U.S. DEPARTMENT OF ENERGY | OFFICE OF FOSSIL ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

CSN CARBON STORAGE NEWSLETTER

NOVEMBER 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

DOE Issues NOI for Carbon Storage FOA.

The U.S. Department of Energy's (DOE) Office of Fossil Energy (FE) *issued a notice of intent (NOI)* for a Funding Opportunity Announcement (FOA) in support of the goals of the *Advanced Storage research and development (R&D)* technology area of *DOE's Carbon Storage Program*. The "Emerging CO_2 Storage Technologies: Optimizing Performance Through Minimization of Seismicity Risks and Monitoring Caprock Integrity" FOA would seek projects to develop tools and methods designed to optimize safe, secure, and verifiable carbon dioxide (CO_2) storage. The FOA intends to achieve three goals: facilitating the development of novel or advanced tools and methods to improve detection and characterization of faults during the site characterization phase; assessing seismic risk associated with large-scale CO_2 injection; and identifying, locating, and quantifying unpredicted CO_2/native fluid migration through the main caprock layer(s) overlying an injection reservoir. From *Office of Fossil Energy Press Release.* November 2020.

NETL Renews Partnership with NCCC.

DOE/FE and the National Energy Technology Laboratory (NETL) renewed their agreement with Southern Company to operate the *National Carbon Capture Center (NCCC)*—a DOE-sponsored research facility focused on next-generation carbon capture technologies. Under the agreement, Southern Company will continue to manage and operate NCCC, which is located in Wilsonville, Alabama (USA), for an additional five years, setting the stage for the facility to expand into new areas of research and to advance CO_2 utilization and direct air capture (DAC) solutions. From *NETL Press Release.* October 2020.

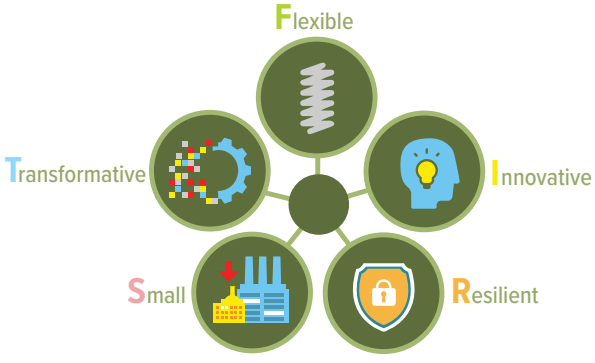
ANNOUNCEMENTS

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 the 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.

DOE Announces Project Selections Under COAL FIRST Initiative.

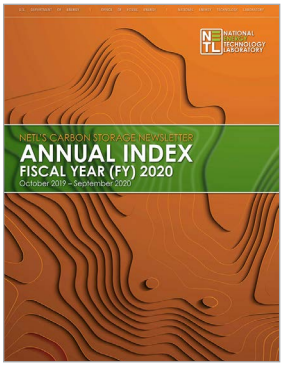
DOE/FE selected *four projects* for cost-shared R&D through the *Coal FIRST (Flexible, Innovative, Resilient, Small, Transformative) Initiative*. DOE's early-stage research for the Coal FIRST Initiative supports the development of 21st century electricity and hydrogen energy plants that have net-zero carbon emissions. These plants will be fueled by coal, natural gas, biomass, and waste plastics and incorporate carbon capture, utilization, and storage (CCUS) technologies.



ANNOUNCEMENTS *(cont.)*

DOE/NETL 2020 Virtual Integrated Project Review Meeting Proceedings.

Proceedings from the DOE/NETL Integrated Project Review Meeting are *available on the NETL website*. The virtual integrated review meeting consisted of a series of free virtual sessions organized by DOE/NETL that featured projects from several DOE/FE portfolios, including *Carbon Capture* and *Carbon Storage*.



FY 2020 Carbon Storage Newsletter Annual Index Available.

The FY 2020 Carbon Storage Newsletter Annual Index is available. The document is a compilation of NETL's Carbon Storage Newsletters published from October 2019 through September 2020.

