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

CSN CARBON STORAGE NEWSLETTER

OCTOBER 2016

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

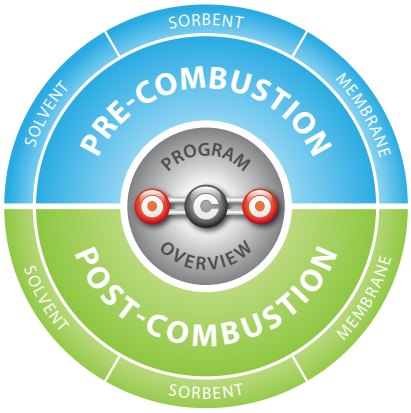
CARBON STORAGE PROGRAM DOCUMENTS and REFERENCE MATERIALS

NATIONAL ENERGY TECHNOLOGY LABORATORY

DOE/NETL HIGHLIGHTS

"DOE-Funded Carbon Capture Technology Moves Forward to Large-Scale Testing."

A *second-generation carbon dioxide (CO_2) solvent technology project* funded by the U.S. Department of Energy (DOE) will begin testing at the *Technology Centre Mongstad (TCM)* in western Norway, DOE announced. DOE has a bilateral Memorandum of Understanding (MOU) with the Royal Norwegian Ministry of Petroleum and Energy that covers fossil energy-related research to leverage each countries' investments in carbon capture, utilization, and storage (CCUS). The ION Engineering project is the first project from *DOE's Carbon Capture Program* to be located at an international host site. From *energy.gov* on October 12, 2016.



Carbon Capture Research and Development Program

"DOE Invests $6 Million to Accelerate Next-Generation Advanced Energy Systems."

DOE selected two projects to advance key technologies that enable development of next-generation advanced energy systems. The two projects, which will receive Phase II research funding from DOE with an approximate three-year performance period, were selected from five DOE-funded Phase I projects. Next-generation advanced energy systems include advanced combustion, chemical looping, gasification, turbines, fuel cells, gas cleaning and separation technologies, and CO_2 separation technologies. Research and development (R&D) in these areas is supported by the Office of Fossil Energy's (FE) *Crosscutting Research Program*, which aims to advance early stage R&D for innovative FE solutions to improve availability, efficiency, and environmental performance of advanced energy systems integrated with carbon capture and storage (CCS). From *energy.gov* on October 5, 2016.

Crosscutting Technology Research Program

ANNOUNCEMENTS

Work Underway to Improve CO_2 Storage Capacity Estimates.

The Energy and Environmental Research Center (EERC) and Hitachi High Technologies America, Inc., are working to improve assessment methods for estimating the storage capacity of CO_2 in tight shale formations. Under the National Energy Technology Laboratory (NETL)-funded project, EERC researchers will develop advanced analytical techniques to better understand and quantify the distribution of clay minerals, organics, pore networks, and fractures in representative shale and tight rock samples.

NRAP National Risk Assessment Partnership

NRAP Featured in Journal.

Carbon storage research conducted under DOE's *National Risk Assessment Partnership (NRAP)* was highlighted in a special August 2016 issue of the *International Journal of Greenhouse Gas Control*, which is comprised of a compendium of research generated by the NRAP team over six years of collaboration. Release of the special issue coincides with the completion of NRAP's first phase of research, which resulted in the generation of first-of-kind scientific data, methodologies, and simulation tools to support quantitative assessment of environmental risks associated with industrial-scale geologic CO_2 storage.

ANNOUNCEMENTS *(cont.)*

Website Launched to Track Potential Climate Change.

In partnership with several organizations, the White House launched a new website aiming to use real-time climate data from National Aeronautics and Space Administration (NASA) satellites to gather climate projections and figures. In addition to gathering data from NASA, the website, called *PrepData*, will also process data from the U.S. Department of Interior (DOI) and other sources. All of the website's functions are expected to be available within the next year.

RGGI Auction 34 Notice.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) released the Auction Notice and application materials for their 34th quarterly CO_2 allowance auction, scheduled for December 7, 2016. The states will offer 14,791,315 CO_2 allowances for sale at a reserve price of $2.10; in addition, a 10 million CO_2 allowance cost containment reserve (CCR) will be available, which will be accessed if the interim clearing price exceeds the CCR trigger price of $8.00.

