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CARBON STORAGE NEWSLETTER

APRIL 2021

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

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CARBON STORAGE PROGRAM DOCUMENTS and REFERENCE MATERIALS

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- ▷ Systems Analysis
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DOE/NETL HIGHLIGHTS

DOE Briefs State Lawmakers on CO₂ Management, Mitigation Technologies.



National Energy Technology Laboratory (NETL) Director Brian Anderson, Ph.D., addressed the Pennsylvania Senate Environmental Resources and Energy Committee, highlighting NETL-supported projects that reduce carbon dioxide (CO₂) emissions, technologies that safely capture and store CO₂, and processes that make value-added products from the carbon waste stream. The *information briefing* focused on the deployment and utilization of CO₂ management technologies in Pennsylvania (USA). NETL conducts research and development (R&D) for the U.S. Department of Energy's (DOE) *Carbon Storage Program* to advance technologies that enable safe, cost-effective, permanent geologic storage of CO₂. DOE's *Carbon Utilization Program* is developing technologies to transform CO₂ and other carbon byproducts and wastes into valuable products in an efficient, economical, and environmentally friendly manner. From *NETL News Release*, March 2021.

ANNOUNCEMENTS

NETL To Host Online Well Integrity Workshop.

NETL will host a virtual workshop focused on well integrity, titled "Identifying well integrity research needs for subsurface energy infrastructure." The workshop is planned for May 18, May 25, and June 1, 2021. Speakers will include international experts from academia, industry, national laboratories, and non-governmental organizations, covering topics such as characterizing well integrity, non-invasive well monitoring, modeling and experimental work, well integrity in challenging environments, data-driven approaches, and ensuring long-term well integrity. Registration information for the free workshop is available on the NETL website.

MGSC Transitions to MRCI.



The Midwest Geological Sequestration Consortium (MGSC), one of DOE's Regional Carbon Sequestration Partnerships (RCSPs), has transitioned to the Midwest Regional Carbon Initiative (MRCI). Led by Battelle Memorial Institute and the Illinois State Geological Survey, MRCI aims to advance carbon capture, utilization, and storage (CCUS) research by addressing key technical challenges, obtaining and sharing data to support CCUS, facilitating regional infrastructure planning, and performing regional technology transfer. Presentations from MRCI's February 2021 virtual partners meeting are *available*.

USDA Requests Information on Climate Policy.

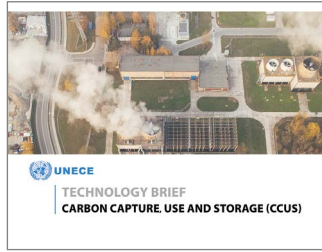
The U.S. Department of Agriculture (USDA) published a Federal Register Notice requesting public input on the climate-smart agriculture and forestry strategy. The Notice, which was available for public input through April 30, 2021, followed an *Executive Order*.



ANNOUNCEMENTS *(cont.)*

Report Highlights CCUS Importance.

The United Nations Economic Commission for Europe released a [report](#) highlighting the importance of CCUS technology for meeting carbon-reduction targets. The technology brief provides an overview of existing CCUS projects in Europe and North America and addresses the requirements and potential costs for large-scale CCUS deployment.



CO2CRC Launches CCUS Technical Advisory and Consultancy.



Building a low emissions future

CO2CRC launched CO2Tech—a technical advisory and consultancy services company. According to the CO2CRC, which specializes in CCUS research, CO2Tech will have

access to the Otway International Test Centre and CO2CRC's knowledge via commercial agreements.

Tool to Measure Carbon Storage in Forests.

ICLEI—Local Governments for Sustainability developed the [Land Emissions and Removals Navigator \(LEARN\) Tool](#) to better understand and measure greenhouse gas (GHG) emissions and storage potential of forests. The LEARN Tool provides preliminary analysis on emissions and removals that may be used to inform and be integrated into nature-based solutions in climate action planning.



Carbon Dioxide Removal Service Launched.

Carbon Engineering (CE) launched a CO₂ removal service enabling the purchase of CO₂ removal units (each represents one metric ton) through CE's direct air capture (DAC) technology. The CO₂ removal will be performed by 1PointFive in the United States and Pale Blue Dot Energy in the United Kingdom.

