be captured within existing processes, recent CCUS examples include the Air Products Steam Methane Reformer CO₂ capture project in Texas and the ADM Illinois Industrial CCS project. To help describe and, in some ways, enable the deployment of CCUS, DOE and USEA engaged FTI and Orrick to provide a guide to the current federal, state, and regional tax strategies and opportunities for CO₂ for EOR and storage. This report identifies federal and state incentives and regulatory regimes that are applicable to CCUS in the United States. It then illustrates several deal structures for application of these incentives. In addition, the report describes the various stakeholders that are critical for CCUS deployment, the roadblocks stakeholders face, and potential solutions that would increase the likelihood of the successful progress of CCUS programs as well as [Corporate Social Responsibility (CSR) and Environmental, Societal Governance (ESG)] implications. The goal of this report is to provide interested parties with an overview of the current landscape, the problems that current stakeholders face, and a preview into the developments that are expected in the coming years."

Impact of Animal-Sourced Food Production on CO₂ Emissions Studied.

According to a study, reduced meat production could result in storing up to 16 years of CO₂ emissions by 2050. The study, conducted by scientists from New York University (USA), found that shifting global food production to plant-based diets by 2050 has the potential to store 332 to 547 gigatons of CO₂. [Published in the journal Nature Sustainability](#), the study concluded that lowering the demand for meat production and regrowing vegetation in areas where native vegetation has been compromised to make space for animal foods has the potential to help store between 9 and 16 years' worth of CO₂ emissions by 2050. From *Plant Based News*. September 2020.

Carbon Pricing as a Policy Instrument to Decarbonize Economies.

The following is from the Summary of Findings of this Earth Institute's Research Program on Sustainability Policy and Management document: "This study analyzes the jurisdictional characteristics of economies where carbon pricing mechanisms (both carbon taxes and cap-and-trade schemes) have been implemented or proposed as a means to support decarbonization. Firstly, [the authors] compare certain average economic and emission-related characteristics of 37 countries, which have implemented or are considering implementing carbon pricing with the global average to derive a set of stylistic facts that appear to be correlated with the adoption of carbon pricing. [The authors] differentiate between carbon tax (CT) and emissions-trading (ETS) jurisdictions where possible. Secondly, [the authors] review the historical experience of 11 national and 2 sub-national jurisdictions, which either implemented carbon pricing or attempted to do so in vain. Finally, [the authors] perform an in-depth review of two case study countries (Chile and Colombia) which are in the process of implementing carbon pricing policies, to identify the key drivers of adoption as well as any barriers that may impact successful policy implementation or effectiveness. Throughout [the authors'] analyses, [the authors] review ETS and carbon tax impacts on five policy choice criteria: (1) effectiveness in delivering environmental outcomes; (2) regulatory stability; (3) costs and distributional effects; (4) the coherence and interaction with other environmental and tax policies; and (5) an evaluation of the impact of global trade."



PUBLICATIONS (cont.)

Community compensation in the context of Carbon Capture and Storage: Current debates and practices.

The following is from the abstract of this article: "Societal opposition has the potential to slow down the implementation of Carbon Capture and Storage (CCS). One of the difficulties is that the perceived benefits associated with a CCS facility for local communities tend to be low compared to its perceived burdens. As is the case for other low carbon technologies, community compensation (or community benefits) has been suggested as a way to restore this perceived imbalance. A diverse literature has looked into the role of community compensation across various land uses and research fields. Synthesis is limited, while at the same time, the provision of community compensation in practice is moving from an ad hoc to a more institutionalized approach. Therefore, it is important to take stock of the literature. This paper provides a review of the community compensation literature in the form of four debates, drawing together environmental social science research on different low carbon technologies (e.g. CCS, renewable energy). In addition, current practices in community compensation for four European countries are discussed. The two parts of this paper are brought together in a set of lessons for the provision of community compensation for future CCS projects; in turn, suggestions for further research are made to address remaining knowledge gaps." **Christine Boomsma, Emma ter Mors, Corin Jack, Kevin Broecks, Corina Buzoianu, Diana M. Cismaru, Ruben Peuchen, Pim Piek, Diana Schumann, Simon Shackley, and Jasmin Werker**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Optimization of CCUS supply chains in the UK: A strategic role for emissions reduction.

