U.S. DEPARTMENT OF ENERGY | OFFICE OF FOSSIL ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

CSN CARBON STORAGE NEWSLETTER

JANUARY 2018

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 Swears in New Assistant Secretary for Fossil Energy.

The new Assistant Secretary for the U.S. Department of Energy's (DOE) Office of Fossil Energy (FE) was officially sworn in by the Energy Secretary. The Assistant Secretary for Fossil Energy (ASFE) will oversee FE's research and development (R&D) program; serve as a primary policy advisor for the Energy Secretary and DOE on issues involving U.S. fossil fuels; and supervise the more than 1,000 scientists, engineers, technicians, and administrative members of the FE staff across the Nation. From *NETL News Release* on December 14, 2017.

NETL Software Developers Win Award.

The National Risk Assessment Partnership (NRAP) Toolset, developed by FE's 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.

NATIONAL ENERGY TECHNOLOGY LABORATORY

Los Alamos NATIONAL LABORATORY

Pacific Northwest NATIONAL LABORATORY

Lawrence Livermore National Laboratory

BERKELEY LAB

NRAP Technical Team

ANNOUNCEMENTS

Reports on Decarbonizing Australia.

A suite of reports released by Energy Networks Australia has found that decarbonizing gas in Australia by 2050 is achievable with the application of carbon capture and storage (CCS) to Australia's gas network infrastructure. The new report, titled "*Decarbonizing Australia's gas networks*," was conducted by Deloitte Access Economics and builds on a previous report, titled "*Gas Vision 2050*."

Carbon Capture Projects Map Developed.

A company developed an interactive map detailing the carbon capture projects across the world. The map filters projects by application, location, and partners. A database of the projects is *available online*.

Webinar on Decarbonizing Industry Using CCS.

The Global CCS Institute and Gassnova conducted a webinar exploring how Norway is working to realize a full-chain CCS project. In addition to providing an overview of the Gassnova-managed Norway *Full Chain CCS project*, the webinar also covered the value Norway seeks to derive and the key stakeholders involved.

ANNOUNCEMENTS *(cont.)*

Seminar on Nordic CCS Cooperation.

A recent seminar conducted by Bellona highlighted the role of CCS in reaching Europe's climate targets. According to the stakeholders, cooperation between Sweden and Norway on the development of common CCS infrastructure may lead to decreases in costs and increases in effectiveness.

Paper Published on CCS Market.

The European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) published an updated paper on their recommendations for the design of the Innovation Fund Delegated Act. The *paper* provides input on how the act can support the development of CCS "Market Makers."

PROJECT and BUSINESS DEVELOPMENTS

CCS Project Begins Feasibility Study.

The Acorn CCS Project in North East Scotland has begun a feasibility study. The project will transport captured CO_2 offshore, storing it underground in a deep saline formation. While the initial phase will focus on CO_2 captured from the St. Fergus gas-processing unit, later phases will store CO_2 from other sources. The feasibility study will demonstrate the commercial and regulatory aspects of CCS project development in the United Kingdom (UK). Researchers will develop a full-chain business case and economic model, as well as locate a North Sea geologic CO_2 storage site for the project. From *Carbon Capture Journal* on December 7, 2017.

MHI to License Capture Technology Capable of CCS.

Mitsubishi Heavy Industries (MHI) has agreed to license its flue gas carbon capture technology to a Swiss engineering company, Casale SA, which in turn will sublicense the technology license to a methanol producer, Metafrax. Casale SA will undertake the engineering, procurement, and construction management (EPCm) for Metafrax's facility, which has the potential to recover 1,200 metric tons of CO_2 per day. While Metafrax will use the CO_2 to produce ammonia, urea, and melamine, MHI's technology can also be used for CCS generated by thermal power plants and enhanced oil recovery (EOR). From *Power Engineering International* on December 27, 2017.

MOU to Include CCUS Research.

