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CARBON STORAGE NEWSLETTER

APRIL 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:

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DOE/NETL HIGHLIGHTS

DOE Announces Milestone for Industrial CCS Project.

The U.S. Department of Energy (DOE) announced that the Illinois Industrial Carbon Capture and Storage (I-CCS) project has begun operation by injecting carbon dioxide (CO₂) into a saline reservoir. Based in Decatur, Illinois, USA, and led by the Archer Daniels Midland Company (ADM), the DOE-funded, large-scale demonstration project is demonstrating an integrated system for collecting CO₂ from an ethanol production plant and storing the CO₂ in an underground reservoir. The CO₂ will be stored in the Mt. Simon Sandstone in the Illinois Basin, and the project can store approximately 1 million tons of CO₂ per year at depths of approximately 7,000 feet; however, researchers estimate the sandstone formation has the potential to store more than 250 million tons of produced CO₂ each year. From *energy.gov* on April 7, 2017.

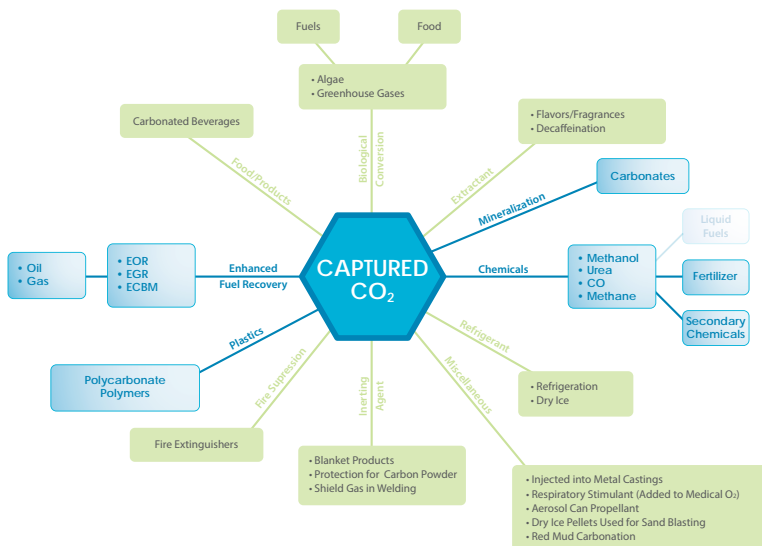


Inter-Stage Piping in Compressor Facility (Courtesy of Archer Daniels Midland Company)

ANNOUNCEMENTS

DOE Invests in Projects to Advance CO₂ Utilization Strategies.

DOE's Office of Fossil Energy (FE) selected seven projects to receive funding to focus on novel ways to use CO₂ captured from coal-fired power plants. The selected research projects, which support the National Energy Technology Laboratory's (NETL) *Carbon Storage Program's Carbon Use and Reuse* research and development (R&D) portfolio, fall under three technical areas of interest: (1) biological-based concepts for beneficial use of CO₂, (2) mineralization concepts utilizing CO₂ with industrial wastes, and (3) novel physical and chemical processes for beneficial use of CO₂. The portfolio will develop and test novel approaches that convert the captured CO₂ to useable products, as well as explore ways to use the captured CO₂ in areas where high-volume uses may not be optimal, such as enhanced oil recovery (EOR).



This figure illustrates opportunities for carbon use and reuse with NETL-supported research highlighted in blue.

ANNOUNCEMENTS *(cont.)*

11th IEAGHG Monitoring Network Meeting.

The International Energy Agency Greenhouse Gas R&D Program (IEAGHG) will be hosting their 11th Monitoring Network Meeting in Traverse City, Michigan, USA, on June 13-15, 2017. The theme of the meeting will be “The Cost and Value-Effectiveness of Monitoring: what key drivers are required to deliver an optimum outcome?”; a sub-theme will be the leveraging of oil and gas industry experience for CO₂ storage. The full agenda of the meeting can be found on the [IEAGHG website](#).

Carbon Storage Webinar.

