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CARBON STORAGE NEWSLETTER

APRIL 2020

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

NETL's Decarbonization Work Highlighted at Meeting.

The National Energy Technology Laboratory (NETL) Director, Brian Anderson, shared information on NETL's decarbonization work while speaking at a Massachusetts Institute of Technology (MIT) Energy Initiative meeting. NETL's advancements in cost-effective implementation of carbon capture, utilization, and storage (CCUS) technologies were highlighted, as was NETL's Carbon Storage Program. Video of the Director's presentation is [available online](#). From *NETL News Release*, March 2020.



ANNOUNCEMENTS

NETL Celebrates 2019 Achievements.

NETL celebrated more than 30 notable 2019 Science and Technology (S&T) accomplishments at the *S&T Accomplishments Session* held at its Pittsburgh, Pennsylvania (USA) site. The interactive poster session featured a broad range of NETL researchers sharing work that showcased NETL's facilities and core science and engineering capabilities.



FY 2021 Congressional Budget Request Released.

The President's FY 2021 Congressional Budget Request seeking funding for the U.S. Department of Energy's (DOE) Office of Fossil Energy (FE) was released. The Budget Request includes funding for the Fossil Energy Research and Development (R&D) Program, which includes R&D programs in CCUS.

NETL Releases New Infographic.

NETL released an infographic highlighting the role of advanced manufacturing in reducing costs associated with carbon capture. The "Advanced Manufacturing to Drive Down Capture Costs" infographic is part of a *series of infographics* published by NETL in support of the *Carbon Capture Program*.



RGGI Releases Interim Compliance Report.

Regional Greenhouse Gas Initiative (RGGI) carbon dioxide (CO₂) budget sources participating in the 2019 interim control period were *required* to provide allowances equal to 50% of their 2019 emissions. The 2019 Interim Compliance Summary Report contains data regarding CO₂ allowances provided by CO₂ budget sources to meet their 2019 interim control period obligation.

ANNOUNCEMENTS *(cont.)*

MOU Includes CCS.

Fortum Corporation, a Finnish clean-energy company, and Kvaerner, a Norwegian engineering, procurement, and construction company, signed a Memorandum of Understanding (MOU) to identify projects and opportunities for technical or commercial operation, which may include plants with carbon capture and storage (CCS) technology.

World Carbon Fund Launched.

A London-based environmental asset management firm launched the *World Carbon Fund*, which ties a percentage of fund investment to carbon storage. Carbon Cap Management's fund also invests in and trades liquid carbon allowance certificates, carbon futures, and carbon options.

CCS Policy Forum Convened.

CO2CRC convened the inaugural CO2CRC CCS Policy Forum to develop an industry view on practical CCS policy framework that will stimulate CCS project investment in Australia.



CCS Forum Held in Washington, DC.

The Global CCS Institute hosted the ninth annual forum on CCS in Washington, DC (USA). Experts discussed key areas to advance CCS in North America, including enabling access to geologic storage hubs and solutions across the CCUS value chain.



PROJECT and BUSINESS DEVELOPMENTS

NETL-Funded Research Project to Study Geologic CO₂ Storage.

Scientists at Virginia Polytechnic Institute and State University (USA) are researching geologic CO₂ storage through two projects, one of which is funded by DOE/NETL's University Coalition for Fossil Energy Research Program. This project aims to develop a machine-learning-based, scale-bridging, data assimilation framework with applications to geologic CO₂ storage. The other project is funded by the National Science Foundation to study the fundamentals of miscible density-driven convection in porous media, which is encountered in geologic carbon storage. From *Carbon Capture Journal*. March 2020.



ADNOC Expands CCUS Program.

The Abu Dhabi National Oil Company (ADNOC) announced plans to expand its CCUS program. According to officials, ADNOC plans to expand the capacity of the program by more 500%, with a goal of reaching 5 million metric tons of CO₂ per year. ADNOC's Al Reyadah facility in the emirate of Abu Dhabi currently has the capacity to capture 800,000 metric tons of CO₂ annually. From *Gasworld*. February 2020.

