SSAE Newsletter

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NATIONAL ENERGY TECHNOLOGY LABORATORY

// 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

Drouven Publishes Review Paper on Optimization Models for Shale Oil & Gas Development in *Computers & Chemical Engineering*

A paper providing a comprehensive review of mathematical programming models for shale oil and gas development, along with a perspective on outstanding research opportunities in this domain, was recently published in *Computers & Chemical Engineering*. SSAE's Markus Drouven was the lead author on the paper, "Mathematical Programming Models for Shale Oil & Gas Development: A Review and Perspective." Professors Diego C. Cafaro (Universidad Nacional del Litoral, Santa Fe, Argentina) and Ignacio E. Grossmann (Carnegie Mellon University, Pittsburgh, USA) served as co-authors.

Techno-Economic Analysis of Co-Generating SOC Systems for H_2 Production Published

Hydrogen (H_2) is seen as a key technology to reduce carbon emissions from the U.S. industrial sector. Today, however, most H_2 demand is met through the carbon-intensive process of steam methane reforming. Water electrolysis provides an avenue for producing low-carbon H_2, especially as renewables' share of electricity generation continues to rise. Electrolysis requires large amounts of electricity, making its economic viability highly dependent on electricity price. Renewable sources of electricity have lower marginal costs than conventional fossil generators in many locations but are intermittent with lower capacity and variable load factors. This presents a tradeoff to electrolyzer operation; running at a low capacity factor to take advantage of cheap renewable power results in high fixed costs per kilogram of H_2. A plant capable of co-generating H_2 and electricity is not subject to the same tradeoff as a stand-alone electrolyzer. The plant can produce H_2 with low-cost electricity and switch to producing power when electricity prices increase, maintaining a high overall capacity factor. Supplemental revenue from electricity sales allows H_2 to be sold at a lower price than a stand-alone electrolyzer.

Solid oxide cell (SOC) technology is unique compared to other electrolysis technologies in that it can be operated reversibly. A reversible SOC (r-SOC) stack combines electrolyzer and fuel cell operation into a single electrochemical device, making it a natural choice for a co-generating plant. A techno-economic analysis of SOC technologies for H_2 production conducted by SSAE researchers was detailed in a recently published paper in *ECS Transactions*. This paper aimed to quantify the economic benefits, if any, of reversible operation by comparing an r-SOC plant to a co-generating plant that consists of separate solid oxide electrolysis cells (SOEC) and solid oxide fuel cells (SOFC) for dedicated production of H_2 and electricity. In both plants, the fuel cells were fueled with natural gas and included carbon capture with rates exceeding 97%. The two plants were modeled in both H_2 and electricity production modes using Aspen Plus®.

Performance modeling shows that there is significant variation in flowrates through equipment between the different operating modes. Equipment used in both modes was sized based on the largest process parameter and costed using the guidelines in NETL's 2022 "Quality Guidelines for Energy System Studies: Capital Cost Scaling Methodology (Revision 4A report)." The capital cost of the SOFC/SOEC plant is only 5% larger than the r-SOC plant. The cost of the additional set of SOFCs is largely diluted by balance of plant costs. The results reveal that despite the slightly higher capital cost of the SOFC/SOEC plant, it produces H_2 more economically under most electricity and natural gas price assumptions. The dedicated SOFC becomes profitable above locational marginal prices of ~$35/MWh and inexpensive natural gas. The r-SOC plant requires electricity prices below $20/MWh or natural gas prices above $13/MMBtu to produce lower cost H_2.

Staff Spotlight

Shannon McNaul* has been supporting NETL in its work on H_2 for over two years. She was a critical contributor to NETL's H_2 Baseline study, which characterized the performance, cost and emissions of commercial, state-of-the-art, fossil-based H_2 production technologies. Shannon was also involved in work supporting the Hydrogen Energy Earthshot Initiative, and as part of a cross-team collaboration, developed cost reduction pathways for various H_2 production technologies to achieve DOE's Hydrogen Shot goal of $1/kg of clean H_2 in one decade. Her current work includes characterizing biomass, municipal solid waste and plastics feedstocks, which can be used for H_2 production via gasification, and performing a literature review and techno-economic analysis of H_2 production via methane pyrolysis. Shannon appreciates that she can use her attention to detail, enjoyment of learning and problem solving skills every day to support NETL's critical mission.

