Carbon Storage Newsletter

JUNE 2015

WHAT'S INSIDE?

HIGHLIGHTS

"Texas CO_2 Capture Demonstration Project Hits Two Million Metric Ton Milestone."

In a U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL)-sponsored project, Air Products and Chemicals Inc. has captured and stored 2 million metric tons of carbon dioxide (CO_2). The project, located at a hydrogen production facility in Port Arthur, Texas, demonstrates vacuum swing adsorption (VSA) to capture more than 90 percent of the CO_2 from the product streams of two commercial-scale steam methane reformers. In addition, the project looks to help verify CO_2-enhanced oil recovery (EOR) as an effective method for permanent geologic storage of CO_2 by capturing the CO_2 and using it for EOR at the West Hastings oilfield in southeast Texas, USA. It is estimated that the West Hastings oilfield has the potential to produce in the range of 60 to 90 million additional barrels of oil through EOR operations. The VSA project is supported through DOE's Industrial Carbon Capture and Storage (ICCS) Program. To date, DOE-sponsored projects have captured and securely stored more than 10 million metric tons of CO_2. From *NETL News Release* on May 15, 2015.

"DOE-Funded Project Testing Laser CO_2 Monitoring at Carbon Storage Site."

A multipoint, laser-based CO_2 monitoring system was installed at an operational carbon storage site in Decatur, Illinois, USA, as part of an NETL-managed project. Developed by Exelis, the system, called GreenLITE, runs autonomously and provides real-time updates of two-dimensional concentrations of CO_2 at the storage site, which is located adjacent to an ethanol production facility where 1 million metric tons of CO_2 have been captured over the past three years and transported for storage. The Midwest Geological Sequestration Consortium (MGSC), one of seven regional partnerships in NETL's Regional Carbon Sequestration Partnership (RCSP) Program, began large-scale CO_2 injection at the Decatur site in 2011. From *Energy.gov* on June 3, 2015.

ANNOUNCEMENTS

NETL Releases Carbon Storage Project Portfolio.

DOE/NETL released the 2015 Carbon Storage Portfolio, which provides a comprehensive overview of the NETL Carbon Storage Program's current and recently completed work. The portfolio includes Storage Division personnel contact information, technology area introductions, project communication products, papers and technical reports, Best Practices Manuals (BPMs), and access to all archived projects.

Announcements (Continued)

DOE Projects Safely and Permanently Store 10 Million Metric Tons of CO_2.

A group of DOE-supported and NETL-managed carbon capture and storage (CCS) projects reached a milestone by safely capturing and storing 10 million metric tons of CO_2. The milestone builds upon the goals of providing clean energy, supporting American jobs, and reducing CO_2 emissions.

Global News Organizations Agree to Share Climate Change Content.

More than two dozen global news organizations have agreed to create a global pool of potential climate change content leading up to the United Nations Climate Change Conference (COP 21), held in Paris, France. Under the initiative, called the Climate Publishers Network, participating publishers will waive licensing fees for related content until December 11, 2015.

Student Training Program for Carbon Capture.

The University of Calgary, through a grant from the Natural Sciences and Engineering Research Council of Canada (NSERC), is offering a training opportunity for students looking to work in the carbon capture industry. The six-year program will focus on training students to develop various carbon capture technologies.

Technical Session on Engineering Geologic CO_2 Storage Systems.

The American Institute of Chemical Engineers' (AIChE) Annual Meeting, scheduled for November 8-13, 2015, in Salt Lake City, Utah, USA, will include a technical session, titled, "Engineering Geologic Carbon Dioxide Storage Systems." Research presentations will cover the science and technology of carbon storage, as well as field demonstrations of CO_2 injection.

2015 Carbon Management Technology Conference (CMTC 2015).

This conference is scheduled for November 17-19, 2015, at the Sugar Land Marriott Town Square in Sugar Land, Texas, USA. The conference will focus on carbon capture, storage, and utilization technologies that are being performed at large scale and provide options for low greenhouse gas (GHG) emissions while maintaining fuel diversity for sustainable growth.

Carbon Storage in the News

"ETI Appoints Consortium to Deliver New CCS Storage Appraisal Project."

