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

CSN CARBON STORAGE NEWSLETTER

JULY 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

HIGHLIGHTS

"DOE Announces $68.4 Million in Funding to Advance the Safe and Permanent Storage of CO_2."

The U.S. Department of Energy (DOE) announced funding for cost-shared research and development (R&D) projects focused on the safe and permanent storage of carbon dioxide (CO_2) during carbon capture and storage (CCS) operations. The Carbon Storage Assurance and Facility Enterprise (CarbonSAFE) initiative is intended to develop integrated CCS storage complexes, constructed and permitted for operation in the 2025 timeframe following a series of developmental phases. *Phase I CarbonSAFE: Integrated CCS Pre-Feasibility* seeks R&D projects to provide pre-feasibility studies for a commercial-scale geologic storage site. *Phase II CarbonSAFE: Storage Complex Feasibility* seeks R&D projects to perform the initial characterization of a storage complex. From *Energy.gov* on June 24, 2016.

ANNOUNCEMENTS

DOE Awards $10 Million to Small Businesses for Fossil Energy Research and Technology Transfer.

DOE selected 10 research projects to be funded under the *Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) Programs* through DOE's Office of Science. Of the 10 selected projects, 8 were made under Topic Area 1: Clean Coal and Carbon Management, and include key R&D programs, such as carbon storage technologies in the area of wellbore release pathway detection techniques.

SBIR·STTR America's Seed Fund™ POWERED BY SBA

DOE Selects Projects to Demonstrate Feasibility of Producing Usable Water from CO_2 Storage Sites.

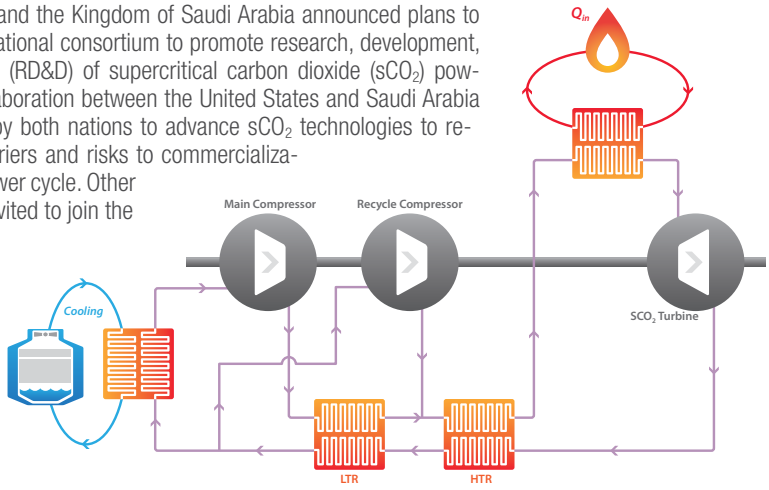
DOE selected two projects to test enhanced water recovery (EWR) technologies for their potential to produce useable water from CO_2 storage sites. The two projects, which will be managed by DOE's National Energy Technology Laboratory (NETL), were selected from the five Brine Extraction Storage Test (BEST) projects *awarded in September 2015*.

NETL Launches University Coalition for Fossil Energy Research.

Pennsylvania State University (PSU) will serve as the lead institution for DOE/NETL's University Coalition for Fossil Energy Research. The Coalition brings together a multi-disciplinary team of researchers from different universities to address the research challenges of fossil energy-based technologies, including CCS. The six-year initiative is expected to help accelerate the development and deployment of fossil fuel-based technologies in a cost-effective and environmentally safe manner.

U.S., Saudi Arabia Announce International Collaboration.

The United States and the Kingdom of Saudi Arabia announced plans to establish an international consortium to promote research, development, and demonstration (RD&D) of supercritical carbon dioxide (sCO_2) power cycles. The collaboration between the United States and Saudi Arabia builds on actions by both nations to advance sCO_2 technologies to reduce technical barriers and risks to commercialization of the sCO_2 power cycle. Other countries will be invited to join the new consortium.



