NETL the ENERGY lab

Carbon Storage Newsletter

October 2014

What's Inside?

Highlights

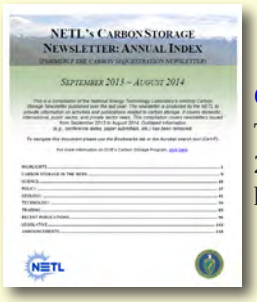
"NETL Collaborations Advance Carbon Management Strategies."

The Carbon Capture Simulation Initiative (CCSI) and the National Risk Assessment Partnership (NRAP) are using predictive computational modeling to help the U.S. Department of Energy (DOE) meet its goal of having carbon capture and storage (CCS) technologies ready for demonstration in the 2020 to 2025 timeframe. Meeting this goal requires the development of new approaches to reduce the number of years typically required for commercial deployment of new technology concepts. Led by the Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL), the two collaborative efforts use computational modeling, which involves developing mathematical equations and computer code to simulate the real-life behavior of engineered and natural systems. The use of these models allows for more efficient, timely, and cost-effective technology development and deployment. For more information, visit DOE's national lab webpage. From *NETL News Release* on August 27, 2014.

"Projects Selected for Safe and Permanent Geologic Storage of Carbon Dioxide."

DOE selected 13 projects to develop technologies, methodologies, and characterization tools to improve the ability to predict geologic storage capacity, understand geomechanical processes, and enhance the geologic storage safety. The projects will be managed by FE's NETL and were awarded in two areas of interest: "Geomechanical Research" and "Fractured Reservoir and Seal Behavior." Project details are available via the link above. CCS research is focused on developing technologies to capture industrially generated CO_2 and safely and permanently store it in underground geologic formations in order to reduce the amount of CO_2 being released into the atmosphere. From *NETL News Release* on August 6, 2014

Announcements



Carbon Storage Newsletter Annual Index 2014 Available.

This document is a compilation of NETL's Carbon Storage Newsletter published over the September 2013 to August 2014 timeframe. Outdated information (e.g., conference dates, paper submittals, etc.) has been removed.

Announcements (Continued)

BSCSP Kevin Dome Carbon Storage Project Blog Available.

The Big Sky Carbon Sequestration Project (BSCSP) has created a "News from the Kevin Dome" blog on the BSCSP website as an effort to regularly update the public about work being done on the Kevin Dome Carbon Storage Project. BSCSP expects to post updates on a weekly basis and as developments occur in the field.

2014 Midwest Carbon Sequestration Science Conference.

The Midwest Geological Sequestration Consortium (MGSC) will hold the conference at the I Hotel and Conference Center in Champaign, Illinois, USA, on November 5-6, 2014. The conference will showcase current research and include a field trip to visit the Illinois Basin Decatur Project (IBDP) injection site. The conference will also feature a full day of presentations on the IBDP saline reservoir injection demonstration, including permitting, groundwater, geophysics, reservoir constraints, and micro-seismic discussions. More details will be available online.

Call for Papers: 2015 CCUS Conference: Abstracts Now Being Accepted.

The Call for Papers for the 14th Annual Conference on Carbon Capture, Utilization, and Storage has been released, and abstracts are being accepted through January 23, 2015. The theme of this year's conference, scheduled for April 28 through May 1, 2015, in Pittsburgh, Pennsylvania, USA, is "Advancing CO_2 Emission Reduction Systems to Achieve Global Reduction Goals, Meet Electricity Needs, and Utilize Domestic Resources."

Carbon Storage in the News

"Carbon Sequestration Research Continues at Sandia Labs under Energy Department funds."

