NATIONAL ENERGY TECHNOLOGY LABORATORY

CARBON STORAGE NEWSLETTER

CSN

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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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- ANNOUNCEMENTS
- PROJECT and BUSINESS DEVELOPMENTS
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CARBON STORAGE PROGRAM DOCUMENTS and REFERENCE MATERIALS

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

DOE/FECM/NETL HIGHLIGHTS

DOE Names Phase I Winners of FECM Initiative.

The U.S. Department of Energy's (DOE) Office of Fossil Energy and Carbon Management (FECM) announced the winners in Phase I of the SMART (Science-informed Machine Learning to Accelerate Real-Time Decisions in the Subsurface) Initiative. SMART leverages the expertise of seven national laboratories, as well as industry partners, universities, field laboratories, and carbon storage regional initiatives, to advance the understanding of the subsurface environment through machine learning. The four winners in Phase I of the *SMART Visualization Platform Prize Challenge* designed prototype platforms and/or mockups that demonstrate a user-friendly visualization platform. The platform concept is intended to transform how scientists, engineers, regulators, and the public interact with subsurface data. The winners will develop the prototypes provided by the SMART Initiative technical team. From *FECM SMART*. August 2021.

NRAP Publishes Integrated Assessment Model Journal Article.

DOE's National Risk Assessment Partnership (NRAP) developed an open-source integrated assessment model (NRAP-Open-IAM) to help address questions about a potential geologic carbon storage site's ability to effectively contain injected carbon dioxide (CO_2) and protect groundwater and other overlying environmentally sensitive receptors. The model's basic components, important features and capabilities, and functionality are highlighted in a *journal article published by Environmental Modelling & Software*. NRAP-Open-IAM is available for download on *GitLab* and the National Energy Technology Laboratory's (NETL) *Energy Data eXchange (EDX)*. NRAP is a collaboration of five U.S. national laboratories focused on quantifying and managing subsurface environmental risks to support implementation of safe and secure large-scale geologic carbon storage. From *NRAP*. July 2021.

ANNOUNCEMENTS

The New Vision of the Office of Fossil Energy.

DOE's Office of Fossil Energy officially changed its name to the Office of Fossil Energy and Carbon Management (FECM), aligning itself with the climate goals set forth by the Biden-Harris Administration. FECM is a key part of DOE's leadership role in the new Administration's all-of-government approach to addressing climate issues. *Click here* to learn more about work conducted by FECM.

U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

CCS Explained.

DOE's FECM released an instructional video titled "Carbon Capture and Storage Explained." In the video, *Secretary of Energy Jennifer Granholm* breaks down how carbon capture and storage (CCS) works and its role in addressing potential climate change.

DOE-Sponsored Partnerships Conclude Work.

The *Southeast Regional Carbon Sequestration Partnership (SECARB)* and the *Midwest Regional Carbon Sequestration Partnership (MRCSP)* concluded their work in support of DOE's *Regional Carbon Sequestration Partnerships (RCSPs)*.

ANNOUNCEMENTS *(cont.)*

DOE Announces Additional DAC Funding.

DOE's FECM announced the selection of four additional direct air capture (DAC)-focused research and development (R&D) projects to receive federal funding, which add to the six DAC projects *announced in June 2021*. The awards are funded under Funding Opportunity Announcement (FOA) DE-FOA-0002402, Carbon Capture R&D: Bench-Scale Testing of Direct Air Capture Components *(Technology Readiness Level [TRL] 3) and Initial Engineering Design for Carbon Capture, Utilization and Storage Systems from Air (TRL 6)*. A detailed list of the selected projects and their associated areas of interest is *available*.

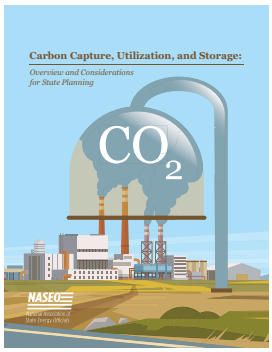
DOE Issues NOI.

DOE's FECM issued a *Notice of Intent (NOI)* for an FOA expected to support front-end engineering design (FEED) studies of DAC combined with dedicated storage and coupled to existing low-carbon energy. The NOI is in collaboration with the Office of Nuclear Energy and the Office of Energy Efficiency and Renewable Energy's Geothermal Technology Office. If issued, the FOA will support the advancement of DAC technologies that remove CO_2 directly from the atmosphere.