Closed Loop SCO_2 Recompression Brayton Cycle Flow Diagram

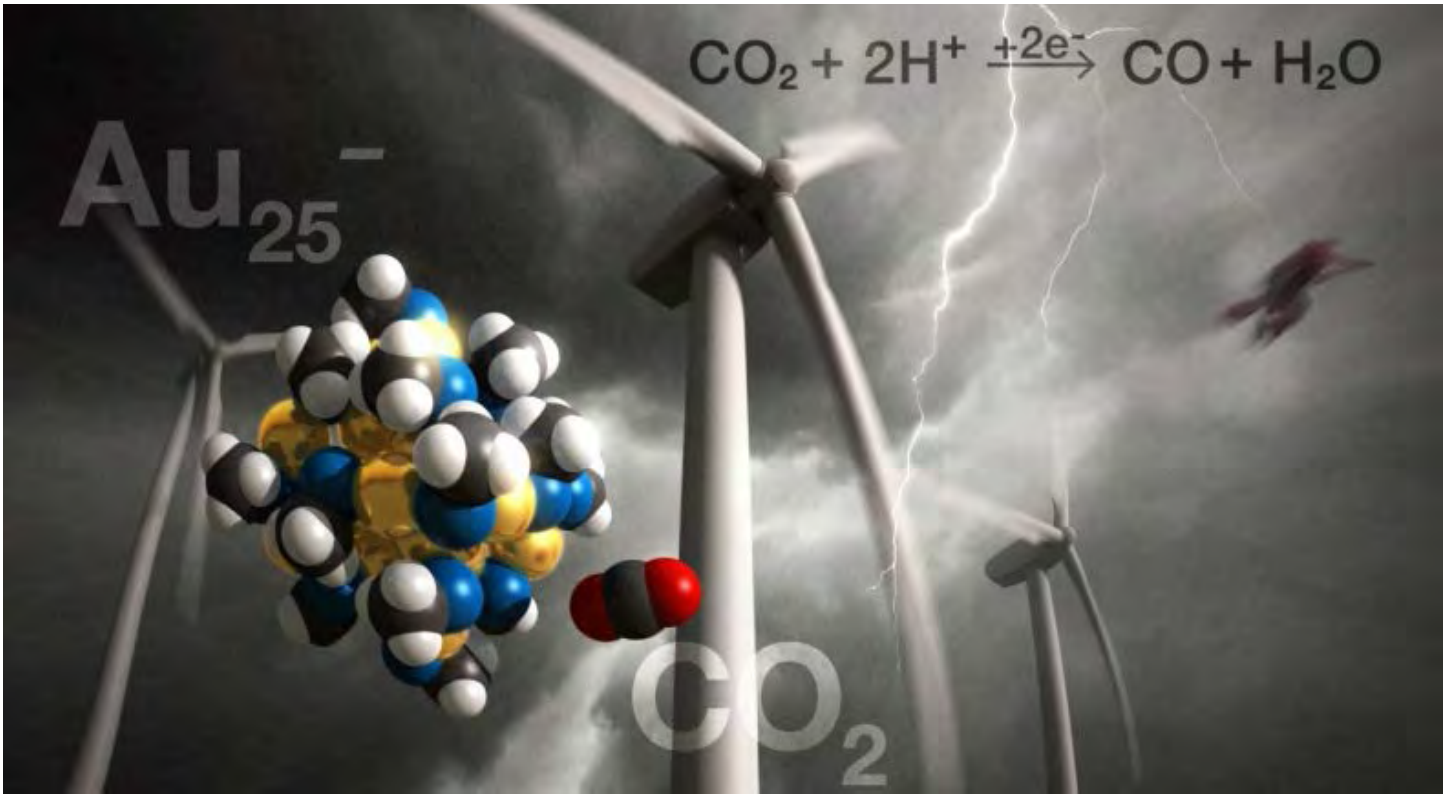
ANNOUNCEMENTS *(cont.)*

NETL Researchers Develop New CO_2 Conversion Process.

A new process developed by an NETL-led research team uses gold nanoparticles to convert CO_2 into usable chemicals and fuels. If implemented on a commercial scale, the new process has the potential to reduce atmospheric CO_2 emissions. The research team estimates that renewable energy sources can efficiently power large-scale CO_2 conversion systems to convert CO_2.

Reports Highlight CCS Technology.

The Global CCS Institute released two public information reports that highlight the long-term application of CCS technology in a variety of industrial sectors. The first report, titled *"Introduction to Industrial Carbon Capture and Storage,"* summarizes 17 CCS projects across multiple sectors. The second report, titled *"Understanding Industrial CCS Hubs and Clusters,"* explores the economic benefits of building shared infrastructure.



CARBON STORAGE in the NEWS

"DOE Awards UND's EERC $15 Million to Continue Carbon Storage Research."

