NATIONAL ENERGY TECHNOLOGY LABORATORY

CSN

CARBON STORAGE NEWSLETTER

VOL. 21, NO. 11

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:

CARBON STORAGE PROGRAM DOCUMENTS and REFERENCE MATERIALS

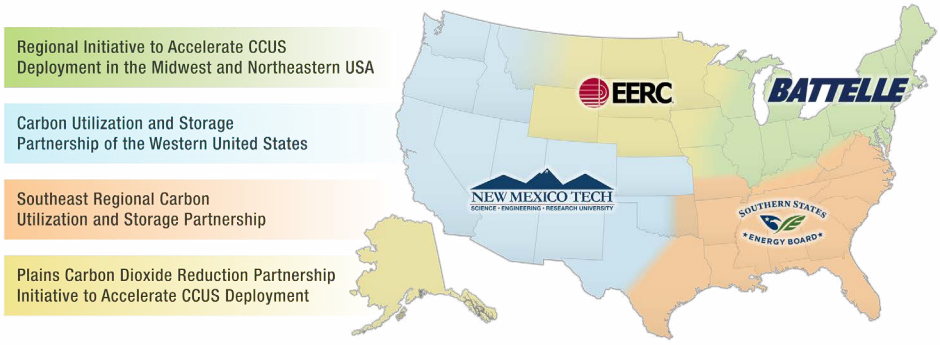
DOE/FECM/NETL HIGHLIGHTS

DOE Announces Intent to Fund Carbon Storage Projects.

The U.S. Department of Energy's (DOE) Office of Fossil Energy and Carbon Management (FECM) released a *Notice of Intent (NOI)* to fund cost-shared research and development (R&D) projects looking to accelerate wide-scale deployment of carbon capture and storage (CCS) and carbon dioxide removal (CDR). 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 carbon dioxide (CO_2). From *energy.gov*. November 2021.

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, representing four regions of the United States, are partnerships with academia, non-governmental organizations, industry leaders, and local and state governments. The initiatives identify and promote carbon storage and transport projects by addressing key technical challenges; facilitating data collection, sharing, and analysis; evaluating regional storage and transport infrastructure; and promoting regional technology transfer. The Regional Initiatives continue the work of predecessors funded under *DOE's Regional Carbon Sequestration Partnership (RCSP) Initiative*, supporting efforts to validate geologic storage technologies and support the commercialization of carbon capture and storage (CCS). From *energy.gov*. October 2021.



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 front-end engineering design studies 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. From *energy.gov*. October 2021.

ANNOUNCEMENTS

DOE Funding to Support Carbon Management Technologies.

DOE's FECM announced funding for four national public power associations to help increase regional- and state-level engagement in carbon management. In one award, the National Association of Regulatory Utility Commissioners will promote learning and discussion of CCUS among its members. In another award, the National Association of State Energy Officials will research, analyze, and develop educational information on new developments in carbon management, including CCUS.

FY 2021 Carbon Storage Newsletter Annual Index Available.

The FY 2021 Carbon Storage Newsletter Annual Index is available. The document is a compilation of NETL's Carbon Storage Newsletters published from October 2020 through September 2021.

ANNOUNCEMENTS *(cont.)*

MRCI Virtual Stakeholder Meeting.

The Midwest Regional Carbon Initiative (MRCI) held their *Fall 2021 MRCI Virtual Stakeholder Meeting* on November 9, 2021. MRCI is one of four individual *Regional Initiatives* that support FECM and build upon advancements made by the RCSP Initiative by identifying and addressing challenges to the widespread, commercial deployment of CCUS.

Partnership Launched to Study CCS.

Louisville Gas and Electric Company, Kentucky Utilities, and the University of Kentucky Center for Applied Energy Research (CAER) launched a partnership to study CCS for gas-powered systems. The partnership will look to develop a flexible, net-negative CO_2 emissions technology that will be applicable to natural gas combined cycle power plants while minimizing the associated capital costs of installation.

CO_2 Capture Collaboration Includes Bio-CCS.

Petrofac and CO_2 Capsol signed an agreement to collaborate on carbon capture projects. The companies are currently collaborating on a bio-energy carbon capture and storage (Bio-CCS) plant in Europe.