The Global CCS Institute, with Australian National Low Emissions Coal Research and Development (ANLEC R&D), conducted a webinar focused on managing carbon storage and natural resources in sedimentary basins. The webinar, the eighth of a series being held by Global CCS Institute and ANLEC R&D, presented a framework for the management of basin resources.

PROJECT and BUSINESS DEVELOPMENTS

CCUS Project Approved in China.

A carbon capture utilization and storage (CCUS) facility has been given final investment approval to begin construction at Xi-an (Shaanxi Province) in China. Yanchang Petroleum CCUS's gasification facility will capture 50,000 metric tons of CO₂ per year from Yanchang's chemical plants. When fully operational in 2018, the facility is expected to capture more than 360,000 metric tons of CO₂ per year. From [Global CCS Institute](#) on March 14, 2017.

Development of CCS Project in Norway.

Norway's EFTA Surveillance Authority (ESA) approved public financing of studies for full-scale carbon capture and storage (CCS) demonstration projects. The Norwegian government presented its CCS strategy in 2014, the goal of which was to realize at least one full-scale CCS demonstration project by 2020. Depending on the results of concept and front-end engineering design (FEED) studies, authorities will decide whether to proceed with a full-scale project. From [EFTA Surveillance Authority Press Release](#) on March 16, 2017.

Carnegie Mellon University Launches Carbon Emissions Index.

Carnegie Mellon University (CMU), along with Mitsubishi Hitachi Power Systems (MHPS), launched an index that measures CO₂ emissions from the U.S. electrical power generation sector. The Carnegie Mellon Power Sector Carbon Index will track the performance of U.S. power producers, comparing current emissions to historical data collected nationwide for more than two decades. CMU will provide an online resource for a wide variety of power sector emissions data and forecasts. From [Phys.org](#) on March 20, 2017.

Partnerships Formed for CO₂ Capture and Reuse.

Two separate agreements have been reached that involve CO₂ capture and reuse on a large-scale level. As part of an agreement between CO₂ Solutions Inc. and global engineering firm Hatch Ltd. to deliver carbon capture systems, both companies will also collaborate on the Valorisation Carbone Québec (VCQ) project, which aims to demonstrate CO₂ capture and beneficial reuse on a large-scale level in an industrial facility. In addition, Carbon Clean Solutions Limited (CCSL) and the resource management company Veolia [have formed a partnership](#) to reduce the greenhouse effect of industrial processes and rollout large-scale CO₂ capture and industrial re-use. From [Gasworld](#) on March 28 and March 29, 2017.

LEGISLATION and POLICY

Bill Would Create Commission in Alaska.

A bill ([House Bill 173](#)) was introduced in Alaska legislature that would establish a 15-member commission to apply for grants, monitor climate, promote green technologies, and look for ways to reduce greenhouse gas (GHG) emissions. From [Alaska Dispatch News](#) on March 12, 2017.

Bill Introduced to Help Finance CCS Projects.

U.S. Senators introduced a bill to help power plants and industrial facilities finance the purchase and installation of CCS equipment. The bill, “The Carbon Capture Improvement Act of 2017,” would allow businesses to use government-issued private activity bonds (PABs) to finance their projects. More specifically, the legislation would look to improve the economic feasibility of CCS projects and increase oil production through EOR. From [U.S. Senator Michael Bennet Press Release](#) on April 5, 2017.

Initiative Launched to Reduce Emissions.

Comeos, the Belgian trade federation, teamed up with ENGIE, a multinational electric utility company, on an initiative to reduce CO₂ emissions in the Belgian retail sector. The initiative will look to reduce CO₂ emissions through the promotion of solar energy and energy-efficient solutions. The collaboration follows an undertaking by businesses in the region to reduce CO₂ emissions by 30 percent by 2025, and to double current renewable energy production by 2020. From [European Supermarket Magazine](#) on March 20, 2017.

Oregon Lawmakers Introduce Carbon Pricing Legislation.

Lawmakers in the Oregon Senate and House introduced legislation to create a statewide cap-and-trade program. The “[Healthy Climate Act of 2017](#)” will aim to repeal 2007 emissions goals, establishing new goals in which emissions would be reduced 20 percent below 1990 levels by 2025. In addition, the new proposal would impose a statewide limit of 45 percent below 1990 levels by 2035 and 75 percent below 1990 levels by 2050. From [Lexology](#) on March 29, 2017.

