CSN CARBON STORAGE NEWSLETTER

JULY 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:

CARBON STORAGE PROGRAM DOCUMENTS and REFERENCE MATERIALS

NATIONAL ENERGY TECHNOLOGY LABORATORY

DOE/NETL HIGHLIGHTS

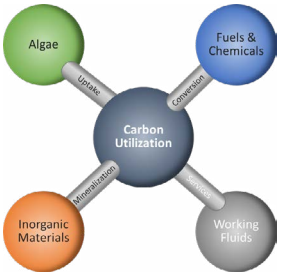
NETL-Led NRAP Expanding Toolset, Collaborations.

Led by the National Energy Technology Laboratory (NETL), the National Risk Assessment Partnership (NRAP) has worked to accelerate the commercial deployment of large-scale carbon storage for the past 10 years. Now into Phase II, NRAP is expanding its *award-winning toolset* and creating new collaborations to continue improving the ability to address risk management for carbon storage sites. NRAP researchers are engaging with new partnerships, such as the U.S. Department of Energy's (DOE) Regional Initiatives, industry, state and federal regulators, and academia. Technical objectives and capability developments continue to be realized in NRAP's Phase II efforts, which began in 2017 and are expected to be completed in 2022. From *NETL News Release*. May 2020.

ANNOUNCEMENTS

NETL Software Helps Estimate CO_2 Storage Potential.

A new iteration of an NETL software application enables researchers to more accurately estimate carbon dioxide (CO_2) storage potential. The *CO_2-SCREEN* (Storage prospeCtive Resource Estimation Excel aNalysis) tool applies methods and equations for estimating prospective CO_2 storage resources in residual oil zones (ROZs), which can be used for large-scale carbon capture, utilization, and storage (CCUS) projects.

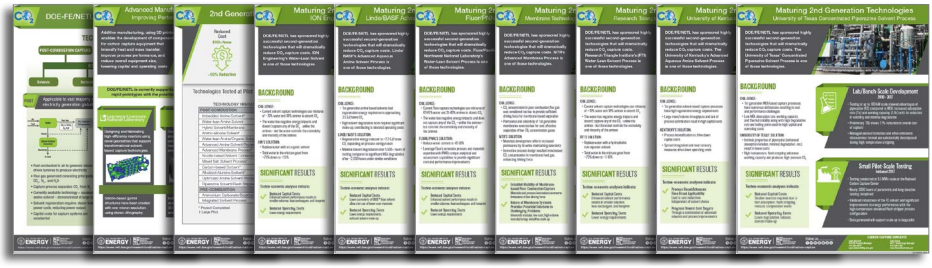


DOE Invests in Carbon Utilization Projects.

DOE's Office of Fossil Energy (FE) and NETL selected 11 carbon utilization projects to receive federal funding for cost-shared research and development (R&D). The NETL-managed projects will develop and test technologies that can utilize CO_2 from power systems or other industrial sources as the primary feedstock. DOE's *Carbon Utilization Program* aims to reduce emissions and transform carbon streams into value-added products.

DOE Infographics Highlight Achievements in Carbon Capture Program.

NETL is developing a *series of infographics* to help convey highlights and achievements of the *Carbon Capture Program*. New infographics on second-generation technologies that have reached engineering-scale testing have been published.



ANNOUNCEMENTS *(cont.)*

DOE-Funded FEED Contract Awarded for CCUS Project.


Image Source: Carbon Capture Journal.

A DOE-funded front-end engineering design (FEED) study contract was awarded for a CCUS retrofit project in North Dakota (USA). Under the contract, Fluor will use its proprietary carbon capture technology on the Minnkota Power Cooperative's Project Tundra at the Milton R. Young Station in Center, North Dakota.

Global CCS Institute Releases Briefs.

The Global CCS Institute released two briefs. "*CCS Development in Southeast Asia*" focuses on why Southeast Asia needs carbon capture and storage (CCS)/CCUS. "*Is CCS Expensive? Decarbonisation costs in the net-zero context*" demonstrates the business-case support needed for large-scale CCS deployment.

GLOBAL CCS INSTITUTE

CCS Facilities Added to Global Database.

The Global CCS Institute added 10 CCS facilities to its global database. The *CO_2RE database* now contains 59 CCS facilities (21 in operation, three under construction, 35 in various stages of development) with a combined CO_2 capture capacity of more than 127 million metric tons per year.