RGGI Holds Program Review Listening Session.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) facilitated a listening session to solicit public input on the RGGI's objectives, topics, and analyses. The listening session presentation is *available*.

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.

CCS to be Studied in Western Australia.

Mitsui and Metals National Corporation will conduct a joint feasibility study on CCS in Western Australia. In addition, Mitsui and Wesfarmers Chemicals, Energy, and Fertilisers Limited will jointly study the viability of building a low-carbon ammonia production plant with CCS in Western Australia.

Companies Sign MOU on CCS in Australia.

Santos, an Australian natural gas supplier, signed a Memorandum of Understanding (MOU) to advance CCS at the Bayu-Undan shallow-water field in the Timor Sea. The MOU details the areas in which the Bayu-Undan Joint Venture (operated by Santos) and Autoridade Nacional do Petróleo e Minerais (ANPM; the Timor-Leste regulator) will collaborate to test the viability of repurposing the existing Bayu-Undan facilities and use the Bayu-Undan reservoir for CCS.

Companies Agree to Collaborate on Carbon Management.

Equinor and Rosneft signed an agreement to share experiences and explore low-carbon opportunities to reduce CO_2 emissions from joint projects. The companies will also evaluate potential cooperation opportunities regarding CCUS.

PROJECT and BUSINESS DEVELOPMENTS

Consortium to Evaluate, Develop CCS Projects on US Gulf Coast.

Carbon-Zero US LLC and international multi-energy company Repsol signed an agreement to evaluate opportunities to develop innovative CCS projects on the U.S. Gulf Coast. The consortium will share technical knowledge and resources to evaluate potential projects that would combine the offshore experience and operations of Cox Oil with Repsol's technical knowledge and global experience with CCS projects. From *GlobeNewswire*. November 2021.

CCUS Project Proposed at Synfuels Plant in North Dakota.

Basin Electric Power Cooperative and the Dakota Gasification Company announced a proposed CCUS project at the Great Plains Synfuels Plant near Beulah, North Dakota. The proposed project is expected to enable the facility to capture up to 3.5 million tons of CO_2 per year and be part of a CCUS project that utilizes both enhanced oil recovery (EOR) and carbon storage. The Great Plains Synfuels Plant currently captures approximately 2 million tons of the plant's CO_2 emissions, which are piped to Saskatchewan, Canada, for EOR operations. From *Devils Lake Journal*. September 2021.

CCS Project Receives Funding.

The U.S. Department of Agriculture (USDA) awarded funding to Red Tail Energy to build a carbon capture processing and storage facility at an existing ethanol manufacturing plant in Richardton, North Dakota. Funded through *USDA's Rural Development Program*, the CO_2 storage project would store the CO_2 in the Broom Creek rock formation. From *Williston Herald*. September 2021.

CCS Project Launched in Iceland.

Climeworks, a Swiss carbon capture company, announced the launch of Orca—a direct air capture (DAC) and storage plant in Iceland with the capacity to capture and store approximately 4,000 tons of CO_2 per year. *Carbfix* will mix the air-captured CO_2 with water and store it underground through a natural mineralization process that takes less than two years. From *Power Engineering International*. September 2021.

Carbon Storage Project Announced in Québec.

Questerre Energy Corporation completed the engineering and work program to test a carbon storage reservoir in Québec, Canada. The operation will include an injectivity test to estimate the optimal injection rate for CO_2 into the storage reservoir and the volume that can be stored in the reservoir at a depth of approximately 3,280 feet below the surface in the Potsdam (a Cambrian age sandstone formation). From *Carbon Capture Journal*. September 2021.

Energy Companies Collaborate on Large-Scale CCS Project.

Energy companies Air Liquide and TotalEnergies announced a collaboration on a large-scale CCS project in Normandy, France. Air Liquide will use its carbon capture technology to help reduce the CO_2 released by TotalEnergies' hydrogen production unit, and TotalEnergies will manage the transportation and storage process through projects such Norway's Northern Lights and the Dutch Aramis CCS project. Air Liquide's technology has the potential to reduce CO_2 emissions from the unit's hydrogen production by approximately 650,000 metric tons per year by 2050. From *gasworld*. September 2021.