EMISSIONS TRADING

Results of RGGI's CO₂ Auction.

The states participating in the Regional Greenhouse Gas Initiative (RGGI) announced the results of their 35th auction of CO₂ allowances, in which 14,371,300 CO₂ allowances were sold at a clearing price of \$3.00. 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 CO₂ allowance prices exceed certain price levels. The first auction of 2017, the auction generated \$43.1 million for reinvestment in strategic programs, such as energy efficiency, renewable energy, and GHG abatement programs. To date, cumulative proceeds from all RGGI CO₂ allowance auctions exceed \$2.68 billion. From *RGGI News Release* on March 10, 2017.

Ontario Announces Results of First Cap-and-Trade Auction.

The Ontario Ministry of the Environment and Climate Change announced the results of the province's first auction of GHG allowances, in which 25,296,367 current allowances and 812,000 future allowances were sold. The proceeds generated from the cap-and-trade program auction will be invested in programs that will help reduce GHG emissions. The auction was administered using services contracted by the Western Climate Initiative (WCI); to ensure market integrity, an independent market monitor was also utilized. A *summary report of the results* of the auction has been made available. From *Ontario Ministry of the Environment and Climate Change News Release* on April 3, 2017.

CLIMATE and SCIENCE NEWS

Chemists Create Usable Material from CO₂.

An international team of scientists achieved a milestone in the search to recycle CO₂ in the Earth's atmosphere into carbon-neutral fuels and other materials. Led by Indiana University, the scientists engineered a molecule that uses light or electricity to convert CO₂ into carbon monoxide (a carbon-neutral fuel source). The study, titled "*Well-Defined Nanographene-Rhenium Complex as an Efficient Electrocatalyst and Photocatalyst for Selective CO₂ Reduction*," appears in the *Journal of the American Chemical Society*. From *Indiana University Bloomington Newsroom* on March 8, 2017.

Scientists Refine Filters for CO₂ Capture.

Scientists from Rice University created a material that may help improve the ability to draw methane from a well while storing CO₂. Natural gas producers use filters that optimize either carbon capture or methane flow. While no single filter will do both, adjustments in the manufacturing of a polymer-based carbon sorbent make it a candidate material for either capturing the CO₂ or

balancing carbon capture with methane selectivity. The material created by Rice University scientists can be tuned to balance CO₂ storage and methane selectivity. For more information, refer to the study, which was published in the *Royal Society of Chemistry journal Sustainable Energy and Fuels*. From *Carbon Capture Journal* on April 2, 2017.

Antarctic Ice Reveals Earth's Accelerating Plant Growth.

According to a recent study conducted by scientists from the University of California, Merced, plants have been growing at a rate faster in the past century than any time in the past 54,000 years and are converting 31 percent more CO₂ into organic matter than before the Industrial Revolution. The results of the study, which were published in the online journal *Nature*, were gathered by analyzing the icy wastes of Antarctica. Scientists found that the increase in atmospheric CO₂ fertilizes the plants; the CO₂ in the extra plant growth amounts to 28 billion tons per year. From *The New York Times* on April 5, 2017.

JOURNAL ARTICLES

How to enhance the future use of energy policy simulation models through ex post validation.

The following is the Abstract of this article: "Although simulation and modeling in general and system dynamics models in particular has long served the energy policy domain, ex post validation of these energy policy models is rarely addressed. In fact, ex post validation is a valuable area of research because it offers modelers a chance to enhance the future use of their simulation models by validating them against the field data. This paper contributes by presenting (i) a system dynamics simulation model, which was developed and used to do a three dimensional, socio-economical and environmental long-term assessment of Pakistan's energy policy in 1999, (ii) a systematic analysis of the 15-years old predictive scenarios produced by a system dynamics simulation model through ex post validation. How did the model predictions compare with the actual data? [The authors] report that the ongoing crisis of the electricity sector of Pakistan is unfolding, as the model-based scenarios had projected." **Hassan Qudrat-Ullah**, *Energy*. (Subscription may be required.)

