CSN CARBON STORAGE NEWSLETTER

DECEMBER 2017

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

NATIONAL ENERGY TECHNOLOGY LABORATORY

DOE/NETL HIGHLIGHTS

ASFE Leads Policy Group During CSLF Meeting.

The U.S. Department of Energy's (DOE) Assistant Secretary for Fossil Energy (ASFE) led the Policy Group meeting at the 7th Ministerial Meeting of the Carbon Sequestration Leadership Forum (CSLF) in Abu Dhabi, United Arab Emirates (UAE), on December 5, 2017. The CSLF is an international initiative focused on the development of cost-effective carbon capture, utilization, and storage (CCUS) technologies. The CSLF, which holds a ministerial-level conference every two years, fosters international collaboration to address key challenges to CCUS technology development and deployment. The Policy Group, chaired by the United States, is responsible for addressing the legal, regulatory, and financial issues associated with CCUS technologies. More information on the Ministerial Meeting, as well as Policy Group documents, is available on the *CSLF website*. From *energy.gov* on December 6, 2017.

NETL Software Developers Win Award.

The National Risk Assessment Partnership (NRAP) Toolset, developed by the Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL) and in collaboration with other national laboratories, was recognized by R&D Magazine as one of the 100 most technologically significant products introduced into the marketplace in the past year. The NRAP Toolset software package includes 10 science-based computational tools that predict environmental risk performance of geologic carbon dioxide (CO_2) storage sites. Led by NETL, NRAP also includes expertise from Lawrence Berkeley National Laboratory (LBNL), Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), and the Pacific Northwest National Laboratory (PNNL). The computational tools in the NRAP Toolset support industry and provide technical insight to regulatory projects to store large volumes of CO_2. A full list of the 2017 award winners is available on the *R&D 100 Conference website*. From *energy.gov* on November 20, 2017.

Accepting a 2017 R&D 100 Award at festivities in Orlando, Florida, for their NRAP Toolset are team members, left to right, Bob Dilmore (NETL), Elizabeth Keating (LANL), Grant Bromhal (NETL), and Phil Stauffer (LANL).

ANNOUNCEMENTS

NCCC Surpasses Milestone.

The DOE-sponsored National Carbon Capture Center (NCCC) surpassed 100,000 hours of technology testing, marking the research facility's work in the development of advanced technologies to reduce greenhouse gas (GHG) emissions from natural gas and coal power plants. Managed and operated by Southern Company, NCCC was created by DOE/FE in 2009 and offers a pathway to advance novel technologies from the laboratory to demonstration in real-world power plant conditions.

DOE/FE Selects Projects to Receive Federal Funding.

DOE/FE selected two projects to receive funding to assess offshore geologic storage of CO_2 and technology development in the Gulf of Mexico. Selected as part of FE's *Carbon Storage Program*, the NETL-managed projects will focus on assembling the knowledge base required for secure, long-term, large-scale CO_2 storage and assessing technology-development needs. In addition, DOE/FE also *selected two projects to receive funding* for cost-shared research and development (R&D) for the safe storage of CO_2 in geologic formations. The two NETL-managed projects will also support the Carbon Storage Program and are supported through Funding Opportunity Announcement (FOA) DE-FOA-0001725, "*Technology Development to Ensure Environmentally Sustainable CO_2 Injection Operations.*"

DOE-Supported CCS Project Reaches Milestone.

An FE/NETL-supported large-scale CO_2 capture and storage (CCS) system reached a milestone by capturing and transporting 4 million metric tons of CO_2. Air Products and Chemicals designed, built, and is currently operating the CCS system at their hydrogen-production facility located at the Valero Port Arthur Refinery in Port Arthur, Texas, USA. Utilizing a gas-separation technology called *vacuum swing adsorption*, the project captures more than 90 percent of the CO_2 from the product streams of two commercial-scale steam methane reformers. In addition, the project is also helping to verify the effectiveness of enhanced oil recovery (EOR) for permanently storing CO_2 by injecting it at the West Hastings Unit oil field in southwest Texas, USA.

FY 2017 Carbon Storage Newsletter Annual Index Available.