The following is from the abstract of this article: "The UK is the second largest emitter of carbon dioxide in Europe. It aims to take urgent actions to achieve the 2030 target for CO₂ emissions reduction imposed by EU environmental policies. Three different carbon capture utilization and storage (CCUS) supply chains are developed giving economic indicators for CO₂ utilization routes not implying carbon dioxide hydrogenation (i.e. with high TRL). The study presents an innovative proposal to reduce CO₂ impact in the UK, a country rich in coal, which requires reduction of carbon dioxide emissions from flue gases as the easiest and best performing solution. Bunter Sandstone, Scottish offshore and Ormskirk Sandstone are the storage sites considered, while several attractive potential utilization options are considered. Through minimization of total costs, the CCUS supply chain with Bunter Sandstone as storage site results in the most economically profitable solution due to the highest value of net present value (€ 0.554 trillion) and lowest value of pay back period (2.85 years). Only carbon tax is considered. The total cost is € 1.04 billion/year. Across the supply chain, 6.4 Mton/year of carbon dioxide emissions are avoided, to be either stored or used for calcium carbonate production. Future work should consider uncertainty, dynamics of market demand and social aspects." **Grazia Leonzio, David Bogle, Pier Ugo Foscolo, and Edwin Zondervan**, *Chemical Engineering Research and Design*. (Subscription may be required.)

CO₂ sequestration on cement.

The following is from the abstract of this article: "The manufacturing of cement is associated with large amount of CO₂ emissions. Carbon capture and storage (CCS) or carbon sequestration is identified as one of the solutions to mitigate high level of CO₂. . . Mineral carbonation of metal oxides present in cement can allow sequestering of CO₂ in cement in the form of stable silica gel and carbonates. Sequestration of CO₂ in cement and cement-based products such as mortar, paste, and concrete is accomplished by accelerated carbonation curing (ACC). This chapter discusses in detail possibility of CO₂ sequestration by cement-based materials through accelerated carbonation curing. Reaction mechanisms, laboratory processes, and resulting performance of carbonation curing have been comprehensively discussed and reviewed based on available literature. The chapter also discusses challenges faced by ACC for industrial implementation and future scope of research on carbonation curing." **Shweta Goyal and Devender Sharma**, *Start-Up Creation*. (Subscription may be required.)

Relationship between oil production and CO₂ storage during low-salinity carbonate water injection in acid carbonate reservoirs.

The following is from the abstract of this article: "This study investigates enhanced oil recovery (EOR) and CO₂ storage efficiencies during low-salinity carbonate waterflooding (LSCWF) in carbonate reservoirs containing 'acid' formation water. In order to identify the detailed geochemical reactions for acidic condition during LSCWF, simulational analysis was performed with 'CMG-GEM'. After core-scaled model was constructed through history-matching processes based on the coreflooding experimental results, primary mechanisms during LSCWF were analyzed for various levels of injection water salinity. From the results of this study, CO₂ dissolved in injected carbonate water yielded CaCO₃ precipitation in acidic reservoirs, decreasing permeability significantly compared to in neutral reservoirs. In terms of wettability alteration and oil swelling by CO₂ mass transfer, their effects were almost similar regardless of the salinity for both acid and neutral reservoirs. In the aspects of EOR and CO₂ storage efficiencies, they strongly depend on the salinity for both acidic and neutral conditions. In the results of EOR-CO₂ storage relationship, enhanced oil was smaller in acidic condition, while CO₂ storage efficiency was not greatly related to acidity of the reservoir. The findings of this study can help for better understanding of smart water injection design into acid carbonate reservoir for the optimal EOR and CO₂ storage efficiencies." **Yeonkyeong Lee, Sooyeon Kim, Jihoon Wang, and Wonmo Sung**, *Journal of Industrial and Engineering Chemistry*. (Subscription may be required.)

Application of ITM to improve the efficiency of SOFC/GTCC triple combined cycle with carbon capture.

The following is from the abstract of this article: "Carbon capture and storage processes are being researched to reduce carbon dioxide emissions from power plants. This paper proposes a new system that applies an ion transport membrane (ITM) to a triple combined cycle, which includes the gas turbine combined cycle and a solid oxide fuel cell. Two systems which differ in the method of utilization of the fluid that is separated by the ion transport membrane were compared. Then, the better system was determined, and its performance characteristics were analyzed in detail. The operating temperature of the fuel cell and the pressure ratio of the compressor were varied within the operating conditions of the ITM as the main design variables. The performance of the proposed system was compared with that of a post-combustion system and other oxy-fuel combustion capture systems. The proposed system had 1.70% and 4.0%p higher power and efficiency than the post-combustion capture system, respectively. Furthermore, the purity of the carbon dioxide captured from the proposed system was 97.4%, which is 9.1%p higher than that of the semi-closed cycle oxy-fuel combustion system, while the efficiency was 7.8%p higher." **Ji Hun Jeong, Ji Ho Ahn, and Tong Seop Kim**, *Energy*. (Subscription may be required.)

PUBLICATIONS (cont.)

An empirical investigation between CO₂ emission, energy consumption, trade liberalization and economic growth: A case of Kuwait.