The University of North Dakota's Energy and Environmental Research Center (UNDEERC) was awarded funding to continue its carbon storage research. UNDEERC was originally selected to study the benefits of active reservoir management (ARM) in CCS (Phase I), which consisted of feasibility studies and project designs. DOE's funding will be utilized for Phase II, which is expected to last approximately four years, beginning with the installation of infrastructure, such as wells and brine treatment and handling equipment, and continuing with active reservoir research and management testing and brine treatment technology demonstration. From *Prairie Business Magazine* on June 8, 2016.

"Iceland Carbon Capture Project Quickly Converts Carbon Dioxide Into Stone."

According to scientists, tests have demonstrated that CO_2 emissions could be stored by turning them into rock. Conducted at the CarbFix project in Iceland, the tests indicated that most of the CO_2 injected into basalt turned into carbonate minerals in less than two years. Scientists' original estimates were that the process would take hundreds to thousands of years. The pilot project injected 230 tons of CO_2 into basalt rocks near the Hellisheidi geothermal plant east of Reykjavik, Iceland, in 2012; scientists also included a set of tracers to monitor the fate of the CO_2. The mineralogy of basalts is favorable for storing CO_2, as the rocks into which the gas is injected need calcium-, magnesium-, or iron-rich silicate materials; while sedimentary rocks do not have enough of those minerals, basalts do. From *Smithsonian Magazine* on June 9, 2016.

"BHP Billiton and Peking University to Accelerate CCUS Research."

BHP Billiton and Peking University (PKU) announced an agreement to accelerate carbon capture, use, and storage (CCUS) research in China. The three-year agreement will identify key policy, technical, and economic barriers to CCUS deployment in the industrial sector. The agreement builds on the BHP Billiton SaskPower Carbon Capture Knowledge Center, which was established in February 2016 to share lessons learned on CCS. From *BHP Billiton News Release* on June 6, 2016.

SCIENCE

"New Study Helps Identify Criteria for Effective Greenhouse Gas Emissions Storage."

A study on natural underground reservoirs of CO_2 has identified criteria for the effective storage of greenhouse gases (GHGs). Research conducted by scientists from Scotland's University of Edinburgh and the University of Strathclyde will be used to develop a new CCS technology to aid underground CO_2 storage. The data for the study was gathered through the evaluation of 76 natural reservoirs in Asia, America, Australia, and Europe. From *Power Technology* on June 22, 2016.

POLICY

"Leaders' Statement on a North American Climate, Clean Energy, and Environment Partnership."

Representatives from the United States, Canada, and Mexico announced a commitment to the North American Climate, Clean Energy, and Environment Partnership, with a goal of achieving 50 percent clean power generation by 2025 through clean energy development and deployment, clean energy innovation, and energy efficiency. The partnership will include domestic initiatives and policies, cross-border projects, a joint study, trilateral collaborations on green government initiatives, aligning efficiency standards, and building on North American leadership in international forums. In addition, the collaboration will result in the identification of joint R&D initiatives to advance clean technologies in areas such as CCUS. From *The White House, Office of the Press Secretary* on June 29, 2016.

"Québec and Saskatchewan Join Forces for Carbon Capture and Storage Technologies."

Officials from Québec, Canada, and Saskatchewan, Canada, agreed to expand their collaboration to accelerate the development of CCS-related technologies. According to Saskatchewan's Executive Council, the collaboration will contribute to the development of knowledge and best practices to reduce GHG emissions through CCS, while improving the economic return on projects by reusing the captured carbon for other purposes. In addition, officials from the two provinces will also exchange CCS project updates and information, and continue to work together to identify future collaboration possibilities. From *Canadian Underwriter* on June 17, 2016.

"CCS Feasible by 2022, Says [Norwegian Petroleum Directorate] Study."

According to a feasibility study conducted by Norway's Ministry of Petroleum and Energy (MPE), full-scale CCS could be achieved in Norway by 2022. The study set out to identify a technically feasible CCS chain with corresponding cost estimates that include CO_2 capture, transport, and storage. The Norwegian government will present further plans for CCS in its state budget for 2017. More information is available via an *MPE press release*. Click *here* for a summary of the feasibility studies. From *Offshore Engineer* on July 4, 2016.

"[United Kingdom (UK)] Sets 2030 Climate Goal..."

