Carbon Sequestration Newsletter

August 2009

What's Inside?

Introduction

This Newsletter is created by the National Energy Technology Laboratory and represents a summary of carbon sequestration news covering the past month. Readers are referred to the actual article(s) for complete information. It is produced by the National Energy Technology Laboratory to provide information on recent activities and publications related to carbon sequestration. It covers domestic, international, public sector, and private sector news.

Highlights

***Fossil Energy Techline*, "Field Test to Advance Geological Carbon Storage While Enhancing Domestic Oil Supply."**

The Midwest Geological Sequestration Consortium (MGSC) has begun injecting carbon dioxide (CO_2) into a mature oil field in Hopkins County, Kentucky, to assess the region's CO_2 storage capacity and feasibility for enhanced oil recovery (EOR). The test is designed to inject up to 8,000 tons of CO_2 over a period of six to eight months into an existing brine-water injection well at a depth of approximately 1,900 feet; at these depths, the CO_2 will remain in a gaseous state and partially mix with the oil it encounters. The Kentucky Geologic Survey (KGS) will monitor the CO_2 through a program that will track the rate and volume of the injection and the pressures and temperatures within the wall. The results will provide an indication of how efficiently the CO_2 displaces oil within the reservoir and how it stores the CO_2. The project will span more than two years and is expected to create 13 full-time jobs. The test is part of the Regional Carbon Sequestration Partnership (RCSP) Program's Validation Phase, which consists of 22 nationwide field tests conducted in saline formations, depleted oil and gas fields, and unmineable coal seams. To visit the MGSC website, click: http://sequestration.org/. June 25, 2009, http://www.fossil.energy.gov/news/techlines/2009/09041-DOE_Partner_Begins_Carbon_Storage_.html.

***Fossil Energy Techline*, "Secretary Chu Announces Two New Projects to Reduce Emissions from Coal Plants."**

On July 1, 2009, U.S. Department of Energy (DOE) Secretary Steven Chu announced the selection of two projects for up to $408 million in funding from the American Recovery and Reinvestment Act (ARRA). The two projects will incorporate advanced technologies to reduce CO_2 emissions. In one project, DOE will provide the Basin Electric Power Cooperative with $100 million to demonstrate the removal of CO_2 from the flue gas from a lignite-based boiler at an existing power plant in Beulah, North Dakota. In the second project, DOE will provide Hydrogen Energy International LLC with $308 million to design, construct, and operate an Integrated Gasification Combined Cycle (IGCC) power plant in Kern County, California, that will utilize blends of coal and petroleum coke and convert them into hydrogen and CO_2. The goal of both projects is to achieve at least 90 percent CO_2 capture efficiency. The selection of the two projects is part of the third round of the Clean Coal Power Initiative (CCPI), a cost-shared collaboration between the Federal government and private industry to increase investment in low-emission coal technology by demonstrating advanced, coal-based power generation technologies. To view the CCPI Program fact sheet, go to: http://www.fossil.energy.gov/programs/powersystems/cleancoal/ccpi/Prog052.pdf. July 1, 2009, http://www.energy.gov/news2009/7559.htm.

***Fossil Energy Techline*, "New Jersey Joins the Energy Department's Carbon Sequestration Regional Partnership Program."**

New Jersey has become the 43rd state to join DOE's RCSP Program, the centerpiece of U.S. efforts to deploy carbon sequestration technologies and

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Highlights (Continued)

reduce greenhouse gas (GHG) emissions. As a member of the Midwest Regional Carbon Sequestration Partnership (MRCSP) and a participant in the MRCSP Phase II Validation Phase projects, New Jersey will focus on developing and integrating data for the potential geologic and terrestrial sequestration capacity within the state. The New Jersey Department of Environmental Protection and Rutgers University will contribute by building and refining the state's geologic and terrestrial sequestration frameworks. Also, due to the abundance of offshore storage potential in New Jersey, MRCSP will include offshore reservoirs in its potential geologic and terrestrial sequestration capacity database for the first time. To learn more about MRCSP, go to: www.mrcsp.org. For more information about DOE's RCSP Program, visit: http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html. June 24, 2009, http://www.fossil.energy.gov/news/techlines/2009/09040-New_Jersey_Joins_Regional_Partners.html.