The Energy Technologies Institute (ETI) has appointed a consortium to identify the next phase of sites under the North Sea to store CO_2. The 12-month project, through funding from the United Kingdom (UK) Department for Energy and Climate Change (DECC), will aim to identify new sites in UK waters to store CO_2 emissions from power stations and other industry plants. The project will make use of the publically available UK CO_2 storage atlas, "CO_2 Stored," developed by The Crown Estate and the British Geological Survey. The results will be shared with the CCS community at the end of the project. From *Gas World* on May 21, 2015.

"CO_2 Solutions Announces Successful Start-Up of Demonstration Plant."

CO_2 Solutions announced the commencement of its CO_2 capture demonstration project at Salaberry-de-Valleyfield, Québec, Canada. The 10-ton-per-day (tpd) demonstration unit's first commissioning was successful, with all controls and equipment responding according to design parameters. The facility has been adapted to produce its own heat and flue gas from a natural gas-fired boiler; the CO_2 is captured from the flue gas and stripped from the solvent using the hot water generated by the boiler. The operation is scheduled to run for at least 1,000 hours, and all test results will be independently reviewed by third parties. From *CO_2 Solutions Press Release* on May 19, 2015.

"Wood Group to Provide Technical Support on Carbon Capture and Storage."

Wood Group entered into an agreement with DECC to provide technical support on CCS. Wood Group subsidiary Wood Group Kenny (WGK) will act as one of six DECC-appointed technical specialists to provide independent advice on the technical understanding and review of CCS developments. Under the technical specialist framework, Wood Group will also provide support as required. The scope of the contract will include carbon capture, transport and storage, power and generations solutions and novel technology, and process and materials for CCS projects. From *Daily Record* on May 27, 2015.

"Large-Scale Experimental Data Released to Enhance CO_2 Pipeline Design Safety."

The DNV GL-led CO2PIPETRANS joint industry project (JIP) has released experimental data focused on assisting the design process of CO_2 pipelines. The data can be used to validate computer models used in CO_2 pipeline design. The data, which marks the third batch of experimental material publically shared by the JIP, was gathered by using computer models for gas dispersion to

Carbon Storage in the News (Continued)

assess CO_2 release. For more information, visit the CO2PIPELINES JIP website. From *DNV GL Press Release* on June 4, 2015.

Science

"Study Backs Seaweed's Carbon Capture Potential."

According to a new study, coastal plants and seaweeds have the potential to contribute to long-term carbon storage. The study, conducted by scientists from the University of Technology, Sydney (UTS), and Deakin University, investigated how a diverse range of macroalgae can contribute to "blue carbon" stocks – the carbon in leaves, sediments, and roots that is naturally captured by plants in coastal habitats. Published in the journal "Ecology," the results show that some seaweed species have the capacity to make a contribution to coastal capture, with their cell wall structure and composition central to their long-term carbon storage potential. In addition, the study claims that some species of seaweed contain compounds that degraded at high temperatures, leading to the potential for a contribution to long-term carbon storage. From *R&D Magazine* on May 19, 2015.

"Diverse Soil Communities Can Help Offset Impacts of [Potential Climate Change]."

In a study led by researchers at Yale, it was discovered that small soil animals can limit the effect of potential climate change by helping to control changes in carbon cycling. The study was conducted by an international collaboration at the Harvard Forest long-term climate change research site. As part of the experiment, researchers examined how atmospheric warming and nitrogen deposition could alter natural ecosystems under future climate change scenarios. The soil communities were manipulated to four levels of complexity to see which types of community would be most affected by global change factors, such as warming temperatures. The results of the study, titled, "Biotic interactions mediate soil microbial feedbacks to climate change," were published in the "Proceedings of the National Academy of Sciences." From *Yale School of Forestry & Environmental Studies* on May 19, 2015.

Policy

"North American Energy Ministers Establish a Working Group on Climate Change and Energy."

The North American Energy Ministers established a new working group called the North American Energy Ministers' Working Group on Climate Change and Energy. The trilateral working group, which was announced at the Energy and Climate Partnership of the Americas (ECPA) and Clean Energy Ministerial (CEM) meetings in Merida, Mexico, supports implementation of clean energy and climate change goals of the U.S., Mexican, and Canadian governments. The working group, which expands on the 2014 North American Energy Ministers Dialogue, includes collaboration in areas such as modeling and deployment of clean energy technologies; carbon capture, use, and storage; and emissions from the oil and gas sector. From *Energy.Gov* on May 25, 2015.

