CSN CARBON STORAGE NEWSLETTER

JUNE 2017

This newsletter is compiled by the National Energy Technology Laboratory to provide information on recent activities and publications related to carbon storage. It covers domestic, international, public sector, and private sector news in the following areas:

CARBON STORAGE PROGRAM DOCUMENTS and REFERENCE MATERIALS

NATIONAL ENERGY TECHNOLOGY LABORATORY

DOE/NETL HIGHLIGHTS

Successful Demonstration of NETL-Supported Project.

A National Energy Technology Laboratory (NETL)-supported project successfully concluded a six-month testing campaign at the Technology Centre Mongstad (TCM) in western Norway, a facility for testing and improving carbon dioxide (CO_2) capture. The testing involved ION Engineering's novel carbon capture system, which achieved all research objectives and represents progress toward commercialization. The system successfully captured more than 90 percent of CO_2 from the flue gas during steady-state testing, with CO_2 product purity greater than 99 percent. Approximately 14,000 metric tons of CO_2 were captured during testing. The U.S. Department of Energy (DOE) and the Royal Norwegian Ministry of Petroleum and Energy have a bilateral Memorandum of Understanding (MOU) covering fossil energy-related research to leverage each country's investments in carbon capture, utilization, and storage (CCUS). From *energy.gov* on June 7, 2017.

NETL employees with hosts at Technology Centre Mongstad (February 2017).

FY 2018 Budget Includes $479.8 for Fossil Energy Programs.

DOE and the Office of Fossil Energy's (FE) FY 2018 Congressional Budget Request was released, in which $479.8 million was requested for FE. Included in the request is $280 million for Fossil Energy Research and Development (FER&D) and $199.8 million for the Office of Petroleum Reserves. More information regarding the budget request is available in *DOE's budget fact sheet and budget in brief.* From *energy.gov* on May 23, 2017.

ANNOUNCEMENTS

Successful Completion of Carbon Capture Project Celebrated.

The DOE-funded Petra Nova Carbon Capture project located at the W.A. Parish power plant in Thompsons, Texas, USA, opened after being completed on-schedule and on-budget. Performance testing of the project, which is a joint venture between NRG Energy and JX Nippon Oil and Gas Exploration Corporation, demonstrated a CO_2 capture rate of more than 90 percent. The CO_2 captured from the project will be used for enhanced oil recovery (EOR).

Petra Nova Groundbreaking in 2014.

RGGI Releases Reports.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the "*Annual Report on the Market for RGGI CO_2 Allowances*." Prepared by independent market monitor Potomac Economics, the report evaluates 2016 activity in the RGGI CO_2 allowance market. In addition, RGGI also released the "*Report on the Secondary Market for RGGI CO_2 Allowances: First Quarter 2017*," which addresses the period from January through March 2017 and contains information on the secondary market for RGGI CO_2 allowances, such as future prices, market activity, and allowance holdings.

New Carbon Economy Effort Launched.

The Center for Carbon Removal launched an industrial innovation initiative to develop solutions that transform waste atmospheric CO_2 into products and services. The launch is in partnership with Arizona State University, as well as Iowa State University and Purdue University; Lawrence Livermore National Laboratory (LLNL) also participated in the launch event.

New CCS Campaign Implemented.

The Global CCS Institute is implementing a new campaign to raise awareness of the role carbon capture and storage (CCS) technology has in meeting international targets. The campaign involves releasing a suite of "memes" – virally transmitted cultural symbols or social ideas – that communicate facts about CCS, such as its chemical process, safety, and low cost.

CCS Webinar Series.

The Carbon Sequestration Leadership Forum (CSLF), with support from the Global CCS Institute, is conducting a series of webinars showcasing academics and researchers working in the CCS field. The first webinar, held in April 2017, focused on CCUS in the United Arab Emirates (UAE).

PROJECT and BUSINESS DEVELOPMENTS

Newly Launched Commercial Plant to Capture Atmospheric CO_2.