Sequestration in the News

***Business First of Louisville*, "Duke Energy Files Plans for Carbon Storage Study,"** and ***Duke Energy News Release*, "Duke Energy Files Plans for Carbon Storage Study in Southwest Indiana."**

Duke Energy Corporation has filed plans with the Indiana Utility Regulatory Commission (IURC) for a proposed CO_2 storage project in southwest Indiana. Duke Energy will invest $121 million to store a portion of the CO_2 emissions from a coal-gasification power plant in Edwardsport, Indiana. The CO_2 will be stored underground in deep saline aquifers and depleted oil and gas fields. If the three-year site characterization is considered a success, Duke Energy will seek permission from IURC to permanently capture and store CO_2. Duke Energy applied for a DOE CCPI Round 3 grant in January, which could offset up to 50 percent of the carbon capture and storage (CCS) costs for the project. July 6, 2009, http://www.bizjournals.com/louisville/stories/2009/07/06/daily7.html, and July 6, 2009, http://www.duke-energy.com/news/releases/2009070603.asp.

***Reuters*, "Alberta to Back Three Carbon Capture Projects,"** and ***The Calgary Herald*, "Alberta Announces Three Winning Projects for Carbon Capture Funding."**

Alberta government officials announced on June 30, 2009, that three CCS projects will be financed using a $1.7 billion fund set aside last year. Alberta expects to provide up to $92.5 million this year for design and engineering work on the three proposals. The three projects, which were selected after a year-long competition, include CCS at Royal Dutch Shell Plc's Scotford oil sands upgrader;

Sequestration in the News (Continued)

a carbon capture facility at a power plant owned by EPCOR and backed by Enbridge, Inc.; and a project that takes CO_2 from an Agrium, Inc. fertilizer plant and a planned upgrader, and ships it by pipeline to oil fields, where it will be used to boost output. The first round of commercial-scale projects is expected to achieve annual CO_2 reductions by 2015. June 30, 2009, http://www.reuters.com/article/internal_ReutersNewsRoom_BehindTheScenes_MOLT/idUSTRE55T78220090630, and July 1, 2009, http://www.calgaryherald.com/Business/Alberta+announces+three+winning+projects+carbon+capture+funding/1747893/story.html.

***International Power Press Release*, "Hazelwood Carbon Capture Project Underway."**

A $10 million CCS pilot project designed to initially capture up to 25 tonnes of CO_2 per day initiated operation in July 2009 at International Power Australia's (IPRA) Hazelwood Plant in the Latrobe Valley in Victoria, Australia. The plant has the potential to eventually capture up to 50 tonnes a day. The CO_2 from the power plant's flue gas is absorbed by a carbon capture technology using a solvent solution; the captured CO_2 is then used to reduce the pH of the power plant's ash water. The CO_2 reacts with the ash water to produce calcium carbonate ($CaCO_3$) – a commercially usable product. Officials said that the Hazelwood project will be assessed for its potential applicability to future large-scale projects. The carbon capture plant received technology support from the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC). July 8, 2009, https://www.ipplc.com.au/_modules/Uploader/_uploaderBin/jbrinkworth/eb82e902c881129d320544a947eb8c14nrInternationalPowermrCCSlaunch080709.pdf.

Announcements

Funding Opportunity Announcement.

The National Energy Technology Laboratory (NETL) issued a Funding Opportunity Announcement (FOA) on June 29, 2009, to provide training opportunities for graduate and undergraduate students that will provide the human capital and skills required for implementing and deploying CCS technologies. The FOA will advance research in: simulation and risk assessment; monitoring, verification, and accounting (MVA); geological related analytical tools; methods to interpret geophysical models; CO_2 capture; and well completion and integrity. The FOA is available at: http://www.fossil.energy.gov/programs/sequestration/publications/arra/DE-FOA-0000032.pdf and applications are due August 11, 2009, at 8:00 p.m. Eastern Time.

WESTCARB Annual Meeting.

The West Coast Regional Carbon Sequestration Partnership (WESTCARB) will hold the WESTCARB 2009 Annual Business Meeting at the FireSky Resort and Spa in Scottsdale, Arizona, on Wednesday, September 16, 2009. Meeting topics include: Phase II geologic and terrestrial field projects, improved characterization of regional CO_2 storage opportunities, progress for the Phase III large-volume geologic storage test, and national and state legislative/regulatory developments. More information is available at: http://www.westcarb.org/AnnualMtg_scottsdale_announcement.html.

BSCSP Annual Meeting.

The Big Sky Carbon Sequestration Partnership (BSCSP) will hold its annual meeting at the Gallatin Gateway Inn in Bozeman, Montana, on September 23-24, 2009. Experts will discuss carbon sequestration technologies; CCS economics, costs, and opportunities; Federal and state regulatory procedures; energy policies; and carbon sequestration site development. Registration is free and open to the public until September 11, 2009; audience members will have an opportunity to ask questions following panel presentations. Registration information is available at: http://www.bigskyco2.org/annual_meeting09.