Khalifa University of Science and Technology, located in Abu Dhabi, United Arab Emirates (UAE), signed a Memorandum of Understanding (MOU) with Tsinghua University in Beijing, China, to collaborate on a program to support transformative scientific research. As part of the agreement, the two universities will form a collaborative program that will include research in engineering fields, such as carbon capture, utilization, and storage (CCUS). The collaboration covers the exchange of materials in education, research, publications, and academic information, as well as visitation and exchange of faculty members, researchers, and students. From *Masdar Institute News* on December 18, 2017.

LEGISLATION and POLICY

Virginia Carbon Emission Legislation Considered.

As part of a proposed *legislative agenda*, Virginia may place a cap on carbon emissions by joining the Regional Greenhouse Gas Initiative (RGGI). The Virginia State Air Pollution Control Board had *previously approved* draft regulations in November 2017 to reduce carbon emissions from power plants and link the state to RGGI. The new legislation would enable the state to auction the allowances and invest the revenues in public-benefiting programs. From *Utility Dive* on January 10, 2018.

Washington State Proposes Carbon Tax.

In a "*State of the State*" address, Washington's Governor detailed a proposal to reduce the state's carbon footprint by implementing a carbon tax plan. Under the proposed plan, a tax starting at $20/ton of CO_2 emissions (with adjustments for inflation) would be put in place in July 2019, generating approximately $1.5 billion every two years. The revenue generated would be reinvested in a series of initiatives aimed at reducing carbon emissions and providing exemptions and credits for some businesses, agricultural operations, and low-income residents. From *The Spokesman-Review* on January 9, 2018.

European Parliament, Council Agree on Forestry GHG Reduction Law.

The European Parliament and Council informally agreed on plans to reduce greenhouse gas (GHG) emissions and increase carbon absorption from forests as a way to offset potential climate change. Under the proposed law, European Union (EU) countries would have to ensure their CO_2 emissions are offset by the CO_2 absorption of forests, croplands, and grasslands. If the countries absorb more CO_2 than they emit in the first five-year period (2021 to 2025), the credit can be used to help achieve goals for the second five-year period (2026 to 2030). From *European Parliament Press Release* on December 14, 2017.

New Zealand Forms Zero Carbon Climate Act.

The government of New Zealand will start public consultation in May 2018 to lay groundwork for a "Zero Carbon Act" and to establish an independent commission. In addition, an Interim Committee will be established while the commission is set up. New Zealand government officials anticipate the framework for a net-zero emissions economy by 2050 to be in place by the end of the New Zealand parliamentary term. From *New Zealand Herald* on December 18, 2017.

EMISSIONS TRADING

RGGI Releases Updated Model Rule.

The states participating in RGGI released an updated model rule, concluding the regional process of the RGGI Program review; these changes will next be brought into effect with state-specific processes. The RGGI states will propose statutory and/or regulatory revisions to their CO_2 Budget Trading Programs consistent with the updated *2017 Model Rule*, which also includes an additional 30 percent regional cap reduction between 2020 and 2030 (summarized in the *Summary of Model Rule Updates*). In addition, the RGGI states agreed to *Principles to Accompany Model Rule Amendments* that will guide the proposing of these revisions. From *RGGI News Release* on December 19, 2017.

China Outlines Details of Emissions Trading Scheme.

The Chinese government announced the details of its nationwide carbon emissions trading scheme (ETS). According to the Chinese State Council and the National Development and Reform Commission (NDRC), trading will be based in Shanghai, China, and involve 1,700 power companies and more than 3 billion metric tons of CO_2 annually. Nine regions and cities (pilot schemes have taken place in seven of them) will coordinate to establish the market-oriented ETS system, which will help companies reduce emissions and carbon-intensified assets through the controlled allocation and trading of carbon emission allowances. From *Reuters* on December 19, 2017.

CLIMATE and SCIENCE NEWS

Report Highlights Whales' Carbon Storage Potential.

A new report documents the role of whales in the storage of atmospheric CO_2. The report, titled "*The Role of Cetaceans in Ecosystem Functioning: Defining Conservation Policies in the 21st Century*," is a product of a workshop conducted at the July 2017 International Congress for Conservation Biology. The report found that whales can trigger phytoplankton blooms that increase the productivity of the entire marine food web and store thousands of tons of atmospheric CO_2. From *Animal Welfare Institute Press Release* on December 19, 2017.