Drilling Project Confirms Carbon Storage Site.

Results from drilling at the *Northern Lights project* were released and, according to the Norwegian Ministry of Energy and Petroleum, the respective area on the Norwegian Continental Shelf could be suitable for CO₂ storage. Part of Norway's full-scale CO₂ capture and return project, the Northern Light project will capture CO₂ from a cement plant in Brevik and a waste-to-energy plant in Klemetsrud, eventually transporting it via pipeline offshore to a storage location below the seabed in the North Sea. From *The Maritime Executive*. March 2020.

CCS Assessment Atlas Completed in Canada.

TGS, a provider of geoscience data for exploration and production companies, announced the completion of a CCS assessment atlas, which provides an understanding of geologic carbon storage locations (onshore and offshore) throughout British Columbia. Collaborating with Canadian Discovery Limited, TGS created a framework for carbon storage assessment and an atlas for potential storage locations. From *TGS Press Release*. March 2020.



Energy Companies Join Forces on CCS.

Energy companies Santos and BP entered into an agreement to store up to 20 million metric tons of CO₂ per year in the Moomba gas fields in Australia. While the initial proposal is to store 1 million metric tons per year, the Cooper Basin (located mainly in the southwest part of Queensland, Australia) has the capacity to store up to 20 million metric tons per year for 50 years. The companies will next seek Australian government support in the form of carbon credits. From *Australian Financial Review*. March 2020.

UK CCS Project Progresses.

Costain, an infrastructure solutions company, was selected to provide technical consultancy services to the Acorn CCS project. The Pale Blue Dot Energy project is a CCS scheme with the objective to enable the capture and storage of current CO₂ emissions from the onshore gas facilities at the St. Fergus terminal in Scotland.

Acorn will take advantage of existing oil and gas infrastructure and a well-understood offshore CO₂ storage site, which has a UK CO₂ appraisal and storage license awarded by the UK Oil and Gas Authority. From *Costain News Release*. March 2020.



CCS Consortium to Develop Teesside Project.

The Oil and Gas Climate Initiative investment fund announced the formation of a consortium to accelerate the development of the Net Zero Teesside project, which plans to build a transportation and storage system to capture industrial CO₂ and store it under the North Sea. In addition, Net Zero Teesside plans to sign three MOUs with existing industrial partners to evaluate technical and commercial cases for CCS. From *Net Zero Teesside*. February 2020.

Research Project Delivers Insights into the Monitoring of Stored CO₂.

CO2CRC's Otway Stage 2C research project provided findings regarding the monitoring of CO₂ stored underground that were used for a larger project: CO2CRC's Otway Stage 3. Work on Otway Stage 3 began in 2019 with the expansion of the Otway National Research Facility by drilling four monitoring wells. Equipped with fiber-optics sensing and subsurface gauges, Otway Stage 3 is expected to demonstrate subsurface monitoring technologies and improve CO₂ storage monitoring. From *CO2CRC Media Release*. February 2020.

LEGISLATION and POLICY

[Executive Order Directs Oregon Agencies to Reduce Emissions.](#)

Oregon's Governor signed an [executive order](#) directing state agencies in Oregon (USA) to adopt a series of measures to reduce the state's overall greenhouse gas (GHG) emissions. Under the order, the state will enforce a standard to lower the carbon impacts of transportation fuels and cap emissions from industrial processes, transportation fuels, and natural gas. According to a [Governor's Office press release](#), the order updates the state's existing carbon emissions goals, setting a standard of 45% reduction from 1990 levels by 2035, and an 80% reduction from 1990 levels by 2050. From *The Register-Guard*. March 2020.

[Vermont House Approves Bill.](#)

The Vermont House approved legislation that would legally mandate the state to meet carbon emissions reduction targets. Under the legislation, Vermont (USA) would be required to develop a plan to reduce GHG emissions to 26% below 2005 levels by 2025. Emissions would also need to be 40% below 1990 levels by 2030, and 80% below by 2050. From *VT Digger*. February 2020.

