VIII.10 Small Business Innovative Research (SBIR) Hydrogen Program New Projects Awarded in FY 2004

The Small Business Innovation Research (SBIR) program provides small businesses with opportunities to participate in DOE research activities by exploring new and innovative approaches to achieve R&D objectives. The funds set aside for SBIR projects are used to support an annual competition for Phase I awards of up to $100,000 each for about 9 months to explore the feasibility of innovative concepts. Phase II is the principal research or R&D effort, and these awards are up to $750,000 over a two-year period.

In FY 2004, the DOE solicited SBIR projects under the categories of Innovative Research for the Hydrogen Economy, New Energy Sources, and Energy Storage and Conversion Technologies for Electric and Hybrid Vehicles. Table 1 lists the SBIR projects awarded in FY 2004 related to the Hydrogen Program. On the following pages are brief descriptions of each.

Table 1. FY 2004 SBIR Awards

Low Cost, High Performance PPSA-based PEM Fuel Cell Membrane	T/J Technologies Inc.	Ann Arbor, MI
Nanocomposite Membranes for High Temperature Proton Exchange Membrane Fuel	Pacific Fuel Cell Corp.	Tustin, CA
Complex Coolant Fluid for PEM Fuel Cell Systems	Advanced Fluid Technologies, Inc.	Whitehall, PA
A High Power-Density Fuel Cell Stack (Direct Methanol Fuel Cell)	Giner, Inc.	Newton, MA
Compact, Regenerative Energy Storage System for Consumer Applications	MicroCell Technologies	Westford, MA
Novel, Combinatorial Approach to the Development of Cathode Catalysts for Fuel Cells	Farassis Energy, Inc.	Alameda, CA
Improved Fuel Cell Cathode Catalysts Using Combinatorial Methods	NuVant Systems, Inc.	Chicago, IL
High Rate and Yield Hydrogen Fermentation	Benemann Associates	Walnut Creek, CA
Cellulose Production and Increased Biomass in Multifunction Crop Plants	Edenspace Systems Corporation	Chantilly, VA
High-Efficiency, Ultra-High Pressure Electrolysis with Direct Linkage to Photovoltaic Arrays	Avalence, LLC	Milford, CT
Novel, Low-Cost Solid Membrane Water Electrolyzer	Giner, Inc.	Newton, MA

Low Cost, High Performance PPSA-based PEM Fuel Cell Membranes (Phase I Project)

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This SBIR project proposes to develop and demonstrate the feasibility of using poly(phenylenesulfonic acid) (PPSA) membranes as a low-cost, high-performance alternative to conventional perfluorinated membranes. The proposed PPSA membranes will be produced with lower-cost precursors and processes than perfluorinated membranes and will meet the DOE target of <$5/kW in high-volume production. The proposed PPSA membranes will also possess superior high-temperature properties compared to current PPSA membranes.

Nanocomposite Membranes for High Temperature Proton Exchange Membrane Fuel (Phase I Project)

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Elevating the working temperatures of the fuel cell could drastically reduce or eliminate poisoning and greatly improve electrode kinetics for oxygen reduction. However, the problem with high-temperature operation is the loss of proton conductivity due to the dehydration of the Nafion membrane. This project proposes to develop a nanomaterial-based composite membrane that can retain high proton conductivity and mechanical strength at elevated temperature. The synthesis of the composite membrane will be achieved by first synthesizing proton-conducting nanoparticles, then introducing this nanomaterial during membrane preparation. In Phase I, the membrane will be characterized, and the feasibility of using these membranes to provide improved power output at a temperature of 130°C will be demonstrated.

Complex Coolant Fluid for PEM Fuel Cell Systems (Phase I Project)

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This SBIR project proposes to develop a complex fuel cell coolant fluid comprised of a base composition and an additive package. The base composition addresses the non-flammability, heat transfer, freezing point, and materials compatibility issues, whereas the proposed additive package will maintain the electrical conductivity of the coolant below a certain level for 2 to 3 years. In Phase I, key ingredients of the additive package will be prepared and incorporated into the coolant fluid. The resultant complex coolant fluid formulations will be tested in a dynamic loop to determine the effectiveness of the additives in keeping the electrical conductivity of the coolant below 2 mS/cm.

A High-Power Density Fuel Cell Stack (Phase I Project)

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High-power density fuel cell designs are required for portable power applications, the most probable initial consumer use of fuel cells, where the fuel cell must provide sufficient power to an external device yet be light enough to be carried around by the consumer.

The overall objective of the proposed project is to develop a high-power density, 20-W fuel cell system based on combined mixed reactant technology for use by the general public. In this design, which eliminates the use of heavy bipolar plates, the fuel and oxidant are mixed together, and reactant-specific electrodes are used.

Compact Regenerative Energy Storage System for Consumer Applications (Phase I Project)

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A compact and regenerative energy storage system is proposed to supply power for consumer devices including power tools, laptop computers, and remote equipment. This energy storage system is designed to supply power in the sub-100 Watt range and will operate for 72 hours before being electrically regenerated. During Phase I, this energy storage system will be demonstrated using ambient air, resulting in an energy density of 300 W-hr/kg and 2,000 W-hr/liter for the complete reversible energy storage system.

The technology platform is based upon a reversible proton exchange membrane fuel cell that is coupled with a hydrogen fuel supply cartridge. This cartridge may be regenerated by operating the fuel cell in the reverse mode as an electrolyzer, or the cartridge may be replaced with another fuel cartridge for immediate power generation.

