JOULES-1K Phase Two Project Descriptions

Jumpstart Opportunities to Unleash Leadership in Energy Storage with 1K Energy Storage Systems

And Battery Aero – Palo Alto, CA

High Energy Renewable AFx eLectroDes (Phase II) - $4,016,555

Building on chemistry validated in Phase 1, the HERALD team will advance fluoride-based (AFx) cathodes that achieve energy density >1,000 watt-hours per kilogram (Wh/kg) cell into a 1 kilowatt-hour (kWh) prototype battery module for testing with multiple commercial drone partners. Using the "Kilostack" platform previously developed during ARPA-E SCALEUP, the resulting 700 Wh/kg-module will deliver a 3-fold improvement in the endurance (flight time) or an equivalent improvement in payload of aerial vehicles, compared to existing commercial lithium-ion batteries.

John Hopkins University – Baltimore, MD

High Density Energy Storage Using Cyclic Hydrogen Carriers - $1,997,000

John Hopkins University will develop a Direct Liquid Fuel Cell (DLFC) designed to meet JOULES-1K targets by using a refuellable liquid energy storage concept. The approach is based on Liquid Organic Hydrogen Carriers (LOHCs), which are chemicals (e.g. hydrocarbons) that can store and release hydrogen. The DLFC is expected to deliver 1 kWh/kg at the system level. A key advantage is fast replenishment compared to long electrical charging times because the LOHC can be refilled in less than 10 minutes through liquid pumping. Phase 2 work will focus on optimizing the cell design, scaling up manufacturing of cell stacks, building the balance of plant (BOP), and demonstrating a 1 kW prototype. This research will deliver high-density, high-efficiency electric power generation for mobile and transportation applications. Marine and ground vehicles for national security missions are a strong fit: the lower operating temperature enables a lower thermal signature than diesel systems, and the fast liquid refueling enables shorter recharge times than traditional battery systems.

University of Maryland – College Park, MD

High-energy, rechargeable, low-cost batteries for train and ship electrification - $1,442,000

The University of Maryland (UMD), working with WH Power, will develop a rechargeable, high-energy cathode related to primary carbon fluorinated carbon (CFx) using a nonfluorine halogen (H) reversible agent to enable rechargeability. This approach is designed to address key limitations of primary CFx, including its inability to recharge, low voltage efficiency, high cost of fluorinated CFx starting material, and manufacturing challenges including the need to use lithium metal. In Phase 2, the team will derisk the cell chemistry, scale up the cell technology, and demonstrate a clear path toward achieving JOULES-1K program performance targets.

Illinois Institute of Technology – Chicago, IL

1K Rechargeable Solid-State Li-Air Battery for Aviation - $3,200,000

Illinois Institute of Technology is building on Phase 1 validation under JOULES-1K to develop a rechargeable, solid-state lithium-air battery for aerial platforms, targeting energy densities exceeding 1,000 Wh/kg-cell. In Phase 2, the team will build a 1 kWh prototype battery module in partnership with Air Energy, Inc., National Laboratory of the Rockies, and RTX targeting greater than 1,000 Wh/kg (gravimetric) and 1,000 Wh/L (volumetric) energy density-module. The multidisciplinary team, working with commercial drone partners, will manufacture and assemble the key cell components, including solid-state electrolyte and custom designed cathode at scale. The resulting 1,000 Wh/kg-module will deliver an up to 4-fold improvement in the endurance (flight time) or an equivalent improvement in weight/payload for drones, compared to existing commercial lithium-ion batteries, thereby advancing national security priorities and U.S. competitiveness.

Georgia Institute of Technology – Atlanta, GA

Alkali Hydroxide Triple Phase Flow Batteries (3PFB) - $1,500,000

Georgia Institute of Technology will develop the Alkali Hydroxide Triple Phase Flow Battery (3PFB) to enable rechargeable ultra-high energy density batteries above the 1,000 Wh/kg and 1,000 Wh/L levels needed for eVTOLs, drones, and other applications. Inspired by flow batteries and internal combustion engine fuel injection, the design uses liquid or gaseous reactants and products and intrinsically separates reactants to improve safety while delivering high energy density. Phase 2 work will focus on designing, building, and validating the electrochemical performance of prototype energy storage systems.

Precision Combustion, Inc. – North Haven, CT

Electrochemical Microchip Paired with Energetic Fuels for MWh Electrified Propulsion (EMPoWEr) - $3,277,111

In Phase 1, Precision Combustion, Inc. (PCI) developed and validated an exceptionally energy-dense, fuel-agnostic “battery analog” that converts on-board liquid or gaseous fuels into electricity in a lightweight, compact form factor. The multifunctional, process-intensified architecture combines an advanced electrochemical microchip-based power module (ProtonBridge) with a small rechargeable battery and balance-of-plant components enabling a scalable pathway to meet and exceed JOULES-1K targets. This hybrid system bypasses battery gravimetric limits by utilizing fuels' high energy density. As a result, the ProtonBridge-based systems can be economically viable and deliver up to 6X higher gravimetric energy density than the best battery-only solutions while preserving the operational benefits of electric drivetrains. For Phase 2, PCI plans to scale the system, enhance power density, and validate its long-term durability. This will involve developing manufacturable packaging, robust controls, and efficient operation with battery-supported transient response.