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

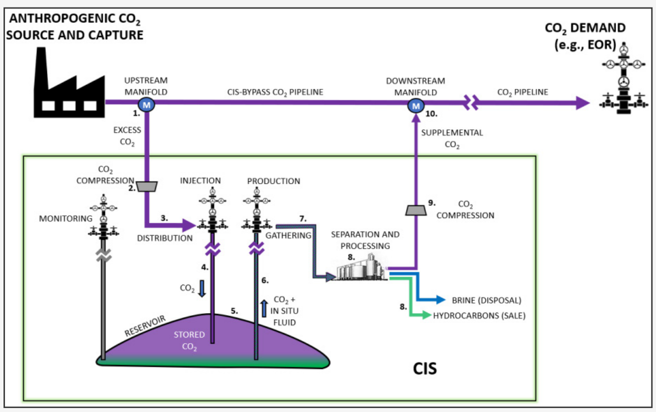
These tools and approaches provide insights into new energy concepts and support the analysis of energy system interactions at the plant, regional, national and global scales.

// HIGHLIGHTS

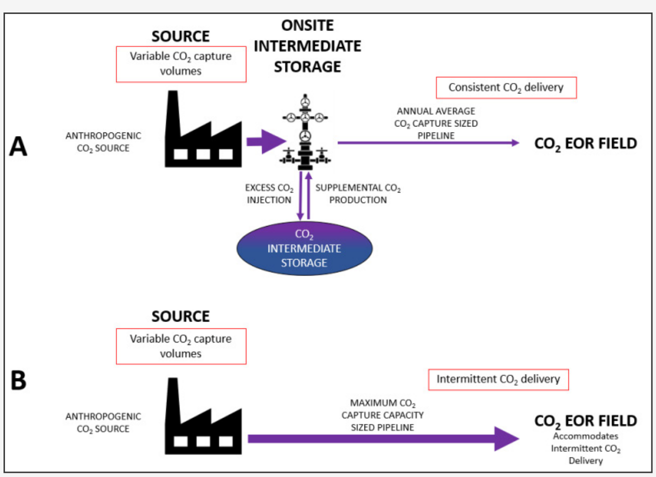
SSAE Experts Explore CIS

The concept and economics of carbon dioxide (CO_2) intermediate storage (CIS) were investigated in two recently released reports, an overview report, and an economic report. CIS is the cyclical process of injection, temporary storage and withdrawal of anthropogenic CO_2 into and out of a geologic or man-made reservoir, providing buffer capacity that can mitigate variability between CO_2 supply and demand. CIS can also decrease the financial risks inherent in anthropogenic CO_2 capture, CO_2 pipeline transmission and CO_2 utilization end-use.

The overview report provides a comprehensive set of qualitative considerations to inform future quantitative technical and economic CIS analyses with sections on: 1) basic CIS operations (example shown in first figure below); 2) literature review and examples of operations analogous to CIS; 3) ideal CIS reservoir and site characteristics; and 4) common supply and demand situations CIS could mitigate. Property rights, CO_2 supply contracts, injection well regulations and federal tax incentives are also discussed in the context of CIS.



Simplified diagram of CIS operations within a CCUS network

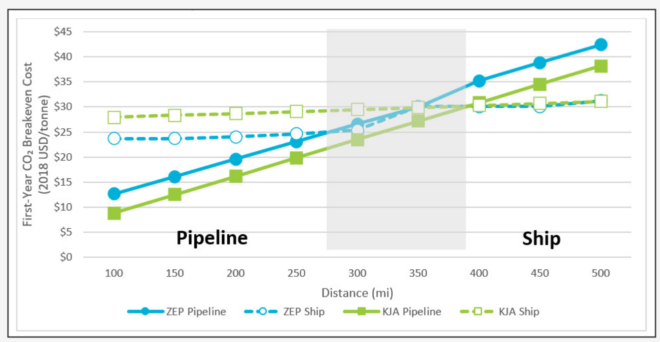


Proposed project cost savings arrangement with CIS (A) compared to larger pipeline sized to maximum capture rates with no CIS (B)

The economics and details of matching CIS with different CO_2 sources to inform future discussions about the economic feasibility of CIS in conjunction with carbon capture, utilization and storage (CCUS) was investigated in the detailed economic report. This report assessed potential CIS reservoir types and CIS withdrawal and injection cycle timing and demonstrated scenarios where CO_2 sources with low capture capacity factors and high peak rates of capture could deploy CIS and smaller pipelines with higher utilization rates to lower overall pipeline transportation costs. A comparison between a project with and without CIS is shown in the second figure to the left.

