CSN CARBON STORAGE NEWSLETTER

NOVEMBER 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

DOE/FE Selects Projects for Offshore Carbon Storage Resources and Technology Development.

Offshore Carbon Storage

Two projects have been selected by the U.S. Department of Energy's (DOE) Office of Fossil Energy (FE) to receive Federal funding to assess offshore geologic storage of carbon dioxide (CO_2) and technology development in the Gulf of Mexico. Selected as part of FE's Carbon Storage Program, the National Energy Technology Laboratory (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, such as infrastructure, operational, and monitoring (the technology-development needs of offshore storage differ from those of onshore storage). From *energy.gov* on November 7, 2017.

DOE Selects Two Projects to Ensure Safe Storage of CO_2 in Geologic Formations.

DOE/FE selected two projects to receive Federal funding for cost-shared research and development (R&D) for the safe storage of CO_2 in geologic formations. The two projects are supported through Funding Opportunity Announcement (FOA) DE-FOA-0001725, "*Technology Development to Ensure Environmentally Sustainable CO_2 Injection Operations*," which focuses on developing modeling and monitoring methods, technologies, and tools that help assess the position of CO_2 plume over time within various geologic formations and sedimentary environments. The NETL-managed projects will support the *Carbon Storage Program*. More information on the selected projects is available on the *FE website*. From *energy.gov* on October 26, 2017.

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. From *energy.gov* on October 11, 2017.

The Valero Port Arthur Refinery

ANNOUNCEMENTS

DOE-Supported Project Reaches Milestone.

The Petra Nova project, DOE's post-combustion carbon capture system, has captured more than 1 million metric tons of CO_2 for use in EOR operations. Located near Houston, Texas, USA, the project demonstrates an advanced amine-based CO_2-capture technology that removes 90 percent of the CO_2 emitted from the flue gas stream. The captured CO_2 is used for EOR at the West Ranch Oil Field, which has increased oil production from 300 barrels per day when it began operations to approximately 4,000 barrels per day currently.

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) have been removed.

DOE/NETL Conference Proceedings Available Online.

Proceedings of the DOE/NETL-sponsored "2017 Mastering the Subsurface Through Technology Innovation, Partnerships, and Collaboration: Carbon Storage and Oil and Natural Gas Technologies Review Meeting," held in Pittsburgh, Pennsylvania, USA, on August 1-3, 2017, are available online. Included are posters and presentations from the three-day meeting.

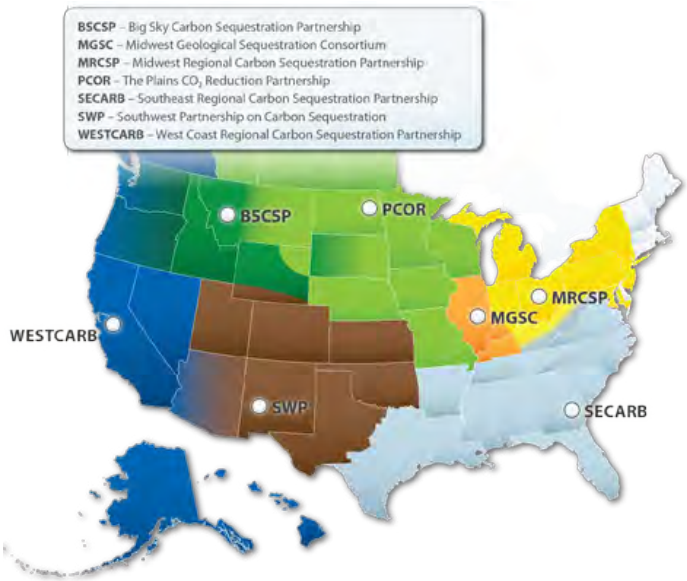
NRAP Commences Phase II Research Program.

DOE's *National Risk Assessment Partnership (NRAP)* entered Phase II of its research, in which researchers will consider how potential geologic carbon storage risks can be mitigated and how uncertainties in site performance can be reduced using strategic monitoring. Phase II objectives include the development of advanced predictive models of geologic carbon storage system containment effectiveness/leakage response; development of a second-generation, open-source integrated assessment framework to quantify containment effectiveness/leakage response; development of improved tools and protocols to support advanced seismic hazard analysis and forecasting; development of tools to model monitoring and optimize design of monitoring networks for leak detection; and testing and validation of NRAP tools and methods using field data sets.