Wetland Erosion from Rising Lake Levels Could Create New Source of Carbon Emissions.

Fast-growing wetland plants use photosynthesis to absorb CO_2, storing it underground in their soil. The Illinois State Geological Survey launched a study to determine if wetlands are now releasing more CO_2 than they are storing as increased erosion releases CO_2. By studying Illinois Beach (USA), which has eroded approximately 21 feet within the past six months, researchers will be able to study how rising lake levels may affect the 500,000 acres of coastal wetlands across the Great Lakes basin. The research is expected to show how much carbon is at risk of being released once the wetland soil erodes. From *Chicago Tribune* on January 1, 2018.

Study Shows Bacteria's CO_2 Storage Potential.

According to scientists from the University of Dundee's School of Life Sciences, E. coli bacteria may lead to a method of capturing and storing CO_2. By developing a process that enables the E. coli bacterium to act as an efficient carbon capture device, scientists also claim that the E. coli solution could convert the CO_2 into a liquid that is "stable and comparatively easily stored." The results of the research have been published in the journal *Current Biology*, in a study titled "*Efficient Hydrogen-Dependent Carbon Dioxide Reduction by Escherichia coli*." From *Carbon Capture Journal* on January 8, 2018.

JOURNAL ARTICLES

U.S. DOE's Economic Approaches and Resources for Evaluating the Cost of Implementing Carbon Capture, Utilization, and Storage (CCUS).

The following is the Abstract of this article: "[DOE] and [NETL] are world leaders in CCUS research and analysis. They have developed resources and a set of economic tools to evaluate the cost to implement CCUS for each segment of the value chain: capture, transport, and storage. This paper provides a comprehensive review of the economic models and analytical approaches DOE/NETL has developed for assessing the CO_2 capture, storage, and transport cost drivers that impact the entire CCUS value chain. Failure to effectively evaluate the economic opportunity for CCUS technology to reduce CO_2 emissions would deter wide-spread deployment. DOE's economic models and resources enable a variety of possible analytical approaches to evaluate the economics associated with deploying CCUS. The resources are open-source so that interested stakeholder groups can apply them to their specific problems, and to enable feedback to improve these models moving forward." **Derek Vikara, Chung Yan Shih, ShangMin Lin, Allison Guinan, Timothy Grant, David Morgan, and Donald Remson**, *Journal of Sustainable Energy Engineering*. (Subscription may be required.)

The Evolution of European CCS Policy.

The following is the Abstract of this article: "The European CCS industry is still grasping for an effective policy structure which will support deployment of commercial CCS projects. This paper will consider the current context of CCS policy given three significant developments: (a) the agreement in 2014 for a technology neutral 2030 EU emissions reduction target; (b) a binding commitment at COP21 in Paris, Dec 2015, for a global emissions reduction target; (c) the collapse of the UK's CCS [Commercialization] Programme in Nov 2015. The period 2010-2015 saw continued stagnation in the European CCS industry, with a series of projects proposed but then subsequently cancelled. This hints as three problems (1) an industry which is weak in communicating why CCS is important, and failed to engage a wider stakeholder base; (2) incumbent governments which are not willing to fund the initially high costs of the first CCS projects; (3) weak market based structures which force industrial consortia to rely on government subsidy, thus leaving projects vulnerable to political forces. The tension within the UK's [Commercialization] Programme could still offer lessons for other potential CCS projects in Europe; and inform policy developments at the UK and European level. Namely (i) payment flows between the emitter / capture plant to the transport & storage provider, and the risk apportionment between those partners; (ii) the cost-benefit of oversized infrastructure and the challenges of a first project to finance the bulk of these costs..." **Matthew Billson and Mohamed Pourkashanian,** *Energy Procedia*. (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

The Politics of Large-scale CCS Deployment.