The Center for Frontiers of Subsurface Energy Security (CFSES), a joint carbon storage program undertaken by Sandia and the University of Texas at Austin, was awarded a contract to research long-term geologic CO_2 storage. The work focuses on three technical challenges: (1) sustaining large storage rates over decades; (2) increasing efficient use of pore space in geologic formations/reservoirs where CO_2 would be stored; and (3) making sure CO_2 does not release from the reservoir. The effort will concentrate on deep saline reservoirs, including issues ranging from the atomic- to full reservoir-scale in a multidisciplinary approach that unites chemistry, microbiology, geomechanics, geophysics, and computer sciences. CFSES also studies how CO_2 dissolves into resident brines over time. In addition, the researchers are working at New Mexico's Bravo Dome (a natural underground CO_2 reservoir) to calculate long-term dissolution rates to understand the importance of solubility to CO_2 trapping. From *Sandia Labs News Release* on September 15, 2014.

"UW Wins DOE Grant for Further Study of Rock Springs Uplift."

University of Wyoming (UW) researchers received a grant to study the possible subsurface effects of injecting CO_2 into the Rock Springs Uplift in southwest Wyoming, USA. According to a UW official, the goal of this research is to improve the understanding of the geomechanical effect(s) of CO_2 injection on two types of reservoir rocks (sandstone and limestone/dolomite). An improved understanding would help to increase the accuracy of subsurface models that predict storage reservoir integrity. The researchers will use a variety of tools, such as lab experiments on core samples taken from the Rock Springs Uplift, computer modeling, and seismic data, to predict the underground impacts of CO_2 injection at the site. Previous work on the Rock Springs Uplift included field work and subsurface characterization of lithology, structure, mechanical stratigraphy, fracture systems, and in situ stress. Research has shown that two deep saline formations in Rock Springs Uplift could store 26 billion tons of CO_2 over 50 years. From *University of Wyoming News Release* on September 26, 2014.

"SaskPower Launches World's First Commercial CCS Process."

SaskPower opened a commercial-scale CCS process on a coal-fired power plant at Boundary Dam Power Station in Estevan, Saskatchewan, Canada. SaskPower's CCS process will capture up to 1 million metric tons of CO_2 per year when fully optimized. The captured CO_2 will be used for enhanced oil recovery (EOR) and will be continuously monitored for safe and permanent underground storage. From *SaskPower News Release* on October 2, 2014.

"$5 Million Assures Otway Project will be Ongoing."

The Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) received an additional $5 million in funding from Victoria's Minister for Energy and Resources for researching CO_2 storage at the Otway site. The Otway Project has injected and stored more than 60,000 metric tons of CO_2 in a depleted gas reservoir near Warrnambool in Victoria, Australia, over the last 10 years. A book, titled, "Geologically Storing Carbon: Learning from the Otway Project Experience," was recently released, highlighting the work of more than 100 researchers from Federal and state governments, Australian and international industry, and the global research community. From *CO2CRC News Release* on September 15, 2014.

Science

"Global Warming Changes the Way Sharks Swim."

According to new research published in the journal "Biology Letters," sharks exposed to ocean water acidified by CO_2 swim for longer time frames than sharks in typical ocean water. The altered behavior happens during nighttime and has the potential to affect the species. By studying two sets of small-spotted catsharks (half in tanks with typical ocean water and half in tanks with acidified ocean water), researchers found that those in the more acidified water had more sodium and bicarbonate ions in their blood, and swam more continuously during nighttime hours than those in typical ocean water, signifying a potential inability to acclimate. From *Discovery* on September 17, 2014.

Policy

"U.S. EPA Approves Carbon Sequestration Permit in Decatur, Illinois."

The U.S. Environmental Protection Agency (EPA) approved a permit allowing the Archer Daniels Midland Company (ADM) to store CO_2 underground in Decatur, Illinois. Before approving the permit, EPA completed a technical review of the Class VI permit and responded to more than 100 public comments. ADM plans to capture and inject underground approximately 1.1 million metric tons of CO_2 annually from an ethanol manufacturing facility. This is the second facility in the United States to receive a Class VI underground injection permit for carbon storage and ADM can begin drilling the well in November. Before injecting CO_2, ADM must demonstrate the integrity of the well, as well as conduct extensive monitoring at the location. Click here for more information. From *U.S. EPA News Release* on September 26, 2014.