2021 DOE/NETL Carbon Management and Oil and Gas Research Project Review Meeting Conference Proceedings Available.

The DOE/NETL *2021 Carbon Management and Oil and Gas Research Project Review Meeting* was held in August 2021 through a series of virtual meetings. The project review meeting allowed researchers to present results from more than 250 projects funded through a variety of program areas, including carbon storage and utilization. The conference proceedings *are available*.

CCUS Report Released.



The National Association of State Energy Officials (NASEO) released a report outlining state energy planning and policy considerations to support carbon capture, utilization, and storage (CCUS). The report, "*Carbon Capture, Utilization, and Storage: Overview and Considerations for State Planning*," also includes an overview of CO_2 source sectors, CCUS activities, CO_2 capture technologies, and the potential utilization of CO_2.

MOU Promotes Collaborative Research.

The state of Wyoming and the Japan Coal Energy Center *signed a Memorandum of Understanding (MOU)* to continue collaborative research into CCUS at the *Wyoming Integrated Test Center* in Gillette, Wyoming. The agreement extends the initial MOU signed in 2016.

CCUS Capacity Studied.

According to GlobalData—a data and analytics company—additional CCUS capacity is needed in reference to the net-zero emissions by 2050 scenario by the International Energy Agency (IEA).

Data Management Platform Designed for Carbon Storage Projects.

Compass Carbon introduced a *new technology platform* designed for large-scale and complex carbon storage projects. The fully automated data management, monitoring, and analysis technology is designed to replace the manual processing methods used in the industry.

Report Outlines G-20 Progress.

A new report outlines the progress each G-20 member country has made toward moving to a low-carbon economy. The *Climate Policy Factbook* was released to increase transparency and inform climate policy priorities.

PROJECT and BUSINESS DEVELOPMENTS

UK Research Center Funds CCS Projects.

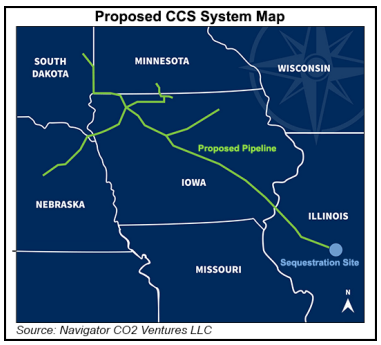
The United Kingdom Carbon Capture and Storage Research Centre (UKCCSRC) announced the funding of 10 CCS projects to help the UK achieve net-zero emissions targets. The projects will research CO_2 capture from industrial sources and directly from air, as well as research environmental protection and CO_2 monitoring. The UKCCSRC's mission is to ensure CCS plays an effective role in reducing net-CO_2 emissions while securing affordable and controllable electricity supplies, providing low carbon heat, and maintaining competitive industries for the UK. From *Energy Voice*. July 2021.

Companies Collaborate on Seismic for CCUS.

PGS, a marine geophysics company, and *CGG*, a geoscience technology company, signed an MOU to combine their seismic products and technical capabilities applied to the CCUS industry. The companies plan to explore, conceptualize, and create new data products using existing seismic data to facilitate screening and evaluating carbon storage sites. From *Carbon Capture Journal*. July 2021.

Companies Plan to Collaborate to Advance CCS Project.

A group of companies will collaborate with Navigator CO_2 Ventures to advance a carbon storage project across five Midwestern U.S. states. Tenaska, Advanced Resources International (ARI), and Chabina Energy Partners will help advance a CO_2 storage pipeline: the Heartland Greenway System. Tenaska and ARI will lead the overall development of the initial CCS site in Illinois, with Chabina helping to promote the commercial outreach and contracting structure. From *Natural Gas Intelligence*. July 2021.



Source: Navigator CO2 Ventures LLC

PROJECT and BUSINESS DEVELOPMENTS *(cont.)*

Large-Scale CCS Facility Proposed in Canada.

Shell announced a proposal to build a large-scale CCS project in Alberta, Canada. The proposed Polaris CCS project would capture CO_2 from the Shell-owned Scotford refinery and chemicals plant located near Edmonton. The initial phase of the project is projected to be operational by the middle of the decade, with the potential to capture and store approximately 750,000 metric tons of CO_2 a year. From *Shell News Release*. July 2021.