Novel, Combinatorial Approach to the Development of Cathode Catalysts for Fuel Cells (Phase II Project)

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A novel, high-throughput, combinatorial process for identifying and developing high-activity, low-cost catalysts for fuel cells that was demonstrated in Phase I will be scaled up for use in this Phase II SBIR project. The approach proposed is to pursue several complex catalyst development strategies that would otherwise take many years to evaluate. The goal is an order-of-magnitude increase in the performance/cost ratio, with the most promising catalyst being scaled up for customer evaluation.

The combinatorial approach to developing catalysts should be broadly applicable to many potential catalyst systems for fuel cell anodes and cathodes used in a broad range of applications, including automotive, stationary and portable power, telecommunications, and military markets. A lower-cost fuel cell should allow greater market penetration and wider use of these environmentally friendly energy systems.

Improved Fuel Cell Cathode Catalysts Using Combinatorial Methods (Phase II Project)

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This project proposes to develop high-throughput combinatorial strategies and a mechanistic model to identify new catalyst compositions that will improve fuel cell oxygen reduction reaction kinetics. In Phase I, highly efficient and multi-function high-throughput screening systems, coupled with advanced process robotics, were established. Compared to the commercial pure Pt catalyst, a significant enhancement of electrocatalytic activity was achieved by alloying Pt and Co. It is proposed in Phase II to concentrate on the combinatorial discovery of ternary alloy electrocatalysts of Pt and transition metals and the high-throughput screening of synthesized catalysts. An order-of-magnitude improvement of catalytic activity is the goal to be demonstrated. A highly efficient oxygen reduction catalyst would be a huge boost to the commercialization of proton exchange membrane (PEM) fuel cells for a wide range of applications in transportation, portable power, communications and military markets.

High Rate and Yield Hydrogen Fermentation (Phase I Project)

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Before hydrogen fuel can be economically produced by the bacterial fermentation of sugars and carbohydrates, increases in both the rate and yield of the process are required. Current processes exhibit modest rates and yields, which are only about one-fourth those of competitive ethanol fuel fermentations. The target cost requirement is $1.50/kg hydrogen. This project proposes to demonstrate that hydrogen fermentations with high yield and rate are feasible and to develop technology to make hydrogen fuels competitive with ethanol production from corn starch. The high hydrogen yields will be achieved by metabolic (genetic) engineering of bacterial strains, diverting their energy metabolism from growth to hydrogen production. In Phase I, feasibility is proposed to be demonstrated by using a model bacterial system in which hydrogen evolution from sugars is coupled to energy-yielding respiratory reactions, thereby providing an increased hydrogen yield. Hydrogen fermentations will also be studied in continuous cultures to determine their maximal rates.

Cellulase Production and Increased Biomass in Multifunction Crop Plants (Phase I Project)

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This project proposes to create new transgenic crop plants, specifically tobacco and corn, that are characterized by (1) greater biomass, (2) constitutive production of heat-stable cellulases to aid the post-harvest hydrolysis of plant biomass to simple sugars, and (3) delayed flowering to prevent the escape of transgenes. In Phase I, an existing accession of tobacco, transformed with the Acidothermus cellulolyticus E1 endoglucanase gene, is proposed to be tested for enzymatic stability and phytoremediation performance. The E1 tobacco line will be modified with the Arabidopsis Flowering Locus C (FLC) gene and tested for increased biomass, delayed flowering, enzymatic stability, and phytoremediation performance. Maize also will be transformed with the E1 and FLC genes for testing in Phase II.

High-Efficiency, Ultra-High Pressure Electrolysis with Direct Linkage to Photovoltaic Arrays (Phase I Project)

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This project proposes to develop a prototype for a photovoltaic (PV)-powered hydrogen fuel producer that supplies high-pressure gas (5,000 to 10,000 psi) to a hydrogen fuel dispenser for the depot-style fueling of commercial or agricultural vehicles, without additional compression or power conditioning equipment. The approach will be based on an innovative ultra-high pressure electrolysis system that has the potential to deliver hydrogen fuel at pressures exceeding 10,000 psi directly from the electrolysis cell. Phase I proposes to (1) instrument and run a series of parametric tests on an ultra-high pressure electrolysis cell and document the efficiency of producing fuel-grade hydrogen at pressures from ambient to 10,000 psi; (2) identify loss mechanisms and efficiency gains associated with high-pressure hydrogen production; and (3) design a stand-alone, PV-powered, high-pressure electrolyzer system with a hydrogen fuel dispenser.

Novel, Low-Cost Solid Membrane Water Electrolyzer (Phase I Project)

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This project proposes to develop a solid membrane alkaline electrolyzer system, based on a unique solid alkaline membrane, which is expected to provide high-current-density, high-differential-pressure electrolyzer operation. Phase I proposes to develop the solid alkaline membrane, identify cell operating conditions, fabricate a three-cell stack, and prepare a preliminary design for the system. In Phase II, it is proposed to demonstrate a complete system powered by a renewable energy source.

The hydrogen generation system should find use in hydrogen-fueled vehicles (both fuel cell and hydrogen internal combustion), as part of a home-based hydrogen generator, in a bulk hydrogen generator for electric utility applications, and in on-board transportation power applications. Small hydrogen generators also could replace cylinders for the supply of hydrogen gas for analytical instrumentation.