

## CSN

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CARBON STORAGE  
NEWSLETTER

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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## DOE/NETL HIGHLIGHTS

*DOE Invests in Projects to Advance Beneficial Use of CO<sub>2</sub>.*

The U.S. Department of Energy's (DOE) Office of Fossil Energy (FE) selected five projects to receive funding to investigate novel uses of carbon dioxide (CO<sub>2</sub>) captured from coal-fired power plants. The newly selected projects fall under three technical areas of interest: (1) Biological-Based Concepts for Beneficial Use of CO<sub>2</sub>; (2) Mineralization Concepts Utilizing CO<sub>2</sub> with Industrial Wastes; and (3) Novel Physical and Chemical Processes for Beneficial Use of Carbon. The five projects join [seven previously selected projects](#) under the "Applications for Technologies Directed at Utilizing Carbon Dioxide from Coal-Fired Power Plants" Funding Opportunity Announcement (FOA). All 12 projects selected under the FOA support FE's *Carbon Storage Program's Carbon Use and Reuse* research and development (R&D) portfolio. From [energy.gov](#) on August 10, 2017.

*NETL Releases Updated BPMs for Geologic Carbon Storage.*

DOE's National Energy Technology Laboratory (NETL) announced the release of the final two of five 2017 revised edition best practice manuals (BPMs) for geologic carbon storage projects. The final two BPMs ("*Operations for Geologic Storage Projects*" and "*Monitoring, Verification, and Accounting (MVA) for Geologic Storage Projects*") join the three *BPMs released in July 2017* to provide a holistic approach to carrying out a geologic storage project from inception to completion. The revised BPMs were developed in conjunction with the *Regional Carbon Sequestration Partnerships (RCSPs)* and include new information learned as the RCSPs progressed to large-scale Development Phase field projects, as well as a variety of carbon storage scenarios at different geologic and geographic settings across the United States. From [energy.gov](#) on September 1, 2017.



## ANNOUNCEMENTS

*DOE Announces FOA for Large-Scale Pilot Fossil Fuel Projects.*

DOE announced the availability of funds to design, construct, and operate two large-scale pilots for transformational coal technologies that improve coal-powered systems' performance, efficiency, emission reduction, and cost of electricity. More details on the three-phase FOA, which closes on October 19, 2017, is [available online](#).

*CCS Research Grant Extended.*

Gassnova, a Norwegian state-owned carbon capture technology firm, extended a grant for research at the CO<sub>2</sub> Technology Centre Mongstad (TCM). TCM conducts carbon capture and storage (CCS) emissions testing using CO<sub>2</sub> from a combined heat and power plant and an oil refinery cracker.

*RGGI Releases Reports on Secondary Market and Results for Auction 37.*

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the "*Report on the Secondary Market for RGGI CO<sub>2</sub> Allowances: Second Quarter 2017*," addressing the period from April 2017 through June 2017. Prepared by independent market monitor Potomac Economics, the report includes information on the secondary market for RGGI CO<sub>2</sub> allowances, including futures prices, market activity and allowance holdings. In addition, RGGI also [announced the results of their 37th auction of CO<sub>2</sub> allowances](#), in which 14,371,585 CO<sub>2</sub> allowances were sold at the auction at a clearing price of \$4.35. More details are available in the [Market Monitor Report for Auction 37](#).

## ANNOUNCEMENTS *(cont.)*

### *Report Details Growth of CCS Market.*

A study by Global Market Insights details how the growing demand for CCS technologies, along with government regulations to reduce greenhouse gas (GHG) emissions, will drive the CCS market size. The report states that the product's ability to reduce carbon emission by 85 to 90 percent makes its adoption preferable over other available alternates.

### *India Plans to Establish Voluntary Carbon Market.*

According to India's union minister for environment, forest, and climate change, India plans to establish a voluntary carbon market. The announcement was made at the Business and Climate Summit (BCS) 2017 in Delhi.