Shannon attended the University of Delaware where she received an Honors Bachelor of Chemical Engineering in 2020. She is also a certified user in Aspen Plus®. In her free time, she likes to play strategy board games and visit local coffee shops in search of the perfect brew.

* NETL Support Contractor

// NOTICES

LCA Researchers Present at Sustainability Conference

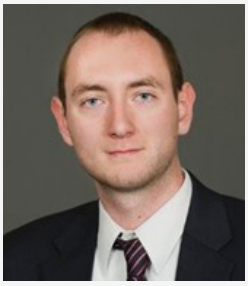
Several members of SSAE's LCA Team presented LCA research at the International Symposium on Sustainable Systems and Technology (ISSST) 2023 Conference in June 2023. Bringing together folks from industry and academia, the meeting featured presentations on defining, designing, assessing, supporting or implementing technologies, policies and systems for sustainability and aimed to generate future collaboration opportunities. Each presenter fielded questions during their session. Publication is pending for one presentation, as noted below:

- Preliminary greenhouse gas results from NETL's U.S. natural gas life cycle model across the production, gathering and boosting, processing, transmission and distribution stages of the natural gas supply chain was presented by Harshvardhan Khutal*. The presentation, "Evaluating U.S. Natural Gas Environmental Performance" (pending publication), also shared model updates including incorporation of measurement-informed data, energy allocation of emissions between natural gas and natural gas supply chain co-products, regionalization of processing stage data, regionalization of transmission and distribution stage data and associated gas production share modeling.
- An overview of the NETL CO2U LCA Toolkit comprising LCA guidance, data and tools for principal investigators funded by DOE's Carbon Conversion Program and for LCA practitioners modeling pathways for converting CO_2 into valuable products was highlighted by Sheikh Moni*. The presentation, "Life Cycle Analysis of Emerging Technologies: Overview and Updates of NETL CO2U LCA Toolkit", also described upcoming updates to the toolkit and NETL's contributions to global collaborations. These updates included expansion and improvements to the existing life cycle inventory database and modification of LCA guidelines and tools.
- A tool for sending customized technology mixes and emissions profiles from the electricityLCI to methodologies for assessing air quality, water scarcity and chemical and environmental impacts was discussed in a presentation, "A Next-Generation Toolset Toward Sustainable Electricity Use," given by Shirley Sam*. The electricityLCI is a collaborative federal life cycle dataset tool for U.S. electricity consumption and generation. During her presentation, Shirley also shared a report viewer for visualizing electricity impacts and showed air quality impact results at census tract level from the Air Pollution Emissions Experiment and Policy model developed in collaboration with Carnegie Mellon University.

SSAE Expands Capabilities With New Hires

SSAE is growing! This summer SSAE welcomed five new team members across their markets, process systems engineering and subsurface competencies:

Kirk Labarbara brings his PROMOD expertise to the Energy Markets Analysis Team. He began supporting NETL in 2014 as a site support contractor. Kirk continues to work on energy markets analysis and electricity market modeling using PROMOD, a power generation and transmission modeling system. Kirk graduated in 2007 from West Virginia University (WVU) with a B.S. in Aerospace Engineering. In his free time, he enjoys wrangling his three-year-old twins as they continue to grow and explore the world. With the little time he has left over, Kirk enjoys cooking interesting new foods, reading fantasy and Sci-Fi novels, playing video games with friends, 3D Printing and building and flying RC airplanes.



Joshua Morgan first joined NETL upon earning his Ph.D. in Chemical Engineering from WVU in 2017. Josh started at NETL as a postdoctoral scholar before transitioning into a full-time role as a site support contractor in the spring of 2019. His research is focused on comprehensive modeling and analysis of solvent-based CO_2 capture systems including process optimization, model validation, Bayesian uncertainty quantification, sequential design of experiments and techno-economic analysis – primarily in the support of DOE's Carbon Capture Simulation for Industry Impact ($CCSI^2$) program. A native of southeastern West Virginia, Joshua's passions outside of work include reading and outdoor adventures such as camping, backpacking and swimming.

