CER Meeting: Basin-Scale Carbon Sequestration

Briefing Book

NATIONAL ACADEMIES

Sciences
Engineering
Medicine

Committee on CER EARTH RESOURCES

Spring 2022
Hybrid Committee Meeting
June 6-7, 2022

June 6, 2022

Open Session - Basin-Scale Carbon Sequestration

10:30AM **Opening and Introductions**
Jim Slutz, CER Chair

10:35AM **Overarching talk (15 min talk + short Q&A)**
Jarad Daniels, Global CCS Institute

11:00AM **Comments from sponsor on topic (10 min)** Darin Damiani, Department of Energy-FECM

Framing the Opportunity:

11:10AM **Panel I (10 min talks)**

- Susan Hovorka, UTexas – Demonstration sites and enabling industry in Gulf Coast
- Sallie Greenberg, Illinois Survey – Large scale demonstration projects
- Dane McFarlane, Carbon Solutions – Regional- and hub-scale carbon storage economics
- Shannon Angielski, CURC – Regulatory framework

12:00PM **Panel I Discussion**
(Moderator: Dan Connell, CONSOL Energy Inc)

12:30PM **Break**

Necessary Technical Advancements:

1:15PM **Overarching talk (15 min talk + short Q&A)**
Robert Dilmore, NRAP – Whole system risk based model

1:40PM **Panel I (10 min talks)**

- Philip Ringrose, Equinor – Site development and monitoring
- Jonny Rutqvist, Berkeley Lab – Induced seismicity
- Joel Sminchak, Battelle – Modeling
- Dustin Crandall, NETL – Wettability

2:25PM **Panel II Discussion**
(Moderator: Tomieka Searcy, BP)

2:58PM **Concluding Remarks**
Jim Slutz, CER Chair

3:00PM **Adjourn**

OPEN SESSION

IN THIS SECTION

SPEAKER BIOGRAPHIES

Jarad Daniels

Jarad Daniels joined as the Chief Executive Officer of the Global CCS Institute in October 2021. He brings 20 years of international collaboration and leadership on clean energy and sustainable development. He has broad expertise in energy and deep experience in Carbon Capture and Storage, having worked with many countries, multilateral organisations, NGOs, and companies on technology development and deployment and government policy.Prior to joining the Institute, Jarad led the Office of Strategic Planning, Analysis, and Engagement within the U.S. Department of Energy's Office of Carbon Management. Earlier responsibilities included managing research, development, and demonstration programs for advanced power systems and environmental stewardship. His professional experience includes life cycle analysis, process engineering and materials science. Jarad holds a Bachelor of Science degree in Chemical Engineering from Kansas State University and a Master of Science degree in Chemical Engineering from the University of California at Berkeley.

Darin Damiani

Darin Damiani is the Carbon Storage Program Manager for the U.S. Department of Energy's Office of Fossil Energy, where he manages a program that supports a portfolio of R&D projects and initiatives aimed at advancing geologic CO2 storage technologies. Darin began a career focused on carbon capture utilization and storage (CCUS) in 2007 when he joined the DOE's National Energy Technology Laboratory (NETL). While at NETL Darin was the project manager for a variety of technology R&D projects in support of the Carbon Storage Program including the Midwest Geological Sequestration Consortium (MGSC), which is one of the seven Regional Partnerships that have been advancing CCUS technologies and infrastructure needed to implement large-scale CO2 storage in different regions and geologic formations of North America. Darin completed his Masters in Environmental Engineering from Manhattan College, NY and a B.E. in Environmental Engineering from Hofstra University, NY.

Susan D. Hovorka

Susan D. Hovorka is a sedimentologist who works on fluid flow in diverse applications, inlcuding water resource protection, oil production, and waste storage. She has led a team working geologic storage of CO2 since 1998, with a focus on field studies, monitoring, and capacity estimation. Projects include saline injection at the Frio Test site and Cranfield Field and EOR studies at SACROC oil field, Cranfield, Hastings and West Ranch industrial CO2 utilization projects and GoMCARB offshore charaterization study. She specializes in monitoring to document retention. The Gulf Coast Carbon Center is leading efforts to develop offshore storage capacity in the the US and globaly. She has a long-term commitment to public and educational outreach. She has a BA from Earlham College and a PhD in Geology from The University of Texas at Austin.