Climeworks has launched a commercial plant that captures atmospheric CO_2 for supply and sale to customers. The Swiss direct air capture (DAC) company launched the plant, which features technology that filters CO_2 from ambient air. Currently, the plant supplies 900 metric tons of CO_2 a year to a nearby greenhouse. In the coming months, Climeworks will look to launch additional commercial pilot projects to test its technology's potential to be combined with CO_2 storage. From *Climeworks Press Release* on May 31, 2017.

North Dakota Ethanol Plant May Store CO_2 Underground.

An ethanol plant in North Dakota, USA, may store CO_2 underground after recent state government approval allowed ethanol plants to capture and store CO_2. Red Trail Energy is located near the center of the Broom Creek Formation, which is conducive to storing CO_2. According to the Energy and Environmental Research Center (EERC), the geologic formation has the potential to store from 10 billion to 40 billion tons of captured CO_2. The plant is capable of producing approximately 4 million tons of CO_2 over a 20-year span, and approximately 20 million tons of CO_2 over a 100-year span. There is a window for public comment before the primacy to oversee the capture and storage of CO_2 will be passed from the federal government to North Dakota. From *Grand Forks Herald* on June 2, 2017.

CO_2 Capture and Reuse Project Launched.

Officials from CO_2 Solutions Inc. and the Québec government officially launched the Valorisation Carbone Québec project (VCQ), the objective of which is to promote the development and demonstration of commercially viable solutions to capture and reuse CO_2 in applications. CO_2 Solutions announced the formation of the VCQ Scientific Committee, which is made up of scientists from university and private sectors to assess the merits of the CO_2 reuse technologies being considered by VCQ. In addition, the following steps have been taken in the deployment of the program: the 10-ton-per-day capture unit will be moved from its Valleyfield location to the new VCQ testing center located at the Parachem facilities in Montreal and a technology to convert CO_2 into acetic acid has been selected to become part of the VCQ project. From *CO_2 Solutions Press Release* on May 18, 2017.

United Kingdom (UK) and Australian Researchers Sign MOU to Reduce CO_2 Emissions.

The UK Carbon Capture and Storage Research Center (UKCCSRC) and CO2CRC Limited signed an MOU continuing their CCS collaboration. Signed at the CSLF meeting in Abu Dhabi, the five-year MOU formalizes the two organizations' commitment to share knowledge, collaborate on research, bring research communities together through joint events, and provide researcher exchange opportunities. The new MOU between CO2CRC and UKCCSRC, which recently secured funding to continue its work through 2022, will build upon the achievements under the previous MOU that expired in March 2017. From *UKCCS Research Center News* on May 1, 2017.

LEGISLATION and POLICY

Executive Action Signed to Reduce Carbon Emissions in Virginia.

The Governor of Virginia signed an executive directive instructing the Department of Environmental Quality to begin the process of establishing regulations that will reduce carbon emissions from power plants. *Executive Directive 11* follows Executive Order 57, which required the Secretary of Natural Resources to convene a work group to study and recommend methods to reduce carbon emissions and build the state's clean energy economy. In addition, Executive Directive 11 includes a structure that enforces carbon-reduction mechanisms. From *Governor Terry McAuliffe News Release* on May 16, 2017.

Commonwealth Legislation to Support CCS Financing.

The Australian government's Commonwealth Minister for the Environment and Energy *announced* that the Clean Energy Finance Corporation (CEFC) will now be allowed to support investment in CCS technologies. The CEFC Act had previously considered CCS ineligible for investment. The CEFC is a fund established to facilitate increased flows of finance into Australia-based renewable energy, energy efficiency, and low-emissions technologies. From *CO2CRC Media Release* on May 30, 2017.

EMISSIONS TRADING

Results of RGGI's CO_2 Auction.