Report Outlines Role of CCS in European Clean Hydrogen Market.

The Zero Emissions Platform, supported by the European Union (EU), released a report providing input on how the European Commission can enable a European clean hydrogen market with clean hydrogen from natural gas with CCS. The overview of the outline is *available online*.

RGGI Releases Results of CO_2 Auction.

RGGI Inc.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) announced results of their 48th auction of CO_2 allowances. Auction 48 saw 16,336,298 CO_2 allowances sold at a clearing price of $5.75, with bids ranging from $2.32 to $8.00 per allowance. The auction generated $93.9 million for reinvestment in strategic programs, including energy efficiency and greenhouse gas (GHG) abatement programs. Additional details are available in the *Market Monitor Report for Auction 48*.

PROJECT and BUSINESS DEVELOPMENTS

Alberta CCS Project Fully Operational.

The Alberta Carbon Trunk Line (ACTL) CCUS system—an approximately 150-mile pipeline that transports CO_2 for geologic storage via enhanced oil recovery (EOR)—was announced as fully operational. The ACTL utilizes and stores CO_2 captured at a refinery and a fertilizer plant located in Alberta, Canada. Combined, the refinery and fertilizer plant connected to the ACTL system have a storage capacity of approximately 1.6 million metric tons of CO_2 per year. From *Gasworld*. June 2020.

Contract Awarded for CCUS Project in Netherlands.

MAN Energy Solutions was awarded an engineering contract for the Port of Rotterdam CO_2 Transport Hub and Offshore Storage (Porthos) project in the Netherlands. The Porthos project plans to store approximately 2.5 million tons of CO_2 per year under the North Sea. As part of the contract, MAN Energy Solutions will engineer three RG compressor trains, with an order for three additional units anticipated at a later stage. From *MAN Energy Solutions Press Release*. May 2020.

CCS Research Grant Issued.

The Energy and Environmental Research Center (EERC) received a grant from the North Dakota Industrial Commission to continue research into CCS at ethanol plants. Red Trail Energy, located near Richardton, North Dakota (USA), will be used as a case study, with the grant enabling EERC to complete a CO_2 storage facility permitting guidance document. From *The Bismarck Tribune*. June 2020.

Consortium to Develop Shared CO_2 Storage and Transport Infrastructure.

A consortium of chemical and energy companies aims to build CO_2 infrastructure to support future CCUS applications at the Belgian port of Antwerp, including a shared CO_2 liquefaction plant, storage facilities, and CO_2 transport infrastructure. From *Energy Live News*. June 2020.

CCS Plant Launched in Sweden.

A CCS plant has begun operations at a refinery in Lysekil, Sweden. Within the Preem CCS pilot project, the entire value chain (e.g., CO_2 capture at the refinery, local storage, transport to storage location off the Norwegian west coast) will be evaluated. According to the Swedish fuel company Preem, the goal is for the tests to form the basis for a full-scale CCS plant that can be operational by 2025. The pilot project is a collaboration among Preem, Aker Solutions, Chalmers University of Technology (Sweden), Equinor, and the Norwegian research institute SINTEF. From *Preem Press Release*. May 2020.

Consortium to Investigate Feasibility of CCUS.

A consortium of Belgian and Dutch companies will investigate the feasibility of CCUS. The Carbon Connect Delta Project will research the technical, economic, and legal aspects of the technology; the infrastructure needed for CO_2 transport; financing options; commercial feasibility; and permit procedures. The consortium expects to conclude the feasibility study by the end of 2020, after which the project will be further developed to completion. From *Smart Delta Resources*. May 2020.

CCS Pilot Phase Successfully Completed.

A waste-to-energy plant in Oslo, Norway, successfully validated its CCS pilot phase. One of two sites being evaluated as part of Norway's plan for a full-scale, full-chain CCS project, Fortum Oslo Varme's Klemetsrud site started the pilot phase in March 2019. Captured CO_2 from the plant will be transported to an onshore storage area in western Norway before transport via pipeline to an offshore storage reservoir. From *The Chemical Engineer*. May 2020.

Contract Awarded for CCS Project.

Wood, an Aberdeen-based engineering company, was awarded a contract to provide design services for the *Humber Zero project*, a CCS project located in the Humber region of England. Work will involve capturing CO_2 emissions from three industrial sites in the area for CO_2 storage in depleted North Sea reservoirs. From *The Herald*. June 2020.