Christopher "Gabe" Creason is a geologist who most recently supported research at NETL through a site support research contract as well as multiple Oak Ridge Institute for Science and Education (ORISE) fellowships. Gabe's research leverages geologic systems knowledge and data-driven approaches to evaluate subsurface risk and resource potential. His work involves several multi-disciplinary efforts including: development of a novel, geo-data science method for predicting and assessing unconventional critical mineral occurrences in sedimentary systems; geomodel development and data compilation and curation as part of DOE's National Risk Assessment Partnership Phase III basin-scale risk modeling and EDX4CCS portfolios; basin processes and subsurface modeling of hydrate accumulations; among other research projects. Past projects at NETL include co-developing an analytical framework for assessing potential fluid migration pathways in the subsurface, as well as geothermal prospectivity modeling. Gabe's degrees are in geology and earth science, earning a B.S. from the University of Kansas (2012) and M.S. from Dalhousie University (2015). He's currently a Ph.D. candidate at Oregon State University. Outside of work, Gabe enjoys spending time with his family and friends in

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the great Oregon outdoors, whether it's hiking, biking, camping, kayaking or just looking at rocks.

Guoxiang "Gavin" Liu spent the last four years working as a site support contractor at NETL in Pittsburgh. His past professional experience includes time working for Baker Hughes Company, GE Company Oil & Gas Technology Center, GE Company Global Research and the Energy & Environmental Research Center. Gavin has experience working with multi-discipline teams and providing reservoir engineering principles and data analytics and machine learning/artificial intelligence for technology developments and applications. His primary foci include the energy sector; low carbon solution and sustainable carbon capture, utilization and storage; enhanced oil recovery; renewable energy such as geothermal; risk assessment technology developments and reservoir characterizations and visualizations. Gavin has applied artificial intelligence, machine learning and high-performance computing applications for decision making in such primary interested in areas as well as pursuing H_2 for renewable energy and environmentally friendly eco-systems with cost effective development and deployment. Guoxiang holds a Ph.D. in Civil and Environmental Engineering with an emphasis in subsurface from WVU. He earned his M.S. in Computer Science from Leiden University, The Netherlands, after earning a B.S. in Chemistry at Yunnan Normal University.

MacKenzie Mark-Moser is a research geologist working on geo-data science solutions for subsurface energy. As an Oregon State University graduate student studying structural geology, their research was focused on the characterization and tectonic implications of the Sisters Fault Zone in central Oregon. MacKenzie's research with NETL began with an ORISE fellowship in 2012, and spanned from offshore to onshore environments including petroleum, carbon storage, geothermal and critical mineral systems. Their recent research as a site support contractor focused on addressing energy problems in these systems through subsurface characterization, hazard and risk assessment and data aggregation using spatio-temporal data science techniques and software development. MacKenzie has authored or co-authored over a dozen publications and technical reports related to subsurface energy and presented their work at conferences and forums including the American Geophysical Union and Geological Society of America annual meetings. Outside of work, MacKenzie likes to backpack, hike, birdwatch and care for their retired horse.

SSAE's Alison Fritz Defends Dissertation

Alison Fritz successfully defended her Ph.D. in Civil and Environmental Engineering from Stanford University in May 2023. Her dissertation titled "Opportunities for Circular Management of Industrial Waters to Support the Clean Energy Transition" assesses tradeoffs between energy security, cost and environmental impacts in both current and future energy systems. Her defense described analyses of wastewater discharge and water consumption tradeoffs of the current transitioning fossil fleet, a structured framework to estimate downstream processing costs for unconventional sources of these minerals and case studies for applications of this framework including techno-economic performance of rare earth element (REE) extraction from REE-enriched acid mine drainage precipitate and recovery of lithium from various alternative brine sources. She also received the JEDI Graduation Award for contribution to promoting justice, equity, diversity and inclusion within the Stanford community and beyond.

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// PERSPECTIVES

U.S. Energy Consumption Profiles Over the Last Ten Years
NETL Energy Related Diagrams – 2022 Edition

Since 1995, U.S. primary energy consumption has hovered between 90 and 100 quadrillion British thermal units (QBtu or quads).[1] In 2022, the U.S. consumed 100 QBtu. The two Sankey Diagrams in figures 1 and 2 depict primary energy consumption from coal, natural gas, nuclear, petroleum and renewables for use to generate electricity and energy use in the residential, commercial, industrial and transportation sectors, along with end-use efficiencies for 2012 and 2022, respectively.