Offshore Delivery Options in the GoM Examined in Recent Study

An SSAE study evaluating the benefits of CO_2 offshore transport via pipeline or ship within the Gulf of Mexico (GoM) was recently published. A top-down analytical approach was used to assess the cost advantages of either pipeline or ship transportation of captured CO_2 to offshore storage sites in the GoM. Regression models using published data from various studies were developed to estimate capital expenses (CAPEX) and operating expenses (OPEX), and then those costs were fed into a reduced-order model (ROM). Developed based on cash flows in the FECM/NETL CO_2 Transport Cost Model (also known as CO2_T_COM), the ROM used the CAPEX and OPEX to calculate the CO_2 breakeven price based on the cash flows. Since the ROM is a simplified cash flow calculation, it is easy to exchange the core regression models to estimate various costs. Thus, the framework can be easily adapted by researchers, decision-makers, operators and regulators to estimate different costs.



Pipeline and ship CO_2 breakeven costs calculated by the ROM and two regression models

The objective of this study was to assess the CO_2 breakeven cost range for pipeline and ship transport of captured CO_2 given the CO_2 source and storage reservoir located in the GoM (see figure above). Two scenario themes were evaluated based on the regression models developed, 1) a baseline scenario to understand the breakeven ranges of an offshore project near the Port of Houston and 2) a hurricane scenario which used the NETL-developed Cumulative Spatial Impact Layers™ tool to estimate hurricane risks and impacts to various routes from the Port of Houston to reservoirs in the non-public FECM/NETL Offshore CO_2 Saline Storage Cost Model's database. Some high-level results from the study included: 1) suitability of ship transport for exploration and

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long-distance shipment and pipeline transport for commercial and short-distance delivery; 2) sensitivity of pipeline costs to transport rates and distances compared to ship costs; and 3) potential to use existing or abandoned oil and gas pipelines and platforms to further reduce costs.

With the abundance of CO_2 sources onshore and offshore in the GoM, offshore carbon capture and storage (CCS) provides a strategy to manage CO_2 emissions. Offshore CCS provides advantages in the United States such as abundant storage potential, isolation of CO_2 plumes from population centers and less complicated logistical hurdles. Since there are currently no active or planned projects in the GoM and only a few studies have been conducted to investigate the options for transporting CO_2, this study helps provide some insight into the feasibility of offshore CCS particularly related to the transport and storage components.

Study Analyzes CHP with ESS

Energy storage systems (ESS) are currently being investigated as a possible option for small combined heat and power (CHP) plants to increase plant flexibility, fill in production power gaps during peak demand and supply energy to the host facility when higher emissions are incurred during operation of the gas turbine at low load conditions. The addition of an ESS to improve the operational flexibility of a CHP plant equipped with an upgraded gas turbine was analyzed in a recently released study conducted under an Office of Energy Efficiency and Renewable Energy's Advanced Manufacturing Office award titled "Advanced Turbine Airfoils for Efficient CHP Systems." A candidate CHP configuration and potential storage systems were identified before a quantitative analysis was completed to down-select possible storage technologies. The selected storage technology was then used to perform a techno-economic analysis (TEA) for the integrated CHP-ESS system. This study also included a brief literature survey on ESSs applicable to CHP plants.

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Focusing on a de-centralized energy storage application (i.e., storage that supports the host facility and supplies energy during high demand), a 15.3-MW capacity CHP plant with a 4-MW capacity ESS was generated as a business case scenario using data obtained from current CHP plant operators to evaluate the feasibility of ESS integration. The selected storage system options for integration were a polysulfide-bromide flow battery (PSBFB) and molten salt thermal storage system (MSTS).

The analysis showed that both of the selected storage system types have the potential to reduce cost of electricity (COE) of a CHP plant, are able to provide the required operational flexibility, create revenue and can reduce the overall emissions. However, MSTS showed more advantages over PSBFB in terms of plant payback period and a more significant reduction in the COE.

