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# CARBON STORAGE NEWSLETTER

FEBRUARY 2020

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

### *NETL Project Validates CO<sub>2</sub> Storage.*

The National Energy Technology Laboratory (NETL) and research partners pioneered technology with the potential to reduce industrial carbon emissions. The Plains CO<sub>2</sub> Reduction (PCOR) Partnership, one of the U.S. Department of Energy's (DOE) seven *Regional Carbon Sequestration Partnerships (RCSPs)*, completed work across the Great Plains and into portions of Canada that demonstrates the ability to reduce carbon dioxide (CO<sub>2</sub>) emissions and enhance the efficiency of oil production. Supported by NETL, RCSP activities have included assessments of geologic and terrestrial storage potential in each region, followed by small-scale validation projects and six large-scale (greater than 1 million metric tons) geologic storage projects. From *NETL News Release* on January 10, 2020.



## ANNOUNCEMENTS

### *Office of Fossil Energy's Year in Review.*

DOE's Office of Fossil Energy (FE) shared highlights of work conducted in 2019 that helped to maximize the use of the nation's energy resources. Among the accomplishments noted was accelerated research and development (R&D) on direct air capture of CO<sub>2</sub> through carbon capture, utilization, and storage (CCUS) R&D.

### *NETL-Supported CCUS Demonstration Project Celebrates Sustainable Operation.*

Petra Nova, an operating post-combustion CO<sub>2</sub> capture project supported by DOE's FE, *celebrated its third anniversary in January 2020*. Administered by NETL, the project is demonstrating how CCUS technologies can economically support the flexibility and sustainability of fossil fuels at commercial scale. Located in Texas (USA), the Petra Nova project addresses capture and beneficial reuse of CO<sub>2</sub> from coal-based electricity production.



### *NETL Develops Flexible CCUS Analysis Tools and Resources.*

NETL researchers developed a first-of-its-kind suite of tools that enables better decision-making regarding the economic challenges of CCUS. The publicly available tools and resources can evaluate CCUS costs during each step in the value chain. More information can be found on *NETL's Energy Analysis page*.

### *DOE Selects Projects to Create New Market Opportunities for Coal.*

DOE's FE announced the selection of three projects to receive federal funding for cost-shared R&D to create new market opportunities for coal. Supported through the Funding Opportunity Announcement (FOA) "Maximizing the Coal Value Chain," the projects will develop innovative uses of domestic coal for upgraded coal-based feedstocks used to produce power and make steel and high-value products. NETL will manage the projects, which will support FE's *Advanced Energy Systems Program*.

## ANNOUNCEMENTS *(cont.)*

### *Digital Portal for Sharing CCS Projects Datasets Opens.*

The international CO<sub>2</sub> Storage Data Consortium launched an open, web-based digital portal for sharing reference datasets from CO<sub>2</sub> storage projects. *The CO<sub>2</sub> DataShare online portal* will attempt to improve understanding, reduce costs, and minimize uncertainties associated with CO<sub>2</sub> storage projects by making curated and well-documented datasets available to interested stakeholders.

### *CCS Facility Provides Capture Totals for 2019.*

The carbon capture and storage (CCS) facility at SaskPower's Boundary Dam Power Station located in Saskatchewan, Canada, reported a total of more than 616,000 metric tons of CO<sub>2</sub> captured in 2019. Since the facility came online in October 2014, it has captured more than 3 million metric tons of CO<sub>2</sub>.

### *Report Indicates Market Opportunities for Carbon Capture.*

A *newly released report* projects the potential worldwide market opportunities for carbon capture, including long-term storage. The Thunderbird School of Global Management (of the Arizona State University Knowledge Enterprise) report projected the broader economic, social, and environmental benefits per year by 2030.

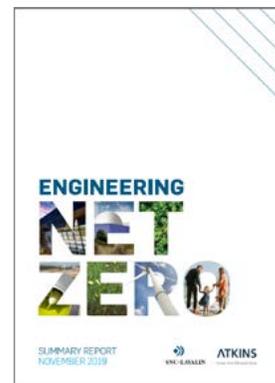


### *Institute to Help Canada Become Net-Zero by 2050.*

The Canadian Institute for Climate Choices was created to help Canada transition to a net-zero emissions economy by 2050. The Ottawa-funded institute will also provide options to help Canada reach its emissions reduction target of 30% below 2005 levels by 2030.

