U.S. DEPARTMENT OF ENERGY | OFFICE OF FOSSIL ENERGY AND CARBON MANAGEMENT

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

CSN CARBON STORAGE NEWSLETTER

VOL. 22, NO. 6

CARBON STORAGE PROGRAM DOCUMENTS and REFERENCE MATERIALS

- Carbon Storage Educational Resources
- Program Reports, Plans, and Roadmaps
- Conference Proceedings
- Carbon Storage Portfolio
- Systems Analysis
- Peer Review
- Best Practices Manuals
- Fossil Energy and Carbon Management Techlines

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

DOE/FECM/NETL HIGHLIGHTS

DOE Announces BIL Effort to Establish DAC Hubs.

The U.S. Department of Energy (DOE) released a ***Notice of Intent (NOI)*** to fund the Bipartisan Infrastructure Law's (BIL) program to capture and store atmospheric carbon dioxide (CO_2) emissions. The Regional Direct Air Capture (DAC) Hubs Program will support four large-scale, regional DAC hubs that each comprise a network of carbon dioxide removal (CDR) projects to help address potential impacts of climate change while creating good-paying jobs and prioritizing community engagement and environmental justice. The widespread deployment of DAC technologies and CO_2 transport and storage infrastructure plays a significant role in delivering on the Biden-Harris Administration's goal of achieving an equitable transition to a net-zero economy by 2050. Each of the projects selected will demonstrate the delivery and storage or end-use of removed atmospheric CO_2. The hubs will have the capacity to capture and store at least 1 million metric tons of CO_2 from the atmosphere annually, either from a single unit or from multiple interconnected units. In the development and deployment of the four regional DAC hubs, DOE will also emphasize environmental justice, community engagement, consent-based siting, equity and workforce development, and domestic supply chains and manufacturing.

From *energy.gov*. May 2022.

CONTINUE

DOE/FECM/NETL HIGHLIGHTS *(cont.)*

DOE Investments to Accelerate CO_2 Storage Projects and Increase CO_2 Storage Sites.

DOE announced two Funding Opportunity Announcements (FOAs) and one NOI to advance carbon storage projects that reduce CO_2 emissions, address potential impacts of climate change, and create good-paying jobs while prioritizing community engagement and environmental justice. DOE first issued an FOA for "***Carbon Management***" to advance a variety of carbon management technologies, including assessments of rock and material resources for CO_2 mineralization. DOE then issued an FOA for "***CarbonSAFE: Phase II - Storage Complex Feasibility***" to increase the number of available CO_2 storage sites in the early developmental levels. The next investment has been announced through an NOI for "***Bipartisan Infrastructure Law: Storage Validation and Testing (Section 40305): Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative: Phases III, III.5, and IV***," which would be funded through the BIL to accelerate commercial-scale geologic carbon storage projects toward operational readiness. CarbonSAFE projects must be capable of storing at least 50 million metric tons of CO_2 within a 30-year operational period. Projects funded under these three opportunities will be managed by DOE's Office of Fossil Energy and Carbon Management (FECM).

From *energy.gov*. May 2022.

ANNOUNCEMENTS

DOE to Host Virtual Carbon Negative Shot Summit.

DOE will host the virtual ***Carbon Negative Shot Summit***, July 20–21, 2022. DOE launched the ***Carbon Negative Shot***, the third target within the ***Energy Earthshots Initiative***, to advance the development of the emerging CDR industry. More information about Carbon Negative Shot is available via ***video*** and ***infographic***.

DOE Funding to Develop Hydrogen Turbines and Production with CCS.

DOE announced funding for ***six research and development projects*** to develop technologies for more efficient hydrogen turbines and production with carbon capture and storage (CCS). DOE's National Energy Technology Laboratory (NETL), under the purview of FECM, will manage the projects.

DOE Invests in DAC and Storage Technology.