LEGISLATION and POLICY

Bill Contains Historic CCS Infrastructure Investment.

The U.S. House of Representatives passed *the Infrastructure Investment and Jobs Act*, which contains the largest appropriation of money for CCS in the history of the technology. The bill contains major provisions for CCS, including $2.5 billion appropriated for CCS demonstration projects, $1 billion for large-scale CCS pilot projects, and $3.5 billion for regional DAC hubs over the next five years. The bill also contains the *Storing CO_2 And Lowering Emissions (SCALE) Act* in its entirety, which will direct nearly $5 billion to support the development and financing of CO_2 transport and storage infrastructure and sites. From *Global CCS Institute*. November 2021.

California to Set CO_2 Storage Goals on State Lands.

Legislation intended to boost CO_2 storage efforts on California state lands was signed into law. *SB 27* will require the state Natural Resources Agency to (1) establish carbon storage goals for natural and working lands by July 2023 and (2) create a registry of projects for public and private investment and track the carbon benefits of each project. Under the bill, the California Air Resources Board (CARB) must establish a specific CO_2 removal target for the state's natural and working lands for 2030 and beyond. CARB will also establish the Natural and Working Lands Climate Smart Strategy to serve as a framework to advance the state's goals. From *Argus Media*. September 2021.

Bill Aims to Store CO_2.

A bill was introduced in the U.S. Senate that aims to increase the natural carbon storage capacity of forests and rangelands. The America's Revegetation and Carbon Sequestration Act directs the U.S. Forest Service and Natural Forest Foundation to develop a carbon credit program for non-federal buyers. Under the current plan, revenue from the carbon market would be used to fund additional carbon storage and emissions mitigation efforts on U.S. Forest Service land. From *Casper Star-Tribune*. September 2021.

Australian Government Invests in CCUS Hubs.

The Australian government announced a program to increase the development of commercial-scale CCUS projects and hubs across the country. *The CCUS Hubs and Technologies Program* will operate across two streams: (1) supporting the design and construction of carbon capture hubs and shared infrastructure and (2) supporting the research and commercialization of carbon capture technologies and the identification of viable storage sites. From *Carbon Capture Journal*. September 2021.

EMISSIONS TRADING

Results of 53rd RGGI Auction Released.

The RGGI-participating states announced the results of their 53rd auction of CO_2 allowances. A total of 22,911,423 CO_2 allowances were sold at a clearing price of $9.30, with bids ranging from $2.38 to $12.51 per allowance. In addition, none of the 11.98 million cost containment reserve (CCR) allowances made available were sold. (The CCR is a fixed additional supply of allowances made available if CO_2 allowance prices exceed certain price levels [$13.00 in 2021].) None of the 11.31 million emissions containment reserve (ECR) allowances made available were sold. (The ECR is a designated quantity of allowances to be withheld if an auction's interim clearing price is below an established price level [$6.00 in 2021]). Auction 53 generated $213 million for states to reinvest in strategic programs, including energy efficiency, renewable energy, and greenhouse gas abatement programs. Additional details are available in the *Market Monitor Report for Auction 53*. From *RGGI News Release*. September 2021.

RGGI States Initiate Auction Process for Auction 54.

The RGGI-participating states released the *Auction Notice* for their 54th quarterly CO_2 allowance auction, to be held December 1, 2021. Auction 54 will offer 23,121,518 CO_2 allowances for sale at a minimum reserve price of $2.38. In addition, an 11,976,778 CO_2 allowance CCR will be made available, as will an ECR of 11,307,333 allowances. Auction 54 will be the last quarterly auction in which states will offer CO_2 allowances for purchase to meet CO_2 compliance obligations for this interim control period (January 1–December 31, 2021). From *RGGI*. October 2021.

Australia to Issue Credits for CCS.

The Australian government set rules to issue carbon credits for projects to capture and store CO_2. Under the rules, CCS projects will earn one Australian Carbon Credit Unit (ACCU) for each metric ton of carbon emissions avoided. ACCUs can either be sold by auction to the Australian government's Emissions Reduction Fund or on the private market. From *Reuters*. October 2021.

SCIENCE

Shell Collaborating on Technology for CCS Applications.

