National Carbon Capture Center

primary project goal

The U.S. Department of Energy (DOE)/National Energy Technology Laboratory (NETL) and Southern Company operate the National Carbon Capture Center (NCCC), a neutral research facility working to advance technologies to reduce greenhouse gas emissions from fossil-based power plants and industrial processes and to promote carbon utilization and direct air capture (DAC) innovations. Located in Wilsonville, Alabama, the center offers a unique test bed for third-party evaluations of cost-effective carbon dioxide (CO_2) capture technologies—bridging the gap between laboratory research and large-scale demonstrations.

The NCCC offers exceptional benefits to technology developers by providing them with testing opportunities in the real-world operating conditions of a power plant, thereby accelerating the commercialization of low-cost, carbon capture processes. The center has surpassed 125,000 hours of testing for carbon capture innovators from the United States and six other countries. Through the testing of 70 technologies, the center has directly participated in the reduction of the projected cost of CO_2 capture by approximately 40%.

The NCCC, shown at left, supports the evaluation of advanced technologies from both domestic and international developers. These evaluations are critical in identifying and resolving environmental, health and safety, operational, component, and system development issues, as well as achieving scale-ups and process enhancements in collaboration with technology developers. DOE-sponsored projects, as well as projects from industry, universities, and other collaborative institutions, provide a full spectrum of technologies for testing at the center.

technical content

The DOE Office of Fossil Energy and Carbon Management's (FECM) NETL, in cooperation with Southern Company, established the NCCC in 2009 to provide an independent, flexible, cost-efficient carbon capture testing facility with industrial operating conditions. Since its inception, researchers at the NCCC have conducted numerous tests for the advancement of post-combustion carbon capture for coal and natural gas power plants. Early testing also included more than 30 projects in the gasification and pre-combustion carbon capture areas, a scope of work that has since concluded. In 2020, the NCCC added new infrastructure to broaden its post-combustion test capabilities under actual natural gas-fired conditions. Additionally, the center has begun to host CO_2 utilization and

project focus:
Carbon Capture Testing Center

participant:
Southern Company

project number:
FE0022596

predecessor projects:
NT0000749

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partners:
American Electric Power; BP; ClearPath Foundation; Electric Power Research Institute; ExxonMobil; NRECA; Peabody; Tennessee Valley Authority; TotalEnergies; Wyoming Integrated Test Center

start date:
06.06.2014

percent complete:
70%

DAC technologies, as well as carbon capture process intensification projects. The testing infrastructure supports the capability to test hybrid concepts that include both DAC and CO_2 capture from concentrated sources.

The NCCC's post-combustion test facilities operate at Alabama Power's Plant Gaston with flue gas supplied from the center's natural gas boiler and Plant Gaston Unit 5, a commercial, base-loaded, 880-megawatt (MW) supercritical pulverized coal-fueled unit. The natural gas boiler produces flue gas representative of that from a commercial natural gas combined-cycle power plant. The NCCC provides test bays for simultaneous lab-, bench- and pilot-scale operation of advanced carbon capture technologies at commercially relevant process conditions. These include two fully integrated processes for solvent evaluations—a pilot-scale test unit (PSTU) and a bench-scale slipstream solvent test unit (SSTU)—as well as seven pilot- and bench-scale test bays and an indoor lab-scale test area. The center also provides support for design, procurement, construction, installation, operation, data collection and analysis, and reporting in compliance with environmental and government requirements. Figure 1 shows the test facilities and the natural gas and coal flue gas configurations.

