Advanced Combustion Systems Projects Selected for Funding

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The Department of Energy's National Energy Technology Laboratory (NETL) has selected ten projects to receive funding through NETL's **Advanced Combustion Systems Program**. The program focuses on lowering costs and improving performance of combustion systems that generate electricity with near-zero emissions, including CO2. Central to the program are systems based on oxy-combustion—which uses oxygen to combust fuel and form a concentrated stream of CO2 for efficient and effective carbon capture—and chemical looping, which produces energy using oxygen from metal oxide oxygen carriers for fuel combustion. Projects being funded fall under three subtopic areas: use of higher efficiency supercritical carbon dioxide (SCO2) power cycles, further research on mature combustion technologies, and development of novel concepts.

Project descriptions follow.

Use of Higher Efficiency SCO2 Power Cycles

High-Efficiency Thermal Integration of Closed Supercritical CO2 Brayton Power Cycles with Oxy-fired Heaters

Electric Power Research Institute (Palo Alto, CA), **Aerojet Rocketdyne, Babcock & Wilcox Power Generation Group, Inc.**, and **Echogen Power Systems, LLC** will team to develop the first process designs for closed steam cycle power plants that use SCO2 for oxy/coal-fired SCO2 heaters. Over 24 months, the team will identify technology gaps in the SCO2 Brayton power cycle plants, develop cost estimates for the plants, identify opportunities to optimize costs via changes to plant design, and identify components whose cost might be reduced by focused research and development.

Cost: DOE: $1,689,466/ Non DOE: $422,367/ Total Funding: $2,111,833 (Cost share: 20%)

Adsorption/Desorption-Based SCO2 Power Cycles for Coal-Fired Power Plants

The team of **Southwest Research Institute** (San Antonio, TX) and **Thar Energy LLC** will evaluate a novel indirect SCO2 power cycle for utility-scale power generation. This 24-month effort will advance indirect fossil-fired utility-scale SCO2 plants by addressing challenges facing the tight integration of the secondary and thermal systems with the SCO2 power block. It will also extend the knowledge of CO2 absorbent mixtures to pressures and temperatures of interest for SCO2 power cycles and evaluate a novel SCO2 cycle that could increase thermal efficiencies by an additional 5 to 10 percent.

Cost: DOE: $500,000/ Non DOE: $125,000/ Total Funding: $625,000 (Cost share: 20%)

Further Research on Mature Combustion Technologies

Enabling Technology for Oxy-fired Pressurized Fluidized Bed Combustor Development

Aerojet Rocketdyne of Delaware Inc. (Canoga Park, CA) with **CanmetENERGY** and **Linde** will develop and test pilot-scale technologies, including an in-bed SCO2 heat exchanger, staged coal combustion, and an isothermal deoxidation reactor (IDR) – a technology that will be used to purify CO2 in flue gas by reacting it with a catalyst – to improve the economics of the current oxy-combustion pathway and address technology gaps associated with scale-up and system performance for NETL's atmospheric- and pressurized oxy-combustion technology pathways. The 24-month project will integrate design modifications on Aerojet Rocketdyne's oxy-fired pressurized fluidized bed combustor pilot plant at CanmetENERGY in Ottawa, Canada. The IDR system is expected to decrease the cost of energy produced by 24%.

Cost: DOE: $1,999,804/ Non DOE: $613,618/ Total Funding: $2,613,422 (Cost share: 23%)

Improvement of Alstom's Limestone Chemical Looping Combustion Process for Higher Purity Flue Gas Production

Alstom Power Inc. (Windsor, CT) is developing a limestone-based chemical looping combustion (LCL-C™) process for generating electricity that will achieve near-zero emissions, include CO2 capture, and reduce the cost of electricity. Alstom will team with the **University of North Dakota** and **Envergex, LLC** to conduct parametric bench-scale tests, data analysis, and facility modification and operation. **Great River Energy** will provide industrial input in designing and operating a coal-fired LCL-C system. Successful execution of the 24-month project will address the critical technology gap of flue gas purity and show that the LCL-C process can be scaled to a demonstration scale.

Cost: DOE: $1,998,940/ Non DOE: $499,735/ Total Funding: $2,498,675 (Cost share: 20%)

Flue Gas Water Vapor Latent Heat Recovery for Pressurized Oxy-Combustion

As part of an 18-month project, the **Gas Technology Institute** (Des Plaines, IL) will adapt a transport membrane condenser (TMC) for pressurized oxy-combustion to be tested with its pilot-scale fluidized-bed coal oxy-combustor. The TMC recovers water from flue gas via a nanoporous ceramic separation membrane – to be developed by **Media and Process Technology, Inc**. – and produces high purity water. The associated latent heat recovery improves system efficiency by reducing the volume of flue gas recycling and purification. **Florida International University** will assist with TMC design simulation and performance optimization. **SmartBurn LLC** will support integration of the technology into the plant water use loop and a techno-economic analysis for its integration into a power plant.