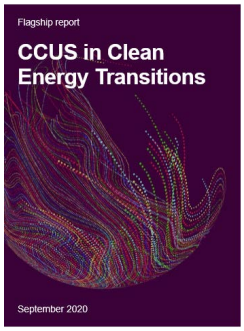
DOE/NETL Launches Carbon Capture Newsletter.

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*.

NETL Releases ROZ Appraisals Featuring FE/NETL Onshore CO_2-EOR Cost Model.

NETL released CO_2 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 CO_2 that can be stored in these fairway regions. The FE/NETL CO_2 Prophet Model and the *FE/NETL Onshore CO_2-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 CO_2-EOR Cost Model."

IEA Report Focuses on Impact of CCUS.



A report from the International Energy Agency (IEA) examines the impact of CCUS technology on reducing CO_2 emissions. The report, "*CCUS in Clean Energy Transitions*," also includes geospatial analysis of power and industrial emissions in key regions and their proximity to potential geologic storage sites.

Study Highlights CO_2 Capture, Storage Potential.

A study funded by the United Kingdom's (UK) Department for Transport found that CO_2 capture could achieve marine decarbonization at 50% of a comparable cost for zero-carbon fuels. *According the study*, vessel stability could be maintained without other modifications, and the captured CO_2 could be delivered to arrival ports in liquid form for geologic storage.

Analysis on CCS Spending in Europe.

An analysis conducted by Rystad Energy found that carbon capture and storage (CCS) technology development in Europe has reached a stage in which large-scale developments could lead to as much as 75 million metric tons of CO_2 captured and stored by 2035.

DNV GL's Energy Transition Outlook 2020.

The scaling of CCS technology has the potential to be a catalyst to decarbonize the oil and gas value chain after 2035, according to *DNV GL's Energy Transition Outlook 2020*. The report provides an independent forecast of developments in the world energy mix to 2050, and presents the demand, supply, and investment forecast to 2050. According to DNV GL's report, 13% of natural gas will be decarbonized in 2050, with 12% of world energy emissions captured through CCS technology.

PROJECT and BUSINESS DEVELOPMENTS

US States to Establish Regional CO_2 Transport, Storage Infrastructure Plan.

Seven U.S. states signed a Memorandum of Understanding (MOU) to establish a regional carbon transport plan by 2021. Under the MOU, the states will commit to the development of safe CO_2 transport and storage. A state coordination group will be facilitated by the Great Plains Institute and informed by ongoing work by the Regional Carbon Capture Deployment Initiative—a network of 25 U.S. states working to ensure near-term deployment of CO_2 capture projects. More information is *available online*. From *Beaver County Times Online*. October 2020.

Japanese Firms to Demonstrate CO_2 Storage.

Two Japanese firms will conduct a demonstration project to store CO_2 in Indonesia. Electric Power Development Co. and Japan NUS Co., with cooperation of the Indonesian government, will execute the four-year plan at Gundih gas field in Central Java Province. A gas pipeline will connect the gas field to the CO_2 storage site. From *Kyodo News*. September 2020.

PROJECT and BUSINESS DEVELOPMENTS *(cont.)*

CCS Project Awarded in North Yorkshire.

Worley, an Australian engineering company, was selected to provide the early front-end engineering and design (pre-FEED) for two carbon capture units at Drax Group's power station in North Yorkshire. The capture units will integrate bioenergy with carbon capture and storage (BECCS) technology. Once operational, the capture units have the potential to capture approximately 4 million metric tons of CO_2 annually. From *Energy Live News*. September 2020.

Norway to Build CCS Project.

The Norwegian government proposed a funding package to enable large-scale implementation of CCS in Norway. The "Longship" funding package seeks to implement a full-scale CCS project that will capture CO_2 emissions from the NORCEM Heidelberg cement plant in Brevik, near Oslo, and transport and store it under the North Sea. The full-scale CCS chain includes CO_2 storage nearly 10,000 feet under the ocean at the Northern Lights project, a collaboration among Equinor, Shell, and Total. Initially able to handle 1.5 million tons of CO_2 per year, the site aims to be able to receive, inject, and store up to 5 million tons of CO_2 per year when fully realized. From *Forbes*. September 2020.

Organizations Sign CCS MOU.

