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. 8

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

DOE/FECM/NETL HIGHLIGHTS

NETL, Partners Release Resource on Computational Tools to Complete CO_2 Storage Permit Applications.

The National Energy Technology Laboratory (NETL) collaborated with the U.S. Environmental Protection Agency (EPA), other contributing national laboratories, and the U.S. Department of Energy's (DOE) Regional Initiatives to Accelerate Carbon Capture, Utilization, and Storage (CCUS) on a report that identifies computational tools useful for addressing aspects of the dedicated carbon storage (Class VI) well permit application under EPA's Underground Injection Control (UIC) Program. "***Rules and Tools Crosswalk: A Compendium of Computational Tools to Support Geologic Carbon Storage Environmentally Protective UIC Class VI Permitting***" is intended to serve as a resource for industry, regulatory, academic, and public stakeholders. The report will be periodically updated as new information on relevant computational tools becomes available.

From *National Energy Technology Laboratory*. July 2022.

CONTINUE

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

DOE Announces Funding for R&D to Turn Buildings into Carbon Storage Structures.

DOE announced funding awards for ***18 projects*** seeking to develop technologies that can transform buildings into net carbon storage structures. Led by DOE's ***Advanced Research Projects Agency-Energy (ARPA-E)***, the ***Harnessing Emissions into Structures Taking Inputs from the Atmosphere (HESTIA) Program*** selected projects that prioritize overcoming barriers associated with carbon-storing buildings, including scarce, expensive, and geographically limited building materials. Decarbonization goals for the HESTIA Program mirror President Biden's plan to reach net-zero emissions by 2050 and aim to increase the total amount of carbon stored in buildings to create carbon sinks, which absorb more carbon from the atmosphere than is released during the construction process.

From *energy.gov*. June 2022.

ANNOUNCEMENTS

DOE Announces NOIs, Launches Online Resources.

Click on the image above to access the interactive diagram.

DOE issued Notices of Intent (NOIs) to fund two programs funded by the Bipartisan Infrastructure Law (BIL)—the ***Carbon Capture Demonstration Projects Program*** and the ***Carbon Dioxide Transport/Front-End Engineering Design (FEED) Program***. Together, these programs help to advance the administration's goal of a net-zero greenhouse gas (GHG) emissions economy by 2050. In addition, DOE's Office of Fossil Energy and Carbon Management (FECM) launched two new interactive tools. The ***Carbon Matchmaker Tool*** is an online information resource designed to increase awareness of carbon management funding opportunities; support private sector development of carbon capture, storage, and transportation infrastructure and carbon dioxide removal (CDR) pathways; and facilitate regional business development opportunities and education. The ***Carbon Management Interactive Diagram*** is an online tool that highlights carbon management programs in the BIL and through other DOE funding opportunities, as well as educates users about resources that fall under each program.

White House Seeking Nominations for CCUS Task Forces.

The White House Council on Environmental Quality (CEQ) is seeking nominations for two task forces that will provide input to inform the responsible development of CCUS. The task forces will provide recommendations to the federal government on how to ensure that CCUS projects are permitted in an efficient manner, reflect the input and needs of a wide range of stakeholders, and deliver benefits rather than harms to local communities. Vacancies for the ***Carbon Dioxide Capture, Utilization and Sequestration Federal Lands and Outer Continental Shelf Permitting Task Force*** and the ***Carbon Dioxide Capture, Utilization and Sequestration Non-Federal Lands Permitting Task Force*** are anticipated to be filled by December 31, 2022.

DOE Issues NOI for Carbon Storage FOA.

DOE issued an NOI for a Funding Opportunity Announcement (FOA) titled "***Regional Initiative to Accelerate Carbon Management Deployment: Technical Assistance for Large-Scale Storage Facilities and Regional Carbon Management Hubs***." The objective of the planned FOA is to establish a consistent, effective mechanism for providing technical assistance to develop multiple large-scale carbon storage facilities and regional carbon management hubs that could store hundreds of millions of tons of carbon dioxide (CO_2) and inject more than 5 million metric tons of CO_2 per year.