Cost: DOE: $1,999,795/ Non DOE: $645,150/ Total Funding: $2,648,945 (Cost share: 24%)

Characterizing Impacts of High Temperatures and Pressures in Oxy-coal Combustion Systems

Reaction Engineering International (Murray, UT) will team with experts from **University of Utah, Praxair,** and **Jupiter Oxygen Corporation** to perform multi-scale experiments, mechanism development, and computational fluid dynamics modeling to generate modeling tools and mechanisms capable of describing high-temperature and -pressure oxy-coal combustion.

The information generated by this 18-month project can be used by industry and other researchers to assess the use of high-temperature and elevated temperature high-pressure oxy-combustion and to guide development of new oxy-coal boiler designs.

Cost: DOE: $1,251,541/ Non DOE: $319,055/ Total Funding: $1,570,596 (Cost share: 20%)

Integrated Oxygen Production and CO2 Separation through Chemical Looping Combustion Process with Oxygen Uncoupling

The **University of Utah** (Salt Lake City, UT) will team with **Amaron Energy** for the first known effort to advance the development of chemical looping combustion with oxygen uncoupling to pilot scale using an existing pilot-scale, dual fluidized bed chemical looping reactor. Oxygen uncoupling is a mechanism whereby oxygen gas is released from oxygen carrier particles so the oxygen can more readily react with fuel. The 24-month project will address critical technology gaps and improve overall system performance by identifying and decreasing unit operation energy requirements. This will reduce technical risk for chemical looping and development of knowledge and tools to support scale-up of chemical looping combustion technologies.

Cost: DOE: $1,784,320/ Non DOE: $446,080/ Total Funding: $2,230,400 (Cost share: 20%)

Integrated Flue Gas Purification and Latent Heat Recovery for Pressurized Oxy-combustion

Washington University (St. Louis, MO) will investigate integrated pollution removal with simultaneous latent heat recovery from flue gas for a staged, pressurized oxy-combustion system. Over 24 months, the team plans to design, construct, and install a unit on the University's 100-kilowatt pressurized furnace to measure the effects of key variables (e.g., pH, pressure, temperature) on the unit's ability to capture sulfur oxides (SOx) and nitrogen oxides (NOx). Results from this testing will be used to develop an accurate reaction model which could be used to design future pilot-scale and ultimately commercial-scale systems.

Cost: DOE: $996,652/ Non DOE: $295,312/ Total Funding: $1,291,964 (Cost share: 23%)

Development of Novel Concepts

Pulse Detonation Engine for Advanced Oxy-combustion of Coal-Based Fuels

Oregon State University (Corvallis, OR) will develop and evaluate a pulse detonation combustion system for magnetohydrodynamics (MHD) – an innovative way to convert a high-velocity coal flame into electricity using a magnetic field – to increase the efficiency of power generation plants. Over 24 months, researchers will design, build, and operate a pulse detonation engine that uses gaseous or solid fuels with air and oxygen, evaluate the operational envelope and combustor performance, and develop and validate a numerical design tool to calculate the performance of two types of MHD systems. By operating the combustor with coal and oxygen, exhaust gases can easily be separated for carbon capture purposes.

Cost: DOE: $673,340/ Non DOE: $201,410/ Total Funding: $874,750 (Cost share: 23%)

Application of Spouting Fluidized Bed to Coal-Fueled Pressurized Chemical Looping Combustion to Improve Plant Efficiency and Reduce Process Complexity

The **University of Kentucky Center for Applied Energy Research** (Lexington, KY) will assess and demonstrate spouting fluidized bed to coal-fueled pressurized chemical looping combustion (PCLC) to improve plant efficiency and reduce process complexity. Over 24 months, the team plans to design, fabricate, and test a 50-kilowatt thermal pressurized facility that will use an industrial waste red mud oxygen carrier, pulverized coal, and a novel spouted bed reactor to address the major technical gaps of solid-fueled PCLC technology. The system's higher overall efficiency and fewer expensive components could reduce the cost of electricity, while capturing CO2.

Cost: DOE: $699,556/ Non DOE: $176,223/ Total Funding: $875,779 (Cost share: 20%)