NATIONAL ENERGY TECHNOLOGY LABORATORY

CSN

CARBON STORAGE NEWSLETTER

VOL. 21, NO. 12

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

DOE/FECM/NETL HIGHLIGHTS

DOE Releases RFI on Deployment-Ready CO_2 Reduction, Removal Tech.

The U.S. Department of Energy (DOE) *released a Request for Information (RFI)* on demonstration-ready technologies that can reduce emissions and remove carbon dioxide (CO_2) from the atmosphere. The RFI seeks feedback from industry, investors, developers, academia, research laboratories, government agencies, non-governmental organizations (NGOs), and potentially affected communities (including environmental justice, tribal, energy transition, and other communities). Information provided through the RFI, which follows the enactment of the Bipartisan Infrastructure Law, is expected to inform the design of successful projects as well as the effective, just, and sustainable deployment of technologies that will enable a safe climate future, with particular attention to including historically marginalized communities in the decision-making process. Responses are due by January 24, 2022. From *energy.gov*. December 2021.

DOE Funding to Support DAC and Carbon Storage.

DOE announced funding to leverage existing low-carbon energy to scale-up direct air capture (DAC) technology combined with carbon storage. DAC, a CO_2-removal (CDR) approach, separates CO_2 from ambient air for either underground storage or conversion into products. The *Funding Opportunity Announcement (FOA)* will facilitate engineering studies of advanced DAC systems capable of removing 5,000 metric tons of CO_2 per year from the air. The studies will provide detailed information on the operation of these systems and potential investment costs that will enable DOE to accelerate research and development (R&D) for existing DAC technologies co-located with domestic low-carbon thermal energy sources, such as nuclear power plants, geothermal resources, and industrial plants. This FOA is a collaborative effort among DOE's Office of Fossil Energy and Carbon Management (FECM), Office of Nuclear Energy, and Office of Energy Efficiency and Renewable Energy's Geothermal Technologies Office. From *energy.gov*. October 2021.

ANNOUNCEMENTS

DOE Announces Intent to Fund Carbon Storage Projects.

DOE's FECM released a *Notice of Intent (NOI)* to fund cost-shared R&D projects to accelerate wide-scale deployment of carbon capture and storage (CCS) and CDR. CDR technologies remove CO_2 directly from the atmosphere, and CCS technologies reduce CO_2 emissions from power plants and industrial facilities by capturing the CO_2 they produce. The potential projects will be selected under DOE's *Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Initiative*, which focuses on developing geologic storage sites with capacities to store at least 50 million metric tons of CO_2.

DOE Announces New CO_2 Removal, Storage Goal.

U.S. Secretary of Energy Jennifer M. Granholm announced DOE's new goal to remove gigatons of CO_2 from the atmosphere and store it for less than $100/ton of net CO_2-equivalent. The "Carbon Negative Shot," the third target within *DOE's Energy Earthshots Initiative*, is a call for innovation in the expanding field of CDR. CDR is defined as a wide array of approaches that capture CO_2 directly from the atmosphere and durably store it in geological, bio-based, and ocean reservoirs or in value-added products to create negative emissions.

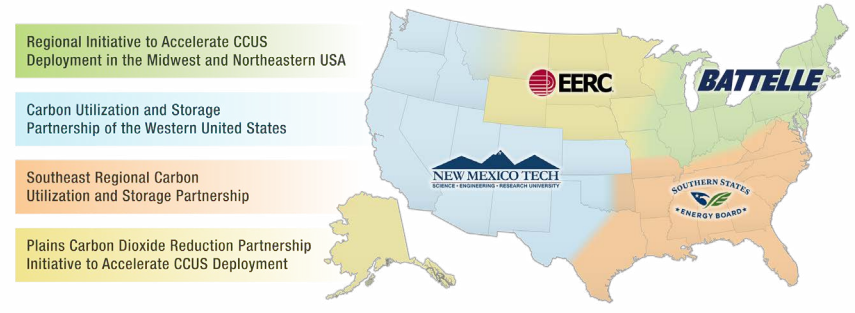
DOE Releases Joint Mission Statement on Carbon Dioxide Removal Mission.