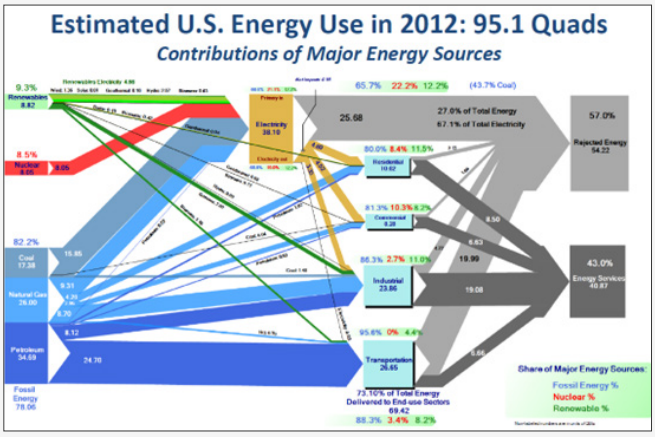

Figure 1. 2012 U.S. energy consumption Sankey Diagram[2]

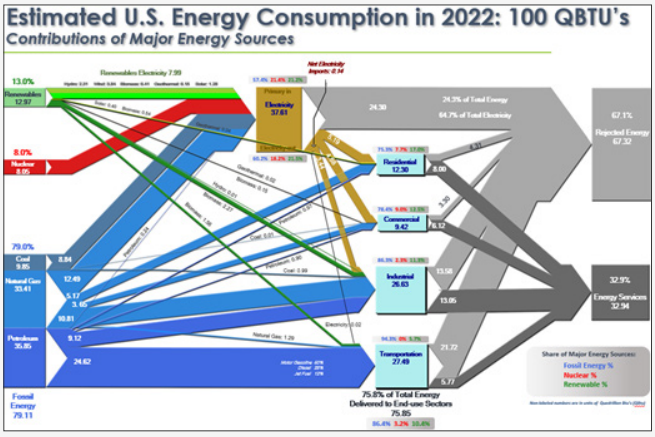

Figure 2. 2022 U.S. energy consumption Sankey Diagram[3]

The Sankey Diagrams compare U.S. energy consumption changes in the last ten years from 2012 (Figure 1) to 2022 (Figure 2). At a quick glance, the two annual energy profiles look very similar. However, Figure 3 shows the absolute and percent changes in U.S. energy and electricity profiles over the ten-year period. U.S. total primary energy consumption increased by 5 QBtu from 2012 to 2022. Looking at the changes in individual primary fuels consumed, nuclear remained constant, coal decreased by 7.5 QBtu (-43%) and the following fuels increased: petroleum 2.0 QBtu (6%), renewables 4.2 QBtu (47%) and natural gas 7.3 QBtu (28%). Though coal consumption has declined over the ten-year period, total fossil fuels have increased by 1.8 QBtu (2.3%) and continue to make up almost 80% of all energy consumption in 2022. Petroleum has continued to be the most consumed energy source in the United States since surpassing coal in 1950. In 2022, U.S. natural gas consumption totaled 33.4 quads, which was the most natural gas consumption in the United States to date. Growth in U.S. natural gas consumption has largely been driven by increased use of natural gas in the electric power sector, which has consumed more natural gas than any other sector every year for the past five years.

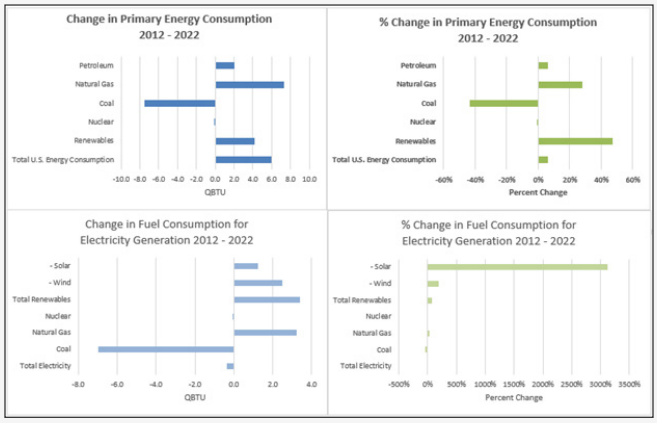

Figure 3. Changes in U.S. energy consumption over a ten-year period (2012-2022)

Electricity generation is a secondary energy source as seen on the Sankey Diagrams and has experienced the largest changes in fuels over the ten-year period. Overall, electricity generation had slightly decreased by 0.5 QBtu (-0.9%). The primary fuels used to generate electricity has changed accordingly: coal has decreased by 7 QBtu (-44%), nuclear has remained constant, natural gas has increased by 3.2 QBtu (34.5%) and total renewables increased by 3.4 QBtu (74%). A detailed breakdown of renewables shows wind has increased by 2.5 QBtu (187%) and solar has increased by 1.2 QBtu (3,128%). With a 3,128% increase in electric generation, wind still only accounted for 10% of the total electricity generation in 2022.