The RGGI-participating states announced the results of their 36th auction of CO_2 allowances, in which 14,597,470 CO_2 allowances were sold at a clearing price of $2.53. None of the 10 million cost containment reserve (CCR) allowances made available were sold; the CCR is a fixed additional supply of allowances only made available if the CO_2 allowance prices exceed certain price levels. The second of 2017, the auction generated $36.9 million for reinvestment in strategic programs, such as energy efficiency, renewable energy, and greenhouse gas (GHG) abatement programs. To date, cumulative proceeds from all RGGI CO_2 allowance auctions exceed $2.7 billion. From *RGGI News Release* on June 9, 2017.

CLIMATE and SCIENCE NEWS

Emerging Technologies Addressing Cost and Performance of CCS.

In a recent study, researchers from Kyoto University's Institute for Integrated Cell-Material Sciences, London's Imperial College, and City University of Hong Kong used a method to develop new materials for capturing and storing CO_2. The research focused on developing highly engineered thin polymer super filters called Mixed Matrix Membranes (MMMs). The study, titled "*Enhanced selectivity in mixed matrix membranes for CO_2 capture through efficient dispersion of amine-functionalized MOF nanoparticles*," was published in the online journal Nature. From *ScienceDaily* on June 5, 2017.

Arctic Ocean Research Expedition Studies Ocean Absorption of CO_2.

According to a study conducted by the *U.S. Geological Survey (USGS) Gas Hydrates Project*, the ocean waters near the surface of the Arctic Ocean absorbed 2,000 times more atmospheric CO_2 than the amount of methane that was released into the atmosphere from the same waters. During the study, U.S., Norwegian, and German scientists measured the concentrations of methane and CO_2 in near-surface waters and in the air just above the ocean surface near Norway's Svalbard Islands, above several seafloor methane seeps. The results showed that significant amounts of CO_2 were being absorbed by the waters near the ocean surface, and that the resulting cooling effect was up to 230 times greater than the potential warming effect expected from the methane emitted. From *USGS News Release* on May 8, 2017.

JOURNAL ARTICLES

Carbon policy in a high-growth economy: The Case of China.

The following is the Abstract of this article: "There is widespread concern that a stringent international agreement will not be reached because it would imply too high costs for fast growing economies. To test this hypothesis [the authors] develop a general equilibrium model with fully endogenous growth and estimate the policy cost for China. The framework includes disaggregated industrial and energy sectors, endogenous innovation, and sector-specific investments. [The authors] find that the governmental target of a 65 percent carbon intensity reduction until 2030 causes a welfare reduction of 0.5 percent for China, compared to the business-as-usual scenario. Costs of carbon policy for China under an internationally coordinated emission reduction amount to 4 percent of total welfare. [The authors] highlight that lower economic growth, faster energy technology development, and stronger induced innovation reduce welfare losses significantly. Increased urbanization raises the policy costs because urban households consume more energy and energy intensive goods." **Lucas Bretschger and Lin Zhang**, *Resource and Energy Economics*. (Subscription may be required.)

Experimental assessment of well integrity for CO_2 geological storage: A numerical study of the geochemical interactions between a CO_2-brine mixture and a sandstone-cement-steel sample.

The following is the Abstract of this article: "Geologic storage of CO_2 is one option for avoiding CO_2 emissions from a large-scale point source such as a thermal power plant and a gas refinery. The alteration of well materials by CO_2 under reservoir conditions requires characterization because the wells are the main possible leakage pathways for CO_2 from a geological reservoir. This paper presents a numerical modeling of interaction experiments involving a composite well sample formed from steel casing surrounded by Portland cement, itself surrounded by sandstone and CO_2-saturated brine at 10 MPa and 50°C during a period of up to 8 weeks, as reported by Mito et al. (2015). A reactive-transport model was developed to simulate diffusion of the CO_2-saturated brine in the well sample and the resulting successive dissolution/precipitation reactions in the sandstone, cement and steel. The observed changes in mineralogy (which primarily consist of dissolution of portlandite and Ca-rich CSH phases and precipitation of calcite, amorphous silica and zeolite) and the associated evolution in brine composition were reproduced by the model. A buffering role of sandstone on the cement degradation was evidenced, thus avoiding the re-dissolution of calcite usually observed in experiments with direct interaction between cement and CO_2-saturated brine. Interestingly, the model results also noted a possible perturbation in the measured pH and Ca content due to CO_2 outgassing during solution sampling. The Si behavior control linked with the uncertainty in zeolite stability is also discussed." **Joachim Tremosa, Saeko Mito, Pascal Audigane, and Ziqiu Xue**, *Applied Geochemistry*. (Subscription may be required.)

