SSAE Newsletter

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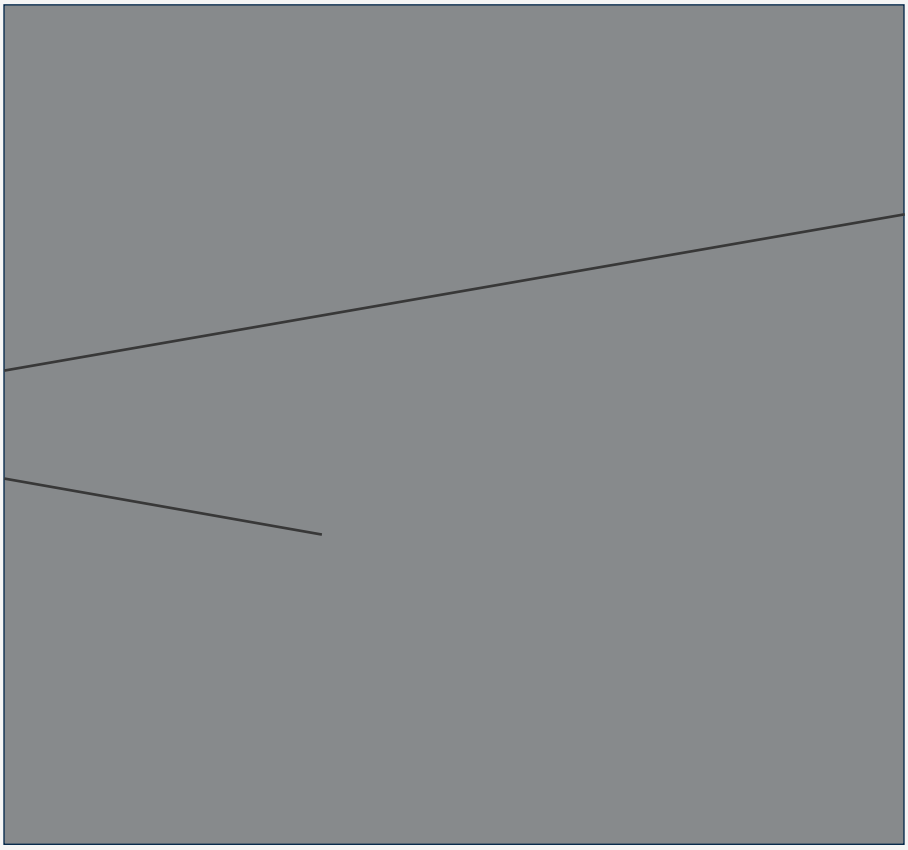

// ABOUT

The Strategic Systems Analysis and Engineering (SSAE) directorate provides the decision science and analysis capabilities necessary to evaluate complex energy systems. The directorate's capabilities address technical, economic, resource, policy, environmental and market aspects of the energy industry. These capabilities are critical to strategic planning, direction and goals for technology R&D programs and the generation of market, regulatory and technical intelligence for NETL senior management and DOE. SSAE offers a range of multi-criteria and multi-scale decision tools and approaches for this support:

- Process systems engineering research: advanced modeling, simulation and optimization tools for complex dynamic systems
- Process and cost engineering: plant-level synthesis, process modeling and simulation of energy systems with performance estimates
- Resource and subsurface analysis: evaluation of technologies, approaches and regulations for subsurface energy systems and storage
- Market and infrastructure analysis: economic impacts and program benefits
- Environmental life cycle analysis: cradle-to-grave emissions and impacts

These tools and approaches provide insights into new energy concepts and support the analysis of energy system interactions at the plant, regional, national and global scales.

NATIONAL ENERGY TECHNOLOGY LABORATORY

// HIGHLIGHTS

SSAE Working to Achieve Carbon Neutrality in Intermountain West

SSAE's Energy Systems Analysis Team, **Luciane Cunha**, **Timothy Grant**, **Donald Remson**, **David Morgan**, and NETL support contractors **Derek Vikara** and **Scott Matthews** will provide technical expertise to the Intermountain West Energy Sustainability & Transitions (I-WEST) Initiative. The I-WEST team includes two national laboratories (Los Alamos National Laboratory [LANL] as lead organization and NETL) working in partnership with five energy research universities.