"Government of Canada Announces 2030 Emissions Target."

Canada announced plans to reduce its GHG emissions by 30 percent below 2005 levels by 2030. Canada formally submitted its target, referred to as an intended Nationally Determined Contribution, to the United National Framework Convention on Climate Change (UNFCCC). In addition, Canada's announcement included new regulatory measures that build upon their existing coal-fired electricity regulations. From *Government of Canada News Release* on May 15, 2015.

"Proposed Clean Power Plan Rule Cuts Power Sector CO_2 Emissions to Lowest Level Since 1980s."

According U.S. Energy Information Administration (EIA) analysis of the U.S. Environmental Protection Agency's (EPA) proposed Clean Power Plan rule, power sector CO_2 emissions may be reduced approximately 1,500 million metric tons per year by 2025 – a level experienced in the early 1980s. EIA's analysis uses the "Annual Energy Outlook 2015" (AEO2015) as a baseline, and aggregates the targets in EPA's proposed rule to the 22 regions represented in its model. A summary of EIA's analysis, titled, "Analysis of the Impacts of the Clean Power Plan," is available in the "Recent Publications" section of this newsletter. From *U.S. Energy Information Administration* on May 26, 2015.

"Impacts of Potential CO_2-Reduction Policies on Air Quality in the United States."

The following is the Abstract of this article: "Impacts of emissions changes from four potential U.S. CO_2 emission reduction policies on 2050 air quality are analyzed using the community multiscale air quality model (CMAQ). Future meteorology was downscaled from the Goddard Institute for Space Studies (GISS) ModelE General Circulation Model (GCM) to the regional scale using the Weather Research Forecasting (WRF) model. [The authors] use emissions growth factors from the EPAUS9r MARKAL model to project emissions inventories for two climate tax scenarios, a combined transportation and energy scenario, a biomass energy scenario and a reference case. Implementation of a relatively aggressive carbon tax leads to improved $PM_{2.5}$ air quality compared to the reference case as incentives increase for facilities to install flue-gas desulfurization (FGD) and CCS technologies. However, less capital is available to install NO_X reduction technologies, resulting in an O_3 increase. A policy aimed at reducing CO_2 from the transportation sector and electricity production sectors leads to reduced emissions of mobile source NO_X, thus reducing O_3. Over most of the U.S., this scenario leads to reduced $PM_{2.5}$ concentrations. However, increased primary $PM_{2.5}$ emissions associated with fuel switching in the residential and industrial sectors leads to increased organic matter (OM) and $PM_{2.5}$ in some cities." **Marcus A. Trail, Alexandra P. Tsimpidi, Peng Liu,**

Policy (Continued)

Kostas Tsigaridis, Yongtao Hu, Jason R. Rudokas, Paul J. Miller, Athanasios Nenes, and Armistead G. Russell, *Environ. Sci. Technol.* (Subscription may be required.)

Geology

"Rates of mineral dissolution under CO_2 storage conditions."

The following is the Abstract of this article: "Evaluating the potential of a sedimentary basin reservoir to securely store CO_2 benefits from a comprehensive understanding of the geochemical reactions that take place once CO_2 is injected into a formation. In particular, models that predict the transport and reaction of CO_2 within a reservoir require a definition of the types of reactions affected by enhanced levels of CO_2 and how the kinetics of these reactions will affect a heterogeneous mineralogy and formation waters within a reservoir over time. In this review [the authors] evaluate rate models used to describe mineral dissolution kinetics and compare the range in values reported for the kinetic parameters used to describe the reactivity of various minerals relevant to mainly siliciclastic reservoirs. Parameters that have a significant impact on model results include the reactive surface area of a mineral, the apparent activation energies used to extrapolate reaction rates to the temperatures of potential storage reservoirs (c. 50–125°C) and the in-situ pH of formation waters with elevated concentrations of dissolved CO_2. The variation in reported values for these parameters can lead to predicted rates that span many orders of magnitude for a given mineral. Despite these uncertainties recent success with geochemical models has been made by applying a Monte Carlo approach to [optimize] the kinetic parameters for minerals where robust thermodynamic and kinetic data do not exist." **Jay R. Black, Susan A. Carrol, and Ralf R. Haese**, *Chemical Geology.* (Subscription may be required.)