The following is the Abstract of this article: "Since the early 2000s, there has been growing recognition of the important role that CCS can play as part of a least-cost, global solution to climate change. Modelling by the International Energy Agency (IEA) has consistently highlighted a significant role for CCS in achieving a 2°C target, and recognition of the role of CCS has also increasingly been a feature of reports by the Intergovernmental Panel on Climate Change (IPCC). However, this growing appreciation of the value of CCS has not been accompanied by commensurate growth in political and policy support for the technology. In fact, support for CCS has been inconsistent and at times tumultuous, and has been closely intertwined with progress in global climate negotiations and wider economic conditions. CCS will not advance without significant public investment and the required support policies will not be put in place without political support – hence the politics of CCS play a major role in this respect. This paper looks at the politics of deploying large-scale CCS projects, including the drivers for CCS support, the opposing political forces and the practical challenges of deploying CCS." **Juho Lipponen, Samantha McCulloch, Simon Keeling, Tristan Stanley, Niels Berghout, and Thomas Berly,** *Energy Procedia*. (Subscription may be required.)

Diffusive leakage of brine from aquifers during CO_2 geological storage.

The following is the Abstract of this article: "The area of investigation in this study is designed around an improved understanding of fundamentals of the diffusive leakage of brine from a storage aquifer into overlying and underlying low permeability layers during geosequestration of CO_2 through development of a theoretical model. Here, [the authors] consider a two-dimensional domain in cylindrical coordinates, comprised of an aquifer and an overburden, where the interaction between the two media is handled by imposing the continuities of pressures and fluid fluxes at the aquifer-overburden interface. This coupled problem is solved by successive implementation of the Laplace and finite Hankel transforms. The developed solutions can be used to analyze diffusive leakage of brine from the aquifer into overburden and generate type curves for average pressures in the aquifer and overburden during injection and post injection periods. The results show that the leakage rate at early times is scaled with $t^{1/2}$ while it remains constant at late times. It is also shown that the average pressure in the aquifer is scaled with t for short and long times. Moreover, the average pressure in the overburden is scaled with t at late times while it is scaled with $t^{3/2}$ at early times. In addition, the results reveal that factors affecting diffusive leakage rate through intact overburden during CO_2 storage are, in decreasing order of significance, thickness of overburden, thickness of aquifer, aquifer to overburden permeability ratio, and aquifer to overburden porosity ratio. However, thickness of aquifer has minimal effect on diffusive leakage of brine within post injection period. To evaluate the theoretical model, case studies for two potential sites in United Kingdom, one in Lincolnshire and the other one in the Firth of Forth, are conducted. The field studies show that the diffusive leakage from the aquifer into the overburden diminishes ~40 years after the injection has ceased for Lincolnshire while it stops after ~12 years for Firth of Forth. The average amount of the brine leaked from the aquifers per standard cubic meter (Sm^3) of the injected CO_2 through diffusive leakage was found to be 6.28×10^{-4} m^3 of brine (or 0.330 kg of brine/kg of CO_2) over ~70 years for Lincolnshire and 4.59×10^{-4} m^3 of brine (or 0.242 kg of brine/kg of CO_2) over ~42 years for Firth of Forth." **Morteza Dejam and Hassan Hassanzadeh,** *Advances in Water Resources*. (Subscription may be required.)

Efficiency of Carbon Dioxide Storage and Enhanced Methane Recovery in a High Rank Coal.

