Carbon Storage Newsletter

August 2015

What's Inside?

Highlights

"DOE Selects Projects to Assess Offshore Carbon Storage."

The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) has selected four projects to receive funding through NETL's Carbon Storage Program. The research projects will assess the geologic storage potential of offshore subsurface depleted oil and natural gas reservoirs and saline formations on the East Coast of the United States and the Gulf of Mexico by using existing geologic and geophysical data that will approximate the amount of carbon dioxide (CO_2) that can be safely stored. More information on the four projects, titled, "Mid-Atlantic U.S. Offshore Carbon Storage Resource Assessment Project," "Assessment of CO_2 Storage Resources in Depleted Oil and Gas Fields in the Ship Shoal Area, Gulf of Mexico," "Southeast Offshore Storage Resource Assessment," and "Offshore CO_2 Storage Resource Assessment of the Northern Gulf of Mexico (Upper Texas-Western Louisiana Costal Areas)," is available via the above link. From *Energy.gov* on July 15, 2015.

Announcements

NETL Releases Carbon Storage Project Portfolio.

DOE's NETL released the 2015 Carbon Storage Portfolio, which provides a comprehensive overview of the NETL Carbon Storage Program's current and recently completed work. The portfolio includes Storage Division personnel contact information, technology area introductions, project communication products, papers and technical reports, Best Practices Manuals (BPMs), and access to all archived projects.

DOE Selects Projects for Crosscutting Technology Research.

DOE's NETL selected 12 projects to receive funding through its Crosscutting Research Program. Among the projects is General Electric's (GE) "Model-Based Extracted Water Desalination System for Carbon Sequestration," in which GE will partner with Pennsylvania State University to develop a water recovery process from high-salinity extracted formation water that can increase the capacity of saline formations for CO_2 storage.

DOE Selects Project to Advance SCO_2-Based Power Cycles.

DOE's NETL selected a project to develop new recuperator technologies leading to more efficient supercritical carbon dioxide (SCO_2)-based power cycles. The project will apply focused research and development (R&D) to produce recuperator technologies suitable for future deployment in large-scale SCO_2 power cycle applications.

Announcements (Continued)

DoD Releases Report on Climate Change.

The U.S. Department of Defense (DoD) released a report in response to a Senate request to identify potential climate-related risks and provide mitigation strategies. A description of the report, titled, "National Security Implications of Climate-Related Risks and a Changing Climate," is available in the "Recent Publications" section of this newsletter.

Alberta Government Publishes CCS Protocol.

The Alberta Environment and Parks (Canada) published the "Carbon Offset Quantification Protocol for CO_2 Capture and Permanent Storage in Deep Saline [Formations]." The document covers carbon capture and storage (CCS) from capture through compression, transport, injection, and storage. The "Summary of Feedback to Draft Protocol and Responses" from the public comment period is also available. A description of the protocol is available in the "Recent Publications" section of this newsletter.

ETI Seeks CCS Partners.

The Energy Technologies Institute (ETI) is seeking a concept for new power generation capacity fitted with CCS. The investment is expected to support development of an investable, low-cost, low-carbon power scheme, and is designed to take advantage of new CCS infrastructure. The Request for Proposal (RFP) will close on September 15, 2015.

Technical Session on Engineering Geologic CO_2 Storage Systems.

The American Institute of Chemical Engineers' (AIChE) Annual Meeting, scheduled for November 8-13, 2015, in Salt Lake City, Utah, USA, will include a technical session, titled, "Engineering Geologic Carbon Dioxide Storage Systems." Research presentations will cover the science and technology of carbon storage, as well as field demonstrations of CO_2 injection.

2015 Carbon Management Technology Conference (CMTC 2015).

This conference is scheduled for November 17-19, 2015, at the Sugar Land Marriott Town Square in Sugar Land, Texas, USA. The conference will focus on carbon capture, storage, and utilization technologies that are being performed at large scale and provide options for low greenhouse gas (GHG) emissions while maintaining fuel diversity for sustainable growth.

RGGI Releases Report.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the "CO_2 Emissions from Electricity Generation and Imports in the Regional Greenhouse Gas Initiative: 2013 Monitoring Report," summarizing data for electricity generation, electricity imports, and related CO_2 emissions for the RGGI states. The report, as well past monitoring reports, are available on the RGGI documents website.

