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CHANGING WHAT'S POSSIBLE

GREENWELLS—Grid-free Renewable Energy Enabling New Ways to Economical Liquids and Long-term Storage

PROJECT DESCRIPTIONS

RTI International – Research Triangle Park, NC

Next-Generation Flexible Modular e-Methanol Production - $3,400,000

RTI International will develop a next-generation e-methanol production process using variable renewable energy from wind and solar, captured carbon dioxide, and electrolytic hydrogen at a scale of engineering relevance. The process integrates key innovations in advanced low-cost catalysts, a novel reactor designed for variable load operations, patented process control strategies for load following and flexible operations, and a global plant optimization and design tool to ensure technoeconomic feasibility of e-methanol production.

HeatPath Solutions – Lewis Center, OH

SIMPLE Process to Dynamic Methanol Synthesis - $4,000,000

HeatPath Solutions is developing a new way to synthesize methanol that works dynamically with intermittent electricity from renewables, called SIMPLE. The SIMPLE process creates a new path for on-site production and collection of methanol from modular reactors operating at modest temperatures and pressures. The process integrates novel catalyst packaging with membrane separation, which removes coproduced water as it forms, to overcome equilibrium limits for direct methanol synthesis in an enabling catalytic microchannel membrane reactor that allows a per pass conversion above 90%.

Illinois Institute of Technology – Chicago, IL

Renewable Propane Production using Dynamic CO2 Electrolysis (E-PROPANE) - $3,853,707

Illinois Institute of Technology's project aims to showcase a prototype-integrated process on a kilowatt scale (equivalent to processing of up to 4 kilograms per day of propane) utilizing a system of multiple carbon dioxide electrolyzer stacks. These stacks will be integrated with separations and recycle functionalities to attain a 97% propane selectivity, energy-to-liquid efficiency surpassing 50%, and a multi-pass carbon yield exceeding 85%. By employing multiple stacks, the configuration permits operation within 1-100% of its nominal capacity, accommodating intermittent and variable power supplies.

Susteon – Cary, NC

ECHO-SAF: Electrified CO2 Hydrogenation to Olefins for Sustainable Aviation Fuel - $4,999,500

Susteon aims to develop a process to produce kerosene-range hydrocarbons using carbon dioxide, hydrogen, and renewable electricity. The process is based on five key innovations: 1) Susteon's patent-pending electrically resistive structured catalyst reactor, 2) a single-step hydrogenation of carbon dioxide to light olefins, 3) olefin oligomerization to produce kerosene-range hydrocarbons, 4) an overall process optimization strategy to operate it dynamically under an intermittent power supply, and 5) a modular reactor design.

Columbia University – New York, NY

Low Temperature Membraneless Carbon Dioxide Electrolyzers for Low-Cost Production of Ethanol Under Dynamic Conditions - $4,275,642

Columbia University will develop a membrane-free electrochemical reactor for converting carbon dioxide into ethanol. Most ion exchange membranes used in electrochemical reactors are susceptible to swelling and plasticization and can breakdown in certain conditions. By removing the membranes—and updating the electrode assembly to minimize cell resistance—Columbia's reactor could spur a sustainable way to produce low-cost ethanol fuel using intermittent renewable energy. The main thrust of the project will be to incorporate the novel reactor into a wholistic system that operates at low temperatures, which are better suited for dynamic operation, to produce high-purity ethanol.

CarbonBridge – Newark, NJ

Microbial Production of Methanol from Methane and Intermittent Power Sources - $719,881

CarbonBridge is harnessing biological systems to convert methane into methanol at low temperatures and pressures, while allowing for variable energy input. The process uses methanotrophic bacteria to convert methane into methanol. By scaling up the system, over 500 million metric tons (MMT) of methanol could be sustainably synthesized from waste methane and Renewable Natural Gas (RNG) sources per year by 2040.

Northeastern University – Boston, MA

Modular Electrochemical Ethanol Production Using Intermittent Power (Electricity) - $986,200

Northeastern University is pioneering new technology to convert dilute carbon dioxide into a concentrated ethanol product using intermittent renewable electricity. Most electrochemical technologies require higher than 95% pure carbon dioxide to create ethanol. Northeastern's approach uses carbon dioxide in concentrations similar to air (400 parts per million). The approach doesn't require thermal steps in the procedure, making it easy to turn on and off the process according to when renewable energy is available.