PROJECT and BUSINESS DEVELOPMENTS

Battelle Completes CO_2 Storage Project.

A 15-year DOE/NETL-funded research project that tested geologic CO_2 storage at a commercial-scale, coal-fired power plant has concluded. Battelle started the CCS research project at American Electric Power's (AEP) Mountaineer Plant in New Haven, West Virginia, USA, in 2002. AEP decided in 2007 to proceed with a 20-MW pilot-test facility with onsite CO_2 capture, compression, transport, and injection. From 2009 through 2011, CO_2 was injected into two injection zones; this was followed by a post-injection monitoring and site-closeout phase, which ended in 2017. The project helped establish the technical viability of CCS to reduce greenhouse gas (GHG) emissions from coal-fired power plants and to store CO_2 in geologic layers with limited prior data. The collaboration has led to geologic, engineering, field implementation, and regulatory lessons learned, with regional and global impact for CCS technology development and new knowledge for DOE's *Regional Carbon Sequestration Partnerships (RCSPs)*. From *Battelle News Release* on October 26, 2017.



Map depicting location of the seven RCSP regions.

Montana Pipeline Proposed to Transport CO_2 for EOR.

Denbury Resources, Inc. is seeking to build a pipeline in eastern Montana, USA, that would transport CO_2 for use in oil production along the North Dakota border. The proposed pipeline would begin near the Wyoming border and extend 110 miles to the Cedar Creek Anticline, an aging oil field with potential reserves of 260 to 290 million barrels of oil, according to Denbury officials. From *Casper Star Tribune* on October 9, 2017.

Partnership to Combine Carbon Capture, Storage in Pilot Plant.

In partnership with Reykjavik Energy, the Swiss company Climeworks will demonstrate a safe, economically viable, and highly scalable carbon removal technology. Part of the CarbFix2 project, which stores air-captured CO_2 safely and permanently in basalt, the pilot plant centers around a geothermal power plant in Hellisheidi, Iceland, where CO_2 is currently being injected and mineralized at an industrial scale. Climeworks has initiated the testing phase, during which the CO_2 is captured from ambient air, bound to water, and sent underground where it reacts with the basalt to form solid minerals, creating a permanent storage solution. From *Climeworks Press Release* on October 12, 2017.

EOR Project in UK North Sea.

Chevron North Sea (CNSL) will proceed with Phase I of its Captain EOR project located in the UK North Sea. The first stage of the project involves the use of polymer technology to increase the overall recovery rate from the Captain heavy oil field, located on the edge of the outer Moray Firth. From *Energy Business Review* on October 23, 2017.

Underground CO_2 Storage Test Facility Opens.

A new facility that will develop and demonstrate technologies for the safe underground storage of CO_2 was officially opened in Alberta, Canada. Built by CMC Research Institute and operated by its Containment and Monitoring Institute, the Field Research Station (FRS) was developed with an investment by the Canadian government's Western Economic Diversification Program and is supported by the University of Calgary. Monitoring technologies developed at the site will provide results that demonstrate methods for tracking the movement of CO_2 underground and verifying safe and secure storage. From *CMC Research Institutes News Release* on October 24, 2017.

LEGISLATION and POLICY

New Standards for the Transport and Storage of CO_2 Announced.

In cooperation with Standards Norway and Gassnova, the Norwegian Petroleum Directorate announced the launch of two international standards for the transport and storage of CO_2. The transport standard stipulates the requirements related to the design, construction, and operation of pipelines; the storage standard contains requirements related to storage site selection, operation, and shutdown. The two CCS standards were researched and developed in the International Organization for Standardization (ISO). From *World Oil* on November 1, 2017.

Singapore Government Seeks Public Consultation on Carbon Bill.

The Singapore government is conducting a second round of public consultation on a carbon tax as it releases a draft carbon pricing bill that sets out the overall carbon tax framework and obligations for GHG emitters. The tax would be a credits-based mechanism in which facilities buy carbon credits that correspond to their GHG emissions, surrendering the credits to the National Environment Agency (NEA). The consultation for the draft bill, which was launched online on October 31, 2017, will last until December 8, 2017. The proposed tax would be applied to companies that emit more than 25,000 metric tons of CO_2-equivalent GHGs a year. From *The Strait Times* on October 31, 2017.