A primary goal of I-WEST is to build a regional coalition, which will ultimately be needed to facilitate the development and rapid deployment of new energy technologies required to achieve carbon neutrality while building a new economic base. I-WEST aims to explore a regional strategy for transitioning the intermountain western U.S. (Arizona, Colorado, Montana, New Mexico, Utah and Wyoming) to a carbon-neutral energy economy. Options to be assessed include technology pathways related to the intersections between the capture, utilization and storage of CO_2; production of sustainable power (fossil and renewable); generation and utilization of hydrogen; and production of sustainable, carbon-neutral fuels and feedstocks. A timeline of 15 years has been targeted for the completion of the energy transition.

Work advanced as part of I-WEST will assess additional factors to be developed to ensure an effective regional strategy, including implications for workforce, regional economy and environmental and social justice. The effort will also engage a broader set of perspectives from regional stakeholders through a series of interviews and workshops. A public report is expected to be released in the summer 2022 timeframe detailing technology pathways and timelines that will support carbon neutrality within the region.

SSAE Working to Advance SMART Initiative

SSAE continues to play an active role in the Science-informed Machine Learning for Accelerating Real-Time Decisions in Subsurface Applications (SMART) Initiative. SMART is a 10-year, multi-organizational effort with the goal of transforming interactions within the subsurface and significantly improving efficiency and effectiveness of field-scale carbon storage and unconventional oil and gas operations.

Through the application of science-based machine learning and data analytics, the initiative is designed to enable real-time visualization of key subsurface features and flows and transform how people interact with subsurface data. Other goals include creating technologies for rapid prediction of reservoir behaviors.

Under SMART Initiative Task 5 (real-time forecasting for optimizing CO_2 storage), SSAE researchers have developed fast and accurate deep learning 2D and 3D models for simulating CO_2 saturation, plume pressure and production rates for CO_2 storage and brine production.

SSAE is also supporting SMART Initiative Task 7 (real-time forecasting for pressure management) in conjunction with researchers at LANL. As the lead on Task 7, LANL researchers have developed a physics-informed machine learning (PIML) framework that allows for history matching and rapid forecasting in unconventional reservoirs. SSAE is leveraging a previously developed Office of Fossil Energy and Carbon Management (FECM)/NETL Unconventional Shale Well Economic Model within the PIML workflow to complete a robust techno-economic analysis and support real-time decisions to optimize production and economic rates of return from unconventional hydrocarbon reservoirs. Using outputs from the PIML tool, SSAE has analyzed the economic implication of different drawdown strategies in unconventional gas wells.

NETL support contractors **Derek Vikara** and **Kolawole Bello** presented SMART Initiative Task 7 efforts at the virtual 2021 SMART Initiative Annual Technical Meeting held October 5-7, 2021. Derek presented a deep dive on enhancing decision support in unconventional oil and gas wells through techno-economic analysis of pressure drawdown production strategies and the potential for leveraging FECM/NETL's carbon capture and storage economic tools in phase 2 of the SMART Initiative for decision support, where the focus is to 1) demonstrate virtual learning in action to support CO_2 storage regulators and stakeholders and 2) deploy and test machine learning-assisted workflows at one to three CO_2 storage field projects. Kolawole presented the economic implications of varied pressure drawdown strategies generated through a real-time, fast predictive, multi-fidelity model for unconventional oil and gas wells.

SSAE Researchers Investigate Dry Cooling Retrofits in a Water-Stressed Region

A newly released manuscript, "Dry cooling retrofits at existing fossil fuel-fired power plants in a water-stressed region: Tradeoffs in water savings, cost and capacity shortfalls," by Haibo Zhai, Edward Rubin, **Eric Grol**, **Andrew O'Connell**, Zitao Wu and **Eric Lewis** will be featured in the January 2022 issue of *Applied Energy*. This study investigates the performance, cost and generating capacity impacts of switching from wet to dry cooling systems to reduce the consumptive water use at existing fossil fuel-fired power plants in a water-stressed region.