The following is the Abstract of this article: "The high affinity and adsorption capacity of coal to [CO_2] provides an alternative approach for the enhanced recovery of methane [CH_4)] from unminable coalfields (CO_2-ECBM) by which a potential solution for long-term CO_2 sequestration in deep geological formations can also be achieved. However, due to chemomechanical effects induced by the interactions between CO_2 and coal, the effective methane production and [CO_2] storage can be degraded which has caused uncertainties about the techno-economic feasibility of the CO_2-ECBM process. This study presents an experimental investigation that aims to address key knowledge gaps related to the efficiency of CO_2 storage and CH_4 recovery in high rank coals for which a comprehensive experimental data set and analysis are largely missing. Competitive displacements of CH_4 with N_2 or CO_2 in an anthracite coal sample from a South Wales coalfield have been studies, based on a series of core flooding experiments. The results show that the N_2 breakthrough time (the time at which 1% of the total gas injected was recovered) was almost spontaneous whereas a considerably delayed breakthrough time was observed for the case of the CO_2-ECBM experiment. In addition it was observed that for the CO_2-ECBM experiment, the ratios of CH_4 recovery with respect to the total amount of gas injected and gas stored were higher by factors of 10 and 2.4, respectively. The results also show that 90% of the total N_2 injected was produced in the outflow gas, whereas for the case of the CO_2 experiment, only 63% of the total injected CO_2 was produced. The presence of a high amount of N_2 in the outflow may lead to additional challenges in order to separate N_2 from CH_4 and thus affect the efficiency of the N_2-ECBM method. Under the conditions of the experiments, the total CH_4 displacement ratio and breakthrough for the case CO_2-ECBM were found to be more favorable compared to those obtained from N_2-ECBM. This study provides new insights into the efficiency of the CO_2-ECBM process and offers a comprehensive experimental data set that can be used for testing the accuracy of predictive models." **Mojgan Hadi Mosleh, Majid Sedighi, Philip J. Vardon, and Matthew Turner,** *Energy Fuels*. (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

Geochemical tracers for monitoring offshore CO_2 stores.

The following is the Abstract of this article: "Chemical tracers are proposed as an effective means of detecting, attributing and quantifying any CO_2 leaks to surface from geological CO_2 storage sites, a key component of CCS technology. A significant proportion of global CO_2 storage capacity is located offshore, with some regions of the world having no onshore stores. To assure regulatory bodies and the public of CO_2 storage integrity it is important to demonstrate that robust offshore monitoring systems are in place. A range of chemical tracers for leakage have been tested at onshore pilot CCS projects worldwide, but to date they have not been trialled at injection projects or CO_2 release experiments located offshore. Here, for the first time, [the authors] critically review the current issues surrounding commercial scale use of tracers for offshore CCS projects, and examine the constraints and cost implications posed by the marine environment. These constraints include the logistics of sampling for tracers offshore, the fate of tracers in marine environments, tracer background levels, marine toxicity and legislative barriers – with particular focus on the Europe and the UK. It is clear that chemicals that form a natural component of the CO_2 stream are preferable tracers for ease of permitting and avoiding cost and risks of procuring and artificially adding a tracer. However, added tracers offer more reliability in terms of their unique composition and the ability to control and regulate concentrations. [The authors] identify helium and xenon isotopes (particularly $^{124,129}Xe$), and artificial tracers such as PFCs and deuterated methane as the most suitable added tracers. This is due to their conservative [behavior], low environmental impact and relative inexpense. Importantly, [the authors] also find that SF_6 and C^{14} are not viable tracers for CCS due to environmental concerns, and many other potential tracers can be ruled out on the basis of cost. Further, [the authors] identify key challenges that are unique to using tracers for offshore monitoring, and highlight critical uncertainties that future work should address. These include possible adsorption or dispersion of tracer compounds during ascent through the overburden, longevity of tracers over the timeframes relevant for CCS monitoring, the permissible environmental effects of tracer leakage, and tracer [behavior] in seabed CO_2 bubble streams and in dissolved CO_2. These uncertainties directly affect the selection of appropriate tracers, the injection program and concentrations necessary for their reliable detection, and appropriate sampling approaches. Hence offshore tracer selection and associated expense are currently poorly constrained. Further, there is limited experience of sampling for tracers in the marine environment; current approaches are expensive and must be streamlined to enable affordable monitoring strategies. Further work is necessary to address these unknowns so as to evaluate the performance of potential tracers for CO_2 leak quantitation and provide more accurate costings for effective offshore tracer monitoring programs." **Jennifer J. Roberts, Stuart M.V. Gilfillan, Linda Stalker, and Mark Naylor,** *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Cleaner coal and greener oil production: An integrated CCUS approach in Yanchang Petroleum Group.