Britain has set a target to reduce its CO_2 emissions by 57 percent, based on 1990 levels, by 2032. Britain's overall target is to reduce emissions by 80 percent based on 1990 levels. Before it can become law, the carbon budget will need to be adopted by Parliament. By 2050, Britain has a legally binding target to cut emissions by 80 percent based on 1990 levels. From *Reuters* on June 30, 2016.

GEOLOGY

"Mechano-chemical interactions in sedimentary rocks in the context of CO_2 storage: Weak acid, weak effects?"

The following is the Abstract of this article: "Due to the corrosive nature of dissolved CO_2, the potential short or long term alteration of rock properties, represents a major issue in several sites where natural CO_2 circulation is observed, as well as in reservoirs targeted for storage of anthropogenic CO_2. To date, this has been primarily studied from a transport-chemical perspective, with laboratory evidence of microstructural modifications together with the consequences for flow properties. Compared to the transport-chemical aspects, the mechanical-chemical aspects have been less investigated, though it is to be expected that mechanical properties (e.g. elastic properties, failure parameters, and time-dependent mechanical [behavior]) could potentially be affected in a similar manner to hydraulic parameters. Yet, since CO_2 is a weak acid, the pH drop is expected to be moderate with a likely lower limit close to 4.0. The buffering of pH by calcite minerals present in most reservoirs targeted for storage may further limit the pH drop, as well as confining it to a localized rock volume around the injection well. This leads to the question of the magnitude and time/spatial scales of chemically-mediated mechanical processes during CO_2 [storage]. The authors propose to address this issue by reviewing recent laboratory-based studies restricted to sedimentary rocks, namely: reservoir rocks (carbonate or sandstone), intact or fractured caprocks and fault rocks. Key findings include the following: [1.] the short-term impact on the elastic and inelastic [behavior] of intact caprocks remains limited; [2.] shear strength weakening is likely to be respectively low and low-to-moderate for shale/clay-rich and anhydrite-rich faults, but without modifying slip stability in either case; [3.] the largest impact is located within carbonate reservoirs, but with a broad range of reported responses depending on hydrodynamic conditions (closed or open) and on dissolution regime (uniform or channelling); and [4.] creep experiments confirm that CO_2-induced dissolution may enhance long-term compaction of carbonate reservoirs, but the magnitude of acceleration (varying from non-significant to 50 times) depends to a large extent on site-specific conditions (grain size, pH, temperature, effective stress state, etc.), which renders any direct extrapolation from laboratory to reservoir scale difficult. Finally, some directions for future research studies are discussed." **J. Rohmer, A. Pluymakers, and F. Renard,** *Earth-Science Reviews*. (Subscription may be required.)

"An integrated core-based analysis for the characterization of flow, transport and mineralogical parameters of the Heletz pilot CO_2 storage site reservoir."

The following is the Abstract of this article: "Heletz, Israel is the location for an onshore deep saline CO_2 storage pilot site. The *'Heletz sandstone'* is the building unit of the deep saline reservoir. Based on core samples of sandstone and caprock taken from the newly drilled injection (H18A) and monitoring wells (H18B), this article examines and reports the petrophysical properties of the Heletz Formation reservoir important for the short and long term trapping of CO_2. A suite of laboratory and pore-scale CT-based modeling techniques are employed to determine the flow and transport parameters used by the continuum-scale numerical simulators and the mineral composition necessary for the understanding of mineral trapping processes. The effect of diagenesis on the reservoir parameters was determined in the laboratory using sedimentological, petrological, and petrophysical analyses. Variations in $^{87}Sr/^{86}Sr$ isotope composition and fluid inclusion analysis bring additional information about the diagenetic development and define the status quo of fluid–mineral reactions before CO_2 injection. Cathodoluminescence microscopy and SEM/XRD revealed the amounts of minerals in the sandstone samples and caprock and explained the poor binding of the sandstone which may lead to mobilized material during injection. Digital image analysis on thin sections, cathodoluminescence, and SEM were integrated with attributes derived from mercury intrusion porosimetry, steady state gas permeametry or nuclear magnetic resonance to form an essential outline for the Heletz Formation reservoir. This relates storage space, injectivity and storage efficiency to features such as grain size, pore size distribution, effective porosity, intrinsic permeability, or tortuosity. Furthermore, the laboratory and numerical CT-based investigation techniques are compared and discussed. The benefit of combining experimental methods and numerical simulations on pore-scale models is the increase in confidence of the parameter accuracy, fundamental for the success of the planned activities at Heletz." **Alexandru Bogdan Tatomir, Matthias Halisch, Florian Duschl, Aaron Peche, Bettina Wiegand, Mario Schaffer, Tobias Licha, Auli Niemi, Jacob Bensabat, and Martin Sauter,** *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

TECHNOLOGY

"The CO_2 storage and EOR evaluation in Daqing Oilfield."