Based on regional averages, retrofitting dry cooling systems in lieu of wet cooling towers decreases total annual plant water consumption at existing coal- and gas-fired power plants by 93% and 100%, respectively, while increasing the levelized cost of electricity generation by approximately 12% and 18%, respectively. Over the course of a year, the change in monthly net regional generating capacity from dry cooling retrofits exhibits a seasonal pattern, with the largest shortfalls occurring in July. The average monthly reduction in net capacity is estimated at 0.7% and 1.2% of the regional nameplate capacity for coal- and gas-based plants, respectively. Dry cooling retrofits thus lead to tradeoffs in water savings, cost and capacity shortfalls, which vary with power plant characteristics.

// NOTICES

SSAE Researchers Present at LCA Conference

Several SSAE professionals, including Federal and NETL support contractor staff, discussed their research at the 2021 American Center for Life Cycle Assessment (ACLCA) Virtual Conference held September 21-24, 2021.

This event allowed innovators within the LCA community to learn, collaborate and create the future of LCA and life cycle thinking. Below is a summary of the presentations.

- "U.S. DOE Special Session: National Energy Technology Laboratory LCA Update," given by **Matt Jamieson**, was part of a special session in which laboratories within the U.S. DOE provided summaries of LCA-related work over the past year and previewed upcoming work.
- "Life Cycle Assessment of Emerging Technologies: Current State, Challenges and Recommendations," co-presented by NETL support contractor **Sheikh Moni**, highlighted NETL's collaboration with a diverse group of LCA experts as part of the Society of Toxicology and Environmental Chemistry North American-ACLCA LCA Working Group to understand the state of the art in LCA for emerging technologies, identify limitations and gaps in current LCA techniques and develop a roadmap to enable LCA of emerging technologies to better serve decision-making. This special session served as a progress update and elicitation of input from the audience, which included a mix of LCA practitioners, technology developers and funders or other stakeholders who rely on LCA to inform decision-making.
- "Accounting for Methane Emission Variability from Natural Gas Distribution Meters" was presented by NETL support contractor **Srijana Rai** and covered recent work by NETL's natural gas LCA team on transmission and distribution stages of the natural gas supply chain. The team enhanced the previous NETL life cycle natural gas model by connecting the production and delivery locations and showing the life cycle results for six U.S. regions instead of a U.S. aggregate. Results from this work and how the team's approach enables the development of scenarios that show how emissions change depending on the origins and destinations of natural gas were discussed. The discussion also briefly touched on how different stakeholders' needs and questions can be answered by inventory vs. LCA methods of emissions accounting.

SSAE 45Q Assessment Efforts to be Discussed at USAEE

"45Q Tax Credit Impacts on Carbon Management Costs: Case Study Finding and Modeling Developments" will be presented by NETL support contractor **Travis Warner** at the 38th Annual USAEE/IAEE North American Conference to be held November 1–2, 2021.

The presentation will cover Section 45Q carbon oxide sequestration tax credit (45Q) eligibility and monetization considerations, tax equity partnerships, the results of NETL assessments of 45Q's impact on carbon management costs and a preview of NETL's 45Q Tax Credit Monetization Model. NETL's efforts to assess the impact of 45Q on carbon management costs for natural gas and coal-fired power plants align with the conference's focus on the interaction of energy economics with businesses, consumers, technology developers and public policy institutions worldwide.

Congratulations Justin Adder

Justin Adder was recently named Supervisory Economist for SSAE's Energy Markets Analysis Team. With nearly 17 years of federal experience, Justin has followed energy and financial markets, as well as statistical and industry data, in order to extend knowledge and offer insight on current and emerging trends within the fossil fuel extraction, delivery and utilization sectors, specifically the natural gas, liquids and oil industries. In addition to his duties as the Contracting Officer Representative for the Energy Market Finance & Technology Deployment Analysis SubCLIN, he has dedicated much of his time to understanding and addressing natural gas and electric power interdependencies and the associated infrastructure build-out.

