

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.

// HIGHLIGHTS

Hackett Co-chairs Session at SOFC Symposium



NETL expertise in energy conversion engineering was highlighted at the recent 17th International Symposium on Solid Oxide Fuel Cells (SOFC-XVII) when NETL SOFC Technical Portfolio Lead **Gregory Hackett** co-chaired the “Cell, Stack and System Modeling and Simulation” session.

“Being selected for this opportunity recognizes NETL’s influence in this technical space, and it was rewarding to network and discuss innovation in this technology area that is critical for meeting clean energy goals,” said Greg, a member of SSAE’s Energy Process Analysis Team. [Learn more.](#)

SSAE Study Basis for Geologic Storage Article

A JD Supra article published in July 2021 used content from a 2019 SSAE study featuring information regarding historical and current underground natural gas (NG) storage operations that may directly or indirectly relate to carbon dioxide (CO₂) geologic storage in saline-bearing formations.

In their study, “[Underground Natural Gas Storage – Analog Studies to Geologic Storage of CO₂](#),” SSAE researchers noted that the extensive operational history of underground NG storage provides significant knowledge and insights from which CO₂ storage stakeholders can benefit. Furthermore, the underground NG storage industry provides case studies that can be used to mitigate leakage concerns, which is essential to gain public confidence in large carbon storage projects.

JD Supra’s newly released article, [Comparing Underground Natural Gas Storage With Deep Saline Injection of Carbon Dioxide](#), stated that underground NG remains an important and useful analog as CO₂ storage transitions to large-scale deployment to meet the nation’s decarbonization goals.

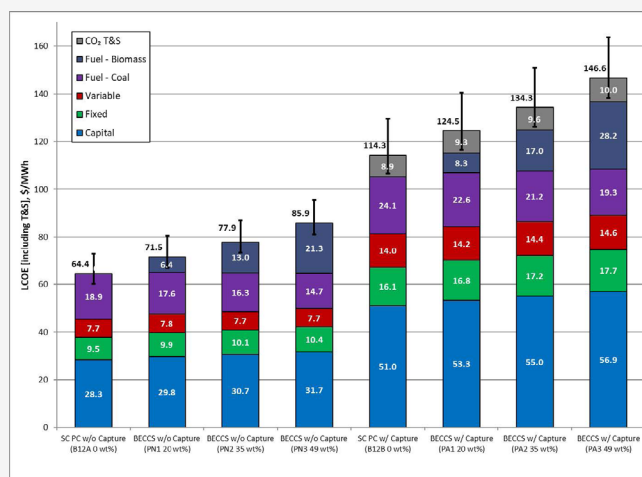
NETL/SSAE Data and Support Aids NREL Baseline

NETL/SSAE played important roles in the development of the National Renewable Energy Laboratory’s (NREL) [2021 Annual Technology Baseline \(ATB\)](#), which provides technology cost and performance data to inform U.S. energy analysis, and in turn, help utility planners and grid operators answer new and emerging questions about the evolving U.S. power system. NETL/SSAE data was used in the ATB, and NETL/SSAE support was leveraged for the F-class combustion turbine case preparation.

Data from the ATB is used widely with NREL’s Standard Scenarios to explore possible pathways for U.S. electric sector evolution over time based on ATB and other assumptions. [Learn more.](#)

SSAE Study Highlights BECCS

A newly released study, “[Technoeconomic and Life Cycle Analysis of Bio-Energy with Carbon Capture and Storage \(BECCS\) Baseline](#),” by **Kyle Buchheit, Eric Lewis, Kishore Mahbubani** and **Derrick Carlson** examines the performance, environmental impact and economics of co-firing biomass in pulverized coal (PC) power plants.



LCOE from BECCS baseline study

BECCS is an attractive option from an environmental standpoint, as biomass regrowth removes atmospheric CO₂, offsetting emissions produced by burning the biomass. Combined with carbon capture, this technology is capable of zero/negative greenhouse gas emissions.