The following is the Abstract of this article: "Injecting CO_2 into oil reservoirs could improve recovery and facilitate the storage of CO_2. For developing countries, especially China, coupling enhanced oil recovery (EOR) and CO_2 storage becomes an economical and environmentally safe method. Daqing Oilfield is the biggest oilfield in China. It has been operational for 50 years, and has faced many EOR challenges. In this study, a CO_2 storage and EOR evaluation method is introduced to calculate the CO_2 storage potential in the Daqing Oilfield. The stream tube simulation method and the mixed cell mesh method are adopted to determine the storage coefficient, recovery factor, and MMP (minimum miscible pressure). The evaluation results of the Daqing Oilfield show that most of the oilfields in Daqing can carry out CO_2 immiscible flooding. For EOR effects, the CO_2 miscible flooding can improve oil recovery by about [nine percent]. The average CO_2 storage factors are 0.4 for miscible flooding while the immiscible flooding is 0.28; miscible flooding has better CO_2 storage capacity and EOR potential. The results show that injecting CO_2 into the reservoirs in Daqing Oilfield is a win-win technology." **Xiaoliang Zhao, Yuedong Yao, and Heng Ye**, *Greenhouse Gases: Science and Technology*. (Subscription may be required.)

"Optimization of miscible CO_2 EOR and storage using heuristic methods combined with capacitance/resistance and Gentil fractional flow models."

The following is the Abstract of this article: "Ongoing increase in worldwide oil demand and emission of [GHGs] persuades engineers to utilize new approaches to optimize enhanced hydrocarbon recovery operations so that the concentration of such gases in atmosphere is reduced, simultaneously. CO_2 injection into geological formations could be a promising alternative for [EOR] and lessening anthropogenic CO_2 emissions. It is [the authors]' objective to employ Capacitance-Resistance Model (CRM) for characterization of inter-well interactions in two reservoir models, which experience miscible CO_2 injection for combined EOR and storage purposes. Then, an efficient model is developed, on the basis of Gentil fractional flow model, coupled with CRM. The introduced strategy is applied to optimize miscible CO_2 injection scenarios. The main goal in this research work is to minimize the fraction of cumulatively produced CO_2 to cumulatively produced oil by varying injection rates pattern with the same total injection as history. Minimizing the produced CO_2 ensures the increase of stored CO_2 through the formation. The developed methodology is validated through comparison with the results obtained from reservoir production history. Three heuristic optimization methods utilized in this work are Artificial-Bee-Colony (ABC), Particle-Swarm-Optimization (PSO), and Genetic-Algorithm (GA). According to results of several simulations and optimizations and compared to reservoir history, amounts of stored CO_2 and recovered oil increased, remarkably, for a real geological formation. In general, all optimization techniques result in favorable outcomes; however, ABC exhibits better performance, followed by PSO and GA. It was also found that well transmissibility is a vital factor to satisfy desired conditions for optimization process." **S. Ehsan Eshraghi, M. Reza Rasaei, and Sohrab Zendehboudi**, *Journal of Natural Gas Science and Engineering*. (Subscription may be required.)

TERRESTRIAL

"Researchers to Study How to Reduce Carbon Dioxide in Ranch Soil."

The U.S. Department of Agriculture is funding research to reduce GHG emissions emanating from soil. The three-year study will also offer the potential for cattle ranchers to receive credit for storing CO_2. Scientists from the University of Florida Institute of Food and Agricultural Sciences will conduct the research, using lab and field studies to investigate how pasture management affects soil microbes, which produce CO_2 when they eat plant litter and soil organic matter. From *ScienceDaily* on June 22, 2016.

"Assessing the carbon [storage] potential of poplar and black locust short rotation coppices on mine reclamation sites in Eastern Germany – Model development and application."