The *Carbon Dioxide Removal Mission* will seek to enable CDR technologies to achieve net reduction of 100 million metric tons of CO_2 per year globally by 2030. The focus of the mission is to enhance the systems that lead to negative emissions through an emphasis on secure CO_2 storage and conversion into long-lived products. Co-leads of the mission include DOE, the Ministry of Energy (Kingdom of Saudi Arabia), and Natural Resources Canada.

ANNOUNCEMENTS *(cont.)*

DOE Announces Funding to Deploy CCUS.

DOE announced funding for an initiative focused on accelerating the regional deployment of carbon capture, utilization, and storage (CCUS). The *Regional Initiative to Accelerate CCUS Deployment* is designed to identify and address regional storage and transportation challenges facing the commercial deployment of CCUS. The four Regional Initiatives, which represent four regions of the United States, continue the work of predecessor projects funded under *DOE's Regional Carbon Sequestration Partnership (RCSP) Initiative*, supporting efforts to validate geologic storage technologies and support the commercialization of CCS.



Regional Initiatives map

DOE Invests to Decarbonize Using CCS.

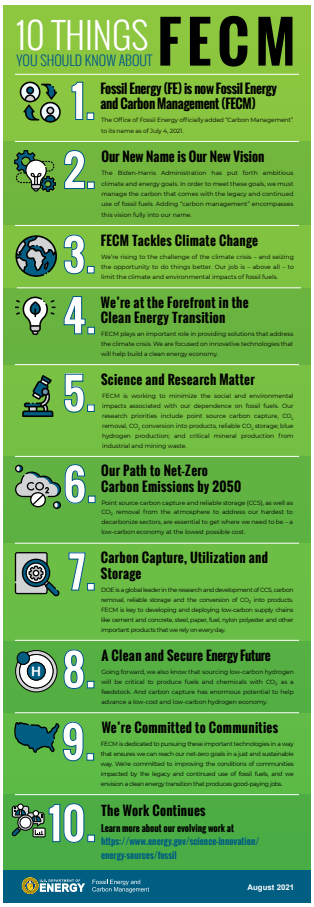
DOE announced funding for 12 projects to advance point-source CCS technologies that can capture at least 95% of CO_2 emissions generated from natural gas power and industrial facilities. The projects were selected by *DOE's FECM* and will be managed by the National Energy Technology Laboratory (NETL). The 12 R&D front-end engineering design and engineering-scale projects are part of DOE's efforts to help achieve the administration's goals of net-zero carbon emissions by 2050 and a 100% clean electricity sector by 2035.

SMART Team Develops Reservoir Models for Depositional Environments.

The Science-informed Machine Learning for Accelerating Real-Time Decisions in Subsurface Applications (SMART) Team has developed machine learning-based predictive models for geologic CO_2 storage. The SMART Initiative is funded by *DOE/NETL's Carbon Storage* and *Upstream Oil and Gas Programs*.

Alliance to Develop Technical, Commercial Solutions to CCS Projects.

Technology provider *TechnipFMC* and offshore energy company *Talos Energy* entered into a partnership to develop technical and commercial solutions for CCS projects along the U.S. Gulf Coast. The companies will collaborate to advance CCS opportunities through the full life cycle.



FECM Infographic Available.

DOE's FECM released an infographic providing facts and information on its vision and goals. "*10 Things You Should Know About FECM*" is available for download.

UK Awards CO_2 Storage License.

The United Kingdom's (U.K.) Oil and Gas Authority awarded a CO_2 appraisal and storage license to Harbour Energy, who proposes to reuse depleted gas fields to store CO_2. Injection is targeted in 2026.

Carbon Zero Grand Challenge Seeks CCUS Solutions.