PROJECT and BUSINESS DEVELOPMENTS

Engineering and Design Contract Awarded for Large-Scale CCS Project.

Audubon Companies—a services company that supports the energy, infrastructure, and industrial markets—was awarded an engineering and design contract for a large-scale carbon capture and storage (CCS) project that has the potential to capture and store approximately 1.5 million metric tons of CO₂ annually from processing facilities. The captured CO₂ will be transported via pipeline to produce a high-purity CO₂ product, then used for enhanced oil recovery (EOR) operations. From [Audubon Companies Press Release](#). March 2021.



audubon

Collaboration to Develop BECCS Plant in California.

Schlumberger, Chevron, and Microsoft announced a collaboration to develop a bioenergy plant with carbon capture and storage (BECCS) in Mendota, California (USA) designed to produce carbon-negative power. The BECCS plant will convert agricultural waste biomass into renewable synthesis gas that will be mixed with oxygen in a combustor to generate electricity. More than 99% of carbon from the BECCS process is expected to be captured and stored in nearby geologic formations. From [Carbon Capture Journal](#). March 2021.

Proposal to Store CO₂ in North Dakota.



SUMMIT CARBON
SOLUTIONS

[Summit Carbon Solutions is proposing](#) a project to capture CO₂ from at least 17 midwestern ethanol plants and pipe it to North Dakota for storage. The project, which is planned to be operational by 2024, has the potential to capture and store up to 10 million tons of CO₂ per year. Summit's plan

involves adding equipment at participating ethanol plants to capture CO₂ and compress it into liquid form, where it would then travel through feeder pipelines to a larger pipeline that extends across the Upper Midwest (USA) into North Dakota for eventual storage, or potentially for EOR. From [The Bismarck Tribune](#). March 2021.

Large-Scale CCS Project Announced.

Valero Energy Corp., the BlackRock Global Energy & Power Infrastructure Fund, and Navigator Energy Services are partnering to develop a large-scale CCS project. The initial phase of the project includes capturing CO₂ and transporting it through a pipeline spanning five midwestern states, with the potential to store up to 5 million metric tons of CO₂ per year. Operations are expected to begin in late 2024. From [Business & Industry Connection Magazine](#). March 2021.

Partnership to Explore DAC and CO₂ Storage in Norway.

Climeworks and Northern Lights have agreed to explore a full-chain CO₂ removal project in Norway. Climeworks will combine their DAC technology, which has the potential to reach a net-CO₂ removal efficiency of more than 90%, with the Northern Lights' infrastructure. The project includes the capture of CO₂ from industrial stationary sources in the Oslo-fjord region; shipping it to an onshore terminal on the Norwegian west coast; and transferring it, in liquid form, to an offshore storage location below the North Sea. From [Climeworks News Release](#). March 2021.

Drax to Build BECCS Power Station.

Drax will begin the planning process for its proposal to build and deploy BECCS in the United Kingdom (UK). The company plans to first secure a Development Consent Order from the UK government. If the application is successful, work to build Drax's first two BECCS units could begin in 2024. From [Carbon Capture Journal](#). March 2021.

Marine CCS Project Underway.

A Finnish company is conducting a pilot project to explore how CCS can be developed and scaled in maritime applications. Wärtsilä, which manufactures and services power sources and other equipment in the marine and energy markets, is installing a 1-megawatt (MW) pilot plant at its test facility in Moss, Norway, which will allow the company to test its CCS technologies in a range of scenarios and conditions. From [Diesel & Gas Turbine Worldwide](#). March 2021.



PROJECT and BUSINESS DEVELOPMENTS *(cont.)*

Study Assesses Feasibility of Establishing CCS.



Elkem, an advanced materials supplier, is conducting a feasibility study to establish CCS at Norwegian smelters. The study will assess the technical and economic feasibility of

installing CCS technology at Elkem's Norwegian plants. As part of the effort, Elkem is partnering with Aker Carbon Capture and Saipem to evaluate various designs of carbon capture facilities and liquefaction facilities, as well as evaluate uploading CO₂ from the Northern Lights project to transport ships. From *Elkem News Release*. February 2021.

Norway CCUS Project Signs Agreement with Technical Advisors.