"The Pretty Hill Formation as a natural analogue for CO_2 storage: An investigation of mineralogical and isotopic changes associated with sandstones exposed to low, intermediate and high CO_2 concentrations over geological time."

The following is the Abstract of this article: "The Pretty Hill Formation of the Otway Basin (Australia) has been studied as a natural analogue for geological storage of anthropogenic CO_2 in order to examine the effects that CO_2 concentration and reservoir heterogeneity have on CO_2-related reactions. New petrographic data are presented, which validate the use of Hylogger™ as a tool to investigate high-resolution vertical changes in reservoir mineralogy. The integrated data set confirms earlier interpretations, showing that chlorite has been altered to kaolinite and siderite/ankerite in reservoir facies exposed to moderate and high CO_2 concentrations, while chlorite remains the dominant clay mineral in all parts of the formation where CO_2 content is low. Differences have been observed in the degree of CO_2-related reaction relative to CO_2 concentration and reservoir heterogeneity. Where CO_2 content is very high (c. 98 mol%) and associated with high water saturations, both chlorite and detrital feldspars have undergone complete reaction in the reservoir facies, resulting in quartzose sandstones with a kaolinite matrix, and with siderite as the dominant carbonate precipitate. Conversely, where CO_2 content is moderate (c. 29–57 mol%) and within the gas leg of the reservoir, chlorite has undergone significant reaction, but much of the original feldspar is preserved, suggesting relatively minor reaction. Carbonate cements from the moderate CO_2 gas-leg comprise calcite, siderite and ankerite, occurring as cemented zones associated with rock heterogeneities and the present-day gas–water contact. Heterogeneities within the gas-leg are likely to have associated pore fluid contacts, whereby relatively high water saturations will be present in the fine-grained baffles and seals. The most advanced feldspar reaction occurs locally at the contact between baffles and reservoir rock, while reactions have been significantly impeded in the finer grained units due to their low permeabilities. Stable isotope data presented for carbonate cements [analyzed] from wells with low and moderate CO_2 levels show no clear distinction. Relatively early formed calcite has $\delta^{13}C$ values that require an organic carbon source, suggesting precipitation unrelated to the reservoir CO_2 in the Otway Basin. In contrast, diagenetically late calcite and siderite samples display two distinct $\delta^{13}C$ groups (dependent on carbonate type), where the calculated fluid carbon isotope compositions are similar to documented magmatic CO_2 reservoired in the nearby Caroline Field. This suggests that magma-derived CO_2 may have been more prevalent through the Pretty Hill Formation than previously thought. Although the CO_2 has not been contained over the long term in the low CO_2 sites, it may have caused the local dissolution of carbonate and laumontite cement, and also contributed a source of carbon for late-stage calcite cements. These studies illustrate the importance of understanding both the reservoir composition and vertical heterogeneity of potential storage systems. Fluid–mineral reactions are likely to be advanced within stacked reservoir facies and impeded within siltstone layers, while the distribution of carbonate cement may increase the reservoir heterogeneity by the formation of cemented siltstone/sandstone layers, thereby creating impermeable barriers or baffles to CO_2." **K.E. Higgs, R.R. Haese, S.D. Golding, U. Schacht, and M.N. Watson**, *Chemical Geology*. (Subscription may be required.)

Technology

"CO_2 migration and pressure evolution in deep saline [formations]."