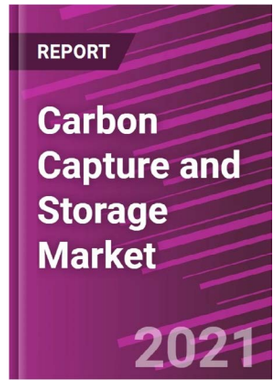
DOE announced the award of federal funding for five front-end engineering design (FEED) studies that will leverage existing zero- or low-carbon energy to supply DAC projects, combined with dedicated and reliable carbon storage. ***The studies*** aim to provide a better understanding of system costs, performance, and business case options for existing DAC technologies coupled with durable storage that can remove a minimum of 5,000 metric tons per year of net CO_2 from the air, and which are co-located with domestic zero- or low-carbon thermal energy sourced from geothermal or nuclear power plants and low-grade heat from industrial facilities.

FECM Releases Strategic Vision.

DOE's FECM released its strategic vision, "***The Role of Fossil Energy and Carbon Management in Achieving Net-Zero Greenhouse Gas Emissions***." FECM's Strategic Vision will enable DOE to make strategic carbon management decisions and prioritize approaches that minimize the environmental impacts of fossil fuels and carbon-based feedstocks and help the nation achieve net-zero greenhouse gas emissions. Three strategic directions were outlined to help the U.S. government achieve a fully decarbonized power sector by 2035 and net-zero emissions by 2050: Advancing Justice, Labor, and Engagement; Advancing Carbon Management Approaches Toward Deep Decarbonization; and Advancing Technologies that Lead to Sustainable Energy Resources. More information on FECM's Strategic Vision is available via ***infographic***.

DOE Welcomes DOT's CO_2 Pipeline Safety Measures.

DOE released a statement welcoming the ***CO_2 pipeline safety measures announced*** by the U.S. Department of Transportation's (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA). The new guidance will be incorporated into DOE's research, development, demonstration, and deployment portfolio to ensure safe operations of commercial CO_2 pipelines in the United States. ***PHMSA*** establishes pipeline safety regulations at the federal level. DOE does not have regulatory oversight of CO_2 pipeline safety.



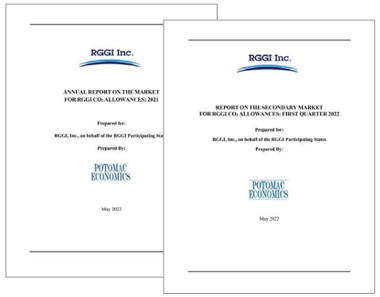
Report on Future Market Growth of CCS Industry.

According to a recent study, the global CCS market is expected to reach $15.2 billion by 2029. The report, "***Carbon Capture and Storage Market Share, Size, Trends, Industry Analysis Report By Application; By Capture Type; By Region, Segments & Forecast, 2022 - 2029***," provides insight into the current market dynamics and offers an analysis of future market growth. (Purchase required.)

ANNOUNCEMENTS *(cont.)*

RGGI Reports Made Available.

Potomac Economics, the independent market monitor for the Regional Greenhouse Gas Initiative (RGGI) CO_2 allowance market, released their annual report evaluating activity in the market for RGGI CO_2 allowances in 2021. The ***Annual Report on the Market for RGGI CO_2 Allowances: 2021*** focuses on allowance prices, trading and acquisition of allowances in the auctions and the secondary market, participation in the market by individual firms, and market monitoring. Potomac also released the ***Report on the Secondary Market for RGGI CO_2 Allowances: First Quarter 2022***, which addresses the period from January through March 2022.



Joint Venture Aims to Increase Carbon Storage Access.

Caracara Services and a subsidiary of Battalion Oil Corporation entered into a joint venture to develop and fund a gas treatment and carbon storage facility in the Delaware Basin of West Texas (USA). Caracara Services constructs, owns, and operates carbon capture, utilization, and storage (CCUS) infrastructure.

PROJECT AND BUSINESS DEVELOPMENTS

Companies Announce Partnership to Develop CCS Project.