Three international organizations signed an MOU to further develop CCS technologies. Through the MOU, Technology Centre Mongstad, DNV GL, and SINTEF aim to help advance CCS technology from pilot demonstration to wide-scale commercial deployment. From *TCM News*. October 2020.

Carbon Storage License Awarded in UK.

The UK's Oil and Gas Authority awarded a CO_2 appraisal and storage license to Eni UK Limited. Under the license, which will cover an area within the Liverpool Bay area of the east Irish Sea, Eni plans to reuse and repurpose depleted hydrocarbon reservoirs and associated infrastructure to store CO_2 captured in northwest England and northern Wales. From *ENI Press Release*. October 2020.

LEGISLATION and POLICY

Company Files to Obtain US EPA Permit for CCS Project.

Gulf Coast Sequestration initiated the process for obtaining a *Class VI Underground Injection Control* permit from the U.S. Environmental Protection Agency (EPA). The Louisiana (USA)-based company plans to build and operate a CO_2 storage project with the potential to store more than 80 million tons of CO_2 in geologic formations. From *Gulf Coast Sequestration*. October 2020.

Carbon Dioxide Removal Law Database Launched.

Researchers at Columbia University (USA) launched a database of CO_2 removal laws that provides an annotated bibliography of legal materials related to CO_2 removal and carbon storage and use. *Publicly available online*, the database has more than 500 resources on legal issues related to CO_2 removal, including techniques such as BECCS and soil carbon storage, as well as more than 230 legal resources on CO_2 storage, utilization, and transportation. From *Phys.org*. October 2020.

EU Invests in CCS Projects.

European Union (EU) member states *agreed* with the *European Commission's (EC) proposal to invest in European infrastructure projects*, including several CCS projects. Funding will be awarded to the Porthos CO_2 transport network project, which aims to develop an open-access, cross-border network to transport CO_2 from industrial sources in Europe's main ports to offshore storage locations in the North Sea. The funding will come from the EU's financial mechanism for trans-European infrastructure, the Connecting Europe Facility (CEF) Program. *The full list of projects selected under the CEF Energy Call for Proposals is available*. From *Carbon Capture Journal*. October 2020.

Alberta Invests in CCUS.

The government of Alberta (Canada) is investing in a CCUS grant program to help industries reduce emissions, increase competitiveness, and lower carbon compliance costs. The *Industrial Energy Efficiency and Carbon Capture Utilization and Storage (IEE CCUS) Grant Program* is part of a larger investment of the *Technology Innovation and Emissions Reduction (TIER) fund*, and targets improvements at facilities that are regulated, or eligible to be regulated, by the *TIER Regulation*. From *Carbon Capture Journal*. October 2020.

EMISSIONS TRADING

RGGI States Initiate Auction Process for Auction 50.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the Auction Notice for their 50th quarterly CO_2 allowance auction, to be held December 2, 2020. Auction 50 will offer 16,237,495 CO_2 allowances for sale at a minimum reserve price of $2.32. An 11.8 million CO_2 allowance cost containment reserve (CCR) will also be made available. (The CCR will be accessed if the interim clearing price exceeds the CCR trigger price of $10.77.) Auction 50 will be the last quarterly auction in which states will offer CO_2 allowances for purchase to meet CO_2 compliance obligations for the fourth control period, which began on January 1, 2018, and extends through December 31, 2020. Market participants can continue to obtain CO_2 allowances through various secondary markets. From *RGGI News Release*. October 2020.

Carbon Market Partnership Launched.

Two companies formed a pilot project to create a voluntary CO_2 removal marketplace. The pilot program, formed by Truterra, LLC and Nori, will focus on using blockchain technology to translate existing farm data that capture the CO_2 removal impact of on-farm conservation practices into potential carbon credits. The pilot is expected to provide farmers with a better understanding of the carbon market potential. From *Successful Farming*. October 2020.

SCIENCE NEWS

Increasing CO_2 Storage Capacity in US Forests.

According to an analysis by the U.S. Department of Agriculture (USDA) Forest Service, fully stocking non-stocked and poorly stocked forests may lead to a 20% increase in the amount of CO_2 that forests can store. The USDA study was based on publicly available data from more than 130,000 forested plots in the *Forest Service's Forest Inventory and Analysis Program*. The study was *published in the journal Proceedings of the National Academy of Sciences*. From *USDA News Release*. September 2020.