## PROJECT and BUSINESS DEVELOPMENTS

### *Ultra-High-Resolution 3D Seismic Technology Deployed in DOE/NETL Offshore CO<sub>2</sub> Storage Monitoring Project.*

Researchers from the Gulf Coast Carbon Center at the Texas Bureau of Economic Geology conducted an ultra-high-resolution 3D seismic data collection survey off Japan's north island of Hokkaido. The location offshore the industrial port of Tomakomai is the site of an extensive CO<sub>2</sub> capture, transport, and offshore injection demonstration project operated by the Japanese Ministry of Economy, Trade, and Industry and an industrial consortium, JCCS Co., Ltd. At the time of the survey, approximately 65,000 tons of CO<sub>2</sub> had been injected into a geologic formation 1,100 meters below the seafloor. Funded through DOE/NETL's Carbon Storage Research Program, the seismic data were collected using technology designed to provide high-resolution 3D data that can be used to characterize the geology above potential CO<sub>2</sub> storage sites. According to the researchers, a high-resolution 3D seismic survey using novel technology at an active offshore CO<sub>2</sub> injection site contributes to national CO<sub>2</sub> storage needs by validating monitoring technologies and reducing potential storage risks. From DOE Project "Field Validation of MVA Technology for Offshore CCS: Novel Ultra-High-Resolution 3D Marine Seismic Technology (P-Cable)."



*Acoustic energy sources (compressed air) being deployed for ultra-high-resolution 3D seismic data acquisition at the Tomakomai CO<sub>2</sub> storage demonstration project offshore Tomakomai, Hokkaido, Japan.*

### *CSLF Middle East and South Africa Regional Meeting.*

The Kingdom of Saudi Arabia's Ministry of Energy and Saudi Arabian Basic Industries Corporation (SABIC) will host a Middle East and South Africa Carbon Sequestration Leadership Forum (CSLF) Regional Stakeholder Engagement Workshop on October 25-26, 2017, in Riyadh, Saudi Arabia. The workshop will bring together the private sector, academia, governments, and non-governmental organizations from the Gulf Cooperation Council and South Africa to discuss regional opportunities and challenges for CO<sub>2</sub> storage and utilization.

### *NETL Research Studies CO<sub>2</sub> Interaction with Shale.*

NETL researchers are using complex experiments to determine if shale formations can serve as a storage reservoir for CO<sub>2</sub> captured from fossil fuel-burning power plants and other industries. Initial NETL research has shown that injected CO<sub>2</sub> may change the rock's porosity and permeability; understanding these and other effects is key to developing successful carbon storage techniques and achieving more accurate predictions of the formation's storage potential. The research supports DOE's goal to increase the ability to predict CO<sub>2</sub> storage capacity in geologic formations to within  $\pm$  30 percent. From *NETL News Release* on September 5, 2017.



### *Researchers Study Potential Leakage and Related Cost.*

A study conducted by researchers from Princeton University shows that CO<sub>2</sub> storage would not be prone to leakage or high costs related to fixing leaks. Based on the levels of leakage at simulated hypothetical subsurface CO<sub>2</sub> storage locations, the researchers found that the cost of the technology, even in worst case scenarios, was not prohibitive. The study, *published in the online journal Climatic Change*, was conducted with modeling based on both the geophysical aspects of CCS (e.g., flow through subsurface geologic formations) and economic modeling of the global energy market, using an integrated assessment model. From *Carbon Capture Journal* on September 1, 2017.

### *Forest Conservation Project to Benefit Carbon Storage.*

The California Department of Forestry and Fire Protection (CAL FIRE) awarded a California Climate Investment grant to Pacific Forest Trust (PFT) for a project that will, among other objectives, promote carbon storage. As part of the multi-partner forest health and conservation project, PFT officials say the project will include higher levels of carbon storage in forests. The California Climate Investment Program reinvests revenue generated by California's cap-and-trade program to reduce GHG emissions. From *Mount Shasta News* on August 17, 2017.