### *Report Highlights Need for CCS in UK.*

A report calls for the United Kingdom (UK) to increase investment in CCS to meet its net-zero emissions target for 2050. According to Atkins Global's "*Engineering Net Zero*" report, the UK will need to facilitate a four-fold increase in low-carbon energy, including CCS, nuclear, wind, and hydrogen energy generation.



### *Study Evaluates China's CO<sub>2</sub> Emissions Pricing System.*

A study, titled "*China's Unconventional Nationwide CO<sub>2</sub> Emissions Trading System: The Wide-Ranging Impacts of an Implicit Output Subsidy*," assesses the overall costs and distributional impacts of China's planned nationwide emissions trading system for CO<sub>2</sub> emissions reductions. The study also describes how China's tradable performance standard mechanism differs from other cap-and-trade programs.

## PROJECT and BUSINESS DEVELOPMENTS

### *Oxy, Total Team Up for Carbon Storage Project.*

Occidental Petroleum (Oxy) and Total announced a consortium to assess the viability of a commercial-scale carbon capture facility. The joint study will evaluate the cost of capturing 725,000 metric tons of CO<sub>2</sub> per year from a cement plant in Florence, Colorado (USA); emissions will be separated utilizing a solid adsorbent nanomaterial developed by the Canadian-based company Svante, and stored underground by Oxy. From *Journal of Petroleum Technology* on January 7, 2020.



### *Oil Company to Expand CCUS Capacity.*

The state oil company of the United Arab Emirates announced plans to expand its CCUS capacity six-fold, reducing its greenhouse gas (GHG) emissions by 25% by 2030. Abu Dhabi National Oil Company's (Adnoc) sustainability plan is to expand the capacity of the region's commercial-scale CCUS facility from its current rate of 800,000 metric tons of CO<sub>2</sub> captured per year to 5 million metric tons per year by 2030. In addition, Adnoc will plant 10 million mangrove seedlings in Abu Dhabi in order to capture and store additional CO<sub>2</sub>. From *Kallanish Energy News* on January 14, 2020.

### *Companies Sign MOU on CCUS R&D.*

Adnoc and Eni—Italy's energy company—signed a Memorandum of Understanding (MOU) to explore potential CCUS collaboration opportunities. According to the terms of the MOU, the two companies will explore geomechanical and geochemical workflows for CCUS programs. From *Adnoc Press Release* on January 20, 2020.

## LEGISLATION and POLICY

### *Norway Proposes to Invest in CCS.*

The Norwegian government proposed to invest in the development of CCS projects in 2020, including support for a full-scale CO<sub>2</sub> capture, transport, and storage project. The government's budget proposal for 2020 would provide funds for operating the *Technology Centre at Mongstad* (a test center for developing CO<sub>2</sub> capture technologies) and the research program *CLIMIT* (a program focusing on the research, development, and demonstration [RD&D] of CCS technologies). From *Energy Live News* on January 8, 2020.



### *Wyoming Budget Proposal Looks to Accelerate CCS.*

The Governor of Wyoming revealed a list of budget priorities that included accelerating the commercial development of CCS technologies. The budget proposal includes the establishment of an Energy Commercialization Program that would focus on advancing coal and CCS research. From *Natural Gas Intelligence* on January 15, 2020.

### *Massachusetts Senate Bills Could Reduce GHG Emissions.*

The Massachusetts Senate unveiled bills that include a package that sets a statewide "net-zero" emissions GHG limit for 2050. To reach the proposed GHG reduction goals, the legislation requires the state to realize its near-term CO<sub>2</sub> limits every five years, beginning in 2025. From *The Hour* on January 23, 2020.