DOE's Clean Energy Corps Accepting Applications. (Video)

DOE's Clean Energy Corps comprises staff from more than a dozen offices across DOE to research, develop, demonstrate, and deploy next-generation clean energy technologies. The Clean Energy Corps is dedicated to fighting climate change through public service and supporting American competitiveness on a global scale. To meet this challenge, DOE is hiring a team of industry veterans, experienced technical experts, and the next generation of climate leaders. More information is ***available via the Clean Energy Corps webpage***.

MRCI Partner and Stakeholder Meeting.

The Midwest Regional Carbon Initiative (MRCI) will hold a partner and stakeholder meeting on September 27 and 28, 2022, in Columbus, Ohio, USA. The meeting will include presentations, roundtables, and panels, as well as a facilitated environmental justice workshop. MRCI, led by the Battelle Memorial Institute and Illinois Geologic Survey, is one of four individual ***Regional Initiatives*** that support FECM by identifying and addressing challenges to the widespread, commercial deployment of CCUS.

Carbon Dioxide Pipeline Proposed in Iowa.

Wolf Carbon Solutions is proposing a CO_2 pipeline to service ethanol plants in eastern Iowa, USA. The Iowa Utilities Board is considering the request for public meetings on the proposal that would be held in multiple counties in September 2022.

ANNOUNCEMENTS *(cont.)*

16th Greenhouse Gas Control Technologies Conference

The 16th Greenhouse Gas Control Technologies (GHGT) Conference, to be held October 23–27, 2022, in Lyon, France, is an international conference on GHG mitigation technologies, including carbon capture and storage (CCS). The GHGT conferences are held every two years in member countries, rotating among North America, Europe, and Asia. Each conference is a forum for technical discussions related to the field of GHGT. Biographies for GHGT keynote speakers are ***available***.

Consortium Wins FEED Contract for UK CCS Station.

A consortium of Aker Solutions, Siemens Energy, and Doosan Babcock was awarded a FEED contract for a proposed power station with CCS. The consortium will deliver the engineering design for SSE Thermal and Equinor's proposed Keadby 3 Carbon Capture Power Station in North Lincolnshire, United Kingdom (UK). The plant is expected to be capable of capturing up to 1.5 million metric tons of CO_2 a year.

Report Offers Insights on CCUS Global Market to 2027.

According to a new report, the global CCUS market is estimated to be $2.84 billion in 2022 and is projected to reach $9.43 billion by 2027 (growing at a compound annual growth rate of 27.14%). The "***Global Carbon Capture, Utilization, and Storage (CCUS) Market (2022-2027) by Service, Technology, End-Use Industry, Geography, Competitive Analysis, and the Impact of Covid-19 with Ansoff Analysis***" report includes qualitative analysis, verifiable data from authentic sources, and projections about market size. (Purchase may be required.)

PROJECT AND BUSINESS DEVELOPMENTS

Shell to Build Ships to Carry More CO_2 for CCS Hubs.

Shell announced plans to build larger vessels that can carry more CO_2 over longer distances to offshore CCS hubs. As part of the Northern Lights project in Norway, Shell has a joint venture with Equinor and TotalEnergies to build two ships capable of carrying 7,500 cubic meters of CO_2. Shell is leading the design and construction of the vessels, which will be powered by liquefied natural gas. The ships are expected to be ready for delivery in 2024.

From *Reuters*. June 2022.

C-Capture Awarded CCUS Innovation 2.0 Program Funding.

CDR firm C-Capture was awarded funding from the UK Department for Business, Energy, and Industrial Sector (BEIS) as part of the CCUS Innovation 2.0 Program aimed at accelerating the deployment of next-generation CCUS technology in the UK. C-Capture's project, called XLR8 CCS, uses a class of capture solvents that are free of amine and nitrogen and can be manufactured on a large scale. C-Capture also recently secured a grant from the UK government to advance its bioenergy and carbon capture and storage (BECCS) project at Drax Power Station in North Yorkshire, England.

From *The Chemical Engineer*. June 2022.

Climeworks to Launch DAC Plant.

Swiss climate tech firm Climeworks broke ground on a large-scale direct air capture (DAC) plant in Iceland. The DAC facility, called "Mammoth," will have the potential to capture 36,000 tons of CO_2 per year when fully operational. Carbon storage firm CarbFix will store the CO_2 and ON Power will supply the plant and the CO_2 injection sites with renewable energy to run the DAC and storage process. Construction is expected to last 18–24 months.