AGR signed a two-year framework agreement with the Norwegian state-owned Gassnova for the Longship CCUS project. *Under the agreement*, AGR (a CCUS solutions technical advising company) will act as technical advisors by offering technical expertise across the geoscience, reservoir, drilling, and well engineering disciplines, in addition to facilities and cost engineering. From *Carbon Capture Journal*. February 2021.

LEGISLATION and POLICY

Bill Funds Tax Credit, Could Benefit CCS Projects.

A pair of U.S. Senators *unveiled* a bill that *would provide tax credits* for energy manufacturers to spur reinvestment in rural areas. *The American Jobs in Energy Manufacturing Act of 2021* would, among other actions, build new or retrofit existing manufacturing and industrial facilities to produce or recycle products that capture, remove, use, or store CO₂. From *Biomass Magazine*. March 2021.

Legislation to Modernize Tax Credit for CCUS Retrofit Projects.

Legislation to modernize tax credits to better support the use of CCUS technology was reintroduced in the U.S. House of Representatives. The *Carbon Capture Modernization Act* would update the Section 48A tax credit's performance efficiency standards to reflect the capabilities of existing technology, which is expected to help promote the adoption of CCUS technology. The Section 48A tax credit was established in 2005, with certain CO₂ capture projects made eligible in 2008. From *MSW*. March 2021.

EMISSIONS TRADING

Adjustment to RGGI Cap Announced.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) announced the third adjustment to the RGGI cap to account for banked allowances. Each of the RGGI states revised its CO₂ Budget Trading Program to be consistent with the *updated RGGI Model Rule*, which was released in 2017. The updated Model Rule addressed the private bank of CO₂ allowances through a Third Adjustment for for Banked Allowances (TABAs), which is a reduction to the states' CO₂ allowance base budgets that are equivalent to the private bank of CO₂ allowances (allocation years 2009–2020). The TABA is made over the five-year period 2021–2025. From *RGGI News Release*. March 2021.

RGGI Inc.



MOU Includes CO₂ Storage.

ENGIE and Equinor signed a Memorandum of Understanding (MOU) to investigate the development of low-carbon value chains in Belgium, the Netherlands, and France. Specifically, the MOU will be to investigate the production and market potential for hydrogen from natural gas, whereby the CO₂ will be captured and stored offshore. From *Equinor News Release*. February 2021.

Proposal Submitted for CCS Facility in Greece.

Energiean, an exploration and production company, submitted a proposal to the Greek government to build a CO₂ storage facility near its Prinos oil field in northern Greece. From *JWN Energy*. February 2021.



Carbon Storage Tax Exemption Bill Passes Legislature.

The North Dakota Legislature passed a bill exempting CO₂ stored underground from sales tax. A similar tax exemption is already in place for CO₂ injected into old oil fields for EOR. *Senate Bill 2152* will advance to the governor of North Dakota. From *The Bismarck Tribune*. March 2021.

Australian Government Opened CCUS Development Fund.

The Australian government opened their CCUS Development Fund, which provides businesses with grants for pilot projects or pre-commercial projects aimed at reducing CO₂ emissions. The fund aims to attract private sector investment. Projects that applied for the grants had to be located in Australia and be completed by June 2025. *More information on the fund and grants is available online*. From *Global CCS Institute*. March 2021.

Malaysia Unveils CCS Opportunities.

Petronas Malaysia Petroleum Management unveiled potential CCS opportunities, including deploying CCS technology at the Kasawari development. The first injection is planned for 2025. A total of 46 trillion cubic feet of storage volume has been identified. From *Energy Voice*. February 2021.

European Parliament Adopts Cross-Border CO₂ Tax.

The European Parliament adopted a resolution to reduce GHG emissions in the European Union (EU) by implementing a carbon tax on imports and commodities covered by the EU's Emissions Trading Systems (ETS). According to the European Parliament, the Carbon Border Adjustment Mechanism (CBAM) must be compatible with the World Trade Organization, and revenues generated should be used to support the *European Green Deal*. The European Commission is expected to present a legislative proposal for the CBAM in the second quarter of 2021. From *Balkan Green Energy News*. March 2021.

SCIENCE

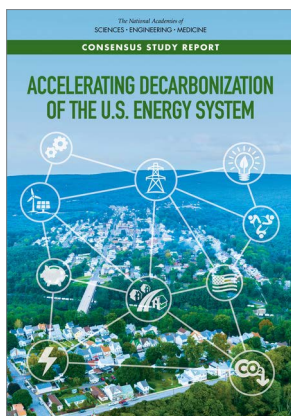
Amazon Rainforest May Release More CO₂ than it Stores—Study.