Staff Spotlight

During her time as a summer research associate supporting SSAE's Energy Process Analysis Team (EPAT), Madison Nichols* conducted a direct air capture (DAC) reconfiguration project, which consisted of reconfiguring adsorption vessel layouts for a DAC facility and designing to-scale ductwork systems for off-gas CO_2 handling. She focused on accurately modeling pressure drop within the ductwork, creating detailed schematics of each layout and analyzing design parameters to determine the optimal configuration in terms of cost and energy use. Madison was mentored by SSAE's Tim Fout.

Originally from a small town in Virginia, Nichols attends the Georgia Institute of Technology as a chemical engineering major. During her time as an undergraduate, she has worked to develop sorbents for carbon capture processes, fostering a passion for environmental conservation. She plans to obtain her Ph.D. in chemical engineering within the next few years and hopes to continue her carbon capture research, expanding her knowledge to help serve a greater purpose. Outside of academics, Madison enjoys playing the piano, shooting hoops and being a mom to her goldendoodle.

* NETL Support Contractor

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NETL Co-Hosts Workshop on Harmonized Guidance for Techno-Economic and Life Cycle Analyses

NETL co-hosted the workshop "CCU TEA and LCA Guidance–A Harmonized Approach" with the [Global CO_2 Initiative (GCI)] at the University of Michigan in May 2022. The workshop focused on developing consistent guidelines for TEA and life cycle analysis (LCA) of CCUS technologies. Discussion also addressed connections between carbon capture utilization (CCU) and social justice, social LCA and policy.

The International CCU Assessment Harmonization Group, an alliance of 30 international researchers aiming to create a harmonized framework for LCA and TEA and co-led by NETL and GCI, organized the workshop to present outcomes of harmonization efforts and plan next steps. Several members of the LCA Team presented or moderated at this workshop:

- "Status of Assessment Harmonization: Alignment, Differences, Applications" was presented by Michelle Krynock, who also co-moderated a breakout session titled "Moving from Guidance to Standards–Increasing Acceptance and Confidence in CCUS Technology Characterization."
- The sessions "Emerging Technologies: ACLCA/SETAC Workgroup" and "Emerging Technology Analysis" were moderated by Sheikh Moni*.
- During the "TEA of Emerging CO2U Technologies" session, "NETL CO2U TEA Guidelines" was presented by Samuel Henry*.
- Welcoming and concluding remarks were provided by Timothy Skone.

SSAE Involvement in NRAP Phase III Task 5 Support

SSAE's Energy Systems Analysis Team (ESAT) has been invited to provide support to the National Risk Assessment Partnership's (NRAP) Phase III Task 5 activity "Quantitative Assessment of Long-term Leakage Risk, Liability and Project-wide Financial Risk Evolution."

ESAT's experience and expertise in the implementation and costing of a CO_2 saline storage project using the FECM/NETL CO_2 Saline Storage Cost Model (also known as CO2_S_COM) will be utilized to support the development of a design basis for carbon storage risk and financial responsibility quantification. The design basis will identify a possible long-term liability problem (like CO_2 leakage or induced seismicity) that would typically be addressed by a storage project's maintenance of financial responsibility instrument(s), and then identify bounds of design from existing emergency remedial response plants, NRAP tools and CO2_S_COM that can be used to quantify the risk and associated financial responsibility.

NETL's Techno-Economic Models Highlighted at SPE Workshop

An overview of the techno-economic models NETL has developed for assessing performance characteristics and cost drivers for CO_2 pipeline transport (CO2_T_COM), CO_2 saline storage (CO2_S_COM) and oil production and CO_2 storage using CO_2 EOR (FE/NETL CO_2 Prophet Model or CO2_Prophet and FE/NETL Onshore CO_2 EOR Cost Model or CO2_E_COM) was given by Travis Warner* per invitation in August 2022 at the SPE Workshop: Future Energy Roadmap–Navigating through the Energy Transition. A high-level description of each model was presented along with useful outputs and example applications that can be generated with each model, like the recent NRAP Phase III Task 5 design basis support work using CO2_S_COM mentioned in the previous article. The presentation also highlighted the open-source nature of these models that allows interested stakeholder groups to download the models and apply them to their specific problems.

