CSN CARBON STORAGE NEWSLETTER

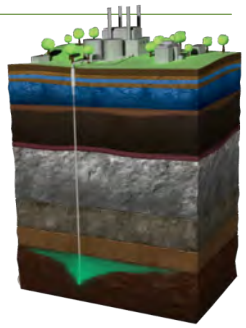
MARCH 2016

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

- Carbon Storage Educational Resources
- Program Reports, Plans, and Roadmaps
- Conference Proceedings
- Carbon Storage Portfolio
- Systems Analysis
- Peer Review
- Best Practices Manuals
- Fossil Energy Techlines

HIGHLIGHTS



"New Tools to Monitor Carbon Storage Risks Released for Testing."

Simulation tools developed by the U.S. Department of Energy (DOE)-led National Risk Assessment Partnership (NRAP) are under review by members of industry, regulatory agencies, universities, and other organizations, such as the *Regional Carbon Sequestration Partnerships (RCSPs)*. The successful deployment of the tools will enable users to predict the safety and permanence of carbon storage systems. Following review, the NRAP project team will implement improvements based on the feedback, with the final tool release expected in late 2016. For more information on NRAP and the new tool set, visit the *NRAP website*. From *Energy.gov* on February 11, 2016.

"U.S. Takes the Helm of International Carbon Capture Test Network."

The International Test Center Network (ITCN), a global consortium of facilities conducting research and development (R&D) on carbon capture technologies, will be led by the United States (represented by the Office of Fossil Energy [FE]), according to an announcement from DOE and *Norway's Technology Centre Mongstad (TCM)*. The ITCN, which also includes facilities in Australia, Canada, Germany, and the United Kingdom (UK), was formed by the DOE-sponsored *National Carbon Capture Center (NCCC)* and TCM to facilitate knowledge transfer from carbon capture test facilities around the world. Since its inception, the ITCN members have shared lessons learned from carbon capture R&D to aid in the commercial development of carbon capture and storage (CCS) technologies. From *Energy.gov* on February 24, 2016.

ANNOUNCEMENTS

DOE/FE Initiative Accepting Applications for Research Experience in Carbon Storage.

The Research Experience in Carbon Sequestration (RECS) Program, a DOE/FE initiative, is accepting applications from graduate students and early career professionals for RECS 2016, scheduled for June 12-20, 2016, in Birmingham, Alabama, USA. RECS 2016 will offer hands-on experience in areas related to carbon capture, utilization, and storage. The deadline to apply is May 13, 2016. For more information, visit the *RECS website*.

RGGI Releases Reports.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the *"Report on the Secondary market for RGGI CO_2 Allowances: Fourth Quarter 2015"* and the *"2015 Interim Compliance Summary Report."* The Secondary Market Report contains information on the secondary market for RGGI carbon dioxide (CO_2) allowances from October through December 2015. The Interim Compliance Report contains CO_2 allowance data to meet 2015 interim control period compliance.

Scientists Collaborate on CCS Research.

The University of Edinburgh (UK) and the University of Regina (Canada) signed a Memorandum of Understating (MOU) focused on strategic international research on CCS. The MOU will establish up to three scholarships each year; successful students will be accepted as visiting graduate students at Regina following the completion of two semesters for the University of Edinburgh's Master of Science (MSc) in CCS.

MITEI Announces Partnership to Support Low-Carbon Future.

The Massachusetts Institute of Technology's Energy Initiative (MITEI) will partner with national energy provider Exelon to advance technologies to address potential climate change through MITEI's eight Low-Carbon Energy Centers. Each center focuses on advancing research in a specific technology area, such as carbon capture, utilization, and storage.

CCS Technical Advisor Named to Gassnova.

AGR, a well construction and engineering project management company, will act as technical advisor to the Norwegian state-owned Gassnova, which focuses on the research, development, and implementation of CCS technology in Norway. As part of the agreement, AGR will offer technical expertise across geoscience, reservoir, and drilling disciplines, as well as facilities and cost engineering.