Similar to the overall energy consumption from the various fuels, the end-use sectors appear to be comparable at first glance when looking at the changes in the ten-year period. However, overall total energy consumption for the four sectors has increased in the ten-year period accordingly: residential 1.9 QBtu (18.6%), commercial 1.2 QBtu (14.6%), industrial 2.5 (10.4%) and transportation 1.4 (5.4%). Electricity to the transportation sector shows a very slight decrease of 0.002 Btu (-9.8%).

The Sankey Diagrams also show the inefficiency in energy conversion (rejected energy) for all sectors and electricity generation. The vast majority of the losses are in the form of waste heat.

The energy consumption diagrams show the total energy consumed by fuel type, but do not show where the fuel originated. Figures 4 and 5 show fossil fuel domestic production and trade for 2012 and 2022, respectively. U.S. imports for all three fossil fuels have decreased in the last ten years. On a Btu basis, petroleum had the largest decrease of 5 QBtu (-22%) and coal had the largest percent change, a decrease of -41% on a Btu basis. Changes in U.S. exports were mixed with petroleum and natural gas exports both

// PERSPECTIVES (cont'd)

increasing over the ten-year period, while coal exports have decreased. Petroleum exports on a Btu basis had the largest increase of 12 QBtu (179%) while natural gas had the largest percent change on a Btu basis with a 326% change. Fossil fuel production changes over the last ten years show similar trends as exports, with petroleum and natural gas production increasing and coal production decreasing. Petroleum production had the largest increase on a Btu basis with 16 QBtu (94%) followed closely by natural gas, 13 QBtu (51%). Figures 6 and 7 show all the changes in fossil production and trade for the ten-year period (2012-2022). It is important to note that the percent changes for each fuel in QBtus and conventional units are not the same. This is because in order to convert between the two units, the heat content of the fuels is used and these values change over the years based on the overall mixture of the fuel type and other factors. For example, general coal is the sum of the different ranks of coals (lignite, subbituminous, bituminous and anthracite), which have different heat contents. – Contributed by Erik Shuster

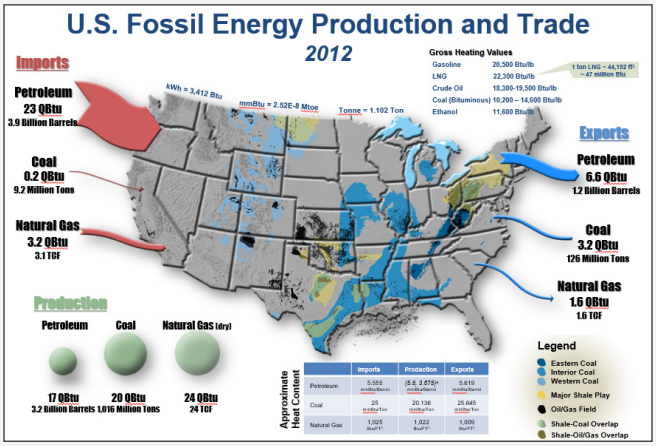

Figure 4. 2012 U.S. fossil energy production and trade[2]

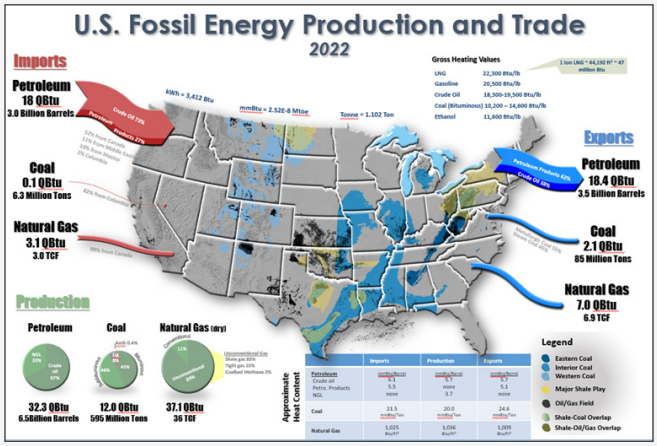

Figure 5. 2022 U.S. fossil energy production and trade[3]