SSAE Research Featured at Carbon Management Meeting

Several SSAE staff joined NETL Director Brian Anderson and other NETL experts to showcase their research at DOE-NETL's 2022 Carbon Management Project Review Meeting in August 2022.

The meeting featured presentations on point source carbon capture, CO_2 removal, carbon conversion and carbon storage. Listed below are the SSAE presentations. Each presenter fielded questions during their session. Interest in certain aspects of projects were indicated. Publication is pending for several presentations, as noted below.

- Updated costs for CO_2 capture from industrial plants, from a pending update to NETL's "Cost of Capturing CO_2 from Industrial Sources", was presented by Sally Homsy*. The presentation, "[Recent Point Source Capture Techno-economic Analysis]," also highlighted other upcoming updates to legacy point-source capture reports, novel point-source capture reports and CO_2 removal reports.
- Methodology used to construct and the results from an application of the System Cost of Replacement Energy (SCoRE) tool were discussed in a presentation, "Development of a Tool to Calculate the System Cost of Replacement Energy" (pending publication), given by Amanda Harker Steele. To date, the SCoRE tool, which was developed to estimate changes in the total systems cost from implementing competing power generation technology pathways to decarbonization in an operating region, has been applied to the Electric Reliability Council of Texas operating region.
- A summary of models and resources for researchers evaluating the environmental performance of existing and emerging energy technologies was presented by Michael

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Whiston*. The tools discussed in the presentation, "LCA Tools Available at NETL," included emissions inventories and impacts associated with electricity generation and consumption in the United States, best practices for DAC studies, biomass profiles and saline aquifer storage assessment.

- Results on site selection, subsurface and infrastructure assessment and cost estimation of a conceptual pilot-scale CO_2 storage project in the offshore GoM was discussed in a presentation, "Site Selection and Cost Estimation of Pilot-Scale CO_2 Saline Storage Study in the Gulf of Mexico," given by Nur Wijaya*. Feedback after the presentation included potential future work to expand on the multi-criteria screening tool to incorporate additional geospatial data on seawater quality and potential adjustment to reflect necessary costs to diagnose, precondition and retrofit existing platforms for the offshore injection operation. Wijaya also presented results from a recent publication on the effect of well spacing on CO_2 plume and pressure interference in regard to basin management of geologic CO_2 storage in a separate presentation, "Numerical Simulation of Commercial-Scale CO_2 Storage in a Saline Formation Evaluating Basin-Scale Pressure Interference and CO_2 Plume Commingling." Some feedback noted the timeliness of the study given CCS growth needed to achieve the decarbonization goals.
- A summary of the supply chain risks facing 11 clean energy technologies or enabling materials was presented by Clint Noack* in the presentation "Supply Chain Vulnerabilities of the Energy Transition: A Focus on Carbon Capture, Transportation, and Storage." One technology, carbon capture, transportation and storage, was explored in more depth, highlighting the relatively low physical constraints on its deployment (technology readiness, material availability, manufacturing capacity) as a platform for decarbonization.
- Updates to two of NETL's techno-economic models, CO2_T_COM and CO2_S_COM, were discussed in a presentation given by David Morgan. The presentation, "Update of CO2_T_COM and CO2_S_COM Models (CO_2 Transport and Storage Costs)," provided an overview of each model and discussed the latest additions or revisions. Example results, such as break-even or levelized CO_2 cost as a function of pipeline length and CO_2 mass flow rate for CO2_T_COM and cost supply curves as a function of key input variables for CO2_S_COM, were also showcased. In a separate session, Alana Sheriff* provided a high-level demonstration on how to perform a run with each of these models highlighting key inputs and noting results.
- An overview and the opportunity for CO_2 geologic storage and utilization in supporting an energy transition for the Intermountain West (I-WEST) Region to carbon neutrality by 2050 was presented by Derek Vikara*. Topics, such as roadblocks and opportunities, technical and non-technical insights to mitigate risk and perceive risk, techno-economic assessment of regional geologic storage options and next steps to help facilitate storage and utilization deployment in the I-WEST Region were discussed in the presentation, "Pathways to CO_2 Utilization and Storage for the Intermountain West Region."
- Highlights of the Carbon Capture Simulation for Industry Impact ($CCSI^2$) program over execution year 21 was discussed in a presentation given by Joshua Morgan*. Projects on process modeling and TEA and optimization were reviewed, as were the collaborations with industrial partners for testing novel CCS technologies at the Technology Centre Mongstad. Finally, some future directions for the $CCSI^2$ program for execution year 22 and beyond were emphasized, including enhanced focus on carbon capture from industrial sources as well as robust design and optimization of CCS systems at high levels of CO_2 capture. $CCSI^2$ was also represented by multiple national laboratories (i.e., Los Alamos National Laboratory [LANL], Lawrence Livermore National Laboratory [LLNL], Oak Ridge National Laboratory [ORNL] and Pacific Northwest National Laboratory [PNNL]). Presentations were provided on various topics: 1) capabilities, progress and applications of sequential design of experiments (SDoE) by LANL, 2) machine learning-based computational fluid dynamics model reduction for rapid computation screening by LLNL, 3) computational design and process intensification of CO_2 absorbers by ORNL and 4) solvent model validation for advanced solvent and contactor design by PNNL (pending publication).
- An overview of the LCA-related work performed by the NETL LCA Team to support the U.S. DOE Carbon Conversion Program was presented by Michelle Krynock. This work includes LCAs of various carbon conversion-related technology pathways; the creation and maintenance of the NETL CO2U LCA Guidance Toolkit and associated 45Q addendum; and coordination with multiple international LCA organizations to develop and harmonize consistent LCA methodology. The session was well attended, and the audience asked questions showing interest in using the NETL toolkit but concern about compatibility with LCAs required for other government programs.
- Main capabilities of the framework for optimization, quantification of uncertainty and surrogates (FOQUS) along with the value it provides to users was highlighted in a presentation given by Anuja Deshpande*. A few of its applications in $CCSI^2$ were also presented, in which FOQUS has been used for implementing comprehensive carbon capture systems analysis and optimization. FOQUS is an open-source computational tool that was developed as a part of the $CCSI^2$ initiative. Updated capabilities of FOQUS were also discussed by Daison Manuel Yancy Caballero* during a poster presentation (pending publication) and demonstrated during a separate session by Anuja. The FOQUS demo session included an overview of the software capabilities that include flowsheet setup, uncertainty analysis, surrogate modeling and optimization. A small case study was implemented for analysis of a monoethanolamine (MEA) solvent-based carbon capture system.