PROJECT and BUSINESS DEVELOPMENTS

"Quest Carbon Capture and Storage Project Reaches Significant One-Year Milestone."

Shell Canada's Quest CCS project successfully captured and stored 1 million metric tons of CO_2 after one year of operation, the company announced. In collaboration with the Alberta and Canadian governments, the intellectual property and data generated (including the detailed engineering plans) have been made publically available to reduce future CCS implementation costs and spur interest across the industry. One of the lessons learned was the achievement of cost savings through joint transportation and storage facilities. From *Shell Canada News Release* on September 14, 2016.

"[Canadian Government Invests in Carbon Reduction Research]."

The Canadian government announced funding for the University of Calgary to research the reduction of CO_2 emissions during unconventional oil and gas operations. The funding will be used to develop more efficient ways of extracting oil and gas, as well as to potentially improve the efficiency of carbon capture and conversion and eliminate the release of CO_2 by developing new means of extracting energy from carbon fuels. The research will be conducted in partnership with researchers from Mexico, China, and Israel. From *CBC News* on September 6, 2016.

"[CO2CRC Limited Opens New CCS Laboratories]."

CO2CRC Limited announced the opening of new CCS laboratories, funded through the Australian Government's Education Investment Fund (EIF), as part of the Australian CCS Research Laboratories Network (CCSNet). One of the laboratories, *located at Federation University Australia's Gippsland campus*, will conduct research on various CCS technologies with the aim of reducing the cost of implementation. CO2CRC *also collaborated with The University of Melbourne* on emissions reduction laboratories that aim to provide clean, efficient, and cost-effective energy for Australia. From CO2CRC *Media Releases* on September 20 and September 28, 2016.

LEGISLATION and POLICY

"U.S., China Ratify Paris Climate Agreement."

The United States and China formally ratified the Paris agreement to reduce greenhouse gas (GHG) emissions. In the agreement reached in Paris, France, in December 2015, nearly 200 countries agreed to a binding global compact to reduce GHGs and keep global temperature increases below 2 degrees Celsius. While 180 countries signed the agreement, 55 need to ratify the treaty to put it into legal effect. From *Reuters* on September 3, 2016.

"[California Governor Signs Carbon Legislation.]"

The Governor of California signed legislation to reduce carbon emissions and establish restrictions on "super pollutants," such as black carbon. The Governor of California will *direct $900 million in cap-and-trade funds to GHG reduction programs* that benefit disadvantaged communities (AB 2722). In addition, the Governor of California signed *SB 1383*, establishing restrictions on "super pollutants" with the aim of reducing the projected rate of potential climate change by 2050. For more information, view a video of the *SB 1383 bill signing*, or read the Governor's signing messages for *AB 2722* and *SB 1383*. From *Governor Edmund G. Brown, Jr., Press Releases* on September 14 and September 19, 2016.

"[State of Washington Adopts Climate Change Rule]."

The State of Washington's Department of Ecology adopted a clean air rule that caps and reduces carbon emissions. Under the rule, businesses responsible for emitting 100,000 metric tons of CO_2 per year will be required to cap and gradually reduce their emissions. Businesses unable to reduce their emissions have the option of developing projects, such as an energy efficiency program, or buying carbon credits from approved carbon markets. The new plan relies on businesses trading independently among themselves and with other markets. More information on the Clean Air Rule is available on the *Washington Department of Ecology's website*. From *Washington Department of Ecology News Release* on September 15, 2016.

"Oslo Sets Out Climate Budget to Halve Carbon Emissions in Four Years."

Oslo, Norway, issued a new climate budget that aims to reduce its carbon emissions within the next four years. In addition, the city is researching clean energy technologies such as CCS; in early 2016, Aker Solutions conducted a CO_2-capture experiment at Oslo's main waste incineration plant. Oslo's target is to reduce CO_2 emissions from 1.2 million metric tons in 1990 to 600,000 metric tons annually by 2020. From *Business Green* on September 29, 2016.

EMISSIONS TRADING

"Canada to Impose Carbon Taxes Nationwide."

Canada's Environmental Minister announced that the federal government is planning to impose taxes on CO_2 emissions across provinces that do not enact them. Provinces will have the first opportunity to determine how to reduce their GHG emissions and establish their own prices on carbon through taxes or cap-and-trade programs. Four provinces (British Columbia, Alberta, Ontario, and Québec) currently have either carbon taxes or cap-and-trade systems, leaving six provinces that would either implement a regulation or be subject to the federal system. From *The Hill* on September 19, 2016.