The study’s analysis is based on various plant configurations using hybrid poplar biomass at three co-fire levels with Illinois No. 6 coal. Overall performance and economics of the plant are used to determine the levelized cost of electricity (LCOE) (shown in the figure above) and perform a full environmental life cycle analysis (LCA) of greenfield PC plants co-firing biomass.

IECM Receives Prestigious Award

The [Integrated Environmental Control Model \(IECM\)](#), developed through an NETL-Carnegie Mellon University (CMU) partnership to analyze power plant performance and costs of emission control equipment, earned the prestigious Outstanding Research Award from CMU’s College of Engineering.

This honor is especially gratifying considering the number of significant projects and impactful research completed through the College of Engineering.

Widely used and cited by organizations and individuals worldwide, the IECM has results of many NETL-sponsored studies in its framework and has allowed engineers, policy makers, and researchers to systematically assess the performance, risks and potential payoffs of different advanced emission control options while also supporting the education and training of engineering students and researchers.

// NOTICES

Wijaya Invited to Present Topic Relevant to NETL Research



Nur Wijaya, an NETL support contractor supporting subsurface analysis for SSAE's Energy Systems Analysis Team, was invited to present his research on "Impact of Shut-in and Surfactant on Shale Oil Production: Analysis on

Wettability and Recovery Driving Mechanism" to the Society of Petroleum Engineers Student Chapter of King Fahd University of Petroleum & Minerals in Saudi Arabia.

Although his work was not performed under NETL efforts, it provides knowledge on a topic relevant to NETL research interests.

During the June 2021 virtual presentation, Nur addressed undergraduates, graduate students and faculty on his research, which focused on efforts to mitigate formation damage in shale reservoirs during unconventional oil and gas well completion through hydraulic fracturing. [Learn more.](#)

Learn About Tax Credits for Carbon Management



At the virtual [38th International Pittsburgh Coal Conference](#), which is set for Sept. 20-23, 2021, **Travis Warner**, an NETL support contractor supporting subsurface analysis for SSAE's Energy Systems Analysis Team, will discuss "Section 45Q Tax Credit Impacts on Carbon Management: Case Study Findings and Modeling Developments."

Warner's presentation will cover Section 45Q carbon

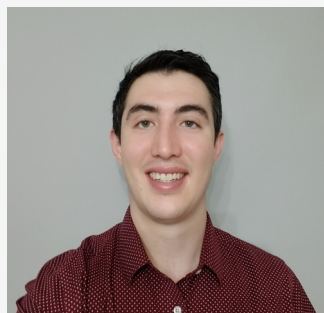
oxide sequestration tax credit eligibility and monetization considerations, tax equity partnerships, results of previous NETL assessments of 45Q's impact on carbon management costs and a preview of NETL's 45Q Tax Credit Monetization Model.

Focused on coal utilization and carbon management, the conference is an appropriate venue to present NETL's efforts to assess the impact of Section 45Q tax credits on carbon management costs for coal-fired power plants and other CO₂ sources.

Welcome Matthew Jamieson and Timothy Bartholomew to SSAE



SSAE welcomes two new team members. **Matthew Jamieson** (left) is joining the Research and Innovation Center (RIC) under SSAE's Energy Systems Analysis Team. He has been working as an NETL site support contractor for nine years, most recently supporting SSAE under the LCA competency. During his time at NETL, Matt has performed analyses in several areas including coal and natural gas power plants, CO₂-EOR and coal and biomass gasification to liquids systems. He also has built or contributed to a number of models and tools for the LCA team and public including the Power Plant Flexible Model, CO₂-EOR Life Cycle Model and most recently the Python-based electricity baseline. Prior to NETL, Matt supported nuclear plant operators on aircraft carriers at the Bettis Atomic Power Laboratory and served in the U.S. Army for six years as a helicopter electrical systems and weapons technician. He has a bachelor's degree in mechanical engineering from the University of Minnesota at Duluth.