CARBON STORAGE in the NEWS

"[Japan Plans Test of Carbon Capture]."

Japan will inject CO_2 into saline formations off the coast of Hokkaido in a pilot project sponsored by the Ministry of Economy, Trade, and Industry (METI). Beginning in April 2016, CO_2 will be injected annually into two separate reservoirs under the seabed off the port of Tomakomai in Hokkaido at a site prepared by the Tokyo-based research company Japan CCS Co. From *Bloomberg* on February 28, 2016.

"Norway Examines Feasibility of CO_2 Shipping."

Norwegian state operator Gassco has commissioned two companies to study the transport of CO_2 by ship. The study will analyze various ship-based solutions for CO_2 transport, with the companies, Knutsen OAS Shipping and Larvik Shipping, submitting their finding to Gassco by mid-April 2016. From *The Maritime Executive* on February 29, 2016.

"Project to Test CO_2 Monitoring from a Subsea [Release]."

Carbon dioxide will be injected into the sea floor in the North Sea as part of a controlled experiment to test the safety of offshore CCS. The Strategies for the Environmental Monitoring of Marine CCS (STEMM-CCS) project, set to take place in 2018, will simulate emissions from a submerged CO_2 storage reservoir. The collaborative project will be led by the National Oceanographic Center (NOC) and will enable scientists to develop a system capable of detecting and quantifying the volume of CO_2 released. The technology will be installed at the site before the controlled release of the CO_2 in order to compare the natural changes from those resulting from the controlled release. From *Carbon Capture Journal* on March 2, 2016.

"ETI Studies Brine Removal from Subsea CO_2 Stores."

The Energy Technology Institute (ETI) launched a project that will study the impact of removing brine from undersea storage reservoirs that have CO_2 storage potential. The "Impact of Brine Production on [Formation] Storage" project will build on earlier CCS research and aid in developing an understanding of potential CO_2 storage reservoirs located beneath UK waters. From *Carbon Capture Journal* on March 2, 2016.

"Kuwait's First CO_2 Plant Officially Opened."

Kuwait's first CO_2 plant, with a design capacity of 280 metric tons of CO_2 per day, has officially opened. The plant is an international joint venture between Equate Petrochemical Company and Gulf Cryo. The Equate Petrochemical Company will provide raw CO_2 from its industrial operations to Gulf Cryo for use in various commercial applications. From *Trade Arabia* on February 17, 2016.

SCIENCE

"Enhanced Levels of Carbon Dioxide are Likely Cause of Global Dryland Greening, Study Says."

According to a study conducted by the School of Science at the Indiana University-Purdue University Indianapolis (IUPUI), enhanced levels of atmospheric CO_2 could be leading to global dryland greening. Researchers analyzed 45 studies from 8 countries, finding the that greening observed through satellite images may be a result of potentially rising levels of atmospheric CO_2 on plant water savings and the consequent increases in available soil water. Published in the journal "Scientific Reports," the study examined the sensitivity of soil water change to varying levels of CO_2, and discovered a positive change in soil water along the CO_2 enrichment gradient. The research also showed that elevated CO_2 enhanced soil water levels in drylands more than in non-drylands. From *Phys.org* on February 16, 2016.

POLICY

"Sweden Reveals Plan to Go 'Carbon Neutral' by 2045."

The Swedish parliamentary committee responsible for environmental policy proposed a plan to go "carbon neutral" by reducing its emissions by at least 85 percent from 1990 levels. The country would then offset the remaining 15 percent by investing in projects to reduce CO_2 emissions abroad. The government is expected to release more details on the legislative proposals later this year. From *Business Green* on February 12, 2016.

"Japan to Target 80 [Percent] Emissions [Reduction] by 2050."