	IMPORTS				EXPORTS				PRODUCTION			
Change - Absolute	Value	Units	Value	Conventional Units	Value	Units	Value	Conventional Units	Value	Units	Value	Conventional Units
Petroleum	-5.0	QBTU	-0.9	Billion Barrels	12	QBTU	2.3	Billion Barrels	16	QBTU	3.3	Billion Barrels
Coal	-0.1	QBTU	-2.8	Million Short Tons	-1.2	QBTU	-41	Million Short Tons	-8	QBTU	-422	Million Short Tons
Natural Gas	-0.1	QBTU	-0.1	Trillion Cubic Feet	5.3	QBTU	5.3	Trillion Cubic Feet	13	QBTU	12	Trillion Cubic Feet

Figure 6. Absolute change in U.S. fossil energy production and trade (2012 – 2022)

	IMPORTS				EXPORTS				PRODUCTION			
Change - Percentage	Value	Units	Value	Conventional Units	Value	Units	Value	Conventional Units	Value	Units	Value	Conventional Units
Petroleum	-22%	QBTU	-23%	Billion Barrels	179%	QBTU	198%	Billion Barrels	94%	QBTU	105%	Billion Barrels
Coal	-41%	QBTU	-31%	Million Short Tons	-36%	QBTU	-33%	Million Short Tons	-40%	QBTU	-42%	Million Short Tons
Natural Gas	-4%	QBTU	-4%	Trillion Cubic Feet	326%	QBTU	326%	Trillion Cubic Feet	51%	QBTU	49%	Trillion Cubic Feet

Figure 7. Percent change in U.S. fossil energy production and trade (2012 – 2022)

References

[1]U. S. Energy Information Administration, "June 2023 Monthly Energy Review," Table 1.1 Primary Energy Overview (Quadrillion Btu), U.S. Energy Information Administration, DOE/EIA-0035(2023/6), Washington, DC, June 27, 2023.

[2]E. Shuster, "Energy Related Flow Diagrams: Domestic Energy and Global Coal, Oil, and Natural Gas Flows," National Energy Technology Laboratory, Pittsburgh, PA, December 2013.

[3]E. Shuster, K. Kern and P. Balash, "NETL Energy Related Diagrams – 2022 Edition," National Energy Technology Laboratory, DOE/NETL-2023/3867, Pittsburgh, PA, June 2023.

// UPCOMING CONFERENCES AND EVENTS

SSAE federal staff and NETL support contractor personnel will attend or present at the following conferences in August 2023:

- NERC Energy Assurance with Energy-Constrained Resources Standards Drafting Team Meeting
  Participant: John Brewer
  Virtual, August 1, 2023
- 2023 Coal Market Strategies Conference
  Participant: Kenneth Kern
  Park City, UT, August 8–10, 2023
- 3rd Annual Workshop: Resilient Supply of Critical Minerals
  Participants: Alison Fritz and Michelle Krynock
  Hybrid (Virtual and Rolla, MO), August 9–10, 2023
- ACS Fall 2023: Harnessing the Power of Data
  Presenter: Alison Fritz – Process-level Cost Benchmarks to Establish Economic Viability of Environmentally and Socially Sustainable Unconventional Rare Earth Element Feedstocks during the Critical Materials: Perspectives from the Industry, Government, and Research Communities session
  Hybrid (Virtual and San Francisco, CA), August 13–17, 2023
- Produced Water Society Permian Basin Summit 2023
  Presenters: Markus Drouven and Naresh Susarla* – Updates to PARETO – DOE's Free and Open-Source Produced Water Optimization Framework
  Hybrid (Virtual and Midland, TX), August 14–16, 2023
- Hydrogen Hubs: Building a Financeable Value Chain
  Participant: Eric Lewis
  Houston, TX, August 28–30, 2023
- 2023 FECM/NETL Carbon Management Research Project Review Meeting
  Presenters: Keith Beattie* and John Shinn* – How to Work with CCSI^2; Alex Dowling* and Chrysanthos Gounaris* – Technical Risk Reduction: Model Based Design of Experiments and Robust Optimization; Jeffrey Eppink* – GEESS as a Mechanism to Facilitate the Commercialization of Geologic Carbon Sequestration (GCS) (FWP-1022435); Charles Finney* and Phan Nguyen* – Solvent Model Validation Hierarchy; Timothy Fout – Systems Analysis for Carbon Dioxide Removal; Eric Grol – Industrial CO_2 Capture Studies; Gregory Hackett – Retrofitting NGCC and PC Power Plants with Carbon Capture Technology (poster); Michelle Krynock – 1) NETL CO2U LCA Guidance Toolkit (demo) and 2) Overview of Carbon Conversion Life Cycle Analysis at NETL; Kirk Labarbara – Economics of Competing CCS Plants; Sarah Leptinsky* – TEA Development for Enhanced Weatherization and Marine Carbon Dioxide Removal Case Studies (poster); Roksana Mahmud* and Jorge Izar-Tenorio* – Biomass Environmental Analysis in Bioenergy with Carbon Capture and Storage Modeling (poster); MacKenzie Mark-Moser and Christopher Creason – Technically Viable CCS Resources Assessment Database; David Morgan – 1) Initial Integration of Output from the SMART Unified Simulation Module into the SMART-NRAP Engineering Economic Module (poster), 2) SMART – Site Specific Visualization and Decision Support (co-presenter) and 3) Task 5: Developing a Tool To Quantify Liability of Geologic Carbon Storage; Joshua Morgan – Computational Guidance for RTI TCM Test Campaign; Abby Nachtsheim* – Technical Risk Reduction: Sequential Design of Experiments and Uncertainty Quantification; Benjamin Omell – An Overview of CCSI^2 Capabilities for Accelerating Technology Commercialization; Alana Sheriff* – Comparative Economic Analysis of Capture, Transport, and Storage from a CO_2 Source Perspective in the Central U.S. (poster); Taylor Vactor* – Cost of CO_2 Capture, Transport, and Storage (CTS) Screening tool (demo); Derek Vikara* – NETL's Techno-Economic Modeling Resources for Analyzing Decarbonization Strategies Using CCUS (poster); Travis Warner* – A Framework for Linking Quantitatively Assessed Risks and Costs for Geologic Carbon Storage (GCS) to Consider Impact of Contingency Plans at a GCS Site (poster); Jay Xu* – Computational Modeling and Optimization of EEMPA Solvent; Daison Yancy Caballero* – Process Modeling and Analysis of a Novel Sorbent Material for Direct Air Capture Applications (poster) and Connie Zaremsky* – Recent Developments in Deployment of CCS Projects in the Offshore Gulf of Mexico (FWP-1022435)
  Participants: Peter Balash, Kolawole Bello*, Ray Boswell, Luciane Cunha, Timothy Grant, Robert James, Matthew Jamieson and Guoxiang Liu
  Pittsburgh, PA, August 28–September 1, 2023

* NETL Support Contractor

// RECENT PUBLICATIONS

Article

- A. Noring, K. Buchheit, A. Iyengar and G. Hackett, "Techno-Economic Analysis of Reversible and Paired Solid Oxide Cell Systems for Hydrogen Production," *ECS Transactions*, vol. 111, article 2445, DOI 10.1149/11106.2445ecst, 2023.
- V. Sick, K. Armstrong and S. Moni, "Editorial: Harmonizing life cycle analysis (LCA) and techno-economic analysis (TEA) guidelines: a common framework for consistent conduct and transparent reporting of carbon dioxide removal and CCU technology appraisal," *Frontiers in Climate*, vol. 5, May 9, 2023.

Report/Supporting Documentation

- C. White, J. Mazzoccoli, B. Soepyan, J. Eslick, N. Weiland, D. Oryshchyn and M. Woods, "DPE Techno-Economic Analyses," National Energy Technology Laboratory, DOE/NETL-2023/3876, Pittsburgh, PA, May 24, 2023.

Presentation

- E. Shuster, K. Kern and P. Balash, "NETL Energy Related Diagrams – 2022 Edition," National Energy Technology Laboratory, DOE/NETL-2023/3867, Pittsburgh, PA, June 2023.