The following is the Abstract of this article: "In the temperate zone short rotation coppice systems for the production of woody biomass (SRC) have gained great interest as they offer a pathway to both sustainable bioenergy production and the potential [storage] of CO_2 within the biomass and the soil. This study used the carbon model SHORTCAR to assess the carbon cycle of a poplar (*Populus suaveolens* Fisch. x *Populus trichocarpa* Torr. et Gray cv. Androscoggin) and a black locust (*Robinia pseudoacacia* L.) SRC. The model was calibrated using data from established SRC plantations on reclaimed mine sites in northeast Germany and validated through the determination of uncertainty ranges of selected model parameters and a sensitivity analysis. In addition to a 'reference scenario', representing the actual site conditions, [seven] hypothetical scenarios, which varied in climate conditions, rotation intervals, runtimes, and initial soil organic carbon (SOC) stocks, were defined for each species. Estimates of carbon accumulation within the biomass, the litter layer, and the soil were compared to field data and previously published results. The model was sensitive to annual stem growth and initial soil organic carbon stocks. In the reference scenario net biome production for SRC on reclaimed sites in Lusatia, Germany amounted to 64.5 Mg C ha^{-1} for *R. pseudoacacia* and 8.9 Mg C ha^{-1} for poplar, over a period of 36 years. These results suggest a considerable potential of SRC for carbon [storage] at least on marginal sites." **A. Quinkenstein and H. Jochheim**, *Journal of Environmental Management*. (Subscription may be required.)

TRADING

"S. Korea, EU Join Hands to Promote Emissions Trading System."

South Korea and the European Union (EU) announced bilateral cooperation on potential climate change with the Seoul-Brussels joint emissions trading system cooperation project. According to Seoul's finance ministry, the cooperation with EU's cap-and-trade system will help South Korea further develop its emissions trading system (ETS) and reach its plan to reduce GHG emissions by 37 percent from the 2030 business-as-usual levels. From *Yonhap News Agency* on July 8, 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.)

"The effects of allowance price on energy demand under a personal carbon trading scheme."

The following is the Abstract of this article: "Personal carbon trading (PCT) is a downstream cap-and-trade scheme which could be used to reduce carbon emissions from the household sector. To explore the effectiveness of this scheme, it is necessary to investigate how consumers respond to allowance price change. In this paper, a general utility optimization (GUO) model and a constant elasticity of substitution (CES) utility function are proposed to examine the price, substitution and income effects of carbon allowance price changes. It is shown that higher income consumers are more sensitive to the allowance price changes than lower income consumers. Moreover, the short-run adjustment in consumers' consumption of electricity in response to a change in allowance price would be lower than the long-run value. According to the sensitivity analysis, downward (upward) adjustments in the elasticity of substitution result in a positive (negative) effect on price effect. The findings in this study are used to draw policy implications. Suggestions for future research are also provided." **Jin Fan, Jun Li, Yanrui Wu, Shanyong Wang, and Dingtao Zhao**, *Applied Energy*. (Subscription may be required.)

LEGISLATIVE ACTIVITY

"South Africa Proposes Carbon Tax Relief in Draft Law."

The South African National Treasury has published *draft regulations* on a potential carbon offset in a step to implement their government's carbon tax into law by January 2017. The carbon offset regulations, if enacted, will set procedures for taxpayers to use carbon offsets to reduce liability and reinvest in areas such as energy efficiency and renewable energy. From *International Tax Review* on June 27, 2016.

"Effectiveness of greenhouse-gas Emission Trading Schemes implementation: a review on legislations."

The following is the Abstract of this article: "[Due to potentially rising global temperatures], controlling [GHG] emissions has become an emerging topic around the world. This situation has led to the implementation of legislations, forcing companies to implement innovations and strategies to prevent and reduce carbon emissions. Nevertheless, the effectiveness of implementing these strategies and the estimation to fulfill Kyoto Protocol's 2020 target Emission Trading Schemes needs to be further [analyzed] and discussed. This paper reviews the existing [GHG]-emission legislations, as well as carbon offset programs worldwide. A detailed analysis on carbon emissions trends related to emissions penalties is shown for six major countries. The optimal penalty for emissions trading schemes is also analyzed and discussed. Future changes that could be made to the existing programs for enhancing their effectiveness are also suggested. It was found that carbon emissions decreased around 1.58 [percent] per year since Emission Trading Schemes implementation. Around 23.43 [percent] of CO_2 reduction can be reached after 10 years of Emission Trading Schemes implementation, compared to the trend when Emission Trading Schemes was not implemented. Despite Emission Trading Schemes implementation is extremely recent, based on the existing data a first estimation of the optimal penalty in achieving the maximum carbon reduction it was found around US$90.22 per [metric ton]. However, as the implementation period of Emission Trading Schemes is still limited for most countries, it is necessary to explore similar analysis as future work." **Paola Villoria-Sáez, Vivian W.Y. Tam, Mercedes del Río Merino, Carmen Viñas Arrebola, Xiangyu Wang**, *Journal of Cleaner Production*. (Subscription may be required.)