Scientists Discover "Natural Laboratory" to Test Carbon Storage Theory.

Geoscientists at the University of Sydney found the Tweed River valley in northeastern New South Wales to be a "natural laboratory" to test the viability of rock weathering to store CO_2. According to the study, *published in the journal Frontiers in Earth Science*, when common rocks break down, they absorb CO_2 to form carbonates that can then be washed into the oceans, essentially allowing river valleys like the Tweed to act as carbon sinks. Scientists believe this act of common rock weathering has the potential to absorb millions of metric tons of CO_2 from the atmosphere; however, it has never been tested at scale. Scientists believe the Tweed catchment area will enable these claims to be tested. From *The University of Sydney News*. October 2020.

PUBLICATIONS

Net-Zero and Geospheric Return: Actions Today for 2030 and Beyond.

The following is from the Executive Summary of this Global CCS Institute document: "The case for rapid and profound decarbonization has never been more obvious or more urgent, and immediate action must match growing global ambition and need. An important new component of this discussion is the necessity of achieving net-zero global greenhouse gas emissions for any climate stabilization target. Until net-zero emissions are achieved, greenhouse gas will accumulate in the atmosphere and oceans, and concentrations will grow, even with deep and profound emissions reduction, mitigation, and adaptation measures. This places a severe constraint on human enterprise: any carbon removed from the earth must be returned to the earth. To manage this aspect of the global carbon budget, carbon capture and storage (CCS) must play a central role. In particular, CCS will be important in two major roles: [1] To manage emissions from existing, long-lived capital stock. This is especially true for rapid emissions reduction from three kinds of facilities: heavy industrial sector (i.e., cement, steel, and chemicals); production of near–zero-C hydrogen in abundance; and recently built power plants, in particular coal and gas facilities in Asia. [2] To enable large-scale rapid carbon dioxide (CO_2) removal through engineered systems. This will include approaches like direct-air capture with storage (DACS), bioenergy with CCS (BECCS), and carbon mineralization."

Carbon Capture and Storage (CCS) Market Sales Outlook.

The following is a description of this report: "The Carbon Capture and Storage (CCS) report provides an independent information about the Carbon Capture and Storage (CCS) industry supported by extensive research on factors such as industry segments size & trends, inhibitors, dynamics, drivers, opportunities & challenges, environment & policy, cost overview, porter's five force analysis, and key companies. In this report, [the authors offer] a thorough investigation of Carbon Capture and Storage (CCS) Market, SWOT examination of the most prominent players right now. Alongside an industrial chain, market measurements regarding revenue, sales, value, capacity, regional market examination, section insightful information, and market forecast are offered in the full investigation, and so forth."

Start-up and Shut-down times of power CCUS facilities.

The following is from the Executive Summary of this UK Department for Business, Energy and Industrial Strategy document: "The Department for Business, Energy and Industrial Strategy (BEIS) has commissioned AECOM to investigate potential improvements to the start-up and shut-down times of gas-fired power Carbon Capture, Utilisation and Storage (power CCUS) facilities. This report summarises the outputs of the study, including process modelling to demonstrate the performance of a range of configuration variants and inputs to the BEIS Dynamic Dispatch Model. A reference or 'standard' configuration case was identified to achieve 95% capture of normal carbon dioxide emissions from a modern H-Class Combined Cycle Gas Turbine power plant. The standard configuration was developed from open literature, project history and AECOM experience of carbon capture processes and is recorded in the Basis of Design, which is appended to this report. Results of the literature review are also provided in an appendix to this report."

Experimental study on the fracture behavior of sandstone after $ScCO_2$–water–rock interaction.

