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CHANGING WHAT'S POSSIBLE

REEACH—Range Extenders for Electric Aviation with Low Carbon and High Efficiency

PROJECT DESCRIPTIONS

Raytheon Technologies Research Center – East Hartford, CT

Compact Propulsion Engine Optimized with Waste Heat Recovery (CO-POWER) - $2,815,760

The CO-POWER project will enable a commercial narrow body electric aircraft by developing an ultra-efficient and lightweight fuel to electricity power generation system that includes the use of supercritical carbon dioxide (sCO_2) as a working fluid. The proposed approach combines decades of knowledge in gas turbine engines with novel advances in additive manufacturing research and sCO_2 power generation experience to increase the overall power system efficiency and its power density. The work will result in the development of a first-of-its-kind aircraft gas turbo-electric engine with a sCO_2 waste heat recovery cycle. This engine will deliver power more efficiently, with greater than 10% absolute increase in the fuel to electricity conversion efficiency and at comparable weight to current state-of-the-art gas turbines. These improvements will result in up to a 20% fuel burn savings. The system can operate with any carbon neutral liquid fuel to achieve net-zero GHG emissions.

Raytheon Technologies Research Center – East Hartford, CT

Zero-carbon Ammonia-Powered Turboelectric (ZAPTurbo) Propulsion System - $2,652,778

The Zero-carbon Ammonia-Powered Turboelectric (ZAPTurbo) Propulsion System is a very high efficiency and light weight turboelectric system that uses green ammonia as both a fuel and a coolant via regenerative cooling. Coke-free heating of this carbon-free ammonia fuel enables a high level of waste-heat recovery that will be used for the endothermic cracking of ammonia prior to its combustion, significantly increasing the cycle efficiency. The proposed propulsion system includes an efficient AC electric powertrain for turboelectric cruise, with battery boost for takeoff and climb flight phases. The ability to optimize the gas turbine at the center of the turboelectric system for cruise power drives maximum efficiency. The proposed system is projected to operate in cruising phase of flight with a 66% energy conversion efficiency.

General Electric Company, GE Research – Niskayuna, NY

FueL CelL Embedded ENgine (FLyCLEEN) - $2,529,340

FLyCLEEN will leverage the robustness and efficiency of metal-supported solid oxide fuel cells that are integrated with the combustion chamber of a gas turbine engine-generator, yielding a hybrid system operating on synfuel with performance that maximizes the power density and energy efficiency of each component. Multiple advancement methods will be pursued to increase the power density of the fuel cell. The system is configured to benefit the balance of plant and optimize thermodynamic synergies for electrified commercial aviation.

University of Maryland – College Park, MD

Hybrid SOFC-Turbogenerator for Aircraft - $2,798,489

The University of Maryland is developing a highly efficient and cost-effective hybrid-electric turbogenerator suitable for powering narrow body aircraft like the B737. A solid oxide fuel cell (SOFC) with integrated autothermal reformer is incorporated directly into the flow path of a gas turbine engine that also drives an electrical generator. The engine moves air through the system while boosting efficiency by recovering waste heat and unused fuel from the fuel cell. The system operates on carbon-neutral, liquefied bio-methane. Unique features include low temperature, redox-stable, high power density SOFC technology with internal reforming, an integrated autothermal reformer/SOFC/combustor that mitigates risks for thermomechanical failure, and a highly efficient turbo-generator.

University of Louisiana at Lafayette – Lafayette, LA

High Performance Metal-Supported SOFC System for Range Extension of Commercial Aviation - $2,263,000

The University of Louisiana at Lafayette will design and optimize an energy storage and power generation (ESPG) system for aircraft propulsion. The proposed system will consist of optimally sized fuel-to-electric power conversion devices; metal-supported solid oxide fuel cells (MS-SOFCs) and turbogenerators using carbon-neutral synfuel. The design concept will ensure adequate propulsive thrust and system power for a future airplane configuration by optimizing the ESPG and component performance, especially the synfuel-powered MS-SOFC. The team will use innovative fabrication techniques for high-performance, ultra-low weight, and low-cost MS-SOFC stacks. They will also develop reforming catalysts for synfuel and biojet fuel.

University of California, San Diego – San Diego, CA

High-Efficiency and Low-Carbon Energy Storage and Power Generation System for Electric Aviation- $2,131,246

The University of California, San Diego (UCSD) aims to develop a high-efficiency and low-carbon energy storage and power generation (ESPG) system operating on bio-LNG for electric aviation. The proposed system concept is a fuel cell, battery, and gas turbine hybrid system that incorporates a novel solid oxide fuel cell (SOFC) stack technology. The proposed SOFC is composed of (1) a lightweight and compact stack architecture based on an array of cell modules in electrical and gas flow parallel and series connections and (2) exceptional high power density direct methane cells made by sputtering thin-film deposition process. The proposed system has been estimated to have the specific power and specific energy properties aligning to the competitive capital costs required for aircraft ESPG applications.

Fuceltech Inc. – Princeton Junction, NJ

Extremely Lightweight Fuel Cell Based Power Supply System for Commercial Aircrafts - $1,656,438

Fuceltech proposes to develop an innovative low-cost, lightweight Energy Storage and Power Generation (ESPG) system for commercial aircraft. Fuceltech will develop a monopolar wound fuel cell potentially as high as 10kW rating and a novel stacking approach to deliver hundreds of kWs of power from a single small and lightweight stack. Fuceltech will use ethanol as a fuel and a reformer that delivers extremely low CO concentration in the reformate to the fuel cell.

Precision Combustion, Inc. – North Haven, CT

SOFC's for FLIGHT - $1,750,590

Precision Combustion (PCI) is proposing an advanced energy storage and power generator design for meeting aggressive specific power and energy targets for all-electric propulsion of narrow-body commercial aircraft. Key enablers are an exceptionally power-dense solid oxide fuel cell operating with energy-dense carbon neutral liquid fuels and a hybridized system architecture that maximizes component efficiencies for ultra-high system efficiency. PCI will validate compliance via component demonstration and develop a verifiable model for scale-up. It will also address performance constraints to conform to takeoff/climb/cruise requirements and examine tradeoffs (weight vs. efficiency vs. complexity). Durability at aircraft operating conditions (e.g., start/stop cycles, peak power, transient operation, altitude) will be demonstrated.

Tennessee Technological University – Cookeville, TN

High Power Density Carbon Neutral Electrical Power Generation for Air Vehicles - $1,437,287

Tennessee Technological University will combine a Solid Oxide Fuel Cell (SOFC) stack with a gas turbine combustor to address challenges faced in all electric propulsion-based aviation. The combined SOFC-combustor concept maximizes power density and efficiency while minimizing system complexity, weight, and cost. By eliminating components and subsystems typically found in fuel cell-gas turbine hybrid systems, this design provides operational flexibility with a rapid response to flight and load conditions and enables system startup in less than 30 minutes. This elegant and revolutionary SOFC-combustor concept meets specific power and energy requirements to enable economically viable net-zero greenhouse gas emissions for long-range electric commercial aviation.