Impact of electrical inertia capacity on carbon policy effectiveness.

The following is the Abstract of this article: "This study investigates the potential cost and emissions reductions that result from an increase in electricity transmission capacity between Canada's two westernmost provinces: Alberta, a fossil fuel dominated jurisdiction, and British Columbia, a predominantly hydroelectric jurisdiction. A bottom-up model is used to find the least cost electricity generation mix in Alberta and British Columbia under different carbon policies. The long-term evolution of the electricity system is determined by minimizing net present cost of electricity generation for the time span of 2010–2060. Different levels of inertia capacity expansion are considered together with a variety of carbon tax and carbon cap scenarios. Results indicate that increased inertia capacity reduces the cost of electricity and emissions under carbon pricing policies. However, the expandable inertia does not encourage greater adoption of variable renewable generation. Instead, it is used to move low-cost energy from the United States to Alberta. The optimal inertia capacity and cost reduction of increased interconnectivity increases with more restrictive carbon policies." **J. English, T. Niet, B. Lyseng, K. Palmer-Wilson, V. Keller, I. Moazzen, L. Pitt, P. Wild, and A. Rowe**, *Energy Policy*. (Subscription may be required.)

JOURNAL ARTICLES (cont.)

Study on the ratio of pore-pressure/stress changes during fluid injection and its implications for CO₂ geologic storage.

The following is the Abstract of this article: "The success of fluid injection into geological formations, which is the main operation during both CO₂ geologic storage and wastewater injection, is contingent on the geomechanical integrity of the site. A key task that allows us to evaluate the risk of geomechanical failure is the precise prediction of pore-pressure buildup and subsequent change in the state of stresses during and after the fluid injection. Contrary to traditional approaches, where total stresses are assumed to remain constant, recent studies have ascertained that total stresses in fact change in every direction as fluid extraction/injection disturbs the pore-pressure field and causes deformations. In this study, [the authors] conduct an in-depth investigation of the ratio of change in total stress to that in pore-pressure, $\Delta\sigma/\Delta P$, which has been denoted in the literature as the pore-pressure/stress coupling. [The authors] employ a numerical simulation method that couples single-phase fluid flow in porous media with poroelasticity to explore the spatiotemporal evolution of the $\Delta\sigma/\Delta P$ ratio for various conditions. These numerical experiments allow [the authors] to examine how different material properties and structural geometries would influence the evolution of $\Delta\sigma/\Delta P$ in both vertical and horizontal directions. These ratios of pore-pressure/stress changes exhibit different spatiotemporal evolutions depending on key factors that include the hydraulic boundary condition, Biot's coefficient, Poisson's ratio, and the hydraulic diffusivity of both the injection zone and caprock. On the basis of observations, [the authors] suggest firsthand guidelines for analytically determining the ratio of pore-pressure/stress changes, $\Delta\sigma/\Delta P$. Finally, [the authors] use examples and case studies to illustrate how the $\Delta\sigma/\Delta P$ ratio can be incorporated into an analytic calculation for determining a maximum sustainable pressure limit."

Sunghee Kim and Seyyed Abolfazl Hosseini, *Journal of Petroleum Science and Engineering*. (Subscription may be required.)

Thermal effects on geologic carbon storage.