The following is the Abstract of this article: "In 2005, the [Intergovernmental Panel on Climate Change (IPCC)] special report on carbon dioxide capture and storage (SRCCS) summarized the state of knowledge about CCS as an emerging technology for reducing CO_2 emissions to the atmosphere. At the time of writing, the emphasis of the SRCCS was on understanding the fate of injected CO_2 whereas less attention was paid to effects of pressure buildup associated with CO_2 injection. Since then, the CCS community has significantly improved the knowledge base and addressed many of the technical gaps mentioned in 2005. A large body of research has been devoted to identify and verify the main processes that control CO_2 migration, trapping, and containment in deep saline [formations]. Much work has also been conducted to better understand the magnitude and implications of reservoir pressure buildup in response to large CO_2 storage projects. The aim of this paper is to provide a summary and overview of the most relevant recent (since publication of the IPCC SRCCS) literature and findings in the areas of CO_2 migration and pressure evolution. The paper first summarizes recent findings related to CO_2 plume migration and trapping, based on analytical and numerical modeling studies as well

Technology (Continued)

as several field injection tests conducted to examine the fate of injected CO_2 in various subsurface settings. The paper then discusses pressure effects as a function of space and time, including the effects of confinement (boundary conditions), highlights possible unwanted pressure impacts such as pressure-driven [release] and geomechanical damage, analyzes potential capacity constraints, reviews current concepts for pressure management, and closes with a discussion about use of pressure signals for advanced monitoring." **Jens T. Birkholzer, Curtis M. Oldenburg, and Quanlin Zhou**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

"Molecular Dynamics Characterizations of the Supercritical CO_2-Mediated Hexane-Brine Interface."

The following is the Abstract of this article: "In the CO_2 EOR process and subsequent geological CO_2 [storage], a ternary system consisting of CO_2, crude oil, and brine exists in the reservoir due to the common practice of injecting CO_2 together with brine. In this paper, [the authors] carried out molecular dynamics simulations to study the interfacial properties of the ternary CO_2, hexane, and 1.52 mol/L sodium chloride (NaCl) solution system under 330 K and 20 MPa with different CO_2 compositions at the supercritical state, which are very important for the efficiency of the EOR and CO_2 [storage] processes. [The authors] observed that CO_2 mixes well with hexane and a clear interface separates the CO_2–hexane mixture with the NaCl solution. The interfacial roughness increases with the CO_2 composition, indicating deeper molecular penetrations and shorter capillary wavelengths, which leads to the reduced interfacial tension. Interestingly, the surface excess of CO_2 reaches maximum at a CO_2 molar fraction of 62.5 [percent] (or a weight fraction of 46 [percent]), which implies the amphiphilic feature of CO_2, acting like surfactants, toward the hexane–brine interface. The orientational preferences of CO_2, hexane, and water molecules at the interface are more random at higher CO_2 compositions, as a result of the increased absolute amount of CO_2 and the absence of hexane at the interface." **Lingling Zhao, Lu Tao, and Shangchao Lin**, *Ind. Eng. Chem. Res*. (Subscription may be required.)

"Impacts of Organic Ligands on Forsterite Reactivity in Supercritical CO_2 Fluids."

The following is the Abstract of this article: "Subsurface injection of CO_2 for enhanced hydrocarbon recovery, hydraulic fracturing of unconventional reservoirs, and geologic carbon [storage] produces a complex geochemical setting in which CO_2-dominated fluids containing dissolved water and organic compounds interact with rocks and minerals. The details of these reactions are relatively unknown and benefit from additional experimentally derived data. In this study, [the authors] utilized an in situ X-ray diffraction technique to examine the carbonation reactions of forsterite (Mg_2SiO_4) during exposure to supercritical CO_2 ($scCO_2$) that had been equilibrated with aqueous solutions of acetate, oxalate, malonate, or citrate at 50°C and 90 bar. The organics affected the relative abundances of the crystalline reaction products, nesquehonite ($MgCO_3 \cdot 3H_2O$) and magnesite ($MgCO_3$), likely due to enhanced dehydration of the Mg^{2+} cations by the organic ligands. These results also indicate that the $scCO_2$ solvated and transported the organic ligands to the forsterite surface. This phenomenon has profound implications for mineral transformations and mass transfer in the upper crust." **Quin R. S. Miller, John P. Kaszuba, Herbert T. Schaef, Mark E. Bowden, and Bernard P. McGrail**, *Environ. Sci. Technol*. (Subscription may be required.)

Terrestrial

"Changes in soil aggregation and microbial community structure control carbon [storage] after afforestation of semiarid shrublands."