According to a draft report, the Japanese government plans to reduce their greenhouse gas (GHG) emissions 80 percent from their current level by 2050. The draft states Japan will also set an official target of a 3.8 percent or more reduction in GHG emissions by 2020 compared to the 2005 level, as well as a target to reduce emissions by 26 percent by 2030 compared to 2013. Those targets, along with the long-term 2050 target, will be registered with the United Nations (UN) after the latest international framework on climate change takes effect. From *Nikkei Asian Review* on February 29, 2016.

"The European low-carbon mix for 2030: The role of renewable energy sources in an environmentally and socially efficient approach."

The following is the Abstract of this article: "The European Union's [EU] commitment to increase the presence of renewable energy sources in its portfolio has resulted in better levels of security of supply, competitiveness and environmental sustainability. This proposed work reviews European legislation regarding the promotion of renewable energy sources, as well as the bibliography that applies portfolio theory methodology to energy policy. This double revision gives rise to the question whether the share limits of renewable energy technologies anticipated for the European power mix in 2020 and 2030 are actually efficient. The optimization model corrects for the attractiveness of renewable energy sources as opposed to conventional sources in terms of costs, risks and pollutant gas emissions. This model successfully and explicitly identifies the positive effect on the environment that is represented by the inclusion of renewable energy sources in the portfolio. The goal is to minimize the cost and risk that society must bear to produce electricity, in addition to compliance with European pollutant gas (CO_2, SO_2, NO_x and PM) objectives. The results for 2020 indicate that the EU would not be able to reach its emissions reduction goals with the anticipated shares of renewable energy sources. In 2030, achieving a lower emissions portfolio would not mean taking on greater costs, although it would be necessary to assume a greater level of risk. The anticipated shares of renewable energy sources (+5 [percent]) and fossil fuel technologies (+15 [percent]) would be overdimensioned in the forecasts analyzed. In terms of technologies, both nuclear and wind energy stand out, both with shares above 20 [percent]. On the contrary, biomass and solar photovoltaic energies would be unnecessary in order to reach efficiency. In any case, one thing is clear: The EU would be the master of its energy future if it prioritizes the importance of renewable energy sources in its efficient portfolio." **Fernando deLlano-Paz, Anxo Calvo-Silvosa, Susana Iglesias Antelo, and Isabel Soares**, *Renewable and Sustainable Energy Reviews.* (Subscription may be required.)

"European Carbon Capture and Storage Project Network: Overview of the Status and Developments."

The following is the Abstract of this article: "The European CCS Project Network [the 'Network'] is currently composed of projects located in the Netherlands, Norway, Spain, and the UK. The goal of the Network is to accelerate deployment of CCS by sharing project development experiences about technology integration, regulatory environment and financial structures. This paper aims to provide a review of some CCS experiences gained from developing the Network projects. Besides technology and project development, sharing knowledge and lessons learned on project-level basis, also gives valuable insights on how to create policies that would assist more effective deployment of technology and can enable development and implementation of regulatory frameworks. Hence, knowledge acquired in CCS aspects during the early development of this technology in Europe will be presented in this paper." **Zoe Kapetaki, Jelena Simjanović, and Jens Hetland**, *Energy Procedia.* (Subscription may be required.)

GEOLOGY

"Effects of rate law formulation on predicting CO_2 [storage] in sandstone formations."