LEGISLATION and POLICY

US Treasury Unveils Rules for CO_2 Tax Credit Program.

The U.S. Department of Treasury *released proposed regulations* for implementing the 45Q federal tax code, which is designed to increase investment in CCS projects. The rules aim to provide clear guidelines to ensure investors and developers are capturing and storing the correct amount of CO_2 required to receive the credits ($50 per metric ton of CO_2 for storage projects and $35 per metric ton for CO_2-EOR projects). Among the new measures in the proposed rule are monitoring requirements for projects to demonstrate safe, underground geologic CO_2 storage and standards for measuring CO_2 utilization. From *Reuters*. May 2020.

Switzerland to Extend CO_2 Act Measures.

Switzerland's Federal Department of the Environment, Transport, Energy, and Communication launched a consultation process for a partial revision of the CO_2 Act. The amendments will extend certain measures until the end of 2021, as recently required by Parliament, and are subject to consultation until August 2020. Under the current CO_2 Act, certain measures, such as CO_2 tax exemptions guidelines, were set to expire at the end of 2020. From *Lexology.* June 2020.

Scottish Support Package Includes Funding for CCS Project.

A support package *announced by the Scottish government* to help fund the energy sector due to impacts of COVID-19 includes funding for the *Acorn CCS project*. The Energy Transition Fund will support businesses in the oil, gas, and energy sectors over the next five years. From *Carbon Capture Journal*. June 2020.

Bill Aims to Help Farmers Sell CO_2 Credits.

Legislation was introduced in the U.S. Congress that would allow the agricultural industry to participate in a carbon credit market. The legislation tasks the U.S. Department of Agriculture with creating a certification program to assist farmers and forest landowners who use sustainable practices in implementing the protocols. From *The Hill*. June 2020.

EMISSIONS TRADING

UK Plans Emissions Trading System.

The United Kingdom (UK) unveiled an Emissions Trading System (ETS) to replace the EU ETS; the UK will leave the EU ETS at the end of 2020. As part of the UK's plan to reach net-zero CO_2 emissions by 2050, its ETS includes plans to reduce the emissions cap by 5%, *according to the UK government*. In addition, the UK ETS would include a fixed auction reserve price ($18.78 per metric ton of CO_2) as well as a cost containment mechanism to prevent price spikes. From *Reuters*. June 2020.

New Zealand Bill to Reform ETS.

A series of annual carbon budgets was included in a bill by the New Zealand government to reform its ETS. A proposed cap on emissions included in the bill would lower the country's GHG emissions by approximately 3% next year. From *Stuff*. June 2020.

SCIENCE NEWS

Researchers Develop Technology for CCS Use.

Australian researchers used a metal organic framework (MOF) nanocomposite to develop sponge-like technology capable of capturing CO_2 from several sources. In the study, published in Cell Reports Physical Science, researchers from Australia's Monash University and the Australian federal government's Commonwealth Scientific and Industrial Research Organization designed a material that delivered an energy cost 45% below that of commercially deployed materials. From *Phys.Org*. June 2020.

Study Uses Sunlight to Convert CO_2.

Researchers at Linköping University in Sweden are attempting to convert CO_2 into fuel using energy from sunlight. *Published in the journal ACS Nano*, the results show that the technique has the potential to produce methane, carbon monoxide, or formic acid from CO_2 and water. The method is at a research stage, with a long-term objective of converting solar energy to fuel. From *Science Magazine*. June 2020.

Researchers Study Oceans' Ability to Store CO_2.

Scientists at Columbia University's Lamont-Doherty Earth Observatory (USA) studied the variability of the ocean as a carbon sink over the last 30 years. According to the findings, *published in the journal AGU Advances*, decreasing global fuel consumption may lead to the ocean absorbing less CO_2 in 2020 than in 2019. The results of the study are expected to enable more accurate measurements and projections of how much oceans can offset CO_2 emissions. From *Phys.Org*. June 2020.

PUBLICATIONS

Conceptual and Mathematical Foundation for the FE/NETL CO_2 Prophet Model for Simulating CO_2 Enhanced Oil Recovery.