Canadian Province Announces Low-Carbon Tax Policy.

The Canadian province of Manitoba will introduce a carbon tax in 2018, government officials announced. The carbon tax of $19 per metric ton is half the amount mandated by the Canadian government, which agreed to the Pan-Canadian Framework on Clean Growth and Climate Change in 2016. Under the framework, Canadian federal carbon levy rates will initially be set for the period of 2018 through 2022; the Manitoban rate of $19 per metric ton will rise after 2018, and a full review of the carbon pricing plan will take place in 2022. From *Tax-News* on November 1, 2017.

EMISSIONS TRADING

RGGI to Hold 38th Quarterly CO_2 Allowance Auction.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the *Auction Notice* and application materials for their 38th quarterly CO_2 allowance auction, to be held on December 6, 2017. As indicated in the Auction Notice, the states will offer 14,687,989 CO_2 allowances for sale with a minimum reserve price of $2.15. In addition, there is also a 10 million CO_2 allowance cost containment reserve (CCR) available, which will be accessed if the interim clearing price exceeds the CCR trigger price of $10.00. Auction 38 will be the final quarterly auction in which states will offer CO_2 allowances for purchase to meet CO_2 compliance obligations for the third control period, which began on January 1, 2015. From *RGGI News Release* on October 10, 2017.

RGGI Inc.

CLIMATE and SCIENCE NEWS

Project to Study Economic Models for CCS.

Three universities are receiving funding as part of a National Science Foundation project to determine if changes in commodity production and capturing CO_2 are sustainable in the Upper Missouri River Basin. The University of Wyoming will develop the economic models; Montana State University will study agriculture and biofertilizers, food security, clean energy, and water supply and quality; and the University of South Dakota will focus on land use, biodiversity, and ecosystem services assessment. Together, the project will look to decrease atmospheric CO_2 through alternative agricultural and energy approaches, such as biofuels and carbon storage. More information on the project is *available online*. From *Carbon Capture Journal* on October 10, 2017.

Potential Climate Change Could Alter Microbial Interactions.

According to a study conducted by scientists at Lamont-Doherty Earth Observatory, rising levels of oceanic CO_2 may influence the activity of two marine organisms essential to ocean health. By potentially altering the relationship between the two ocean-dwelling microbes, Prochlorococcus and Alteromonas, the overall structure and function of an ecosystem can be impacted, the study claims. The new study builds on previous research conducted in 2015, which concluded that "vast swaths of the ocean where Prochlorococcus now dominates" may change due to potentially high CO_2 levels and ocean acidification. From *phys.org* on November 1, 2017.

JOURNAL ARTICLES

Estimation of soil carbon sequestration and profit analysis on mitigation of CO_2-eq. emission in cropland cooperated with compost and biochar.

The following is the Abstract of this article: "Only a few have evaluated the mitigation of greenhouse emissions and profit analysis along with soil carbon sequestration for corn cultivation. This experiment was conducted to evaluate the carbon sequestration and mitigation of [GHG] emissions as well as their profit analysis with different composts mixed with biochar during corn cultivation. This experimental data provided the second year of corn cultivation. The soil type used was clay loam. The application amounts of synthetic fertilizer and biochar were 220–30–155 kg ha^{-1} (N–P–K) as the recommended amount after soil analysis and 2600 kg ha^{-1} based on 1.3% of soil bulk density. For the biannual experimental results, it appeared that carbon sequestration in cow manure cooperated with biochar was highest at 2.3 tons ha^{-1} and recovered from 67.3 to 78.5% with biochar application. Furthermore, mitigation of CO_2-eq. emission as [GHGs] was estimated to be at 7.3–8.4 MT ha^{-1}, and its profit was evaluated from $7.2 to 8.4 as lowest, from $57.2 to 66.6 as medium and from $139.7 to 162.7 as highest per hectare regardless of organic compost types used. For agricultural practice in Korea, it is evaluated that the market price of CO_2 in corn field cooperated with 2600 kg ha^{-1} of biochar application ranged from $57.2 to 162.7 per hectare in Korean Climate Exchange. For corn biomass, the treatment with biochar application did not significantly decrease compared with the only organic compost application. Based on these experimental results, it might be applied for carbon trading with clean development mechanism for agricultural practices." **JoungDu Shin, Seung Gil Hong, SunIl Lee, SungChang Hong, and JongSik Lee**, *Applied Biological Chemistry*. (Subscription may be required.)

