CHANGING WHAT'S POSSIBLE

FLECCS—FLExible **C**arbon **C**apture and **S**torage

PROJECT DESCRIPTIONS

GE Global Research – Niskayuna, NY

Flexible Oxy-Fuel Combustion for High-Penetration Variable Renewables - $717,658

GE Global Research will optimize an oxy-combustion natural gas-fired turbine—the Allam-Fetvedt cycle—for flexible generation on a grid with high-variable renewable energy (VRE) penetration at near-zero carbon emissions. The team will use gas or liquid buffering tanks and tight thermal integration between the air separation unit and the oxy-combustion turbine. The proposed technology easily separates the CO_2 and H_2O in the flue gas of an oxy-combustor. The post-combustion outlet gas is more easily separated into water and CO_2 to the pipeline, thereby lowering the electricity costs of grids with high levels of VRE.

8 Rivers Capital – Durham, NC

Enhancing Responsiveness of Gas Turbine Generators through Retrofitting with Exhaust Gas Recycle and a Phase-Change CO_2 Capture Process - $1,178,453

8 Rivers Capital seeks to enhance the profitability and responsiveness of gas turbine generators in high variable renewable energy environments by retrofitting existing plants with Exhaust Gas Recycle (EGR) and a novel phase-change solvent CO_2 capture system known as UNO MK3, offering a lower cost pathway than new gas turbines with capture. The team's system uses a low-energy regeneration solvent to maximize EGR potential by reducing absorber and stripper size and cost. The technology uses 10-15% less energy than existing amine absorbents. UNO MK3 allows CO_2 to be withdrawn and stored as solid potassium bicarbonate during high energy demand, eliminating stripper energy and enabling profitable regeneration.

Colorado State University – Fort Collins, CO

Synergistic Heat Pumped Thermal Storage and Flexible Carbon Capture System - $1,000,000

Colorado State University will develop a thermal energy storage system combined with partner ION Clean Energy's flexible advanced solvent carbon capture technology. The system aims to decrease the levelized cost of electricity for natural gas-fired combined cycle (NGCC) power plants to <75 $/MWh while simultaneously capturing 95% of CO2 emissions when operating in highly variable renewable energy penetration markets. The team's approach uses a novel and low-cost heat-pump thermal storage system. This system nables load shifting and NGCC efficiency benefits to reduce capital costs and achieve higher net plant capacities for electrical grid markets that require substantial dynamic changes in power plant output.

RTI International – Research Triangle Park, NC

Advanced Co_2 Capture Solvent Systems for Dynamic Power- $999,470

RTI International will develop a cost-effective, resilient, load-following advanced CO_2 capture technology for natural gas power plants. The team's CO_2 capture process maximizes the net present value of the plant by using advanced water-lean solvents (WLSs) and process intensification equipment, such as a rotating packed bed (RPB) centrifugal absorber and dual-stage flash solvent regeneration. Advanced WLSs decrease operating costs by requiring low energy for solvent regeneration. RPBs reduce power plant capital cost by intensifying the absorption process to enable a reduced absorber size compared to conventional packed beds. The dual-stage flash regenerator will improve flexibility and reduce capital cost compared to a conventional reboiler.

University of Pittsburgh – Pittsburgh, PA

Natural Gas/Direct Air Capture Hybrid Plant - $800,283

The University of Pittsburgh will develop a natural gas-fired combined cycle (NGCC) power plant hybrid that uses membrane and sorbent carbon capture systems. Under normal operations, the NGCC plant produces power, and the two carbon capture systems capture roughly 99% of the CO_2. During off-peak hours, the NGCC plant powers the two carbon capture systems, one corresponding to the post-combustion gases of the power plant and the other to CO2 capture from the air. The team will develop models, optimize the system using DOE-developed tools, and perform dynamic simulations. It is expected that the hybrid plant's negative emissions technology captures more CO_2 than the plant produces, is flexible to changes in the electric grid, and can profit from carbon prices during off-peak hours to minimize capital costs.

Georgia Institute of Technology – Atlanta, GA

Positive Power with Negative Emissions: Flexible NGCC Enabled by Modular Direct Air Capture - $1,009,210

The Georgia Institute of Technology (Georgia Tech) will develop a modular direct air capture (DAC) process to be integrated with flexible natural gas-fired combined cycle (NGCC) power plants. This approach couples CO_2 emissions capture from the natural gas plant using conventional technology with a novel design based on materials capable of removing CO_2 from the air. The NGCC plant will run continuously, and the conventional technology will perform at its most efficient level. In times of low demand, steam and power from the natural gas plant are directed to remove CO_2 from the atmosphere. The modular nature of the direct air capture system allows for partial operation, making it highly flexible and allowing power generators to respond to variable renewable energy production.