The following is a description of this FE/NETL product: "This document provides the mathematical basis for the FE/NETL CO_2 Prophet Model. The FE/NETL CO_2 Prophet Model is a streamline/stream tube reservoir simulator for modeling CO_2 EOR. It is comprised of two Fortran programs, StrmtbGen (generates streamlines and stream tubes) and StrmtbFlow (solves the multiphase flow equations within stream tubes). StrmtbGen and StrmtbFlow along with their user's manuals are available on NETL's website under the Collection Name: FE/NETL CO_2 Prophet Model."

Net Zero and Beyond: What Role for Bioenergy with Carbon Capture and Storage?

The following is from the Introduction of this Chatham House research paper: "In the context of seeking to reduce greenhouse gas emissions to net zero, policymakers are beginning to pay more attention to options for removing carbon dioxide from the atmosphere – a process referred to as CDR ('carbon dioxide removal'). Without the rapid scale-up of such measures, achieving Paris Agreement temperature targets will be increasingly challenging: current emissions abatement efforts are not progressing quickly enough to prevent the world from overshooting global emissions targets. In theory, CDR measures may permit the total costs of a climate mitigation strategy to be reduced in absolute terms (or amortized over a longer period); enable ambitious targets (such as limiting global warming to 1.5°C) to become more feasible; or delay the point when peak emissions are reached, retroactively compensating for overshooting the cumulative carbon budget. A wide range of potential CDR measures are currently being discussed. Alongside afforestation and reforestation, the main option featuring in integrated assessment models (IAMs) is bioenergy with carbon capture and storage (BECCS). BECCS refers to a set of technologies and processes through which the carbon emissions from burning biomass for energy are captured before release into the atmosphere, and then stored in underground reservoirs. If this biomass energy is assumed to be carbon-neutral, BECCS should theoretically result in net negative emissions, as the accompanying carbon sequestered by biomass is permanently stored. The prominence of BECCS in the models does not, however, represent a prescriptive judgment about its merits relative to other negative emissions options. Nor does it necessarily validate the current, highly constrained, development trajectory of BECCS technology. It is, rather, a reflection mainly of the fact that BECCS is based on well-understood biology, so it is easier to make assumptions about and model the impacts on emissions at various carbon prices. In contrast, evaluating the potential of newer and more speculative negative emissions technologies is more challenging. In reality, there are many reasons to question the reliance on BECCS assumed in the models – including the carbon balances achievable, the substantial demand for land, water and other inputs that is associated with BECCS solutions, and the underlying assumption that technically and economically viable carbon capture and storage (CCS) technologies will be available 'off the shelf' in the near term, which is not being borne out in practice."

Active surface and borehole seismic monitoring of a small supercritical CO_2 injection into the subsurface: experience from the CO_2CRC Otway Project.

The following is from the abstract of this article: "Time-lapse (TL) (4D) seismic monitoring of injected CO_2 in geological formations is being increasingly employed as the principal method for ensuring containment of CO_2 and testing conformance of predicted plume behavior. However, to bring further confidence in this method, the CO_2 volume detection limit in the seismic monitoring and key factors controlling it need to be quantitatively understood. The CO_2CRC Otway Project attempts to improve this understanding by exploring the capability of seismic reflection method to detect and monitor a 15-kt injection of supercritical CO_2/CH_4 mixture in a saline aquifer at a depth of 1500 m. The monitoring program consists of TL 3D seismic surveys using a buried geophone array, TL 3D vertical seismic profiling (VSP), and offset VSP. Seismic acquisition was carried out at injection intervals of 5, 10, and 15 kt over a 5-month period and also, 9 and 23 months after the end of injection. The TL seismic images clearly show the distribution and evolution of the stored CO_2/CH_4 plume. The results demonstrate the potential of TL reflection seismic to provide key information to both operators and regulators for confirming the security and behavior of stored CO_2 at very small volumes." **Roman Pevzner, Milovan Urosevic, Konstantin Tertyshnikov, Hussain AlNasser, Eva Caspari, Julia Correa, Tom Daley, Tess Dance, Barry Freifeld, Stanislav Glubokovskikh, Andrew Greenwood, Anton Kepic, Dmitry Popik, Sofya Popik, Matthias Raab, Michelle Robertson, Valeriya Shulakova, Rajindar Singh… Boris Gurevich,** *Active Geophysical Monitoring* (Second Edition). (Subscription may be required.)

Imine-linked polymer/silica composites for CO_2 sequestration.