Shell and BASF are collaborating to evaluate and deploy BASF's Sorbead® Adsorption Technology for pre- and post-combustion CCS applications. The technology is used to dehydrate CO_2 gas after it has been captured by Shell's carbon capture technologies. According to the companies, the technology treats the CO_2 gas to meet pipeline and underground storage specifications. From *BASF News Release*. September 2021.

Researchers Find Catalyst to Convert CO_2 to Fuel.

Researchers used a supercomputer to identify a group of "single-atom" catalysts that has the potential to convert CO_2 into fuel. Led by Queensland University of Technology's Centre for Materials Science in Australia, the researchers used theoretical modeling to identify six metals that would be effective in a reaction that can convert CO_2 into sustainable and clean energy sources. The study was published in the journal *Nature Communications*. From *ScienceDaily*. October 2021.

Study Measures Reaction of Trees to Elevated Levels of CO_2.

Researchers from the University of Birmingham found that mature oak trees have the potential to increase their rate of photosynthesis by up to one-third. The results, published in the journal *Tree Physiology*, are derived from an outdoor experiment in which an old oak forest was exposed to elevated levels of CO_2. The researchers found, through the first three years of the 10-year project, that the 175-year-old oak trees consistently increased their rate of photosynthesis. The researchers will next measure leaves, wood, roots, and soil to determine where and for how long the extra carbon captured is stored. From *ScienceDaily*. October 2021.

PUBLICATIONS

Carbon Capture and Storage - Global Market Trajectory & Analytics.

The following is from the abstract of this market study published by Global Industry Analysts Inc.: "Amid the COVID-19 crisis, the global market for Carbon Capture and Storage estimated at US$2.8 Billion in the year 2020, is projected to reach a revised size of US$4.9 Billion by 2026, growing at a CAGR of 9.9% over the analysis period. Pre-Combustion, one of the segments analyzed in the report, is projected to grow at a 10.1% CAGR to reach US$4.1 Billion by the end of the analysis period. After a thorough analysis of the business implications of the pandemic and its induced economic crisis, growth in the Post Combustion segment is readjusted to a revised 11.2% CAGR for the next 7-year period. This segment currently accounts for a 11.3% share of the global Carbon Capture and Storage market. Post-combustion capture process involves extraction of carbon dioxide from low-pressure flue gases at conventional power plants and other large point sources after the combustion of fossil fuels or other carbonaceous materials such as biomass. This technology has been widely used for capturing carbon dioxide in the food and beverage sector. Pre-combustion capture technology is more beneficial than post-combustion technology as separating carbon dioxide from hydrogen is much easier than from flue gas due to the fact that the partial pressure and concentration of carbon dioxide is much higher than in flue gases. The technology expands options for various gas separation methodologies, which previously were not possible in post-combustion capture processes."

Influence of capillary threshold pressure and injection well location on the dynamic CO_2 and H_2 storage capacity for the deep geological structure.

The following is from the abstract of this article: "The subject of this study is the analysis of influence of capillary threshold pressure and injection well location on the dynamic CO_2 and H_2 storage capacity for the Lower Jurassic reservoir of the Sierpc structure from central Poland. The results of injection modeling allowed [the authors] to compare the amount of CO_2 and H_2 that the considered structure can store safely over a given time interval. The modeling was performed using a single well for 30 different locations, considering that the minimum capillary pressure of the cap rock and the fracturing pressure should not be exceeded for each gas separately. Other values of capillary threshold pressure for CO_2 and H_2 significantly affect the amount of a given gas that can be injected into the reservoir. The structure under consideration can store approximately 1 Mt CO_2 in 31 years, while in the case of H_2 it is slightly above 4000 tons. The determined CO_2 storage capacity is limited; the structure seems to be more prospective for underground H_2 storage. The CO_2 and H_2 dynamic storage capacity maps are an important element of the analysis of the use of gas storage structures. A much higher fingering effect was observed for H_2 than for CO_2, which may affect the withdrawal of hydrogen. It is recommended to determine the optimum storage depth, particularly for hydrogen. The presented results, important for the assessment of the capacity of geological structures, also relate to the safety of use of CO_2 and H_2 underground storage space." **Katarzyna Luboń and Radosław Tarkowski,** *International Journal of Hydrogen Energy*. (Subscription may be required.)