New Zealand Joins International Carbon Storage Group.

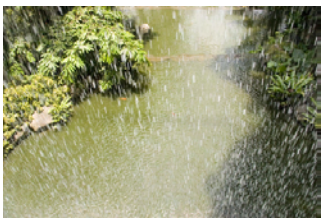
New Zealand became the 23rd member of the Carbon Sequestration Leadership Forum (CSLF) during a meeting in San Francisco, California, on June 29, 2009. To visit the CSLF website, go to: http://www.cslforum.org/. For more information, click: http://www.fossil.energy.gov/news/techlines/2009/09042-New_Zealand_Joins_CSLF.html.

SEG CO_2 Sequestration Geophysics Workshop.

This Society of Exploration Geophysicists- (SEG) hosted workshop, scheduled for August 23-27, 2009, will focus on the geophysical aspects of CCS, such as rock and fluid physics, flow-to-seismic simulations, site characterization, CO_2 plume imaging and monitoring, quantitative CO_2 estimation and inversion, risk assessment, and novel case studies. For detailed information, visit: http://www.seg.org/SEGportalWEBproject/portals/SEG_Online.portal?_nfpb=true&_pageLabel=pg_gen_content&Doc_Url=prod/SEG-Meetings/Mtgs-Upcoming-Mtgs/SRW2009Alberta/index.htm.

Science

***MSNBC.com*, "Study: Tropical Rain Band is Shifting North."**



Authors of a recent study state that the Earth's most prominent rain band, which they believe bordered the equator 350 years ago during the planet's Little Ice Age from approximately 1400 to 1850, has shifted north at an average rate of approximately one mile a year for three centuries due to climate change. The band supplies freshwater to almost 1 billion people and if the northern migration continues, the scientists asserted that some Pacific islands near the equator may no longer receive freshwater by mid-century or sooner. While the scientists noted there is no global water shortage, humans are placing additional pressure on water resources. According to the scientists, the band of tropical rainfall stems from the "intertropical convergence zone," where winds from the northern and southern hemispheres meet and heat enters into the atmosphere from the tropical sun. To arrive at their conclusions, the authors analyzed rainfall records from annual layers of lake and lagoon sediments on four Pacific islands at or near the equator. The researchers found that areas like Washington Island, which sits at the southern edge of the intertropical convergence zone, and the island of Palau, which lies in the heart of the modern convergence zone, receive an ample supply of rainfall. Researchers also found evidence that areas located on the equator in the Eastern Pacific like the Galapagos Islands possessed a wet climate during the Little Ice Age and currently have an arid climate. The study, titled, "Southward movement of the Pacific intertropical convergence zone AD 1400-1850," is available at: http://www.nature.com/ngeo/journal/v2/n7/abs/ngeo554.html. July 2, 2009, http://www.msnbc.msn.com/id/31709811/ns/us_news-environment/.

***Science Daily*, "Climate Change May Spell Demise of Key Salt Marsh Constituent."**

New research shows that a component of salt marshes known as pannes could be affected by climate change. Pannes, which are waterlogged, low-oxygen zones of salt marshes, are considered "plant diversity hotspots," as at least a dozen species of plants called forbs inhabit them, including Limonium nashii (sea lavender), Salicornia europaea (pickleweed), and Triglochin maritima. To arrive at their conclusions, the researchers subjected plots of forb pannes to air about six degrees Fahrenheit warmer than the surrounding area; they found that plant growth initially increased, but the plants began a rapid die-off and were replaced by the salt marsh grass Spartina patens. In tests that spanned from 2004 to 2006, the forbs pannes cover dropped from 50 percent to less than 10 percent at two sites – Nag Creek (Prudence Island, Rhode Island) and Little River (Maine). At the third test site, Drakes Island (Maine), the forb pannes cover decreased from 50 percent to 44 percent in Summer 2007. The researchers believe the forbs disappeared due to changes in the plant-water balance, meaning the warmer air caused the forbs to take in more water, making the area less waterlogged and more welcoming for Spartina patens, which prefers less water-soaked environments. In the New England region, pannes span from Connecticut, where they make up less than 10 percent of a salt marsh's area, to Maine, where they can consist of about 40 percent of the salt marsh ecosystem. The study, titled, "Experimental warming causes rapid loss of plant diversity in New England salt marshes," is available at: http://www3.interscience.wiley.com/journal/122473116/abstract. July 15, 2009, http://www.sciencedaily.com/releases/2009/07/090713085016.htm.