Geomechanical effects of CO_2 storage in depleted gas reservoirs in the Netherlands: Inferences from feasibility studies and comparison with aquifer storage.

The following is the Abstract of this article: "In this paper, the geomechanical impact of large-scale CO_2 storage in depleted Dutch gas fields is compared with the impact of CO_2 storage in saline aquifers. The geomechanical behavior of four potential CO_2 storage sites is examined using flow and geomechanical simulations. Many gas reservoirs in the Netherlands are found in fault blocks, one to a few kilometers wide, laterally bounded by sealing faults. Aquifer depletion or re-pressurization in the lateral direction is seldom an issue because of a lack of active aquifers. Reservoir pressure changes are therefore limited to a gas-bearing fault block, while the induced stress changes affect the gas reservoir and extend 1–3 km away into the surrounding rock. Arguments in favor of CO_2 storage in depleted gas fields are: proven seal quality, availability of field data, no record of seal integrity failure by fault reactivation from the seismically active producing Dutch gas fields, and the potential benefits of restoring the virgin formation pressure and stress state to geomechanical stability. On the other hand, CO_2 injection in saline aquifers causes pressure build-up that exceeds the virgin hydrostatic pressure. Stress perturbations resulting from pressure build-up affect large areas, extending tens of kilometers away from the injection wells. Induced stresses in top seals are, however, small and do not exceed a few tenths of megapascal for a pressure build-up of a few megapascals in the storage formation. Geomechanical effects on top seals are weak, but could be enhanced close to the injection zone by the thermal effects of injection. Uncertainties related to characterization of large areas affected by pressure build-up are significant, and seal quality and continuity are more difficult to be demonstrated for aquifers than for depleted gas reservoirs that have held hydrocarbons for millions of years." **Bogdan Orlic**, *Journal of Rock Mechanics and Geotechnical Engineering*. (Subscription may be required.)

Quantifying the value of CCS for the future electricity system.

The following is the Abstract of this article: "Many studies have quantified the cost of CCS power plants, but relatively few discuss or appreciate the unique value this technology provides to the electricity system. CCS is routinely identified as a key factor in least-cost transitions to a low-carbon electricity system in 2050, one with significant value by providing dispatchable and low-carbon electricity. This paper investigates production, demand and stability characteristics of the current and future electricity system. [The authors] analyze the Carbon Intensity (CI) of electricity systems composed of unabated thermal (coal and gas), abated (CCS), and wind power plants for different levels of wind availability with a view to quantifying the value to the system of different generation mixes. As a thought experiment [the authors] consider the supply side of a UK-sized electricity system and compare the effect of combining wind and CCS capacity with unabated thermal power plants. The resulting capacity mix, system cost and CI are used to highlight the importance of differentiating between intermittent and firm low-carbon power generators. [The authors] observe that, in the absence of energy storage or demand side management, the deployment of intermittent renewable capacity cannot significantly displace unabated thermal power, and consequently can achieve only moderate reductions in overall CI. A system deploying sufficient wind capacity to meet peak demand can reduce CI from 0.78 t_{CO2}/MWh, a level according to unabated fossil power generation, to 0.38 t_{CO2}/MWh. The deployment of CCS power plants displaces unabated thermal plants, and whilst it is more costly than unabated thermal plus wind, this system can achieve an overall CI of 0.1 t_{CO2}/MWh. The need to evaluate CCS using a systemic perspective in order to appreciate its unique value is a core conclusion of this study." **Clara F. Heuberger, Iain Staffell, Nilay Shah, and Niall Mac Dowell**, *Energy & Environmental Science*. (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

Carbon capture and storage: Lessons from a storage potential and localization analysis.