Carbon Storage in the News

"NRG Expects 2016 Startup for Texas Carbon Capture Coal Plan."

Operations are expected to commence at a new carbon capture project at NRG Energy's WA Parish Texas coal facility in late 2016. The WA Parish CO_2 Capture Project, which will receive funding from DOE's Clean Coal Power Initiative (CCPI) Program, is being developed jointly by NRG and JX Nippon Oil & Gas Exploration. The facility is expected to capture approximately 90 percent of the CO_2 from a 240-mewawatt (MW) slipstream of flue gas, and will use or store approximately 1.6 million tons of CO_2 a year. From *Utility Dive* on August 7, 2015.

"S. Arabia's SABIC Starts Up CO_2 [Utilization] Plant in End-'15."

According to SABIC officials, operations at the CO_2 utilization plant located at SABIC's chemical complex in Jubail, Saudi Arabia, are set to begin by the end of 2015. Plant construction has been completed and commissioning work is currently underway at the unit, which will capture CO_2 emitted from SABIC's 500,000 metric tons/year ethylene glycol (EG) plant in Jubail, which is set to begin operations around the same timeframe. From *ICIS News* on July 15, 2015.

"Launching the [Kingdom of Saudi Arabia's] First Carbon Capture Project."

A CO_2-enhanced oil recovery (EOR) pilot project led by Saudi Aramco's EXPEC-Advanced Research Center is expected to capture approximately 40 million standard cubic feet per day of CO_2 at the Hawiyah gas recovery plant. The CO_2 will then be transported, via pipeline, approximately 50 miles to the 'Uthmaniyah field where it will be used for EOR. The project, which will inject 800,000 tons of CO_2 a year, includes a monitoring and surveillance program that consists of seismic monitoring, electromagnetic surveys, borehole and surface gravity, and tracer tests. From *Saudi Aramco* on July 29, 2015.

Science

"Rapid Decline in Bumblebee Species Caused by Climate Change, Study Finds."

According to a study published in "Science," declines in bumblebee species across North America and Europe could be linked to potential climate change. Researchers from the University of Ottawa's Department of Biology used long-term observations of 67 bumblebee species collected over a 110-year period across Europe and North America. Previous smaller-scale studies have shown that other species expand to the North Pole as the climate warms; however, the new study found that bumblebee species are not relocating, and are instead disappearing over large areas. From *University of Ottawa, Canada* on July 9, 2015.

"'Carbon Sink' Detected Underneath World's Deserts."

New research conducted by the University Corporation for Atmospheric Research has found that large formations underneath deserts may have the potential to store more CO_2 than plants on land. By examining the flow of water through a Chinese desert, scientists found that carbon from the atmosphere is being absorbed by crops, released into the soil, and transported underground. The study found that underground formations store the dissolved carbon deep below the desert, where it cannot enter the atmosphere. According to their data, the researchers estimate that due to agriculture, approximately 14 times more carbon than previously thought could be entering the underground desert formations every year. The Abstract of the study, titled, "Hidden carbon sink beneath the desert," is available in the "Terrestrial" section of this newsletter. From *ScienceDaily* on July 28, 2015.

Policy

"Clean Power Plan to Protect Public Health, Spur Clean Energy Investments, and Strengthen U.S. Leadership."

The White House and the U.S. Environment Protection Agency (EPA) announced the Clean Power Plan, which aims to reduce U.S. carbon emissions from the power sector by 870 million tons (32 percent below 2005 levels) in 2030. The plan reflects public input, with more than 4 million public comments on the proposal. The final rule establishes guidelines for states to follow in developing and implementing their plans. EPA is proposing a model rule states can adopt, as well as a Federal plan that EPA can put in place. Both the proposed model rule and the Federal plan focus on emissions trading mechanisms to make sure carbon-reduction goals are met. More information on the Clean Power Plan is available in a White House Fact Sheet. From *U.S. Environmental Protection Agency News Release* on August 3, 2015.

"Inslee Directing Ecology to Develop Regulatory Cap on Carbon Emissions."

The Washington State Department of Ecology has been directed to develop a regulatory cap on CO_2 emissions. The process of developing the emissions reductions by using existing authority, as well as allowing stakeholders the opportunity to provide input, is expected to take approximately a year. Similar legislation was previously proposed in late-2014; this regulatory cap differs in that it would not charge emitters. From *Governor Jay Inslee News Release* on July 28, 2015.