According to research *supported by National Geographic*, the Amazon rainforest might be releasing more GHGs into the atmosphere than it can absorb. The report, *published in the journal Frontiers in Forests and Global Change*, found that GHGs (e.g., methane and nitrous oxide) being released in the Amazon basin offset and may potentially exceed the region's ability to store CO₂. From *The Weather Channel*. March 2021.

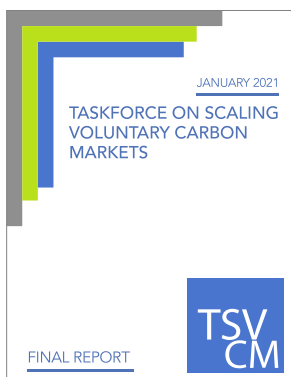
PUBLICATIONS

Accelerating Decarbonization of the U.S. Energy System.

The following is from a description of this National Academies of Sciences, Engineering, and Medicine report: "The world is transforming its energy system from one dominated by fossil fuel combustion to one with net-zero emissions of carbon dioxide (CO₂), the primary anthropogenic greenhouse gas. This energy transition is critical to mitigating climate change, protecting human health, and revitalizing the U.S. economy. To help policymakers, businesses, communities, and the public better understand what a net-zero transition would mean for the United States, the National Academies of Sciences, Engineering and Medicine convened a committee of experts to investigate how the U.S. could best decarbonize its transportation, electricity, buildings, and industrial sectors. This report, *Accelerating Decarbonization of the United States Energy System*, identifies key technological and socio-economic goals that must be achieved to put the United States on the path to reach net-zero carbon emissions by 2050. The report presents a policy blueprint outlining critical near-term actions for the first decade (2021-2030) of this 30-year effort, including ways to support communities that will be most impacted by the transition." (Purchase may be required.)

***Taskforce on Scaling Voluntary Carbon Markets: Final Report.***

The following is from the Executive Summary of this Institute of International Finance (IFF) report: "... Achieving a global net-zero goal is critical for the health of the planet, the stability of ecosystems, and to ensure safe conditions for future generations. To achieve this goal, deep, broad-ranging, and rapid action to reduce emissions must begin immediately across all sectors of the economy. In support, an increasing number of firms are making commitments to achieve their own net-zero targets, by reducing their own emissions, emissions associated with supply chains, and the use of their products. Firms setting such targets will be expected to demonstrate how net-zero emissions goals will be achieved. Carbon credits, purchased voluntarily, enable organizations to compensate or neutralize emissions not yet eliminated by financing the avoidance/reduction of emissions from other sources, or the removal of greenhouse gases from the atmosphere and thus meaningfully contribute in the transition to global net-zero. The projects generating these carbon credits can be broadly grouped into two categories: i) GHG avoidance/reduction projects, such as renewable energy or avoided deforestation and ii) GHG removal/sequestration projects,

***Engineers Developing Concrete with Increased CO₂ Storage Capability.***

Research conducted by Purdue University (USA) engineers led to the discovery of a way to potentially double the carbon storage potential of concrete. The study, which *appeared in the scientific journal Construction and Building Materials*, showed that by adding small amounts of nano-titanium dioxide to the cement mix to make concrete, it became more efficient at absorbing CO₂ than other cement pastes. The addition also accelerated the rate of carbon absorption and increased the total volume of CO₂ the cement could absorb. Purdue University also *released a video based on their work*. From *Carbon Capture Journal*. February 2021.

such as reforestation or technology-based removal. In addition to climate mitigation, many projects can also generate broader environmental, social, and economic benefits, ranging from increased biodiversity, job creation, support for local communities, and health benefits from avoided pollution. Similarly, credits supporting emerging climate technologies can help scale down cost curves, bringing these technologies to market earlier and decreasing their 'green premiums' against carbon-intensive alternatives. Furthermore, as a significant share of potential projects are located in the Global South, carbon credits can generate flows of private capital to these economies."

Biomass-based integrated gasification combined cycle with post-combustion CO₂ recovery by potassium carbonate: Techno-economic and environmental analysis.