[EU Unveils Industrial Strategy to be Carbon-Neutral by 2050.](#)

The European Commission presented a new industrial strategy to help Europe become carbon-neutral by 2050. Included in the strategy are measures intended to strengthen current carbon release tools and secure a supply of low-carbon energy, as well as the development of an alliance of low-carbon industries. The [government also announced](#) that CCS will be established in at least two sites in the United Kingdom, one by the mid-2020s and a second by 2030. From *ReNews.biz*. March 2020.



EMISSIONS TRADING

[S&P Dow Jones Launches EU Carbon Allowance Index.](#)

S&P Dow Jones Indices launched an index to track European Union carbon allowance prices. According to a [press release](#), the new index provides investors with a publicly available investment performance benchmark for European Carbon Emission Allowances and is an expansion of the single-commodity series of indices based on the [S&P GSCI](#). From *Carbon Pulse*. March 2020.

[Results of 47th RGGI Auction Released.](#)

The RGGI-participating states announced the results of their 47th auction of CO₂ allowances. A total of 16,208,347 CO₂ allowances were sold at a clearing price of \$5.65, with bids ranging from \$2.32 to \$6.75 per allowance. In addition, none of the 11.8 million cost containment reserve (CCR) allowances made available were sold. (The CCR is a fixed additional supply of allowances made available if CO₂ allowance prices exceed certain price levels [\$10.77 in 2020].) Auction 47 generated \$91.6 million for states to reinvest in strategic programs, including energy efficiency and GHG abatement programs. Additional details are available in the [Market Monitor Report for Auction 47](#). From *RGGI News Release*. March 2020.

RGGI Inc.



SCIENCE NEWS

[Scientists Use AI to Store CO₂.](#)

MIT scientists [developed](#) a machine learning system that uses artificial intelligence (AI) to map underground structures for storing CO₂. The research team studied "hidden correlations" in components of high-frequency data from simulated earthquakes to spot low-frequency waves that would best help map the subterranean landscape. The AI learned how to find patterns that could be used to infer low frequencies, creating an algorithmic system that has the potential to estimate low frequencies and map the underground with greater accuracy. From *Engadget*. March 2020.



[New Method Converts CO₂ to Methane at Low Temperatures.](#)

Scientists from Waseda University in Tokyo, Japan, developed a new method that converts CO₂ to valuable chemicals for use in carbon capture and utilization. [Reported in the journal Chemical Letters](#), the method has the potential to convert CO₂ into methane more efficiently and quickly than previous methods. According to the research, the method could produce methane from atmospheric CO₂, possibly enabling an unlimited amount of methane production by recycling CO₂ released from factories. From *Waseda University News*. February 2020.



WASEDA
University

PUBLICATIONS

Natural Gas Combined Cycle Carbon Capture Retrofit Database.

The following is a description of this DOE/NETL document: "This tool provides high-level analysis on the incremental costs for retrofitting point sources with carbon dioxide (CO₂) capture and/or compression systems. Options are available to include costs of other technological improvements that would be required to comply with various regulations and New Source Performance Standards when installing CO₂ scrubbing technology."

Innovating to Net Zero.

The following is from the Executive Summary of this Energy Systems Catapult document: "Meeting the UK's Net Zero target will require unprecedented innovation across the economy. Innovation not just in new technologies, but in new ways of deploying existing technologies, new business models, new consumer offerings, and, crucially, new policy, regulation and market design. Unleashing innovation at the pace and scale needed requires a deep understanding of how the different parts of the energy system interact; in short, taking a whole system approach. This report updates Energy Systems Catapult's national Energy System Modelling Environment (ESME) to consider the potential pathways to 2050, and to help identify the technologies, products and services which are most important to meeting Net Zero. It recommends what needs to happen during this Parliament to deliver Net Zero levels of investment, infrastructure and innovation. While the challenge is daunting, the commercial opportunity for those companies able to deliver the innovations needed is huge. This analysis will help identify those opportunities, and what may be needed to unlock them."



Leveraging operational information from wastewater injection wells to evaluate CO₂ injection performance for carbon storage applications in the Appalachian Basin.