"New Experimental Data Released to Enhance CO_2 Pipeline Design."

The CO2PIPETRANS joint industry project (JIP) is releasing data related to the depressurization of CO_2 pipelines. The data is intended to fill knowledge gaps associated with the safe and reliable pipeline transport of CO_2 and result in cost efficiencies and improved design basis for the pipelines. In addition to making datasets for model validation publicly available, the DNV GL-led CO2PIPETRANS JIP also involves work to improve the understanding of CO_2 pipeline propagating cracks and corrosion rates with various CO_2 stream impurities. Click here for more information on CO2PIPETRANS. From *DNV GL New Release* on October 7, 2014.

"CCS (carbon capture and storage) investment possibility in South East Europe: A case study for Croatia."

The following is the Abstract of this article: "In order to reduce carbon emissions, great efforts are required to [optimize] the processes and solve the main technical and economic problems which currently limit a large-scale diffusion of CCS technologies. In this paper, the main results of a techno-economic comparison between USCPC or USC plants (ultra supercritical [pulverized] coal combustion) with and without CCS are presented. In this study, a few related questions about the development of CCS and power generation technologies in SEE (South East Europe) are answered. The main questions considered are: (1) what are the current cost estimates for building a new entrant power plant with an installed CCS system compared to a typical USC power plant (2) what is the breakeven [CO_2] price to justify CCS investment for USCPC power plants. To answer these questions, a LCOE ([levelized] cost of electricity) model is built for the power plants in study, with assumptions best representing the current costs and technologies in the EU (European Union). Then, a sensitivity analysis of some of the key parameters of the LCOE to reveal their impact on the financial viability of the project is done. The technical model of the plant is implemented in the database of the SEE REM (South East Europe Regional Electricity Market) in order to evaluate its performance on the electricity market and results gained are [analyzed]." **Alfredo Višković, Vladimir Franki, and Vladimir Valentić**, *Energy*. (Subscription may be required.)

Geology

"Environmental considerations for subseabed geological storage of CO_2: A review."

The following is the Abstract of this article: "Many countries are now using or investigating offshore geological storage of CO_2 as a means to reduce atmospheric CO_2 emissions. Although associated research often focuses on deep-basin geology (e.g. seismic, geomagnetics), environmental data on the seabed and shallow subseabed is also crucial to (1) detect and [characterize] potential indicators of fluid seeps and their potential connectivity to targeted storage reserves, (2) obtain baseline environmental data for use in future monitoring, and (3) acquire information to facilitate an improved understanding of ecosystem processes for use in impact prediction. This study reviews the environmental considerations, including potential ecological impacts, associated with subseabed geological storage of CO_2. Due to natural variations in CO_2 levels in seafloor sediments, baseline CO_2 measurements and knowledge of physical–chemical processes affecting the regional distribution of CO_2 and pH are critical for the design of appropriate monitoring strategies to assess potential impacts of CO_2 seepage from subseabed storage reservoirs. Surficial geological and geophysical information, such as that acquired from multibeam sonar and sub-bottom profiling, can be used to investigate the connectivity between the deep reservoirs and the surface, which is essential in establishing the reservoir containment properties. [Carbon dioxide release] can have a pronounced effect on sediments and rocks which in turn can have carryover effects to biogeochemical cycles. The effects of elevated CO_2 on marine organisms are variable and species-specific but can also have cascading effects on communities and ecosystems, with marine benthic communities at some natural analogue sites (e.g. volcanic vents) showing decreased diversity, biomass, and trophic complexity. Despite their potential applications, environmental surveys and data are still not a standard and integral part of subseabed CO_2 storage projects. However, the habitat mapping and seabed [characterization] methodology that underpins such surveys is well developed

Geology (Continued)

and has a strong record of providing information to industry and decision makers. This review provides recommendations for an integrated and interdisciplinary approach to offshore geological storage of CO_2, which will benefit national programs and industry and will be valuable to researchers in a broad range of disciplines." **A.G. Carroll, R. Przeslawski, L.C. Radke, J.R. Black, K. Picard, J.W. Moreau, R.R. Haese, and S. Nichol**, *Continental Shelf Research*. (Subscription may be required.)