"[New York City] Announces New Greenhouse Gas Emissions Cuts."

New York City announced new GHG emissions targets, committing to reduce their emissions by 40 percent by 2030. New York City is currently a member of an alliance of cities around the world committed to reducing emissions by 80 percent by 2050. The announcement was made at a meeting of mayors on addressing climate change. From *Yahoo! Finance* on July 21, 2015.

"A carbon market sensitive optimization model for integrated forward-reverse logistics."

The following is the Abstract of this article: "Globalized supply chains, volatile energy and material prices, increased carbon regulations and competitive marketing pressure for environmental sustainability are driving supply chain decision makers to reduce carbon emissions. Enterprises face the necessity and the challenge of implementing strategies to reduce their supply chain environmental impact in order to remain competitive. One of the most important strategic issues in this context is the configuration of the logistics network. The decision concerning the design of an optimal network of the supply chain plays a vital role in determining the total carbon footprint across the supply chain and also the total cost. Therefore, the logistics network should be designed in a way that it could reduce both the cost and the carbon footprint across the supply chain. In this context, this research proposes a quantitative optimization model for integrated forward–reverse logistics with carbon-footprint considerations, by integrating the carbon emission into a quantitative operational decision-making model with regard to facility layout decisions. The proposed research incorporates carbon emission parameters with various decision variables and modifies traditional integrated forward/reverse logistics model into decision-making quantitative operational model, minimizing both the total cost and the carbon footprint. The proposed model investigates the extent to which carbon reduction requirements can be addressed under a particular set of parameters such as customer demand, rate of return of products etc., by selecting proper policy as an alternative to the costly investment in carbon-reducing technologies. To solve the quantitative model, this research implements a modified and efficient forest data structure to derive the optimal network configuration, minimizing both the cost and the total carbon footprint of the network. A comparative analysis shows the outperformance of the proposed approach over the conventional Genetic Algorithm (GA) for large problem sizes." **Alok Choudhary, Sagar Sarkar, Srikar Settur, and M.K. Tiwari**, *International Journal of Production Economics*. (Subscription may be required.)

Geology

"Kinetics of CO_2-fluid-rock reactions in a basalt [formation], Soda Springs, Idaho."

The following is the Abstract of this article: "The dissolution of silicate minerals by CO_2-rich fluids and the subsequent precipitation of CO_2 as carbonate minerals represent a means of permanently storing anthropogenic CO_2 waste products in a solid and secure form. Modelling the progression of these reactions is hindered by poor understanding of the rates of mineral dissolution–precipitation reactions and mineral surface properties in natural systems. This study evaluates the chemical evolution of groundwater flowing through a basalt [formation], which forms part of the [releasing] CO_2-charged system of the Blackfoot Volcanic Field in south-eastern Idaho, USA. Reaction progress is modelled using changes in groundwater chemistry by inverse mass balance techniques. The CO_2-promoted fluid–mineral reactions include the dissolution of primary plagioclase, orthoclase, pyroxene and gypsum which is balanced by the precipitation of secondary albite, calcite, zeolite, kaolinite and silica. Mineral mole transfers and groundwater flow rates estimated from hydraulic head data are used to determine the kinetics of plagioclase and orthoclase feldspar dissolution. Plagioclase surface area measurements were determined using the evolution of the U-series isotope ratios in the groundwater and are compared to published surface area measurements. Calculated rates of dissolution for plagioclase range from 2.4×10^{-12} to 4.6×10^{-16} mol/m^2/s and orthoclase from 2.0×10^{-13} to 6.8×10^{-16} mol/m^2/s respectively. These feldspar reaction rates, correlate with the degree of mineral–fluid disequilibrium and are similar to the dissolution rates for these mineral measured in other natural CO_2-charged groundwater systems." **Alexandra Maskell, Niko Kampman, Hazel Chapman, Daniel J. Condon, and Mike Bickle**, *Applied Geochemistry*. (Subscription may be required.)

"Environmental considerations for subseabed geological storage of CO_2: A review."