The following is from the abstract of this article: "Geological sequestration of carbon dioxide is one way of offsetting carbon emissions. During geological CO_2 sequestration, any effects that CO_2 may have on the physical and mechanical properties of the caprock can potentially affect the stability of its storage. This paper investigates the fracturing behavior of sandstone immersed in water dissoluted with supercritical carbon dioxide ($ScCO_2$). For this purpose, the fracture toughness of sandstone was tested after different durations of immersion in water with $ScCO_2$ (10 days, 20 days and 30 days). Furthermore, the surface and fracture characteristics of the sandstone were evaluated with X-ray diffraction (XRD), X-ray fluorescence (XRF), and scanning electron microscopy (SEM). The results show that: (1) The mode I fracture toughness (KIC) of sandstone reduced by up to 23.91%, 20.43%, and 31.92% after immersion in water with $ScCO_2$ for 10 days, 20 days and 30 days, respectively, indicating clear temporal heterogeneity in the damage caused to sandstone by $ScCO_2$ and water. (2) Similar variation occurs in the maximum deviation distance of sandstone failure cracks with an increase in saturation time as in fracture toughness (KIC); that is, the maximum deviation distance increases in parallel with fracture toughness. (3) $ScCO_2$–water–rock interactions change the mineral composition of sandstone. As a result, many pores and cracks appear in the sandstone, especially after 30-day saturation, seriously damaging its structure; this is the direct cause of the decrease in the ability of the sandstone to resist fracture. The results of this study provide a significant theoretical reference for evaluating the long-term stability of geological CO_2 sequestration under caprock." **Ze-dong Sun, Xuan-min Song, Gan Feng, Yu-ming Huo, Shao-qi Kong, and De-fu Zhu,** *Journal of Natural Gas Science and Engineering*. (Subscription may be required.)

PUBLICATIONS *(cont.)*

Modeling CO_2 wettability behavior at the interface of brine/CO_2/mineral: Application to CO_2 geo-sequestration.

The following is from the abstract of this article: "Carbon capture and storage (CCS) has been introduced as an effective method for reduction of CO_2 emissions to the atmosphere. While different aspects and controlling parameters of geological CO_2 sequestration process are well understood, there is still large uncertainty regarding brine/CO_2/rock wettability and no model has yet been presented for characterizing the contact angle of brine/CO_2/rock system at different environmental conditions. In this study, various intelligent models have been developed for accurate estimation of brine/CO_2/rock contact angles. Results demonstrated that the proposed models have the ability to accurately simulate the brine/CO_2 wettability behavior for quartz, calcite, feldspar, and mica minerals at different pressures, temperatures and salinities. Additionally, results revealed that adaptive neuro-fuzzy interference system has the best performance compared with the other models and its superiority is shown through statistical and graphical analyses. Afterward, the most effective input parameters on brine/CO_2/rock wettability were investigated by employing Monte-Carlo algorithm, which showed that mineral type, salinity and pressure are the most sensitive variables for this process. As wettability can highly affect the residual and structural trapping mechanisms during carbon geo-sequestration, presenting reliable models for estimating brine/CO_2/rock wettability is crucial. Therefore, the outcomes of this study can be useful for accurate estimation of these mechanisms capacity." **Amin Daryasafar, Amin Keykhosravi, and Khalil Shahbazi,** *Journal of Cleaner Production*. (Subscription may be required.)

Can carbon emission trading scheme achieve energy conservation and emission reduction? Evidence from the industrial sector in China.

The following is from the abstract of this article: "Whether the emission trading scheme (ETS) can achieve energy conservation and emission reduction in developing countries is crucial for these countries to achieve sustainable economic and environmental development. This study investigates the energy conservation and emission reduction effects of China's carbon dioxide (CO_2) ETS pilot policy implemented in 2011. Based on panel data of the two-digit industry at province level from 2005 to 2015, [the authors] adopt the difference-in-differences (DID) model to examine the effects of the CO_2 ETS on energy conservation and emission reduction. The results show that the CO_2 ETS decreases the energy consumption of the regulated industries in pilot areas by 22.8% and the CO_2 emissions by 15.5% compared to those in nonpilot areas. Further analysis indicates that the policy effects are mainly driven by improving technical efficiency and adjusting industrial structure. In addition, [the authors] find that the CO_2 ETS performs better in areas with high levels of environmental enforcement and marketization. Overall, [the authors'] findings suggest that the CO_2 ETS has achieved energy conservation and emission reduction effects in developing countries." **Yucai Hu, Shenggang Ren, Yangjie Wang, and Xiaohong Chen,** *Energy Economics*. (Subscription may be required.)

A near-term to net zero alternative to the social cost of carbon for setting carbon prices.