Timothy Bartholomew (left) is joining RIC under SSAE's Process Systems Engineering Research Team. Tim's experience in developing advanced process systems engineering tools and assessing the technoeconomic viability of emerging water treatment technologies will

be a valuable addition to the team. Tim has been working as an NETL site support contractor supporting the Institute for the Design of Advanced Energy Systems. Tim holds a bachelor's degree in chemical engineering from Washington University in St. Louis, Missouri and a Ph.D. in civil and environmental engineering from CMU.

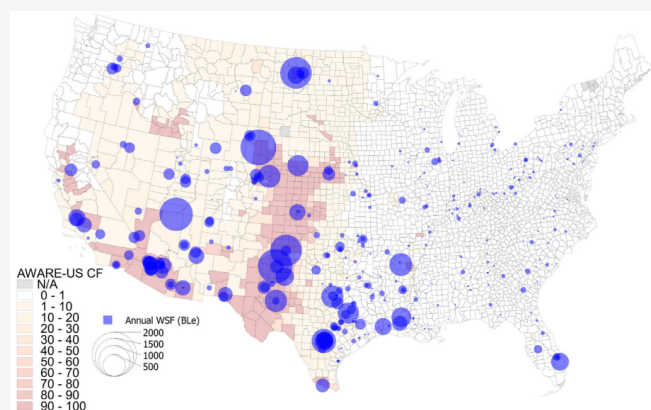
// PERSPECTIVES

SSAE Water Research Efforts

Reducing water use and consumption is a pillar of the Office of Fossil Energy and Carbon Management's environmental stewardship thrust. In support of NETL's water research, SSAE analyses touch nearly all facets of water management including evaluation of the regional impact of fossil power generation on water availability, costs and benefits of technology deployment (such as dry cooling) on fossil generation in water-constrained areas and public benefits of successful government R&D on select water technologies. PC and NG combined cycle (NGCC) power plants must reject waste heat, which is generally accomplished using water-based cooling systems. Regional water authorities need to balance demand with other use sectors (industrial, residential and agricultural) in conditions of sometimes tight supply. Many combustion by-products end up in discharge water streams, which require treatment before they can be safely returned to their sources. A few of SSAE's steps in assessing aspects of water management are highlighted below.

Water Stress Analysis of U.S. Thermoelectricity

In partnership with Argonne National Laboratory (ANL), NETL integrated thermoelectric cooling water data into the Available Water Remaining for the United States (AWARE-US) Model to understand water scarcity for management at the county level. This work can target power plants or regions where water cooling technology upgrades could be most beneficial in reducing water scarcity and thermoelectric cooling water-induced water stress. Analysis on a monthly basis allows for seasonal tracking of water scarcity footprints. The model is flexible to help project how future retirements and planned additions may impact water scarcity as well as the water impacts of the addition of carbon capture systems.



Annual water scarcity footprints by water consumption of U.S. thermoelectric power plants

This work was published in the *Journal of Cleaner Production* as “[Regional and Seasonal Water Stress Analysis of United States Thermoelectricity](#)” on October 10, 2020. NETL and ANL held a free webinar on October 20, 2020 to disseminate this open-access publication and advertise the features and results of modeling.

Thermoelectric Power Plants Water Use and Technology Benefits Model

SSAE's Thermoelectric Power Plants Water Use and Technology Benefits Model (update in progress) estimates water withdrawal and consumption at the U.S. national and regional levels. Freshwater requirements for thermoelectric generation are estimated in four cases using U.S. Energy Information Administration's Annual Energy Outlook data for regional projections of capacity additions and retirements. The cases are business as usual, dry cooling additions, saline water alternative and cooling tower retrofit. The model shows that nationally, thermoelectric water withdrawals will continue to decrease over time; however, water consumption will increase, and these changes in withdrawal and consumption vary by region.