Prior to joining NETL in 2010, Justin worked for the Federal Energy Regulatory Commission (FERC) in Washington, D.C., where he was responsible for analyzing data in natural gas and oil pipeline tariff filings to resolve economic issues and determine compliance with the FERC rules, regulations, rates and policies. Justin earned his master's degree in business administration with a concentration in finance from The George Washington University and received his bachelor's degree in economics and accounting from Washington and Jefferson College

SSAE Welcomes Eric Lewis

Eric Lewis is joining SSAE's Energy Process Analysis Team. Eric's journey into fossil energy research began at Penn State University's Energy Institute where he worked as a student researcher within the institute's Coal Utilization Laboratory. After graduating with his bachelor's degree in chemical engineering, he returned to his hometown and joined NETL at the Pittsburgh site in 2008 as a site support contractor. Between 2008 and 2011, Eric performed techno-economic analyses on numerous fossil-based advanced energy systems before transitioning to the private sector where he held engineering project management and process engineering roles in the coal chemicals and midstream natural gas industries. In 2015, Eric rejoined NETL to continue supporting DOE's mission as a site support contractor and has since led numerous analyses focused on hydrogen production, gasification systems, advanced power plant cooling technologies and advanced ultra-supercritical steam cycles. In addition to spending time with his wife Nicole and daughters Violet and Elliana, he enjoys Penguins hockey, playing guitar and working on home projects.

// SSAE CORE CAPABILITIES

Energy Process Analysis at NETL

The mission of the NETL SSAE Directorate's design, process and cost engineering (energy process analysis) capability is to establish and maintain world-class competencies in unit- and plant-level process and cost engineering analyses to benefit stakeholders with diverse interests and objectives, from DOE to commercial developers, institutions of higher learning, and research and development (R&D) organizations, including NETL's own Research and Innovation Center.

Energy process analysis supports both intramural and extramural NETL R&D, spanning the technology readiness spectrum. A primary focus is effectual support and guidance for the lab's existing research portfolio. Support of the future portfolio, through the identification of new energy conversion concepts and development of insight on the potential of new technology ideas, is another critical function. Energy process analysis 1) provides bases for the evaluation of external techno-economic analyses, technology maturation plans, technology readiness assessments, etc., 2) supports strategic planning, portfolio analysis and program evaluation efforts and 3) provides rapid-response analyses for NETL and DOE's FECM.

The primary objective of performance and cost estimates is the evaluation of the potential benefits of advanced technologies relative to state-of-the-art commercial alternatives, thereby providing detailed performance and cost guidance at the process level to researchers. The standardization of analytic methodologies, feedstock, ambient conditions, financial assumptions, generic site characteristics, etc. across the portfolio of analyses facilitates this comparison. Core functions include steady-state process and cost analysis; standards, tools and database development; and stakeholder engagement. SSAE has expertise in conducting engineering analysis on many technologies, including carbon capture technologies, fuels and chemicals production, solid fuel combustion and gasification technologies, solid oxide fuel and electrolysis cells, energy storage, combustion turbines and supercritical CO_2-based power cycles.

The team executes process- and plant-level performance and cost model development and analyses, including those incorporating novel energy conversion, energy storage and/or environmental control technologies. These analyses may address single technologies or the integration of multiple technologies. Process analyses are generally conducted through steady-state process modeling and simulation using commercial process modeling software (e.g., ASPEN, Thermoflow, and ChemCAD) augmented in some cases with user-defined models. Capital cost estimation is typically conducted at the Association for the Advancement of Cost Engineering Class 4 and Class 5 levels, making use of vendor quotes and commercial cost estimation software (e.g., ASPEN Activated Economics).

High-profile energy process analysis products include the highly referenced "Cost and Performance of Fossil Energy Plants" report series (commonly referred to as "Baseline Studies" and listed below). These reports present an independent assessment of the cost and performance of select commercial fossil power technologies and systems such as integrated gasification combined cycle, pulverized coal and natural gas combined cycle plants. The analyses supporting these report volumes utilize a systematic, transparent and comprehensive, technical and economic approach. Cases studied include those with and without carbon capture, providing critical cost information on reducing carbon emissions. The cost and performance of fossil fuel-based generation technologies represented in these reports are essential inputs to assessments and determinations of technology combinations that meet projected demands of future power markets. In addition to informing technology comparisons, the reference plant configurations found in these reports provide perspective for regulators and policy makers. From an R&D perspective, these reports are used to assess goals and metrics and to provide a consistent basis for comparing developing technologies.