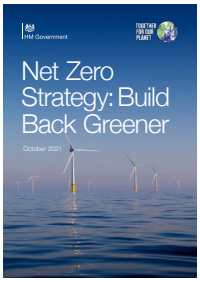
Singapore's *national water agency* launched the Carbon Zero Grand Challenge, seeking CCUS and removal solutions for its water treatment facilities to achieve net-zero emissions by 2050. Proposals are being accepted through February 2022.

Canada Co-Op Plans CCS Facilities.

Canada's Federated Co-Operatives signed a Memorandum of Understanding with Whitecap Resources Inc. to store 500,000 metric tons of CO_2 equivalent annually at Whitecap's Weyburn, Saskatchewan, carbon storage site.

UK Government Issues Response to Climate Change Committee Report.

The U.K. government released its response to a *Climate Change Committee* report on the progress made in adapting to climate change and recommendations moving forward. The U.K. government's *Net-Zero Strategy is available*.



PROJECT and BUSINESS DEVELOPMENTS

North Dakota Approves CCS Project.

The North Dakota Industrial Commission approved a CCS project, marking the first time a CCS project in the United States has fallen under the authority of a state rather than the U.S. Environmental Protection Agency. North Dakota received primacy of Class VI wells in 2018, giving the state primary regulatory authority over the use of wells for underground CO_2 injection. The project involves Red Trail Energy capturing CO_2 from its ethanol facility near Richardton, North Dakota, with the intent to inject and store approximately 180,000 metric tons of CO_2 per year. From *Upstream*. October 2021.

Clean Energy Complex to Feature CCS.

Air Products plans to build, own, and operate a project that will produce more than 750 million standard cubic feet per day of blue hydrogen in Louisiana (USA). The "blue" products at the clean energy complex will be produced utilizing hydrocarbons as a feedstock, with the CO_2 in the production process captured for storage. From *Air Products*. October 2021.

PROJECT and BUSINESS DEVELOPMENTS *(cont.)*

Partnership to Accelerate CCUS Technology.

Aker Carbon Capture and U.K. waste management company Viridor announced plans for a partnership for next-generation modular CCUS technology. Viridor plans to explore the installation of modular CCS plants on five of its waste-to-energy sites across the U.K. The modular plants enable the CCUS technology to be deployed more quickly following planning and permitting. From *Aker Carbon Capture*. October 2021.

Consortium to Explore CCS Opportunities in Australia.

Woodside, BP, and Japan Australia LNG formed a consortium to advance feasibility studies for a CCS project near Karratha in Western Australia. The consortium will assess the technical, regulatory, and commercial feasibility of capturing CO_2 released by multiple industries located near Karratha on the Burrup Peninsula and storing it in offshore reservoirs in the Northern Carnarvon Basin. From *Rigzone*. November 2021.

Companies Agree on Full-Scale Pilot Retrofit of CCS System.

Wärtsilä Exhaust Treatment and Solvang ASA, a Norwegian shipping company, agreed on a full-scale pilot retrofit installation of a CCS system on one of Solvang's ethylene carriers. Wärtsilä will design the retrofitted unit while it also completes a land-based, 1-megawatt (MW) test system. The land-based unit is planned for completion in 2021, and the companies project completion of the retrofit pilot system by 2023. From *The Maritime Executive*. October 2021.

Large-Scale Facility to Convert CO_2 to Fuel.

Preliminary engineering and design has begun on a large-scale, commercial facility in British Columbia, Canada, that will capture CO_2 and convert it to clean fuels. Clean energy company Huron Clean Energy will partner with The Upper Nicola Band, Oxy Low Carbon Ventures, and Carbon Engineering (CE) on the facility, which will combine atmospheric CO_2 with hydrogen to produce fuels. The proposed facility is being designed to utilize CE's technologies to capture atmospheric CO_2 and deliver up to 100 million liters of carbon fuel each year. From *Carbon Engineering*. October 2021.

LEGISLATION and POLICY

Australia Announces CCUS Initiatives.