The following is from the abstract of this article: "In this study, a thermodynamic model depicting integrated bioenergy with carbon capture and storage (BECCS) system is developed using Aspen Plus under thermodynamic equilibrium for the power generation segment, and a rate-based model for the carbon capture segment representing CO₂ recovery from the exhaust flue of a biomass based integrated gasification combined cycle (BIGCC). A thorough techno-economic analysis is conducted for the integrated system to evaluate system-wide environmental impacts and economic costs. The carbon capture is modeled using post combustion technology with chemical absorption by means of Piperazine promoted potassium carbonate to absorb the CO₂ from the exhaust stream of the gas turbine. The results demonstrate that the proposed system with 80% carbon capture has negative emissions of -0.31 kg/kWh of CO₂-e, when assuming neutral emissions from the BIGCC. For a production of 419 kW of net electricity, the overall energy and exergy efficiencies are 43.8% and 57.2%, respectively." **Ikhlas Ghiat, Ahmed AlNouss, Gordon McKay, and Tareq Al-Ansari**, *Computers & Chemical Engineering*. (Subscription may be required.)

Techno-economic analysis for the integration of a power to fuel system with a CCS coal power plant.

The following is from the abstract of this article: "In this paper, an analysis of the integration of a carbon capture unit and a power to fuel system for methanol synthesis with a coal power plant is presented from the energetic, environmental and economic standpoints. The study is carried out in three different sections. In the first part, the impact of the integration of a carbon capture system (CCS) and of a power to fuel plant (PtF) for methanol production is investigated in terms of plant average efficiency, fuel consumption, CO₂ emissions. In the second part, the annual fixed and variable costs of the power plant, and the annual cost of electricity (COE) are assessed for different plant configurations. Additionally, future scenarios are analyzed considering the impact of European policies on the CO₂ emission's cost, defined by the European Emission Trading System (ETS). Finally, an economic feasibility analysis of the power to fuel plant is performed and the methanol production is evaluated. Moreover, a sensitivity analysis is carried out to evaluate the impact of the most affecting parameters (electrical energy cost, the methanol selling price and the capital cost of the electrolyzer) in terms of Internal Rate of Return (IRR)." **D. Bellotti, A. Source, M. Rivarolo, and L. Magistri**, *Journal of CO₂ Utilization*. (Subscription may be required.)

PUBLICATIONS (cont.)

Assessing the viability of soil successive straw biochar amendment based on a five-year column trial with six different soils: Views from crop production, carbon sequestration and net ecosystem economic benefits.

The following is from the abstract of this article: "Converting straw to biochar (BC) followed by successive application to soil has been increasingly suggested as a multi-win approach for soil fertility improvement, carbon (C) sequestration and efficient disposal of straw residues in intensive cropping agroecosystems. However, different soil types response differently in terms of crop growth and non-CO₂ greenhouse gas (GHG) emissions after BC application. Furthermore, few studies have comprehensively evaluated the net global warming potential (GWP) and net ecosystem economic benefits (NEEB) after long-term BC incorporation across representative soil types in China. A five-year outdoor column experiment was conducted using three rice-wheat rotated paddy soils and three millet-wheat rotated upland soils developed from different parent materials. Rice straw BC application rates of 0, 2.25 and 11.3 Mg ha⁻¹ were used in each crop season with identical doses of NPK fertilizers. Compared with the no BC controls, BC significantly boosted crop growth, enhanced C sequestration, and decreased cumulative N₂O and CH₄ emissions in all six soils over five rotation cycles. The response of the upland soils to BC was better in terms of crop growth and N₂O mitigation, whereas the soil organic carbon (SOC) increment and CH₄ mitigation were less effective compared with the paddy soils. Net GWP decreased 0.6–19 fold after BC application; however, given the low trade price of CO₂ (0.21 × 10³ CNY Mg⁻¹), only a small contribution was made in terms of C costs to the NEEB. The BC-induced NEEB was mainly dependent on grain yield gains and BC costs. These findings highlight that widespread adoption of successive straw BC application to farmland requires an increase in crop yield and substantial lowering of the BC cost regardless of the soil type. From the standpoints of agronomics, environment and economics, acid upland soil shows most potential in terms of BC application." **Yucui Bi, Siyuan Cai, Yu Wang, Yongqiu Xia, Xu Zhao, Shenqiang Wang, and Guangxi Xing**, *Journal of Environmental Management*. (Subscription may be required.)