The following is from the Abstract of this article: "[The challenges involve totally rethinking the world's energy system. In particular, CCS technologies are still presented as a solution to reach ambitious targets.] However, avoiding the required Gt of CO_2 emissions by investing in CCS technologies supposes the development of carbon storage capacities. This analysis, conducted with TIAM-FR and based on a wide review of geological storage potential and various data, aims to discuss the impact of this potential on the development of the CCS option. [The authors] also specify a scenario allowing the exclusion of onshore storage due to a hypothetic policy considering public resistance to onshore storage, and carbon transport costs variation effects. The implementation of CCS is less impacted by the level of carbon storage potential - except in the lowest case of availability - than by the type of sequestration site. However, the development of CCS is lower at the end of the period in the case of a decrease in carbon storage potential. Indeed, the question of type of storage site appears to have a greater impact, with an arbitrage between deep saline aquifers and depleted basins and enhanced recovery. Doubling the cost of carbon transport does not limit the penetration of carbon capture technologies, but it does impact the choice of site. Finally, a limitation of onshore storage could have a significant impact on the penetration of the CCS option. The explanation for this limited deployment of CCS is thus the higher cost of offshore storage more than the level of storage potential." **Sandrine Selosse and Olivia Ricci**, *Applied Energy*. (Subscription may be required.)

Review of CO_2 price in Europe using feed-in tariff rates.

The following is the Abstract of this article: "The price of carbon emitted by thermal plants has always been a favorite topic of researchers and policy makers. A substitute price for CO_2 is calculated in this study based on real-time payments through government tariffs. These payments aim to mitigate CO_2 emission caused by unregulated electricity generation. The total CO_2 produced by the thermal plants of 10 European countries is shown in this study. The government's payment for each technology is utilized to clear the final CO_2 abatement cost. The substitute price of avoiding CO_2 emission (SPAC) for each technology and country is estimated. SPAC is basically the price that each country pays to avoid producing CO_2. The conducted survey shows that the SPAC of the 10 European countries ranges from 63 to 2951 Euros depending on the type of technology used and the country's policy. Results confirm a competitive payment by governments only for German and UK hydro and UK wind technologies. Comparison of the countries' payments for renewable energies and CO_2 market price shows that governments incurred an inefficient payment of liquidity as a carbon mitigation policy." **B. Bakhtyar, A. Fudholi, Kabir Hassan, M. Azam, C.H. Lim, N.W. Chan, and K. Sopian**, *Renewable and Sustainable Energy Reviews*. (Subscription may be required.)

Trade-off between carbon reduction benefits and ecological costs of biomass-based power plants with carbon capture and storage (CCS) in China.

The following is the Abstract of this article: "Integrating [CCS] into biomass power plants (BioCCS) can reduce carbon emissions, but its ecological performance associated with natural resources consumption remains unexamined. Taking a typical BioCCS project – the Maowusu biomass direct-fired power plant with the CCS of Spirulina cultivation in Inner Mongolia of China – as a case, this study observed the trade-offs between the carbon reduction benefits and ecological performance of adding CCS to the power plant. Life cycle assessment (LCA) revealed that the combination of CCS avoids 1228 metric tons of CO_2 emissions annually, while energy analysis revealed that it deteriorated the ecological performance of the BioCCS system because considerable nonrenewable resources were required by Spirulina cultivation. The BioCCS system is unsustainable in the long run from the ecological point of view. The sensitivity analyses show that there would be no carbon reduction benefits by adding CCS when 60% of designed CO_2 capacity is fixed by Spirulina, and insufficient biomass for electricity generation also affects system performance significantly, which are two main barriers to the BioCCS project. These results indicate that decision-makers should take into account both the carbon reduction benefits and the ecological costs in the development of BioCCS systems." **Mingyue Pang, Lixiao Zhang, Sai Liang, Gengyuan Liu, Changbo Wang, Yan Hao, Yafei Wang, and Ming Xu**, *Journal of Cleaner Production*. (Subscription may be required.)