Lapis Energy—an infrastructure investment firm—and LBS Industries—a chemical product manufacturer for the agricultural, mining, and industrial markets—entered into an agreement to develop a CCS project at LSB Industries' El Dorado, Arkansas, facility (USA). Subject to the approval of a U.S. Environmental Protection Agency (EPA) Class VI permit, the project is projected to be completed by 2025, at which time CO_2 injections would begin. Once operational, the project would have the potential to initially capture and store more than 450,000 metric tons of CO_2 per year, with the potential to increase that amount, according to the companies.

From *Business Wire*. April 2022.

Chevron Signs on to Joint Venture to Develop CCS Hub.

U.S. oil company Chevron signed a Memorandum of Understanding (MOU) with U.S. oil company Talos and CCS project development and finance company Carbonvert to join their joint venture to develop an offshore CCS hub. The Bayou Bend CCS project—a ***2021 joint venture*** between Talos and Carbonvert—encompasses more than 40,000 acres and, according to the preliminary estimates, has the potential to store 225–275 million metric tons of CO_2 from industrial sources in the area (offshore Beaumont and Port Arthur, Texas).

From *Offshore Engineer*. May 2022.

FEED Contract Awarded for CCS Project.

NPCC
شركة البناءات البترولية الوطنية

A FEED contract for a Malaysian CCS project was awarded to a consortium led by the National Petroleum Construction Company (NPCC). Per the terms of the contract, consortium member Technip Energies—a provider of consulting, engineering services, and technologies for the low-carbon energy market—will provide project management and technological capabilities, while NPCC will utilize its offshore installation experience and fabrication capabilities. The Kasawari CCS project is located off the coast of Sarawak, Malaysia, and is expected to average 3.7 million metric tons of CO_2 annually.

From *Construction Review Online*. April 2022.

Summit Carbon Solutions Joins CO_2 Storage Project.

SUMMIT CARBON SOLUTIONS

Summit Carbon Solutions, an Iowa (USA) pipeline builder, announced plans to collaborate with Minnkota Power Cooperative to develop a CO_2 storage facility. The project would include capturing and storing CO_2 from Minnkota's Milton R. Young Station near Center, North Dakota (USA). Summit has also proposed a pipeline across five states, including Iowa, that would capture CO_2 at ethanol, fertilizer, and other industrial agriculture facilities, liquefy it under pressure, and then transport it via the pipeline to North Dakota for storage.

From *Des Moines Register*. April 2022.

Carbon Storage Licenses Awarded in Southern North Sea.

Britain's North Sea Transition Authority (NSTA) awarded energy firms Equinor and BP two carbon storage licenses on the United Kingdom Continental Shelf off the coast of Humberside. Combined with existing nearby licenses held by the Northern Endurance Partnership (which includes Equinor and BP), the licenses have the potential to enable the storage of up to 23 million metric tons of CO_2 per year, ***according to NSTA***.

From *Reuters*. May 2022.

CCS Venture Proposed for Texas Gulf Coast.

BP and industrial gas supplier Linde launched a CCS venture proposed for the Texas Gulf Coast. The offshore facility aims to collect up to 100 million metric tons of CO_2 annually. The project, which targets a 2026 startup, will begin storing CO_2 from Linde's hydrogen gas plants. BP will develop and permit the venture's subterranean sites, and Linde will provide gas compression technology.

From *Reuters*. May 2022.

LEGISLATION AND POLICY

Legislative Changes to Carbon Storage Projects Proposed in Canada.

The Canadian Ministry of Northern Development, Mines, Natural Resources, and Forestry (NDMNRF) filed a proposal on the Environmental Registry of Ontario website to gather input from stakeholders on possible legislative changes related to carbon storage projects. The proposal aims to narrow prohibitions under the ***Oil, Gas, and Salt Resources Act*** and the ***Mining Act*** that relate to CO_2 storage. Possible changes to the regulatory structure also include (1) allowing proponents to voluntarily enter into agreements with NDMNRF to use wells to explore, test, pilot, or demonstrate new technology, such as carbon storage, in areas where oil, gas, and salt resources are typically found; (2) enhancing protections by allowing the issuance of orders related to public or environmental risks; and (3) changing the Mining Act framework to allow the NDMNRF to grant authorizations to use Crown land for carbon storage activities.