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- The useability and benefits of autoencoders for dimension reduction in machine learning modeling of subsurface reservoir processes was given by Kolawole Bello* in a poster presentation, "Application of Dimensionality Reduction in Machine Learning Modeling of CO_2 Storage" (pending publication). Case studies of this application were done with deep learning models that can predict spatio-temporal outputs of CO_2 saturation, pressure and brine production in a three-dimensional saline storage reservoir over 30 years of continuous CO_2 injection and a 50-year post-injection timeframe. More details can be found in the study's report.
- A DAC case study that examined a solid sorbent-based DAC technology and configuration was the focus of a poster presentation (pending publication) given by Timothy Fout and Sally Homsy*. The study examined the use of fixed bed and monolith sorbent configurations. These configurations illustrated that the air contactor pressure drop is a key aspect of the performance of DAC systems and the overall cost.
- Mathematical modeling and economics of a solid sorbent-based CO_2 capture process for natural gas power generation plants was presented by Ryan Hughes* in a poster presentation (pending publication). The work also featured economic optimization done using the FOQUS toolset developed as part of the Carbon Capture Simulation Initiative (CCSI).
- The results of a recently completed TEA characterizing the cost of CO_2 capture on cement plants was presented by Eric Grol in a poster presentation, "Additional Analysis of Carbon Capture at Industrial Facilities." Consistent with other techno-economic studies of capturing CO_2 from low-purity industrial sources, a significant portion of the operating cost impact is due to the purchasing of additional power and natural gas required to operate the capture system. This study also considered the potential impact of additional flue gas cleaning prior to CO_2 capture, to protect the stability of the amine capture solvent. The poster was based on a recently completed collaborative analysis between SSAE's EPAT and the Portland Cement Association, which is expected to be publicly available in the fourth quarter of 2022.
- An economic analysis of the potential for CCUS in the GoM was presented by Tim Grant and Connie Zaremsky* in a poster presentation (pending publication). A CCUS model was developed that provides a high-level economic analysis of CCUS opportunities in the GoM. The intent of the model is to act as a guidance tool, giving a high-level cost analysis throughout the entire project supply chain to indicate whether a specific project scenario could be profitable. The model consists of eight segments or links that define the overall CCUS supply chain: capture, transportation and operations. It also looks at both saline and CO_2 EOR storage opportunities, either brownfield or greenfield.
- A summary of modeling and optimization of a natural gas combined cycle (NGCC) plant with a MEA solvent-based CO_2 capture system with high levels of CO_2 capture—up to and beyond net-zero emissions—was presented by Joshua Morgan* in a poster presentation (pending publication). The overall purpose of this ongoing work is to understand the incremental cost of high levels of CO_2 capture in order to compare with DAC and other net-negative technologies, as well as to understand optimal operation and design of the capture unit to achieve high capture with minimal increase in cost.
- During the DAC Test Center Workshop, a presentation focused on outlining NETL capabilities in supporting testing via process systems engineering capabilities was given by Benjamin Omell. The presentation outlined available tools in both the CCSI and Institute for the Design of Advanced Energy Systems (IDAES) toolsets, including model libraries of solid-gas contactors, uncertainty quantification, sequential design of experiments and other advanced capabilities in multi-scale optimization. Also, during this workshop, an overview of NETL's energy process analysis work and TEA methodology was presented by Sally Homsy* on behalf of Timothy Fout. Results and lessons learned from the recently published "Direct Air Capture Case Studies: Sorbent System" were also highlighted.