The following is from the abstract of this article: "Geologic parameters, geophysical logging, injection testing, and operational metrics from wastewater injection wells were integrated to develop a preliminary design of a carbon storage facility in the Appalachian Basin. A scattered group of 10–20 commercial wastewater injection wells dispose off produced water from oil and gas wells in the region, utilizing a sequence of stacked deep saline formations for injection zones. These wastewater injection wells provide practical benchmarks for understanding the feasibility of carbon dioxide (CO₂) storage. Geologic models were developed based on characterization data from the wastewater injection wells. Reservoir simulations were calibrated according to injection testing and operational data from the wastewater injection wells. Long-term operational data on injection flow rates and pressures measured in the wastewater injection wells were especially useful to evaluate the performance of carbon storage applications. The simulations were used to estimate injection pressures, radius of CO₂ saturation, and pressure response for industrial scale CO₂ storage applications. Results were also used to provide a design basis in terms of number of injection wells, well spacing, area of review, injection system components, monitoring plan, and CO₂ pipeline distribution system. The analysis demonstrates that there is sufficient injectivity in the deep saline formations in the west-central Appalachian Basin to store commercial volumes of anthropogenic CO₂. The geologic system appears suitable for supporting CO₂ injection rates of 0.5–1.0 million metric tons per year at injection pressures below formation fracture pressure in a single well. The long-term operational data of wastewater injection wells within the study area suggested a lower permeability-thickness values than indicated by initial reservoir tests. A workflow for developing realistic permeability values for input into reservoir simulations is presented." **Manoj Valluri, Joel Sminchak, Lydia Cumming, Joel Main, and Glenn Larsen,** *Greenhouse Gases: Science and Technology.* (Subscription may be required.)

Large CO₂ Storage Volumes Result in Net Negative Emissions for Greenhouse Gas Life Cycle Analysis Based on Records from 22 Years of CO₂-Enhanced Oil Recovery Operations.

The following is from the abstract of this article: "Emissions were documented in a greenhouse gas emission life cycle analysis of 22 years of CO₂-enhanced oil recovery (CO₂-EOR) operations for a site in the Northern Michigan Basin, U.S. At the site, CO₂ was cycled through a series of 10 carbonate reef structures 1500–2000 m deep in the subsurface. The CO₂ mobilized oil in the reefs, and the operator produced [294,321 metric tons (2,290,000 barrels)] of oil with CO₂-EOR at the site from 1996 to 2017. In the process, a total of [2,089,000] metric tons of CO₂ were stored in the deep rock formations, which is a very large volume for CO₂-EOR applications of this scale. The life cycle analysis accounted for greenhouse gas emissions related to CO₂ capture, compression, pipeline transport, CO₂ injection, oil processing, CO₂ recycle, dehydration, fugitive emissions, construction, land use, well drilling, oil transport, oil refining, hydrocarbon product combustion, and other processes. The analysis was based on site-specific operational records such as natural gas usage, drilling records, and system flow metering. Altogether, the upstream CO₂ capture, 'gate-to-gate' CO₂-EOR operations, and downstream fuel product refining/combustion had total emissions of [1,929,443] metric tons of CO₂ equivalent. Thus, the life cycle analysis showed [–159,907] metric tons of CO₂ equivalent net balance for the CO₂-EOR system for 1996–2017. The CO₂-EOR system obtains CO₂ from a gas processing facility that separates CO₂ from natural gas produced in the area, and the CO₂ would be otherwise vented to the atmosphere. A ready source of CO₂ that allowed a large volume of associated CO₂ storage, compressors that run on natural gas, a small pipeline distribution network, highly contained reservoirs, and government incentives to encourage CO₂ storage also contributed to the lower CO₂ emission balance when compared to other CO₂-EOR life cycle studies. While this site had many favorable factors to result in net negative emissions, it provides an example of managing CO₂-EOR operations and optimizing associated CO₂ storage to reduce net greenhouse gas emissions." **Joel R. Sminchak, Sanjay Mawalkar, and Neeraj Gupta,** *Energy & Fuels.* (Subscription may be required.)