- Volume 1: Bituminous Coal and Natural Gas to Electricity
- Volume 1 Supplement: Sensitivity to CO_2 Capture Rate in Coal-Fired Power Plants
- Volume 2: Coal to Synthetic Natural Gas and Ammonia
- Volume 3: Low-Rank Coal to Electricity
- Volume 4: Coal-to-Liquids via Fischer-Tropsch Synthesis

Additionally, SSAE develops and maintains standards, tools and databases to support the efficient, timely execution of high-quality technoeconomic analyses, including those carried out by external entities. For example, the Quality Guidelines for Energy Systems Studies (QGESS) report series establishes methodologies and assumptions used to ensure transparency, consistency and comparability among baseline and advanced technology studies. A selection is listed below; search for others. Studies reference the Baseline and QGESS reports for common design basis and methodology matters, thereby permitting a particular report to be succinct and focused on the matter at hand. SSAE also maintains an up-to-date suite of commercial and custom process simulation tools and capital cost estimation capabilities, and expertise in their application.

- Cost Estimation Methodology for NETL Assessments of Power Plant Performance
- Capital Cost Scaling Methodology
- Detailed Coal Specifications
- Carbon Dioxide Transport and Storage Costs in NETL Studies
- Process Modeling Design Parameters
- Specification for Selected Feedstocks
- Performing a Techno-Economic Analysis for Power Generation Plants

// SSAE CORE CAPABILITIES (cont'd)

Work is disseminated through NETL-published reports, peer-reviewed journal manuscripts and conference papers/presentations. SSAE also publishes analytical tools and models such as the Carbon Capture Retrofit Databases (CCRD):

- Pulverized Coal CCRD
- Natural Gas Combined Cycle CCRD
- Industrial Sources CCRD

SSAE's energy process analysis capability is of paramount importance, providing a wide array of analytical engineering support and performance and cost assessment and defining programmatic goals and objectives. Working in direct collaboration with stakeholders, the analysis provided is tailored to meet the specific requirements of a diverse group of stakeholders, including policy makers, FECM programmatic leadership, commercial developers and the broad scientific and engineering community. Such guidance is critical to ensuring an environmentally sustainable and prosperous energy future, in direct alignment with NETL and DOE's mission.– Contributed by **Gregory Hackett**, SSAE's Energy Process Analysis Team

// UPCOMING

SSAE Federal staff and NETL support contractor personnel will attend or present at the following meetings and conferences in October and November 2021:

- Society of Exploration Geophysicists (SEG)/American Association of Petroleum Geologists (AAPG) International Meeting for Applied Geoscience & Energy (IMAGE) 2021
  Timothy Grant (presenter) —Comparative Analysis of CO_2 Transport, Storage, and Produced Water Management Options from a CO_2 Source Perspective
  Hybrid (Virtual and Denver, CO), September 26–October 1, 2021
- EPRI Generation Virtual Advisory Meeting
  Timothy Fout, **Eric Grol**, **Robert James** and **Chuck White** (participants)
  Virtual, September 27–October 7, 2021
- Global Syngas Technologies Conference
  Eric Lewis and **Robert Stevens** (participants)
  San Antonio, TX, October 10–12, 2021
- Energy Bar Association 2021 Mid-Year Energy Forum
  Peter Balash (presenter)
  Virtual, October 12–13, 2021
- 23rd Annual Experience Power Conference
  Sarah Leptinsky and **Alexander Zoelle** (participants)
  San Antonio, TX, October 18–21, 2021
- 6th Post Combustion Capture Conference (PCCC-6)
  Alexander Zoelle (participant)
  Virtual, October 19–21, 2021
- 38th Annual USAEE/IAEE North American Conference
  Travis Warner (presenter)
  Peter Balash, **Christopher Nichols** and **Gavin Pickenpaugh** (participants)
  Virtual, November 1–2, 2021
- 6th Low Emission Advanced Power (LEAP) Workshop
  Travis Shultz (presenter)
  Virtual, November 1–5, 2021
- 2021 AIChE Annual Meeting
  Chad Able (presenter)
  Dale Keairns (participant)
  Hybrid (Virtual and Boston, MA), November 7–11 (Boston, MA) and 15–19 (virtual), 2021
- 2021 International Water Conference (IWC)
  Marc Turner (participant)
  Scottsdale, AZ, November 7–11, 2021