Can energy policies affect the cycle of carbon emissions? Case study on the energy consumption of industrial terminals in Shanghai, Jiangsu and Zhejiang.

The following is the Abstract of this article: "This paper proposes an approach to calculate the time series of cumulative CO_2 emissions between 1995 and 2014 based on industrial energy consumption data in three Eastern China jurisdictions in Shanghai, Jiangsu and Zhejiang during these two decades. Using the Hodrick-Prescott filter, the fluctuation components of the cumulative CO_2-emission time-series data in the three provinces are obtained. Subsequently, a grey correlation-based change-point search algorithm is used to determine change-points in these data. Additionally, the CO_2-emission time-series is divided into stages based on the change-points. The cycle characteristics of national energy policies, laws, and regulations are compared with those of the cumulative CO_2-emission cycle of the three provinces to [analyze] the impact of energy policies on CO_2 emissions. This study shows that, although the industrial structure and trends in the CO_2 emission time-series data of the three provinces are different, their cumulative CO_2-emission cycle remains the same from 1995 to 2014. The variation characteristics of the cumulative CO_2 emissions for each cycle during this period are well aligned with the stage characteristics of energy policies, laws, and regulations, indicating that energy policies play a consistent role in regulating such emissions. This study examines low-carbon production and sustainable energy development, and offers suggestions for issuing and perfecting energy policies, laws, and regulations, considering the indicators of energy consumption and CO_2 emissions." **Lihong Wang, Zaiwu Gong, Ge Gao, and Changkai Wang**, *Ecological Indicators*. (Subscription may be required.)

CCS Leakage Detection Technology - Industry Needs, Government Regulations, and Sensor Performance.

The following is the Abstract of this article: "Reliable CCS monitoring is vital in order to confirm that injected CO_2 stays in the reservoir as intended, and that any occurring leakage is promptly detected allowing corrective actions to be initiated. Motivations for implementing monitoring strategies beyond the legal minimum required by government regulations, can be divided into economic, environmental and reputational factors, where the latter is significant; adequate monitoring is important for attaining public acceptance. CCS monitoring methods can be divided into deep focused (reservoir, overburden) and shallow focused (seabed, water column) methods. Shallow monitoring methods include acoustic and chemical sensors placed in the water column. For the CCS application, these sensor technologies are complementary; acoustic sensors are sensitive to CO_2 in gas phase and chemical sensors can detect water-dissolved CO_2 or formation fluids. [The authors] discuss the motivations for CCS monitoring, and offer a structured overview of acoustic and chemical technologies for CCS monitoring at the seabed and in the water column. Each technology is evaluated in terms of its applicability to CCS monitoring, highlighting its strengths and limitations for detection, quantification and characterization of CCS related leakage. [The authors] conclude that while state of the art sensor technology is sufficient to meet government requirements, there is potential for improved integrated monitoring through optimal use and combination of technologies. The concept of integrated monitoring where different sensor types measure different parameters is emerging as a promising monitoring strategy." **Ivar-Kristian Waarum, Ann E.A. Blomberg, Espen Eek, Jock Brown, Amund Ulfsnes, Mike Carpenter, Torleiv S. Grimsrud, Joonsang Park, Gerard Cornelissen, and Per Sparrevik**, *Energy Procedia*. (Subscription may be required.)

Recent increases in terrestrial carbon uptake at little cost to the water cycle.

The following is the Abstract of this article: "Quantifying the responses of the coupled carbon and water cycles to current global warming and rising atmospheric CO_2 concentration is crucial for predicting and adapting to climate changes. Here [the authors] show that terrestrial carbon uptake (i.e. gross primary production) increased significantly from 1982 to 2011 using a combination of ground-based and remotely sensed land and atmospheric observations. Importantly, [the authors] find that the terrestrial carbon uptake increase is not accompanied by a proportional increase in water use (i.e. evapotranspiration) but is largely (about 90%) driven by increased carbon uptake per unit of water use, i.e. water use efficiency. The increased water use efficiency is positively related to rising CO_2 concentration and increased canopy leaf area index, and negatively influenced by increased [vapor] pressure deficits. [The authors'] findings suggest that rising atmospheric CO_2 concentration has caused a shift in terrestrial water economics of carbon uptake." **Lei Cheng, Lu Zhang, Ying-Ping Wang, Josep G. Canadell, Francis H. S. Chiew, Jason Beringer, Longhui Li, Diego G. Miralles, Shilong Piao, and Yongqiang Zhang**, *Nature Communications*. (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

Laboratory measurements monitoring supercritical CO_2 sequestration using ghost reflections retrieved by seismic interferometry.