From *Mondaq*. April 2022.

Japan Plans Legal CCS Framework.

Japan's industry ministry plans to create a legal framework for CCS to enable companies to begin storing CO_2 underground or under the seabed by 2030. According to the ministry, Japan expects to store approximately 120–240 million metric tons of CO_2 per year in 2050. The Japanese government plans to submit (1) a draft bill to establish a new right to store CO_2 in Japan and limit liability, and (2) a scheme in the legal framework to transport CO_2 released in Japan to other countries for storage.

From *Reuters*. April 2022.

Ohio Legislation Seeks Primacy of Carbon Storage Injection Wells.

Legislation has been signed into law in Ohio (USA) that seeks primacy over EPA Class VI injection wells for carbon storage. ***House Bill 175*** includes a provision that requires the Ohio Department of Natural Resources to begin the process of seeking primacy over Class VI injection wells for carbon storage from EPA no later than 90 days after the effective date of the bill (the legislation takes effect on July 19, 2022).

From *JD Supra*. April 2022.

New Bill Would Require Contribution to Blue Carbon Projects.

An Assembly Bill in California (USA) would require projects on public lands to offset their emissions by building or contributing to blue carbon projects. "Blue carbon" refers to coastal habitats that capture and store CO_2 in soil, plant matter, and the seafloor. ***AB 2593*** will continue through Assembly committees before advancing to the full Assembly and then the Senate for a vote.

From *Phys.org*. May 2022.

EMISSIONS TRADING

EU Proposal Aims to Unify Carbon Removal Processes.

The European Commission plans to present a proposal to unify the European Union's (EU) carbon-removal measurement, reporting, and verification processes by the end of 2022, according to EU officials. The proposal aims to regulate the bloc's carbon-removal market and will be based on existing verification and certification schemes. The commission's proposal will apply to carbon credits generated in the EU and not to international credits.

From *EURACTIV*. May 2022.

European Commission

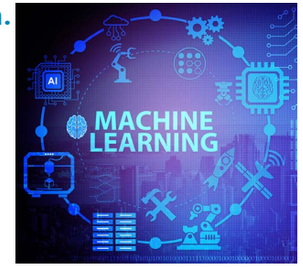
Bahamas Planning to Sell Blue Carbon Credits.

According to officials, the Bahamas plans to sell blue carbon credits on the international market by the end of the year. The nation has identified at least $300 million worth of carbon-sink assets (e.g., seagrasses, mangroves) that could be offered on the voluntary carbon market, according to the Prime Minister.

From *Bloomberg*. April 2022.

SCIENCE

Researchers Study Subsurface CO_2 Storage Monitoring System.



Researchers from Texas A&M University are studying machine-learning methods to analyze sensor-gathered data from geologic carbon storage sites to rapidly depict underground CO_2 plume locations and movements over time. The research, which looks to help reduce the risk of an unregistered release of CO_2, was published in the journal ***Expert Systems with Applications***.

From *Texas A&M Today*. April 2022.

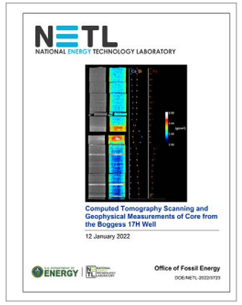
Researchers Study Carbon-Storing Microbes in Ocean.

Two recent studies examined the impact of ocean temperatures and the ocean's ability to store CO_2. The first study, published in ***Nature Communications*** and conducted by researchers at Bigelow Laboratory for Ocean Sciences in Maine (USA), analyzed 30 years of data and found that phytoplankton, which live on the surface of the ocean and store atmospheric CO_2, may become more efficient as the ocean warms. In the second study, also published in ***Nature Communications***, oceanographers from the University of Technology Sydney in Australia reported the discovery of a new, widely distributed ocean microbe species that also has the potential to store CO_2.

From *Eos*. May 2022.