The *FY 2017 Carbon Storage Newsletter Annual Index* is available online in a new, updated format. The document is a compilation of NETL's Carbon Storage Newsletters published over the October 2016 through September 2017 timeframe, organized by section. Outdated information (e.g., conference dates and paper submittals) has been removed.

Global CCS Institute Releases Report on CCS.

The Global CCS Institute released its "*Global Status of CCS Report: 2017*" at the 23rd Conference of the Parties (COP23) in Bonn, Germany. The report details the importance of CCS to meet international targets, and highlights CCS as the conduit to a new energy economy of hydrogen production, bioenergy, and CO_2 re-use applications.

Global Summit on CCUS.

The International Energy Agency (IEA) held a high-level summit to support investment in CCUS. Attended by energy ministers, government officials, and chief executives of major energy companies, the summit was held ahead of the IEA 2017 Ministerial Meetings and co-chaired by the United States. In addition, IEA offered a document on the "*Five Keys to Unlock CCS Investment*." A summary of the summit is available on the *IEA website*.

RGGI Report on Secondary Market.

The independent market monitor for the Regional Greenhouse Gas Initiative (RGGI) released a report containing information on the secondary market for RGGI CO_2 allowances, including future prices, market activity, and allowance holdings. Potomac Economics' "Report on the Secondary Market for RGGI CO_2 Allowances: Third Quarter 2017" addresses the period from July through September 2017.

Results of 38th RGGI Auction Released.

The nine states participating in the RGGI market-based regulatory program to reduce GHGs announced the results of their 38th auction of CO_2 allowances. The last of 2017, Auction 38 saw 14,687,989 CO_2 allowances sold at a clearing price of $3.80. Bids for the CO_2 allowances ranged from $2.15 to $8.00 per allowance, generating a total of $55.8 million for reinvestment in strategic programs such as energy efficiency, renewable energy, and GHG abatement. Additional details are available in the "*Market Monitor Report for Auction 38*."

PROJECT and BUSINESS DEVELOPMENTS

DOE Issues Grant for CO_2 Storage.

DOE issued a grant to the University of Texas at Austin Bureau of Economic Geology to lead a regional partnership to explore the safe storage of CO_2 in geologic formations under the Gulf of Mexico. The Gulf Coast Carbon Center (GCCC) will lead the partnership, whose mission is to develop a large storage capability and support economic growth. In addition, the program will focus on offshore storage resources geologic characterization; risk assessment, simulation, and modeling; monitoring, verification, and accounting; infrastructure, operations, and permitting assessment; and knowledge dissemination. From *The University of Texas at Austin* on December 4, 2017.

DOE-Funded Study to Determine Feasibility of Underground CO_2 Storage.

Two exploratory wells are being drilled in central North Dakota, USA, to help researchers determine the feasibility of safely storing CO_2 deep underground. The drilling is part of the DOE-funded *CarbonSAFE* project, led by the University of North Dakota's Energy and Environmental Research Center (UNDEERC). Researchers will investigate the geology more than one mile underground to determine its suitability for CO_2 storage captured from coal-based energy facilities. The study will provide researchers with information to use in computer modeling. The DOE study is looking to determine the feasibility of injecting 2 million tons of CO_2 per year for 25 years. From *WDAZ* on December 1, 2017.

Contract for Onshore CO_2 Storage Terminal.

KBR Inc. will perform the front-end engineering and design (FEED) on Statoil's onshore CO_2 storage terminal, called Northern Lights, in Norway. The project is a key component of the CCS demonstration project being undertaken by Gassnova, with Statoil, in partnership with Royal Dutch Shell PLC and Total SA, responsible for transport and storage. In Phase I of the project, as much as 1.5 million metric tons of CO_2 will be captured per year from onshore industrial plants in eastern Norway, eventually transported to the onshore storage terminal. From *Oil and Gas Journal* on November 30, 2017.

States, Canadian Province Sign MOU on CCUS.

The states of Wyoming, Montana, and North Dakota signed a Memorandum of Understanding (MOU) with the Canadian province of Saskatchewan to collaborate on CCUS research. According to a press release, the MOU calls for engagement of other related research groups within the states/province, prioritizes joint cooperative projects, and ensures a formal evaluation process of activities and accomplishments. From *Gillette News Record* on December 3, 2017.

