Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS) – Selected Projects

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Technology Focus – Application: Project Title*** **Project Description**
ABB Inc (SuperPower Inc., Brookhaven National Lab)	$4,200,000	Cary, NC	*Superconducting Magnetic Energy Storage (SMES): Superconducting Magnet Energy Storage System with Direct Power Electronics Interface* ABB will lead a team in the development of an advanced superconducting magnetic energy storage (SMES) system that will store significantly more energy than current SMES at a fraction of the cost. In this project, the team will develop a 20 kW ultra-high field (UHF) SMES system with a capacity of 3.4 MJ, a field of up to 30 T at 4.2 K, and roundtrip efficiency in excess of 85%. The system will have the conventional advantages of SMES, namely instantaneous dynamic response and nearly infinite cycle life, but with costs that approach or potentially are less than those of lead-acid batteries. To achieve these goals, the performance of each of the individual subsystems that compound the proposed SMES system will be propelled far beyond the present state-of-the-art. The result will advance SMES from a high-cost solution for delivering short bursts of energy to a technology that is cost competitive for delivering megawatt hours of stored electricity to address the renewables ramping challenge.
Beacon Power Corporation (Imlach Consulting Engineering, IONICORP)	$2,250,000	Tyngsboro, MA	*Flywheel: Development of a 100 kWh/100 kW Flywheel Energy Storage Module* Beacon Power will lead a team in developing a next generation flywheel energy-storage module that stores four times the energy at 1/8 the cost-per-energy of the lowest cost state-of-the-art flywheels. The proposed 100kW, 100kWh system will use a "flying ring": a lightweight hoop of co-mingled fiber composite with bonded magnetic materials mounted on the structure. This configuration eliminates the central shaft and hub allowing full utilization of the composite properties, thereby reducing cost and increasing energy density to 76Wh/kg. This design will be capable of very high cycling (>40,000 full charge/discharge cycles) and will have a 20 year life, making it ideal to simultaneously address multiple grid-scale energy storage applications, including frequency regulation as well as emerging for ramping power to firm intermittent renewable generation.
Boeing	$2,264,136	Huntington Beach, CA	*Flywheel: Low-Cost, High-Energy Density Flywheel Storage Grid Demonstration* In this project, Boeing will use advanced fiber technology to develop a low-cost, extremely high energy-density, high-efficiency flywheel technology for energy-storage. This project will increase flywheel energy density to allow for the practical use of this technology in longer-duration applications including renewable energy ramping on the electric power grid. To increase energy density, Boeing will develop a new proprietary fiber that will enable high rotor tip speeds. If successful in this high-risk technology development program, a flywheel systems will be scalable to a utility-size unit (~100 kWh)

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Technology Focus – Application: Project Title*** **Project Description**
			and amenable to factory production to achieve low cost ($100/kWh).
CUNY Energy Institute (Rechargeable Battery Corporation)	$3,000,000	New York, NY	*Battery: Low-cost Grid-Scale Electrical Storage using a Flow-Assisted Rechargeable Zinc-Manganese Oxide Battery* In this project, the CUNY Energy Institute, in partnership with Rechargeable Battery Corporation (RBC) and Ultralife Corporation, will develop and construct a water-based flow-assisted battery for grid-scale energy storage. This novel battery starts with the same low-cost materials found in disposable consumer-grade alkaline batteries, namely zinc and manganese dioxide, and then transforms the chemistry into a long-lasting, fully-rechargeable system. CUNY has initially demonstrated a zinc and nickel oxide battery that proves the basic science behind the concept of flow-assist for enabling zinc to repeatedly store electrical energy. In this project, the team will push this approach in a new direction by replacing nickel with reversible electrodes by leveraging key material innovations by RBC. The result of this effort will be a 25kW rechargeable system that lasts for 5,000 cycles, costs under $100/kWh, and shows strong potential for scaling to megawatt-hour levels in grid-scale electric energy storage applications.
Fluidic Energy, Inc.	$3,000,000	Scottsdale, AZ	*Battery: Enhanced Metal-Air Energy Storage System with Advanced Grid-Interoperable Power Electronics Enabling Scalability and Ultra-Low Cost* Fluidic Energy, in cooperation with partners Satcon and Chevron Energy Solutions, proposes a high-risk-reward program to develop a novel, low-cost, battery for intermittent renewable energy ramp support on the electric power grid. The proposed advanced multi-function energy storage (AMES) prototype is highly scalable and will provide multiple modes of operation. The AMES device will be built around highly-efficient battery chemistry, but will use novel approaches to address traditional challenges for grid storage deployment, including limited rechargeability, low power density, and poor roundtrip efficiency. The AMES device will provide energy storage at low cost, in part by developing domestically-sourceable and geologically abundant active materials in an advanced battery chemistry. The system will be scalable to the megawatt-hour levels necessary for grid-scale energy storage.
General Atomics (UC San Diego)	$1,986,308	San Diego, CA	*Flow Battery: GRIDS Soluble Lead Flow Battery Technology* General Atomics and the University of California San Diego will develop a novel flow battery technology based on lead-acid chemistry that significantly reduces costs and extends battery life. For a century, the lead-acid battery has been used in a variety of energy storage applications. While few battery technologies can match lead-acid's combination of low-cost, high-efficiency, safety, and proven reliability, the lead-acid chemistry inherently suffers from poor cycle life when deeply discharged as well as poor electrochemical materials utilization. The proposed flow battery will use novel electrode materials that greatly increase the surface area available for chemical reactions, minimizing the amount of excess lead in the battery. In addition, the electrodes will resist the corrosion that typically limits the cycle life of conventional lead acid batteries. These innovations will result in a battery that easily can be scaled for grid-scale energy storage, but which costs less than existing technologies to accelerate the adoption and integration or