The following is from the abstract of this article: "The social cost of carbon (SCC) is commonly described and used as the optimal CO_2 price. However, the wide range of SCC estimates provides limited practical assistance to policymakers setting specific CO_2 prices. Here [the authors] describe an alternate near-term to net zero (NT2NZ) approach, estimating CO_2 prices needed in the near term for consistency with a net-zero CO_2 emissions target. This approach dovetails with the emissions-target-focused approach that frames climate policy discussions around the world, avoids uncertainties in estimates of climate damages and long-term decarbonization costs, offers transparency about sensitivities and enables the consideration of CO_2 prices alongside a portfolio of policies. [The authors] estimate illustrative NT2NZ CO_2 prices for the United States; for a 2050 net-zero CO_2 emission target, prices are US$34 to US$64 per metric ton in 2025 and US$77 to US$124 in 2030. These results are most influenced by assumptions about complementary policies and oil prices." **Noah Kaufman, Alexander R. Barron, Wojciech Krawczyk, Peter Marsters, and Haewon McJeon,** *Nature Climate Change*. (Subscription may be required.)

A meta-analysis of global cropland soil carbon changes due to cover cropping.

The following is from the abstract of this article: "Including cover crops within agricultural rotations may increase soil organic carbon (SOC). However, contradictory findings generated by on-site experiments make it necessary to perform a comprehensive assessment of interactions between cover crops, environmental and management factors, and changes in SOC. In this study, [the authors] collected data from studies that compared agricultural production with and without cover crops, and then analyzed those data using meta-analysis and regression. [The authors'] results showed that including cover crops into rotations significantly increased SOC, with an overall mean change of 15.5% (95% confidence interval of 13.8%–17.3%). Whereas medium-textured soils had highest SOC stocks (overall means of 39 Mg ha^{-1} with and 37 Mg ha^{-1} without cover crops), fine-textured soils showed the greatest increase in SOC after the inclusion of cover crops (mean change of 39.5%). Coarse-textured (11.4%) and medium-textured soils (10.3%) had comparatively smaller changes in SOC, while soils in temperate climates had greater changes (18.7%) than those in tropical climates (7.2%). Cover crop mixtures resulted in greater increases in SOC compared to mono-species cover crops, and using legumes caused greater SOC increases than grass species. Cover crop biomass positively affected SOC changes while carbon:nitrogen ratio of cover crop biomass was negatively correlated with SOC changes. Cover cropping was associated with significant SOC increases in shallow soils (≤30 cm), but not in subsurface soils (>30 cm). The regression analysis revealed that SOC changes from cover cropping correlated with improvements in soil quality, specifically decreased runoff and erosion and increased mineralizable carbon, mineralizable nitrogen, and soil nitrogen. Soil carbon change was also affected by annual temperature, number of years after start of cover crop usage, latitude, and initial SOC concentrations. Finally, the mean rate of carbon sequestration from cover cropping across all studies was 0.56 Mg ha^{-1} yr^{-1}. If 15% of current global cropland were to adopt cover crops, this value would translate to 0.16 ± 0.06 Pg of carbon sequestered per year, which is ~1–2% of current fossil fuels emissions. Altogether, these results indicated that the inclusion of cover crops into agricultural rotations can enhance soil carbon concentrations, improve many soil quality parameters, and serve as a potential sink for atmosphere CO_2." **Jinshi Jian, Xuan Du, Mark S. Reiter, and Ryan D. Stewart,** *Soil Biology and Biochemistry*. (Subscription may be required.)

Efficient sequestration of terrigenous organic carbon in the New Britain Trench.