## LEGISLATION and POLICY

### *New Regulations to Reduce GHG Emissions.*

Massachusetts introduced new regulations that will bring the state into full compliance with the state law calling for a 25 percent reduction in GHG emissions by 2020. Among the new set of rules are clean energy requirements for utilities and reductions in CO<sub>2</sub> emissions from electricity-generating plants. In addition to the 2020 target of a 25 percent reduction in emissions relative to 1990 levels, the state law also sets an 80 percent reduction goal by 2050. From *Sentinel and Enterprise* on August 11, 2017.

### *CO<sub>2</sub> Storage Legislation Reintroduced.*

The *CO<sub>2</sub> Regulatory Certainty Act*, which encourages CO<sub>2</sub> storage, has been reintroduced. The legislation looks to ensure taxpayers are better able to utilize the Section 45Q carbon storage tax credit by aligning tax guidelines with existing federal regulations. While project developers can currently claim credit for CO<sub>2</sub> storage, the Internal Revenue Service (IRS) does not provide guidance that reflects differences between permanent or geologic storage and enhanced oil and gas recovery. This legislation will look to clarify and align IRS guidelines with current U.S. Environment Protection Agency (EPA) regulations, which reflect the differences between oil and gas recovery and geologic storage. From *U.S. Senator John Hoeven News Release* on August 2, 2017.

## EMISSIONS TRADING

### *RGGI States Announce Proposed Program Changes.*

The states participating in RGGI announced a set of draft program elements to guide them on the final economic analysis and to help establish a post-2020 path forward for the program. The RGGI states propose a regional cap trajectory that will provide an additional 30 percent cap reduction by 2030, relative to 2020 levels. In addition, the proposal also includes: additional adjustments to the RGGI cap to account for the full bank of excess allowances at the end of 2020; modifications to the Cost Containment Reserve (CCR); and the implementation of an Emissions Containment Reserve (ECR) in 2021, which would allow states to withhold allowances from circulation to secure additional emission reductions if prices fall below established trigger prices. From *RGGI News Release* on August 23, 2017.

### *China to Launch Carbon Emissions Market.*

According to a report by *Scientific American*, China's National Development and Reform Commission (NDRC) plans to establish a national carbon-trading system and launch a carbon emissions market. NDRC stated in a report that a carbon emissions quota control system will be applied to manage the cap-and-trade program, and that a state and local two-level management system will be set up for the emissions market. From *China Daily* on August 16, 2017.

### *Governments Look to Increase Carbon Trading.*

Officials from 26 governments have agreed to "renewed cooperation" on carbon trading markets as part of efforts to reduce GHG emissions. The governments, which include Mexico, European Union (EU) member states, California, and the United Kingdom, released the [joint statement](#) following a meeting of policymakers in Lisbon, Portugal. Organized by the International Carbon Action Partnership (ICAP), the event brought policymakers from around world together to discuss best practices on carbon markets. From *BusinessGreen* on September 4, 2017.

## CLIMATE and SCIENCE NEWS

### *Elevated CO<sub>2</sub> Levels May Strip Food Crops of Nutrients.*

According to a study conducted at Harvard's School of Public Health, higher levels of atmospheric CO<sub>2</sub> have the potential to lower the level of key nutrients in some food crops. To quantify the effect it could have on the world's population, scientists built a database detailing the foods people eat, and its nutrient content, for 152 countries. Accounting for differences in diets, age, and gender, the researchers calculated the number of people not getting enough of certain nutrients, projecting potential changes in the protein and iron content through 2050. The results, published in two separate reports, showed that an additional 150 million people may be at risk for protein deficiency due to elevated levels of CO<sub>2</sub> in the atmosphere. From *domain-b.com* on August 3, 2017.