The Australian government announced initiatives encouraging CCUS efforts. Among the initiatives is the CCUS Hubs and Technologies Program, which aims to deploy CCUS at scale by encouraging domestic and international research collaborations and lowering the cost of technology adoption. From *The Chemical Engineer*. October 2021.

Potential Tax Incentives Include CCS Modifications.

The U.S. House Ways and Means Committee released legislation that includes "Green Energy Provisions" that would incentivize cleaner, more efficient operations that focus on reducing emissions. In addition, the provisions contain several modifications to the development of the CCUS market. From *Financial Executives International*. October 2021.

Iowa Task Force to Review Carbon Storage Policy Recommendations.

The Iowa Carbon Sequestration Task Force (USA) *met to discuss policy recommendations* for lawmakers within the state. *Announced in July 2021*, the Carbon Sequestration Task Force is supported by two working groups: the Agriculture Working Group and the Energy Working Group. From *Radio Iowa*. October 2021.

UK Plan Includes CCS Funding.

The U.K. government unveiled its *Net-Zero Strategy*, which includes the funding of two CCS hubs. The East Coast Cluster project will look to develop offshore infrastructure to transport and store CO_2 in the U.K.'s North Sea. The Hynet project plans to produce clean hydrogen and capture and store CO_2 from industry. From *Bloomberg*. October 2021.

North Carolina Bill Calls for CO_2 Reductions.

The Governor of North Carolina (USA) signed a bipartisan energy measure aimed at reducing the state's greenhouse gas emissions in the coming decades. *HB 951* requires the North Carolina Utilities Commission to take steps needed to achieve the goal of reducing energy producers' CO_2 emissions by 70% by 2030 and to reach carbon neutrality by 2050. From *Watauga Democrat*. October 2021.

EMISSIONS TRADING

Western Australia Legislation to Enable Carbon Trading by Forest Products Commission.

The Western Australia Forestry Minister introduced a bill that would allow the state's Forest Products Commission (FPC) to own and trade carbon assets. The bill would amend the Forest Products Act 2000, under which the FPC was limited to dealing with "forest products." (Forest products are defined to mean trees, parts of trees, and similar products.) The amendments would also allow the FPC to obtain and trade Australian Carbon Credit Units. From *Government of Western Australia.* October 2021.

SCIENCE

New Research Findings Could Help Inform How Zeolites Used in CCS.

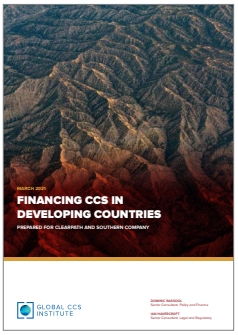
Researchers from Northwestern University analyzed ancient zeolite specimens collected from the edges of East Iceland and discovered that zeolites separate calcium isotopes differently than previously thought. The findings could help quantify temperatures in both modern and ancient geologic systems, as well as inform CCS efforts. The results of the study were published in the journal *Communications Earth and Environment*. From *Science Daily*. October 2021.

Researchers Study Effects of Antibiotics, Temperature on Carbon Sinks.

Ecologists from Cary Institute of Ecosystem Studies (New York, USA) investigated the effects of rising temperatures and a common livestock antibiotic on soil microbes. The research team found that heat and antibiotics disrupt soil microbial communities—degrading soil microbe efficiency, resilience to future stress, and ability to store CO_2. The study, published in the journal *Soil Biology and Biochemistry*, found that rising temperatures alone increased soil respiration and dissolved organic carbon, which could reduce long-term carbon storage capacity. From *Science Daily.* November 2021.

PUBLICATIONS

Financing CCS in Developing Countries.