SSAE Welcomes Alison Fritz

On August 15, 2022, Alison Fritz joined SSAE's EPAT at NETL Albany. She has been working in the critical minerals sphere for over six years. Most recently, Alison worked with NETL as an Oak Ridge Institute for Science and Education (ORISE) research associate applying TEA, data analysis and statistical modeling to assess economic viability of alternative rare earth element feedstocks. Prior to her work as a research associate, she supported the implementation of environmental data management and emission quantification software for industrial clients and developed tools for a programmatic approach to sustainable infrastructure evaluation using the Envision framework.

Alison earned her bachelor's degree in Environmental Engineering from Yale University and is currently completing her Ph.D. in Civil and Environmental Engineering at Stanford University in the Water and Energy Efficiency for the Environment research group, focusing on solutions for energy transition and evaluation of water consumption and quality constraints of power generation. In her free time, she can usually be found running, trying new recipes or playing ultimate frisbee.

// PERSPECTIVES

Case Study Conducted to Explore Sorbent-Based DAC Systems

In view of the Biden Administration's goals to achieve a fully decarbonized power sector by 2035 and a net-zero economy by 2050, research and development (R&D) into CCS technology is of vital interest to the country. To aid in the removal of CO_2 in sectors from which the emissions are difficult to abate and to address historical anthropogenic emissions, carbon dioxide removal (CDR) technologies have become a focal point of R&D in DOE's FECM. CDR technologies focus on addressing non-point source CO_2 emissions through effectively removing CO_2 directly or indirectly (via biomass with CCS) from the air. The capture and storage or conversion of CO_2 directly from the air is commonly referred to as DAC. DAC has been identified as an important tool to meet the Administration's goals; thus, it is a priority for DOE and figures prominently in the Bipartisan Infrastructure Law. In fact, $3.5 billion has been dedicated to the development of regional DAC Hubs that will each capture at least 1 million tonnes of CO_2 from the atmosphere. DOE also established Carbon Negative Shot to reduce the cost of CDR technologies within ten years to $100/net tonnes CO_2 removed from the atmosphere and utilized or stored permanently.

Because of its anticipated role in decarbonization and a lack of detailed historical performance and cost assessments, SSAE performed a case study on DAC technology (learn more). The objective was to develop an independent assessment of the performance and cost of a generic sorbent-based DAC system. This assessment also applied reporting standards similar to those used by SSAE's EPAT in its other reports, including the Fossil Energy Baseline. This is an important feature of the DAC report, as much of the literature information available on the techno-economic evaluation of DAC is limited in detail. In order to provide a preliminary estimate of this emerging technology on the threshold of commercial application, the sorbent considered in the study was not reflective of any one material type, or functionalization approach. Additionally, the system configuration represented what was judged to be the most reasonable configuration from a cost perspective if these systems were to be deployed in the near term.