## JOURNAL ARTICLES

### *A techno-economic analysis of EU renewable electricity policy pathways in 2030.*

The following is the Abstract of this article: "The aim of this paper is to assess several pathways of a [harmonized] European policy framework for supporting renewable electricity (RES-E) in a 2030 horizon according to different criteria. The pathways combine two main dimensions: degrees of [harmonization] and instruments and design elements. A quantitative model-based analysis with the Green-X model is provided. The results of the simulations show that there are small differences between the evaluated cases regarding effectiveness. All the policy pathways score similarly with respect to RES-E deployment, i.e., with different degrees of [harmonization] and whether using a feed-in tariff, a feed-in premium, a quota system with banding or a quota without banding scheme. In contrast, the policy costs clearly differ across the pathways, but the differences can mostly be attributed to the instruments rather than to the degrees of [harmonization]. This is also the case with other criteria (static and dynamic efficiency and the socioeconomic and environmental benefits in terms of CO<sub>2</sub> emissions and fossil fuels avoided). Both the degree of [harmonization] and the choice of instrument influence the distribution of support costs across countries. Finally, [the authors'] findings suggest that keeping strengthened national support leads to similar results to other policy pathways." **Pablo del Rio, Gustav Resch, Andre Ortner, Lukas Liebmann, Sebastian Busch, and Christian Panzer**, *Energy Policy*. (Subscription may be required.)

### *An analysis of CO<sub>2</sub> emissions in Italy through the Macro Multiplier (MM) approach.*

The following is the Abstract of this article: "The issue of policy design into the environmental economic literature is becoming a crucial point especially for the relevance of its implication on international agreements for climate change and for the definition of climate actions against GHGs emissions. The identification of economic drivers accountable for the CO<sub>2</sub> emissions, which represent the major part of GHGs emissions, represents a central topic on literature using Input-Output analysis. The paper proposes a methodological innovation on the study of suitable policy instrument against the raise of CO<sub>2</sub> emissions, which is based on the approach of the Macro Multipliers (MM) that leads with the recognition of the impact of all those industries responsible for CO<sub>2</sub> emissions. From the policy perspective, the relevance of industries responsible for CO<sub>2</sub> emissions is also [analyzed] in this approach in which [the authors] introduce the target efficiency index and the control effectiveness index across industries. As part of final demand vector, each commodity has its own relevance, or effectiveness, in pursuing the attainment of the target vector. On the other hand as part of the target vectors, each industry emission has its own efficiency in being conveniently modified by changing the policy control vector. The results deriving from the MM approach demonstrate the possibility to overcome the limits of the linkages analysis. In particular, the set of information deriving from the target efficiency and the control effectiveness indices for industries allows designing environmental policies in a framework where economic aggregates are defined in value and physical units. Using the input-output table, this study investigates the impacts of industries activities on CO<sub>2</sub> emission using the MM approach for the Italian economy." **Yousaf Ali, Maurizio Ciaschini, Claudio Socci, Rosita Pretaroli, and Francesca Severini**, *Journal of Cleaner Production*. (Subscription may be required.)