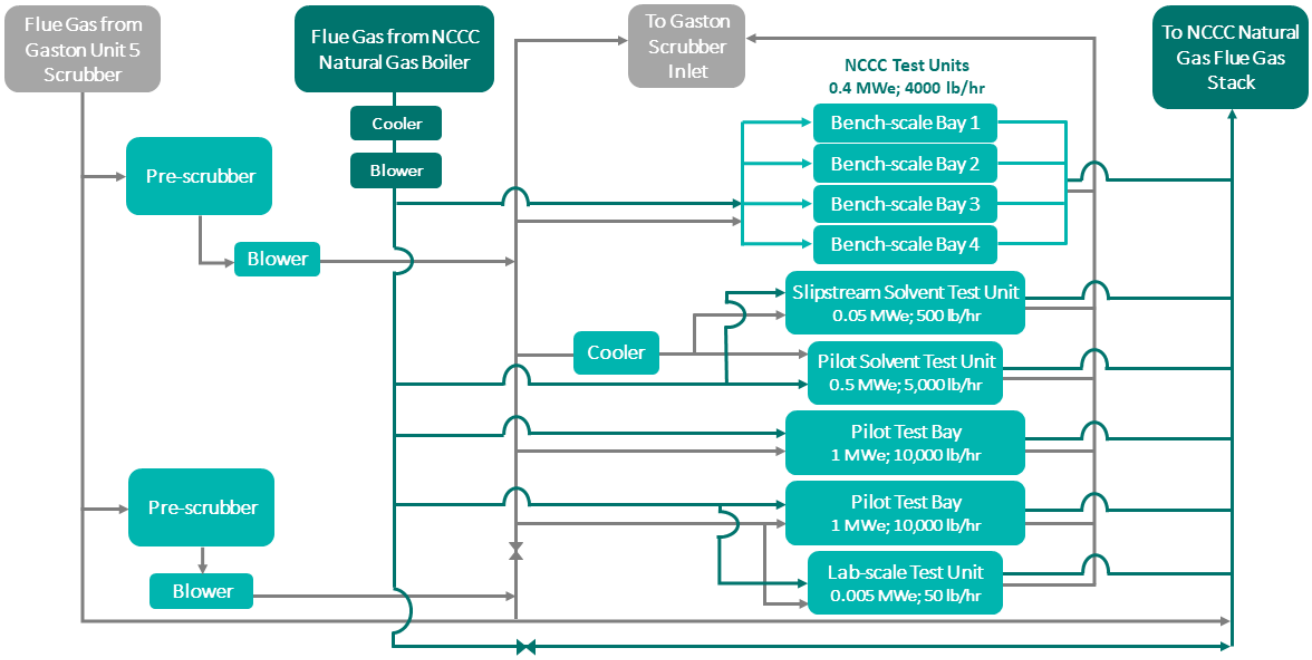

Figure 1: Diagram of post-combustion test facilities at the National Carbon Capture Center.

The PSTU is a nominal 0.5-megawatt-electric (MWe) solvent-based CO_2 capture absorber/stripper system designed to process a flow rate of 5,000 pounds per hour (lb/hr) coal-derived flue gas or up to 8,000 lb/hr natural gas-derived flue gas. The major components of the system are a pre-scrubber, cooler/condenser, absorber, wash tower, and regenerator. The PSTU has three options available for solvent regeneration to release the CO_2 from the solvent:

1. A packed-bed column regenerator that provides heat via steam in a sump-located pump-around loop with a shell and tube heat exchanger to release CO_2 in a conventional simple stripper configuration.
2. A continuous stirred tank reactor (CSTR), designed by GE Global Research for their testing, which is a one-stage separation unit with reduced space requirements and potentially lower capital requirements compared to conventional regenerator columns.
3. An advanced flash stripper, developed by the University of Texas at Austin and AECOM for their testing, which recovers the stripping steam heat by employing cold and warm rich bypasses.

The SSTU is a 0.05-MWe solvent-based CO_2 absorber/regenerator system with the ability to test innovative CO_2 capture solvents under a variety of conditions using up to 500 lb/hr of flue gas. The SSTU is optimized for validating lab-based results under industrial conditions to yield scalable data for further pilot-scale testing.

technology advantages

The NCCC's ability to support multiple developers and tests simultaneously at various scales, and to offer flexibility in capacity and process conditions, offers a wide range of data and information to accelerate the commercialization of CO_2 capture and utilization technologies. The NCCC also offers advantages to DAC developers, including a proficient staff, the capability to test both DAC and capture from concentrated sources (or hybrid concepts), and assistance in finding domestic and international partners for scale-up.