The following is the Abstract of this article: "One of the most promising ways to significantly reduce [GHG] emissions, while carbon-free energy sources are developed, is CCS. Non-isothermal effects play a major role in all stages of CCS. In this paper, [the authors] review the literature on thermal effects related to CCS, which is receiving an increasing interest as a result of the awareness that the comprehension of non-isothermal processes is crucial for a successful deployment of CCS projects. [The authors] start by reviewing CO₂ transport, which connects the regions where CO₂ is captured with suitable geostorage sites. The optimal conditions for CO₂ transport, both onshore (through pipelines) and offshore (through pipelines or ships), are such that CO₂ stays in liquid state. To minimize costs, CO₂ should ideally be injected at the wellhead in similar pressure and temperature conditions as it is delivered by transport. To optimize the injection conditions, coupled wellbore and reservoir simulators that solve the strongly non-linear problem of CO₂ pressure, temperature and density within the wellbore and non-isothermal two-phase flow within the storage formation have been developed. [Carbon dioxide] in its way down the injection well heats up due to compression and friction at a lower rate than the geothermal gradient, and thus, reaches the storage formation at a lower temperature than that of the rock. Inside the storage formation, CO₂ injection induces temperature changes due to the advection of the cool injected CO₂, the Joule-Thomson cooling effect, endothermic water vaporization and exothermic CO₂ dissolution. These thermal effects lead to thermo-hydro-mechanical-chemical coupled processes with non-trivial interpretations. These coupled processes also play a relevant role in 'Utilization' options that may provide an added value to the injected CO₂, such as EOR, Enhanced Coal Bed Methane (ECBM) and geothermal energy extraction combined with CO₂ storage. If the injected CO₂ leaks through faults, the caprock or wellbores, strong cooling will occur due to the expansion of CO₂ as pressure decreases with depth. Finally, [the authors] conclude by identifying research gaps and challenges of thermal effects related to CCS." **Victor Vilarrasa and Jonny Rutqvist**, *Earth-Science Reviews*. (Subscription may be required.)

Effect of Char Preparation Conditions on Gasification in a Carbon Dioxide Atmosphere.

The following is the Abstract of this article: "Pyrolysis conditions have a substantial impact on the properties of the resulting char and, consequently, on the kinetics of the gasification process. The aim of this study was to determine the impact of coal pyrolysis on the gasification stage. By applying the thermogravimetric method, kinetic analyses of CO₂ gasification of chars derived from Polish 'Janina' coal were conducted. Gasification examinations were performed for chars prepared earlier in an argon atmosphere at various heating rates, which, after cooling, were subjected to CO₂ gasification (indirect char gasification). Examinations were also carried out in the case of chars formed during heating of coal samples in a CO₂ atmosphere (direct char gasification). Samples of chars were gasified in non-isothermal conditions of up to 1100°C under 0.1 MPa pressure at various heating rates. The char gasification reaction order with CO₂ was determined with the use of the Coats–Redfern method, and it can be assumed that it is a first-order reaction. The activation energy and pre-exponential factor were calculated using two first-order models: Coats–Redfern method and Senum–Yang method. The results were subsequently compared to kinetic parameters calculated on the basis of the model-free isoconversional method combined with the model-dependent Coats–Redfern method. Despite the differences in values of kinetic parameters obtained from the use of a given model, all results confirmed that the method of char preparation has an influence on the gasification stage and direct char gasification is more favorable. Activation energy obtained from the use of models based on the first-order reaction ranged between 275 and 296 kJ/mol for direct gasification of chars, while the chars gasified indirectly between 307 and 342 kJ/mol, depending upon the heating rate that was used. The model-free isoconversional method confirmed these results. The values for chars gasified directly amounted to $E_a = 257\text{--}277$ kJ/mol, and the values for indirect char gasification obtained by the pyrolysis process at heating rates of 3, 10, and 20 K/min amounted to $E_a = 280\text{--}291$, 287–309, and 289–305 kJ/mol, respectively." **Grzegorz Czerski, Katarzyna Zubek Przemyslaw Grzywacz, and Stanislaw Porada**, *Energy Fuels*. (Subscription may be required.)

Influence of wettability and permeability heterogeneity on miscible CO₂ flooding efficiency.