### *The role of carbon dioxide in the transport and fractionation of metals by geological fluids.*

The following is from the Abstract of this article: "Although [CO<sub>2</sub>] is one of the major components of crustal fluids responsible for ore deposit formation, its effect on transport and precipitation of metals remains unknown, due to a lack of direct experimental data and physical-chemical models for CO<sub>2</sub>-rich fluids. To fill this gap, [the authors] combined laboratory experiments and thermodynamic modeling to systematically quantify the role played by CO<sub>2</sub> for the solubility of economically important metals such as Fe, Cu, Zn, Au, Mo, Pt, Sn under hydrothermal conditions. Solubility measurements of common ore minerals of these metals (FeS<sub>2</sub>, CuFeS<sub>2</sub>, ZnS, Au, MoS<sub>2</sub>, PtS, SnO<sub>2</sub>) were performed, using a flexible-cell reactor equipped with a rapid sampling device, in a single-phase fluid (CO<sub>2</sub>-H<sub>2</sub>O-KCl) at 350–450°C and 600–750 bar, buffered with iron sulfide and oxide and alkali-aluminosilicate mineral assemblages. In addition, another type of experiments was conducted to measure gold solubility in more sulfur-rich supercritical CO<sub>2</sub>-H<sub>2</sub>O-S-NaOH fluids at 450°C and 700 bar using a batch reactor that allows fluid quenching. [The authors'] results show that the solubilities of Si, Au, Mo, Pt and Cu either decrease (within <1 log unit) or remain constant upon CO<sub>2</sub> increase, whereas those of Fe, Zn and Sn increase significantly (>1 log unit) with CO<sub>2</sub> contents in the fluid increasing from 0 to 50 wt%. These data were interpreted using a simple model that does not require any new adjustable parameters, and is based on the dielectric constant of the H<sub>2</sub>O-CO<sub>2</sub> solvent and on the Born solvation parameter for the dominant metal-bearing species in an aqueous fluid. [The authors'] predictions using this model suggest that in a supercritical CO<sub>2</sub>-H<sub>2</sub>O-S-salt fluid typical of metamorphic Au deposits, in equilibrium with pyrite and chalcopyrite, the Cu/Fe ratio decreases by up to 2 orders of magnitude with an increase of CO<sub>2</sub> content from 0 to 70 wt%. This effect is due to the decrease of the fluid dielectric constant in the presence of CO<sub>2</sub>, which favors the stability of neutral species (FeCl<sub>2</sub><sup>0</sup>) compared to charged ones (CuCl<sub>2</sub><sup>-</sup>)..." **Maria A. Kokh, Nikolay N. Akinfiev, Gleb S. Pokrovski, Stefano Salvi, and Damien Guillaume**, *Geochimica et Cosmochimica Acta*. (Subscription may be required.)

### *Phase equilibrium of CCS mixtures: Equation of state modeling and Monte Carlo simulation.*

The following is the Abstract of this article: "To understand the role played by the impurities (such as N<sub>2</sub>, Ar, H<sub>2</sub>, CO, SO<sub>2</sub>, O<sub>2</sub> and NO) during the processes of CCS, it is essential to know the thermodynamic properties of the CO<sub>2</sub>-impurities mixtures under the conditions of CO<sub>2</sub> capture, transport and storage. Considering the variety of composition of these gas mixtures, it is necessary to have at one's disposal suitable models to predict their thermodynamic properties. In this work, two thermodynamic models: the E-PPR78 (Enhanced Predictive Peng-Robinson, 1978) and the PC-SAFT (Perturbed-Chain Statistical Associating Fluid Theory) models, are applied for describing the phase equilibria properties of 77 binary CCS mixtures containing CO<sub>2</sub>, gas impurities (SO<sub>2</sub>, O<sub>2</sub> and NO), water and hydrocarbons. [The authors'] research results indicate that both models are able to accurately predict the phase behavior of binary CCS mixtures. It was however necessary to adjust the binary interaction parameters ( $K_{ij,PC-SAFT}$ ) within the PC-SAFT model to improve the prediction accuracy. Compared to the PC-SAFT model with one temperature-independent binary interaction parameter, the E-PPR78 model normally shows better prediction accuracy for the investigated systems. In addition, to extend the experimental database which was built for the evaluations of Equation-of-State (EoS) modeling, the Monte Carlo (MC) simulation method is employed in this work to generate phase-equilibrium data of a few CCS mixtures deemed as insufficiently described by experimental measurements reported in the open literature." **XiaoChun Xu, Romain Privat, Jean-Noel Jaubert, Veronique Lachet, and Benoit Creton**, *The Journal of Supercritical Fluids*. (Subscription may be required.)