## EMISSIONS TRADING

### *RGGI States Initiate Auction Process for Auction 47.*

The states participating in the Regional Greenhouse Gas Initiative (RGGI) initiated the auction process for their 47th quarterly CO<sub>2</sub> auction scheduled for March 11, 2020. Auction 47 will offer 16,208,347 CO<sub>2</sub> allowances for sale at a minimum reserve price of \$2.32. An 11.8 million CO<sub>2</sub> allowance cost containment reserve (CCR) will also be made available (the CCR will be accessed if the interim clearing price exceeds the CCR trigger price of \$10.77). From *RGGI* on January 14, 2020.



### *Fund to Help Industries in EU ETS Reduce CO<sub>2</sub> Emissions.*

The European Commission proposed a European Union (EU) Just Transition Fund to help heavy industries reduce their CO<sub>2</sub> emissions. Only plants in the EU's Emissions Trading Scheme (ETS) and located in EU regions with carbon emissions at least twice the EU average would receive support through the proposed fund, which is part of a wider plan to keep the EU on the path to becoming carbon-neutral by 2050. From *S&P Global* on January 14, 2020.

### *Indonesia Plans to Start Carbon Trading in 2020.*

Indonesian government officials announced plans to start carbon trading later this year. The draft regulation, anticipated to be submitted for approval in 2020, is expected to allow different carbon trading schemes, with the rules stipulating how carbon credits will be priced (e.g., credits from forest preservation and credits from industrial emissions reductions will be priced differently). From *Reuters* on January 16, 2020.

## SCIENCE NEWS

### *Military Researching Utilization of CO<sub>2</sub> for Fuel.*

The *National Defense Authorization Act*, passed in December 2019, included a provision directing the Pentagon to work with DOE and Homeland Security to research methods by which CO<sub>2</sub> from ocean water and ambient air could be converted to fuel. According to a spokesperson, the U.S. Department of Defense is researching ways to use carbon capture technology "to address energy security for the military," including capturing carbon for conversion to military transportation fuel and "alternative fuels or products" to be used at military installations. From *Bloomberg Environment* on January 15, 2020.



### *Testing Looks to Eliminate Some CCS Barriers.*

The International CCS Knowledge Centre is developing a portable testing apparatus for post-combustion amine-based capture. The testing apparatus will seek to eliminate barriers to widespread deployment of CCS and further advance the technology. A design feature will allow the apparatus to connect to a variety of CO<sub>2</sub>-containing gas streams beyond coal-fired plants, creating the potential for advancement of CCS across industry sectors. From *Carbon Capture Journal* on January 13, 2020.



### *Study: Wildfires Could Transform Amazon From Carbon Sink to Carbon Source.*

A study led by U.S. and Brazilian researchers has found that Amazon wildfires have the potential to convert the Amazon region from a carbon sink to a carbon source. The study used a model to examine different scenarios with various levels of deforestation, with the model predicting the behavior and spread of wildfires, as well as the way forest ecosystems would respond. The results, *published in the journal Science Advances*, also suggested that remaining Amazon trees, as a result of the wildfires, may store less CO<sub>2</sub> as they grow. From *Scientific American* on January 14, 2020.

## PUBLICATIONS

***Comparative Analysis of Transport and Storage Options from a CO<sub>2</sub> Source Perspective.***

The following is the description of this DOE/NETL product: "This analysis evaluated integrated CCS costs (i.e., capture, transport, and storage) from the perspective of a CO<sub>2</sub> source. Capture costs for sources with annual CO<sub>2</sub> capture rates from 0.65 to 3.90 Mt were based on two NETL reports. Transportation costs from source to storage reservoir were modeled for two pipeline systems (dedicated and trunkline) using the FE/NETL CO<sub>2</sub> Transport Cost Model. Storage costs were modeled in dome and regional dip structural settings for two reservoirs in the Rose Run Formation, three within the Mt. Simon, one in the Lower Tuscaloosa, and one in the Frio using the FE/NETL CO<sub>2</sub> Saline Storage Cost Model. A paper with the same name and information as well as additional details on this analysis was published in The International Journal of Greenhouse Gas Control along with a supplementary document that provides additional material (i.e., key parameters used in the models for obtaining transport and storage costs and CCS cost and pipeline results)."