The following is the Abstract of this article: "Many countries are now using or investigating offshore geological storage of CO_2 as a means to reduce atmospheric CO_2 emissions. Although associated research often focuses on deep-basin geology (e.g. seismic, geomagnetics), environmental data on the seabed and shallow subseabed is also crucial to (1) detect and [characterize] potential indicators of fluid seeps and their potential connectivity to targeted storage reserves, (2) obtain baseline environmental data for use in future monitoring, and (3) acquire information to facilitate an improved understanding of ecosystem processes for use in impact prediction. This study reviews the environmental considerations, including potential ecological impacts, associated with subseabed geological storage of CO_2. Due to natural variations in CO_2 levels in seafloor sediments, baseline CO_2 measurements and knowledge of physical–chemical processes affecting the regional distribution of CO_2 and pH are critical for the design of appropriate monitoring strategies to assess potential impacts of CO_2 seepage from subseabed storage reservoirs. Surficial geological and geophysical information, such as that acquired from multibeam sonar and sub-bottom profiling, can be used to investigate the connectivity between the deep reservoirs and the surface, which is essential in establishing the reservoir containment properties. [Carbon dioxide release] can have a pronounced effect on sediments and rocks which in turn can have carryover effects to biogeochemical cycles. The effects of elevated CO_2 on marine organisms are variable and species-specific but can also have cascading effects on communities and ecosystems with marine benthic communities at some natural analogue sites (e.g. volcanic vents) showing decreased diversity, biomass, and trophic complexity. Despite their potential applications, environmental surveys and data are still not a standard and integral part of subseabed CO_2 storage projects. However, the habitat mapping and seabed [characterization] methodology that underpins such surveys is well developed and has a strong record of providing information to industry and decision makers. This review provides recommendations for an integrated and interdisciplinary approach to offshore geological storage of CO_2, which will benefit national programs and industry and will be valuable to researchers in a broad range of disciplines." **A.G. Carroll, R. Przeslawski, L.C. Radke, J.R. Black, K. Picard, J.W. Moreau, R.R. Haese, and S. Nichol**, *Continental Shelf Research*. (Subscription may be required.)

Technology

"Model Predictions via History Matching of CO_2 Plume Migration at the Sleipner Project, Norwegian North Sea."

The following is the Abstract of this article: "The Sleipner Project in Norway is the world's first industrial-scale geological carbon storage project. Seismic surveys have produced high fidelity 4D seismic data that delineated the CO_2 plume migration history. Therefore, the Sleipner Project provides a somewhat unique opportunity to simulate the dynamics of CO_2 plume migration in a real geological system. [The authors] simulated CO_2 plume migration in the uppermost layer (Layer 9) in the Utsira Sand, Sleipner field and calibrated the model against the time-lapsed seismic monitoring data from 1999 to 2008. Instead of using ideal geometry and homogenous geological properties, [the authors] adopted the grid mesh from the Sleipner Benchmark model to represent the complexity of real geological systems. Approximate match with the observed plume was achieved by introducing lateral permeability anisotropy coupled with either an increased reservoir temperature with CH_4 impurities in the CO_2 stream or a second feeder. Predicted gas saturation, thickness of the CO_2 accumulation and CO_2 solubility in brine–none of them has been used as calibration metrics–are comparable with interpretations of the seismic data in the literature. [The authors'] simulation results illustrate that the actual behaviors of the injected CO_2 plume conform to the modeled behaviors. The Sleipner project is on-going. The good match of plume history provides a calibrated model for making predictions of CO_2 plume migration into the future. By comparing the model prediction and monitoring data that are not used in the calibration, [the authors] will have a well-grounded assessment of modeling uncertainties." **Guanru Zhang, Peng Lu, and Chen Zhu**, *Energy Procedia*. (Subscription may be required.)

"CO_2 retention values in enhanced oil recovery."

The following is the Abstract of this article: "Carbon dioxide retention is the fraction of the injected volume trapped in the subsurface as a result of EOR. [Carbon dioxide] retention is determined by multiple factors acting generally in combinations varying according to the geology of the reservoir and the implementation of the recovery. Primarily, the factors are the amount of CO_2 remaining in the pore space connected

Technology (Continued)

to injection wells but not to the producer; dissolution into the formation water, subjacent [formation], or both; accumulation in the pore space vacated by produced oil; chemical reaction with the minerals in the matrix; and loss to a thief zone. Accurate modeling of retention is important in the evaluation of the economics of reservoir development and in the assessment of potential CO_2 [storage]. This contribution deals with 23 units containing information relating retention rates to the amount of CO_2 injected in EOR operations. For all but two units, the flooding is miscible and all but two units are in the United States. Compilation of values reported in the literature shows a tendency for higher values of retention for carbonate than for siliciclastic reservoirs." **Ricardo A. Olea**, *Journal of Petroleum Science and Engineering*. (Subscription may be required.)