The model also quantifies the water-saving benefits of NETL technologies funded by Water Management R&D, including those related to External Alternative Water Sources, Internal Water Sources, Plume Abatement, Condenser Coatings and Enhanced Cooling Towers (such as dry cooling systems). Results show that at a 50% market penetration of such technologies, water withdrawals and consumption would be reduced by 603 and 154 billion gallons per year, respectively.

Regional Analysis of Dry Cooling Technology Deployment

A techno-economic analysis using the Thermoelectric Power Plants Water Use and Technology Benefits Model examines dry cooling systems. Such systems eliminate the use of water for nearly all power plant cooling and are a key technology in achieving the goal of significantly reducing the water footprint for fossil power generation (whether based on coal or natural gas).

When dry cooling was applied to 4.7 GW coal-fired capacity in Arizona and New Mexico (12 units), total annual water consumption was reduced by 93% while increasing the unit-LCOE by an average 12%. Similar performance and cost results were generated for existing NGCC units: based on annual average ambient conditions, dry cooling deployment on 7.5 GW of existing NGCC capacity eliminated freshwater withdrawal at these units, at an average LCOE increase of approximately 18%.

During summer, a capacity reduction of approximately 1–3% exists on existing coal and NGCC units. The finest temporal resolution available for this study was monthly; if daily or hourly ambient conditions had been available and modeled, there might have been periods where the capacity reduction was in excess of 1–3%, and this could have resulted in insufficient generation available to meet demand.

This work formed the basis of a journal article submitted to *Applied Energy* and pending acceptance. [Learn more](#) about related techno-economic analysis of dry cooling systems applied to coal and NGCC power systems (with and without 90% CO₂ capture) – Contributed by **Eric Grol**, NETL SSAE Energy Process Analysis Team

Acknowledgement—This work was funded by the Crosscutting/Water program under the RIC Water Management for Power Systems field work proposal and performed under the leadership of Nick Siefert (Technical Portfolio Lead), Briggs White (Crosscutting Technology Manager) and Steve Richardson (Project Management).

// UPCOMING

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

DOE-NETL's 2021 Carbon Management and Oil and Gas Research Project Review Meeting

Presenters: **Derrick Carlson** — Bio-energy with Carbon Capture and Storage: Achieving Net Zero and Beyond; **Timothy Fout** — Updated Costs for Carbon Capture Retrofits; **Timothy Grant** — Examining Possible CCS Deployment Pathways: Onshore and Offshore (FWP-1022464); **Christopher Nichols** — Modeling the Deployment and Impacts of Capture R&D

Participants: **Kolawole Bello; Luciane Cunha; Gregory Hackett; Samuel Henry; Sally Homsy; Sydney Hughes; David Morgan; Nathan Pastorek; Donald Remson; Thomas Schmitt; Alana Sheriff; Robert Stevens; Mazin Tarhoni; Derek Vikara; Travis Warner; Nur Wijaya; Alexander Zoelle**

Virtual, August 2–31, 2021

38th Annual International Pittsburgh Coal Conference

Presenters: **Thomas Tarka** — Rare Earth Elements from Coal and Related Materials: An Overview of Research at the National Energy Technology Laboratory; **Travis Warner** — Section 45Q Tax Credit Impacts on Carbon Management: Case Study Findings and Modeling Developments

Participant: **Marc Turner**

Virtual, September 21–23, 2021

Society of Exploration Geophysicists (SEG) / American Association of Petroleum Geologists (AAPG) International Meeting for Applied Geoscience & Energy (IMAGE)

Timothy Grant (presenter) — Comparative Analysis of CO₂ Transport, Storage and Produced Water Management Options from a CO₂ Source Perspective

Hybrid (Virtual and Denver, CO), September 26–October 1, 2021.