"RGGI Report: Investments Generate Savings, Reduce [Emissions]."

The nine RGGI-participating states released a report tracking the cumulative investment of proceeds generated by RGGI's regional CO_2 allowance auctions through 2014. According to the report, titled "*The Investment of RGGI Proceeds through 2014*," $1.37 billion in RGGI proceeds have been invested in programs such as energy efficiency, clean and renewable energy, and GHG abatement. The report also estimates the investments are projected to save approximately 76.1 million MMBtu of fossil fuels and 20.6 MWh of electricity, avoiding the release of 15.4 million tons of carbon emissions. From *RGGI News Release* on September 26, 2016.

CLIMATE and SCIENCE NEWS

"Asphalt-Based Carbon-Capture Material Advances."

Researchers from Rice University have developed a method to turn asphalt into a porous material that can store 154 percent of its weight in CO_2 at high pressures that are common at gas wellheads. Initial field test conducted in 2015 found that pressure at the wellhead made it possible for a Rice-developed asphalt material, capable of being used in place of amines to remove CO_2 from natural gas, made it possible to adsorb 114 percent of its weight in CO_2 at ambient pressures. The new form of the material, detailed in a study titled "*Ultra-High Surface Area Activated Porous Asphalt for CO_2 Capture through Competitive Adsorption at High Pressures*" and published in the online journal *Advanced Energy Materials*, is less expensive and therefore more practical for industry. From *Rice University News Release* on September 12, 2016.

"Scientists Uncover Surprising Source of Carbon Storage…"

A team of researchers from Asia, Africa, and Europe conducted a study that quantifies the role trees on agricultural land play in storing CO_2. Published in the online journal *Scientific Reports*, the study used estimates of global farmland tree cover derived from remote sensing observations and calculated the amount of CO_2 captured and stored by trees growing on farmland. The researchers found that when CO_2 stored by the trees was included, the total carbon storage for agricultural land measured more than four times higher than current Intergovernmental Panel on Climate Change (IPCC) default values. The study, titled "*Global Tree Cover and Biomass Carbon on Agricultural Land: The contribution of agroforestry to global and national carbon budgets*," found that as the world's forest resources decline, tree cover on agricultural land is expanding. From *Ensia.com* on September 19, 2016.

"Soil will absorb less atmospheric carbon than expected this century, study finds."

Scientists from the University of California, Irvine, found that the ground might absorb less atmospheric CO_2 this century than previously thought. By adding highly accurate radiocarbon dating of soil to standard Earth system models, using carbon-14 data from 157 sample sites, researchers determined that current soil carbon is approximately 3,100 years old (previous models hypothesized soil carbon to be 450 years old). Through photosynthesis, plants absorb CO_2 from the air; when they die and decay, they become part of the soil and "lock in" carbon on or beneath the surface. Since this process takes place over millennia as opposed to decades or centuries, the researchers expect less of this type of geologic carbon storage in the 21st century than previous Earth system models had suggested. From *ScienceDaily* on September 22, 2016.

Des Lacs wildlife refuge in Kenmare, North Dakota

JOURNAL ARTICLES

"Translating risk assessment to contingency planning for CO_2 geologic storage: A methodological framework."