// CONFERENCES AND EVENTS

- SEG/AAPG, International Meeting for Applied Geoscience and Energy (IMAGE) 2021
  Hybrid (Virtual and Denver, CO), September 26–October 1, 2021
- EPRI, Generation Virtual Advisory Meeting
  Virtual, September 27–October 7, 2021
- Wood Mackenzie, 2021 Global Energy Summit
  Virtual, September 28–October 8, 2021
- 50th Annual Eastern Section AAPG Meeting
  Hybrid (Virtual and Pittsburgh, PA), October 2–6, 2021
- AAPG Midcontinent Section Meeting 2021
  Tulsa, OK, October 3–5, 2021
- 2021 UCFER Annual Technical Review Meeting
  Virtual, October 5–6, 2021
- SPE, Annual Caspian Technical Conference
  Virtual, October 5–7, 2021
- American Society of Mechanical Engineers (ASME), Advanced Manufacturing & Repair for Gas Turbines
  Virtual Symposium, October 5–8, 2021
- IAEE, The Role of Fundamentals and Policy in New Zealand's Carbon Prices
  Webinar, October 6, 2021
- U.S. Department of Energy, Identifying and Understanding National Energy Storage Workforce Gaps
  Virtual, October 6, 2021
- AIChE, 3rd Battery and Energy Storage Conference
  Virtual, October 6–8, 2021
- ASCE 2021 Convention
  Virtual, October 6–8, 2021
- GR/SPE, High-Temperature Well Cementing Workshop Part II
  San Diego, CA, October 7–9, 2021
- 2021 Global Syngas Technologies Conference
  San Antonio, TX, October 10–12, 2021
- The Geological Society of America®, Connects 2021
  Portland, OR, October 10–13, 2021
- IAEE, Electricity Markets Assessment: Europe & the U.S.
  Webinar, October 11, 2021
- Energy Bar Association 2021 Mid-Year Energy Forum
  Virtual, October 12–13, 2021
- SPE/IATMI, Asia Pacific Oil & Gas Conference and Exhibition
  Virtual, October 12–14, 2021
- Reuters Events, Downstream USA 2021
  Hybrid (Virtual and Houston TX), October 12–15 (digital conference) and 21–22 (conference & exhibition), 2021
- SPE, Russian Petroleum Technology Conference
  Virtual, October 12–15, 2021
- Wood Mackenzie, LME Forum 2021
  Virtual, October 13, 2021
- Reuters Events, Offshore & Floating Wind Europe Conference & Exhibition
  Virtual, October 13–14, 2021
- Wood Mackenzie Focus: Market and Scalability Opportunities for Carbon Capture, Utilization & Storage
  Virtual, October 14, 2021
- IAEE, Trucking: The Potential and the Pitfalls of Decarbonizing Big Rigs
  Webinar, October 18, 2021
- IEA, WEO Week: Hopes for COP26 and beyond
  Virtual, October 18, 2021
- SPE, Artificial Intelligence - Towards a Resilient and Efficient Energy Industry
  Virtual Symposium, October 18–19, 2021
- 23rd Annual Experience Power Conference
  San Antonio, TX, October 18–21, 2021
- EAGE 82nd Annual Conference & Exhibition 2021
  Amsterdam, Netherlands, October 18–21, 2021
- IEA, WEO Week: Energy security in transition: orderly or disorderly?
  Virtual, October 19, 2021
- USEA CONSENSUS Webinar: Beyond Boundary Dam – What's Next For CCS in Canada and the International CCS Knowledge Centre
  Webinar, October 19, 2021
- IEA, 8th Annual EPRI-IEA Workshop Challenges in Decarbonisation: Building a Resilient Net-Zero Future
  Webinar, October 19–21, 2021
- UK CCS Research Centre, 6th Post Combustion Capture Conference (PCCC-6)
  Virtual, October 19–21, 2021
- ACEEE, 2021 National Conference on Energy Efficiency as a Resource
  Virtual, October 19–21 and 26–27, 2021
- AIChE, Carbon Capture, Transport and Sequestration: Rigorous Electrolyte Chemistry Based Process Simulation
  Webinar, October 20, 2021

// CONFERENCES AND EVENTS
(cont'd)