The following is the Abstract of this article: "The Ordos Basin has the richest natural resources in China. It has over one third of the coal resources of China and it is the second largest oil and natural gas sedimentary basin in China. The Yanchang Petroleum Group is the only company that has both coal and petroleum mineral rights in this basin, which provides a unique favorable condition for implementing a CCUS project in China. The CCUS project conducted by the Yanchang Petroleum Group integrates a clean coal chemical plant with low-cost CO_2 capture facilities and CO_2 enhanced oil recovery (EOR) and storage in tight formations. The coal chemical plant produces methanol and acetic acid from coal using the Texaco coal gasification process. High purity CO_2 is separated from the methanol rich solvent. After compression and deep-freezing treatment, liquid CO_2 with a purity of 99% is produced for CO_2 EOR and the storage project. The cost of the CO_2 product is about 117 Renminbi (RMB)/[metric ton] CO_2, which is less than US $18/[metric ton] of CO_2. This cost is about half of the cost of CO_2 in the coal power plant (US $30-40/[metric ton]). The captured CO_2 is transported to a CO_2 EOR and storage project about 30–100 km away, which is a much shorter distance than the required transportation distances of other commercial CO_2 EOR and storage projects. For example, the transportation distance is over 300 km for the Weyburn project. The short distances between the CO_2 capture facility and the oil fields further reduce the transportation costs of the CCUS project in China. The oil fields in the Ordos Basin are mainly tight formations with low reservoir pressures. Water resources are very limited in the basin. Thus, minimizing water usage in the petroleum industry can significantly protect the environment in this area. Carbon dioxide EOR can reduce the water usage and [EOR] at the same time. An extensive experimental study was conducted to maximize the performance of CO_2 EOR in tight formations with low reservoir pressures. The current reservoir pressure in those oil fields is less than 10 MPa, which is far lower than the minimum miscible pressure (MMP) (16–22 MPa). Different approaches, such as CO_2 foam flooding and huff-n-puff, have been proposed to build up the reservoir pressure to enhance the oil recovery performance. A field pilot test, containing about 50 wells, has been conducted for four years, and the oil production rates for those wells have been doubled or tripled. This project is the first integrated CCUS project operated in China. Currently seventy thousand [metric tons] of CO_2 have been injected. In the next five years, this project will be expanded to 1 million [metric tons] of CO_2 injection, which will make it the second largest CCUS project in the world after Canada's Weyburn project." **Xiangzeng Wang, Fanhua Zeng, Ruimin Gao, Xisen Zhao, Shiyan Hao, Quansheng Liang, and Shaojing Jiang**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

The impact of carbon emission costs on manufacturers' production and location decision.

The following is the Abstract of this article: "This paper investigates how emerging carbon emission costs may affect the joint production and location decisions for a manufacturer across the world's regions. Specifically, [the authors] develop a new theoretical model which explicitly links product demand, production costs and carbon emission levels to location decisions, and investigate the manufacturer's optimal decisions between two distinct regions. The results show that the influence of carbon emissions on manufacturers' decisions can vary greatly under different circumstances: both off-shoring and near-shoring are possible under rising carbon emission costs; manufacturers with high or low demand have different tolerance levels to the rising carbon emission costs when considering an alternative location; trade costs can change the pattern of relocation. To gain policy insights for those who pursue reducing carbon emissions, different product examples are used to calculate the critical carbon price which triggers different location choices. The results suggest that if production technology is stable, raising carbon cost itself has only limited effects on reducing total carbon emissions, especially for high-value-low-emission industries. The location shift, which is more sensitive to changes in variable carbon emissions, may lead to a significant emission reduction when completed. Additional pricing decision from the manufacturer shows no significant effect on the location decisions; however, if demand is linked directly to carbon emission footprint of the product, then it is more hopeful that a raised carbon price would reduce the carbon emissions significantly through relocation." **Peng Wu, Ying Jin, Yongjiang Chi, and Hawfeng Shyu,** *International Journal of Production Economics.* (Subscription may be required.)