PUBLICATIONS

Computed Tomography Scanning and Geophysical Measurements of Core from the Boggess 17H Well.



The following is from the abstract of this DOE/NETL report: "The computed tomography (CT) facilities and the Multi-Sensor Core Logger (MSCL) at the National Energy Technology Laboratory (NETL) in Morgantown, West Virginia were used to characterize the Marcellus Shale and underlying formations. The core is from a vertical pilot well (Boggess 17H) drilled in western Monongalia County near Core, West Virginia by Northeast Natural Energy for the second Marcellus Shale Energy and Environmental Laboratory (MSEEL). MSEEL is a joint venture between NETL, Northeast Natural Energy, and West Virginia University. The primary impetus for this report is to characterize the core to better understand the structure and variation of the Marcellus Shale and surrounding formations. This report, and the associated scans, provide detailed datasets not typically available from unconventional shales for analysis. The resultant datasets are presented as part of this report and can be accessed from NETL's Energy Data eXchange (EDX) online system using the following link: ***https://edx.netl.doe.gov/dataset/boggess-17h-well***. All equipment and techniques used were non-destructive, enabling future examinations to be performed on these cores. None of the equipment used was suitable for direct visualization of the shale pore space, although fractures and discontinuities were detectable with the methods tested. CT imagery with the NETL medical CT scanner was performed on the entire core. Qualitative analysis of the medical CT images, coupled with X-ray fluorescence (XRF), P-wave, and magnetic susceptibility measurements from the MSCL were useful in identifying zones of interest for more detailed analysis and locating fractured zones. The ability to quickly identify key areas for more detailed study with higher resolution will save time and resources in future studies. The combination of all methods used provides a multi-scale analysis of the core; the resulting macro and micro descriptions of the core are relevant for many subsurface energy related examinations of core that have traditionally been performed at NETL." [***Click here to access NETL's EDX***.]

State of the Art: CCS Technologies 2022.

The following is from the Foreword of this Global CCS Institute technical report: "Carbon Capture and Storage (CCS) has emerged as an indispensable tool in humanity's efforts to combat climate change and reach its goal of net-zero emissions. Industries as diverse as cement, iron and steel, chemicals, natural gas and electricity generation can benefit from the ability of CCS to cut industrial CO_2 emissions deeply. CCS is also moving into carbon dioxide removal (CDR) in applications such as Direct Air Capture (DAC) and Bioenergy with CCS (BECCS), drawing down historical CO_2 emissions from the atmosphere. The CCS sector has been growing at an unprecedented rate in recent years, and that growth is only accelerating. The increased dependence of global plans for net-zero on CCS means that the economic performance of CCS is becoming increasingly important. Technology development will be a significant driver of improved economics for CCS. Higher energy efficiency, reduced variable operating costs, capital cost reductions, and plant performance improvements, enabled by new technologies, are meeting the demand for improved CO_2 capture system performance, transport system costs, and CO_2 storage options. CCS is happening now, and the technology is ready to purchase today. This inaugural Technology Compendium is intended to showcase the breadth and depth of commercially-available CCS technologies worldwide."

PUBLICATIONS *(cont.)*

Policy Brief: Unlocking the governance challenges of Just Transition in the EU.

The following is from a summary of this European Roundtable on Climate Change and Sustainable Transition (ERCST) Policy Brief: "This brief looks into the European Just Transition process, with a specific focus on the Just Transition Fund (JTF) and its underpinning Territorial Just Transition Plans (TJTPs). It examines the governance challenges identified from the consultations and literature review and injects some ideas for strengthening the Just Transition governance process both at EU and Member State level. [Key messages:] While in certain Member States and regions of the EU [the ERCST] see strong Just Transition governance frameworks in place, in some others accountability, clarity on implementation plans, inclusive dialogue and transparency are lacking. Establishing a long-term vision and a detailed transition plan will prove crucial for the socio-economic success of regions in transition in the following decades. Looking beyond the JTF and the TJTPs, in the longer term, political and economic decisions will have to be made in this context and [the ERCST] believe that the basic principle to be followed should be to make Just Transition self-sustainable and cost-efficient beyond grant-based instruments as the JTF. One example would be to strengthen the InvestEU component of the JTM. Social and environmental objectives throughout the EU decarbonisation process will only be reached by a well-proportioned mix of market approaches, standards, and regulations in conjunction with a strong political vision."