- Columbia University SIPA Center on Global Energy Policy, Exploring an Uncertain Energy Future: Equinor Energy Perspectives 2021
  Virtual, October 20, 2021
- IEA, WEO Week: Electricity sector transitions: policy and finance
  Virtual, October 20, 2021
- Japan-Asia CCUS Forum 2021
  Virtual, October 20, 2021
- U.S. Department of Energy - Office of Fossil Energy & Carbon Management's Division of Minerals Sustainability Multi-Year Program Plan Rollout
  Webinar, October 20, 2021
- Carbon Capture Technology Expo Europe
  Messe Bremen, Germany, October 20–21, 2021
- Naftogaz Group, Ukraine Gas Investment Congress
  Kyiv, Ukraine, October 20–21, 2021
- IEA, Energy Efficiency and Economic Recovery after COVID-19
  Webinar, October 21, 2021
- IEA, WEO Week: Sectoral transitions to new energy industries
  Virtual, October 21, 2021
- Wood Mackenzie, North America natural gas winter outlook 2021
  Webinar, October 21, 2021
- IEA, WEO Week: How can social and economic dimensions be core elements of transitions?
  Virtual, October 22, 2021
- USEA Virtual Press Briefing: Natural Gas – The Essential Grid Stabilizer
  Virtual, October 22, 2021
- Verge, The Climate Tech Event
  Virtual, October 25–28, 2021
- Carbon Capture, Utilization and Sequestration: A State Comparison of Technical and Policy Issues
  Virtual, October 26, 2021
- Asia Clean Energy Summit Conference & Exhibition
  Hybrid (Virtual and Singapore), October 26–28 (conference) and 26–27 (exhibition), 2021
- SPE, Sand Control and Management – Converting Past Failures and Learnings into Future Success
  Virtual Workshop, October 26–28, 2021
- SPE, Reservoir Simulation Conference
  On-demand recorded presentations, October 26–November 1, 2021
- SPE, Haynesville Basin, the Next Chapter in Unconventionals – Learning from the Past and Opportunities for the Future
  Virtual Forum, October 26–28 and November 2–4, 2021
- IAEE, Modeling Infrastructure Risk Under Future Climate Scenarios
  Webinar, October 27, 2021
- 71st Annual Gulf Coast Geoscience Convention (GeoGulf 2021)
  Austin, TX, October 27–29, 2021
- U.S. Department of Energy, Building Solutions to Address the National Energy Storage Workforce Needs
  Virtual, October 28, 2021
- USEA, 13th Annual Energy Supply Forum
  Virtual, October 28, 2021
- Wood Mackenzie, North American LNG winter outlook 2021
  Webinar, October 28, 2021
- Wood Mackenzie, The Petroleum Industry Act: a gamechanger for Nigeria's upstream?
  Webinar, October 28, 2021
- Wood Mackenzie Focus: U.S. Market Opportunity for Flex Services and Impacts of FERC 2222
  Webinar, October 28, 2021
- IEA, Evaluating the impacts of energy innovation policies
  Webinar, October 29, 2021
- 26th UN Climate Change Conference of the Parties (COP26)
  Glasgow, Scotland, October 31–November 12, 2021
- USAEE/IAEE, 38th Annual North American Conference
  Virtual, November 1–2, 2021
- 6th Low Emission Advanced Power (LEAP) Workshop
  Virtual, November 1–5, 2021
- SPE, 2021 Eastern Regional Meeting
  Farmington, PA, November 2–3, 2021
- SPE Workshop: Optimizing the Near Wellbore Region – Technologies, Procedures and Best Practices to Enable Successful Completions
  Scottsdale, AZ, November 2–3, 2021
- 3rd EAGE/SPE Geosteering Workshop
  Virtual, November 2–4, 2021
- Wood Mackenzie, Solar Series
  Virtual, November 2–December 7, 2021
- IAEE, Electric Vehicles Diffusion Challenges
  Webinar, November 3, 2021

// CONFERENCES AND EVENTS
(cont'd)