Carbon emissions quotas in the Chinese road transport sector: A carbon trading perspective.

The following is the Abstract of this article: "In response to the growing need to reduce carbon emissions, it is necessary to explore the design of carbon trading mechanisms and discuss allocation options for the transport sector. This paper examines the allocation of carbon quotas with the introduction of an emissions trading scheme (ETS) in the Chinese road transport sector. Aiming to simulate the allocation of carbon emissions quotas, [the authors] forecast vehicle possession using a gray forecast model and trend extrapolation; consider the CO_2 emissions of the transport sector using a top-down approach; and design three policy scenarios. [The authors] provide the following findings. First, vehicle possession in the road transport sector and carbon emissions both display an increasing trend, reaching 180 million units and 6.6 billion tons by 2020, respectively. Second, the road transport sector has the largest carbon quota under the benchmark scenario and the smallest under a low-carbon scenario. The difference between these two scenarios is 2.7 billion tons of carbon emissions. Finally, [the authors] design a carbon emissions trading mechanism for the transport sector based on China's special development period, and provide a sensitivity analysis." **Rong Han, Bi-Ying Yu, Bao-Jun Tang, Hua Liao, and Yi-Ming Wei,** *Energy Policy.* (Subscription may be required.)

Probabilistic modeling and global sensitivity analysis for CO_2 storage in geological formations: a spectral approach.

The following is the Abstract of this article: "This work focuses on the simulation of CO_2 storage in deep underground formations under uncertainty and seeks to understand the impact of uncertainties in reservoir properties on CO_2 leakage. To simulate the process, a non-isothermal two-phase two-component flow system with equilibrium phase exchange is used. Since model evaluations are computationally intensive, instead of traditional Monte Carlo methods, [the authors] rely on polynomial chaos (PC) expansions for representation of the stochastic model response. A non-intrusive approach is used to determine the PC coefficients. [The authors] establish the accuracy of the PC representations within a reasonable error threshold through systematic convergence studies. In addition to characterizing the distributions of model observables, [the authors] compute probabilities of excess CO_2 leakage. Moreover, [the authors] consider the injection rate as a design parameter and compute an optimum injection rate that ensures that the risk of excess pressure buildup at the leaky well remains below acceptable levels. [The authors] also provide a comprehensive analysis of sensitivities of CO_2 leakage, where [the authors] compute the contributions of the random parameters, and their interactions, to the variance by computing first, second, and total order Sobol' indices." **Bilal M. Saad, Alen Alexanderian, Serge Prudhomme, and Omar M. Knio,** *Applied Mathematical Modelling.* (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."

CSLF Technology Roadmap 2017.

The following is from the Executive Summary of this Carbon Sequestration Leadership Forum (CSLF) document: "The CSLF Technology Roadmap 2017 aims to provide recommendations to Ministers of the CSLF member countries on technology developments that are required for CCS to fulfill the CSLF mission to facilitate the development and deployment of CCS technologies via collaborative efforts that address key technical, economic, and environmental obstacles."

Global Landscape of Climate Finance 2017.

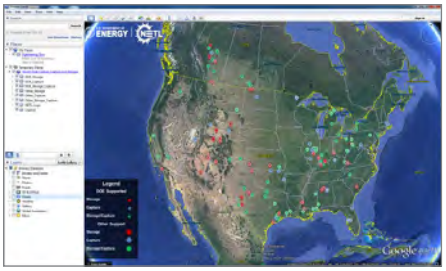
The following is from the Executive Summary of this Climate Policy Initiative document: "Climate Policy Initiative's 2017 edition of the Global Landscape of Climate Finance updates the most comprehensive assessment of annual climate finance flows with data from 2015 and 2016, providing, for the first time, a five-year trend analysis on the how, where, and from whom finance is flowing toward low-carbon and climate-resilient actions globally in order to identify trends, gaps, and opportunities to scale up investment. As with previous reports, the figures identified in this Landscape represent overall global finance flows and should be compared with estimates of total investment needed consistent with the goal of limiting global temperature rise to below 2 degrees Celsius."

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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