"A preliminary assessment of geological CO_2 storage in Cambodia."

The following is the Abstract of this article: "This study screens and rank Cambodian sedimentary basins in terms of their containment, capacity, and feasibility for the geological storage of CO_2. The results of the screening and ranking procedure indicate that the Khmer Basin is the most suitable basin, followed by the Kampong Saom and Tonle Sap basins. A quantitative volumetric assessment-based evaluation of CO_2 storage capacity is performed on these three suitable basins. The evaluation yields a range in the national CO_2 storage capacity of 90 Mt (in structural traps) to 45 Gt (in hydrodynamic traps), representing low- and high-case estimates, respectively. The saline [formations] associated with this storage capacity should be considered prospective storage options as hydrodynamic traps because of containment and capacity issues associated with the structural traps. Eight major point sources of CO_2 are identified that have a combined output (estimated for 2008–2024) of 43.1 Mt annually and 82 billion m3 in place, and the potentially prospective matched storage capacity is assumed. Overall, a combination of the initial suitabilities of the basins and estimates of prospective matched storage capacity shows that the Khmer, Kampong Saom, and Tonle Sap basins may provide a solution to the problem of reducing future atmospheric emissions. The present results should assist both exploration geologists and experts in [CCS] to gain a better understanding of the CO_2 storage resources of Cambodia. However, the results should be regarded as preliminary because of the limited available data on which the assessments were based; future geological and geophysical data should improve the reliability of the estimates of carbon storage capacity reported here." **Chanrithyrouth Mao, Yasuhiro Yamada, and Toshifumi Matsuoka**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

Technology

"Regional Assessment of CO_2-Solubility Trapping Potential: A Case Study of the Coastal and Offshore Texas Miocene Interval."

The following is the Abstract of this article: "This study presents a regional assessment of CO_2-solubility trapping potential (CSTP) in the Texas coastal and offshore Miocene interval, comprising lower, middle, and upper Miocene sandstone. Duan's solubility model was applied to estimate carbon content in brine saturated with CO_2 at reservoir conditions. Three approaches (simple, coarse, and fine) were used to calculate the CSTP. The estimate of CSTP in the study area varies from 30 Gt to 167 Gt. Sensitivity analysis indicated that the CSTP in the study area is most sensitive to storage efficiency, porosity, and thickness and is least sensitive to background carbon content in brine. Comparison of CSTP in [the authors'] study area with CSTP values for seven other saline [formations] reported in the literature showed that the theoretical estimate of CO_2-solubility trapping potential (TECSTP) has a linear relationship with brine volume, regardless of brine salinity, temperature, and pressure. Although more validation is needed, this linear relationship may provide a quick estimate of CSTP in a saline [formation]. Results of laboratory experiments of brine-rock–CO_2 interactions and the geochemical model suggest that, in the study area, enhancement of CSTP caused by interactions between brine and rocks is minor and the storage capacity of mineral trapping owing to mineral precipitation is relatively trivial." **Changbing Yang, Ramón H. Treviño, Tongwei Zhang, Katherine D. Romanak, Kerstan Wallace, Jiemin Lu, Patrick J. Mickler, and Susan D. Hovorka**, *Environ. Sci. Technol*. (Subscription may be required.)

"Coal bed reservoir simulation with geostatistical property realizations for simultaneous multi-well production history matching: A case study from Illinois Basin, Indiana, USA."