The volatility spillover effect of the European Union (EU) carbon financial market.

The following is from the abstract of this article: "This paper modifies the BEKK-GARCH model based on the empirical results of the VAR model to analyze the dynamic volatility spillover effect between the European Union allowance (EUA) and certified emissions reduction (CER) markets during the second and third phases of the European Union Emission Trading System (EU ETS). The empirical results show that (1) an asymmetric volatility spillover effect exists between the EUA and CER markets and that the EUA market has a more significant volatility spillover effect on the CER market, and (2) the volatility spillover effect between the EUA and CER becomes weaker in phase III since the European Commission has limited the substitution of CER for EUA more strictly and the global carbon reduction requirements have become less demanding. [The authors'] study can help investors and managers of carbon market to have a more comprehensive understanding of the information and risk transmission mechanism between the EUA and CER markets, thus, providing them with a basis to make investment decisions and formulate policies." **Shihong Zeng, Jingmin Jia, Bin Su, Chunxia Jiang, and Guowang Zeng**, *Journal of Cleaner Production*. (Subscription may be required.)

Investigating the competitiveness of Carbon Capture and Storage in Italian power plants under different investment scenarios.

The following is from the abstract of this article: "This paper explores the viability of Carbon Capture and Storage (CCS) in Italy by examining two different scenarios. The first scenario evaluates the investments on traditional power generation technologies, i.e. USC (Ultra Super Critical), NGCC (Natural Gas Combined Cycle) and IGCC (Integrated Gas Combined Cycle), with and without CCS, and on wind farms; the second scenario studies the convenience of retrofitting existing Italian power plants with respect to the construction of new capture-ready plants. To the scope, a techno-economic analysis based on the calculation of the LCOE (Levelised Cost Of Electricity), the CCAV (cost of CO₂ avoided) and the CCAP (cost of CO₂ captured) is assessed. Beyond these measures, the analysis in both scenarios accounts for the calculation of the so-called LACE (Levelised Avoided Cost of Electricity) in order to evaluate the profitability of CCS systems and, therefore, to properly orient CCS investment decision in Italy." **Alberto Fichera and Rosaria Volpe**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Technology readiness assessment of ultra-deep salt caverns for carbon capture and storage in Brazil.

The following is from the abstract of this article: "This article presents a Technology Readiness Assessment (TRA) of a new concept called the Salt Cavern Hybrid Subsea Carbon Capture and Storage (CCS) System, which performs all the offshore natural gas and CO₂ separation process with subsequent storage in offshore underground salt caverns. Currently there is a demand for CCS of large quantities of CO₂ associated with CH₄ in the pre-salt offshore oil fields in Brazil. The pre-salt reservoirs have as caprock 2000 m of continuous rock salt. This hybrid system is expected to perform, at the same time, the separation between the natural gas and CO₂, and Carbon Capture and Storage of CO₂, allowing the monetization of the separated natural gas. The Technology Readiness Levels (TRL) approach is discussed in this paper for estimating the maturity of the CCS System. The TRL analysis concluded that no technological gaps were identified that would made the project unfeasible and the TRL level enables the project to advance to the field test stage within a reasonably short time horizon. Once implemented it could be one of the largest CCS projects in the world. Also, this paper describes the conceptual design of this hybrid system and presents the results of a TRA showing the methodology that was employed in the process, the technology critical items that were analyzed and the results obtained for each of them and the design of a salt cavern for the storage of 1 billion Sm³ (Standard cubic meter) of a natural gas stream with high CO₂ content." **Mariana Barbero Ribeiro Goulart, Pedro Vassalo Maia da Costa, Alvaro Maia da Costa, Antonio C.O. Miranda, Andre Bergsten Mendes, Nelson F.F. Ebecken, Julio R. Meneghini, Kazuo Nishimoto, and Gustavo R.S. Assi**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

PUBLICATIONS *(cont.)*

Towards a clean environment: The potential application of eco-friendly magnesia-silicate cement in CO₂ sequestration.