R&D challenges

The NCCC's state-of-the-art facility, which delivers necessary infrastructure, flue gases, utilities, and other support, enables the effects of system interactions to be understood to ensure a smooth transition of technologies from a laboratory setting to an industrial setting. By executing field-testing under realistic power plant conditions, technologies can be scaled-up with confidence for larger-scale demonstrations. For technologies that are not ready for scale-up, improvements are identified, and further engineering-scale testing needs are defined.

status

NCCC operation has provided more than 75,000 hours of testing enzymes, membranes, sorbents, solvents, hybrids, and associated systems for post-combustion carbon capture, as well as CO_2 utilization technologies, and included 46 technologies from 33 developers, with eight technologies scaled-up (or ready) to be demonstrated at 10+ MW. More than 8,000 hours of testing has been conducted under simulated natural gas conditions. In addition, test campaigns are planned for DAC technologies. The PSTU has operated for more than 24,000 hours in support of commercial developers and DOE's Carbon Capture Simulation Initiative, with several technologies progressing to larger-scale testing at other facilities and commercial demonstration. Since its creation, the NCCC has more than tripled its plant capacity from 12,000 to 40,000 lb/hr flue gas and has added systems (lab-scale test unit [LSTU], advanced flash stripper, natural gas flue gas infrastructure, etc.), along with enhanced instrumentation, sampling methods, and analysis systems. Performance data generated in technology testing at the NCCC has been used to validate laboratory data allowing for engineering scale-up and, in turn, driving new breakthroughs in carbon capture solutions.

available reports/technical papers/presentations

"National Carbon Capture Center Technology Testing Update (FE002256)," presented by Tony Wu, Southern Company, 2021 NETL Carbon Management and Oil and Gas Research Project Review Meeting, August 2021. *https://netl.doe.gov/sites/default/files/netl-file/21CMOG_PSC_Wu.pdf*.

"Carbon Utilization and the National Carbon Capture Center," presented by John Northington, Southern Company, 2020 NETL Integrated Project Review Meeting – Carbon Utilization, October 2020. *https://netl.doe.gov/sites/default/files/netl-file/20VPRCU_Northington.pdf*.

"Advanced Carbon Capture Testing at the National Carbon Capture Center (FE0022596)", presented by Michele Corser, Southern Company, 2019 NETL Carbon Capture, Utilization and Storage, and Oil and Gas Technologies Integrated Review Meeting, Pittsburgh, PA, August 2019. *https://netl.doe.gov/sites/default/files/netl-file/M-Corser-Southern-Co-NCCC-Testing.pdf*.

"Status of Technology Development at the National Carbon Capture Center," presented by Justin Anthony, John Carroll, Michele Corser, Frank Morton, Tony Wu, and Ruth Ann Yongue, Southern Company, International Conference on Greenhouse Gas Control Technologies, GHGT-14, October 2018. *https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3366390*.

"Update on National Carbon Capture Center (FE0022596)," presented by Tony Wu, Southern Company, 2018 NETL CO_2 Capture Technology Project Review Meeting, Pittsburgh, PA, August 2018. *https://www.netl.doe.gov/sites/default/files/netl-file/T-Wu-Southern-National-Carbon-Capture-Center.pdf*.

"Advanced Technology Testing at the National Carbon Capture Center (FE0022596)," presented by John Carroll, Southern Company, 2017 NETL CO_2 Capture Technology Project Review Meeting, Pittsburgh, PA, August 2017. *https://www.netl.doe.gov/File Library/Events/2017/co2 capture/1-Monday/J-Carroll-Southern-National-Carbon-Capture-Center.pdf*.

"Advanced Technology Testing at the National Carbon Capture Center," presented by Justin Anthony and John Carroll, Southern Company, 2016 NETL CO_2 Capture Technology Project Review Meeting, Pittsburgh, PA, August 2016. *https://www.netl.doe.gov/File Library/Events/2016/c02 cap review/1-Monday/J-Anthony-SouthernCo-Testing-at-National-Carbon-Capture-Center.pdf*.

National Carbon Capture Center website: *https://www.nationalcarboncapturecenter.com/*.