"Hydromechanical modelling of shaft sealing for CO_2 storage."

The following is the Abstract of this article: "The geological [storage] of CO_2 in abandoned coal mines is a promising option to mitigate climate changes while providing sustainable use of the underground cavities. In order to certify the efficiency of the storage, it is essential to understand the [behavior] of the shaft sealing system. The paper presents a numerical analysis of CO_2 transfer mechanisms through a mine shaft and its sealing system. Different mechanisms for CO_2 [release] are considered, namely multiphase flow through the different materials and flow along the interfaces between the lining and the host rock. The study focuses on the abandoned coal mine of Anderlues, Belgium, which was used for seasonal storage of natural gas. A two-dimensional hydromechanical modelling of the storage site is performed and CO_2 injection into the coal mine is simulated. Model predictions for a period of 500 years are presented and discussed with attention. The role and influence of the interface between the host rock and the concrete lining are examined. In addition the impact of some uncertain model parameters on the overall performance of the sealing system is [analyzed] through a sensitivity analysis." **A.C. Dieudonne, B. Cerfontaine, F. Collin, and R. Charlier,** *Engineering Geology.* (Subscription may be required.)

Terrestrial

"Hidden carbon sink beneath desert."

The following is the Abstract of this article: "For decades, global carbon budget accounting has identified a 'missing' or 'residual' terrestrial sink; i.e., CO_2 released by anthropogenic activities does not match changes observed in the atmosphere and ocean. [The authors] discovered a potentially large carbon sink in the most unlikely place on earth, irrigated saline/alkaline arid land. When cultivating and irrigating arid/saline lands in arid zones, salts are leached downward. Simultaneously, dissolved inorganic carbon is washed down into the huge saline [formations] underneath vast deserts, forming a large carbon sink or pool. This finding points to a direct, rapid link between the biological and geochemical carbon cycles in arid lands which may alter the overall spatial pattern of the global carbon budget." **Yan Li, Yu-Gang Wang, R.A. Houghton, and Li-Song Tang**, *Geophysical Research Letters*. (Subscription may be required.)

"Impacts of CO_2 concentration and climate change on the terrestrial carbon flux using six global climate-carbon coupled models."

The following is the Abstract of this article: "Based on the simulations of the fifth phase of the Coupled Model Intercomparison Project (CMIP5), [the authors] estimated the response of net primary production (NPP) and net ecosystem production (NEP) to rising atmospheric CO_2 concentration and climate change on global and regional scales. The modeled NPP and NEP significantly increased by about 0.4 Pg C yr^{-2} and 0.09 Pg C yr^{-2}, respectively, in response to the rising atmospheric CO_2 concentration. However, adverse trends of the two variables were driven by climate change on a global scale. Regarding the spatial pattern, the decreases were mainly located in tropical and temperate regions. Thus, the terrestrial carbon sink was accelerated not only by a rising atmospheric CO_2 concentration, but also by global warming at high latitude and altitude regions, e.g. Tibet and Alaska. Although the simulations indicated increases of NPP and NEP owing to the CO_2 fertilization effect, the strength of the trends significantly differed from the CMIP5 models. The enhanced trend in the terrestrial carbon sink simulated by MPI-ESM-LR was about 47 times larger than that simulated by CESM-BGC considering the CO_2 fertilization effect. Differences in the modeled responses of NPP and NEP resulted from the various processes of the land surface component accounting for the nitrogen limitation effect and plant functional types (PFTs). [The authors] also found that the difference in the accelerating terrestrial carbon loss forced by global warming between CMIP5 models, ranged between 6.0 Tg C yr^{-2} in CESM-BGC and 52.7 Tg C yr^{-2} in MPI-ESM-LR. Such a divergence was partially responsible for the difference in the simulated climate between the CMIP5 models: the difference in increasing temperature was about 1.4 K." **Jing Peng and Li Dan**, *Ecological Modelling*. (Subscription may be required.)