Impacts of the coming emission trading scheme on China's coal-to-materials industry in 2020.

The following is the Abstract of this article: "China will establish a national emission trading scheme (ETS) in 2017, and the excessive development of coal-to-materials may hinder China's emission reduction goals, specifically to reduce carbon emissions intensity by 40–45% from 2005 to 2020. In this study, the status of China's coal-to-materials projects is presented, based on which [the authors] forecasted the high, middle and low CO_2 emission scenarios for the coal-to-materials industry in 2020, which were determined to be approximately 580, 290, and 180 Mt CO_2, respectively. The high scenario is approximately equivalent to the total emission from Canada, the world's 11th-largest emitter in 2014. The main purpose of this study is to research the impacts of ETS on the coal-to-materials industry in 2020. Oil-to-materials is an ineluctable and powerful competitor to the coal-to-materials industry, complicating this matter. Therefore, the Cournot model was applied to quantitatively analyze the competition between these two monopolistic entities and determine the influence of oil, coal and carbon prices on CO_2 emissions from coal-to-materials. The visual simulation of the results shows that ETS can improve the competitiveness of oil-to-materials, resulting in a decline in production of coal-to-materials. However, the effect of the carbon cost with historical price range of Chinese ETS pilots on mitigating CO_2 emissions from the coal-to-materials industry is limited. High oil prices and low coal prices can increase the emissions from coal-to-materials significantly. [The authors'] study also provides a tool to analyze the feasibility of ETSs for a set emission reduction goal. Additionally, the necessary sensitivity analysis was also provided." **Guangyoa Li, Jin Yang, Dingjiang Chen, and Shanying Hu**, *Applied Energy*. (Subscription may be required.)

REPORTS and OTHER PUBLICATIONS

Development of a General Form CO_2 and Brine Flux Input Model.

The following is the Abstract of this National Risk Assessment Partnership (NRAP) document: "The NRAP project is developing a science-based toolset for the quantitative analysis of the potential risks associated with changes in groundwater chemistry from CO_2 injection. In order to address uncertainty probabilistically, NRAP is developing efficient, reduced-order models (ROMs) as part of its approach. These ROMs are built from detailed, physics-based process models to provide confidence in the predictions over a range of conditions. The ROMs are designed to reproduce accurately the predictions from the computationally intensive process models at a fraction of the computational time, thereby allowing the utilization of Monte Carlo methods to probe variability in key parameters. This report presents the procedures used to develop a generalized model for CO_2 and brine leakage fluxes based on the output of a numerical wellbore simulation. The resulting generalized parameters and ranges reported here will be used for the development of third-generation groundwater ROMs."

Characterizing Construction of Existing Wells to a CO_2 Storage Target: The Kimberlina Site, California.

The following is from the Executive Summary of this NRAP document: "Early versions of the NRAP integrated risk model treated plugged wells as a continuous cemented interval of homogeneous porous media from the storage formation to an underground source of drinking water (USDW) and the atmosphere. This assumption of homogeneity is simplistic, but was necessary for the purpose of calculating CO_2 and brine movement via these features without a better statistical understanding of well characteristics. Future generations of the integrated risk model will move toward incorporating more detail, such as heterogeneity of the geological formation along the well path, and construction heterogeneity of the wells themselves. This study identified approximately 100 wells penetrating the Vedder Formation storage reservoir within the simulated 6 bar (0.6 MPa) or greater pressure increase associated with a hypothetical Kimberlina industrial-scale CO_2 injection and storage operation. This study collected cemented interval information for these wells from scanned well records maintained by the State of California, and developed a statistical representation of cement seal and plug extents and depths from those data."