Conference Proceedings and Events

- G. Stinchfield, J. Morgan, M. Zamarripa and C. Laird, "Optimal Design Approaches for Rapid, Cost-Effective Manufacturing and Deployment of Industrial Decarbonization Processes," poster at the 2023 FECM Spring R&D Project Review Meeting, Pittsburgh, PA, April 18–19, 2023.
- J. Clarke, G. Guglielmi, X. Shen, S. Moni and M. Krynock, "Utilization Procurement Grants (UPGrants) Program LCA Support," poster at the 2023 CCU TEA/LCA Workshop on Harmonizing CCUS Assessments, Hybrid (Virtual and Ann Arbor, MI), May 16–18, 2023.
- S. Moni, J. Chou, M. Henriksen, J. Clarke and M. Krynock, "NETL CO2U LCA Toolkit: Applications and Upcoming Updates," poster at the 2023 CCU TEA/LCA Workshop on Harmonizing CCUS Assessments, Hybrid (Virtual and Ann Arbor, MI), May 16–18, 2023.
- N. Susarla, E. Shamlou, T. Arnold, P. Tominac, M. Zamarripa and M. Drouven, "Project PARETO – DOE's Produced Water Optimization Initiative," poster at the 2023 Shale Network Workshop, State College, PA, May 18–19, 2023.
- A. Dowling, J. Wang, K. Wang and K. Jones, "Adaptively Optimizing Experiments: Past, Present, and Future," presentation at the SIAM Conference on Optimization (OP23), Seattle, WA, May 31–June 3, 2023.
- J. Wang and A. Dowling, "Characterizing the Pareto Optimal Trade-off between Model-Based Information Content and Measurements Cost," poster at the SIAM Conference on Optimization (OP23), Seattle, WA, May 31–June 3, 2023.
- D. Ovalle, J. Pulsipher, C. Gomez, J. Gomez, M. Drouven, C. Laird and I. Grossmann, "Study of Different Formulations for the Multiperiod Blending Problem Applied to Lithium Recovery from Produced Water," presentation at the WCCE11-11th World Congress of Chemical Engineering, Buenos Aires, Argentina, June 4–8, 2023.
- D. Vikara and B. Chen, "Overview of the Pathways to CO_2 Utilization and Storage for the Intermountain West Region," presentation at the I-WEST Seminar Series, Virtual, June 7, 2023.
- S. Sam, T. Davis, M. Jamieson and T. Skone, "A Next-Generation Toolset Toward Sustainable Electricity Use," presentation at the International Symposium on Sustainable Systems and Technology (ISSST) 2023 Conference, Fort Collins, CO, June 15, 2023.
- D. Ovalle, J. Pulsipher, C. Gomez, J. Gomez, M. Drouven, C. Laird and I. Grossmann, "Study of Different Formulations for the Multiperiod Blending Problem Applied to Lithium Recovery from Produced Water," presentation (conference proceedings) at the 33rd European Symposium on Computer-Aided Process Engineering (ESCAPE-33), Athens, Greece, June 18–21, 2023.
- G. Stinchfield, B. Ammari, J. Morgan, J. Siirola, M. Zamarripa and C. Laird, "Optimization of Process Families for Improved Deployment of Industrial Decarbonization using ML Surrogates," presentation (conference proceedings) at the 33rd European Symposium on Computer-Aided Process Engineering (ESCAPE-33), Athens, Greece, June 18–21, 2023.
- S. Bayramoglu, G. Nemhauser and N. Sahinidis, "Learning to Branch with Interpretable Machine Learning Models," poster at the 24th Conference on Integer Programming and Combinatorial Optimization (IPCO XXIV), Madison, WI, June 21–23, 2023.
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// REFERENCE SECTION

Models / Tools / Databases

Carbon Capture Simulation Initiative (CCSI) Toolset

FECM/NETL CO_2 Transport Cost Model

FE/NETL CO_2 Saline Storage Cost Model

FE/NETL CO_2 Prophet Model

FE/NETL Onshore CO_2 EOR Cost Model

FECM/NETL Unconventional Shale Well Economic Model

Life Cycle Analysis Models

NETL CO2U LCA Guidance Toolkit

NETL UPGrants LCA Guidance Toolkit

IDAES Integrated Platform

IDAES Power Generation Model Library

Pulverized Coal Carbon Capture Retrofit Database (CCRD)

Natural Gas Combined Cycle CCRD

Industrial Sources CCRD

Key Reports

Baseline Studies for Fossil Energy Plants

Cost of Capturing CO_2 from Industrial Sources

Quality Guidelines for Energy System Studies

Life Cycle Analysis

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