The following is the Summary of this article: "Injection of CO_2 into confined geological formations, given their massive carbon storage capacity and widespread geographic distribution, represents one of the most promising options for CO_2 [storage]. Reactive transport models have been constructed to understand the process of carbon storage and predict the fate of injected CO_2. Model results, however, differ dramatically because of the large uncertainties attributed to reaction kinetics. The root of this problem is partly related to the one of the biggest challenges in modern geochemistry: The persistent two to five orders of magnitude discrepancy between laboratory-measured and field-derived feldspar dissolution rates. Recently, advances in reaction kinetics research suggest that the slow precipitation of secondary minerals produces negative feedback in the dissolution–precipitation loop, which reduces the overall feldspar dissolution rates by orders of magnitude. In this study, [the authors] focused on how the coupling between feldspar dissolution and secondary mineral precipitation, as well as mineral carbonation, is affected by rate law uncertainties. Reactive transport models with four different rate law scenarios were used for CO_2 [storage] in a sandstone formation resembling the Mt. Simon saline reservoir in the Midwest, USA. The results indicate that (1) long-term mineral trapping is more sensitive to rate laws for feldspar dissolution than to rate laws for carbonate mineral precipitation and (2) negligence of the sigmoidal shape of rate – ΔGr relationships and the mitigating effects of secondary mineral precipitation can overestimate both the extent of feldspar dissolution during CO_2 injection and in turn mineral trapping." **Guanru Zhang, Peng Lu, Yilun Zhang, Xiaomei Wei, and Chen Zhu**, *International Journal of Energy Research*. (Subscription may be required.)

"Reduced order models of transient CO_2 and brine [release] along abandoned wellbores from geologic carbon [storage] reservoirs."

The following is the Abstract of this article: "[The authors] have developed reduced order models (ROMs) for CO_2 and brine [release] rates along wellbores including abandoned wells at geologic CO_2 storage sites using a Multivariate Adaptive Regression Splines (MARS) algorithm. The ROMs were developed for use within systems level performance assessment models such as Los Alamos National Laboratory's CO_2-PENS model. The ROMs are used to compute [release] rates as a function of wellbore properties including effective permeability, depth as well as pressures and saturations in the reservoir where the wellbore intercepts the reservoir. The ROMs were created using results of complex, 3-D multi-phase numerical simulations of large-scale CO_2 injection at a generic CO_2 storage site with an abandoned wellbore. The generic site included not only the primary storage reservoir but also a groundwater [formation] and an intermediate permeable zone. Two sets of simulations were performed, one with and one without an abandoned wellbore in order to capture the effect of coupling between the storage reservoir and wellbore in a system level model where it is assumed that they are decoupled. Cross-validation against the complex, multi-phase numerical simulation results were used to evaluate the ability of the ROMs to reproduce numerical simulation results. Further, [the authors'] ROM development approach effectively captures transient CO_2 and brine [release] during and after CO_2 injection as well as the effects of an intermediate permeable zone on [release] to a shallow groundwater [formation] and to the atmosphere. Ultimately, the ROM is a computationally efficient model that effectively captures many of the complex underlying processes taking place during CO_2 and brine [release] along a wellbore at a geologic CO_2 storage site." **Dylan R. Harp, Rajesh Pawar, J. William Carey, and Carl W. Gable**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

"Integration of reservoir simulation, history matching, and 4D seismic for CO_2-EOR and storage at Cranfield, Mississippi, USA."

The following is the Abstract of this article: "In this paper, [the authors] compare 4D seismic interpretations of CO_2 plume evolution with fluid-flow numerical simulation results for Cranfield, Mississippi. Historic pressure trends, oil and gas production rates, and current CO_2-[enhanced oil recovery (EOR)] production data from the field were history matched, and a tuned model was used for predictive simulations. For CO_2-EOR operations, numerical simulation results of the CO_2 plume distribution and CO_2 first arrival (breakthrough) times in production wells were compared to the available field data. Three interpretations of 4D seismic data show discrepancies on the edges of the seismic survey, and along the sealing fault, where numerical simulations show high CO_2 saturations. In areas between these two limits, the match between simulation and 4D seismic interpretation improves. In addition, for most of the production wells, comparison of the breakthrough time of CO_2 showed a reasonable match. The tuned model was then used to predict reservoir response and storage capacity in different field development scenarios under CO_2 injection. [The authors] compared hypothetical scenarios where the operator transitions from CO_2-EOR to CO_2 injection without oil production (CO_2-EORT) when oil production is not economical anymore, to a scenario of continuing with CO_2-EOR. [The authors'] results show that CO_2-EOR can store more CO_2 and operations will last longer, whereas if switched to CO_2-EORT, the field must be abandoned earlier because of spillover of the CO_2 plume. However, the amount of CO_2 stored per year is larger for CO_2-EORT as compared to CO_2-EOR." **Masoud Alfi and Seyyed A. Hosseini**, *Fuel*. (Subscription may be required.)