The following is the Abstract of this article: "[Carbon dioxide] flooding is a proven EOR technique and is also considered as a potential method for CO₂ sequestration. Despite having successful field trials on CO₂ EOR, the effects of reservoir wettability and permeability heterogeneity on the efficiency of miscible CO₂ flooding are not well understood. In this work, laboratory investigations have been carried out to evaluate the influence of these properties on the miscible CO₂ EOR performance. The wettability of hydrophilic Berea core samples was altered to be oil-wet by vacuum saturation of the clean and dry core samples with n-hexadecane. The permeability heterogeneity was obtained by combining two half pieces of axially split water-wet core samples of different permeabilities. Core flooding experiments were conducted for n-hexadecane – synthetic brine – CO₂ systems at 1400 psig backpressure to achieve minimum miscibility pressure (MMP) of CO₂ in n-hexadecane at the test temperature (24 ± 1 °C). It was found that wettability strongly influences CO₂ EOR. For the alternate cases of previously brine flooded (to remaining oil saturation) oil-wet and water-wet core samples, five pore volumes (PVs) of CO₂ recovered 100% and only 43% of remaining oil in place (ROIP) respectively. Three PVs of CO₂ could recover only about 0–5% ROIP from the split core samples. The mechanisms underlying these results are discussed. This study sheds light on the significant influence of reservoir wettability and permeability heterogeneity on the performance of miscible CO₂ EOR." **Prem Bikkina, Jiamin Wan, Yongman Kim, Timothy J. Kneafsey, and Tetsu K. Tokunaga**, *Fuel*. (Subscription may be required.)

JOURNAL ARTICLES *(cont.)*

CO₂ Emission Trading Effect on Baltic Electricity Market.

The following is the Abstract of this article: "This paper investigates the CO₂ cost pass-through to electricity prices of the Baltic market, as well as CO₂ prices effect on merit order of generation sources and consequently marginal changes of CO₂ emissions in response to changes in electricity demand. Authors use multiple regression analysis to demonstrate that a 1 EUR change in the price of CO₂ emissions would increase the price of the Nordic power market by 0.55 EUR and in the Baltic countries by 0.67 EUR. Additionally, it has been shown that CO₂ prices significantly impact merit order of electricity generators and consequently marginal emissions of CO₂ due to reduction of electricity consumption in case of energy efficiency measures. Based on analysis, it can be concluded that, in the low price scenario (7.5 EUR per ton of CO₂), combined heat and power plants are marginal generators emitting 0.25 tons of CO₂ per 1MWh in cogeneration mode. If CO₂ prices are above 20 EUR, the marginal emitter will become oil shale power plants that emit around 1 ton of CO₂ per 1 MWh of electricity." **Uldis Bariss, Elvijs Avenitis, Gatis Junghans, and Dagnija Blumberga**, *Energy Procedia*. (Subscription may be required.)

Chinese companies' awareness and perceptions of the Emissions Trading Scheme (ETS): Evidence from a national survey in China.

The following is the Abstract of this article: "China announced the launch of a national Emissions Trading Scheme (ETS) in 2017; however, companies appear show little enthusiasm for participation in the ETS in China. This paper identifies the factors affecting companies' awareness and perceptions of ETS by conducting a national survey based on an online questionnaire from May to November 2015 in seven carbon trading pilots. The results indicate that companies' attitudes towards the ETS are positively influenced by government regulations and policy, public relations management and estimated economic benefit. Of these, public relations management is the decisive factor and estimated economic benefit is confirmed to be a relatively weak predictor. A company's environmental and energy strategy exerts insignificant effects on its preference for the ETS, although the sampled companies are very willing to save energy and reduce emissions. There exists an inverted U-shape relationship between a company's level of mitigation technologies and its attitudes towards the ETS. The carbon price fails to stimulate companies to upgrade mitigation technologies. The majority of companies treat participation in the ETS only as a means of improving ties with governments, as well as of earning a good social reputation, rather than as a cost-effective mechanism to mitigate [GHG] emissions." **Lin Yang, Fengyu Li, and Xian Zhang**, *Energy Policy*. (Subscription may be required.)

Coupled effect of CO₂ attack and tensile stress on well cement under CO₂ storage conditions.