The following is the Abstract of this article: "Monitoring of seismic changes inside the reservoir layer during CO_2 sequestration can be valuable for extraction of reservoir quantities like saturation and pore pressure. The accuracy of the monitoring could be deteriorated due to nonrepeatability errors in the source and receiver geometry. Applying seismic interferometry (SI) to permanent networks of seismic stations to retrieve virtual sources at the positions of the stations eliminates the non-repeatability in the source positioning. SI is traditionally applied using crosscorrelation. [The authors] show results from application of SI to ultrasonic data for layer-specific monitoring of sequestration of supercritical CO_2. The data are recorded on a two-layer sample consisting epoxy (caprock) and Bentheimer sandstone (reservoir). [The authors] apply SI by crosscoherence, which has the potential to retrieve results with higher temporal resolution that SI by crosscorrelation. Using SI, [the authors] retrieve non-physical reflections from the bottom of the sandstone as if source and receiver were placed at the top of the sandstone. The velocities [the authors] estimate from the non-physical reflections during injection of brine aiming to displace supercritical CO_2 and during injection of supercritical CO_2 aiming to displace brine indicate rather similar saturation for both injection cases. [The authors] confirm the latter by transmission measurements, but with lower resolution." **Deyan Draganov, Alex Kirichek, Karel Heller, and Ranajit Ghose**, *Society of Exploration Geophysicists*. (Subscription may be required.)

Carbon dioxide and heat integration of industrial parks.

The following is the Abstract of this article: "The depletion of natural resources and the increase in [GHGs] emissions has led to policies aiming at drastic [CO_2] emissions reductions over current levels. This work addresses the [CO_2] integration of industrial parks, i.e. the integration of [CO_2] sources, sequestration and utilization options to achieve required emissions reductions at minimum cost. The work makes use of the recently proposed [CO_2] integration approach to explore carbon management options across an industrial park together with energy integration approaches to (1) minimize net energy demand of the industrial park and therefore cut fuel and corresponding emissions, and (2) explore synergies available from utilizing excess process heat to provide low-cost, emissions free heat and power sources for energy intensive carbon capture and compression costs. The proposed approach integrates methods for [CO_2] and heat integration. The approach is demonstrated through a case study for which substantial savings are identified with the new approach." **Raid J. Hassiba, Dhabia M. Al-Mohannadi, and Patrick Linke**, *Journal of Cleaner Production*. (Subscription may be required.)

Accounting and structure decomposition analysis of embodied carbon trade: A global perspective.

The following is the Abstract of this article: "In this paper, a multi-regional input-output model is built to estimate the global embodied carbon trade from 1995 to 2009 based on the World Input-Output Database (WIOD). The method of structure decomposition analysis (SDA) is applied to quantify the changes in the scale and structure of embodied carbon trade in China, India, Japan, and the United States. According to the results, the top three countries with the most embodied carbon trade were: the United States, China and Japan in 1995, and the United States, China and India in 2009. In 1995 and 2009, the sectors which have the highest direct carbon emission coefficients and total carbon emission coefficients in China, India and the United States are electricity, gas and water supply sectors, while each country maintained a different coefficient. A decrease of direct carbon emission coefficient will result in a reduction of the imports and exports, as well as the self-consumption of embodied carbon. Therefore, it is suggested that countries should develop low-carbon industries, and reduce the carbon emissions per unit of output. In addition, those countries with higher carbon emission coefficients should consider of importing products to lower carbon emissions." **Guangyao Deng and Yan XU**, *Energy*. (Subscription may be required.)

REPORTS and OTHER PUBLICATIONS

Reduced-Order Model for Leakage through an Open Wellbore from the Reservoir due to CO_2 Injection.