Sallie E. Greenberg

Sallie E. Greenberg, Ph.D. is a Principal Research Scientist of Energy & Minerals at the Illinois State Geological Survey - University of Illinois. Dr. Greenberg acts as a Strategic Advisor for Energy & Minerals as well as working on multiple projects, including Co-leading the Midwest Regional Carbon Initiative Partnership and the Illinois Corridor CarbonSAFE project. Over the last 20+ years, she led the Illinois Basin – Decatur Project to completion and has consulted or contributed to more than 30 energy and carbon capture and storage projects, especially in project development, risk reduction, and stakeholder engagement. Dr. Greenberg specializes and consults in many areas including strategic development, government relations, energy policy, environmental and social justice, project review, and relationship building. Dr. Greenberg uses her advanced degrees in low temperature geochemistry and education to create strategies for change based on understanding public challenges related to balancing societal demands for energy with environmental concerns. Dr. Greenberg holds a Ph.D. in Secondary and Continuing Education and Master of Science degree in Geology from the University of Illinois, and a Bachelor of Arts degree in Geology from Alfred University in New York.

Dane McFarlane

Dane McFarlane is the Director of Climate and Policy at Carbon Solutions, LLC. McFarlane is the primary author of the Great Plains Institute's Atlas of Carbon and Hydrogen Hubs, as well as the Transport Infrastructure for Carbon Capture and Storage whitepaper published by GPI and the Regional Carbon Capture Deployment Initiative. Dane has led research and analysis on energy and climate for 14 years, working directly with a number of research institutions such as Argonne National Lab, Los Alamos National Lab, NREL, and NETL, and has a B.S. in Electrical Engineering and a M.S. in Energy and Environmental Policy.

Shannon Angielski

Shannon Angielski is the Executive Director of the Carbon Utilization Research Council (CURC) and the president of the Clean Hydrogen Future Coalition, Shannon develops and supports those coalition's federal policy initiatives. She also serves as the coalition's spokesperson before federal policymakers and the media. Shannon works for Van Ness Feldman LLP. Her practice focuses on developing and advocating for clean energy and carbon management policies on behalf of her clients, with a particular focus on decarbonizing hydrogen as well as carbon capture and sequestration (or "CCS") policies. Shannon's 20 years of experience includes working with the electric power and industrial sectors, equipment manufacturers, technology developers, trade associations and labor unions in the development, implementation and management of policy designs and advocacy strategies that have led to successful enactment of key legislation. Through her representations, Shannon engages federal policymakers, state and local agencies, key stakeholders and non-governmental entities in developing creative policy solutions.

Robert Dilmore

Robert Dilmore is a research engineer in the Geological and Environmental Systems Directorate of NETL's Research & Innovation Center where he engages in interdisciplinary, collaborative research to characterize the technical and environmental performance of complex engineered geologic systems. Robert serves as Technical Director of the U.S. DOE's National Risk Assessment Partnership – a multi-national laboratory collaboration to quantify and manage leakage and induced seismicity risks at geologic carbon storage sites. Dr. Dilmore earned his doctorate in environmental engineering from the University of Pittsburgh in 2004, is a licensed Professional Engineer in the Commonwealth of Pennsylvania (2004 – present), and a Board Certified Environmental Engineer, as recognized by the American Academy of Environmental Engineers and Scientists (2005 – present).