## JOURNAL ARTICLES (cont.)

### *Using noble gas fingerprints at the Kerr Farm to assess CO<sub>2</sub> leakage allegations linked to the Weyburn-Midale CO<sub>2</sub> monitoring and storage project.*

The following is the Abstract of this article: "For [CCS] technology to successfully contribute to climate mitigation efforts, the stored CO<sub>2</sub> must be securely isolated from the atmosphere and oceans. Hence, there is a need to establish and verify monitoring techniques that can detect unplanned migration of injected CO<sub>2</sub> from a storage site to the near surface. Noble gases are sensitive tracers of crustal fluid input in the subsurface due to their low concentrations and unreactive nature. Several studies have identified their potential to act as tracers of deep fluid migration to the shallow subsurface, but they have yet to be used in a contested situation. In January 2011 it was reported extensively in global media that high CO<sub>2</sub> concentrations in soils and related groundwater pollution had been identified on a farm property belonging to the Kerr family, located near to the town of Weyburn in Saskatchewan, Canada. The origin of this CO<sub>2</sub> pollution was cited to be the nearby Weyburn-Midale CO<sub>2</sub> Monitoring and Storage Project. Here, as part of an investigation funded independently of the Weyburn-Midale field operators, [the authors] present  $\delta^{13}\text{C}_{\text{DIC}}$ ,  $^3\text{He}/^4\text{He}$ ,  $^4\text{He}/^{20}\text{Ne}$ ,  $^{20}\text{Ne}$ ,  $^{36}\text{Ar}$ ,  $^{40}\text{Ar}$  and Kr measured in waters obtained from four groundwater wells located on and surrounding the Kerr property. [The authors] aim to establish if stable carbon and noble gas natural tracers are effective at determining if migration of CO<sub>2</sub> from the storage project was responsible for the alleged high CO<sub>2</sub> concentrations and water pollution measured on the Kerr farm. [The authors] compare the stable carbon isotope and noble gas 'fingerprints' of the Kerr groundwaters to those expected in a water equilibrated with the atmosphere under local recharge conditions, the produced CO<sub>2</sub> obtained from production wells, and the CO<sub>2</sub> injected into the Weyburn and Midale oil fields. [The authors] find that the stable carbon isotope data do not constrain the origin of the dissolved CO<sub>2</sub> in the Kerr groundwaters. Due to low noble gas concentrations in the captured CO<sub>2</sub> [the authors] are unable to completely rule out the presence of 20–34% contribution from injected CO<sub>2</sub> to the groundwaters surrounding the Kerr property. However, [the authors] find that all of the Kerr groundwater samples exhibit noble gas fingerprints that would be expected in a shallow groundwater in contact with the atmosphere and hence there is no evidence for the addition of a deep radiogenic component or dilution from the addition of a gas phase low in atmospheric derived noble gases. [The authors'] findings corroborate previous studies that indicate that elevated CO<sub>2</sub> concentrations found on the Kerr property are almost certainly of biological origin, and not migrated from the deep subsurface. The comprehensive follow up to these CO<sub>2</sub> leakage allegations outlined in this study provides a robust framework for responses to any future leakage allegations at CO<sub>2</sub> storage sites and further highlights that no single technique can categorically identify the origin of CO<sub>2</sub> in the shallow subsurface. Hence, it is essential that the full range of geochemical tracers (stable carbon and <sup>14</sup>C isotopes, noble gases, water chemistry, process based gas ratios) are integrated with a good understanding of geological and engineering data in response to CO<sub>2</sub> leakage allegations in the future." **Stuart M.V. Gilfillan, George William Sherk, Robert J. Poreda, and R. Stuart Haszeldine**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

### *The New Zealand forestry sector's experience in providing carbon sequestration services under the New Zealand Emissions Trading Scheme, 2008 to 2012.*

The following is the Abstract of this article: "The New Zealand government established the New Zealand Emissions Trading scheme (NZ ETS) as the primary mechanism for achieving New Zealand's Kyoto obligations between 2008 and 2012. The legislation made planted forests the first sector to participate in the NZ ETS, starting in 2008. At the same time, other schemes to encourage carbon sequestration through forestry were also implemented. The implementation of the NZ ETS has [focused] on meeting New Zealand's international obligations between 2008 and 2012 at minimum cost, and there is little evidence it has led to any reduction in [GHG] emissions or investment in new planted forests in New Zealand. The NZ ETS has been most effective at facilitating the transfer of international (Kyoto compliant) carbon credits from emitters to the