LEGISLATION and POLICY

U.S., Saudi Arabia Sign Carbon Management MOU.

Officials from DOE and Saudi Arabia signed an MOU to establish a framework for mutually beneficial cooperation in the area of clean fossil fuels and carbon management. Under the MOU, the United States and Saudi Arabia will exchange experts, engineers, and scientists; facilitate the transfer of technology; and encourage the organization of joint seminars and workshops, as well as visits by experts to facilities (e.g., research labs, institutes, industrial sites). Technical fields covered under the MOU include supercritical carbon dioxide (sCO_2) and CCUS. From *energy.gov* on December 4, 2017.

Brazilian Low-Carbon Emissions Program Bill Passed.

The lower house of Brazil's National Congress passed a bill to create a nationwide carbon credits program to drive the use of renewable fuels. Referred to as RenovaBio, the bill will create a carbon credit scheme to increase the value of biofuels. The bill, which is estimated to become law in 2018 according to the Brazilian Sugarcane Industry Association (UNICA), establishes goals for lowering carbon emissions by distributors and the use of carbon credits. From *Platts* on November 29, 2017.

EMISSIONS TRADING

Virginia Approves Carbon Cap-and-Trade Program.

Virginia state regulators granted preliminary approval to regulate carbon emissions from power plants through a state-wide carbon cap-and-trade program. Approved by the Virginia Air Pollution Control Board, the proposal would cap emissions from most power plants beginning in 2020, then require a 30 percent reduction over a decade. In addition, eligible carbon emitters would have to participate in the RGGI cap-and-trade program. From *AP News* on November 17, 2017.

California and Québec Release Results of Cap-and-Trade Auction.

Officials from California, USA, and Québec, Canada, released the results of their 13th joint cap-and-trade auction of carbon allowances. According to the California Air Resources Board (CARB), all of the 79,548,286 allowances for current vintages (2016 and 2017) were sold at a settlement price of $15.06, and all of the 9,723,500 allowances for 2020 vintages were sold at a settlement price of $14.76. More detailed results of the auction, as well as maximum and minimum bids placed, are available on the *CARB website*. From *California Air Resources Board* on November 21, 2017.

CLIMATE and SCIENCE NEWS

Modified Plant Capable of Storing CO_2.

A team of biologists from the Salk Institute for Biological Studies at the Howard Hughes Medical Institute (HHMI) created a plant capable of storing CO_2. The research team created new plant varieties that can capture and store atmospheric CO_2 with the infusion of suberin, a naturally produced material that can last a few thousand years when infused with CO_2. According to the study, the plant has the potential to reduce CO_2 emissions by 50 percent by using 5 percent of Earth's cultivatable ground. From *International Business Times* on December 5, 2017.

Researchers Study Geologic Storage of CO_2.

Researchers from Stanford University are using computed tomography (CT) scanners to help understand the behavior of CO_2 in geologic subsurface storage projects. The experiments are intended to recreate, at small-scale, the movement of various substances through vast rock formations and to provide real-world validation of computer simulations of the same processes. From *Carbon Capture Journal* on November 10, 2017.

Monitoring Offshore CO_2 Storage Using Chemical Tracers.

Scientists from the Scottish Carbon Capture and Storage (SCCS) partnership conducted a study focusing on the use of chemical tracers in CO_2 leakage monitoring for offshore CCS projects. Following consultation from the CCS community, the scientists identified the measuring of CO_2 leakage to the seabed as an area requiring further research. The research team then identified key challenges to using tracers for offshore monitoring. The work was published by the *International Journal of Greenhouse Gas Control* in a paper, titled "*Geochemical tracers for monitoring offshore CO_2 stores*." From *SCCS News* on November 16, 2017.

JOURNAL ARTICLES

Considerations in the Development of Flexible CCS Networks.