- IEA, Digitalisation for optimising integrated district heating systems
  Webinar, November 3, 2021
- Wood Mackenzie, Energy Storage Series
  Virtual, November 4–December 8, 2021
- 2021 AIChE Annual Meeting
  Hybrid (Virtual and Boston, MA), November 7–11 (Boston, MA) and 15–19 (virtual), 2021
- 2021 International Water Conference (IWC)
  Scottsdale, AZ, November 7–11, 2021
- IAEE, Can't Give It Away – Negative Energy Pricing
  Webinar, November 8, 2021
- 2021 University Turbine Systems Research (UTSR) Project Review Meeting
  Virtual, November 8–10, 2021
- Africa Oil Week
  Dubai, United Arab Emirates, November 8–11, 2021
- SPE Workshop: Montney and Duvernay - the Heart and Soul of Canadian Unconventionals
  Calgary, Alberta, Canada, November 9–10, 2021
- SPE, Asia Pacific Digital Week - Enhancing the Energy Value Chain through Innovation and Digital Ecosystem
  Virtual Workshop, November 9–11, 2021
- AAPG, Latin America and Caribbean Region Energy Opportunities 2021 Conference
  Virtual, November 10–12, 2021
- H_2-CCS Network, Hydrogen & Carbon Capture Conference
  Canonsburg, PA, November 11, 2021
- 39th NAPE Annual International Conference & Exhibition
  Hybrid (Virtual and Lagos, Nigeria), November 14–18, 2021
- IAEE, Innovation & Disruption in the Electricity Sector: What Future for Markets?
  Webinar, November 15, 2021
- SPE, The Abu Dhabi International Petroleum Exhibition & Conference (ADIPEC)
  Abu Dhabi, United Arab Emirates, November 15–18, 2021
- SPE, Hydrogen's Role in Fuelling the Energy Transition
  Virtual Workshop, November 16–17, 2021
- 22nd Annual Solid Oxide Fuel Cell (SOFC) Project Review Meeting
  Virtual, November 16–18, 2021
- SPE/AAPG/SEG Asia Pacific Unconventional Resources Technology Conference
  Virtual, November 16–18, 2021
- U.S. Department of Energy, Measuring Success and Impact on National Energy Storage Workforce Solutions
  Virtual, November 17, 2021
- IAEE, How Much More Electricity is Needed for Decarbonization? Drivers and Impacts in New York
  Webinar, November 22, 2021
- SPE, Next Generation Drilling
  Virtual Workshop, November 23–24, 2021
- SPE Eastern Europe Subsurface Conference
  Kyiv, Ukraine, November 23–24, 2021
- AAPG, High CO_2, High Contaminant Challenging Fields and Alternative Energy - Impact and Monetization: Asia Pacific Region
  Virtual, November 23–25, 2021
- SPE, Joint Industry Solutions Series - Reducing Carbon Footprint in Drilling Operations
  Virtual Workshop, November 23–25, 2021
- 3rd Edition - AAPG/EAGE Hydrocarbon Seals of the Middle East
  Virtual, November 28–December 2, 2021
- SPE, Thermal Well Integrity and Design Symposium
  Banff, Alberta, Canada, November 29–30, 2021
- AAPG Europe Workshop in Carbon Capture and Storage (CCS)
  Virtual, November 29–December 2, 2021
- Reuters Events, Hydrogen North America
  Virtual, November 30–December 1, 2021
- SPE Workshop: Intelligent and Advanced Wellbore Technologies
  Banff, Alberta, Canada, November 30–December 1, 2021
- SPE, Decommissioning and Abandonment
  Virtual Symposium, November 30–December 2, 2021

// RECENT PUBLICATIONS

Manuscripts

H. Zhaia, E. Rubin, **E. Grol**, **A. O'Connell**, Z. Wua and **E. Lewis**, "Dry cooling retrofits at existing fossil fuel-fired power plants in a water-stressed region: Tradeoffs in water savings, cost, and capacity shortfalls," *Applied Energy*, vol. 306, part A, January 2022.

Conference Proceedings and Events

T. Grant, "Examining Possible CCS Deployment Pathways: Onshore and Offshore (FWP-1022464)" presentation at DOE-NETL's 2021 Carbon Management and Oil and Gas Research Project Review Meeting – Carbon Storage, Virtual, August 6, 2021.

// REFERENCE SECTION

Models / Tools

- FE/NETL CO_2 Transport Cost Model
- FE/NETL CO_2 Storage Cost Model
- FE/NETL CO_2 Prophet Model
- FE/NETL Onshore CO_2 EOR Cost Model
- Life Cycle Analysis Models
- IDAES Power Generation Model Library

Key Reports

- Baseline Studies for Fossil Energy Plants
- Quality Guidelines for Energy Systems Studies
- Life Cycle Analysis

- SSAE website
- Search for other SSAE products
- Institute for the Design of Advanced Energy Systems webpage
- Life Cycle Analysis webpage

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