***NETL Baseline Studies for Fossil Energy Plants.***

The following is the overview of these NETL studies: "The NETL Baseline Studies for Fossil Energy Plants establish estimates for the cost and performance of combustion- and gasification-based power plants, as well as options for co-generating synthetic natural gas and fuels - all with and without carbon dioxide capture and storage - for several ranks of coal. These studies are considered to be the most comprehensive set of public data available for state-of-the-art technologies. The primary value of these studies lies not in the absolute accuracy of estimates for the individual cases, but in the fact that all cases are evaluated using a common methodology with an internally-consistent set of technical and economic assumptions. This consistency allows for meaningful comparisons of relative costs among the cases and with advanced technology cases build upon the same case assumptions." The four volume set consists of the following: *Volume 1: Bituminous Coal and Natural Gas to Electricity*; *Volume 2: Coal to Synthetic Natural Gas and Ammonia (Various Coal Ranks)*; *Volume 3: Low-Rank Coal to Electricity*; and *Volume 4: Bituminous Coal to Liquid Fuels with Carbon Capture*.

***Feasibility of limestone reservoirs as a carbon dioxide storage site: An experimental study.***

The following is from the abstract of this article: "Carbon capture and storage technology is a means to permanently store carbon dioxide (CO<sub>2</sub>) in suitable geologic formations, such as depleted oil and gas reservoirs and saline aquifers. The potential of depleted carbonates reservoirs for being a secure storage site has been assessed in several studies based on the key storage aspects. However, minor attention has been given to rock type and the potential compaction of carbonates at different injection rates when geochemical interactions posed by supercritical CO<sub>2</sub> reduces their elastic properties and strength. In this study, limestone samples were tested to investigate changes in their physical and mechanical characteristics once flooded by CO<sub>2</sub> at a very low injection rate. The results obtained indicate that an excessive pressure drop might be experienced even under a very low injection rate because of continuous dissolution of carbonates in the presence of CO<sub>2</sub> and brine. Creation of wormholes and the dissolution of the matrix were also observed through scanning electron microscope, computerized tomography scan, and nuclear magnetic resonance tests. It was also observed that the elastic parameters and the strength of the limestone samples may significantly decrease after CO<sub>2</sub> flooding, which might be linked to calcite dissolution and weakening of the solid skeleton." **Arshad Raza, Raof Gholami, and Mohammad Sarmadivaleh**, *AAPG Bulletin*. (Subscription may be required.)

***Numerical assessment of fault impact on caprock seals during CO<sub>2</sub> sequestration.***

The following is from the abstract of this article: "Coupled fluid-flow and geomechanical analysis of caprock integrity has gained a lot of attention among scientists and researchers investigating the long-term performance of geologic carbon storage systems. Reactivation of pre-existing fractures within the caprock or re-opening of faults can create permeable pathways which can influence the seal integrity. Stability of the caprock during and after injection of super-critical CO<sub>2</sub>, and the impact of pre-existing fractures in the presence or absence of one or multiple faults have been investigated in this study. The impact of the wellbore orientation and the injection rate are among other key factors in understanding the structural trapping mechanisms within such geological formations. In this study, [the authors] numerically investigated the impact of each of these factors. This study revealed the interplay between joints and faults and how different leakage pathways are formed and under which scenario they play a dominant role in terms of CO<sub>2</sub> leakage. This study also highlights the role of one versus multiple faults in the domain and the importance of the fault hydrological property in forming leakage pathway." **P. Newell and M.J. Martinez**, *International Journal of Greenhouse Gas Control*. (Subscription may be required.)