The following is the Abstract of this article: "This paper discusses considerations for the design of flexibly operated CCS pipeline networks and is based on the findings of the Flexible CCS Network Development project (FleCCSnet), funded as part of the UK CCS Research Centre. The project considered the impact of flexibility across the whole CCS chain, as well as studying the interfaces between each element of the system; e.g. at the entry to the pipeline system from the capture plant and at the exit from the pipeline to the storage site. The factors identified are intended to allow CCS network designers to determine the degree of flexibility in the system; allowing them to react effectively to short, medium and long term variations in the flow of CO_2 from capture plants and the constraints imposed on the system by CO_2 injection and storage. The work of the project is reviewed in this paper which explores the flexibility of power plants operating with post combustion capture systems; quantifies the available time to store (line pack) CO_2 in the pipeline as a function of pipeline size, the inlet mass flow rate and operating pressure; and explores the influence that uncertainty in injection and storage parameters have on the design of the pipeline. In addition, parameters influencing short and longer term network designs are discussed in terms of varying flow rates. Two practitioner workshops contributed to the direction of the project. The first workshop identified and confirmed key questions to be considered in order to understand the most likely impacts of variability in both the CO_2 sources and CO_2 sinks on CO_2 transport system design and operation. The second workshop focused on transient issues in the pipeline and storage site. Although the case studies in the work are UK based, this work is applicable to other situations where large and small sources of CO_2 are expected to be feeding into a CCS transportation system. The work is expected to inform a broad range of stakeholders and allow network designers to anticipate potential problems associated with the operation of a CCS network. For an effective design of CCS infrastructure, all of the factors that will have a substantial impact on CO_2 flow will have to be [analyzed] at an early stage to prevent possible bottle necks in the whole chain." **Ben Wetenhall, Julia Race, Hamed Aghajani, Eva Sanchez Fernandez, Mark Naylor, Mathieu Lucquiaud, and Hannah Chalmers**, *Energy Procedia*. (Subscriptions may be required.)

Multiple Pollutants, Co-Benefits, and Suboptimal Environmental Policies.

The following is the Abstract of this article: "In [the authors'] analytical general equilibrium model, polluting inputs can be substitutes or complements. [The authors] study a tax increase on one pollutant where the other faces a tax or permit policy. [The authors'] solutions highlight key parameters and welfare effects with gains from abatement plus positive or negative co-benefits from other pollutants in the covered and uncovered sectors. [The authors] demonstrate several ways taxes and permits differ. First, the change in taxed pollutant depends on whether the other pollutant faces a tax or permit policy. Also, only with a tax on the other pollutant can a co-benefit arise. The sign of co-benefits depends on the sign of cross-price elasticities and on whether the other pollutant's price is above or below marginal damages. Finally, the other pollutant's tax or permit policy also affects emissions in the uncovered sector (leakage). In a numerical illustration of carbon tax in U.S. electricity, [the authors] calculate emissions of CO_2 and [sulfur dioxide (SO_2)] in both sectors. For plausible parameters, co-benefits are larger than direct." **Don Fullerton and Daniel H. Karney**, *Journal of Environmental Economics and Management*. (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

High Temperature CO_2-in-Water Foams Stabilized with Cationic Quaternary Ammonium Surfactants.

The following is the Abstract of this article: "The design of surfactants for stabilizing CO_2-in-water (brine) (C/W) foams at high temperature is challenging given the low density (solvent strength) of CO_2, limited surfactant solubility in brine, and a lack of knowledge of the interfacial and rheological properties. Herein, the tail length of trimethylammonium cationic surfactants was optimized to provide the desired phase behavior and interfacial properties for formation and stabilization of the C/W foams. The headgroup was properly balanced with a $C_{12–14}$ hydrocarbon tail to achieve aqueous solubility in 22% total dissolved solids (TDS) brine up to 393 K (120°C) along with high surfactant adsorption (area/surfactant molecule of 154 $Å^2$) at the CO_2–water (C–W) interface which reduced the interfacial tension from ~40 mN/m to ~6 mN/m. For $C_{12–14}N(CH_3)_3Cl$, these properties enabled stabilization of a C/W foam with an apparent viscosity of 14 mPa•s at 393 K in both a crushed calcium carbonate packed bed (75 μm^2 or 76 Darcy) and a capillary tube downstream of the bed. In addition, the partition coefficient of the surfactant between oil and 22% TDS (255 kg/m^3) brine was less than 0.15, which would be beneficial for minimizing the loss of the surfactant to an oil phase in applications including [EOR] and hydraulic fracturing." **Yunshen Chen, Amro S. Elhag, Andrew J. Worthen, Prathima P. Reddy, Anne Marie Ou, George J. Hirasaki, Quoc P. Nguyen, Sibani L. Biswal, and Keith P. Johnston**, *Journal of Chemical and Engineering Data*. (Subscription may be required.)