The following is the Abstract of this article: "Coal seam degasification is a means to recover energy from the methane gas retained in coal, and is also a supplementary measure to ventilation, which is proven to be one of the most effective ways to reduce methane emissions to a safe level in coal mines. Reservoir simulation is probably the most effective way to assess the coal seam as a 'gas reservoir' and thereby its fluid-storage and flow-related properties. This objective is achieved by taking advantage of history matching of wellbore production. Reservoir simulation with multi-well history matching is a tedious process as important coal properties that affect wells' production characteristics are spatially variable across the seam. The common practice is to change various properties at the well blocks during the history matching process, and assume that they are uniform across the domain of interest. This process, however, often does not produce realistic and effective results for well or coal reservoir management. In this work, a multi-level approach to coal bed reservoir simulation is demonstrated for a group of coalbed methane wells in the Illinois Basin producing from the Seelyville Coal Member of the Linton Formation of the Carbondale Group (Pennsylvanian) in Indiana. This approach includes, in order, gas and water deliverability analyses of wells, geostatistical simulation and co-simulation, and coal bed reservoir simulation. It is shown that a reservoir model, which utilizes the geostatistical maps of important coal properties, is effective for simultaneous history matching of all wells, and eliminates the need for guessing and changing values of coal properties at and around individual well blocks. This methodology also provides realistic distributions of reservoir parameters and how they change during gas depletion, and thus aids in coal seam and coal gas management." **C. Özgen Karacan, Agnieszka Drobniak, and Maria Mastalerz**, *International Journal of Coal Geology*. (Subscription may be required.)

"Comparative life cycle assessment of biomass co-firing plants with carbon capture and storage."

The following is the Abstract of this article: "Combining co-firing biomass and CCS in power plants offers attractive potential for net removal of CO_2 from the atmosphere. In this study, the impact of co-firing biomass (wood pellets and straw pellets) on the emission profile of power

TECHNOLOGY (CONTINUED)

plants with [CCS] has been assessed for two types of coal-fired power plants: a supercritical [pulverized] coal power plant (SCPC) and an integrated gasification combined cycle plant (IGCC). Besides, comparative life cycle assessments have been performed to examine the environmental impacts of the combination of co-firing biomass and CCS. Detailed calculations on mass balances of the inputs and outputs of the power plants illustrate the effect of the different content of pollutants in biomass on the capture unit. Life cycle assessment results reveal that 30 [percent] co-firing biomass and applying CCS net negative CO_2 emissions in the order of 67–85 g/kWh are obtained. The impact in all other environmental categories is increased by 20–200 [percent]. However, aggregation into endpoint levels shows that the decrease in CO_2 emissions more than offsets the increase in the other categories. Sensitivity analyses illustrate that results are most sensitive to parameters that affect the amount of fuel required, such as the efficiency of the power plant and assumptions regarding the supply chains of coal and biomass. Especially, assumptions regarding land use allocation and carbon debt of biomass significantly influence the environmental performance of BioCCS." **Wouter Schakel, Hans Meerman, Alireza Talaei, Andrea Ramírez, and André Faaij**, *Applied Energy*. (Subscription may be required.)

"Probabilistic electrical resistivity tomography of a CO_2 sequestration analog."