Commercial Scale Feasibility of Clean Hydrogen.

The following is from the Executive Summary of this European Zero Emission Technology and Innovation Platform document: "It is widely recognized that hydrogen has the potential to decarbonize a number of different industries and play a key role in the energy transition. Decarbonized hydrogen can be produced through the application of CCS on established natural gas to hydrogen production units ('clean'/'low GHG emissions' hydrogen), or electrolysis using renewable energy sources. This report addresses the role of clean hydrogen and provides recommendations for its promotion. Clean hydrogen currently has lower production costs than that of electrolysis-derived hydrogen from renewable energy (3-4 €/kg ex-works at 30-40 bar) and could be a key accelerator of the hydrogen economy. This report shows that, depending on location specifics, clean hydrogen production is currently achievable at the same cost as that projected for the renewables route for around 10 to 25 years. Furthermore, hydrogen production equipped with CCS in industrial clusters - where several large users for hydrogen can co-exist - could also trigger the initiation of a CO_2 transport and storage network. There are multiple country roadmaps and studies that discuss the ability of hydrogen to decarbonize different industries...The technologies required to produce clean hydrogen from natural gas are available, with multiple projects already capturing CO_2 from the hydrogen production process. Today the limiting factors are the availability of CO_2 transport and storage infrastructure, demand for hydrogen as a clean fuel, and the requirement for substantial hydrogen infrastructure and adaptations at points of use."

Enabling Efficient Networks for Low Carbon Futures: Options for Governance & Regulation.

The following is from Chapter 1 of this report: "This report summarizes key themes emerging from the Energy Technologies Institute's (ETI) project 'Enabling efficient networks for low carbon futures'. The project aimed to explore the options for reforming the governance and regulatory arrangements to enable major changes to, and investment in, the UK's energy network infrastructures. ETI commissioned four expert perspectives on the challenges and options facing the UK. The ETI decided to initiate this new thinking because its scenarios for a low carbon UK energy transition highlight major challenges for energy network infrastructures and how investment decisions are governed, incentivized and regulated. The ETI scenarios were developed from a 'whole system' perspective, and point to the high value of enabling a broader mix of energy vectors (heat, power and gaseous fuels), within a more integrated 'system' of energy transmission, storage and distribution."

ABOUT DOE'S CARBON STORAGE PROGRAM

The **Carbon Storage Program** advances the development and validation of technologies that enable safe, cost-effective, permanent geologic storage of CO_2. The Carbon Storage Program also supports the development of best practices for CCS that will benefit projects implementing CCS at a commercial scale, such as those being performed under NETL's Clean Coal Power Initiative and Industrial Carbon Capture and Storage Programs. The technologies being developed and the small- and large-scale injection projects conducted through this program will be used to benefit the existing and future fleet of fossil fuel power-generating facilities by developing tools to increase our understanding of the behavior of CO_2 in the subsurface and identifying the geologic reservoirs appropriate for CO_2 storage.

The *Carbon Storage Program Overview* webpage provides detailed information of the program's structure, as well as links to the webpages that summarize the program's key elements.

Carbon Storage Program Resources

The *National Energy Technology Laboratory's CCS Database* includes active, proposed, and terminated CCS projects worldwide. The information is taken from publically available sources to provide convenient access to information regarding efforts by various industries, public groups, and governments towards development and eventual deployment of CCS technology. NETL's CCS Database is available as a Microsoft Excel spreadsheet and also as a customizable layer in Google Earth.

Newsletters, program fact sheets, best practices manuals, roadmaps, educational resources, presentations, and more are available via the *Carbon Storage Program Publications webpage*.

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

ABOUT NETL'S CARBON STORAGE NEWSLETTER

Compiled by the National Energy Technology Laboratory, this newsletter is a monthly summary of public and private sector carbon storage news from around the world. The article titles are links to the full text for those who would like to read more.

National Energy Technology Laboratory

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