Emission trading and carbon market performance in Shenzhen, China.

The following is the Abstract of this article: "China has developed its own domestic carbon markets by setting up emission trading schemes. This study addresses concerns about the functioning of these schemes and the financial performance of the Chinese carbon market. It aims to assess an actual outcome of this policy intervention, i.e. trading records, which were used in [the authors'] analysis to examine a key financial property of the allowance-based market in Shenzhen. In a mature market, assets that incur higher risks are likely to yield higher returns, i.e. a positive relationship. To examine this property, [the authors] solicited historical data on the price and trading volume of emission allowances. [The authors] statistically estimated the degree of volatility in the Shenzhen market and its relationship with expected return premium. [The authors] found that the rate of return was negatively associated with expected risk. This stands at odds with the usual expectation in the financial market and the prediction of asset pricing theory. Also, kurtosis in trading volume was excessively high and its fluctuations were highly concentrated. [The authors] discuss these findings in terms of market liquidity and information uncertainties, and offer some policy recommendations. More regulatory attention and economic fixes are needed to improve market efficiency and eliminate sources of market distortions." **Ren Cong and Alex Y. Lo**, *Applied Energy*. (Subscription may be required.)

Management and dewatering of brines extracted from geologic carbon storage sites.

The following is the Abstract of this article: "Subsurface pressure management is a significant challenge in geologic CO_2 storage. Elevated pressure generated from the injection of supercritical CO_2 can be managed by the withdrawal of brine from saline formations before or during CO_2 injection; however, management of the extracted brines is non-trivial because they may have high concentrations of dissolved solids and other contaminants. Dewatering a brine can reduce the volume needing disposal; in addition, water separated from the brine can be a source of usable low salinity water. This review will summarize the composition of brines extracted from select domestic geologic CO_2 storage sites, will calculate the minimum of work of dewatering, and will provide a critical review of developed and developing desalination/dewatering technologies that could be applied to brines extracted from saline formations before or during geologic CO_2 storage operations. Herein are also highlighted, when appropriate, the similarities and the differences between dewatering brines produced from oil/gas operations and brines extracted from geologic CO_2 storage. Since a source of steam or natural gas is likely unavailable/unsuitable for dewatering brines extracted during CO_2 storage, the ideal treatment processes should have a high electrical efficiency and, if possible, should be able to take advantage of the inherent elevated temperature of these brines." **Jason T. Arena, Jinesh C. Jain, Christina L. Lopano, J. Alexandra Hakala, Timothy V. Bartholomew, Meagan S. Mauter, and Nicholas S. Siefert**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Thermal effects on geologic carbon storage.

The following is the Abstract of this article: "One of the most promising ways to significantly reduce [GHG] emissions, while carbon-free energy sources are developed, is CCS. Non-isothermal effects play a major role in all stages of CCS. In this paper, [the authors] review the literature on thermal effects related to CCS, which is receiving an increasing interest as a result of the awareness that the comprehension of non-isothermal processes is crucial for a successful deployment of CCS projects. [The authors] start by reviewing CO_2 transport, which connects the regions where CO_2 is captured with suitable geostorage sites. The optimal conditions for CO_2 transport, both onshore (through pipelines) and offshore (through pipelines or ships), are such that CO_2 stays in liquid state. To minimize costs, CO_2 should ideally be injected at the wellhead in similar pressure and temperature conditions as it is delivered by transport. To optimize the injection conditions, coupled wellbore and reservoir simulators that solve the strongly non-linear problem of CO_2 pressure, temperature and density within the wellbore and non-isothermal two-phase flow within the storage formation have been developed. [Carbon dioxide] in its way down the injection well heats up due to compression and friction at a lower rate than the geothermal gradient, and thus, reaches the storage formation at a lower temperature than that of the rock. Inside the storage formation, CO_2 injection induces temperature changes due to the advection of the cool injected CO_2, the Joule-Thomson cooling effect, endothermic water vaporization and exothermic CO_2 dissolution. These thermal effects lead to thermo-hydro-mechanical-chemical coupled processes with non-trivial interpretations. These coupled processes also play a relevant role in 'Utilization' options that may provide an added value to the injected CO_2, such as EOR, Enhanced Coal Bed Methane (ECBM) and geothermal energy extraction combined with CO_2 storage. If the injected CO_2 leaks through faults, the caprock or wellbores, strong cooling will occur due to the expansion of CO_2 as pressure decreases with depth. Finally, [the authors] conclude by identifying research gaps and challenges of thermal effects related to CCS." **Victor Vilarrasa and Jonny Rutqvist**, *Earth-Science Reviews*. (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