Philip Ringrose

Philip Ringrose is a specialist in CO2 storage and reservoir geoscience at the Equinor Research Centre, Trondheim, Norway. He is also Adjunct Professor in CO2 Storage at the Norwegian University of Science and Technology (NTNU) and a leader in the Centre for Geophysical Forecasting based at NTNU. He has published widely on reservoir geoscience and flow in rock media and has published textbooks on 'Reservoir Model Design' and 'How to Store CO2 underground.' He was elected as the 2014-2015 President of the European Association of Geoscientists and Engineers (EAGE) and in 2018 he was appointed as Honorary Professor (Sustainable Geoenergy) at the University of Edinburgh, School of Geosciences, Edinburgh, UK.

Jonny Rutqvist

Jonny Rutqvist is a Senior Scientist in the Energy Geosciences Division at Lawrence Berkeley National Laboratory. Dr. Rutqvist has over 30 years of experience in modeling coupled fluid flow and geomechanics for a wide range of geoscientific and geoengineering applications and has authored over 200 peer-reviewed journal articles. Dr. Rutqvist has applied coupled geomechanical modeling to geologic carbon sequestration since the 1990s, such as at the In Salah CO2 storage project, and for modeling of induced seismicity and caprock integrity.

Joel Sminchak

Joel Sminchak is a Senior Research Scientist in the Energy Resilience Division at Battelle Memorial Research Institute in Columbus, Ohio. He received his BSc from the University of Dayton and MSc from Ohio State University. He has 24 years of experience with research on reservoir characterization, geotechnical testing, and performance monitoring for geologic CO2 storage and other subsurface investigations.

Dustin Crandall

Dustin Crandall is a mechanical engineer at National Energy Technology Laboratory. He has a strong desire to mix the power of today's computational analysis with proven experimental procedures to achieve extra-ordinary results. He is particularly interested in fluid mechanics and alternative energy sources.

COMMITTEE INFORMATION

IN THIS SECTION

COMMITTEE BIOGRAPHIES

James Slutz (Chair)

James Slutz (Chair) is the Director of Study Operations for the National Petroleum Council (NPC), an independent federal advisory committee to the United States Secretary of Energy. Prior to NPC, Jim led a global consulting practice with projects in North America, Asia, and Europe. Previously, Mr. Slutz served as Acting Assistant Secretary of Fossil Energy at the United States Department of Energy (DOE). He also previously served as Deputy Assistant Secretary of Oil and Natural Gas at DOE. Prior to joining DOE, Slutz served as the Indiana Oil and Gas Director, regulating the State's upstream oil and gas industry and natural gas storage wells. He is a former Vice-Chair of the Interstate Oil and Gas Compact Commission. Jim serves as a member of the Committee on Earth Resources and is an advisor to the National Bureau of Asia Research. Jim has published papers in collaboration with the American Enterprise Institute, the East West Center, the U.S. Chamber of Commerce Foundation, and the National Bureau of Asia Research. Mr. Slutz holds an M.B.A. degree from The Ohio State University, Fisher College of Business, and a B.S. degree from The Ohio State University, School of Natural Resources.

Bridget F. Ayling

Bridget F. Ayling is an Associate Professor at the Nevada Bureau of Mines and Geology and the College of Science at the University of Nevada, Reno (UNR) and is the director of UNR's Great Basin Center for Geothermal Energy. In this role, Dr. Ayling is responsible for developing research and education programs in the field of geothermal energy, overseeing research to understand the complexities of fluid flow in the upper crust and the implications of this for geothermal resource exploration and management, managing the public dissemination of Nevada's geothermal datasets, and supervising graduate students. Dr. Ayling's research interests focus on reservoir characterization including use of geochemical datasets (aqueous geochemistry and tracer testing), mineralogical characterization, fluid-flow modelling, and geomechanical characterization. She joined UNR in early 2016 after working at Geoscience Australia, the Australian Government's geoscience agency, and the Energy and Geoscience Institute at the University of Utah. In these positions, Dr. Ayling worked in both conventional and unconventional geothermal settings in Australia and the USA, contributing to regional geothermal resource assessments, surface heat-flow measurement, and several Engineered Geothermal System (EGS) demonstration projects. She served on the Geothermal Resources Council Board of Directors in 2017-2018 and on the National Academies of Sciences, Engineering, and Medicine's study committee for "Future Directions for the U.S. Geological Survey's Energy Resources Program". Dr. Ayling holds a B.S. with honors in geology and physical geography from Victoria University of Wellington, New Zealand. She received her Ph.D. in paleoclimate and environmental geochemistry from the Australian National University in 2006.