TECHNOLOGY

"Solving the [CO_2] buoyancy challenge: The design and field testing of a dissolved CO_2 injection system."

The following is the Abstract of this article: "Long-term security is critical to the success and public acceptance of geologic carbon storage. Much of the security risk associated with geologic carbon storage stems from CO_2 buoyancy. Gaseous and supercritical CO_2 are less dense than formation waters providing a driving force for it to escape back to the surface via fractures, or abandoned wells. This buoyancy can be eradicated by the dissolution of CO_2 into water prior to, or during its injection into the subsurface. Here [the authors] demonstrate the dissolution of CO_2 into water during its injection into basalts leading directly to its geologic solubility storage. This process was verified via the successful injection of over 175 t of CO_2 dissolved in 5000 t of water into porous rocks located 400–800 m below the surface at the Hellisheidi, Iceland CarbFix injection site. Although larger volumes are required for CO_2 storage via this method, because the dissolved CO_2 is no longer buoyant, the storage formation does not have to be as deep as for supercritical CO_2 and the [caprock] integrity is less important. This increases the potential storage resource substantially compared to the current estimated storage potential of supercritical CO_2." **Bergur Sigfusson, Sigurdur R. Gislason, Juerg M. Matter, Martin Stute, Einar Gunnlaugsson, Ingvi Gunnarsson, Edda S. Aradottir, Holmfridur Sigurdardottir, Kiflom Mesfin, Helgi A. Alfredsson, Domenik Wolff-Boenisch, Magnus T. Arnarsson, and Eric H. Oelkers**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

"Density Measurement and Modeling of CO_2–Brine System at Temperature and Pressure Corresponding to Storage Conditions."

The following is the Abstract of this article: "The densities of CO_2 solution of the brine from Teikoku Oil Field located at Niigata Prefecture in Japan are measured by a magnetic suspension balance at temperatures from 303.15 to 323.15 K, pressures from 10 to 20 MPa, and CO_2 mole fractions of 0, 0.0038, 0.0040, 0.0087, 0.0100, and 0.0160. Results show that the densities of CO_2–brine solution increase to 0.86 [percent] from that of brine and linearly increases with pressure at a gradient of 0.411 $kg \cdot m^{-3} \cdot MPa^{-1}$ and with CO_2 mole fraction at an average gradient of 514 $kg \cdot m^{-3} \cdot mol^{-1}$ at a temperature of 303.15 K. On the other hand, the density of CO_2–brine solution decreases with increasing temperature at an average rate of -0.377 $kg \cdot m^{-3} \cdot K^{-1}$ under [the authors'] experimental conditions. The ePC-PSAFT model is applied to predict the data obtained from this study and those from literature. It is demonstrated that the model works well with average relative deviation (ARD) of 0.27 [percent]. A correlation of density ratio of CO_2–brine solution to brine is provided and validated by data used in the ePC-PSAFT model, which is convenient for engineering application in comparison with that by the ePC-PSAFT. The ARDs for density ratio predicted by ePC-PSAFT and correlation are 0.075 [percent] and 0.019 [percent] for this work, respectively." **Yi Zhang, Tongtong Li, Baixin Chen, Masahiro Nishio, and Yongchen Song**, *J. Chem. Eng. Data*. (Subscription may be required.)

TERRESTRIAL

"Villagers and Scientists [Collaborate in Mangrove Project]."