Hydraulic characterization of fractured carbonates for CO_2 geological storage: Experiences and lessons learned in Hontomín Technology Development Plant.

The following is the Abstract of this article: "The Hontomín Technology Development Plant for CO_2 geological storage located in Spain, owned by Fundación Ciudad de la Energía (CIUDEN) is the only current onshore injection site in the European Union. It has been recognized by the European Parliament as a key test facility. The storage reservoir is a deep saline aquifer comprised of carbonates (limestones and dolomites) of the120 m thick Sopeña Fm, and seal rocks belong to the overlying series of Pozazal and Lias formations. In this article experiences and lessons learned during the reservoir hydraulic characterization are discussed, analyzing the methodology of different types of tests performed at laboratory and field scale. [Carbon dioxide] injection in this reservoir shows specific features that are different than injection in porous media. Considering the low porosity/permeability of the rock matrix in the case study, the CO_2 transmissivity is dominated by the fracture network where hydrodynamic and geochemical effects play a key role influencing the reservoir behavior and defining conditions for safe and efficient injection. The challenge at Hontomín was to manage the low injectivity in the reservoir. Recommendations to overcome this difficulty are analyzed. The design of injection strategies must consider characteristic parameters at the well head, tubing and bottom hole according to the interpretation of results from petrophysical laboratory tests, in particular those performed under reservoir conditions, and from field tests conducted on site. The use of an appropriate dynamic model is essential to achieve a realistic assessment of reservoir behavior. The hypothesis, data interpretation and conclusions reached with the modeling are discussed." **J. Carlos de Dios, Miguel A. Delgado, Carlos Martínez, Alberto Ramos, Iñaki Álvarez, Juan A. Marín, and Ignacio Salvador**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Regional carbon emission evolution mechanism and its prediction approach driven by carbon trading – A case study of Beijing.

The following is the Abstract of this article: "Resources and environmental issues have become the main obstacles to the global sustainable development. For example, the global warming and paroxysmal environmental problems induced by fossil energy consumption are highlighted in recent years. As a big energy consumption and carbon emission country, China has tried to establish and implement the carbon emission trading mechanism in order to adjust the economic development patterns, optimize the energy structure and fulfill the emission goals. This mechanism has played a certain role in guiding and supporting the energy saving and carbon emission reduction. With the wide popularization and acceptance of low-carbon and green development, the advantages and the benefits of regional carbon emission trading mechanism will gradually show up with more trading activities and enterprise participation. Therefore, it's imperative to explore the carbon emission trading mechanism and provide relative suggestions for government and enterprises. For analyzing the carbon emission trading mechanism in China, the development situations of economy, energy and policy were reviewed firstly. Then, based on the direct and indirect emissions, the carbon emission measurement method was used to study the emission trends of Beijing and pilot areas. With the system dynamics analysis model, the key factors and evolution circuits influential to the carbon emission mechanism were identified from the aspects of society, energy, economy and environment. The factors were further selected by extended STIRPAT model and ridge regression model in order to construct the BP Neural Network prediction model of carbon emissions. Meanwhile, take Beijing as an example, seven different development scenarios were set to test the rational levels of carbon emissions in the next five years. At last, with the prediction and scenario analysis results, some policy advices were discussed and provided theoretical and practical references for reasonable and efficient carbon emission trading." **Jin-peng Liu, Xu-bei Zhang, and Xiao-hua Song**, *Journal of Cleaner Production*. (Subscription may be required.)