Policy

***UK Department of Energy and Climate Change*, "Clean Coal to Support Up to 60,000 UK Jobs,"** and ***UK Department of Energy and Climate Change*, "Clean Coal Funding Bill Announced."**

The United Kingdom (UK) proposed a new energy bill for the upcoming Parliamentary session as part of an effort to advance clean coal technologies. The bill would enable the Secretary of State for Energy and Climate Change to fund up to four commercial-scale CCS demonstration plants; the first of these could be in operation by the middle of the next decade. The bill follows the publication of a consultation document, titled, "A Framework for the Development of Clean Coal," (available at: http://www.decc.gov.uk/Media/viewfile.ashx?FilePath=Consultations\A framework for the development of clean coal\1_20090617164456_e_@@_cleancoalcondoc2.pdf&filetype=4) on June 17, 2009, which lays the foundation for how the UK Government proposes integrating emissions reducing technologies into future coal-fired power plants. Specifically, the proposals under consultation in the document include: providing funding for up to four commercial-scale CCS demonstrations; requiring new coal-fired power plants to demonstrate CCS; and requiring new coal-fired power plants to retrofit CCS within five years of CCS being independently judged technically and economically proven. The consultation also contains proposals for the design of the financial support mechanism introduced in the bill. June 29, 2009, http://www.decc.gov.uk/en/content/cms/news/pn068/pn068.aspx, and June 17, 2009, http://www.decc.gov.uk/en/content/cms/news/pn061/pn061.aspx.

"A survey on the public perception of CCS in France."

The following is the Abstract of this article: "An awareness and opinion survey on CCS was conducted on a representative sample of French residents aged 15 years and above. About [six percent] of respondents were able to provide a satisfactory definition of the technology. The key question about 'approval of or opposition to' the use of CCS in France was asked twice, first after presenting the technology, then after explaining its potential adverse consequences. The approval rates, which were 59 [percent] and 38 [percent], respectively, show that there is no a priori rejection of the technology. The sample was split in two to test for a semantic effect: half of the questionnaires used 'stockage' (English: storage), the other half 'Sequestration.' Manipulating the vocabulary had no statistically significant effect on approval rates. Stockage is more meaningful, but does not convey the idea of permanent monitoring." **Minh Ha-Duong, Alain Nadaï, and Ana Sofía Campos**, *International Journal of Greenhouse Gas Control*, Available online June 23, 2009, doi:10.1016/j.ijggc.2009.05.003, http://www.sciencedirect.com/science/article/B83WP-4WKJ5MD-3/2/bc6a8c7e9e404ca4ea4498a5ca1e1037. (Subscription may be required.)

Geology

"Optimizing geologic CO_2 sequestration by injection in deep saline formations below oil reservoirs."

The following is the Abstract of this article: "The purpose of this research is to present a best-case paradigm for geologic CO_2 storage: CO_2 injection and sequestration in saline formations below oil reservoirs. This includes the saline-only section below the oil-water contact (OWC) in oil reservoirs, a storage target neglected in many current storage capacity assessments. This also includes saline aquifers (high porosity and permeability formations) immediately below oil-bearing formations. While this is a very specific injection target, [the authors] contend that most, if not all, oil-bearing basins in the [United States] contain a great volume of such strata, and represent a rather large CO_2 storage capacity option. [The authors] hypothesize that these are the best storage targets in those basins. The purpose of this research is to evaluate this hypothesis. [The authors] quantitatively compared CO_2 behavior in oil reservoirs and brine formations by examining the thermophysical properties of CO_2, CO_2-brine, and CO_2-oil in various pressure, temperature, and salinity conditions. In addition, [the authors] compared the distribution of gravity number (N), which characterizes a tendency towards buoyancy-driven CO_2 migration, and mobility ratio (M), which characterizes the impeded CO_2 migration, in oil reservoirs and brine formations. [The authors] research suggests competing advantages and disadvantages of CO_2 injection in oil reservoirs vs. brine formations: (1) CO_2 solubility in oil is significantly greater than in brine (over 30 times); (2) the tendency of buoyancy-driven CO_2 migration is smaller in oil reservoirs because density contrast between oil and CO_2 is smaller than it between brine and oil (the approximate density contrast between CO_2 and crude oil is ~100 kg/m^3 and between CO_2 and brine is ~350 kg/m^3); (3) the increased density of oil and brine due to the CO_2 dissolution is not significant (about 7–15 kg/m^3); (4) the viscosity reduction of oil due to CO_2 dissolution is significant (from 5790 to 98 mPa s). [The authors] compared these competing properties and processes by performing numerical simulations. Results suggest that deep saline CO_2 injection immediately below oil formations reduces buoyancy-driven CO_2 migration and, at the same time, minimizes the amount of mobile CO_2 compared to conventional deep saline CO_2 injection (i.e., CO_2 injection into brine formations not below oil-bearing strata). Finally, to investigate practical aspects and field applications of this injection paradigm, [the authors] characterized oil-bearing formations and their thickness (capacity) as a component of the Southwest Regional Partnership on Carbon Sequestration (SWP) field deployments. The field-testing program includes specific sites in Utah, New Mexico, Wyoming, and western Texas of the United States." **Weon Shik Han and Brian J. McPherson**, *Energy Conversion and Management*, Available online July 12, 2009, http://dx.doi.org/10.1016/j.enconman.2009.06.008, http://www.sciencedirect.com/science/article/B6V2P-4WRKF58-3/2/b40c9bdede3002b3ec95edd7e93fdb45. (Subscription may be required.)