// CONFERENCES AND EVENTS

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| <ul style="list-style-type: none">• DOE-NETL, 2021 Carbon Management and Oil and Gas Research Project Review Meeting
Virtual, August 2–31, 2021• NETL, 2021 Workshop on Multiphase Flow Science
Virtual, August 3–5, 2021• SPE, The Next Chapter in the Midland Basin – Learning from the Past and Opportunities for the Future
Virtual Forum, August 3, 5, 10 and 12, 2021• AIChE, 3rd Sustainable Waste Management Conference
Virtual, August 4–6, 2021• NETL, Thermal-Mechanical-Chemical Energy Storage (TMCES) Workshop
San Antonio, TX, August 10–11, 2021 | <ul style="list-style-type: none">• SPE, Subsea Well Intervention
Virtual Symposium, August 10–12, 2021• IEA, Launch of Hydrogen in Latin America
Webinar, August 12, 2021• Reuters, Including Hydrogen Strategy in Offshore Wind Project Development Plans
Webinar, August 12, 2021• 2021 Offshore Technology Conference
Hybrid (Virtual and Houston, TX), August 16–19, 2021• SPE, The Next Chapter in the Eagle Ford – Learning from the Past and Opportunities for the Future
Virtual Forum, August 16, 18, 23 and 25, 2021 |
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// CONFERENCES AND EVENTS

(cont'd)

- [SPE, The Next Chapter in the Bakken - Learning from the Past and Opportunities for the Future](#)
Virtual Forum, August 17, 19, 24 and 26, 2021
- [IAEE, From Paris to Glasgow: International Climate Agreements and Energy Transition](#)
Webinar, August 18, 2021
- [SPE, Well Completions for Unconventional Resource Development Optimization and Parent-Child Interaction](#)
Workshop, Franklin, TN, August 23–25, 2021
- [Rystad Energy, Winning in the Energy Transition: What are the Investment Opportunities?](#)
Japan Virtual Information Session, August 24, 2021
- [SPE, Deepwater - Raising Potential Through Innovation](#)
Virtual Symposium, August 24–26, 2021
- [IAEE, Do You See a Natural Resource Curse in Texas?](#)
Webinar, August 25, 2021
- [Columbia University SIPA, Center on Global Energy Policy, Zero-C Hydrogen in a Circular Carbon Economy](#)
Webinar, August 26, 2021
- [Global CCS Institute, Part II—Reaching Net Zero: the Paris Agreement, Regional Climate Commitments and the Role of CCS](#)
Virtual, August 30, 2021
- [IAEE, What Has ERCOT Learned \(So Far\) in 2021?](#)
Webinar, August 30, 2021
- [SPE, Sustainability and Energy Transition](#)
Virtual Workshop, August 30–September 1, 2021
- [U.S. Department of Energy \(DOE\), Hydrogen Shot Summit](#)
Virtual, August 31–September 1, 2021
- [SPE, Delaware, the Next Chapter in Unconventionals - Learning from the Past and Opportunities for the Future](#)
Virtual Forum, August 31 and September 2, 7 and 9, 2021
- [IAEE, The Outlook for Global Oil Demand During the Energy Transition](#)
Webinar, September 1, 2021
- [SPE, Offshore Europe Virtual Conference](#)
Virtual, September 7–10, 2021
- [BIEE, Energy for a Net Zero Society](#)
Oxford, UK, September 13–14, 2021
- [IADC/SPE, Managed Pressure Drilling & Underbalanced Operations Conference & Exhibition](#)
Virtual, September 14–16, 2021
- [IAEE, EU Energy: Green and Connected Beyond EU Borders](#)
Webinar, September 15, 2021
- [Wood Mackenzie, Rare Earths: a Global Outlook for Key Market Trends](#)
Webinar, September 15, 2021
- [EarthShift Global, Paths to Carbon Neutrality Panel](#)
Webinar, September 16, 2021
- [38th Annual International Pittsburgh Coal Conference](#)
Virtual, September 20–23, 2021
- [SPE, Annual Technical Conference and Exhibition \(ATCE\)](#)
Dubai, United Arab Emirates, September 21–23, 2021
- [SEG/AAPG, International Meeting for Applied Geoscience & Energy \(IMAGE\) 2021](#)
Hybrid (Virtual and Denver, CO), September 26–October 1, 2021
- [SPE, CCUS Management - Achieving Net Zero Carbon and Sustainability Goals](#)
Virtual Symposium, September 28–30, 2021
- [Wood Mackenzie, 2021 Global Energy Summit](#)
Virtual, September 28–October 8, 2021
- [Columbia University SIPA, Center on Global Energy Policy, How are China's Companies Responding to China's 2060 Carbon Neutrality Goal?](#)
Webinar, September 29, 2021
- [IEA, Clean Energy Transitions in Sahel Countries Regional Dialogue](#)
Virtual, September 30, 2021