The following is from the abstract of this article: "The key point of this study is the fabrication of magnesia-based cement with promising mechanical properties and high efficiency of CO₂-capture. The naturally occurring volcanic ashes (white & red ashes) and reactive magnesium oxide are the main materials used in the synthesis of eco-friendly CO₂-capture materials. Volcanic ashes were individually mixed with reactive magnesium oxide at ash to magnesium oxide ratio of 25:75 wt %. The dry blends can react with water to yield hardened materials (at ambient temperature) with compressive strength depends on the type of volcanic ash. A considerable change in the features of the hardened samples was recorded when the fabricated materials exposed to 100% CO₂ gas for 28-days. This change is mainly due to CO₂-capture by magnesium hydroxide Mg(OH)₂ within the fabricated materials, resulting in the formation of Nesquehonite minerals MgCO₃·3H₂O as proved by X-ray diffraction, thermo-gravimetric, and infra-red instrumental techniques. The thermo-gravimetric analysis demonstrates that, the fabricated sample containing low amorphous red ashes has higher CO₂-capture capacity (~260 kg/ton) compared to that having high amorphous white volcanic ashes (~220 kg/ton) at 28-days of CO₂-exposure. Accordingly, the fabricated magnesia-based cement is not only used as cementitious material with outstanding mechanical properties, but also used as a super CO₂-absorbent precursor. This can strongly contribute in the mitigation of global warming potential caused by different industrial activities."

Hamdy A. Abdel-Gawwad, Hassan Soltan Hassan, S.R. Vásquez-García, Isabel Israde-Alcántara, Yung-Chin Ding, Marco Antonio Martínez-Cinco, S. Abd El-Aleem, Hesham M. Khater, Taher A. Tawfik, and Ibrahim M. El-Kattan, *Journal of Cleaner Production.* (Subscription may be required.)

Anthropogenic alteration of nutrient supply increases the global freshwater carbon sink.

The following is from the abstract of this article: "Lakes have a disproportionate effect on the global carbon (C) cycle relative to their area, mediating C transfer from land to atmosphere, and burying organic-C in their sediments. The magnitude and temporal variability of C burial is, however, poorly constrained, and the degree to which humans have influenced lake C cycling through landscape alteration has not been systematically assessed. Here, [the authors] report global and biome specific trajectories of lake C sequestration based on 516 lakes and show that some lake C burial rates (i.e., those in tropical forest and grassland biomes) have quadrupled over the last 100 years. Global lake C-sequestration (~0.12 Pg year⁻¹) has increased by ~72 Tg year⁻¹ since 1900, offsetting 20% of annual CO₂ freshwater emissions rising to ~30% if reservoirs are included and contributing to the residual continental C sink. Nutrient availability explains ~70% of the observed increase, while rising temperatures have a minimal effect." **N.J. Anderson, A.J. Heathcote, D.R. Engstrom, and Globocarb data contributors,** *Science Advances.* (Subscription may be required.)

ABOUT DOE'S CARBON STORAGE PROGRAM

The **Carbon Storage Program** at the National Energy Technology Laboratory (NETL) is focused on developing and advancing technologies to enable safe, cost-effective, permanent geologic storage of CO₂, both onshore and offshore, in different depositional environments. The technologies being developed will benefit both industrial and power sector facilities that will need to mitigate future CO₂ emissions. The program also serves to increase the understanding of the effectiveness of advanced technologies in different geologic reservoirs appropriate for CO₂ storage—including saline formations, oil reservoirs, natural gas reservoirs, unmineable coal, basalt formations, and organic-rich shale basins—and to improve the understanding of how CO₂ behaves in the subsurface. These objectives are key to increasing confidence in safe, effective, and permanent geologic CO₂ storage.

The [Carbon Storage Program Overview](#) webpage provides detailed information of the program's structure, as well as links to the webpages that summarize the program's key elements.

Carbon Storage Program Resources

Newsletters, program fact sheets, best practices manuals, roadmaps, educational resources, presentations, and more information related to the Carbon Storage Program is available on [DOE's Energy Data eXchange \(EDX\) website](#).



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

ABOUT NETL'S CARBON STORAGE NEWSLETTER

Compiled by the National Energy Technology Laboratory, this newsletter is a monthly summary of public and private sector carbon storage news from around the world. The article titles are links to the full text for those who would like to read more (note that all links were active at the time of publication).

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