The following is the Abstract of this article: "In order to ensure safe and effective long-term geologic storage of CO_2, existing regulations require both assessing [release] risks and responding to [release] incidents through corrective measures. However, until now, these two pieces of risk management have been usually addressed separately. This study proposes a methodological framework that bridges risk assessment to corrective measures through clear and collaborative contingency planning. [The authors] achieve this goal in three consecutive steps. First, a probabilistic risk assessment (PRA) approach is adopted to characterize potential [release] features, events and processes (FEP) in a Bayesian events tree (BET), resulting in a risk assessment matrix (RAM). The RAM depicts a mutually exclusive and collectively exhaustive set of [release] scenarios with quantified likelihood, impact, and tolerance levels. Second, the risk assessment matrix is translated to a contingency planning matrix (CPM) that incorporates a tiered-contingency system for risk-preparedness and incident-response. The [release] likelihood and impact dimensions of RAM are translated to resource proximity and variety dimensions in CPM, respectively. To ensure both rapid and thorough contingency planning, more likely or frequent risks require more proximate resources while more impactful risks require more various resources. In addition, the minimum and maximum risk tolerance levels are translated to contingency thresholds, and all tolerable risk scenarios are categorized under three contingency tiers: Tier 1, Tier 2, and Tier 3. [The authors] highlight how the upper, lower, and inter-tier contingency boundaries should be collaboratively pre-negotiated between the operating party and multiple relevant stakeholders to ensure effective preparedness and response. Finally, [the authors] present a model contingency plan to demonstrate how all newly introduced concepts integrate together. Specifically, [the authors] focus on explaining how the designed contingency tiers facilitate important aspects of contingency planning, primarily: evaluating [release] and initiating response; designing a corrective measures matrix (CMM) that assigns specific control and remediation measures to each [release] scenario; mobilizing, deploying, and sustaining necessary human and equipment resources; and formulating a decision-making hierarchy, a notification protocol, and a communication scheme to effectively administer the CO_2 storage site." **Karim Farhat and Sally M. Benson**, *International Journal of Greenhouse Gas Control.* (Subscription may be required.)

"Efficiency of magnesium hydroxide as engineering seal in the geological [storage] of CO_2."

The following is the Abstract of this article: "Injection of CO_2 at depth will cause the acidification of groundwater. As a preliminary study for the potential use of MgO as an alternative to Portland cement in injection wells, MgO carbonation has been studied by means of stirred batch experiments under subcritic (pCO_2 of 10 and 50 bar and T of 25, 70 and 90°C) and supercritic (pCO_2 of 74 bar and T of 70 and 90°C) CO_2 conditions. Magnesium oxide reacts with CO_2-containing and Ca-rich water nearly equilibrated with respect to calcite. MgO quickly hydrates to brucite ($Mg(OH)_2$) which dissolves causing the precipitation of magnesium carbonate phases. Precipitation of these secondary phases (magnesite and/or metastable phases such as nesquehonite ($MgCO_3 \cdot 3H_2O$) or hydromagnesite ($Mg_5(CO_3)_4(OH)_2 \cdot 4(H_2O)$) depends on pCO_2, temperature and solid/water content. In a constant solid/water ratio, the precipitation of the non-hydrated Mg carbonate is favored by increasing temperature and pCO_2. The experimental variation of Mg and Ca concentrations and pH over time at the different temperatures and pCO_2 has been simulated using the CrunchFlow reactive transport code. Simulations reproduce the experimental evolution of the aqueous concentrations and indicate a decrease in porosity when increasing temperature and pCO_2. This decrease in porosity would be beneficial for the sealing properties of the cement. These results have been used in the simulation of an application case with a deep borehole surrounded by MgO cement at 90°C." **Gabriela Dávila, Jordi Cama, Salvador Galí, Linda Luquot, and Josep M. Soler**, *International Journal of Greenhouse Gas Control.* (Subscription may be required.)

"The Lower Jurassic Johansen Formation, northern North Sea – Depositional model and reservoir characterization for CO_2 storage."

The following is the Abstract of this article: "The Lower Jurassic, Johansen Formation sandstone, located in the Northern North Sea, has been proposed as a reservoir candidate for CO_2 storage by Norwegian authorities. The objective of this study is to evaluate the reservoir quality of the Johansen Formation, as function of depositional history and architecture. [The authors] propose a depositional model comprising an early phase delta progradation, with clinothems building into deep waters, associated with delta front and pro-delta turbidites sourced from river mouths or/and upper delta front collapse. During a subsequent, aggradational stage, thick spit bar deposits developed in the southern, down-current part, sheltering a brackish lagoon, before rapid transgression caused back-stepping and preservation of sandy deposits encased in mud. Considering the depositional model presented, the inferred high porosity spit bar deposits would provide a suitable injection site and reservoir for CO_2. Climatic controlling factors, rather than structural, are interpreted to have exerted the major force on the asymmetric sand distributions observed in the Johansen Formation, an architectural style which is repeated in later Jurassic successions on the Horda Platform. On a local scale, accommodation was created by differential compaction above rotated, Permian fault blocks, in addition to regional, post-thermal subsidence and rising sea-level." **Anja Sundal, Johan Petter Nystuen, Kari-Lise Rørvik, Henning Dypvik, and Per Aagaard**, *Marine and Petroleum Geology.* (Subscription may be required.)