The following is from the Introduction of this Global CCS Institute report: "CCS is vital to solving the climate crisis, which experts believe will require the world's emissions to reach net-zero by 2050. To this, the IEA's Sustainable Development Scenario (SDS) estimates that ±9% of the world's emissions reductions must come as a result of deployment of CCS across numerous sectors. It is one of the few technologies that can substantially reduce emissions from hard-to-abate sectors as well as in decarbonising fossil fuel powered electricity generation. It is also one of the few technologies that can be used to create negative emissions through bioenergy with CCS or Direct Air Capture (DAC). To ensure that CCS can meet the SDS' requisites, its deployment must occur in all parts of the world where opportunities exist for its application. This means that CCS must be deployed in both developed and developing countries. Given the long lead times associated with developing CCS projects, the steps taken between now and 2030 will determine whether CCS technology will be deployed at the scale necessary to meet net-zero emissions by 2050. It must, therefore, be the case that between 2030 and 2050 the rate of deployment of CCS must increase by more than a factor of 100. This implies that a rapidly growing demand for CCS projects emerges from debt and capital markets by 2030, and for this to happen, investments in CCS must be significantly derisked during the intervening years. Some parts of the world will lend themselves better to the challenge of early deployment than others, specifically the difference in levels of deployment in developed countries versus developing countries. Developing countries represent high-risk environments for investments in CCS, which create funding gaps for CCS projects. This in turn poses a significant risk to the timely deployment of this vital technology. It is the role of climate finance to help close such funding gaps. This report examines how CCS projects can be structured so as to avail themselves to the different climate finance options currently available to support their deployment around the world."

Waste Incineration and Carbon Capture and Storage.

The following is a segment of this Bellona Europa Position Paper: "In 2019, the European Union (EU) generated 224 Mt of municipal waste. Out of these 224 Mt, 53 Mt were landfilled, 60 Mt incinerated and 107 Mt recycled. Export of hazardous and non-hazardous waste had tripled between 2001 and 2020, growing from 6.3 million tonnes to 32.7 million tonnes respectively. With a 3% share of EU greenhouse gas emissions in 2017, the municipal waste sector is the fourth largest contributor to emissions in the EU. In 2017, the emissions registered for the waste sector amounted to approximately 138 million tonnes of greenhouse gases. That number grows even larger when emissions from waste to energy plants, currently covered by emission accounting in the power sector, are included. Emissions from waste incineration in Europe grew from 5,373kt^3 CO_2 in 1990 to 95,628kt of CO_2 and are now approximately equivalent to emissions coming from landfills. Other than its impact on the climate, waste disposal has significant impacts on biodiversity and public health. Reducing waste, retaining the value of resources and minimising the overall impact of the products we use and dispose of is essential to reduce the environmental pressures created by the growing amount of waste we create. To do so, we need to establish a set of integrated waste reduction and management measures. Waste management conditions vary from region to region; due to these differences, waste management measures must be tailored to local waste management systems. Within the EU the amount of generated waste per capita varies from 280 kg in Romania to 844 kg in Denmark (per person, per year)."

Achieving negative emissions through oceanic sequestration of vegetation carbon as Black Pellets.

The following is from the abstract of this article: "Natural processes and human activities produce vast amounts of dead vegetation which return CO_2 to the atmosphere through decay and combustion. If such vegetation could be converted into biocoal and sequestered on the ocean floor, it could reduce the accumulation of atmospheric CO_2 without involving sequestration in the form of CO_2. Given that raw vegetation is unsuitable for large-scale energy applications, a process was developed to convert raw vegetation into a form of biocoal, termed Black Pellets, that solves the logistical and energy conversion problems of using raw vegetation for power generation. Seemingly overlooked is that properties of Black Pellets—higher density than seawater and resistance to microbial decay—may offer an environmentally safe way of sequestering vegetation carbon on the sea floor. Sequestering vegetation carbon by depositing biocoal as Black Pellets in the deep ocean (oceanic sequestration of biocoal—OSB) would be a means of achieving long-lasting negative emissions. Sacrificing the energy content of the deposited pellets would require substituting energy from other sources. If the substitute energy could be from lower-carbon natural gas or carbon-free sources, the effects would be less accumulation of atmospheric CO_2 compared to using the pellets for energy and a nearly 60 to 100% reduction in the need for geologic sequestration compared to bioenergy carbon capture and storage (BECCS). If confirmed by research, OSB would be an addition to the sparse toolbox of negative emission technologies (NETs) which would give humankind more flexibility in meeting the goals of the Paris Agreement." **Leonard A. Miller and Philip M. Orton**, *Climatic Change*. (Subscription may be required.)