Linde Gas North America – Murray Hill, NJ

Process Integration and Optimization of an NGCC Power Plant with CO_2 Capture, Hydrogen Production and Storage - $479,966

Linde Gas aims to develop such a system for natural gas-fired power plants using post-combustion carbon capture and hydrogen technologies. Integrating an electrolyzer for hydrogen production and tanks for hydrogen storage with a natural gas power plant that has carbon capture will enable the plant to operate under more steady-state conditions, improve its efficiency, and increase its capital utilization. Eliminating frequent starts and stops of these large power systems will also reduce fugitive carbon emissions during ramp-ups and ramp-downs. The value of this process design becomes greater as the differential in high and low prices of electricity increases and value for CO_2 emissions improves.

Massachusetts Institute of Technology – Cambridge, MA

Power Plant CO_2 Capture Integrated with Lime-based Direct Air Capture - $810,000

The Massachusetts Institute of Technology (MIT) will investigate the cost-effective design and operation of a negative carbon emissions power plant concept that combines flue gas CO_2 capture with a lime-based direct air capture (DAC) process while not affecting power plant flexibility. First, the power plant flue gas is fed into a calciner, a reactor that breaks down calcium carbonate ($CaCO_3$) into lime and carbon dioxide (CO_2). Next, the CO_2-rich gas (>30% CO_2) from the calciner is separated to recover high- purity CO_2, which can be stored. Last, the lime goes through a novel DAC process that captures additional CO_2 from the air in the form of solid $CaCO_3$ that can be sequestered or reused as feed to the calciner. The process can be retrofitted to existing power plants or deployed as part of new low-carbon emissions power plants.

Susteon Inc., – Cary, NC

A Rapid Temperature Swing Adsorption Carbon Capture Technology for Optimal Operation of a Fossil Power Plant- $789,009

Susteon will evaluate a CO_2 capture technology using solid sorbents based on thermal swing adsorption that enables power generators to operate the power plant in a "load following" mode in response to grid conditions in a high variable renewable energy penetration environment. The proposed capture technology is currently being demonstrated with flue gas derived from natural gas combustion. Susteon plans to simulate the integration of this technology with an existing natural gas power plant in southern California, a region with a large amount of renewable electricity on the grid.

Southwest Research Institute – San Antonio, TX

Oxygen Storage Incorporated into the Allam Oxy-Fuel Power Cycle - $762,953

Oxygen-fueled supercritical carbon dioxide (sCO_2) power generation cycles, such as the Allam-Fetvedt cycle, improve efficiency and enable simpler carbon capture strategies. Southwest Research Institute will apply energy storage concepts to this power generation cycle by incorporating oxygen storage adjacent to the air separation unit (ASU). By operating the ASU at higher capacities when power from alternative energies is available (e.g., wind power at night or solar photovoltaic power during the day) and storing liquid oxygen (LOX), greater output from the power plant can be achieved during times of peak electricity demand. Further savings can be achieved by using LOX's vaporization cooling to reduce the compression power of CO_2 needed for the power cycle.

Luna Innovations, Inc. – Roanoke, VA

Flexible FlueCO_2 - $989,660

Luna Innovations is developing FlueCO_2, a process that enables traditional power generators to respond to increased variable renewable energy while reducing greenhouse gas emissions. FlueCO_2 is a combined membrane and gas processing technology that integrates into existing natural gas combined cycle (NGCC) power plants and actively removes CO_2 from the exhaust gas. The membrane separates CO_2 at unrivaled rates using steam generated within the plant. The CO_2-rich steam leaving the membranes is processed further to remove the water so it can be regenerated into steam at the most energy efficient conditions. Remaining CO_2 is then compressed for pipeline transport.

Envergex, LLC – Sturbridge, MA

Flexible Low Temperature CO_2 Capture System, E-CACHYS™- $1,953,416

Envergex aims to integrate a flexible, low-temperature CO_2 capture system (E-CACHYS™) into a natural gas combined cycle power plant, capable of operating in a highly variable renewable energy environment, to attain a net-zero carbon electricity system. The technical approach is based on an innovative multi-phase sorbent technology for post combustion capture of CO_2 from flue gas. The hybrid sorbent technology, which consists of a regenerative sorbent and a novel heat exchange system for optimal energy recovery, seamlessly integrates into the natural gas combined cycle architecture. The size of the proposed carbon capture system can align with the average capacity factor of the power plant, enabling constant operating conditions in the capture system and reducing overall plant operating expenses.