Project Makes CO_2 Storage Recommendations.

The Subsurface Evaluation of CCS and Unconventional Risks (SECURe) project developed several monitoring and remediation techniques to help raise the carbon storage readiness levels of potential storage sites. The British Geological Survey-led project also provided guidance on communicating with stakeholders and communities to develop public acceptance of CCS. Knowledge gained through *the SECURe project* can be used to show the potential of CO_2 storage as a safe, efficient, and viable option for advancing decarbonization of industrial and energy emitters. From *Carbon Capture Journal*. August 2021.

Carbon Storage to be Tested in North Dakota.

With funding from the North Dakota Industrial Commission, Midwest AgEnergy will study the feasibility of storing CO_2 in a rock formation underground. Midwest AgEnergy will use seismography to study the Deadwood Formation approximately 3,000 feet below the surface in North Dakota. According to Midwest AgEnergy, if the study shows the formation is capable of holding the CO_2, it could reduce or eliminate 200,000 tons of CO_2. From *The Jamestown Sun*. July 2021.

CO_2 Capture Plant Installed on Ship.

A project led by Japan's Kawasaki Kisen Kaisha ("K" LINE) completed the installation of an operational CO_2 capture plant aboard an ocean-going vessel, and is now advancing to the commissioning and testing phase. The project is being conducted with support from the Maritime Bureau of Japan's Ministry of Land, Infrastructure, Transport, and Tourism, and involves converting the design of an existing CO_2 capture system for onshore power plants to a marine environment. The CO_2 captured from the vessel is expected to be recycled as a new CO_2 source for enhanced oil recovery (EOR) or as a raw material in synthetic fuel through methanization. From *The Maritime Executive*. August 2021.

LEGISLATION and POLICY

UK Government Opens Consultation on CCUS Policy.

The UK's Department for Business, Energy, and Industrial Strategy sought views on proposed duties, powers, functions, and objectives of an economic regulator for CO_2 transport and storage networks. The purpose of *the consultation* was to inform the continued development of CCUS policy and legislative proposals. The responses will be used to help the UK government continue to develop policy and consider alternatives, as appropriate. A response to the consultation will include a summary of the responses received. From *GOV.UK*. August 2021.

Department for Business, Energy & Industrial Strategy

EMISSIONS TRADING

Nationwide Carbon Market Opens in China.

A nationwide carbon market opened in China. In 2011, the country launched a pilot carbon trading scheme in Beijing, Tianjin, Shanghai, Chongqing, Shenzhen, Hubei Province, and Guandong Province. In September 2020, China announced its goal to have carbon emissions peak by 2030 and to achieve carbon neutrality by 2060. From *Pinsent Masons*. August 2021.

Britain ETS Update.

According to Intercontinental Exchange®, Britain auctioned 2,594,000 UK emissions permits at 47.25 pounds ($65.49) per metric ton at its auction held in August 2021. Britain's Emissions Trading Scheme (ETS) started trading in May 2021 to replace the European Union's (EU) ETS. Since the launch, more than 38 million CO_2 permits have been traded. From *Reuters*. August 2021.

SCIENCE

Amine Technology Capable of 99% CO_2 Capture.

Scientists from Imperial College London's Department of Chemical Engineering and the Centre for Environmental Policy found that post-combustion capture of CO_2 using amine absorption—a liquid-based CCS technology—can capture up to 99% of CO_2 from emission sources. Using computational models to demonstrate that amine-based CCS could cost-effectively capture high levels of CO_2 across a wide range of applications in power and industry, the researchers highlighted the areas with the highest potential for cost reduction. The study was published in the journal *Environmental Science & Technology*. From *Carbon Capture Journal*. August 2021.

Study Explores Feasibility of Blue Hydrogen and CCS.

A new study will explore the feasibility of blue hydrogen and CCS in Australia. The feasibility study, to be conducted by Pilot Energy, is designed to assess blue hydrogen and CCS projects that can integrate with existing assets and infrastructure to deliver clean energy. The objective of the study is to assess the CCUS potential of the Cliff Head oil project and additional reservoirs across the broader Perth Basin. The projects identified will form the basis for future FEED studies, and may include a CO_2 pipeline and injection facility, blue hydrogen plants, and CCS sites. From *H2 View*. August 2021.

PUBLICATIONS

Supply Chain Excellence for CCUS.