Comparing the explicit and implicit attitudes of energy stakeholders and the public towards carbon capture and storage.

The following is from the abstract of this article: "Research on the attitudes of energy stakeholders and the general public towards Carbon Capture and Storage is a necessary starting point for the industry to understand the development trajectory of the technology. However, previous studies have only used explicit approaches, such as self-report questionnaires, to measure attitudes. Some researchers have argued that explicit measures are not able to reflect participants' true thoughts. To investigate the potential gap between the results of explicit tests and the true attitudes of participants, this study uses the implicit association test, to detect the attitudes towards environmental technology for the first time (to [the authors'] knowledge), by comparing the explicit and implicit attitudes of energy stakeholders and the public towards carbon capture and storage. The results indicate that energy stakeholders hold favorable attitudes, whereas public vary across the two tests. Public show supportive attitudes in the explicit test, but present their concerns about the risk of carbon capture and storage in the implicit test. The inconsistencies between the explicit and implicit test results among the public indicate that researchers need to be very cautious about the method they use to understand attitudes towards carbon capture and storage as well as other environmental technologies. Further, [the authors] suggested that implicit association test would be an effective and easy-to-use approach to complement traditional explicit tests to discover participants' real attitudes towards environmental technologies in the future research." **Yan Sun, Yang Li, Bo-feng Cai, and Qi Li,** *Journal of Cleaner Production.* (Subscription may be required.)

PUBLICATIONS (cont.)

The permitting procedure for CO₂ geological storage for research purposes in a deep saline aquifer in Spain.

The following is from the abstract of this article: "Most European Member States that transposed the *EU Directive 2009/31/CE* on geological storage of carbon dioxide to each national legislation have not yet developed a regulatory framework to govern the permitting process of this industrial activity. This scenario does not help the deployment of Carbon Capture and Storage (CCS) technologies, as regulators, administrations, operators and general public do not handle a clear compendium of rules and standards to follow. This lack of regulation affects even more to the on-shore sites, which are usually surrounded by communities, industries, farms and other environmental elements that require the compliance of regulations to assure safe and controlled industrial processes. This article describes and analyses the workflow followed for granting the storage permit of Hontomín Technology Development Plant (TDP) in Spain. Hontomín is today the only onshore CO₂ injection site in Europe, recognized by the European Parliament as a key test facility for CCS technology development. The authors aim to show the experience gained from this real case as a guideline for regulators, operators and administrations to facilitate the grant of storage permits for supporting the development of industrial scale projects." **J. Carlos de Dios and Roberto Martínez**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

An economic-environmental asset planning in electric distribution networks considering carbon emission trading and demand response.

The following is from the abstract of this article: "Initiatives such as government programs and investment in low-carbon technologies have been adopted to mitigate the carbon emissions in the electricity sector. These initiatives have resulted in new challenges in the power sector, and to address them adequately, innovative frameworks are required in the electric distribution network (EDN) expansion planning and operation problems. Therefore, this work proposes an environmentally committed asset planning approach to remedy the existing issues to some extent. The proposed strategy investigates the benefits of the simultaneous allocation of several assets such as capacitor banks (CBs), distributed generation (DG) units based on renewable energy sources, and energy storage systems (ESSs). Moreover, an innovative carbon emission trading scheme is formulated in the planning stage to mitigate the CO₂ emissions while a demand response program is applied to modify the consumption behavior. The proposed approach is formulated as a two-stage robust mixed-integer programming model, which considers uncertainties associated with the electricity demand and renewable-based DG. To cope with the difficulties of this complex model, utilizing an efficient decomposition algorithm, such as the C&CG decomposition algorithm, is essential. The potential of the proposed approach is studied under different operating conditions and via several test cases on a 137-node EDN. In addition, to validate the performance of the proposed carbon emission scheme, a multi-region 54-node distribution network is adequately evaluated. Results show that by considering simultaneously multiple planning alternatives, carbon emission trading scheme, and the demand response program, the total CO₂ emissions are reduced by up to 15%." **Ozy D. Melgar-Dominguez, Mahdi Pourakbari-Kasmaei, Matti Lehtonen, and José R. Sanches Mantovani**, *Electric Power Systems Research*. (Subscription may be required.)