Immediate and long-term effects of tillage practices with crop residue on soil water and organic carbon storage changes under a wheat-maize cropping system.

The following is from the abstract of this article: "Reasonable tillage management benefits soil structure optimization and agricultural sustainability. However, the differences of immediate (i.e. changes between post- and pre- tillage) and long-term effects (i.e. changes between treatments after certain years) under different tillage practices is often neglected. This study involved a 16-year field experiment including three tillage practices (plow tillage, PT; subsoiling tillage, ST and rotary tillage, RT) and two crop residue management practices (no residue return and all residue return). Those immediate and long-term effects on soil physical properties and soil organic carbon were investigated. For the immediate effects after tillage, the soil water storage under PT, ST, and RT decreased by 5.8%, 4.0%, and 3.2%, respectively; while those under residue return and no residue return decreased by 3.9% and 4.6%, respectively. Under the same conditions, ST was more beneficial to reduce soil penetration resistance. The soil bulk density post-tillage was significantly lower than that pre-tillage at 0–10 cm soil depth, meanwhile the soil bulk density at 10–40 cm soil depth was generally decreased after tillage practice under ST treatment. For the long-term effects, the penetration resistance at 10–50 cm soil depth and the soil bulk density at 10–30 cm soil depth were lower under the ST treatment than those under PT and RT treatments. Additionally, residue return was beneficial for soil water storage, soil bulk density, and soil organic carbon storage. Overall, both for the immediate and long-term effects, subsoiling tillage with residue return significantly increased soil water storage, total porosity, soil organic carbon storage and crop yields, while decreased soil bulk density and penetration resistance." **Hongxiang Zhao, Jihao Qin, Tianping Gao, Mengkun Zhang, Hongchang Sun, Shuwei Zhu, Cailong Xu, and Tangyuan Ning,** *Soil and Tillage Research*. (Subscription may be required.)

A storage-driven CO_2 EOR for a net-zero emission target.

The following is from the abstract of this article: "Stabilizing global climate change to within 1.5°C requires a reduction in greenhouse gas emissions, with a primary focus on carbon dioxide (CO_2) emissions. CO_2 flooding in oilfields has recently been recognized as an important way to reduce CO_2 emissions by storing CO_2 in oil reservoirs. This work proposes an advanced CO_2 enhanced oil recovery (EOR) method—namely, storage-driven CO_2 EOR—whose main target is to realize net-zero or even negative CO_2 emissions by sequestrating the maximum possible amount of CO_2 in oil reservoirs while accomplishing the maximum possible oil recovery. Here, dimethyl ether (DME) is employed as an efficient agent in assisting conventional CO_2 EOR for oil recovery while enhancing CO_2 sequestration in reservoirs. The results show that DME improves the solubility of CO_2 in in situ oil, which is beneficial for the solubility trapping of CO_2 storage; furthermore, the presence of DME inhibits the 'escape' of lighter hydrocarbons from crude oil due to the CO_2 extraction effect, which is critical for sustainable oil recovery. Storage-driven CO_2 EOR is superior to conventional CO_2 EOR in improving sweeping efficiency, especially during the late oil production period. This work demonstrates that storage-driven CO_2 EOR exhibits higher oil-in-place (OIP) recovery than conventional CO_2 EOR. Moreover, the amount of sequestrated CO_2 in storage-driven CO_2 EOR exceeds the amount of emissions from burning the produced oil; that is, the sequestrated CO_2 offsets not only current emissions but also past CO_2 emissions. By altering developing scenarios, such as water alternating storage-driven CO_2 EOR, more CO_2 sequestration and higher oil recovery can be achieved. This work demonstrates the potential utilization of DME as an efficient additive to CO_2 for enhancing oil recovery while improving CO_2 storage in oil reservoirs." **Yueliang Liu and Zhenhua Rui**, *Engineering*. (Subscription may be required.)