The following is from the Executive Summary of this Carbon Capture and Storage Association (CCSA) document: "The CCSA estimates that expenditure on Net Zero CCUS (including hydrogen and greenhouse gas removals) projects could reach c.£41bn by 2035. Investment and ongoing expenditure of this size will deliver a huge boost to the economies of the industrial clusters on which most of these projects will be built. This report demonstrates that not only will CCUS be vital for achieving the UK's Net Zero goal, but also the significant role CCUS will play in boosting the UK's prosperity and delivering the government's levelling-up agenda by supporting jobs and growth in the UK's industrial heartlands. [The authors] set out recommendations to maximise this impact by developing supply chain strategies to deliver long-term benefit to the UK and its domestic projects, and to ramp up the export opportunities created though international deployment of CCUS. A successful Net Zero rollout will involve intensive project work all the way through to 2050 – a long-term prospect for industry. Current onshore major energy projects in the UK are themselves targeting a 50–60% UK content and offshore projects in the North Sea are targeting a 30% UK technology spend. If these levels of UK content persist, half of the estimated project expenditure could be spent outside the UK. A focused and effective approach to supporting UK supply chains could displace imports and capture a larger portion of the growth opportunity, providing domestic jobs and business, as well as securing export opportunities for the UK as other countries seek to develop CCUS."

Engineered greenhouse gas removals.

The following is from the Executive Summary of this UK National Infrastructure Commission document: "Engineered greenhouse gas removals capture carbon dioxide directly from the atmosphere and permanently store it. They will become a major new infrastructure sector for the UK over the coming decades, helping the UK meet its climate targets in the 2030s and beyond by offsetting residual emissions. Government needs to make a clear commitment to deploy engineered removals at scale no later than 2030. In total this commitment to the first engineered removals plants should deliver 5-10 $MtCO_2e$ of removals a year no later than 2030. The biggest barrier to deploying engineered removals is a lack of demand for negative emissions. There are currently no obligations on some of the UK's most carbon intensive industries to reduce their emissions. Government has set ambitious targets to reduce the UK's emissions to net zero. Given some sectors are hard to abate fully, this will not be possible without engineered removals. Engineered removals are expensive, although the costs will be phased in over time. By 2030, revenues of around £2 billion per year could be required to support a sector capable of delivering the necessary engineered removals. Polluting industries, not taxpayers, should bear these costs. But government should support the initial deployment of a portfolio of engineered removals, and, in time, the transition to a competitive market, which will be the most efficient solution. This new sector will need to be independently monitored to provide confidence to the public and investors. Government, regulators and infrastructure operators will need to plan for the enabling infrastructure, including carbon transport and storage networks. All this needs to happen alongside, not instead of, action to reduce and prevent emissions."

Improving the Business Case for CCS in the Electric Power Generation Industry.

The following is from the abstract of this paper: "Supporting new, high impact energy and environmentally friendly initiatives has been a regular and important component of US tax policy. A production tax credit (PTC) of up to 2.3 cents per kWh (now reduced) was available for electricity generated by wind. Solar photovoltaic projects receive a 30% investment tax credit (ITC). These tax credits, along with state-level renewable performance standards, have significantly increased investments in renewables and supported their growth in the electricity generation sector. A similar opportunity now exists for supporting accelerated installation of large-scale Carbon Capture and Storage (CCS) in the US electric power generation industry. Section 45Q of the US tax code represents a first, but still insufficient, step for covering the costs of using CCS with electric power generation. It provides a $50 per metric ton (mt) tax credit for captured CO_2 stored in geological formations and a $35 per mt tax credit for captured CO_2 used and stored with enhanced oil recovery. However, the 45Q tax credits contain limitations, including-- a rapidly approaching "commence construction" deadline, limited years for claiming the tax credit, a tax credit level insufficient for economically viable installation of CCS by natural gas-fueled power plants, and little support for first-of-a-kind (FOAK), higher CO_2 capture rate facilities. In a previous paper (Esposito, et al., 2019), the authors illustrated the basic arithmetic for assessing the economic viability of CCS in the electric power generation industry with availability of the Section 45Q tax credits, including an extensive look at the business case for installing CCS by coal-fueled power plants. This paper discusses a series of modifications to the Section 45Q tax credit, as well as additional steps, that would improve the business case for installing CCS on natural gas-fueled power plants." **Richard Esposito, Vello Kuuskraa, Charles Rossmann, and Michele M. Corser,** *Proceedings of the 15th Greenhouse Gas Control Technologies Conference 15-18 March 2021.* (Subscription may be required.)