A research project exploring mangroves on the coasts of Kenya found that mangrove forests are being impacted by coastal development. Mangrove forests filter pollutants and can reduce the impact of CO_2 emissions. The research, led by Edinburgh Napier University (UK) and the Kenya Marine and Fisheries Research Institute, has led to the conservation and restoration training of scientists, provided data for the Kenyan government's conservation policies, and led to the creation of a Community Forest Association. Since it was initiated in 2010, the project has led to the restoration of 20 hectares of degraded land. From *The Star* on February 26, 2016.

"Aquatic carbon cycling in the conterminous United States and implications for terrestrial carbon accounting."

The following is the Abstract of this article: "Inland water ecosystems dynamically process, transport, and [store] carbon. However, the transport of carbon through aquatic environments has not been quantitatively integrated in the context of terrestrial ecosystems. Here, [the authors] present the first integrated assessment, to [their] knowledge, of freshwater carbon fluxes for the conterminous United States, where 106 (range: 71–149) teragrams of carbon per year ($TgC \cdot y^{-1}$) is exported downstream or emitted to the atmosphere and sedimentation stores 21 (range: 9–65) $TgC \cdot y^{-1}$ in lakes and reservoirs. [The authors] show that there is significant regional variation in aquatic carbon flux, but verify that emission across stream and river surfaces represents the dominant flux at 69 (range: 36–110) $TgC \cdot y^{-1}$ or 65 [percent] of the total aquatic carbon flux for the conterminous United States. Comparing [the authors'] results with the output of a suite of terrestrial biosphere models (TBMs), [the authors] suggest that within the current modeling framework, calculations of net ecosystem production (NEP) defined as terrestrial only may be overestimated by as much as 27 [percent]. However, the internal production and mineralization of carbon in freshwaters remain to be quantified and would reduce the effect of including aquatic carbon fluxes within calculations of terrestrial NEP. Reconciliation of carbon mass–flux interactions between terrestrial and aquatic carbon sources and sinks will require significant additional research and modeling capacity." **David Butman, Sarah Stackpoole, Edward Stets, Cory P. McDonald, David W. Clow, and Robert G. Striegl**, *Proceedings of the National Academy of Sciences of the United States of America*. (Subscription may be required.)

TRADING

"[Ontario Releases Draft Cap-and-Trade Regulations]."