Christopher D. Barton

Christopher D. Barton is a Professor of Forest Hydrology and Watershed Management in the Department of Forestry and Natural Resources at the University of Kentucky. He is currently working in the areas of ecosystem restoration, reforestation and remediation of streams, wetlands and mined lands. Best management practices for protecting water resources are also being examined. Dr. Barton is an Associate Editor for the International Journal of Phytoremediation and the International Journal of Mining, Reclamation and Environment. Dr. Barton is also the founder and President of Green Forests Work, an NGO that aims to improve the environment and economy of mined landscapes. Through this program, over 4 million trees have been planted on mined lands in Appalachia and Australia and over 22,000 volunteers have participated. Dr. Barton was the recipient of several State and National awards including: the American Society of Mining and Reclamation's 2020 William T. Plass Award; the Kentucky Department of Environmental Protection's 2018 Environmental Excellence Award for Resource Caretaker; and the 2011 United States Department of Interior - Presidential Migratory Bird Federal Stewardship Award. Recently, Dr. Barton was named a Fulbright Distinguished Chair and will work with CSIRO in Australia in 2023. Dr. Barton received his Ph.D. in soil science from the University of Kentucky.

Erin A. Campbell

Erin A. Campbell is the Wyoming State Geologist and Director of the Wyoming State Geological Survey, where she serves as a cabinet member for the governor of Wyoming, and as a commissioner for the Wyoming Oil and Gas Conservation Commission and the Enhanced Oil Recovery Commission. Dr. Campbell is also a member of Wyoming Board of Professional Geologists, State Groundwater Coordination Committee, the State GIS Advisory Board, and the Yellowstone Volcano Observatory. Additionally she worked as a geologist for Chevron in Louisiana and California and taught at the University of Wyoming, where she directed the Geology Field Camp and conducted research in structural geology and geomechanics. She was manager of Energy and Mineral Resources at the Wyoming State Geological Survey before being appointed as state geologist. She has served on executive committees and as president of the Association of American State Geologists, and the Rocky Mountain Section of GSA. Erin has received awards for excellence in research, teaching and service from AGU, GSA, the University of Wyoming, the Association for Wyoming Geoscientists, and Wyoming Women of Influence. Dr. Campbell holds a bachelor's degree in geology from Occidental College and a Ph.D. in geology from the University of Wyoming.

Daniel P. Connell

Daniel P. Connell is Senior Vice President of Strategy for CONSOL Energy Inc., which is a producer and exporter of thermal and metallurgical coal from the Eastern US. In his current position, Dan is focused on developing and executing CONSOL's growth strategy and advancing the company's initiatives to create value through the application of new technologies. He also oversees the company's sales, marketing, and business development efforts and has profit and loss responsibility for the CONSOL Marine Terminal in the Port of Baltimore and the Itmann Mine project in West Virginia. Prior to this role, Dan spent about 17 years working in CONSOL's Research & Development, Marketing, Strategy & Engineering, and Business Development & Technology groups, where he focused on the development and economic analysis of advanced power generation and environmental control technologies, technical marketing for thermal and metallurgical coal customers, energy market analysis, strategic planning, new market development, and major transactions. He also has been spearheading the company's efforts around waste coal utilization, carbon dioxide capture and storage, and development of sustainable products and materials from coal.Dan has authored or co-authored more than 50 publications and presentations on topics related to coal, energy, and the environment. Dan earned his B.S. in chemical engineering, from the University of Notre Dame and he is a graduate of CONSOL's Leadership Education and Development program.