***Experimental study on natural gas hydrate exploitation: Optimization of methane recovery, carbon dioxide storage and deposit structure preservation.***

The following is from the abstract of this article: "Aim of this work is locating how CO<sub>2</sub> replacement into methane hydrate deposits may be performed, in order to increase both methane recovered and carbon dioxide stored quantities. The experimental section deals with the study of natural gas hydrate formation process and replacement of methane, contained into water cages, with carbon dioxide. In particular, the formation of methane hydrate is analyzed to understand the parameters that most influence the replacement process. A total of 10 tests were carried out in a laboratory scale reactor. Test 1–8 were performed adopting thermal stimulation as replacement technique, while in Test 9 and Test 10 depressurization was used. Results obtained have led to the conclusion that the rate of methane hydrate formation positively influences the percentage of CO<sub>2</sub> stored, while the initial saturation of the sand pores has a negative effect. The presence of hydrate agglomerates hinders the gas transition preventing the replacement process. Finally, a greater quantity of CO<sub>2</sub> hydrate, both via replacement process and via new hydrate formation, is related to a higher deposit structure preservation. As emerges from the experimental tests, the adopted replacement strategy influences the experimental relationships." **Alberto Maria Gambelli, Beatrice Castellani, Andrea Nicolini, and Federico Rossi**, *Journal of Petroleum Science and Engineering*. (Subscription may be required.)

## PUBLICATIONS (cont.)

***Bringing value to the chemical industry from capture, storage and use of CO<sub>2</sub>: A dynamic LCA of formic acid production.***

The following is from the abstract of this article: "Low carbon options for the chemical industry include switching from fossil to renewable energy, adopting new low-carbon production processes, along with retrofitting current plants with carbon capture for ulterior use (CCU technologies) or storage (CCS). In this paper, [the authors] combine a dynamic Life Cycle Assessment (d-LCA) with economic analysis to explore a potential transition to low-carbon manufacture of formic acid. [The authors] propose new methods to enable early technical, environmental and economic assessment of formic acid manufacture by electrochemical reduction of CO<sub>2</sub> (CCU), and compare this production route to the conventional synthesis pathways and to storing CO<sub>2</sub> in geological storage (CCS). Both CCU and CCS reduce carbon emissions in particular scenarios, although the uncertainty in results suggests that further research and scale-up validation are needed to clarify the relative emission reduction compared to conventional process pathways. There are trade-offs between resource security, cost and emissions between CCU and CCS systems. As expected, the CCS technology yields greater reductions in CO<sub>2</sub> emissions than the CCU scenarios and the conventional processes. However, compared to CCS systems, CCU has better economic potential and lower fossil consumption, especially when powered by renewable electricity. The integration of renewable energy in the chemical industry has an important climate mitigation role, especially for processes with high electrical and thermal energy demands." **Rubén Aldaco, Isabela Butnar, María Margallo, Jara Laso, Marta Rumayor, Antonio Dominguez-Ramos, Angel Irabien, and Paul E. Dodds**, *Science of The Total Environment*. (Subscription may be required.)

***A carbon price prediction model based on secondary decomposition algorithm and optimized back propagation neural network.***

The following is from the abstract of this article: "Carbon trading is one of the important mechanisms used to reduce carbon dioxide emissions. The increasing interest in the carbon trading market has heightened the need to decrease the prediction error of the carbon price. In this paper, a new hybrid model for carbon price forecasting is proposed, and the secondary decomposition algorithm is innovatively introduced into carbon price forecasting. First, time series data were decomposed into several intrinsic modal functions by empirical mode decomposition (EMD). Second, the first intrinsic mode function (IMF1) was further decomposed by variational mode decomposition (VMD). Then, the model input was determined by partial autocorrelation analysis (PACF). Finally, the back propagation (BP) neural network model optimized by genetic algorithm (GA) was utilized for prediction. In the empirical analysis of the Hubei market, the proposed model outperforms other comparative models. The mean absolute percentage error (MAPE), goodness of fit (R<sup>2</sup>) and root mean square error (RMSE) of the model are 1.7577%, 0.9929 and 0.5441, respectively. In the complementary cases of the Beijing and Shanghai carbon markets, the model also performs best. The results suggest that the proposed model is effective and robust and could predict carbon prices more accurately." **Wei Sun and Chenchen Huang**, *Journal of Cleaner Production*. (Subscription may be required.)