From *Reuters*. June 2022.

Canadian CCUS Plant Announced.

Teck Resources Limited announced a CCUS pilot project at its Trail Operations metallurgical complex in southern British Columbia, Canada. The plant will capture CO_2 from the acid plant flue gas at Trail Operations at a rate of 3 metric tons per day. Expected to begin operation in 2023, the pilot project will also evaluate options for the utilization and/or storage of the captured CO_2. If successful, the project could be scaled up to an industrial CCUS plant with the potential to capture more than 100,000 metric tons of CO_2 per year at Trail Operations.

From *Teck News Release*. June 2022.

Lease Agreement for CCS Project in Louisiana Announced.

1PointFive, a CCUS platform and subsidiary of Occidental's Low Carbon Ventures business, and Manulife Investment Management entered into a lease agreement for a CCS project in Louisiana, USA. The agreement provides 1PointFive with access to subsurface pore space and surface rights to develop and operate a carbon storage hub on approximately 27,000 acres of timberland in western Louisiana. Two EPA Class VI injection permits have been filed for the site. The companies are also exploring other locations and projects with the potential to add additional acreage for CO_2 removal and storage.

From *GlobeNewswire*. June 2022.

PROJECT AND BUSINESS DEVELOPMENTS *(cont.)*

Collaborative Agrees to Progress CCS Project.

Neptune Energy, Rosewood Exploration Ltd, EBN Capital BV, and ExxonMobil subsidiary XTO Netherlands Ltd. signed a cooperation agreement to progress a large-scale, offshore CCS project in the Dutch North Sea. The agreement intends to have the project FEED-ready by the end of 2022, followed by a storage license application. This CCS project has the potential to store 4–5 million tons of anthropogenic CO_2 annually in the exhausted gas fields located in Neptune-operated L10-A, B, and E areas. The L10 area would be the first step in the development of CO_2 storage.

From *Pipeline Technology Journal*. June 2022.

Companies to Evaluate Potential CCS Hub in China.

ExxonMobil, Shell, China National Offshore Oil Corporation (CNOOC), and Guangdong Provincial Development & Reform Commission initiated a joint study to identify CCS opportunities. The companies and local authorities signed a Memorandum of Understanding (MOU) to evaluate a potential CCS hub project at the Dayawan Petrochemical Industrial Park in Huizhou, Guangdong Province, China. As part of the agreement, the companies will also evaluate the carbon policy systems in China and propose policies for consideration that would support the deployment of CCS in Dayawan Petrochemical Industrial Park.

From *Offshore Energy*. June 2022.

LEGISLATION AND POLICY

US BLM Issues Carbon Storage Policy for Public Lands.

The U.S. Department of Interior's (DOI) Bureau of Land Management (BLM) issued a new policy related to geologic storage of CO_2 on public lands. The new instruction memorandum provides a path for geologic carbon storage projects on BLM-managed lands by providing direction for authorizing rights-of-way (ROWs) for site characterization, transportation, injection, capture, and storage of CO_2 at appropriately classified injection well locations. The ***instruction memorandum*** ensures consistent processing of ROW applications for carbon storage projects across BLM-managed lands.

From *BLM Press Release*. June 2022.

California (USA) Releases Draft Blueprint to Achieve Carbon Neutrality by 2045.

The California Air Resources Board (CARB) released a proposed plan for the state to achieve carbon neutrality by 2045. The draft 2022 Scoping Plan Update, developed after more than 15 public workshops and meetings, also assesses progress toward meeting the interim statutory mandate of reducing GHG emissions by at least 40% below 1990 levels by 2030. This is the third update to CARB's original 2008 Scoping Plan, which was the original blueprint for achieving the goals of the ***California Global Warming Solutions Act of 2006 (Assembly Bill 32)***.

From *Reuters*. June 2022.

UK Opens Carbon Storage Licensing Round.

The North Sea Transition Authority (NSTA) opened a carbon storage licensing round in the UK, with 13 new areas. The new carbon storage areas are a mixture of saline aquifers and depleted oil and gas field storage opportunities. Combined with the six previous licenses, the new areas are expected to help the UK reach its goal of storing 20–30 million metric tons of CO_2 by 2030. This is the first of several more rounds, as it is estimated that up to 100 CO_2 storage facilities may be required to achieve the UK's goal to achieve net-zero emissions by 2050. The application window closes in September 2022.