REPORTS and OTHER PUBLICATIONS

Geological Storage of CO_2 in Deep Saline Formations.

The following is a description of this book: "This book offers readers a comprehensive overview, and an in-depth understanding, of suitable methods for quantifying and characterizing saline aquifers for the geological storage of CO_2. It begins with a general overview of the methodology and the processes that take place when CO_2 is injected and stored in deep saline-water-containing formations. It subsequently presents mathematical and numerical models used for predicting the consequences of CO_2 injection. This book provides descriptions of relevant experimental methods, from laboratory experiments to field scale site characterization and techniques for monitoring spreading of the injected CO_2 within the formation. Experiences from a number of important field injection projects are reviewed, as are those from CO_2 natural analog sites. Lastly, the book presents relevant risk management methods. Geological storage of CO_2 is widely considered to be a key technology capable of substantially reducing the amount of CO_2 released into the atmosphere, thereby reducing the negative impacts of such releases on the global climate. Around the world, projects are already in full swing, while others are now being initiated and executed to demonstrate the technology. Deep saline formations are the geological formations considered to hold the highest storage potential, due to their abundance worldwide. To date, however, these formations have been relatively poorly characterized, due to their low economic value. Accordingly, the processes involved in injecting and storing CO_2 in such formations still need to be better quantified and methods for characterizing, modeling and monitoring this type of CO_2 storage in such formations must be rapidly developed and refined."

A Reduced-Order Model of Fault Leakage for Second-Generation Toolset.

The following is the Abstract of this NRAP document: "This report describes the NRAP second-generation fault leakage model. The key features of the new model are: [(1) A three-dimensional (3-D) site model has been developed; (2) Geomechanical changes in permeability due to fault slip are now included; and (3) The Kimberlina reservoir model is used as a reference to specify boundary conditions for pressure and saturation.] This report briefly describes both the high-fidelity leakage simulations and their subsequent reduction to a response-surface model. This response-surface model constitutes a reduced-order model (ROM) that can be incorporated into a system model that predicts the potential for CO_2 or brine to be released from a storage reservoir to an overlying aquifer or the atmosphere. This second-generation ROM builds on the first-generation ROM, which was two-dimensional (2-D) and did not incorporate geomechanical effects. Note that this ROM considered aseismic, quasi-static slip behavior. The third-generation ROM will look at leakage response due to seismic events."

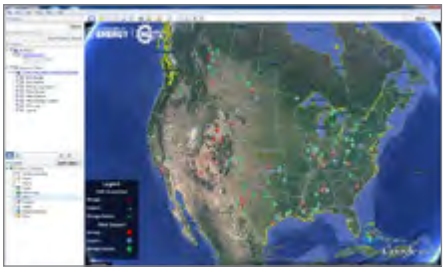
NRAP
National Risk Assessment Partnership

ABOUT DOE'S CARBON STORAGE PROGRAM

The **Carbon Storage Program** advances the development and validation of technologies that enable safe, cost-effective, permanent geologic storage of CO_2. The Carbon Storage Program also supports the development of best practices for CCS that will benefit projects implementing CCS at a commercial scale, such as those being performed under NETL's Clean Coal Power Initiative and Industrial Carbon Capture and Storage Programs. The technologies being developed and the small- and large-scale injection projects conducted through this program will be used to benefit the existing and future fleet of fossil fuel power-generating facilities by developing tools to increase our understanding of the behavior of CO_2 in the subsurface and identifying the geologic reservoirs appropriate for CO_2 storage.

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

Carbon Storage Program Resources



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

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

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

ABOUT NETL'S CARBON STORAGE NEWSLETTER

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

National Energy Technology Laboratory

The *National Energy Technology Laboratory (NETL)*, part of DOE's national laboratory system, is owned and operated by the U.S. Department of Energy (DOE). NETL supports DOE's mission to advance the national, economic, and energy security of the United States.

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