PUBLICATIONS *(cont.)*

A real options approach to production and injection timing under uncertainty for CO_2 sequestration in depleted shale gas reservoirs.

The following is from the abstract of this article: "Depleted shale gas reservoirs may be candidates for conversion to injection wells for the long-term geologic storage of CO_2, but the decision to transition from production to injection depends on economic and policy factors that may be uncertain. This paper aims to comprehend the uncertainty inherent to the underlying assumptions of CO_2 sequestration and their impact on the injection decision. [The authors] view and analyze the production to injection transition decision as a kind of options problem, where the owner of a producing well can choose to exercise the option to stop producing natural gas and start injecting CO_2. [The authors'] approach integrates a detailed reservoir model for shale-gas production and CO_2 injection in the Marcellus shale formation with a multi-period decision problem under uncertainty in future prices for CO_2 and produced natural gas. With no uncertainty, the modeling framework is able to identify the optimal timing of the transition to CO_2 injection as a function of natural gas prices and a hypothetical CO_2 price. [The authors] find that a CO_2 price of approximately $15 per tonne to be needed in order to incentivize a producer to transition to CO_2 injection earlier. If these prices are uncertain, [the authors] find that the option to delay CO_2 injection has value even when CO_2 prices are relatively high and natural gas prices are low, although the option value is highly sensitive to the choice of discount rate and the option value to delay injection is generally very low when CO_2 prices are $20/tonne or higher. [The authors'] modeling suggests that commitment in carbon pricing regimes is of equal importance to the choice of the price level." **Farid Tayari and Seth Blumsack**, *Applied 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.)

A guideline for appropriate application of vertically-integrated modeling approaches for geologic carbon storage modeling.

The following is from the abstract of this article: "Mathematical modeling is an essential tool for answering questions related to geologic carbon storage (GCS). The choice of modeling approach depends on the type of questions being asked. In this paper [the authors] discuss a series of approaches with a hierarchical complexity including vertically-integrated single-phase flow approaches, vertically-integrated multi-phase flow approaches (with and without vertical equilibrium assumption), three-dimensional multi-phase flow approaches, and fully-coupled multi-phase flow approaches that couple flow with geochemistry and/or geomechanics. Three spatial scales are used to categorize the questions to be addressed by modeling: regional scale (encompasses CO_2 plume extent and majority of area of pressure impact of one or more injection operations), site scale (includes the CO_2 plume extent and some of the area impacted by the pressure increase of a single injection site), and well scale (the immediate vicinity of an injection well). A set of guidelines is developed to help modelers choose the most appropriate modeling approach, and show when simpler modeling approaches may be the better choice. Vertically-integrated single-phase flow models are the most appropriate choice at both the site and regional scales, if the pressure impact outside of the CO_2 plume is of interest. Vertically-integrated multi-phase flow models should be chosen at the regional scale, if the locations of CO_2 plumes are of interest, and at the site scale if vertical segregation of CO_2 and brine is fast or vertical heterogeneity in properties can be presented by distinct, continuous layers. Three-dimensional multi-phase flow models are the appropriate choice at the well and site scales for cases with significant vertical flow components of CO_2 and brine. Fully-coupled multi-phase flow models should only be chosen if pore-space alteration through geochemistry or geomechanics feeds back to fluid flow." **Karl W. Bandilla, Bo Guo, and Michael A. Celia**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Co-optimizing water-alternating-carbon dioxide injection projects using a machine learning assisted computational framework.