Price dynamics in the European Union Emissions Trading System and evaluation of its ability to boost emission-related investment decisions.

The following is from the abstract of this article: "The price of permits in the European Union Emissions Trading System (EU ETS) has historically been highly sensitive and prone to jumps. [The authors] consider different stochastic processes to model the price of permits, and show that the Variance Gamma (VG) model provides the best fit for the price distribution, among a selection of infinite activity processes. Using this result as a starting point, [the authors] assess the effects of the EU ETS in delivering low-carbon investments at the firm level, by modeling a price taker electricity producer subject to the EU ETS jurisdiction. [The authors] compute, via Least Squares Monte Carlo, the value of the real option the greenhouse gas emitter has, consisting in the opportunity to switch from its current high-carbon technology to a cleaner one. [The authors] use a VG specification for carbon prices, and a mean-reverting (Brennan-Schwartz) process for the price of fuel. Moreover, [the authors] further analyze the investment decision problem, in case of a CO₂ price stabilization mechanism in the form of a price floor, by explicitly computing the expected value of the investment project by means of Fourier methods. [The authors'] results show that the introduction of the price stabilization mechanism significantly affects the timing of the investment decision, and supports emission-related investments." **Maria Flora and Tiziano Vargiolo**, *European Journal of Operational Research*. (Subscription may be required.)

Flexible Carbon Capture and Utilization technologies in future energy systems and the utilization pathways of captured CO₂.

The following is from the abstract of this article: "Future 100% renewable energy systems will have to integrate different sectors, including provision of power, heating, cooling and transport. Such energy systems will be needed to mitigate the negative impacts of economic development based on the use of fossil fuels, but will rely on variable renewable energy resources. As two-thirds of global greenhouse gas emissions can be attributed to fossil fuel combustion, decarbonization of energy systems is imperative for combating the climate change. Integrating future energy systems with CO₂ capture and utilization technologies can contribute to deep decarbonization. As these technologies can be operated flexibly, they can be used to balance the grid to allow for high levels of variable renewable energy in the power mix. The captured CO₂ can be either utilized as a feedstock for various value-added applications in the chemical industry and related sectors such as the food and beverage industries. This paper reviews the state-of-the-art literature on CO₂ capture and utilization technologies, with an emphasis on their potential integration into a low-carbon, high-renewables penetration grid. The potential market size for CO₂ as raw material is also elaborated and discussed. The review paper provides an insight to the development and the technological needs of different energy system sectors, as well the limitations, challenges and research gaps to the integration of the variable renewable energy sources and flexible carbon capture and utilization technologies." **Hrvoje Mikulčić, Iva Ridjan Skov, Dominik Franjo Dominković, Sharifah Rafidah Wan Alwi, Zainuddin Abdul Manan, Raymond Tan, Neven Duić, Siti Nur Hidayah Mohamad, and Xuebin Wang**, *Renewable and Sustainable Energy Reviews*. (Subscription may be required.)

PUBLICATIONS *(cont.)*

Improved Vinegar & Wellington calibration for estimation of fluid saturation and porosity from CT images for a core flooding test under geologic carbon storage conditions.