The following is the Abstract of this article: "Changes in plant cover after afforestation induce variations in litter inputs and soil microbial community structure and activity, which may promote the accrual and physical-chemical protection of soil organic carbon (SOC) within soil aggregates. In a long-term experiment (20 years) [the authors] have studied the effects, on soil aggregation and SOC stabilization, of two afforestation techniques: a) amended terraces with organic refuse (AT), and b) terraces without organic amendment (T). [The authors] used the adjacent shrubland (S) as control. Twenty years after stand establishment, aggregate distribution (including microaggregates within larger aggregates), sensitive and slow organic carbon (OC) fractions, basal respiration in macroaggregates, and microbial community structure were measured. The main changes occurred in the top layer (0–5 cm), where: i) both the sensitive and slow OC fractions were increased in AT compared to S and T, ii) the percentage and OC content of microaggregates within macroaggregates (Mm) were higher in AT than in S and T, iii) basal respiration in macroaggregates was also higher in AT, and iv) significant changes in the fungal (rather than bacterial) community structure were observed in the afforested soils (AT and T) – compared to the shrubland soil. These results suggest that the increase in OC pools linked to the changes in microbial activity and fungal community structure, after afforestation, promoted the formation of macroaggregates – which acted as the nucleus for the formation and stabilization of OC-enriched microaggregates." **N. Garcia-Franco, M. Martinez-Mena, M. Goberna, and J. Albaladejo**, *Soil Biology and Biochemistry*. (Subscription may be required.)

Trading

"Carbon Pricing Initiatives Valued at Close to $50 Billion."

Emissions trading systems have grown in value from $32 billion in 2014 to $34 billion currently, according to a new report from the World Bank Group. In addition, the report also states that existing carbon tax systems are currently valued at approximately $14 billion. The publication, titled, "Carbon Pricing Watch 2015," is a preview of a report to be launched later this year, titled, "State and Trends of Carbon Pricing 2015." An abstract of "Carbon Pricing Watch 2015" is available in the "Recent Publications" section of this newsletter. From *The World Bank Press Release* on May 26, 2015.

Trading (Continued)

"EEM Buys European Operations of the Carbon Trade Exchange Group."

Environmental commodities exchange operator European Environmental Markets (EEM) has acquired Carbon Trade Exchange Ltd (CTX EU), the European operations of the Carbon Trade Exchange Group (CTX Group). Based in Sydney, Australia, the CTX Group operates the global electronic exchange platform in the voluntary carbon market. The transaction includes CTX EU's European Clients and exchange businesses for both voluntary and regulated carbon emissions trading. EEM plans to launch spot trading for the European Union Emissions Trading Scheme (EU ETS) using CTX's infrastructure later this year. From *Commodities Now* on May 21, 2015.

"Statistical regularities of Carbon emission trading market: Evidence from European Union allowances."

The following is the Abstract of this article: "As an emerging financial market, the trading value of carbon emission trading market has definitely increased. In recent years, the carbon emission allowances have already become a way of investment. They are bought and sold not only by carbon emitters but also by investors. In this paper, [the authors] analyzed the price fluctuations of the European Union allowances (EUA) futures in European Climate Exchange (ECX) market from 2007 to 2011. The symmetric and power-law probability density function of return time series was displayed. [The authors] found that there are only short-range correlations in price changes (return), while long-range correlations in the absolute of price changes (volatility). Further, detrended fluctuation analysis (DFA) approach was applied with focus on long-range autocorrelations and Hurst exponent. [The authors] observed long-range power-law autocorrelations in the volatility that quantify risk, and found that they decay much more slowly than the autocorrelation of return time series. [The authors'] analysis also showed that the significant cross correlations exist between return time series of EUA and many other returns. These cross correlations exist in a wide range of fields, including stock markets, energy concerned commodities futures, and financial futures. The significant cross-correlations between energy concerned futures and EUA indicate the physical relationship between carbon emission and energy production process. Additionally, the cross-correlations between financial futures and EUA indicate that the speculation behavior may become an important factor that can affect the price of EUA. Finally [the authors] modeled the long-range volatility time series of EUA with a particular version of the GARCH process, and the result also suggests long-range volatility autocorrelations." **Zeyu Zheng, Rui Xiao, Haibo Shi, Guihong Li, and Xiaofeng Zhou,** *Physica A: Statistical Mechanics and its Applications*. (Subscriptions may be required.)