The following is the Abstract of this article: "In CCS wells, the well cement is attacked by CO₂-rich fluids, coupled with tensile stress. In this study, well cement samples were designed to be exposed to humid CO₂ gas and CO₂ saturated brine and simultaneously subjected to external tensile stresses with load levels of 25%, 50%, and 75% of the initial tensile strength. The experimental results showed that a higher external tensile stress (50% and 75%) facilitated the generation and propagation of micro-cracks in the tension zone of loaded samples. Hence, the aggressive CO₂-rich medium found direct paths to penetrate further into the core, significantly accelerating the rate of carbonation and failure of the well cement. As a result of the faster ion exchange and transfer, the carbonation rate was faster and the onset of failure in samples immersed in CO₂-saturated brine occurred earlier than in the supercritical CO₂ scenario. Findings from this study provide new, important information for understanding the integrity of well cement sheath under actual CCS well conditions, thereby promoting superior cement system design and safer operation." **Tao Gu, Xiaoyang Guo, Zaoyuan Li, Xiaowei Cheng, Xiaoxia Fan, Asghar Korayem, Wen Hui Duan**, *Construction and Building Materials*. (Subscription may be required.)

REPORTS and OTHER PUBLICATIONS

Feasibility study for full-scale CCS in Norway.

The following is the Introduction of this Norwegian Ministry of Petroleum and Energy document: “In the Sundvolden Political platform, the Government states that it will ‘invest on a broad front to develop cost-effective technology for CCS and seek to build at least one full-scale carbon capture demonstration plant by 2020.’ The Government’s CCS strategy was presented in Proposition 1 S to the Storting (2014-2015). The strategy covers a wide range of activities, including the assessment of potential full-scale CCS projects in Norway. Gassnova’s pre-feasibility ‘Study report on potential full-scale CCS projects in Norway’ from May 2015 identified several emission sources and storage sites that may be technically feasible for a CCS project. It also identified industrial players that could be interested in participating in further studies. In the autumn of 2015, the Government decided to continue this work and initiated a feasibility study. The Ministry of Petroleum and Energy (MPE) has had overall responsibility for the feasibility study. Gassnova SF has been project coordinator and responsible for the CO₂ capture and storage components of the study, while Gassco AS has been responsible for the CO₂ transport component. Three companies have studied the feasibility of CO₂ capture at their industrial facilities. Norcem AS has assessed the feasibility of capturing CO₂ from the flue gas at its cement factory in Brevik; Yara Norge AS has assessed CO₂ capture from three different emission points at its ammonia plant at Herøya in Porsgrunn; the Waste-to-Energy Agency in Oslo municipality (EGE) has assessed CO₂ capture from the energy recovery plant at Klemetsrud (Klemetsrudanlegget AS). Gassco has carried out a ship transport study with assistance from Larvik Shipping AS and Knutsen OAS Shipping AS. Statoil ASA has assessed the feasibility CO₂ geological storage at three different sites on the Norwegian Continental Shelf. The aim of this feasibility study was to identify at least one technically feasible CCS chain (capture, transport and storage) with corresponding cost estimates and this has been achieved. The results of this study demonstrate that a flexible CCS chain is feasible that makes use of CO₂ transport by ship from multiple sources to a single storage hub. That would mean the initial investment in CO₂ infrastructure can benefit several CO₂ capture projects.”

Energy Security and Prosperity in Australia: A ROADMAP FOR CARBON CAPTURE & STORAGE.

The following is from this document: “As the world makes the necessary and urgent transition to a low carbon future, resource and system diversity will be key to maintaining a resilient, competitive energy economy. Australia’s abundant, cost competitive and high quality coal and gas resources have long underpinned the economic strength and high standard of living achieved in Australia. The challenge that Australia and the world face is to continue to realize the benefits and value of fossil energy resources without the associated emissions. It is therefore imperative that commercial-scale CCS is developed and available. This assures that Australia and its trading partners can maintain energy security and meet future emissions reduction targets at the lowest economic cost. Australia has the capability to provide leadership in CCS, especially CO₂ storage with the Otway and Gorgon projects. These are considered leading examples of CO₂ storage research, development and demonstration (RD&D) and commercial-scale deployment. Urgent investment in CO₂ storage site characterization, CCS projects, techno-economic assessments, and public engagement is required to ensure that CCS can be deployed to achieve the deep reduction in greenhouse gas emissions required to meet national and global targets.”

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 CO₂. 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 CO₂ in the subsurface and identifying the geologic reservoirs appropriate for CO₂ 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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