"In-situ CO_2 generation huff-n-puff for enhanced oil recovery: Laboratory experiments and numerical simulations."

The following is the Abstract of this article: "The major objective of this paper was to evaluate the validity of in-situ CO_2 generation technique as an enhanced oil recovery method in sandstone reservoirs. In this study, the endothermic decomposition of ammonium bicarbonate solution was used to generate CO_2. The theoretical prediction model of generated CO_2 volume under reservoir conditions was deduced from the reaction kinetics. It was verified by the experimental data from gas-forming reaction test. The results indicated that the prediction based on the established theoretical model was well matched to experimental results at the tested NH_4HCO_3 concentrations of 10, 15, 20 wt%. The oil displacement efficiency of in-situ CO_2 generation huff-n-puff (ISCGHP) were further examined through both sandpack test and reservoir simulation. The gas-forming agent was composed of ammonium bicarbonate, surfactants and polymers. The displacement performance of ISCGHP was examined through the sandpack huff-n-puff test. Effects of the main injection parameters were analyzed, including concentration, slug size, injection mode and chasing water. The sandpack huff-n-puff test indicated that a higher concentration of NH_4HCO_3 and a larger slug size of reagent contributed to an improved oil displacement efficiency. Gradually increasing the slug size reached the remaining oil left in the previous cycle, and simultaneously enlarged swept volume in the following cycle. In the numerical study, the reservoir model of ISCGHP was established using data from interfacial tension test, PVT test and reaction kinetics. It was then calibrated based on sandpack test results and past production observations of the candidate-well. Results showed ISCGHP effectively improved single-well productivity with a growth rate of 56 [percent] in oil production, the effective sweep radius reached about 50 m away from the wellbore along with a slight fall of formation temperature and a maximal 22.8 [percent] of oil viscosity reduction." **Yong Wang, Jirui Hou, and Yong Tang**, *Journal of Petroleum Science and Engineering.* (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

"The impact of emission trading scheme and the ration of free quota: A dynamic recursive CGE model in China."

The following is the Abstract of this article: "To cope with global warming, China has promulgated Enhanced actions on climate change: China's intended nationally determined contributions and will start the national carbon emissions trading market in 2017. Carbon emissions are distributed by the form of free quota and paid quota. However, few literatures have focused on how the economy and the environment would be changed by the change of free quota ratio. This paper establishes the 10 scenarios of different free quota ratio of carbon emissions rights and uses a dynamic, recursive computable general equilibrium (CGE) model to simulate the carbon emissions trading market, to explore the relationship between free quota ratio and carbon trading price, and the impact of carbon trading scheme (ETS) on China's economy and environment. The results show that free quota ratio will not have a direct impact on gross domestic product (GDP) and other economic and environment indicators but carbon trading prices. The prices and the rate of free payment in the current pilot cities in China are still relatively conservative. It is possible to reach emission peak, 8.21 billion ton, in 2025 and accumulative CO_2 reduction from 2017 to 2030 is 20.02 billion tons, or 59.60 [percent] of 2010 world's total CO_2 emission. Cement, minerals, electricity and nonferrous metals under ETS will suffer great losses, so subsidy should be considered. Finally, [the authors] suggested that China should reduce the total carbon rights to increase the carbon price in 2017, and gradually reducing the proportion of free quota, from 90 [percent] in 2017 to 50 [percent] or less in 2030, by which the peak year of CO_2 emission can meet in 2025. [The authors] also suggest that ETS is an effective strategy for CO_2 reduction and the ratio should be gradually reduced in ETS to prevent violent fluctuation of carbon price in China." **Wei Li and Zhijie Jia**, *Applied Energy*. (Subscription may be required.)

"Geomechanical effects of CO_2 storage in depleted gas reservoirs in the Netherlands: inferences from feasibility studies and comparison with [formation] 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 [formations]. 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. [Formation] depletion or re-pressurization in the lateral direction is seldom an issue because of a lack of active [formations]. 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 [formations] 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 [formations] 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.)

REPORTS and PUBLICATIONS

"A Clean Energy Action Plan for the United States."