Recovery of calcium and magnesium bearing phases from iron– and steelmaking slag for CO_2 sequestration.

The following is from the abstract of this article: "Large amounts of iron– and steelmaking slag and greenhouse gas are annually produced by the steel industry worldwide. Using Ca/Mg in the slag to capture and store the CO_2 via mineral carbonation is a promising approach to the reduction of waste emissions. Since iron– and steelmaking slags are a mixture of numerous types of minerals, understanding the dissolution behavior of various phases in solution system is of critical importance for Ca/Mg recovery. In this work, seven Ca/Mg–bearing phases and four typical solutions were prepared and studied. Theoretical results indicated that the order of mineral solubility in aqueous solution is as follows: (CaO and Ca_2SiO_4) > ($Ca_3MgSi_2O_8$, $Ca_2MgSi_2O_7$, and MgO) > $Ca_2Al_2SiO_7$ > $MgCr_2O_4$. A batch of leaching tests was conducted at room temperature, and the recovery yield of Ca/Mg was investigated. It was found that minerals show different dissolution behavior in various systems, and the metallic oxide phases exhibited a relatively higher solubility than silicate phases. The solubility of minerals in various systems was illustrated by radar plots. Moreover, leaching tests for silicate briquettes were performed to investigate the transformation mechanism. On the basis of the results, it was proposed that a silicic acid layer generated on the surface of briquettes in the leaching process, and could transform into porous silica phase via dehydration process. The formed Si–rich layer obstructed the dissolution of inner mineral leading to a low recovery efficiency of Ca/Mg." **Qing Zhao, Jingyu Li, Kaiwen You, and Chengjun Liu,** *Process Safety and Environmental Protection*. (Subscription may be required.)

Is hydrothermal treatment coupled with carbon capture and storage an energy-producing negative emissions technology?

The following is from the abstract of this article: "This paper evaluates the feasibility of hydrothermal treatment (HTT) with carbon capture and storage (CCS) as an energy producing negative emissions technology (NET) and compares such system with a conventional bioenergy with carbon capture and sequestration (BECCS) system. Machine learning models were developed to predict product yields and characteristics from HTT of various feedstocks. The model results were then integrated into a life cycle assessment (LCA) model to compute two metrics: energy return on investment (EROI) and net global warming potential (GWP). Results showed random forest models had better prediction accuracy than regression tree and multiple linear regression to model HTT of feedstocks (e.g., microalgae, crops/forest residues, energy crops, and biodegradable organic wastes) and predicted the mass yields of multiple products (biocrude, hydrochar, gas, and aqueous co product) as well as the energy and carbon contents of biocrude and hydrochar. LCA results revealed that the proposed HTT-CCS system constituted a net-energy producing NET for some combinations of feedstock characteristics and reaction conditions. Best overall energy and GWP performance was achieved for HTT-CCS of lignocellulosic biomass at low temperature. Compared with the conventional BECCS system, HTT-CCS generally exhibited higher EROI but higher net GWP, depending on processing conditions and the feedstock types." **Fangwei Cheng, Michael D. Porter, and Lisa M. Colosi,** *Energy Conversion and Management*. (Subscription may be required.)

Chitosan-based zeolite-Y and ZSM-5 porous biocomposites for H_2 and CO_2 storage.

The following is from the abstract of this article: "Sustainable energy is the most valuable clean and renewable energy for the future. A simple, robust, and inexpensive ecofriendly method has been developed here to prepare chitosan-based zeolite porous biocomposites via solvent exchange followed by calcination. The resulting chitosan-based zeolite biocomposites were characterized using advanced technologies including attenuated total reflection-infrared (ATR-IR) spectroscopy, X-ray powder diffraction (XRD) analysis, thermogravimetric analysis (TGA), high-resolution field-emission scanning electron microscopy (HR-FE-SEM), high-resolution transmission electron microscopy (HR-TEM), and nitrogen adsorption-desorption isotherms. The Brunauer-Emmett-Teller (BET) surface area of the ZeY@CS composite (795 $m^2\ g^{-1}$) was greater than those of ZSM-5@CS (444 $m^2\ g^{-1}$), pure chitosan, pure zeolite Y, and ZSM-5. The chitosan-based zeolite biocomposites show enhanced gas storage for small molecule like CO_2 and hydrogen. Therefore, chitosan-based zeolite biocomposites should be suitable for energy storage, carbon capture, and sequestration (CCS) applications." **Santosh Kumar, Ranajit Bera, Neeladri Das, and Joonseok Koh,** *Carbohydrate Polymers*. (Subscription may be required.)