The following is from the abstract of this article: "In this article, a robust machine-learning-based computational framework that couples multi-layer neural network (MLNN) proxies and a multi-objective particle swarm optimizer (MOPSO) to design water-alternating-carbon dioxide injection (CO_2-WAG) projects is presented. The proposed optimization protocol considers various objectives, including oil recovery and CO_2 storage volume. Expert MLNN systems are trained and employed as surrogate models of the high-fidelity compositional simulator in the optimization workflow. When multiple objective functions are considered, two approaches are employed to treat the objectives: the weighted sum method and the Pareto-front-based scheme. A field-scale implementation focusing on tertiary recovery in the Morrow B formation at Farnsworth Unit (FWU) is presented. The developed Pareto-optimal solutions indicate the maximal available oil production can be 1.64 × 107 barrels and maximal carbon storage can achieve 2.35 × 107 tons. Trade-offs factor is defined to divide the constructed Pareto front into 4 sections with the trade-off factors' value ranges from 0.35 to 49.9. This work also compares the optimum solution found by the aggregative objective function and the solution repository covered by the Pareto front that considers the physical and operational constraints and reduces uncertainties involved by the multi-objective optimization process. [The authors'] comparison indicates multiple solutions exist to satisfy the objective criteria of the WAG design, and these results cannot be found using the traditional weighted sum method. The Pareto front solution can provide more options for project designers, but decisions regarding necessary trade-offs must be made using the solution repository to balance the project economics and CO_2 storage amount." **Junyu You, William Ampomah, and Qian Sun**, *Applied Energy*. (Subscription may be required.)

PUBLICATIONS *(cont.)*

Using socio-technical analogues as an additional experience horizon for nuclear waste management A comparison of wind farms, fracking, carbon capture and storage (CCS) with a deep-geological nuclear waste disposal (DGD).

The following is from the abstract of this article: "Energy technologies can be described as socio-technical ensembles, in which social, political, economic and technical dimensions are embedded. Based on this concept as well as other theoretical approaches dealing with the deployment and development of technologies (e.g. the multi-level perspective of Geels (2002)) this contribution investigates the dynamics and interactions that can occur within the socio-technical ensemble of a deep geological disposal (DGD) for high-level radioactive waste (HLRW). [The authors] compare socio-technical analogues and relate findings of three energy technologies with large-scale infrastructures to a DGD. The analysis is based on a systematic literature review and aims to gain indirect knowledge for nuclear waste management (NWM) deduced from the dynamics within the socio-technical ensembles of wind farms, fracking and carbon dioxide capture and storage (CCS). The analysis is based on a systematic literature review along four central dimensions with eight respective criteria e.g. public participation, conflicts, role of science, etc." **DörteThemann and Achim Brunnengräber**, *Utilities Policy*. (Subscription may be required.)

High-resolution 3D marine seismic acquisition in the overburden at the Tomakomai CO_2 storage project, offshore Hokkaido, Japan.

The following is from the abstract of this article: "Monitoring injected CO_2 is an important part of assuring permanence of long term storage to mitigate atmospheric emissions. Three-dimensional (3D) seismic has been shown to be an effective technology for visualizing and quantifying subsurface geology and fluids. In this study, [the authors] demonstrate the successful acquisition, processing, and initial interpretation of a first-of-its-kind high-resolution 3D (HR3D) marine seismic survey above an active CO_2 injection site offshore Tomakomai, Japan. An initial sensitivity study indicated generally favorable subsurface conditions for imaging subsurface pore fluid changes. A unique processing workflow incorporating multiple data processing software packages has been tailored to the short-offset and low-fold HR3D acquisition. The final 3D volume shows generally flat and laterally-continuous stratigraphy in the overburden above the injection zone without identifiable faults, indicating coherent overburden above the CO_2 injection site and low associated risk of vertical CO_2 migration. The successful deployment of this novel marine seismic monitoring technology in the overburden at a small-scale (100 kt/yr) demonstration project suggests HR3D will also be a useful characterization and monitoring tool for larger demonstration and commercial-scale (~10 MT) offshore Carbon Capture and Storage (CCS) sites." **T.A. Meckel, Y.E. Feng, R.H. Treviño, and D. Sava**, *International Journal of Greenhouse Gas Control.* (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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