

Reliable Electricity Based on Electrochemical Systems – REBELS

PROJECT DESCRIPTIONS

Category I: Intermediate Temperature Fuel Cells for Distributed Generation

Redox Power Systems – Fulton, MD

Low-Temperature Solid Oxide Fuel Cells - \$5,000,000

Redox Power Systems will develop a fuel cell with a mid-temperature operating target of 400°C while maintaining high power density and enabling faster cycling. Using a combination of oxide materials that have traditionally been unstable alone, a new two-layer electrolyte configuration will allow these materials to be used in a manner that increases system power density while maintaining stability. Redox's new material configuration also allows the operating temperature to be reduced when incorporated into commercially fabricated fuel cells. The fuel cells will have a startup time of less than 10 minutes, making them more responsive to demand.

SAFCe – Pasadena, CA

Solid Acid Fuel Cell Stack - \$3,700,000

SAFCe will develop solid acid fuel cells (SAFCs) that will operate at 250°C and are nearly free of precious metal catalysts. The team will dramatically lower system costs by reducing precious metals, such as platinum, from the electrodes and developing new catalysts based on carbon nanotubes and metal organic frameworks. The proposed SAFC stack design will lead to the creation of fuel cells that can withstand common fuel impurities, making them ideal for distributed generation applications.

Oak Ridge National Laboratory – Oak Ridge, TN

Nanocomposite Electrodes for a Solid Acid Fuel Cell Stack - \$2,750,000

Oak Ridge National Laboratory (ORNL) will redesign a fuel cell electrode that operates at 250°C using highly porous carbon nanostructures that dramatically increase the amount of surface area, lowering the amount of expensive platinum catalysts used in the cell. The team will also modify existing fuel processors to operate efficiently at reduced temperatures, and those processors will work in conjunction with the fuel cell to lower costs at the system level. ORNL's innovations will enable efficient distributed electricity generation from domestic fuel sources using less expensive catalysts.

United Technologies Research Center – East Hartford, CT

Metal Supported Proton Conducting Solid Oxide Fuel Cell Stack - \$3,200,000

The United Technologies Research Center (UTRC) will develop an intermediate-temperature fuel cell for residential applications that will combine a building's heating and power systems into one unit. Currently, metal-supported fuel cells use high-temperature electrolytes; using an intermediate temperature electrolyte will allow an operating temperature of 500°C while a redesigned cell architecture will increase the efficiency and lower the cost of UTRC's overall system.

Colorado School of Mines – Golden, CO*Fuel-Flexible Protonic Ceramic Fuel Cell Stack - \$1,000,000*

The Colorado School of Mines (CSM) will develop a mixed proton and oxygen ion conducting electrolyte that allows a fuel cell to operate at temperatures less than 500°C, which is a departure from today's ceramic fuel cells. Additionally, the team will leverage a recently developed ceramic processing technique that decreases fuel cell manufacturing cost and complexity by reducing the number of manufacturing steps from 15 to 3 to provide low-cost power for distributed generation applications.

Georgia Tech Research Corporation – Atlanta, GA*Fuel Cell Tailored for Efficient Utilization of Methane - \$1,000,000*

Georgia Tech Research Corporation will develop a fuel cell that operates at temperatures less than 500°C by integrating nanostructured materials into all cell components. The Georgia Tech team will fabricate electrodes to directly process methane and develop nanocomposite electrolytes to reduce cell temperature without sacrificing system performance. These advances will enable an efficient, intermediate-temperature fuel cell for distributed generation applications.

Palo Alto Research Center – Palo Alto, CA*Reformer-less Fuel Cell - \$1,500,000*

Palo Alto Research Center (PARC) will develop an intermediate-temperature fuel cell that is capable of utilizing a wide variety of carbon-based input fuels. This design will include a novel electrolyte membrane system that transports oxygen in a form that allows it to react directly with almost any fuel. This membrane eliminates the need for a separate fuel processing system, which reduces overall costs. Further, PARC's cell will operate at relatively low temperatures of 200-300°C, avoiding the long-term durability problems associated with existing higher-temperature fuel cells.

Category II: Load-Following Intermediate Temperature Fuel Cells

SiEnergy Systems – Cambridge, MA*Hybrid Fuel Cell-Battery Electrochemical System - \$2,650,000*

SiEnergy Systems will develop a hybrid electrochemical system that uses a multi-functional electrode to allow the cell to perform as both a fuel cell and a battery, which is a capability that does not exist today. In fuel cell mode, the system will create electricity directly from hydrocarbon fuels. In battery mode, the system will provide storage capability that offers faster response to changes in power demand compared to a standard fuel cell. SiEnergy's technology will operate at relatively low temperatures of 300-500°C, which makes the system more durable than existing high-temperature fuel cells.

The University of California Los Angeles – Los Angeles, CA*Fuel Cells with Dynamic Response Capability - \$1,000,000*

The University of Los Angeles (UCLA) will develop a low-cost, intermediate-temperature fuel cell that will also function like a battery to increase load-following capability. The fuel cell will use new metal-oxide electrode materials with superior energy storage capacity and cycling stability, making it ideal for distributed generation systems. UCLA's new materials also have high catalytic activity, which will lower the cost of the overall system.

The University of South Carolina – Columbia, SC*Bi-functional Ceramic Fuel Cell Energy System - \$3,200,000*

The University of South Carolina will develop an intermediate-temperature, ceramic-based fuel cell that will

both generate and store electrical power with high efficiencies. The device will incorporate a newly discovered ceramic electrolyte and nanostructured electrodes that enable it to operate at temperatures lower than 500°C. The fuel cell's unique design includes an iron-based layer that stores electrical charge like a battery, enabling a faster response to changes in power demand.

Category III: Liquid Fuel-Producing Intermediate Temperature Fuel Cells

Argonne National Laboratory – Argonne, IL

Hybrid Fuel Cell System for Converting Natural Gas to Electricity and Liquid Fuels - \$2,000,000

Argonne National Laboratory will develop a hybrid fuel cell technology that will both generate electricity and produce liquid fuel. This dual mode capability is enabled by a device that removes protons from the reaction site, which allows the cell to operate at lower temperatures. In addition to conventional fuel cell capabilities, Argonne's cell could use natural gas to produce ethylene for conversion into liquid fuel or high-value chemicals.

Materials & Systems Research, Inc. – Salt Lake City, UT

Electrogenerative Cells for Flexible Cogeneration of Power and Liquid Fuel - \$2,800,000

Materials & Systems Research, Inc. (MSRI) will develop an intermediate-temperature fuel cell capable of electrochemically converting natural gas into electricity or liquid fuel in a single step. The electrodes will be designed to use catalysts more effectively and the entire cell will be fabricated using a cost-effective process that can be readily scaled up for mass production. MSRI's technology will provide low-cost power while operating in a temperature range of 400-500°C, enabling better durability than today's high-temperature fuel cells.

FuelCell Energy – Danbury, CT

Liquid Fuels and Electricity from Intermediate-Temperature Fuel Cells - \$3,500,000

FuelCell Energy will develop an intermediate-temperature fuel cell that will directly convert methane to methanol and other liquid fuels using advanced metal catalysts. These catalysts will be optimized to improve the yield and selectivity of the methane-to-methanol reaction. In addition, a new reactive spray deposition technique will be employed to manufacture the cell in a continuous process. The combination of these advanced catalysts and advanced manufacturing techniques will reduce overall system-level costs.