The following is from the abstract of this article: "The fate of terrigenous organic carbon (OC_{terr}) in the ocean remains an enigma for four decades. Hadal trenches, the deepest ocean realm (6–11 km deep), were recently proposed to be OC depocenters, but whether and how much OC_{terr} was sequestrated there remain elusive. Here [the authors] conducted comprehensive analyses for four sediment cores from the New Britain Trench (NBT) close to Papua New Guinea to assess source, translocation and burial of OC. The bulk and molecular radiocarbon data suggest that the NBT landward slope and axis sediments mainly receive young and biogenic rather than petrogenic OC. The three-endmember mixing model based on $\Delta^{14}C$, $\delta 13C$ and OC contents reveals that sediments of the NBT axis (8225 m) comprise relatively high OC contents (0.66 ± 0.08%), of which biogenic OC_{terr} accounts for 62 ± 10%. The high proportion of biogenic OC_{terr} was attributed to the selective translocation of OC_{terr}-enriched coarse particles and rapid delivery of sediments supported by unique V-shape feature of the trench. In contrast, the sediment OC at the oceanward slope is primarily of a marine origin, suggesting that OC_{terr} was efficiently trapped in the trench bottom. It is estimated that the burial rate is 2.75 ± 0.32 g C m^{-2} yr^{-1} for OC and 1.69 ± 0.41 g C m^{-2} yr^{-1} for OC_{terr} in the NBT. Given a fact that many trenches are close to the landmasses, [the authors] propose that the hadal trenches may contribute significantly to the burial of OC_{terr} in the ocean." **Wenjie Xiao, Yunping Xu, Negar Haghipour, Daniel B. Montluçon, Binbin Pan, Zehua Jia, Huangmin Ge, Peng Yao, and Timothy I. Eglinton,** *Chemical Geology*. (Subscription may be required.)

PUBLICATIONS *(cont.)*

Effects of soil texture and nitrogen on ability of carbon sequestration in different organs of two Tamarix species as a good choice for carbon stock in dry lands.

The following is from the abstract of this article: "The present study was conducted to examine how different organs of plants (leaf, stem and root) of *Tamarix aphylla* and *Tamarix kotschyi* could affect carbon sequestration in soil depths ranging from 0 to 15 cm and 15 to 30 cm. This study was carried out in the Ahoochar region, 25 km north of Shiraz, during 2015–2017. This study was carried out in two separate factorial experiment arranged in a randomized complete design. The first factor was the type of plant species in both experiments. The second factor was the plant organs in experiment I and different soil depths in experiment II. The results showed that there was a higher degree of carbon sequestration in depths that ranged from 0–15 cm, compared to soil at 15–30 cm depth. The results of correlation coefficients showed that the percentage of clay was the strongest parameter that contributed to carbon sequestration. Furthermore, *Tamarix aphylla* and *T. kotschyi* showed similar amounts of organic carbon stored in their tissues. Stems had higher amounts of stored organic carbon compared to the leaves. In general, it was observed that carbon sequestration reached its highest level (54.15 t/ha) in soil with *T. kotschyi* at 0–15 cm depth. The stem of both plants had a higher ability for carbon sequestration." **Mahbobeh Iranmanesh and Hossein Sadeghi,** *Ecological Engineering*. (Subscription may be required.)

Tree layer carbon stock quantification in a temperate food forest: A peri-urban polyculture case study.

The following is from the abstract of this article: "Food forests offer a number of potential benefits and one of those is the ability to sequester carbon and increase terrestrial carbon stocks on urban, peri-urban and rural land. There is little research on the carbon storage capabilities within agroforestry systems let alone food forests and it is considered an underexploited option for carbon storage. This case study quantified the carbon stored within the above and below ground components of all tree layer woody biomass above 2 m in height and greater than 2 cm diameter at breast height (DBH) in the Agroforestry Research Trust's peri-urban food forest in Devon, UK. The study formed a population census, which measured all 528 trees across 68 species within the 0.64 ha food forest. Twenty-three allometric equations were used to estimate above ground biomass (AGB) while the below ground biomass (BGB) was calculated using a root to shoot ratio of 0.18:1. The stored carbon content was calculated as 50% of the total biomass. The temperate food forest case study site was estimated to store 39.53 ± 4.05 Mg C ha^{-1} in above and below ground living biomass. This result highlights the potential for a food forest stand to store a considerable amount of carbon that is at least within a similar range to other literature sourced urban and peri urban land uses. Thus, a purposely selected food forest assemblage whose primary focus is food production can also be a valuable carbon sink The results offer a promising initial study into the carbon storage potential within a food forest, which is only made more valuable given the other prospective benefits of food forests." **Luke J. Schafer, Marin Lysák, Christian B. Henriksen,** *Urban Forestry & Urban Greening*. (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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