A Computationally Efficient Method for Field-Scale Reservoir Simulation of CCS in Basalt Formations.

The following is from the abstract of this paper: "Unlike sedimentary formations, flood basalts have the potential for relatively rapid mineral trapping when used as an injection target for CO_2 storage. While CO_2 storage in basalt and its underlying geochemistry have been studied in various ways, including two successful small-scale pilot projects, there are still open questions surrounding the viability of large-scale CO_2 storage in basalt, including how the properties of the target formation will be altered after decades of geochemical activity. Field-scale numerical models can play a part in answering these questions. In this work, [the authors] present an overview and initial results of [their] recent development of a flexible, computationally efficient reactive transport model for CO_2 mineral trapping in basalt. The model combines a fully customizable geochemistry solver with a vertically integrated description of two-phase flow in porous media. It provides a platform for extensive field-scale numerical modeling studies of large-scale CO_2 storage in basalt, which in turn can help address some of the current barriers to its implementation in the field." **Tom Postma, Karl W. Bandilla, and Michael Celia,** *Proceedings of the 15th Greenhouse Gas Control Technologies Conference 15-18 March 2021.* (Subscription may be required.)

PUBLICATIONS *(cont.)*

Storage Readiness Levels: communicating the maturity of site technical understanding, permitting and planning needed for storage operations using CO_2.

The following is from the abstract of this article: "A framework of Storage Readiness Levels (SRLs) is presented to communicate the entirety of technical appraisal, permitting and planning activities achieved at a potential CO_2 storage site and what remains to be completed for CO_2 storage operations. The schema, based on learning gained from the experience of researchers, regulators and industry from the 1990s, is described and assessed by application to 742 saline formation and hydrocarbon field sites, offshore the UK, Norway and The Netherlands. The framework is flexible to accommodate national differences in procedures and practise and the unique character of each site. It is applicable regardless of the time-scale of appraisal or scale of assessment. The framework is consistent with and extends the industry commercial project development classification to include categories for sites with a lesser level of data and evaluation. Application to the phases of appraisal of three sites illustrates that investigations may advance understanding by different pathways and rates. The standardised framework enables comparison of the experience of permitting and planning activities completed within different jurisdictions, the level of investment and the duration required to achieve permitted or permit-ready sites. It is intended that the framework of SRLs should be widely applied." **Maxine Akhurst, Karen Kirk, Filip Neele, Alv-Arne Grimstad, Michelle Bentham, and Per Bergmo,** *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Multiscale design and analysis of CO_2 networks.

The following is from the abstract of this article: "Carbon Capture and Storage (CCS) is an essential technology for CO_2 emissions reductions, which will allow us to continue consuming fossil fuels in the short to medium term. In this work, [the authors] developed a multiscale modeling and optimization approach that links detailed models of the capture plant, compression train and pipelines with the CO_2 supply-chain network model. This was used to find the cost-optimal CO_2 network considering a case-study of meeting a national reduction target in the United Arab Emirates that supplies CO_2 for EOR activities. The main decision variables were the optimal location and operating conditions of each CO_2 capture and compression plant in addition to the topology and sizing of the pipelines while considering the whole-system behaviour. A key result of [the authors'] study was that the cost-optimal degree of capture should be included as a degree of freedom in the design of CO_2 networks and it is a function of several site-specific factors, including exhaust gas characteristics, proximity to transportation networks and adequate geological storage capacity. This conclusion serves to underscore the need to comprehend the science governing the physical behaviour at different scales and the importance of a whole-system analysis of potential CO_2 networks." **Ahmed Alhajaj and Nilay Shah,** *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Storage of hydrogen, natural gas, and carbon dioxide – Geological and legal conditions.