RECENT PUBLICATIONS

"Clean Energy Resource Options for Massachusetts to Meet GHG Reduction Goals under the Global Warming Solutions Act (GWSA)."

The following is the Introduction of this white paper: "The long-term energy policy of the Commonwealth of Massachusetts has been hotly debated for the past few years. During the current legislative session, Massachusetts policymakers will be deciding how the Commonwealth will enact policies to guide the development of clean energy resources to meet the near-term and long-term GHG emissions reductions of the 2008 Global Warming Solutions Act ('GWSA') while providing reliable electricity at a reasonable cost. The purpose of this paper is to inform the Massachusetts policy makers of the resource options and the key policy considerations."

"Energy Technology Perspectives 2016."

The following is the Executive Summary of this International Energy Agency (IEA) document: "The agreement reached at the 21st Conference of the Parties (COP21) in Paris could prove to be a historic turning point for reversing the currently unsustainable trends in the global energy system, provided that this heightened low-carbon ambition is translated into fast, radical and effective policy action. Even in the context of low fossil fuel prices, policy support for low-carbon technologies should [mobilize] all levers available to accelerate research, development, demonstration and deployment (RDD&D) to make decarbonisation the preferred development path. Chief among such levers is governments' support for urban energy transitions, a conclusion that is supported by the analysis of Energy Technology Perspectives 2016 (ETP 2016), which shows the vast number and size of cost-effective, sustainable energy opportunities available in cities. [Realizing] this potential, and the multiple non-climate benefits it presents, will require national and local governments to work together effectively."

"Tees Valley: Opportunity Unlimited."

The following is a description of this Independent Report from the UK Department for Communities and Local Government: "This is Lord Heseltine's independent review of the Tees Valley following a range of discussions with local private and [public] sector leaders and businesses to identify opportunities to unlock, promote and support economic growth. Building on the momentum provided by the Tees Valley devolution deal and the new Combined Authority, the report makes recommendations to further develop the Tees Valley area with the emphasis on creating the conditions for a sustainable prosperous future. Lord Heseltine worked closely with local leaders to bring forward the creation of the new South Tees Development Corporation, which will set the future vision for the SSI site and surrounding area. This will be the first Mayoral Development Corporation outside of London."

"Achieving a low-carbon society: CCS expertise and opportunity in the UK."

The following is a description of this Scottish Carbon Capture and Storage (SCCS) document: "This report, published on 23 March 2016, derives from the SCCS 2015 Conference, which brought together policymakers, industry, academia and representatives from Scottish, UK and European governments. It presents the UK's unique set of assets and opportunities that can create a viable route to a zero-carbon economy. These include: [1] Retaining skilled jobs and creating new industries at clusters of industrial emitters around the UK coastline, with plans already developed for shared-cost CCS 'hubs' [2] A globally significant and exceptional North Sea geological asset for CO_2 storage [3] An oil and gas workforce that routinely delivers high-quality infrastructure and could build a new offshore CCS industry serving the UK and Europe [4] An enviable [R&D] community with its amassed knowledge and strategic international collaborations [5] Large-scale CCS projects poised to [decarbonize] industry and power generation."

"Lessons Learned – Lessons and Evidence Derived from the UK CCS [Program], 2008 – 2015."

The following is from the Executive Summary of this Carbon Capture and Storage Association (CCSA) document: "Following the decision of the UK Government (HMG) to cancel the UK CCS [Commercialization Program] in November 2015, it became clear that there was a need to identify and collate the key lessons learned by those who have sought to develop CCS. It is hoped that making these lessons available will help to inform the future development and deployment of CCS in the UK… Interviews were conducted with CCS project developers and a selection of other CCS stakeholders between January and April 2016. Views were sought on the recent UK CCS [Commercialization Program] (2012 – 2015); and more generally around experiences with developing CCS projects in the UK and Europe over the last decade. This exercise was evidence-based. The document identifies 36 key lessons based on evidence provided by participants. This document aims to avoid advocacy, and does not provide any specific recommendations; however readers should be able to draw a number of important conclusions from the evidence."

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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