University of California, Los Angeles – Los Angeles, CA

e-CO2LUMN: The Dynamic CO2 Electrolyzer Column - $3,076,000

The University of California, Los Angeles (UCLA) is developing a new prototype design for a carbon dioxide electrolyzer that will operate with a much lower energy requirement than current electrolyzers. UCLA's modular design will be stacked and multiplied in parallel to achieve scalability, overcoming a major hurdle of current-day gas-diffusion electrodes-based carbon dioxide electrolyzers. The control of the reactor will be based on a machine-learning predictive control system. The team will also innovate the catalyst composition for better performance.

SRI International – Palo Alto, CA

Printed Microreactor for Renewable Energy Enabled Fuel Production (PRIME-Fuel) - $3,648,906

SRI International is developing a modular microreactor that converts carbon dioxide into methanol using a fluctuating supply of renewable energy. The team will leverage mathematical modeling to design the microreactor and proprietary printing technology necessary to manufacture it. The approach seeks to optimize energy consumption by using advanced control algorithms and real-time monitoring systems. The microreactor will continue producing methanol even when renewable energy input is as low as 5% capacity.

Georgia Institute of Technology – Atlanta, GA

AIRCAP: Advancing Integration and Reactors for Carbon Capture and Conversion - $1,970,200

Georgia Institute of Technology (Georgia Tech) is developing an electrochemical reactor that responds quickly to dynamic changes in renewable energy to work with direct air capture systems. The team's bipolar membrane electrolysis reactor will overcome the common challenges faced by the current state of technology. For example, existing micro-channel bipolar membrane reactors operate at high overpotentials, leading to inefficient energy use. Georgia Tech will integrate activating layers to improve energy efficiency. This reactor can also be integrated with air capture systems, sourcing CO2 directly from air.

North Carolina State University – Raleigh, NC

Distributed Methanol from CO2 via Plasma-Enhanced Catalysis (PEC) - $2,729,143

North Carolina State University (NC State) is designing a dielectric barrier discharge plasma-enhanced catalysis (PEC) system to efficiently convert carbon dioxide and hydrogen into methanol at low pressures. This approach has several advantages to current technologies, since the plasma-enhanced system is operated under ambient pressure and without the need for external heating. As a result, the system is both cost-effective and flexible to accommodate high turndown ratio and rapid start-up and shutdown.

Washington State University – Pullman, WA

Dynamic CO2 Hydrogenation to Produce Liquid Hydrocarbon Fuels in Induction Heating Catalytic Reactor - $4,000,000

Washington State University (WSU) is developing a carbon dioxide hydrogenation process that converts carbon dioxide and hydrogen into liquid hydrocarbons using renewable energy sources. The project leverages innovative metal alloy catalysts and a novel reactor design to address key challenges associated with renewable energy's intermittency. The proposed system combines rapid induction heating with precise temperature controls to optimize chemical reactions.

New York University – New York, NY

The Renewthanol Process: CO2-Derived Ethanol Production via Tandem Electro- and Thermo-Catalytic Conversions - $1,000,000

New York University is developing an electrocatalytic system designed to efficiently transform carbon dioxide, water, and variable renewable electricity into ethanol. Partnering with Argonne National Laboratory, the team's approach uses a dynamically operated carbon dioxide electrolyzer equipped with copper-based electrocatalysts that can deliver carbon products efficiently and variable pulse sequence to stabilize the output stream as the input energy varies.

Emvolon – Woburn, MA

Novel Reciprocating Reactor for Intermittent Renewables to Liquid Sustainable Fuels - $2,339,828

Emvolon is repurposing automotive engines as chemical reactors to convert renewable power and greenhouse gas emissions to liquid clean fuels. The project develops a modular, scalable system capable of rapidly adjusting to the intermittent nature of renewable energy sources like wind and solar. By leveraging mature, mass-produced internal combustion engine technology to compress and convert gases into liquids such as methanol, a flexible, cost-effective solution can be produced that drastically reduces the expenses associated with traditional gas-to-liquid technologies.