New Zealand government. These credits have been used to partially meet New Zealand's obligations for the first Kyoto commitment period, allowing other units to be carried over to meet obligations from 2013 to 2020. The paper shows that participation in the NZ ETS is unlikely to contribute a long-term positive impact on profitability of commercial forestry, and that the liabilities created through participation in the NZ ETS do not assist the development of the forestry sector in New Zealand. The paper suggests that the NZ ETS is not the correct policy instrument to encourage carbon sequestration by planted forests." **David Evison**, *Forest Policy and Economics*. (Subscription may be required.)

### *The allowance mechanism of China's carbon trading pilots: A comparative analysis with schemes in EU and California.*

The following is the Abstract of this article: "The allowance mechanism is one of the core and sensitive aspects in the design of a carbon emissions trading scheme and affects the compliance cost for each entity covered under the scheme. By examining China's allowance mechanism from two aspects—allowance allocation and allowance distribution, this paper compares China's carbon trading pilots with the EU Emissions Trading Scheme and California Cap-and-Trade Program. The comparison identifies the unique features in allowance mechanism and particular issues that affect the efficiency of the pilots. The paper also recommends courses of action to strengthen China's existing pilots and to build valuable experiences for the establishment of the national cap-and-trade system in China." **Ling Xiong, Bo Shen, Shaozhou Qi, Lynn Price, and Bin Ye**, *Applied Energy*. (Subscription may be required.)

### *An improved correlation to estimate the minimum miscibility pressure of CO<sub>2</sub> in crude oils for carbon capture, utilization, and storage projects.*

The following is the Abstract of this article: "The utilization of anthropogenic CO<sub>2</sub> for [EOR] while sequestering CO<sub>2</sub> in depleted oil and gas fields is increasingly being viewed as an attractive economic proposition for reducing [GHG] emissions. Typically, CO<sub>2</sub> assisted [EOR] projects are operated at the minimum miscibility pressure (MMP), beyond which the CO<sub>2</sub> and oil phases are completely miscible and the incremental oil recovery from CO<sub>2</sub> displacement does not increase dramatically anymore. Thus, the MMP is a critical parameter in screening-level performance assessments of potential CO<sub>2</sub> floods. The MMP can be measured from displacement experiments in a laboratory using a slim tube apparatus. Alternatively, it can be estimated from statistical correlations developed using reservoir temperature and detailed crude oil composition and analytical methods such as equation of state based simulations. In this paper, [the authors] describe the development and validation of an improved correlation to estimate the MMP of CO<sub>2</sub> in crude oil based only on: (a) reservoir temperature, and (b) molecular weight of the C5+ fraction, which can also be estimated from the oil's specific gravity. A power law based predictive model for MMP has been developed through statistical analysis of data from published literature pertaining to crude oil with a wide range of temperatures and molecular weights. The resulting predictions were compared with those obtained from previously established and widely used correlations and found to have a higher degree of accuracy." **Manoj Kumar Valluri, Srikanta Mishra, and Jared Schuetter**, *Journal of Petroleum Science and Engineering*. (Subscription may be required.)