The study identified four base cases, utilizing either a packed bed sorbent system or a monolithic sorbent support for reduced pressure drop and considering either a NGCC power system with 90% carbon capture or generic carbon-free (e.g., renewable) generation. Systems were sized at 100,000 tonnes of CO_2 net removed from the atmosphere per year, with CO_2 at 400 ppmv concentration. Because of residual emissions primarily from the power system, total tonnes of CO_2 removed from the air will be higher.

Capital cost estimates were developed with an uncertainty range of +/- 50%, consistent with Association for the Advancement of Cost Engineering (AACE) Class 5 cost estimates (i.e., concept screening). Since DAC systems are an immature technology, the cost estimate methodology presented in this report does not fully account for the unique cost premiums associated with the initial complex integrations of established and emerging technologies in a commercial application. The costs in the report represent neither first-of-a-kind (FOAK) nor Nth-of-a-kind (NOAK) costs. Nevertheless, the application of a consistent methodology—and the presentation of detailed equipment specifications and costs based on contemporary sources—facilitate comparison between cases as well as sensitivity analyses to guide R&D, and generally improve upon many publicly available estimates characterized by more opaque methods and sources with less detail.

The report focuses on the monolithic sorbent support cases. Figure 1 highlights the results of the NGCC case in terms of cost of CO_2 capture (COC). The figure shows the COC metric in three different ways. COC DAC Net, as previously indicated, is the COC based on the CO_2 effectively removed from the atmosphere. COC DAC Gross is based on total CO_2 captured by the DAC system. COC DAC Total Plant Gross accounts not only the CO_2 gross captured by the DAC plant, but also the CO_2 captured by the NGCC plant with CO_2 capture. NETL recommends through this report that the DAC Net metric be utilized as it is the true cost for the removal of CO_2 from the atmosphere.

The report also presents a case for carbon-free power. This case assumes an electric boiler powered by carbon-free renewables for steam generation. When examining the electric boiler case, it is important to note that the NETL report treats net capture costs as equal to the gross capture cost. However, all electricity imported for use by DAC systems will have some life cycle carbon emissions, and it will be important to account for those emissions in overall power/economic systems modeling. The report also analyzes several sensitivities that illustrate both the potential for R&D advancement on the DAC process as well as areas of interest that could cause the cost of DAC to increase if not considered carefully in system development and design.

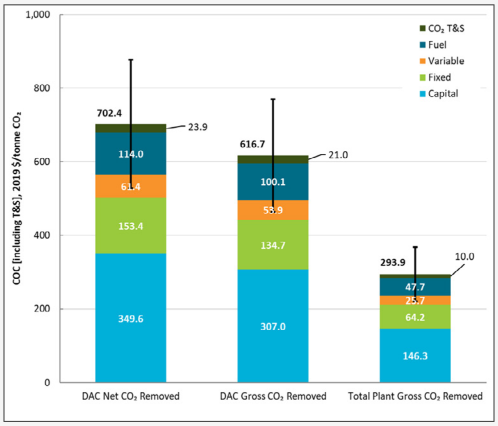

Figure 1. COC including capital cost uncertainty ranges

SSAE is also preparing a similar case study for solvent-based DAC systems.

SSAE's Process Systems Engineering Research Team is performing sorbent-based DAC optimization work based on the present sorbent-based study using IDAES tools under an ExxonMobil Research & Engineering-funded cooperative research and development agreement. – Contributed by Timothy Fout, SSAE's EPAT

// UPCOMING CONFERENCES AND EVENTS

SSAE Federal staff and NETL support contractor personnel will attend or present at the following conferences and events in September 2022:

- The International Meeting for Applied Geoscience & Energy
  Participant: Luciane Cunha
  Houston, TX, August 28–September 1, 2022
- NERC Reliability Assessment Subcommittee Third Quarter Meeting
  Participant: John Brewer
  Hybrid (Virtual and Montreal, Canada), August 31–September 1, 2022
- Hydrogen Hubs Summit
  Participant: Eric Lewis
  Arlington, VA, September 12–14, 2022
- 39th Annual International Pittsburgh Coal Conference
  Presenter: Robert James–1) Baseline Cost and Performance Assessment of Low-Rank Coal-Fueled Power Plants with Carbon Capture and Sequestration and 2) High CO_2 Capture Rate Cost and Performance Baseline Results for Natural Gas Combined Cycles (NGCC)
  Participant: Gavin Pickenpaugh
  Virtual, September 19–22, 2022
- EPRI Generation Advisory and Council Meetings – September 2022
  Presenter: Timothy Fout–Direct Air Capture Case Studies
  Participants: Erik Shuster and Marc Turner*
  Louisville, KY, September 19–23, 2022
- Global Clean Energy Action Forum
  Participant: Timothy Fout
  Pittsburgh, PA, September 22, 2022
- Carbon Intel Forum 2022
  Presenter: Timothy Fout–Direct Air Capture Case Studies
  Participant: Peter Balash
  Houston, TX, September 28–29, 2022

// RECENT PUBLICATIONS

Reports/Supporting Documentation

- S. C. Uysal, "Advanced Turbine Airfoils for Efficient CHP Systems: Energy Storage Integration Analysis," National Energy Technology Laboratory, DOE/NETL-2021/2877, Pittsburgh, PA, June 21, 2021.
- A. K. S. Iyengar, A. A. Noring, J. K. Mackay and D. L. Keairns, "Techno-economic Analysis of Natural Gas Fuel Cell Plant Configurations," National Energy Technology Laboratory, DOE/NETL-2022/3259, Pittsburgh, PA, April 30, 2022.
- A. K. S. Iyengar, A. A. Noring, R. A. Newby and D. L. Keairns, "Techno-economic Analysis of Integrated Gasification Fuel Cell Systems," National Energy Technology Laboratory, DOE/NETL-2022/3250, Pittsburgh, PA, April 30, 2022.
- T. McGuire, T. Warner and A. Sheriff, "Characterizing the Value of Single Source CO_2 Intermediate Storage (CIS) to Optimize Pipeline Utilization/Economics," National Energy Technology Laboratory, DOE/NETL-2022/3806, Pittsburgh, PA, July 7, 2022.
- T. Warner, R. Knapp, A. Sheriff and T. McGuire, "CO_2 Intermediate Storage (CIS) Concept Overview," National Energy Technology Laboratory, DOE/NETL-2022/3805, Pittsburgh, PA, July 7, 2022.
- J. Valentine and A. Zoelle, "Direct Air Capture Case Studies: Sorbent System," National Energy Technology Laboratory, DOE/NETL-2021/2865, Pittsburgh, PA, July 8, 2022.
- M. Krynock, A. Pegallapati, M. Mutchek and G. Cooney, "CO2U Example Report: NETL CO_2 to Renewable Diesel and Co-products via Algal Production," U.S. Department of Energy, National Energy Technology Laboratory, Pittsburgh, PA, August 8, 2022.

* NETL Support Contractor

// RECENT PUBLICATIONS cont'd

Presentation

- J. Brewer and N. Messina, "New Energy Infrastructure Outlook, Data as of December 31, 2021," National Energy Technology Laboratory, DOE/NETL-2022/3297, Morgantown, WV, 2022.

Conference Proceedings and Events

- S. C. Uysal, D. Straub and J. B. Black, "Impact on Cycle Efficiency of Small Combined Heat and Power Plants From Increasing Firing Temperature Enabled by Additive Manufacturing of Turbine Blades and Vanes," GT2021-58718, paper presented at the ASME 2021 Turbo Expo, Virtual, June 7–11, 2021.
- S. R. Pidaparti, C. W. White and N. T. Weiland, "Impact of Plant Siting on Performance and Economics of Indirect Supercritical CO_2 Coal Fired Power Plants," GT2021-58867, paper presented at the ASME 2021 Turbo Expo, Virtual, June 7–11, 2021.
- S. R. Pidaparti, C. W. White and N. T. Weiland, "Optimized Performance and Cost Potential for Indirect Supercritical CO_2 Coal Fired Power Plants," GT2021-58865, paper presented at the ASME 2021 Turbo Expo, Virtual, June 7–11, 2021.
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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

Life Cycle Analysis Models

NETL LCA CO2U 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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Life Cycle Analysis webpage

CCSI[2] webpage

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