From *Industry and Energy*. June 2022.

Government of Canada Enacts Offset Regulations.

The government of Canada enacted offset regulations that will enable projects governed by the Canadian federal Output-Based Pricing System (OBPS) to generate and sell carbon credits. The carbon credits can be used by facilities covered by the federal OBPS to meet GHG emissions compliance obligations. Requirements for projects registered under the ***Canadian Greenhouse Gas Offset Credit System Regulations*** are further set out in applicable Canadian federal offset protocols, which describe the approach for quantifying GHG reductions or removals for a given type of project.

From *Lexology*. June 2022.

EMISSIONS TRADING

Parliament Groups Reach Compromise on EU ETS Reform.

The European Parliament reached a deal on the reform of the European Union's (EU) emissions trading scheme (ETS). The main elements of the agreement include the following: emissions reductions from industries covered by the ETS, which will reach 63% by 2030 compared to 2005 levels; a phase-out of free ETS allowances for industry from 2027 to 2032; initiation of the EU's new carbon border adjustment mechanism in 2033; the Linear Reduction Factor, which defines the annual cap on CO_2 allowances available for auction, will reach 4.6% by 2029 (it will be reduced by 4.4% annually from 2024 to 2026 and by 4.5% from 2026 to 2029); and an agreement on a gradual "rebasing" of the overall level of allowances.

From *EUROACTIV*. June 2022.

EU Votes to Expand Carbon Market.

EU government ministers voted on an expansion of the EU's carbon market to include shipping and road transport. Shipping emitters will have to pay for CO_2 produced when sailing within the EU and 50% of voyages outside the bloc until 2027. After 2027, the scope of the carbon market will be automatically extended to 100% of ships entering and leaving European ports. EU ministers also agreed to a carbon market for road transport and heating (proposed for these emissions to be regulated from 2027).

From *European Federation for Transport and Environment*. June 2022.

Singapore to Host Carbon Credit Auction.

Singapore-based carbon exchange Climate Impact X (CIX) and UK-based finance company Respira International will jointly host a carbon credit auction in the third quarter of 2022. The auction will make available 600,000 $mtCO_2e$ of nature-based voluntary carbon credits, according to a joint statement released by the companies. In November 2021, CIX completed a pilot auction with 170,000 carbon credits cleared from eight nature-based projects.

From *S&P Global*. June 2022.

SCIENCE

Paper Shows Potential of Offshore Storage.

Scientists conducted an experiment in the North Sea, northeast of Aberdeen, Scotland, where they simulated a release of CO_2 below the seabed over a period of 12 days to test whether new technologies were able to detect releases of CO_2. The pilot study, led by the ***National Oceanography Centre (NOC)***, demonstrated that the releases were detectable and quantifiable through new technologies. NOC is a marine science research and technology institution based in the UK.

From *KeyFacts Energy*. June 2022.

Companies to Develop Forest Management Model Incorporating Carbon Storage.

TotalEnergies is partnering with Compagnie des Bois du Gabon (CBG) to develop a forest management model that combines long-term storage, sustainable harvesting, and biodiversity conservation. The forest management model will make it possible to develop a balance between the harvesting and processing of wood combined with carbon storage and the production of related carbon credits.

From *TotalEnergies Press Release*. June 2022.

Researchers Look to Engineer Crops that Absorb CO_2 Faster, Longer.

Innovative Genomics Institute

The Innovation Genomics Institute (IGI) is researching genetically engineering plants to absorb more atmospheric CO_2 and hold on to it longer. The IGI research project relies on a gene-editing tool called CRISPR to give plants and soil microbes traits that improve their ability to capture and store CO_2. The project will be carried out by three research groups that will study commercial crops: the first group will focus on rice crops, the photosynthesis process, and root development to encourage carbon storage; the second group will study a biomass crop for genome-editing techniques that spur CDR; and the third group will develop ways of tracing the captured CO_2 and study the soil microbial communities that help CO_2 storage.

From *S&P Global*. June 2022.

Researchers Use Remote Sensing to Track Carbon Storage in Mangroves.