Recent Publications

"Carbon Pricing Watch 2015."

The following is the Abstract of this document: "Significant progress in carbon pricing has been made over the last ten years. In 2015, about 40 national and over 20 subnational jurisdictions, representing almost a quarter of global [GHG emissions], are putting a price on carbon. Together, the carbon pricing instruments in these jurisdictions cover about half of their emissions, which translates into approximately 7 $GtCO_2e$ or about 12 percent of annual global GHG emissions. This figure represents a threefold increase over the past decade. The total value of the emissions trading schemes (ETSs) reported in the State and Trends of Carbon Pricing 2014 report was about $30 billion. Despite the repeal of Australia's Carbon Pricing Mechanism in July 2014, and mainly due to the launch of the Korean ETS and the expansion of GHG emissions coverage in the California and Quebec ETSs, the value of global ETSs as of April 1, 2015, increased slightly to about $34 billion. In addition, carbon taxes around the world, valued for the first time in this report, are about $14 billion. Combined, the value of the carbon pricing mechanism globally in 2015 is estimated to be just under $50 billion."

"Analysis of the Impacts of the Clean Power Plan."

The following is from the Background of this document: "This report responds to an August 2014 request to EIA from…the U.S. House of Representatives Committee on Science, Space, and Technology, for an analysis of [EPA's] proposed Clean Power Plan under which states would be required to develop plans to reduce CO_2 emissions rates from existing fossil-fired electricity generating units…The starting point for EIA's analysis of the Clean Power Plan is the Annual Energy Outlook 2015 (AEO2015) Reference case rather than earlier AEO projections that were developed using versions of EIA's National Energy Modeling System (NEMS) that lack the model structure needed to analyze key features of the Clean Power Plan proposal. With EIA's decision, unrelated to this project, to publish shorter and longer editions of the AEO in alternating years, AEO2015 does not include all of the alternative cases presented in earlier AEO editions. However, in the spirit of [the Committee on Science, Space, and Technology's] request, this report analyzes the Clean Power Plan in the context of the AEO2015 High Economic Growth and High Oil and Gas Resource cases as well as the Reference case in order to examine indicators of the proposed rule's impacts on energy markets under varying assumptions regarding economic growth, electricity demand, and fuel prices. To address some of the additional questions raised in [the] request, the report includes additional Clean Power Plan sensitivity cases including: (1) extension of the Clean Power Plan targets beyond 2030 to reduce CO_2 emissions from electric power generation by 45 [percent] relative to the 2005 level by 2040; (2) treatment of future nuclear capacity similar to the treatment of renewable capacity; (3) sensitivities for expenditures and effectiveness of energy efficiency programs; (4) sensitivities for the cost and effectiveness

Recent Publications (Continued)

of heat rate improvement measures; (5) no availability of markets for CO_2 captured from electric power plants for EOR; (6) an alternative compliance phase-in trajectory during the 2020-29 period; (7) alternative accounting rules for emissions from biomass generation; (8) national compliance cooperation; and (9) limited interregional trade."

Legislative Activity

"Manchin Bill Aims to Add Carbon Utilization to DOE R&D Priorities."

A West Virginia Senator introduced legislation aimed at prioritizing research and development (R&D) of carbon utilization technologies under DOE's Office of Fossil Energy (FE) Program. The legislation, S. 1282, looks to amend a section of the Energy Policy Act of 2005 by adding an objective to improve the conversion, use, and storage of CO_2 produced from fossil fuels. S. 1282 has been referred to the Committee on Energy and Natural Resources. From *Biomass Magazine* on May 18, 2015.

About DOE's Carbon Storage Program

The Carbon Storage Program is implemented by the U.S. Department of Energy's Office of Fossil Energy and managed by the National Energy Technology Laboratory. The program is developing technologies to capture, separate, and store CO_2 in order to reduce greenhouse gas emissions without adversely influencing energy use or hindering economic growth. NETL envisions having a technology portfolio of safe, cost-effective, carbon dioxide capture, transport, and storage technologies that will be available for commercial deployment.

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 Reference Shelf.

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

There are several ways to join the conversation and connect with NETL's Carbon Storage Program:

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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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