Trading

"Revised Emission Trading System Will Help EU Deliver on Climate Goals."

The European Commission presented a legislative proposal to revise the European Union's (EU) Emission Trading Scheme (ETS) for the period after 2020. The proposal is a step toward achieving the EU's target of reducing its GHG emissions by at least 40 percent (domestically) by 2030. Specifically, the sectors covered by the EU ETS will reduce their GHG emissions by 43 percent compared to 2005 levels by proposals such as increasing the rate of GHG emissions cuts after 2020 and creating support mechanisms to aid industry and power sectors in the low-carbon transition. More information is available via the European Commission's press release. From *European Commission* on July 15, 2015.

"Tactical supply chain planning under a carbon tax policy scheme: A case study."

The following is the Abstract of this article: "[GHG] emissions are receiving greater scrutiny in many countries due to international forces to reduce anthropogenic global climate change. Industry and their supply chains represent a major source of these emissions. This paper presents a tactical

Trading (Continued)

supply chain planning model that integrates economic and carbon emission objectives under a carbon tax policy scheme. A modified Cross-Entropy solution method is adopted to solve the proposed nonlinear supply chain planning model. Numerical experiments are completed utilizing data from an actual organization in Australia where a carbon tax is in operation. The analyses of the numerical results provide important organizational and policy insights on (1) the financial and emissions reduction impacts of a carbon tax at the tactical planning level, (2) the use of cost/emission tradeoff analysis for making informed decisions on investments, (3) the way to price carbon for maximum environmental returns per dollar increase in supply chain cost." **Behnam Fahimnia, Joseph Sarkis, Alok Choudhary, and Ali Eshragh**, *International Journal of Production Economics*. (Subscription may be required.)

"Carbon emissions trading scheme exploration in China: A multi-agent-based model."

The following is the Abstract of this article: "To develop a low-carbon economy, China launched seven pilot programs for carbon emissions trading (CET) in 2011 and plans to establish a nationwide CET mechanism in 2015. This paper formulated a multi-agent-based model to investigate the impacts of different CET designs in order to find the most appropriate one for China. The proposed bottom-up model includes all main economic agents in a general equilibrium framework. The simulation results indicate that (1) CET would effectively reduce carbon emissions, with a certain negative impact on the economy, (2) as for allowance allocation, the grandfathering rule is relatively moderate, while the benchmarking rule is more aggressive, (3) as for the carbon price, when the price level in the secondary CET market is regulated to be around RMB 40 per metric ton, a satisfactory emission mitigation effect can be obtained, (4) the penalty rate is suggested to be carefully designed to balance the economy development and mitigation effect, and (5) subsidy policy for energy technology improvement can effectively reduce carbon emissions without an additional negative impact on the economy. The results also indicate that the proposed novel model is a promising tool for CET policy making and analyses." **Ling Tang, Jiaqian Wu, Lean Yu, and Qin Bao**, *Energy Policy*. (Subscription may be required.)

Recent Publications

"Mobilization and Transport of Organic Compounds from Geologic Carbon [Storage] Reservoirs."

The following is from the Executive Summary of this NETL document: "This report summarizes results of research conducted during FY2012–FY2013 to support the assessment of environmental risks associated with geologic [CCS]. Several research focus areas are ongoing as part of this project. This includes the quantification of the mobility of organic compounds and metals from representative CO_2 storage reservoir and caprock materials, the fate of organic compounds and metals after release, and the development of a method to measure pH in situ under supercritical CO_2 ($scCO_2$) conditions. This report focuses specifically on results for organic compounds. Experiments have been conducted to evaluate the potential for mobilization of organic compounds from representative reservoir materials and caprock and their fate in porous media (quartz sand). Results with Fruitland coal and Gothic shale indicate that lighter organic compounds were more susceptible to mobilization by $scCO_2$ compared to heavier compounds. Alkanes demonstrated very low extractability by $scCO_2$. No significant differences were observed between the extractability of organic compounds by dry or water saturated $scCO_2$. Reaction equilibrium appears to have been reached by 96 hours. When the $scCO_2$ was released from the reactor, less than 60 [percent] of the injected lighter compounds (benzene, toluene) were transported through the dry sand column by the CO_2, while more than 90 [percent] of the heavier organics were trapped in the sand column. For wet sand columns, most (80–100 [percent]) of the organic compounds injected into the sand column passed through, except for naphthalene which was substantially removed from the CO_2 within the column…"

"NSealR–A User's Guide, Third-Generation."