Researchers from the Institute of Industrial Science at the University of Tokyo developed a model that uses remote sensing of environmental conditions to determine how much carbon is stored in mangrove forests. Published in *Scientific Reports*, the study used satellite data to develop a productivity model appropriate for mangroves. The researchers developed a model that considered the effects of tidal inundation and then combined the model with satellite data on photosynthetically active radiation to estimate the productivity of mangrove forests along the coastline of China.

東京大学 生産技術研究所 Institute of Industrial Science, The University of Tokyo

From *Phys.org*. June 2022.

PUBLICATIONS

Benefit Analysis of CO_2 Delivery Options for Offshore Storage or Enhanced Oil Recovery.

The following is a description of this DOE/NETL product: "The analysis presented in this report evaluates the benefits of CO_2 offshore transport via pipeline or ship within the [Gulf of Mexico (GOM)]. It takes a top-down framework to estimate the costs. First, this analysis designed a reduced-order model (ROM) based on the cash flows in the FECM/NETL CO_2 Transport Cost Model (also known as CO2_T_COM). The ROM takes capital expenses (CAPEX) and operating expenses (OPEX) to calculate the CO_2 breakeven price based on the cash flows. Second, this analysis developed regression models utilizing published data from other analyses to estimate CAPEX and OPEX. Since the ROM is a simplified cash flow calculation, it is easy to exchange the core regression models to estimate various costs. The ROM and regression models provided a framework that can be easily used by other researchers, decision-makers, operators, and regulators. The objective of this analysis is to assess the CO_2 breakeven cost range for pipeline and ship transport of captured CO_2 given the CO_2 source and storage reservoir located in the GOM."

Role of heterogeneous surface wettability on dynamic immiscible displacement, capillary pressure, and relative permeability in a CO_2-water-rock system.

The following is from the abstract of this article: "Surface wettability is one of the major factors that regulate immiscible fluid displacement in porous media. However, the role of pore-scale wettability heterogeneity on dynamic immiscible displacement is rarely investigated. This study investigated the impact of pore-scale wettability heterogeneity on immiscible two-fluid displacement and the resulting macroscopic constitutive relations, including the capillary pressure-water saturation (*Pc-Sw*) and relative permeability curves. A digital Bentheimer sandstone model was obtained from X-ray micro-computed tomography (micro-CT) scanning and the rock surface wettability fields were generated based on in-situ measurements of contact angles. A graphics processing unit-accelerated lattice Boltzmann model was employed to simulate the immiscible displacement processes through the primary drainage, imbibition, and second drainage stages in a CO_2-water-rock system. [The authors] found that pore-scale surface wettability heterogeneity caused noticeable local supercritical CO_2 ($scCO_2$) and water redistribution under less water-wet conditions. At the continuum scale, the *Pc-Sw* curves under the heterogeneous wetting condition were overall similar to those under the homogeneous wetting condition. This is because the impact of local wettability heterogeneity on the large-scale *Pc-Sw* curve was statistically averaged out at the entire-sample scale. The only difference was that heterogeneous wettability led to a negative entry pressure at the primary drainage stage under the intermediate-wet condition, which was caused by local, $scCO_2$-wet surfaces. The impact of pore-scale wettability heterogeneity was more noticeable on the relative permeability curves. Particularly, the variation of the $scCO_2$ relative permeability curve in the heterogeneous wettability scenario was more significant than that in the homogenous wettability scenario. This suggests that pore-scale wettability heterogeneity enhances the coalescence and snap-off behaviors of $scCO_2$ blobs. This is the first study that systematically investigated the role of pore-scale wettability heterogeneity on dynamic immiscible displacement and associated *Pc-Sw* curves in complicated, three-dimensional porous media."

Ruichang Guo, Laura Dalton, Dustin Crandall, James McClure, Hongsheng Wang, Zhe Li, and Cheng Chen, *Advances in Water Resources*. (Subscription may be required.)

Screening for Geologic Sequestration of CO_2: A Comparison Between SCO_2T^{PRO} and the FE/NETL CO_2 Saline Storage Cost Model.