The following is from the abstract of this article: "The purpose of the present study is to investigate the link among CO₂ emissions, energy consumption, gross domestic product, and trade liberalization as related to Kuwait. The study used annual data, starting from 1971 to 2017, which was obtained from a world development indicator of the World Bank. For the empirical analysis, the study adopted Augmented Dicky Fuller and Phillips-Perron methods to review stationarity among the data sets. Their results explained a mixed trend, some variables followed the I (1) process, and few are I (0). Based on the findings, a well-defined Autoregressive Distributed Lag Model was applied to the data sets and the outcome was in support of the long and short-run relationship between variables. Carbon dioxide and energy consumption accelerate economic growth; an increase in CO₂ emission also plays a significant role in increasing energy consumption. Furthermore, the Granger Causality test shows evidence of bi-directional causality existing between CO₂ emissions and energy consumption. A unidirectional causality is running from the gross domestic product to CO₂ emissions and energy consumption to trade liberalization."

Syed Khurram Arslan Wasti and Shumaila Waqar Zaidi, *Journal of Building Engineering*. (Subscription may be required.)

Optimization of well placement and operating conditions for various well patterns in CO₂ sequestration in the Pohang Basin, Korea.

The following is from the abstract of this article: "The aquifer consists of multi-layers and has pre-existing faults and heterogeneous reservoir properties that restrict CO₂ injection to a certain amount. To store large amounts of CO₂ and maintain storage security, it is important to define the optimal injection well pattern, placement, and operating conditions. This study applied various well patterns and optimized their locations and fluid injection rates with monitoring the pressure build-up in the aquifer to improve the storage capacity. Four well patterns in this study were employed: (1) a single vertical injection well (SVI), (2) two vertical injection wells (TVI), (3) a single horizontal injection well (SHI), and (4) two vertical wells for brine extraction and CO₂ injection (TVEI). The results showed TVEI at the optimal location and fluid rate that allowed an almost eight times larger volume of CO₂ to be stored compared to the base case (simulation result of SVI drilled for the CO₂ storage pilot project in the Pohang basin, Korea), and maintained the pressure within the boundary for security. When using a single well (SVI and SHI), SVI injected 126 kton of CO₂, which is larger than that of SHI, but storage security of SHI is better than that of SVI due to the difference in CO₂ migration. Through this research, the effects of various well patterns in CO₂ geological storage in the Pohang Basin can be forecasted and the optimal well pattern and conditions for the largest storage capacity can be determined." **Changhyeok Jun, Min Kim, and Hyundon Shin**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

New soil carbon sequestration with nitrogen enrichment: a meta-analysis.

The following is from the abstract of this article: "Through agriculture and industry, humans are increasing the deposition and availability of nitrogen (N) in ecosystems worldwide. Carbon (C) isotope tracers provide useful insights into soil C dynamics, as they allow to study soil C pools of different ages. [The authors] evaluated to what extent N enrichment affects soil C dynamics in experiments that applied C isotope tracers. Using meta-analysis, [the authors] synthesized data from 35 published papers. [The authors] made a distinction between 'new C' and 'old' stocks, i.e., soil C derived from plant C input since the start of the isotopic enrichment, or unlabeled, pre-existing soil C. Averaged across studies, N addition increased new soil C stocks (+30.3%), total soil C stocks (+6.1%) and soil C input proxies (+30.7%). Although N addition had no overall, average, effect on old soil C stocks and old soil C respiration, old soil C stocks increased with the amount of N added and respiration of old soil C declined. Nitrogen-induced effects on new soil C and soil C input both decreased with the amount of extraneous N added in control treatments. Although [the authors'] findings require additional confirmation from long-term field experiments, [the authors'] analysis provides isotopic evidence that N addition stimulates soil C storage both by increasing soil C input and (at high N rates) by decreasing decomposition of old soil C. Furthermore, [the authors] demonstrate that the widely reported saturating response of plant growth to N enrichment also applies to new soil C storage." **Xiaomin Huang, César Terrer, Feike A. Dijkstra, Bruce A. Hungate, Weijian Zhang, and Kees Jan van Groenigen**, *Plant and Soil*. (Subscription may be required.)

The role of soil carbon in natural climate solutions.

The following is from the abstract of this article: "Here [the authors] quantify the role of soil carbon in natural (land-based) climate solutions and review some of the project design mechanisms available to tap into the potential. [The authors] show that soil carbon represents 25% of the potential of natural climate solutions (total potential, 23.8 Gt of CO₂-equivalent per year), of which 40% is protection of existing soil carbon and 60% is rebuilding depleted stocks. Soil carbon comprises 9% of the mitigation potential of forests, 72% for wetlands and 47% for agriculture and grasslands. Soil carbon is important to land-based efforts to prevent carbon emissions, remove atmospheric carbon dioxide and deliver ecosystem services in addition to climate mitigation." **D. A. Bossio, S. C. Cook-Patton, P. W. Ellis, J. Fargione, J. Sanderman, P. Smith, S. Wood, R. J. Zomer, M. von Unger, I. M. Emmer, and B. W. Griscom**, *Nature Sustainability*. (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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Program staff are also located in
Houston, Texas and **Anchorage, Alaska**.

CUSTOMER SERVICE: 1-800-553-7681

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