PUBLICATIONS *(cont.)*

3D grid based screening process for large-scale CO_2 geological storage in Gunsan Basin, Yellow Sea, Korea.

The following is from the abstract of this article: "This study presents an approach to screen sedimentary basins for their CO_2 geological storage potential based on a 3D grid with geological data. The 3D grid-based screening was applied to the Gunsan Basin, offshore Korea, for selecting potential sub-basins. Six sub-basins were recognized and prioritized using a set of quantifiable criteria, reflecting storage capacity, geological risk, and socio-economic aspects. Nine criteria were defined and weighed to reflect local priority and geological characteristics. Every grid cell was populated with geological and geometrical properties, scored and ranked for each criterion. Typically, the storage capacity is used for evaluating the storage potential of a basin, which, however, was not estimated here due to the low quantity of available data. Instead, the capacity potential was quantified by combining the pore volume and Gravitational Number for each grid cell. Mean score values for each sub-basin indicate that the East Sub-basin is the most promising region, containing a suitable aquifer with an estimated storage capacity of a few hundreds of $MtCO_2$. Therefore, [the authors] suggest that the Gunsan Basin is suitable for implementing a CCS program with an injection rate of 4 $MtCO_2$/year for 30 years. Moreover, [the authors] suggest that the 3D grid-based screening process could be used to quickly screen different sub-basins or potential aquifers by depth." **Young Jae Shinn, Hyun Suk Lee, Youngmin Lee, Insun Song, and Myong-HoPark,** *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

A carbon price floor in the reformed EU ETS: Design matters!

The following is from the abstract of this article: "Despite the reform of the European Emissions Trading System (EU ETS), discussions about complementing it with a carbon price floor (CPF) are ongoing. This paper analyzes the effect of a European CPF in the reformed EU ETS using a Hotelling model of the EU ETS, amended by the market stability reserve (MSR), and the cancellation mechanism. Two CPF designs are compared: (1) a buyback program and (2) a top-up tax. The buyback program sets a minimum price for the allowances from the implementation year onwards. After the announcement, firms anticipate the CPF, which immediately increases the carbon price to the discounted CPF level. Therefore, firms emit less and bank more allowances, leading to more intake into the MSR, and more cancellation of allowances. The top-up tax imposes a tax on emissions, which enhances the market price of allowances to the CPF level from the implementation year onwards. Firms increase their short-run emissions in anticipation of the upcoming tax. Only after the implementation year firms start to lower their emissions. Thus, the effect on aggregate cancellation is ambiguous. Despite being equivalent in a static setting, the design choice for the CPF matters in a dynamic context, such as the EU ETS." **Martin Hintermayer,** *Energy Policy*. (Subscription may be required.)

Evaluation of the carbon sequestration capacity of arid mangroves along nutrient availability and salinity gradients along the Red Sea coastline of Saudi Arabia.

The following is from the abstract of this article: "In the present work, [the authors] assessed the carbon sequestration capacity of mangrove forests (Avicennia marina) in relation to nutrient availability and salinity gradients along the Red Sea coast of Saudi Arabia. This was achieved through estimating the sediment bulk density (SBD), sediment organic carbon (SOC) concentration, SOC density, SOC pool, carbon sequestration rate (CSR) and carbon sequestration potential (CSP). The present study was conducted at 3 locations (northern, middle and southern), using 7 sites and 21 stands of mangrove forests (A. marina) along ~1134 km of the Red Sea coastline of Saudi Arabia (from Duba in the north to Jazan in the south), all of which are in an arid climate. The correlation coefficients between the water characteristics and the first two Canonical Correspondence Analysis (CCA) axes indicated that the separation of the sediment parameters along the first axis were positively influenced by TDS (total dissolved solids) and EC (electric conductivity) and were negatively influenced by total N and total P. On the other hand, the second axis was negatively correlated with total N, total P, EC and TDS. The SOC pools at the northern (10.5 kg C m^{-2}) and southern locations (10.4 kg C m^{-2}) were significantly higher than the SOC pool at the middle location (6.7 kg C m^{-2}). In addition, the average CSR of the northern (5.9 g C m^{-2} yr^{-1}) and southern locations (6.0 g C m^{-2} yr^{-1}) were significantly higher than they were in the middle location (5.0 g C m^{-2} yr^{-1})." **Kamal H. Shaltout, Mohamed T. Ahmed, Sulaiman A. Alrumman, Dalia A. Ahmed, and Ebrahem M. Eid,** *Oceanologia*. (Subscription may be required.)