The following is from the Introduction and Summary of this Center for American Progress document: "This report proposes policy recommendations that promote the three elements of decarbonization—energy efficiency, low-carbon electricity generation, and the electrification of end uses—and that address their integration, financing, and implementation at the federal level. It examines specific policy actions that a new administration and Congress can take in the short term to expedite deployment of renewable energy and energy efficiency technologies. This is just one part of an overall climate mitigation strategy U.S. leaders will need to employ to meet the nation's long-term carbon pollution reduction targets."

"3D Mapping and correlation of Intraformational seals within the Latrobe Group in the nearshore Gippsland Basin."

The following is from the Introduction of this Global CCS Institute document: "In this study [the authors] approach the issue of intraformational seals in the Gippsland Basin from a variety of perspectives: these include the observations of actual trapped hydrocarbons with some gas columns in excess of 100m, measurements of seal capacity (MICP) from core samples, observations of pressure and salinity differences across key intraformational aquitards (seal units), and full 3D seismic geobody mapping and attribute extraction of seal-related lithologies. [The authors] use these observations to interpret the geometry of active seal units and their depositional context within the basin. [The authors] will show that a series of backstepping coal sequences are associated with intraformational petroleum traps and aquitards across at least 50 km of basin dip extent, and 20 million years of geologic time. The basal shales and seat earths underlying the freshwater facies of these coals will be shown to have distinctive properties that lead to effective sealing characteristics. This study is based on depositional geometries and facies interpreted from the extensive open-file 3D seismic data that has been collected in the basin by the Esso-BHP Joint Venture and other operators. Individual and composite coal beds are mapped and fluvial cut-outs are identified. As a result, a detailed 3D basin model is developed which maps fluvial and swamp facies to predict reservoirs and seals at Intra-Latrobe levels, and the lateral connections of these facies to coeval paralic barrier bar systems further to the east at top Latrobe Group. A revised well and seismic correlation of the Traralgon T2 Member in the nearshore Gippsland Basin is presented, and the implications of this correlation discussed."

"Effective enforcement of underground storage of carbon dioxide."

The following is from the Executive Summary of this Global CCS Institute document: "The perception of an effective enforcement regime that ensures the secure and safe storage of CO_2 in underground geologic formations will be crucial in increasing public and industry confidence in CCS as a viable low-carbon technology. An effective enforcement regime for underground storage of CO_2 has the following key features: [1] comprehensive obligations that address the key risks of underground storage of CO_2; [2] comprehensive monitoring and verification (M&V) requirements, including baseline monitoring, M&V obligations during the injection phase and M&V obligations post-injection; [3] enforcement mechanisms that are risk-based, layered and flexible, grounded in science and fact-based decision-making, and include the ability to deal with 'serious situations' (such as unintended releases and CO_2 not behaving as predicted); and [4] a clear allocation of roles and responsibilities for enforcement."

"Global Carbon Capture & [Storage] Market Insights, Opportunity Analysis, Market Shares and Forecast, 2016 – 2022."

The following is a description of this document: "The [CCS] market globally is estimated to be $4.25 Billion in year 2016, and is likely to grow with a [compound annual growth rate (CAGR)] of 13.9 [percent] from year 2016 to 2022, to grow $8.15 Billion by the end of year 2022. [These capturing] technologies separates CO_2 from other gases produced via industrial processes and electricity generation mainly by three different ways, pre-combustion, post-combustion and last oxy-fuel combustion. Millions of tons of CO_2 are being transported for commercial uses every year this can be fulfilled by this capturing process. Transportation stages includes transfer by ship, pipelines and road tanker for commercial purpose majorly for oil recovery projects. The CO_2 which is stored in cautiously targeted geological rocks that are located several [kilometers] below the earth surface. Growth in exploration activities, research, and investment is expected to drive the growth. The [CCS] market is likely to witness significant growth in the coming years owing to growing investment in emission reduction technologies. The carbon capturing and packing technology is still in its stages of development and globally, and later with the increasing awareness, growth in the market is expected."

ABOUT DOE'S CARBON STORAGE PROGRAM

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

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

Carbon Storage Program Resources

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

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

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

ABOUT NETL'S CARBON STORAGE NEWSLETTER

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

National Energy Technology Laboratory

The *National Energy Technology Laboratory (NETL)*, part of DOE's national laboratory system, is owned and operated by the U.S. Department of Energy (DOE). NETL supports DOE's mission to advance the national, economic, and energy security of the United States.

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