The following is the Abstract of this article: "Electrical resistivity tomography (ERT) is a well-established method for geophysical characterization and has shown potential for monitoring geologic CO_2 [storage], due to its sensitivity to electrical resistivity contrasts generated by liquid/gas saturation variability. In contrast to deterministic inversion approaches, probabilistic inversion provides the full posterior probability density function of the saturation field and accounts for the uncertainties inherent in the petrophysical parameters relating the resistivity to saturation. In this study, the data are from benchtop ERT experiments conducted during gas injection into a quasi-2-D brine-saturated sand chamber with a packing that mimics a simple anticlinal geological reservoir. The saturation fields are estimated by Markov chain Monte Carlo inversion of the measured data and compared to independent saturation measurements from light transmission through the chamber. Different model parameterizations are evaluated in terms of the recovered saturation and petrophysical parameter values. The saturation field is parameterized (1) in Cartesian coordinates, (2) by means of its discrete cosine transform coefficients, and (3) by fixed saturation values in structural elements whose shape and location is assumed known or represented by an arbitrary Gaussian Bell structure. Results show that the estimated saturation fields are in overall agreement with saturations measured by light transmission, but differ strongly in terms of parameter estimates, parameter uncertainties and computational intensity. Discretization in the frequency domain (as in the discrete cosine transform parameterization) provides more accurate models at a lower computational cost compared to spatially discretized (Cartesian) models. A priori knowledge about the expected geologic structures allows for non-discretized model descriptions with markedly reduced degrees of freedom. Constraining the solutions to the known injected gas volume improved estimates of saturation and parameter values of the petrophysical relationship." **Tobias Lochbühler, Stephen J. Breen, Russell L. Detwiler, Jasper A. Vrugt,and Niklas Lindea**, *Journal of Applied Geophysics*. (Subscription may be required.)

"Mobilization and Transport of Organic Compounds from Reservoir Rock and Caprock in Geological Carbon Sequestration Sites."

The following is the Abstract of this article: "Supercritical CO_2 ($scCO_2$) is an excellent solvent for organic compounds, including benzene, toluene, ethyl-benzene, and xylene (BTEX), phenols, and polycyclic aromatic hydrocarbons (PAHs). Monitoring results from geological carbon sequestration (GCS) field tests has shown that organic compounds are mobilized following CO_2 injection. Such results have raised concerns regarding the potential for groundwater contamination by toxic organic compounds mobilized during GCS. Knowledge of the mobilization mechanism of organic compounds and their transport and fate in the subsurface is essential for assessing risks associated with GCS. Extraction tests using $scCO_2$ and methylene chloride (CH_2Cl_2) were conducted to study the mobilization of volatile organic compounds (VOCs, including BTEX), the PAH naphthalene, and n-alkanes (n-C_{20} – n-C_{30}) by $scCO_2$ from representative reservoir rock and caprock obtained from depleted oil reservoirs and coal from an enhanced coal-bed methane recovery site. More VOCs and naphthalene were extractable by $scCO_2$ compared to the CH_2Cl_2 extractions, while $scCO_2$ extractable alkane concentrations were much lower than concentrations extractable by CH_2Cl_2. In addition, dry $scCO_2$ was found to extract more VOCs than water saturated $scCO_2$, but water saturated $scCO_2$ mobilized more naphthalene than dry $scCO_2$. In sand column experiments, moisture content was found to have an important influence on the transport of the organic compounds. In dry sand columns the majority of the compounds were retained in the column except benzene and toluene. In wet sand columns the mobility of the BTEX was much higher than that of naphthalene. Based upon results determined for the reservoir rock, caprock, and coal samples studied here, the risk to [formations] from contamination by organic compounds appears to be relatively low; however, further work is necessary to fully evaluate risks from depleted oil reservoirs." **Zhong L, KJ Cantrell, AV Mitroshkov, and JL Shewell**, *Environmental Earth Sciences*. (Subscription may be required.)

TERRESTRIAL

"Reduced global warming potential after wood ash application in drained Northern peatland forests."