The following is from the abstract of this article: "X-ray computed tomography (CT) of fluid flow in formation rocks is an important characterization technique in geologic carbon sequestration research to provide insight into the migration and capillary trapping of CO₂ under reservoir conditions. An improved calibration method adapted from traditional Vinegar & Wellington calibration is proposed to map the 3D pore and fluid distributions from the CT images of CO₂/brine displacement flooding. Similar to Vinegar & Wellington calibration, the proposed method adopts the linear scaling law of CT number transformation to mass density. However, different from Vinegar & Wellington calibration that uses a 100% brine-saturated core image and a 100% CO₂-saturated core image as references to calculate CO₂ and brine saturations at all time steps, the proposed method uses the CT numbers of CO₂ and brine to calculate the incremental of CO₂ and brine saturations from time step *i* to time step *i* + 1. The method is intended for cases in which the two 100% brine saturation and 100% CO₂ saturation images can not be successfully obtained. Overall, the improved calibration proposed by this study presents more reasonable results of CO₂ and brine distribution in a Berea sandstone core, as compared to traditional Vinegar & Wellington calibration. The reconstructed porosity image agrees with the laminated structure of the Berea sandstone core, and the average porosity evaluated over the entire core (0.176) is comparable to the physical porosity (0.165). Furthermore, the reconstructed saturation images using the improved calibration reveal a flat piston-like flooding front from a homogeneous longitudinal-section of the 3D orthogonal view and preferential fingerings from another non-homogeneous longitudinal-section, which are not present in the reconstructed saturation images using traditional Vinegar & Wellington calibration. Concerns and causes with respect to the uncertainty of linear CT number calibration are also explained, and approaches to alleviate the uncertainty are suggested." **Xiuxiu Miao, Yan Wang, Liwei Zhang, Ning Wei, and Xiaochun Li**, *Micron*. (Subscription may be required.)

Towards carbon sequestration using stainless steel slag via phase modification and co-extraction of calcium and magnesium.

The following is the abstract of this article: "Iron- and steelmaking processes produce a large quantities of greenhouse gas and metallurgical slag. Using Ca/Mg-rich phases in the slag to capture and bind the CO₂ via mineral carbonation is a promising approach to reduction of emissions and solid wastes to be landfilled. However, Cr-bearing stainless steel slag (SSS) cannot straightforwardly be employed for carbon capture and storage (CCS) or rather carbon capture and utilization (CCU). For the dual-purpose of chromium immobilization and co-extraction of calcium and magnesium, a slag modification using added MnO is performed followed by an acid leaching treatment. Results show that the MnO content has a significant influence on the phase composition and element distribution of SSS. A Box-Behnken design (BBD) based acid leaching treatment of SSS is investigated and optimized. Second-order polynomial regression models that reveal a functional relationship between processing parameters and leaching yields of calcium and magnesium are established and verified by the analysis of variance (ANOVA). Model calculation results show a good agreement with the experimental data. The direct (linear) and cross-correlated effects of the processing parameters on the leaching yields are illustrated by three-dimensional (3D) response surfaces. The maximum leaching yields of calcium and magnesium obtained in this work are 65 % and 55 %, respectively, while for chromium the leached amounts are well below legislative limits." **Qing Zhao, Kun Liu, Lifeng Sun, Chengjun Liu, Maofa Jiang, Henrik Saxén, and Ron Zevenhoven**, *Process Safety and Environmental Protection*. (Subscription may be required.)

Understanding public support for carbon capture and storage policy: The roles of social capital, stakeholder perceptions, and perceived risk/benefit of technology.

The following is from the abstract of this article: "As climate change mitigation technologies emerge, there is an increased need to understand public support for the technology and the policies that will shape or thwart its evolution. Of particular importance are the communities most directly impacted. The current study focuses on a random sample of 970 adults in eight counties within the oil and gas industry-reliant region of southeast Texas in order to explore support for carbon capture and storage (CCS), which is a climate change mitigation technology that has seen a great deal of investment in that area. Results of ordinary least squares (OLS) regression analysis and general linear modeling (GLM) suggest that policy support – individual support and perceived community support – is dependent on perceived risks and benefits of CCS, community-focused perceptions (including Bourdieu's social capital), and perceptions about stakeholders (trustworthiness and expected role in CCS policy making). One key takeaway is that social capital was both a predictor and moderator in community-level CCS support and helped explain the hidden effects of risk perception of CCS and CCS knowledge on community-level CCS support. Implications for public policy and stakeholder relations are discussed." **Won-Ki Moon, Lee Ann Kahlor, and Hilary Clement Olson**, *Energy Policy*. (Subscription may be required.)

ABOUT DOE'S CARBON STORAGE PROGRAM

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

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

Carbon Storage Program Resources

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



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

ABOUT NETL'S CARBON STORAGE NEWSLETTER

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

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