The following is from the Executive Summary of this NETL document: "This report provides a guide to the use of the third-generation of the NSealR computer code. The NSealR code is being developed as part of the effort to quantify the risk of geologic storage of CO_2. NSealR is constructed as a stand-alone code to describe the flow or [release] of [CO_2] through the low permeability rock formation (or seal) overlying the storage reservoir into which [CO_2] is injected. Eventually, the NSealR is intended to be integrated into the CO_2-PENS system as a separate module, and therefore, NSealR incorporates CO_2-PENS assumptions, parameters, formats, and definitions as appropriate for consistency. At present, CO_2-PENS does not incorporate a seal horizon, but includes a possible description of this aspect in code documentation. NSealR is intended to address this gap and adds functionality such as allowing spatially-variable flow properties and adding complexity relative to flow through the seal. For example, to emulate CO_2-PENS flexibility, NSealR allows a number of ways to describe the seal horizon, to correspond to the user's current understanding of the barrier. The NSealR code provides for the simulation of [CO_2] flow through the seal barrier horizon, a rock formation that is assumed to be a thin, relatively impermeable, fractured rock unit, initially saturated with saline groundwater. A two-phase, relative permeability approach and Darcy's law are used for one-dimension (1-D) flow computations of [CO_2] through the horizon in the vertical direction. The code is written using GoldSim's simulation software platform and is structured using seven upper-level containers (or

Recent Publications (Continued)

subroutines) for the top level code logic. The logic proceeds from two containers for seal property and simulation input, followed by logic to establish the analysis basis of permeability and seal horizon thickness and fluid properties, which in turn serves as the basis for the computation container and a final container for output control…"

"Quantification Protocol for CO_2 Capture and Permanent Storage in Deel Saline [Formations]."

The following is from a description of this Protocol: "Carbon dioxide is emitted as a by-product in many industrial production processes. This CO_2 may be captured for other uses, or vented directly to the atmosphere. Capturing CO_2 emissions, and transferring them to permanent storage in deep saline [formations] results in a permanent reduction in CO_2 emissions. [CCS] projects applicable under this protocol consist of three main components: [1] CO_2 capture infrastructure, which includes a process modification to a facility to capture vented CO_2 emissions. The carbon capture facility is usually separate from the emission source facility, and typically uses a chemical solvent CO_2 capture technology; [2] A CO_2 pipeline to transport CO_2 from the capture facility to the injection well(s); and [3] Disposal of CO_2 through injection wells and into deep saline [formations]. Project developers using this protocol must have familiarity with [CCS] projects and [GHG] quantification methodologies."

"National Security Implications of Climate-Related Risks and a Changing Climate."

The following is a description of this DoD report: "This report responds to the Congressional request to [DoD] to identify the most serious and likely climate-related security risks for each Combatant Command, the ways in which the Combatant Commands are integrating mitigation of these risks into their planning processes, and a description of the resources required for an effective response."

Legislative Activity

"France Passes New Energy Law Quadruples Carbon Price."

France passed legislation that will reduce reliance on nuclear reactors and increase the target price of carbon to approximately $61.00 a ton in 2020 and approximately $109.00 a ton in 2030. Currently at approximately $16.00 a ton, the price will increase to approximately $24.00 a ton in 2016. Under the new energy transition law, France will have to lower carbon emissions by 40 percent by 2030 compared to 1990 levels. The law also stipulates reducing "primary" fossil-fuel consumption by 30 percent in 2030 compared to 2012 levels, among other actions. From *Bloomberg Business* on July 23, 2015.

About DOE's Carbon Storage Program

The Carbon Storage Program is implemented by the U.S. Department of Energy's Office of Fossil Energy and managed by the National Energy Technology Laboratory. The program is developing technologies to capture, separate, and store CO_2 in order to reduce greenhouse gas emissions without adversely influencing energy use or hindering economic growth. NETL envisions having a technology portfolio of safe, cost-effective, carbon dioxide capture, transport, and storage technologies that will be available for commercial deployment.

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 Reference Shelf.

Get answers to your carbon capture and storage questions at NETL's Frequently Asked Questions webpage.

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

NETL RSS Feed

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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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