***CO<sub>2</sub> leakage environmental damage cost – A CCS project in South Korea.***

The following is from the abstract of this article: "The safety of CCS, namely the prevention of CO<sub>2</sub> leakage, is one of the most sensitive issues in the CCS project. In order to solve this issue efficiently, the knowledge of environmental damage cost of CO<sub>2</sub> leakage, in advance of CCS project, is indispensable. Therefore, this study estimates this cost by employing a contingent valuation (CV) method with data collected from a nationwide survey in South Korea. In addition, numerous zero willingness to pay (WTP) responses were dealt through the spike model in setting one-and-one-half-bound dichotomous choice data (OOHBDC). The estimate of the annual mean WTP was 2645.9 Korean won (USD 2.4), while the annual mean WTP is 3489.8 Korean won (USD 3.2) for those supporting the introduction of CCS technology in South Korea. The environmental damage cost of CO<sub>2</sub> leakage was 49.5 billion Korean won (USD 45.0 million) annually." **Joo Suk Lee and Eun Chul Choi**, *Renewable and Sustainable Energy Reviews*. (Subscription may be required.)

***Carbon reduction in a supply chain via dynamic carbon emission quotas.***

The following is from the abstract of this article: "... governments have issued a series of policies to control carbon emissions. A carbon quota policy is one of them. This study aimed to verify the effectiveness of the policy by examining its impact on supply chain members. This paper investigates emissions reduction in a supply chain under different carbon emission quotas in two stages. This paper constructs a supply chain model in three modes: (i) no carbon emission quota policy, (ii) the government implements the first stage of a carbon quota policy, and (iii) the government offers lower carbon quotas in the second stage. The analysis reveals that when the initial carbon quota allocated by the government meets certain conditions, the emission reduction rate in the first stage of the carbon quota policy is greater than that without the carbon quota policy; and an interesting finding is that the reduction rate further increases when the government reduces carbon quotas in the second stage. In addition to the reduction rate, the manufacturer's and the retailer's profits increase with consumers' preference for low-carbon products. With an increase of the decline parameter of free allocated carbon emission rights, the profits of both the manufacturer and the retailer decrease, but the profit of the manufacturer in the second stage is always lower than that in the first stage, whereas the retailer's profit is higher in the second stage than in the first stage." **Wenbin Wang, Changya Zhou, Xingyue Li**, *Journal of Cleaner Production*. (Subscription may be required.)

***Impacts of horizontal integration on social welfare under the interaction of carbon tax and green subsidies.***

The following is from the abstract of this article: "Both a carbon tax and green subsidies are efficient approaches to limit greenhouse gas emission. However, interactions between these two policies remain a critical gap area. In this paper [the authors] consider a channel structure originally consisted of two manufacturers and two retailers each of whom sells only one manufacturer's product exclusively. The products produced by the two manufacturers are substitutable. The government subsidizes consumers who buy low carbon products but imposes a carbon tax on the manufacturer producing high carbon products. [The authors] analyze tripartite games among manufacturers, retailers, and the government when horizontal integration between manufacturers or retailers is presented. It is a common belief that horizontal integration reduces competition and thus causes a loss in social welfare. However, [the authors] find that, with government intervention, neither type of horizontal integration has an effect on social welfare. Although horizontal integration may change the optimal subsidy and carbon tax levels, it has no effect on the equilibrium demands for both products. [The authors] also show that the integration of manufacturers does not affect retailers' profits, but the integration of retailers hurts both manufacturers due to the direct head-to-head competition." **Changyan Xu, Chuanxu Wang, and Rongbing Huang**, *International Journal of Production Economics*. (Subscription may be required.)

## PUBLICATIONS *(cont.)*

### *Assessment of the carbon emissions reduction potential of China's iron and steel industry based on a simulation analysis.*