Gary J. Goldberg

Gary J. Goldberg is a non-executive director of BHP Ltd. Mr. Goldberg brings extensive executive, operational and sustainability experience. He served as President and Chief Executive Officer of Newmont Mining Corporation from 2013 to 2019. During his time at Newmont, Mr. Goldberg was honored with a lifetime achievement award by the Society for Mining, Metallurgy & Exploration (SME) for his contribution to safety in the mining industry in 2014; inducted into the American Mining Hall of Fame in 2017; awarded the Charles F. Rand Memorial Gold Medal for his leadership and contributions to the mining industry in value, sustainability and safety in 2018; and was inducted into the National Mining Hall of Fame in 2021. Mr. Goldberg's community and industry leadership appointments include serving as Vice Chair for the Mining and Metals sector of the World Economic Forum; and as a Board Director for the International Council on Mining & Minerals, World Gold Council, and National Mining Association. He holds a bachelor's of science degree in Mining Engineering from the University of Wisconsin – Platteville, and a master's of business administration degree from the University of Utah.

Douglas W. Hollett

Douglas W. Hollett is President of Melroy-Hollett Technology Partners, a consulting practice in energy and aerospace technology and policy. His current work focuses on carbon capture utilization and storage (CCUS), geothermal energy, the critical minerals supply chain, and renewable energy integration. He is particularly interested in the role of energy availability and cost in equitable economic growth, and the technology and policy tools required to implement environmental and climate targets. A geologist by training, Doug has over 29 years' experience in the oil and gas sector, combined with 6 years at the U.S. Department of Energy, including Deputy Assistant Secretary for Renewable Power and Acting Assistant Secretary Fossil Energy. He is a member of the Sandia National Laboratory Energy and Homeland Security Board, is on the Board of Trustees at Wellesley College, and was recently a member of the National Academies CORES Committee which produced the "Earth in Time: A Vision for NSF Earth Sciences 2020-2030" report. Doug also advises several U.S. Universities on research strategies and priorities, and is technology advisor to startups in geothermal energy and uncertainty quantification.

Kramer D. Luxbacher

Kramer D. Luxbacher is the Charles T. Holland Professor and Department Head in the Mining and Minerals Engineering Department at Virginia Tech. She has also served as associate director of the Virginia Center for Coal and Energy Research. Prior to joining academia, Dr. Luxbacher worked for U.S. Steel Mining Company and Consol Energy as a mining engineer, industrial engineer, and underground production foreman. Her broad research interests are in mine health and safety including monitoring and characterization of gases and particulates, fire simulation and prevention, and risk analysis. As a member of an advisory board to NIOSH from 2016 to 2020 she led the Metal Mining Automation Technologies Workgroup. She has a keen interest in promoting inclusion and diversity and serves as faculty advisor to the Watford Society – a group of undergraduate students who work towards these goals. She has been recognized as an SME Henry Krumb Lecturer and received the Stephen McCann Education Excellence Award from the Pittsburgh Coal Mining Institute. She is also a registered professional engineer (VA). Dr. Luxbacher holds a B.S (2002), M.S. (2005), and Ph.D. (2008), all in Mining Engineering from Virginia Tech; additionally, she earned a graduate certificate in Engineering Education (2008).