The following is from the abstract of this article: "The silica supported imine polymers are synthesized using a facile single step Schiff-base condensation. The formation of imine linkage on silica support is confirmed using FT-IR and solid state ^{13}C NMR. The crystallinity and surface morphology of the materials are examined by PXRD and SEM analyses. The thermal stability of the materials is confirmed from TGA analysis. N_2 sorption isotherms for Si-TPA-1 and Si-TPA-2 exhibit surface area of 105.8 m^2/g and 404.5 m^2/g respectively. The adsorption isotherms exhibit meso- and microporous environments of Si-TPAs. The CO_2 uptake capacity of Si-TPAs are around 38.86 mg/g - 121. 85 mg/g. The experimental adsorption data is fitted with Langmuir and Freundlich adsorption isotherm models. The thermodynamic parameters emphasis that the adsorption process is spontaneous and exothermic physisorption. Isosteric heats of adsorption for Si-TPAs are around 38.5–32.5 kJ/mol. The high selectivity of CO_2 over N_2 is obtained for both Si-TPAs at 273 K and also high selectivity of CO_2 over CH_4 is achieved at 298 K." **Marimuthu Senthilkumaran, Lakshmanan Eswaran, Chokalingam Saravanan, Pillaiyar Puthiaraj, Perumal Rameshkumar, and Paulpandian Muthu Mareeswaran,** *Materials Chemistry and Physics.* (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 CO_2 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, and John Asafu-Adjaye,** *Energy Policy.* (Subscription may be required.)

PUBLICATIONS *(cont.)*

Methane production via syngas fermentation within the bio-CCS concept: A techno-economic assessment.

The following is from the abstract of this article: "The study provides a comprehensive approach on assessing the feasibility of a novel process configuration that couples synthetic natural gas (SNG) production via syngas fermentation with carbon capture and storage (CCS). The present research constitutes the first endeavour to examine the techno-economic performance of this sophisticated hybrid SNG+CCS infrastructure. For this purpose, a flowsheet analysis within the Aspen Plus environment served to quantify the material and energy flows and then based on the simulations technical and economic indicators were estimated. A plant processing 6.25 dt/h of virgin biomass yields 1.32 t/h of SNG, achieves 51.2% energy efficiency and stores 2.97 t/h of CO_2. The threshold SNG price (NPV=0) for the project to become economically viable is 92.14 £/MWh. A combination of existing policy schemes and the establishment of new instruments that will reward negative emissions has the potential to generate profits. A thorough cost breakdown along with a sensitivity analysis revealed that the process is CAPEX and feedstock intensive while larger plants can reduce the SNG price by about 15%. A stochastic Monte Carlo analysis indicated that even if the project shows promising techno-economic potential without the establishment of a consistent and robust legislation framework there is no realistic prospect for the proposed bio-CCS plant to compete with fossil natural gas." **Stavros Michailos, Oluchi Emenike, Derek Ingham, Kevin J. Hughes, and Mohamed Pourkashanian,** *Biochemical Engineering Journal*. (Subscription may be required.)

Modified mineral carbonation of phosphogypsum for CO_2 sequestration.

The following is from the abstract of this article: "A modified phosphogypsum carbonation was systematically investigated, and ammonium acetate was used to separate Ca^{2+} and concentrate impurity ions from PG. The effect of technological conditions on salt-leaching and carbonation results were discussed. The calcium leaching rate was 98.1%, and the only crystal phase of salt-leaching product was quartz with granular morphology and some pores in the surface. The carbonation ratio (η) was 98.32%, and 1000 kg of phosphogypsum produced 510 kg of high-purity $CaCO_3$ and sequestered 224 kg of CO_2 under the optimized conditions. The spherical vaterite carbonation product met the recommended Chinese standard (HG/T 2226-2010). The carbonation filtrate can be reused for salt-leaching experiments. Various polymorph and morphology of $CaCO_3$ were achieved by adjusting the carbonation temperature and ammonia dosage. The mechanism of phosphogpysum carbonation was studied by using thermodynamics research. All of this indicated that the whole procedure setup of phosphogypsum carbonation showed potential application for phosphogypsum utilization and CO_2 sequestration." **Wenjin Ding, Qiuju Chen, Hongjuan Sun, and Tongjiang Peng,** *Journal of CO_2 Utilization*. (Subscription may be required.)

Exploring the potential of carbon capture and storage-enhanced oil recovery as a mitigation strategy in the Colombian oil industry.