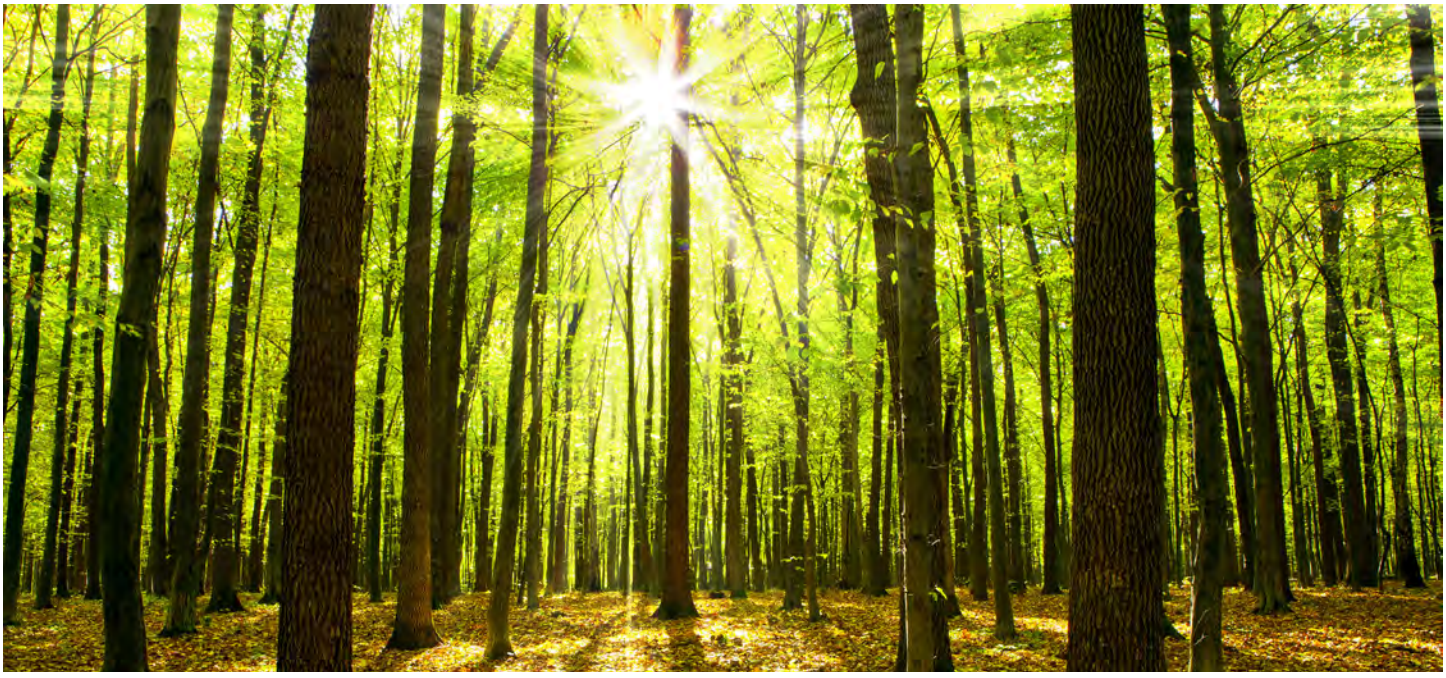
The Ontario government proposed annual emissions cuts of more than four percent for its cap-and-trade system in recently released draft regulations. Amendments to the regulations, which will undergo a period of public consultation, will allow for Ontario's program to be connected to the cap-and-trade programs in California and Québec (once a linking deal has been agreed upon). The draft proposed to cap CO_2 emissions for included sectors at 142.332 million metric tons in 2017, when the scheme starts, falling more than four percent per year to 124.668 million metric tons in 2020. From *Carbon Pulse* on February 26, 2016.

"Guangdong Becomes China's First Carbon Market to Green-Light OTC Forward Trading."

The Guangdong emissions exchange became China's first carbon market to release rules for forward trading in carbon. Under the rules, published in a bid to formalize the practice, parties may negotiate forward trades of Guangdong Emissions Allowances (GDAs) and Chinese Certified Emissions Reductions (CCERs). From *Carbon Pulse* on February 3, 2016.

"An optimal control model for reducing and trading of carbon emissions."

The following is the Abstract of this article: "A stochastic optimal control model of reducing and trading for carbon emissions is established in this paper. With considerations of reducing the carbon emission growth and the price of the allowances in the market, an optimal policy is searched to have the minimum total costs to achieve the agreement of emission reduction targets. The model turns to a two-dimension HJB equation problem. By the methods of reducing dimension and Cole–Hopf transformation, a semi-closed form solution of the corresponding HJB problem under some assumptions is obtained. For more general cases, the numerical calculations, analysis and comparisons are presented." **Huaying Guo and Jin Liang**, *Physica A: Statistical Mechanics and its Applications*. (Subscription may be required.



RECENT PUBLICATIONS

"A User's Guide to DFNGen."