The following is from the abstract of this article: "Meeting greenhouse gas emission reduction targets will likely require identifying and assessing subsurface storage space for sequestering billions of tonnes of CO_2 each year. Accomplishing this feat could include estimating the cost and capacity for thousands to hundreds-of-thousands of potential geologic CO_2 storage sites with CO_2 storage screening tools. In this study, [the authors] introduce a screening tool, SCO_2T^{PRO}, and compare and contrast it to the FE/NETL CO_2 Saline Storage Cost model (CSSC) using publicly available databases of saline reservoir properties in the United States. [The authors] find that the two tools use different methodologies to execute site-screening: SCO_2T^{PRO} calculates dynamic CO_2 injection rates and plume evolution that are used to estimate operationally-realistic well spacing designs and CO_2 storage capacities, whereas CSSC combines a volumetric storage estimation approach with geology-engineering well injectivity equations that can lead to an unrealistically high number of wells. These methodological differences translate into CSSC cost estimates that are several times higher than the SCO_2T^{PRO} estimates and around double for the capacity estimates. SCO_2T^{PRO} can also screen thousands of potential storage sites in seconds, which is thousands of times faster than CSSC. Lastly, [the authors] also find there is no single publicly available dataset of saline formation properties that can be used for screening across the United States."

Jonathan D. Ogland-Hand, Ryan M. Kammer, Jeffrey A. Bennett, Kevin M. Ellett, and Richard S. Middleton, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

The role of carbon capture, utilization, and storage for economic pathways that limit global warming to below 1.5°C.

The following is from the abstract of this article: "The 2021 Intergovernmental Panel on Climate Change (IPCC) report, for the first time, stated that CO_2 removal will be necessary to meet […] climate goals. However, there is a cost to accomplish CO_2 removal or mitigation that varies by source. Accordingly, a sensible strategy to prevent climate change begins by mitigating emission sources requiring the least energy and capital investment per ton of CO_2, such as new emitters and long-term stationary sources. The production of CO_2-derived products should also start by favoring processes that bring to market high-value products with sufficient margin to tolerate a higher cost of goods."

Jenny G. Vitillo, Matthew D. Eisaman, Edda S.P. Aradóttir, Fabrizio Passarini, Tao Wang, and Stafford W. Sheehan, *iScience*. (Subscription may be required.)

PUBLICATIONS *(cont.)*

Carbon mineralization and geological storage of CO_2 in basalt: Mechanisms and technical challenges.

The following is from the abstract of this article: "Climate change is taking place due to significant emissions of greenhouse gases into the atmosphere. CO_2 storage in geological formations is a promising approach that can help to reduce greenhouse gas emissions from large emitters such as the steel and cement industries. However, effective storage in underground formations requires active trapping mechanisms to reduce the likelihood of leakage. Carbon mineralization is a trapping technique that can permanently store CO_2 in reactive rocks such as basalt. Although this method has been known for a long time, only two pilot projects in Iceland and the USA practiced CO_2 injection into basalts. This could be mainly due to the complexity of the interactions, the rapid carbon mineralization, and the difficulty to estimate the storage capacity in the long term. In this paper, [the authors] discuss different mechanisms and technical challenges of CO_2 storage in igneous rocks and propose a selection criterion based on laboratory and field-scale experience. It appears that basalt is a suitable rock for rapid carbon mineralization given its worldwide distribution, vesicular texture, and favourable mineral composition, but the lack of effective monitoring techniques and the amount of water required for injection are two major challenges that need to be addressed."

Arshad Raza, Guenther Glatz, Raoof Gholami, Mohamed Mahmoud, and Saad Alafnan, *Earth-Science Reviews*. (Subscription may be required.)

Characterisation of UK Industrial Clusters and Techno-Economic Cost Assessment for Carbon Dioxide Transport and Storage Implementation.