The following is from the abstract of this article: "This study provides a feasible approach for decreasing the carbon emissions of China's iron and steel industry (ISI) by 2030 using the environmental-economic simulation model. The ISI and its upstream industries are optimized by introducing both technological upgrades and environmental policies. Six scenarios are designed, including business-as-usual (BaU), industrial upgrades (*tec*), carbon tax (*tax*), carbon trading (*tra*), and combination (*cob*) 1 and *cob*2, which combine the *tec*, *tax* and *tra* scenarios. The results show that the *tec* scenario can effectively curb carbon emissions. The *tax* scenario significantly promotes low emissions technologies. The *cob*2 scenario has the most stringent carbon emissions control effect and helps the ISI meet the Intended Nationally Determined Contributions (INDCs) target of China. Moreover, the rates of carbon emissions increase under the *tec*, *cob*1, and *cob*2 scenarios will decrease after 2027, indicating that it is highly possible that carbon emissions will peak in 2030. The decrease in crude steel production and electricity demand is also essential for the carbon emissions reduction of the ISI. This research comprehensively analyzes the factors influencing carbon emissions from the Chinese ISI. Analyzing this issue from the industrial chain perspective provides a new research scope for future simulation model studies." **Zhaoling Li, Hancheng Dai, Junnian Song, Lu Sun, Yong Geng, Keyu Lu, and Tatsuya Hanaoka**, *Energy*. (Subscription may be required.)

### *Trends in global research in forest carbon sequestration: A bibliometric analysis.*

The following is from the abstract of this article: "Based on the Web of Science Core Collection databases from 1990 to 2018, a scientometric analysis of 1,284 academic works related to forest carbon sequestration is carried out to characterize the intellectual landscape by identifying and revealing the basic characteristics, research power, intellectual base and research hotspots in this field. The results of this work show that: [1] the number of publications in forest carbon sequestration research has increased rapidly and the research in this field is in its 'growth stage'; Forest Ecology and Management is the most productive journal and Forestry is the most popular subject category; [2] the most productive authors and institutions in this subject area are in the USA, China and Canada, with the Chinese Academy of Sciences being the key institution performing such research; [3] in the sample, 9 papers have played a key role in the evolution of the field and laid a solid foundation for future research; [4] Keyword clustering analysis showed that the main research topics in the domain of forest carbon sequestration could be summarized as: (a) temperate forest; (b) forest management; (c) uncertainty analysis; (d) forest floor; (e) REDD; (f) net primary productivity..." **Li Huang, Mi Zhou, Jie Lv, and Ke Chen**, *Journal of Cleaner Production*. (Subscription may be required.)

### *Quantifying the soil organic carbon sequestration performance and carbon emissions offset potential of the City of Calgary's Willow Biomass and Marginal Land Reclamation Demonstration Project.*

The following is from the abstract of this article: "The primary objective of this study was to measure the soil organic carbon (SOC) sequestration performance of The City of Calgary Dewatered Biosolids Land Application Program – Willow Biomass and Marginal Land Reclamation Demonstration Project (hereafter, 'the demonstration Project') after five years of operation. The second objective was to assess the demonstration Project's potential to earn soil-based carbon offset revenue through the Alberta Emissions Offset System in the future. To accomplish the first objective, SOC stocks were measured at three sampling locations subject to different combinations of recommended management practices (RMP) for SOC sequestration by the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21)." **Chelsey Greene**, *UWSpace*. (Subscription may be required.)

## ABOUT DOE'S CARBON STORAGE PROGRAM

The **Carbon Storage Program** at the National Energy Technology Laboratory (NETL) is focused on developing and advancing technologies to enable safe, cost-effective, permanent geologic storage of CO<sub>2</sub>, both onshore and offshore, in different depositional environments. The technologies being developed will benefit both industrial and power sector facilities that will need to mitigate future CO<sub>2</sub> emissions. The program also serves to increase the understanding of the effectiveness of advanced technologies in different geologic reservoirs appropriate for CO<sub>2</sub> storage—including saline formations, oil reservoirs, natural gas reservoirs, unmineable coal, basalt formations, and organic-rich shale basins—and to improve the understanding of how CO<sub>2</sub> behaves in the subsurface. These objectives are key to increasing confidence in safe, effective, and permanent geologic CO<sub>2</sub> 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

Newsletters, program fact sheets, best practices manuals, roadmaps, educational resources, presentations, and more information related to the Carbon Storage Program is available on [DOE's Energy Data eXchange \(EDX\) website](#).



Parallel, vertical, orthogonal natural fracture faces (joint sets) in an outcrop of organic-rich Millboro Shale (Marcellus equivalent), Clover Creek, VA. Photo by Dan Soeder, 2014.

## 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 (note that all links were active at the time of publication).

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