The following is the Executive Summary of this NRAP document (NRAP is an initiative within DOE's National Energy Technology Laboratory [NETL]): "This report is the user manual for the initial release of the computer code [Discrete Fracture Network Generator Interface (DFNGen)]. DFNGen is a graphical user interface for the computer code FracGen and several supplementary ('ancillary') programs developed at NETL in Morgantown, West Virginia. The intent of DFNGen is to facilitate use of FracGen, to increase the understanding of FracGen's input options and to reduce errors in input. DFNGen is a Windows-based interface, which allows for the generation and control of input files using specially-created forms (windows). DFNGen runs FracGen as a background process and can analyze the resulting output using a range of options. The code also allows the import of input files from prior versions of FracGen. The analysis options in DFNGen allow the user to examine fracture length, fracture orientation, scanline spacing, and the spatial distribution of fracture center points. DFNGen implements a special version of FracGen, termed version 14M (i.e., FracGen version 2014, modified for current application), which has a revised input format. FracGen 14M, as with other versions of FracGen, incorporates three fracture "models" (Model1, Model2, Model3) to simulate randomly located fractures, randomly-located swarms or clusters of fractures and regularly-distributed cluster zones. Another option (termed Model0) permits the input of fracture data collected along boreholes, cores or outcrop scans by the user. Of importance for flow modeling, the generated fractures of the network can be subsequently adjusted for varying connectivity by several approaches, including synthetic annealing, to facilitate flow modeling with a network with a sparse number of fractures. This user guide provides an essential, but directed summary of DFNGen operation. For more details on FracGen, NFflow, or the ancillary codes, the user is referred to the user guide for these codes."

"Key Factors for Assessing Potential Groundwater Impacts Due to [Release] from Geologic Carbon [Storage] Reservoirs."

The following is from the Executive Summary of this NRAP document: "NRAP is developing a science-based toolset for the analysis of potential impacts to groundwater chemistry from CO_2 injection should [release] from a deep storage reservoir occur. The toolset adopts a stochastic approach in which predictions address uncertainties in shallow groundwater and [release] scenarios. It is derived from detailed physics and chemistry simulation results that are used to train more computationally efficient models, referred to here as reduced-order models (ROMs), for each component system. In particular, these tools can be used to help regulators and operators understand the expected sizes and longevity of plumes in pH, [total dissolved solids (TDS)], and dissolved metals that could result from a [release] of brine and/or CO_2 from a storage reservoir into [formations]. This information can inform, for example, decisions on monitoring strategies that are both effective and efficient. This approach was used to develop predictive ROM for two common types of [formations], but the approach could be used to develop a model for a specific [formation] and/or other common types of [formations]."

"Coupled Inversion of Hydrological and Geophysical Data for Improved Prediction of Subsurface CO_2 Migration."

The following is from the Executive Summary of this NRAP document: "This report is one of two deliverables resulting from a Lawrence Berkeley National Laboratory (LBNL) NRAP project that aimed at developing, testing, and applying novel methods for modeling geologic storage of CO_2 and jointly inverting monitoring data for [release] detection. This first NRAP report summarizes the method for jointly inverting hydrological and geophysical monitoring data. The ability to identify potential [release] pathways with monitoring data and continually monitor localized [release] of CO_2 and/or brine is essential for the science-based quantitative risk assessment at the core of the mission of NRAP. The second NRAP report describes the development, demonstration, and application of an inversion-based methodology for early [release] detection using pressure and surface deformation monitoring data."

"Future of carbon capture and storage in the UK."

The following is from the Summary of this UK Energy and Climate Change Committee document: "Meeting the UK's climate change commitments will be challenging if [CCS is not applied] to new gas-fired power stations and to energy intensive industries. Building the transport and storage infrastructure needed for CCS requires large upfront investments, but costs of later projects are expected to fall rapidly once this primary infrastructure is in place. Without CCS it may be necessary to find large and potentially more expensive carbon savings to meet the legally binding targets set out in the Climate Change Act as well as the more recent challenging ambitions set out at the Paris climate summit."

LEGISLATIVE ACTIVITY

"[Carbon Capture Bill Introduced]."

A group of lawmakers proposed a bill supporting deployment of carbon capture equipment at coal facilities for EOR. The measure would make permanent the existing CCS incentive (known as the *45Q tax credit*), which is set to expire once reaching 75 million tons of CO_2. Under the proposal, the credit value for CO_2 storage through EOR or other types of geologic storage would be gradually increased from $10 and $20 per ton, respectively, to $30 per ton by 2025. From *Utility Dive* on February 26, 2016.

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

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