Carbon capture: Prospects and policy agenda for CO_2-neutral power generation.

The following is from the abstract of this article: "By mid-century, global mean temperature increase from pre-industrial levels must remain below 1.5°C to resist the forces of climate chaos. Recent studies emphasize the central role that the electricity system must play in achieving 100% carbon-free generation, particularly through greater reliance on zero-carbon, firm output. Major firm power options that emit little or no carbon include hydro, nuclear, geothermal, and carbon capture and storage (CCS). This article examines the status of CCS, now applied at coal-fired power plants and under consideration at natural gas plants in North America and certain European nations. [The authors] identify key developments: (i) CCS can eliminate and permanently store virtually all fossil-fired CO_2 emissions from power plants; (ii) following targeted policies, doing so would be cost-competitive with other strategies to generate zero-carbon, firm electricity; and (iii) combining aggressive upstream greenhouse gas emissions mitigation with near-100% carbon capture at the power plant can create significant benefits on par with the lifecycle emissions of other renewable and clean generation resources. Finally, [the authors] examine the policy pathways, infrastructure, and jurisdictions central to CCS expansion—particularly in the U.S. and its subdivisions. Also discussed is the critical need to export CCS technology to all parts of the globe, especially areas like China and Southeast Asia that are likely to depend on fossil electricity for decades." **Deepika Nagabhushan, R.H. Russell, Kurt Waltzer, John Thompson, Lee Beck, and Marc Jaruzel,** *The Electricity Journal*. (Subscription may be required.)

PUBLICATIONS *(cont.)*

What are the potential paths for carbon capture and storage in Sweden? A multi-level assessment of historical and current developments.

The following is from the abstract of this article: "Carbon capture and storage (CCS), including bioenergy with carbon capture and storage (BECCS), could contribute to climate change mitigation strategies. However, the 2020s is not the first time that CCS is high on the agenda. This study explores the differences between the past and current developments of CCS and discusses how incumbent actors' experiences can inform the understanding of potential future energy system transitions in Sweden. For this purpose, a multi-level perspective (MLP) analysis was conducted based on documents, interviews and focus groups with key actors. Since the 2000s, increased urgency of climate change has further pushed policy makers into action. In addition, there is a new framing of CCS that underscores the potential of BECCS to provide negative carbon dioxide (CO_2) emissions, as well as prospects for offshore storage of CO_2 in Norway and other territories. As such, this study shows that Sweden could be on a transformation pathway towards implementing CCS alongside other mitigation measure." **Adrian Lefvert, Emily Rodriguez, Mathias Fridahl, Stefan Grönkvist, Simon Haikola, and Anders Hansson,** *Energy Research & Social Science*. (Subscription may be required.)

Bamboo construction materials: Carbon storage and potential to reduce associated CO_2 emissions.

The following is from the abstract of this article: "The construction industry is one of the largest contributors of CO_2 emissions. To achieve the goal of carbon peaking by 2030 and carbon neutrality by 2060, China needs to develop carbon reduction pathways for the construction industry. Bamboo is believed to be one of the most appropriate candidates for afforestation to reduce CO_2 concentration and alleviate the effects of climate change. It is also an ideal building material with high tensile and compressive strengths. However, the carbon emissions and storage of bamboo building materials have not been well understood. This study aims to quantify the CO_2 emissions and carbon storage of bamboo building materials and to analyse the potential to reduce these carbon emissions. Results show that the planting phase contributes the largest amount of carbon uptake whilst the production phase contributes the largest amount of carbon emissions. 'Carbonisation' is found to be the production process with the highest carbon emissions, followed by 'antimould, anticorrosion and drying treatment' and 'glue application'. Three strategies that are useful in reducing carbon emissions are proposed and validated. After the implementation of the proposed strategies, the average and median amount of carbon emissions changed from 1291.63 and 1290.75 kg to 1088.36 and 1090.29 kg. Taking all phases into account, one cubic meter of bamboo assembled components can reduce 249.92 kg CO_2 from the atmosphere. Compared to dimensioned lumber, engineered lumber, cement, steel, timber, hempcrete, bamboo building materials have the highest CO_2 emissions and carbon storage. The carbon storage of bamboo assembled components per tonne is around 140 kg more than that of timber per tonne. This study is expected to assist not only researchers in understanding the carbon reduction potential of bamboo building materials but also practitioners in promoting bamboo building-based carbon reduction pathways." **Xiaoxiao Xu, Peiyu Xu, Jianjun Zhu, Haitao Li, and Zhenhua Xiong,** *Science of The Total Environment*. (Subscription may be required.)