## REPORTS and OTHER PUBLICATIONS

***Compressive and Tensile Strength of Class H Cement Exposed to High Pressure and Temperature Storage Conditions.***

The following is the Abstract of this National Risk Assessment Partnership (NRAP) document: "In the United States, the implementation of [co]-storage (CO<sub>2</sub>-O<sub>2</sub>-SO<sub>2</sub> mixtures) from oxy-fueled combustion, coal gasification and sour gas is currently being considered in saline geologic formations. [DOE's] NETL, as part of NRAP, was tasked to determine the risk related to geologic carbon storage. This report addresses the potential impacts on wellbore cement integrity following exposure to storage conditions. When plumes of injected CO<sub>2</sub> (or co-stored) gas come in contact with existing wells, the cement lining in the well is vulnerable to geochemical alteration, and impact the well's effectiveness as a barrier for unwanted fluid migration. In this study, cured Class H cement paste, used in well construction, was exposed to co-storage conditions, and the tensile and compressive strength were measured to understand the effects of co-stored gas on the geomechanical properties of cement. In addition, co-storage settings at higher formation temperatures may result in loss of cement strength under acidic conditions, though cement integrity has not been tested under fully in situ conditions. These observed effects have implications for the long-term effectiveness of wells using Class H cement paste in co-storage scenarios."

***Chemical – Mechanical – Transport Model for Wellbore Permeability for CO<sub>2</sub> Storage.***

The following is the Introduction of this NRAP document: "Wellbores are considered to be a primary pathway of concern for potential CO<sub>2</sub> and brine leakage from storage reservoirs to drinking water aquifers and the atmosphere. This study investigated how chemical alteration of wellbore cement affects the mechanical and hydraulic properties of wellbore fractures and interfaces to better assess the risk for CO<sub>2</sub> leakage from storage reservoirs. The observed trends are explained in hydraulic aperture in these experiments by proposing that chemical alteration weakens the asperities that hold open pathways at cement-caprock interfaces, thereby causing the fracture to close in response to pressure placed on the sample."

***Public outreach approaches for carbon capture and storage projects.***

The following is a description of this International Energy Agency Clean Coal Center (IEA CCC) document: "Following a few early failures of large-scale CCS demonstration projects due to public opposition to the technology, a considered public communication strategy is now regarded as an essential factor in the success of any prospective CCS project. Most active opposition to CCS has occurred in parts of Europe, where public fears over CO<sub>2</sub> leaks, water contamination, or '[industrialization]' of rural areas have combined with opposition by environmental groups and others to fossil fuels playing any role in a future energy mix. However, many other projects have since won acceptance or even widespread support, thanks either to improved public engagement or more [favorable] local context. Several key features of a successful communications strategy have been identified, including the need for engagement early in the process, encouraging and responding to community feedback, building and maintaining trust in the project developers, and use of a dedicated communications team with clear messages which are tailored to their intended audience. This report provides a comprehensive review of the public outreach strategy and results at most notable CCS demonstrations to date, and looks to future challenges for CCS communication. With the barrier of local acceptance appearing surmountable in most regions, the problem of making the wider case for CCS as a viable option for climate change mitigation largely remains. This could potentially be addressed through education initiatives and more effective use of mass media."

## ABOUT DOE'S CARBON STORAGE PROGRAM

The **Carbon Storage Program** advances the development and validation of technologies that enable safe, cost-effective, permanent geologic storage of CO<sub>2</sub>. The Carbon Storage Program also supports the development of best practices for CCS that will benefit projects implementing CCS at a commercial scale, such as those being performed under NETL's Clean Coal Power Initiative and Industrial Carbon Capture and Storage Programs. The technologies being developed and the small- and large-scale injection projects conducted through this program will be used to benefit the existing and future fleet of fossil fuel power-generating facilities by developing tools to increase our understanding of the behavior of CO<sub>2</sub> in the subsurface and identifying the geologic reservoirs appropriate for CO<sub>2</sub> 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



The [National Energy Technology Laboratory's CCS Database](#) includes active, proposed, and terminated CCS projects worldwide. The information is taken from publically available sources to provide convenient access to information regarding efforts by various industries, public groups, and governments towards development and eventual deployment of CCS technology. NETL's CCS Database is available as a Microsoft Excel spreadsheet and also as a customizable layer in Google Earth.

Newsletters, program fact sheets, best practices manuals, roadmaps, educational resources, presentations, and more are available via the [Carbon Storage Program Publications webpage](#).

Get answers to your carbon capture and storage questions at NETL's [Frequently Asked Questions webpage](#).

## 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.



### National Energy Technology Laboratory

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### Get Social with Us

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



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