The following is the Abstract of this article: "Past land use change has converted vast areas of Northern peatland by drainage to agricultural or forested land. This change often reduces the [greenhouse gas (GHG)] sink strength of peatlands or turns them even from sinks to sources, which affects the global climate. Therefore, there is a need for suitable mitigation options for GHG emissions from drained peatlands. Addition of wood ash to peatland forests has been suggested as such a measure, but the overall effect on the global warming potential (GWP) of these ecosystems is still unclear. In order to fill this knowledge gap, [the authors] investigated three drained peatland forests in Sweden that had been fertilized with wood ash and monitored stand growth as well as the GHG

Terrestrial (Continued)

emissions from soil, i.e. net effluxes of CO_2, methane (CH_4) and nitrous oxide (N_2O). [The authors'] results show that over the first five to eight years after wood ash application, tree growth was enhanced at all sites. This was accompanied by generally little changes in the GHG emissions. Overall, [the authors] found that wood ash application reduced the GWP of drained peatland forests. Even though that [the authors'] study was limited to eight years after wood ash application, [the authors] can conclude that in the short term wood ash application may be a suitable mitigation option for GHG emissions from Northern drained peatland forests." **Tobias Rütting, Robert G. Björk, Astrid Meyer, Leif Klemedtsson, and Ulf Sikström**, *Forest Ecology and Management*. (Subscription may be required.)

Trading

"RGGI States Initiate Bidding Process for Auction 26."

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the Auction Notice and application materials for their 26th quarterly CO_2 allowance auction scheduled for December 3, 2014. The Auction Notice for CO_2 Allowance Auction 26 provides potential participants with the information needed to indicate their intent to bid on the 18,198,685 CO_2 allowances offered for sale at a reserve price of $2.00. Auction 26 will be the last quarterly auction that states will offer CO_2 allowances for purchase in order to meet CO_2 compliance obligations for the second control period (January 1, 2012, through December 31, 2014). From *RGGI News Release* on October 6, 2014.

"California and Québec Announce First Joint Cap-and-Trade Auction."

The California Air Resources Board and the Québec Ministry of Sustainable Development, Environment, and the Fight Against Climate Change will hold their first joint cap-and-trade auction on November 19, 2014. The two jurisdictions officially linked their programs on January 1, 2014, but have been working together for several years to ensure their regulations are equally stringent and can be integrated. The online platform that will hold the joint auction (the same platform both parties used for their individual auctions) was tested by stakeholders during a "practice" joint auction held in August 2014. All participants of the auction must be registered in the Compliance Instrument Tracking System Service (CITSS) and the auction platform; carbon allowances sold in the auction may be used in either the California or Québec cap-and-trade programs. From *California Air Resource Board News Release* on September 18, 2014.

"S. Korea Increases Emissions Cap in Proposed Carbon Trading Scheme."

The South Korean government announced that the CO_2 cap expected to be introduced as part of a carbon trading scheme will be approximately three percent larger than previously anticipated. According to the environment ministry, 1.687 billion metric tons of carbon-equivalent emission permits would be distributed from 2015 through 2017 as part of what is projected to be one of the world's largest carbon emissions trading schemes. The environment ministry also stated that 1.598 billion of the total permits will be distributed to the 526 covered emitters before the trading starts, which is more than 1.64 billion than were previously expected. The remaining 89 million permits will be distributed from 2015 to 2017. The South Korean government's goal is reduce CO_2 emissions in 2020 to 30 percent below business-as-usual levels. From *Reuters Africa* on September 11, 2014.

"How will the emissions trading scheme save cost for achieving China's 2020 carbon intensity reduction target?"

The following is the Abstract of this article: "Chinese government has committed to reduce its carbon intensity by 40–45 [percent] over the period 2005–2020 at the 2009 Copenhagen Summit. To achieve the target in a cost-effective way, China is signaling strong intentions to establish emissions trading scheme, and presently seven pilots have been established. This paper focuses on the cost-saving effects of carbon emissions trading in China for the 2020 target. First, an interprovincial emissions trading model is constructed. Then, three kinds of policy scenarios, including no carbon emissions trading among provinces (NETS), the carbon emissions trading only covering the pilots (PETS), and the unified carbon emissions trading market (CETS), have been designed. The results show that China needs to reduce its emissions by 819 $MtCO_2$ for achieving the 42.5 [percent] reduction in carbon intensity over the period 2005–2020. The PETS and the CETS, which may result in a carbon price of 99 yuan/tCO_2 and 53 yuan/tCO_2, could reduce the total abatement costs by 4.50 [percent] and 23.67 [percent], respectively. This paper also finds that the carbon emissions trading could yield different impacts on different provinces, and the cost-saving effects of the eastern and western provinces are more pronounced than the central provinces. Necessary sensitivity analysis is also provided at the end of the research. These findings may be useful for promoting the development of carbon emissions trading in China." **Lian-Biao Cui, Ying Fan, Lei Zhu, and Qing-Hua Bi**, *Applied Energy*. (Subscription may be required.)