Technical Perspective of Carbon Capture, Utilization, and Storage.

The following is from the abstract of this article: "Carbon dioxide (CO_2) is the primary greenhouse gas contributing to anthropogenic climate change which is associated with human activities. The majority of CO_2 emissions are results of the burning of fossil fuels for energy, as well as industrial processes such as steel and cement production. Carbon capture, utilization, and storage (CCUS) is a sustainable technology promising in terms of reducing CO_2 emissions that would otherwise contribute to climate change. From this perspective, the discussion on carbon capture focuses on chemical absorption technology, primarily due to its commercialization potential. The CO_2 absorptive capacity and absorption rate of various chemical solvents have been summarized. The carbon utilization focuses on electrochemical conversion routes converting CO_2 into potentially valuable chemicals which have received particular attention in recent years. The Faradaic conversion efficiencies for various CO_2 reduction products are used to describe efficiency improvements. For carbon storage, successful deployment relies on a better understanding of fluid mechanics, geomechanics, and reactive transport, which are discussed in details." **Qingyang Lin , Xiao Zhang, Tao Wang, Chenghang Zheng, and Xiang Gao,** *Engineering*. (Subscription may be required.)

Temporal dynamics of carbon storage in a Mediterranean mountain scrubland managed by prescribed fire.

The following is from the abstract of this article: "Farmland abandonment and reduction of grazing activity, mainly in mountain areas with remote access and ageing population, have been contributing to shrub encroachment in such territories and, consequently, to increase fuel load available for triggering wildfires. Accordingly, it is necessary to use vegetation management practices in order to reduce wildfire risk, prescribed fire being one of the most common techniques used in the Mediterranean region. This research focused in the effects of a prescribed fire (PF) applied in Montesinho Natural Park (PNM), NE Portugal, on the temporal dynamics of carbon storage in mineral soil, litter layer (organic horizon), and shrub biomass. Before PF and thirty-six months after PF, aboveground shrub biomass was collected in areas of 1 m^2 in 11 plots randomly distributed in the experimental shrub area. Also, in the same plots, litter thickness was measured and soil samples were collected before, two, six and thirty-six months after PF, in order to assess carbon concentration, bulk density and coarse elements content. Despite low to moderate fire intensity, carbon storage changes were observed in all compartments evaluated. Thirty-six months after PF, carbon storage in aboveground biomass of shrub species (7.4 Mg C ha^{-1}) was roughly two-thirds of that recorded prior to PF, and in litter layer (1.6 Mg C ha^{-1}) it was about half of that in the original situation (before PF). In contrast, the mineral soil showed a 10% carbon increase (6.4 Mg C ha^{-1}). Based on the balance between losses (shrub species and litter layer) and gains (mineral soil), at the end of the monitoring period (36 months), there was an annual positive rate of carbon storage, equivalent to 0.2 Mg C ha^{-1} $year^{-1}$. Even after anthropogenic disturbances, such as prescribed fire, shrub communities constitute important terrestrial carbon pools; hence, these ecosystems might play an important role in mitigating climate change." **Felícia Fonseca, Diego Silva, Paulo Bueno, Zulimar Hernández, Ana Caroline Royer, and Tomás de Figueiredo,** *CATENA*. (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***.

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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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