The following is the Abstract from this NRAP document: "Potential CO_2 leakage through existing open wellbores is one of the most significant hazards that needs to be addressed in geologic carbon sequestration (GCS) projects. In the framework of NRAP which requires fast computations for uncertainty analysis, rigorous simulation of the coupled wellbore-reservoir system is not practical. This study developed a 7,200-point look-up table reduced-order model (ROM) for estimating the potential leakage rate up open wellbores in response to CO_2 injection nearby. The ROM is based on coupled simulations using T2Well/ECO2H which was run repeatedly for representative conditions relevant to NRAP to create a look-up table response-surface ROM. The ROM applies to a wellbore that fully penetrates a 20-m thick reservoir that is used for CO_2 storage. The radially symmetric reservoir is assumed to have initially uniform pressure, temperature, gas saturation, and brine salinity, and it is assumed these conditions are held constant at the far-field boundary (100 m away from the wellbore). In such a system, the leakage can quickly reach quasi-steady state. The ROM table can be used to estimate both the free-phase CO_2 and brine leakage rates through an open well as a function of wellbore and reservoir conditions. Results show that injection-induced pressure and reservoir gas saturation play important roles in controlling leakage. Caution must be used in the application of this ROM because well leakage is formally transient and the ROM lookup table was populated using quasi-steady simulation output after 1,000 time steps which may correspond to different physical times for the various parameter combinations of the coupled wellbore-reservoir system."

NRAP
National Risk Assessment Partnership

Influence of Geochemical Processes on the Geomechanical Responses of Overburden Strata during CO_2 Storage in Saline Aquifers.

The following is the Executive Summary of this NRAP document: "Saline aquifers have been identified as types of desirable geologic formations suitable for storage of CO_2 in large amounts. While the impermeable caprock layer(s) in the overburden provides the primary trap for injected CO_2, other trapping mechanisms such as solubility, residual, ionic or mineral trapping help contribute to CO_2 storage. Geochemical reactions alter the petrophysical properties in the target reservoir, and may have an influence on the reservoir storage capacity. When CO_2 is injected for long periods of time, it changes the fluid pressures and overburden geomechanical response. In this study, coupled multiphase fluid flow and geomechanical modeling with geochemical processes was performed to simulate long-term (1,000 years), large-scale injection of CO_2 (up to10 million metric tons per year) into a deep saline aquifer, to investigate the influence of geochemical processes on the geomechanical response of overburden during long-term CO_2 injection. Geochemical modeling results from this study show that geochemical processes such as mineral dissolution and precipitation have very little influence on reservoir rock porosity at the reservoir scale. Results from the coupled fluid flow and geomechanics models with geochemical reactions for large-scale CO_2 injection scenarios indicate that the inclusion of geochemical reactions in the geomechanical models have a very little influence on the computed vertical ground displacements during injection and post-injection periods. Modeling results show that the pressure increases and ground displacements caused due to CO_2 injection decay with time during the post-injection period. Thus, the study findings are that geochemical interactions have no significant impact on geomechanical response at the reservoir scale. It should be noted, however, that the impacts of geochemistry on geomechanical response at the local scale, such as in faults or fractures that are found in a caprock layer, were not addressed in this study."

Principles for Best Practice Geomechanics for CCS Injection Operations and its Application to the CarbonNet Project.

The following is from the Executive Summary of this Global CCS Institute document: "For the CCS industry to make a significant contribution to global emissions reduction, it must be deployed at scale, worldwide. This 'new' industry will inherit much of the data and experience of the petroleum industry especially as regards safe operation and pressure management. An important element for every CCS project is the identification of subsurface injection pressure limits to ensure CO_2 retention. The purpose of the pressure limits is to protect the overlying aquifers, for surface equipment integrity, and to ensure subsurface geomechanical stability. A high confidence is required that during the operation of an injection project, any geomechanical events will be small and/or relatively [localized] and that adequate safeguards exist to prevent or [minimize] adverse events. Best Practice manuals for CCS are in development worldwide but to date no comprehensive code of practice or manual has been published. Extensive datasets exist in the experience of drilling oil and gas wells in a wide variety of stress regimes. The process of well drilling samples and tests the geomechanical environment in a near-wellbore context (tens to hundreds of [meters]) over a relatively short timeframe of days to months, while injection of fluids leads to a test over a larger spatial extent (km to tens of km) over longer timeframes (years to decades), and therefore a more stringent pressure management approach is required due the larger potential scale of geomechanical effects. Although working pressure guidelines are commonly identified for injection projects, the resultant approaches applied worldwide are inconsistent, since they have been partially guided by local jurisdictions that account for the geomechanical in-situ conditions in different ways."

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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