Recent Publications

"Legal Liability and Carbon Capture and Storage: A Comparative Perspective."

The following is from the "Context and Purpose of the Report" chapter of this document: "This report addresses the legal issues concerning liability for operations connected with CCS. CCS activities involve three distinct operations – capture of CO_2 at power or industrial plants, transportation of CO_2 in a dense phase by pipe, sea or land transport, and long-term storage deep underground under land or sea. Liability issues connected with capture and transport are unlikely to be significantly different from those associated with any other industrial activity, and though there will be considerable overlap in the applicable law, the focus of this report is with storage because this can raise particular challenges in designing appropriate liability regimes: time-scales for storage are lengthy and the technology remains relatively novel. The report is intended to highlight key themes that have emerged in thinking about the design of appropriate legal liability regimes for CCS, and uses as core examples for comparison three jurisdictions - the State of Victoria, Australia; the Province of Alberta, Canada; and the United Kingdom. It is not intended to provide a comprehensive analysis of the legislation in each of the jurisdictions. Instead it will examine the law in order to highlight the typical legal liability issues that need to be addressed in the design of legal and regulatory models for the technology. The study will consider the CCS liability issues that have emerged, and compare the differences that appear to exist, as well as the uncertainties that remain."

Legislative Activity

"Chile Becomes the First South American Country to Tax Carbon."

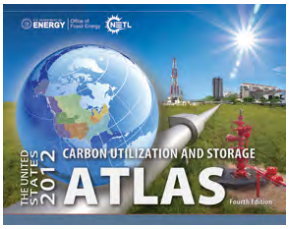
The President of Chile signed legislation that makes Chile the first country in South America to tax CO_2 emissions. The carbon tax targets the power sector, specifically generators operating thermal plants with installed capacity equal to or larger than 50 megawatts (MW). These generators will be charged $5 per metric ton of CO_2 released. Thermal plants that use biomass and other smaller installations will be exempt from the tax. As part of a broad tax reform, the new tax is intended to move power producers to cleaner sources. Chile's government will start measuring CO_2 emissions from thermal power plants in 2017 and the new tax would be charged from 2018; the Chilean government expects to collect approximately $160 million from the carbon tax. Chile has a voluntary target of cutting GHG emissions 20 percent from 2007 levels by 2020. From *Reuters* on September 26, 2014.

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 U.S. Department of Energy's 2012 United States Carbon Utilization and Storage Atlas (Atlas IV) shows that the United States has at least 2,400 billion metric tons of potential carbon dioxide storage resource in saline formations, oil and gas reservoirs, and unmineable coal. Data from Atlas IV is available via the National Carbon Sequestration Database and Geographic Information System (NATCARB), which is a geographic information system-based tool developed to provide a view of carbon capture and storage potential.

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:

NETL RSS Feed

NETL on Facebook

NETL on Twitter

NETL on LinkedIn

NETL on YouTube

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.

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880

13131 Dairy Ashford Road, Suite 225
Sugar Land, TX 77478

420 L Street, Suite 305
Anchorage, AK 99501

1450 Queen Avenue SW
Albany, OR 97321-2198

Contacts

Traci Rodosta
304-285-1345
traci.rodosta@netl.doe.gov

Disclaimer