The following is from the abstract of this article: "The analysis of geological and reservoir conditions of the underground storage of hydrogen, methane, and carbon dioxide, that are important when choosing rock formations for the storage of gas, was presented. Physico-chemical properties of the discussed gases, affecting underground storage, were taken into account. Aquifers, hydrocarbon reservoirs, and caverns leached in salt rocks were analyzed. Legal aspects of underground gas storage were indicated. The physico-chemical conditions of the gases considered (especially molecular mass, and dynamic viscosity) are important for the selection of geological structures for their storage. The reservoir tightness is one of the most important geological and reservoir conditions when taking the appropriate porosity and permeability of rocks building underground storage sites into account. Salt caverns should be mainly used for hydrogen storage due to the tightness of rock salt. Geochemical and microbiological interactions affecting the operation of the underground storage site and its tightness are especially important and should be taken into account. The size of the underground storage site, while not as crucial in the case of H_2 storage, is important for CO_2 storage. When it comes to reservoir conditions, the amount of cushion gas and storage efficiency are important. The legal status of gas storage sites is highly variable. While there are existing regulations regarding natural gas storage, CO_2 storage requires further legislation. In the case of H_2 storage legal regulations need to be developed based on the experience of storage of other gases. The potential competition from other entities focused on the use of underground space for gas storage should be taken into account." **Radosław Tarkowski, Barbara Uliasz-Misiak, and Piotr Tarkowski,** *International Journal of Hydrogen Energy*. (Subscription may be required.)

Assessing the influence of injection temperature on CO_2 storage efficiency and capacity in the sloping formation with fault.

The following is from the abstract of this article: "Complex factors can affect carbon dioxide (CO_2) geological storage efficiency and capacity. In this paper, a three-dimensional (3D) conceptual model of the Shiqianfeng formation in the Ordos basin was established (a total of 16 sets of schemes) to study the influence of injection temperature on CO_2 storage efficiency and migration safety in the sloping formation with a fault. In addition, storage capacity is investigated for CO_2 storage site selection. The results show that injection temperature and formation slope have a significant effect on CO_2 storage efficiency. Faulting provides a possible channel for CO_2 leakage. High injection temperature is more likely to cause CO_2 leakage in the sloping formation. When the injection temperatures are 11, 31.5, 51 and 71 °C in the 15° slope formation, the time points of CO_2 leakage are 200, 170, 150 and 140 years, respectively. The lower injection temperature results in a higher CO_2 concentration near the injection well and a closer migration distance of dissolved CO_2. The larger the formation slope is, the farther the dissolved CO_2 migration distance will be. The higher injection temperature results in a greater gas phase, dissolved phase, and total CO_2 storage amount in the whole formation. The larger the formation slope is, the smaller the CO_2 storage capacity will be for CO_2 injected over 20 years. However, the larger formation slope resulted in a smaller gas phase and larger storage amount of the dissolved phase CO_2 for CO_2 migration after 140 years. The influence of the formation slope on the dissolved CO_2 migration safety is more obvious than that of injection temperature. However, the influence of the injection temperature on CO_2 storage capacity is more obvious than that of the formation slope." **Jing Jing, Yanlin Yang, and Zhonghua Tang,** *Energy*. (Subscription may be required.)

PUBLICATIONS *(cont.)*

Efficient marine environmental characterisation to support monitoring of geological CO_2 storage.

The following is from the abstract of this article: "Carbon capture and storage is key for mitigating greenhouse gas emissions, and offshore geological formations provide vast CO_2 storage potential. Monitoring of sub-seabed CO_2 storage sites requires that anomalies signifying a loss of containment be detected, and if attributed to storage, quantified and their impact assessed. However, monitoring at or above the seabed is only useful if one can reliably differentiate abnormal signals from natural variability. Baseline acquisition is the default option for describing the natural state, however we argue that a comprehensive baseline assessment is likely expensive and time-bound, given the multi-decadal nature of CCS operations and the dynamic heterogeneity of the marine environment. [The authors] present an outline of the elements comprising an efficient marine environmental baseline to support offshore monitoring. [The authors] demonstrate that many of these elements can be derived from pre-existing and ongoing sources, not necessarily related to CCS project development. [The authors] argue that a sufficient baseline can be achieved by identifying key emergent properties of the system rather than assembling an extensive description of the physical, chemical and biological states. Further, that contemporary comparisons between impacted and non-impacted sites are likely to be as valuable as before and after comparisons. However, as these emergent properties may be nuanced between sites and seasons and comparative studies need to be validated by the careful choice of reference site, a site-specific understanding of the scales of heterogeneity will be an invaluable component of a baseline." **Jerry Blackford, Katherine Romanak, Veerle A.I. Huvenne, Anna Lichtschlag, James Asa Strong, Guttorm Alendal, Sigrid Eskeland Schütz, Anna Oleynik, and Dorothy J. Dankel,** *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Modeling trade-offs across carbon sequestration, biodiversity conservation, and equity in the distribution of global REDD+ funds.