// RECENT PUBLICATIONS

Reports

K. Buchheit, E. Lewis, K. Mahbubani and D. Carlson, "[Technoeconomic and Life Cycle Analysis of Bio-Energy with Carbon Capture and Storage \(BECCS\) Baseline](#)," U.S. Department of Energy, National Energy Technology Laboratory, Pittsburgh, PA, July 16, 2021.

Presentations

E. Shuster, K. Kern and P. Balash, "[NETL Energy Related Diagrams: 2020 Edition](#)," U.S. Department of Energy, National Energy Technology Laboratory, DOE/NETL-2021/2745, Pittsburgh, PA, 2021.

Conference Proceedings and Events

T. Fout, "[Techno-Economic Analyses for Direct Air Capture \(DAC\) Overview](#)," presentation at Direct Air Capture Kickoff Meeting, Virtual, February 24–25, 2021.

T. Skone, "[Life Cycle Greenhouse Gas Analysis of Direct Air Capture Systems](#)" presentation at Direct Air Capture Kickoff Meeting, Virtual, February 24–25, 2021.

R. Stevens, E. Lewis and S. McNaul, "[Comparison of Commercial, State-of-the-Art, Fossil-Based Hydrogen Production Technologies](#)," presentation at 2021 Gasification Systems Program Project Review Meeting, Virtual, May 4–5, 2021.

E. Shuster, T. Skone, J. Chou, D. Carlson, U. Lee and H. Xu, "[AWARE-US and Cumulative R&D Benefits](#)," presentation at 2021 Water Management Program Project Review Meeting, Virtual, May 10–17, 2021.

J. Brewer, "[Energy Technology Systems and Market Analyses \(FWP-1022461 - Task 2\)](#)," presentation at 2021 Transformative Power Generation Program Project Review Meeting, Virtual, May 11–12, 2021.

S. Zitney, E. Hedrick, K. Reynolds, V. Dwivedy and D. Bhattacharyya, "[Dynamic Power Plant Modeling for Flexible Operations \(FWP-1022461 - Task 3\)](#)," presentation at 2021 Crosscutting Research and Advanced Energy Systems Project Review Meeting, Artificial Intelligence & Machine Learning Session, Virtual, May 13, 2021.

D. Miller, "[Institute for the Design of Advanced Energy Systems \(IDAES\) \(FWP-NETL\)](#)," presentation at 2021 Crosscutting Research Simulation Based Engineering Project Review Meeting, Virtual, May 24, 2021.

M. Summers and C. Noack, "[Rare Earth Elements-Critical Minerals - Systems Analysis \(FWP-NETL\): Systems Perspective, Expanding Focus to Critical Mineral](#)," presentation at 2021 Rare Earth Elements – Critical Minerals Project Review Meeting, Virtual, May 25, 2021.

// REFERENCE SECTION

Models / Tools

[FE/NETL CO₂ Transport Cost Model](#)

[FE/NETL CO₂ Storage Cost Model](#)

[FE/NETL CO₂ Prophet Model](#)

[FE/NETL Onshore CO₂-EOR Cost Model](#)

[Life Cycle Analysis Models](#)

[IDAES Power Generation Model Library](#)

Key Reports

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