Deborah Peacock

Deborah Peacock, is a Metallurgical Engineer, Registered Professional Engineer (registered in New Mexico and Colorado), and Registered Patent Attorney (licensed in New Mexico, Colorado and New York, and with the U.S. Patent & Trademark Office). In addition to managing her law firm, Peacock Law P.C., she is on the Board of Directors of THEMAC Resources/ New Mexico Copper Corporation (TSX: MAC), which is involved in permitting and developing a copper/gold/silver/ molybdenum mine property in southern New Mexico. She is also on the Board of Westwater Resources, Inc. (NASDAQ: WWA) a graphite mining/processing company with a mine site in Alabama. Ms. Peacock previously worked at a tin mine in Tasmania and a copper mine in Utah. Deborah is also on the Board of Directors of New Mexico Gas Company (natural gas utility) and Emera Technologies, LLC (DC microgrid technologies) (both companies are wholly owned subsidiaries of Emera). She is the Chair of the Board of Regents of New Mexico Institute of Mining & Technology and on the New Mexico Mining Safety Board. Both of these positions were appointments from the Governor of New Mexico. Previously, she chaired the New Mexico Environmental Improvement Board (also Governor-appointed). She has gained expertise in academia, mine safety, Federal and State environmental and mining laws and rules, and water rights. Because of these experiences, she is exposed to not only copper/gold/silver/molybdenum mining, but also graphite, vanadium, coal, uranium, and potash, because of her boards and the vast natural resources in New Mexico. She is also familiar with tribal issues regarding mining, particularly the legacy uranium mines in Western New Mexico. She is a member of the New Mexico and National Society of Professional Engineers; Society of Mining, Metallurgy and Exploration; Canadian Institute of Mining, Metallurgy and Petroleum; Women's Mining Coalition; New Mexico Mining Association; New Mexico Oil & Gas Association; Prospector and Developers Association of Canada (PDAD); American Society of Safety Engineers; and National Association of Corporate Directors. Even though many of her mining activities are on Earth, Ms. Peacock is also a national keynote speaker and published author regarding the future of mining on the Moon and asteroids. She earned her B.S. in Metallurgical Engineering from the Colorado School of Mines and her law degree from Harvard Law School.

Ann Robertson-Tait

Ann Robertson-Tait is President of GeothermEx, Inc. and has worked in the geothermal sector since 1985. She has worked in 28 countries on hundreds of geothermal projects, including nearly 50 that have been developed for power generation (with a combined capacity of nearly 7 GW), and many more projects at earlier stages of exploration and development. Her geoscientific work focuses on integrated analyses of multi-disciplinary data sets to quantify resource capacity, identify drilling targets and optimize the production/injection scheme to ensure resource sustainability and longevity. Ann is well known for her work on an effective pathway for increasing the global deployment of geothermal power: reducing the risks associated with discovering and proving the geothermal resource. On behalf of the World Bank, she assessed the effectiveness of various risk reduction methods used in various countries. More recently she identified the full spectrum of risks that are holding back geothermal development in East Africa to develop a framework for a new risk mitigation fund specific for that region. Ann has worked extensively on Enhanced Geothermal Systems (EGS) projects in Europe, Australia and the United States (California, Nevada, New Mexico, Oregon and Alaska), including projects within and adjacent to existing conventional geothermal projects and greenfield EGS developments. From the late 1990s to 2017, Ann served on the Board of Directors of the Geothermal Energy Association (GEA), the Washington DC-based group representing the US geothermal industry. In 2018, she was elected to the Board of Directors of the Geothermal Resources Council (GRC, the world's first geothermal association, recently renamed Geothermal Rising). She serves on the Geothermal Rising Policy Committee, continuing her earlier work with the GEA. Ann is currently the Global Chair of Women in Geothermal (WING), an international organization that promotes the education, professional development and advancement of women in the geothermal sector and seeks gender equality in its membership.

Tomieka Y. Searcy

Tomieka Y. Searcy serves as the Petroleum Systems Analysts Community of Practice Lead at BP. She was born and raised in a rural town - Butler, Georgia. While in high school, Tomieka was a part of Fort Valley State University's (FVSU) Mathematics, Science, and Engineering Academy. Upon graduation she received a full scholarship for a dual degree in Chemistry and Geology from Fort Valley State University and University of Oklahoma. While earning her degrees from both universities she interned for five summers with major oil companies- Texaco, Shell and BP. She went on to obtain her graduate degree in Geology at The University of Oklahoma. Her 16 year career at BP has been filled with petroleum exploration and production work in various basins within Wyoming (Onshore USA), North Sea, Gulf of Mexico, and Latin America. During college she became a member of sorority Alpha Kappa Alpha, Inc. Along with her sorors she was able to community service and health programs for fellow female schoolmates. At work, she has raised money for FVSU and serves as a mentor for several younger co-workers in Houston and Norwegian students. She currently holds the office National Secretary for National Association of Black Geoscientists.