The following is from the abstract of this article: "The program on Reducing Emissions from Deforestation and Forest Degradation (REDD+) is one of the major attempts to tackle climate change mitigation in developing countries. REDD+ seeks to provide result-based incentives to promote emission reductions and increase carbon sinks in forest land while promoting other cobenefits, such as the conservation of biodiversity. [The authors] model different scenarios of international REDD+ funds distribution toward potential recipient countries using 2 carbon emission reduction targets (20% and 50% compared to the baseline scenario, i.e., deforestation and forest degradation without REDD+) by 2030. The model combines the prioritization of environmental outcomes in terms of carbon sequestration and biodiversity conservation and social equity, accounting for the equitable distribution of international REDD+ funds. Results highlight the synergy between carbon sequestration and biodiversity conservation under alternative fund allocation criteria, especially for scenarios of low carbon emission reduction. Trade-offs increase when distributional equity is considered as an additional criterion, especially under higher equity requirements. The analysis helps to better understand the inherent trade-offs between enhancing distributional equity and meeting environmental targets under alternative REDD+ fund allocation options." **Ignacio Palomo, Yann Dujardin, Estelle Midler, Manon Robin, María J. Sanz, and Unai Pascual,** *Proceedings of the National Academy of Sciences of the United States of America*. (Subscription may be required.

Effects of Temporal Variation in Long-Term Cultivation on Organic Carbon Sequestration in Calcareous Soils: Nile Delta, Egypt.

The following is from the abstract of this article: "Soil carbon sequestration is a riskier long-term strategy for climate mitigation than direct emissions reduction, but it plays a main role in closing carbon emission gaps. Effects of long-term cultivation on soil carbon sequestration were studied at the western edge of the Nile Delta near Alexandria, Egypt. Seven agricultural fields of different ages (0–50 years in use) were selected and compared with the surrounding desert (virgin soil) and desert shrub-land. Samples were taken at three horizons, 0–30, 30–60, and 60–90 cm, and tested for differences in physical and chemical properties. The results of long-term cultivation reveal that the European Commission (EC) value was 11.77 dS/m in virgin soil, while the EC values decreased to 5.82, 4.23, 3.74, 2.40, and 2.26 dS/m after 5, 10, 20, 30, and 50 years of cultivation, respectively. The calcareous rock fraction smaller than 50 µm in size revealed another phenomenon, where active calcium carbonate content increased with cultivation practices from 1.15% (virgin soil) to 5.42%, 6.47%, 8.38%, and 10.13% after 5, 10, 20, and 30 years of cultivation, respectively, while shrub-land also showed a low amount of active $CaCO_3$ with 1.38%. In fifty years of cultivation, soil bulk density decreased significantly from 1.67 to 1.11 g/cm^3, and it decreased to 1.65, 1.44, 1.40, and 1.25 g/cm^3 after 5, 10, 20, and 30 years, respectively. These results reveal that the increase in soil carbon stock in the upper 90 cm amounted to 41.02 t C/ha after five years of cultivation, compared to virgin soil with 13.47 t C/ha. Soil carbon levels increased steeply during the five years of cultivation, with an average rate of 8.20 t C/ha per year in the upper 90 cm. After the first five years of cultivation, the carbon sequestration rate slowed, reaching 4.68, 3.77, 2.58, and 1.93 t C/ha per year after 10, 20, 30, and 50 years, respectively, resulting in sequestration-potential values of 46.78, 75.63, 77.43, and 96.45 t C/ha. These results indicate that potential soil carbon sequestration resembles a logarithmic curve until the equilibrium state between carbon application and decomposition by microorganisms is reached." **Manal Alnaimy, Martina Zelenakova, Zuzana Vranayova, and Mohamed Abu-Hashim,** *Sustainability*. (Subscription may be required.)

ABOUT DOE/NETL'S CARBON STORAGE PROGRAM

The **Carbon Storage Program** at the U.S. Department of Energy's (DOE) 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 *DOE/NETL 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.

DOE/NETL Carbon Storage Program Resources

Newsletters, program fact sheets, best practices manuals, roadmaps, educational resources, presentations, and more information related to the DOE/NETL 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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