The following is from the abstract of this article: "The use of CO_2 for enhanced oil recovery (CO_2-EOR) is a promising alternative for reducing the cost of carbon capture and storage (CCS). In this study the techno-economic potential of integrated CCS-EOR projects for reducing greenhouse gas (GHG) emissions in the Colombian oil industry is estimated. For this purpose, a source-sink matching process is carried out, including CO_2 capture potentials in sources from the petroleum, cement, power generation, and bioethanol industries, as well as from the CO_2 storage in suitable oil fields for EOR. The results indicate that a total of 142 million tons of carbon dioxide ($MtCO_2$) could be stored, while delivering 465 MMbbl through five CCS-EOR projects in four clusters identified around the country. The levelised cost for capture ranged between 12–209 €/tCO_2, followed by the cost of CO_2 during EOR operations with a variation of 24–59 €/tCO_2, and finally the CO_2 transport, from 1 €/tCO_2 to 23 €/tCO_2. The CO_2 mitigation potential of CCS-EOR represents 25% of the forecasted oil industry emissions in Colombia for the period of 2025–2040. As compared to the intended nationally determined contribution (INDC) target set by the Colombian government, CCS-EOR projects could contribute 7% of the total accumulated emissions reductions by 2040." **Edgar Yáñez, Andrea Ramírez, Vanessa Núñez-López, Edgar Castillo, and André Faaij,** *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Impact of deadwood decomposition on soil organic carbon sequestration in Estonian and Polish forests.

The following is from the abstract of this article: "The deadwood of different tree species with different decomposition rates affects soil organic carbon sequestration in Estonian and Polish forests. In warmer conditions (Poland), the deadwood decomposition process had a higher rate than in cooler Estonian forests. Soil organic matter fractions analysis can be used to assess the stability and turnover of organic carbon between deadwood and soil in different experimental localities." **Ewa Błońska, Jarosław Lasota, Arvo Tullus, Reimo Lutter, and Ivika Ostonen,** *Annals of Forest Science*. (Subscription may be required.)

Challenges and potentials for soil organic carbon sequestration in forage and grazing systems.

The following is from the abstract of this article: "Forage and grazing (FG) systems can store a substantial amount of soil organic carbon (SOC) under appropriate land use management and reduce atmospheric CO_2 concentrations. Increasing SOC levels along with many interlinked ecosystem services are essential for increased productivity and sustainability of FG lands (FGLs). Although adoption of improved management practices (MPs) that support SOC sequestration (SOCq) is necessary, clear understandings of challenges and opportunities which are sometimes unique to individual FGLs, are also important for implementation of MPs. The objective of this forum paper is to explore the latest scientific knowledge on opportunities to address major challenges for increasing SOCq in FGLs. In intensively managed FGLs where the goal is often to maximize yields, lands are heavily fertilized and thus, usually drive towards SOC loss. Diversifications of both forage and grazing species along with strategic grazing plans have been proven as effective MPs for increasing SOCq. However, challenge of maintaining productivity levels still remains. Implementing improved grazing for nutrient cycling and integrating forage diversification for increased biodiversity are found to improve soil health attributes, which are critical for SOCq. However, to achieve this, [the authors] also need to consider site- and soil- specific factors. Extreme climatic events often lead to a decline in soil fertility status, SOCq and overall productivity of FGL systems. To address these challenges, uses of models to simulate the FGL systems and have definite choices of suitable MPs are helpful. However, [the authors] must be able to access a wide range of datasets to develop system-level adaption strategies that are effective in mitigating these adverse effects. Ultimately, participatory research with novel views and improved perceptions based on the value of SOCq and long-term benefits of the implementation of the best MPs and developing education and outreach materials to enrich the producers' knowledge gaps are helpful for climate-resilient FGL systems." **Reshmi Sarkar, Vanessa Corriher-Olson, Charles Long, and Anil Somenahally,** *Rangeland Ecology & Management*. (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 CO_2, both onshore and offshore, in different depositional environments. The technologies being developed will benefit both industrial and power sector facilities that will need to mitigate future CO_2 emissions. The program also serves to increase the understanding of the effectiveness of advanced technologies in different geologic reservoirs appropriate for CO_2 storage—including saline formations, oil reservoirs, natural gas reservoirs, unmineable coal, basalt formations, and organic-rich shale basins—and to improve the understanding of how CO_2 behaves in the subsurface. These objectives are key to increasing confidence in safe, effective, and permanent geologic CO_2 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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