"Oil Recovery and Sequestration Potential of Naturally Fractured Reservoirs During CO_2 Injection."

The following is the Abstract of this article: "With urgent need of [GHG] sequestration and booming oil prices, underground oil/gas reservoirs seem the only value-added choice. A great portion of current CO_2 injection projects in the world is in naturally fractured reservoirs. The matrix part of these reservoirs constitutes the major oil storage unit and this oil is targeted during CO_2 injection. It is [the authors'] intention to show that this media could also be used as permanent CO_2 storage unit while recovering oil from it. These reservoirs, however, are complex in nature and the physics of the matrix−fracture interaction process during CO_2 injection is still not known to a great extent. To ease the complex nature of the problems, experiments were performed on fractured sandstone cores (single fracture) saturated with n-decane and carbonate cores saturated with dead crude oil. CO_2 was injected at constant rates into the fracture while maintaining the high pressure into the core and the system. Injection and production data were monitored and collected using continuous data logging system. After continuous injection, diffusion of CO_2 was allowed to occur by shutting down the system for a specific period of time and followed by a blowdown period to recover oil that diffused from matrix to fracture. At different pressure steps, produced liquid was analyzed using gas chromatography while the produced gas was measured using a flow meter. The CO_2 storage capacity of the rock with change in the pressure and the amount of oil recovered during blow down period were analyzed. The results of the continuous injection experiments were used to obtain diffusion coefficients by matching the simulation results. Using dimensionless analysis and matrix−fracture diffusion groups, [the authors] obtained a critical number for optimal recovery/sequestration. The pressure decay behavior during the shutdown was analyzed in conjunction with the gas chromatograph analysis of produced oil sample collected during blowdown after the quasiequilibrium reached during pressure decay. This led to insights into the governing mechanism of extraction/condensation and miscibility for recovering lighter to heavier hydrocarbons during pressure depletion from fractured reservoirs." **J. J. Trivedi and T. Babadagli**, *Energy Fuels*, Available online July 8, 2009, DOI:10.1021/ef900361n, http://pubs.acs.org/doi/abs/10.1021/ef900361n. (Subscription may be required.)

"Coal energy conversion with carbon sequestration via combustion in supercritical saline aquifer water."

The following is the Abstract of this article: "The standard idea for deep saline aquifer sequestration is to separate [CO_2] from a process stream, compress it, and inject it underground. However, since [CO_2] is less dense than water, even at the high pressures found in aquifers, it is buoyant and will move towards the surface unless trapped by an impermeable seal. Also, significant energy expenditure is required to separate and compress [CO_2], even though neat [CO_2] is not a desired product. These issues may be addressed by combining the idea of fast dissolution at the surface with supercritical water oxidation (SCWO). By burning coal at high pressure in supercritical water drawn from an aquifer, and then sequestering the entire pre-equilibrated effluent, all carbon from the fuel is captured, as well as all non-mineral coal combustion products including sulfur and metals. A possible block diagram of an SCWO-based electric power plant is proposed, including processes to handle salts from the aquifer brine and minerals from coal. The plant is thermodynamically modeled, using an indirectly fired combined cycle to convert energy from hot combustion products to work. This model estimates the overall thermal efficiency that can be achieved, and reveals unanticipated interactions within the plant that have significant effects on efficiency. The assumptions and results of the model highlight design challenges for an actual system." **J.R. Heberle and C.F. Edwards**, *International*