Performance evaluation and carbon assessment of IGCC power plant with coal quality.

The following is from the abstract of this article: "Techno-economic and environmental impacts of coal type were evaluated using a 500 MW-class integrated coal gasification combined cycle (IGCC), including reheat combined cycle process with three-pressure level based on higher than 99.9% sulfur removal and 90% carbon capture. Efficiency and cost of electricity (COE) of four different coals in the IGCC power plant were compared: two bituminous and two sub-bituminous coals. As coal with higher heating value per unit weight was fed into a gasifier, higher cold gas efficiency of the gasifier and greater net overall plant efficiency was achieved. The highest overall plant efficiency of 31.62% could be achieved by using bituminous. Raw water consumption was also affected by the moisture content of the as-received coal. The as-received coal with the highest moisture content consumed the least amount of water. The exergy flow and destruction were presented in Grassmann diagrams to provide more detailed information on main units. However, according to the sensitivity test, the COE was mainly influenced by fuel prices and costs of CO_2 transport and storage. If the price difference between bituminous coals and sub-bituminous coals is reduced, the utilization of bituminous coals becomes more competitive in terms of COE and capital cost." **Hyun-Taek Oh, Woo-Sung Lee, Youngsan Ju, and Chang-Ha Lee,** *Energy*. (Subscription may be required.)

Research trends in carbon capture and storage: A comparison of China with Canada.

The following is from the abstract of this article: "In order to effectively address climate change, academia and industry have paid much attention to the development trend of Carbon Capture and Storage (CCS). However, there is no mature CCS research trend monitoring system. China is likely to be the largest market for CCS technology in the future, while Canada is the first country to start the research and development of CCS. Existing studies have discussed the CCS research trends at the global level, in China, Canada, and in other countries. However, few comparative studies have been carried out in key countries. In this study, an integrated method of bibliometrics and S-Curve is proposed with the purpose of comparing CCS research trends between China and Canada. Firstly, the bibliometrics method was used to compare the conceptual structure and research route of CCS research in China and in Canada. Secondly, the key collaborators were [identified] through the comparison of collaboration relationships. Finally, the S-Curve model was employed to forecast the CCS research output trend in China and Canada. This study found that China's CCS research had the advantage of pre-combustion carbon capture, while Canada's advantage lied in the ecosystem carbon sequestration. It was also shown that Canada's CCS cumulative publication may reach saturation 15 years later than that in China. This paper provides insight into the CCS research and development optimization for China, Canada and globally. The CCS research trends comparison tools proposed in this study can benefit to monitor the CCS research by governments and enterprises." **Jin-Wei Wang, Jia-Ning Kang, Lan-Cui Liu, Ioan Nistor, and Yi-Ming Wei,** *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).

Click here to manage your NETL Carbon Storage Newsletter subscription options or to unsubscribe.

The *National Energy Technology Laboratory (NETL)*, part of the U.S. Department of Energy's (DOE) national laboratory system, is owned and operated by DOE. NETL supports DOE's mission to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions.

1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

Program staff are also located in
Houston, Texas and **Anchorage, Alaska**.

CUSTOMER SERVICE: 1-800-553-7681

www.netl.doe.gov

Contacts

If you have questions, feedback, or suggestions for NETL's Carbon Storage Newsletter, please contact:

Carbon Storage Newsletter Support
CSNFeedback@netl.doe.gov

Mark McKoy
Technology Manager
Carbon Storage
304-285-4426
Mark.McKoy@netl.doe.gov

Get Social with Us

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