The following is from the abstract of this article: "The UK Government and British industries are making important efforts for the development and implementation of carbon capture, transport and storage (CCTS). Critical to this will be an understanding of the composition and characteristics of the industrial clusters and of the costs for the CCTS systems. However, the available literature presents a wide range of cost values and many of the studies do not tend to consider all of the carbon transport and storage elements together. Moreover, there are a very limited number of UK specific analyses and in some cases the studies are considered to be too historical. In this paper, [the authors] present a review and characterisation of the main UK industrial clusters, in terms of geographical limits, available infrastructure, industries present and level of emissions. [The authors] then provide a brief review of carbon transport and storage (T&S) cost models and costing information before conducting a techno-economic assessment of the potential T&S system costs for the UK industrial clusters. To the best of [the authors'] knowledge, this integrated analysis has not been conducted for the UK context, and this is key for policy development and to assess the wider economic impacts of CCTS. From [the authors'] cluster characterisation and techno-economic analysis, [they] found that there is important potential for CCTS for industrial decarbonisation in the UK. Also, the creation of a CO_2 shipping industry will allow for industrial clusters that do not have an adequate storage sites nearby to use the CCTS infrastructure in other sites. The development of a CO_2 shipping infrastructure also enables carbon management and storage services to be exported to polluters overseas, potentially creating and maintaining jobs and economic growth."

Christian Calvillo, Julia Race, Enrong Chang, Karen Turner, and Antonios Katris, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

3D micro-structural changes of an artificial flow channel in wellbore cement under geologic CO_2 storage conditions: Combined effect of effective stress and flow.

The following is from the abstract of this article: "Understanding CO_2-induced micro-structural changes at the imperfections in wellbore cement is vital for assessing the risk of CO_2 leakage through wellbore cement under geologic CO_2 storage (GCS) conditions. To investigate the evolution of a flow channel width in cement under GCS conditions and the influence of effective stress and flow on the micro-structural changes of the flow channel in cement, [the authors] carried out a set of experiments in which the flow condition (flow-through v.s. static) and the effective stress (3 MPa effective stress v.s. no effective stress) were varied. Micro-structural changes of an artificial flow channel were investigated by X-ray micro-computed tomography (CT). CT images revealed a clear micro-structural change of the flow channel and distributions of $Ca(OH)_2$/C-S-H dissolution and calcite precipitation zones near the channel after reacting with CO_2-saturated brine. CT results showed that a flow rate of 0.01 mL/min through the channel turned channel self-sealing (as observed in the static scenario) into channel opening. Effective stress accelerated the dominant chemical reaction, i.e., enhancement of $Ca(OH)_2$/C-S-H dissolution around the channel in a flow-through scenario and enhancement of calcite precipitation around the channel in a static scenario. It seems that effective stress and flow have a combined contribution to micro-structural change of the flow channel in hydrated Portland cement, which may increase the risk of CO_2 leakage through wellbore cement when exposed to high concentration CO_2."

Manguang Gan, Liwei Zhang, Yan Wang, Kaiyuan Mei, Xiaojuan Fu, Xiaowei Cheng, Mingxing Bai, Hejuan Liu, and Xiaochun Li, *Construction and Building Materials*. (Subscription may be required.)

From CO_2 sources to sinks: Regulatory challenges for trans-boundary trade, shipment and storage.

The following is from the abstract of this article: "Carbon Capture and Storage (CCS) technologies have been hailed as a solution to climate change with capacity not only to reduce atmospheric carbon di-oxide (CO_2) but also to achieve net-zero emission by the mid-21st century. CO_2 captured (either directly from the atmosphere or from large point sources), is compressed and transported to storage sites, either via pipelines or through shipping. Often, the CCS projects are deployed nationally where capture, transport and storage take place within the jurisdiction of one State. However, wide scale deployment of CCS projects is imperative for global matching of CO_2 sources to sinks. To that end, the outreach of CCS technology needs to go beyond the developed world. Studies have indicated that developing countries have vast storage resource potential. Internationalization of CCS projects where CO_2 is captured in one State and is then transported to another State for storage raises a number of challenges particularly in terms of trans-boundary transport and storage. This paper explores some of these challenges particularly in terms of international trade law, liability framework for shipping and storage and potential of insurance to act as a stop-gap arrangement until a regulatory regime is in place. It examines questions such as: whether CO_2 and CCS technologies are environmental goods and services under trade law; are there any regulatory frameworks in place to ensure liability against long-term health and safety as well environmental risks, and; what role can insurance industry play in promoting global deployment of CCS projects?"

Swati Gola and Kyriaki Noussia, *Resources, Conservation and Recycling*. (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***.

Get Social with Us

There are several ways to join the conversation and connect with NETL's Carbon Storage Program:

Disclaimer

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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