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Technology Focus – Application: Project Title*** **Project Description**
			renewable energy sources.
General Compression	$750,000	Newton, MA	*Compressed Air Energy Storage (CAES): Fuel-Free, Ubiquitous, Compressed Air Energy Storage and Power Conditioning* General Compression will lead a team to develop a novel compressed air energy storage process (GCAES™) that is highly efficient and requires no fossil fuel. In this project, a team of industry and academic researchers will investigate near-isothermal CAES, which offers the potential of round-trip electrical efficiency up to 75% and a response time of less than one second. Unlike conventional CAES installations, no fuel will be burned in the expansion stage of the proposed process, dramatically reducing emissions and operating costs. If successful, this innovative compressed air energy storage technology could accelerate the integration of renewable electricity resources, particularly wind, into the grid.
Lawrence Berkeley National Laboratory (DuPont, Bosch, 3M, and Proton Energy)	$1,592,730	Berkeley, CA	*Flow Battery: Hydrogen-Bromine Flow Batteries for Grid-Scale Energy Storage* Lawrence Berkeley National Laboratory and its team of industrial partners (DuPont, Bosch, 3M, and Proton Energy) will develop a hydrogen-bromine (H_2-Br_2) flow-battery system for grid applications. H-Br cells use two highly reversible and kinetically-favored electrodes to provide high round-trip efficiency. In addition, the proposed technology is expected to offer high power capabilities, thereby reducing the cost of stack components. The H-Br system promises to meet the most stringent demands of costs, performance, lifetimes, and safety. To solve these technical challenges in this project, the LBNL team will apply novel technical approaches to deliver a proof-of-concept cell that will demonstrate the potential of this chemistry in grid-scale energy storage applications.
Primus Power	$2,000,000	Alameda, CA	*Flow Battery: Low-Cost, High Performance 50 Year Electrodes* Primus Power will develop an extremely durable, highly active, conductive, and inexpensive metal electrode for flow batteries. Flow batteries are ideal for bulk energy storage applications, but are often limited by the high cost and poor durability of the carbon materials used in the battery electrodes. In this project, Primus Power will leverage processes common in other chemical manufacturing industries to develop novel, low-cost metallic flow battery electrodes. In addition, the team will develop a production process for the metal electrode by taking advantage of high volume processes used in the metals industry. Together, the low cost electrode and volume manufacturing process will result in a significant decrease in energy storage costs for the proposed flow battery technology, while simultaneously increasing the power density of the system. This project will yield a novel flow battery system that will provide scalable, low-cost energy storage that is ideally-suited for addressing the renewable ramping challenge.

Lead Research Organization (Partner Organizations)	**Amount**	**Lead Organization Location** (City, State)	***Technology Focus – Application: Project Title*** **Project Description**
Proton Energy (Penn State University)	$2,148,719	Wallingford, CT	*Fuel Cell: Transformative Renewable Energy Storage Devices Based on Neutral* Proton Energy and Penn State University will develop an advanced electrochemical energy storage device that incorporates a regenerative electrolyzer and fuel cell (REFC) and an alkaline membrane. Many fuel cells rely on acidic membranes which require costly noble metal catalysts and semi-precious metal components inside the cell stack to maintain conductivity. Transitioning to an alkaline membrane in the proposed REFC will eliminate the highest-cost materials and enable higher efficiency through reductions in current density. In this project, an inexpensive, alkaline membrane will be developed and then utilized in a 20kW reversible electrochemical advanced storage system that converts water to fuel and then back to water to for grid-level electrical energy storage.
United Technologies Research Center (University of Texas, Clipper Windpower, Pratt & Whitney, Sandia National Labs)	$3,000,000	East Hartford, CT	*Flow Battery: Transformative Electrochemical Flow Storage System (TEFSS)* United Technologies Research Center (UTRC), in partnership with the University of Texas and Sandia National Laboratory and Clipper Windpower will develop a flow battery system that uses a novel cell design to deliver 10X higher power density than current state-of-the art flow batteries. This breakthrough will enable a dramatic reduction in the size and cost of the cell-stack, which is the most expensive component of flow-battery systems. To take maximum advantage of this new cell-stack technology, a number of other innovative concepts will be incorporated into the system to transform the system to an energy-storage device with both rapid response times and long run times at rated power as needed for renewable energy support on the grid. A 20-kW advanced prototype flow battery will be developed in this program that will lay the scientific and technical foundation for development of a commercially-available grid-scale energy storage solution.
University of Southern California (Jet Propulsion Laboratory (JPL))	$1,459,324	Los Angeles, CA	*Battery: A Robust and Inexpensive Iron-Air Rechargeable Battery for Grid-Scale Energy Storage* Researchers at the University of Southern California and NASA's Jet Propulsion Laboratory will team to develop a high-performance iron-air rechargeable battery for large-scale energy storage for the integration of renewable energy sources on the electricity grid. Iron-air batteries have the potential to store large amounts of energy inexpensively since they rely on extremely low-cost active materials: iron, which is abundant at extremely low cost and oxygen which is obtained from ambient air. However, current iron-air battery technologies have suffered from low round-trip energy efficiency and poor cycle life. To overcome these challenges in this project, novel strategies will be used to address these issues, including the use of additives at the iron electrode to suppress inefficient and parasitic losses, the application of nano-structured electrodes with thin films of catalysts layers at the air electrode that reduce losses, use of a unique cathode catalyst support that resists degradation and increases battery life, and a novel technique to avoiding carbon dioxide from being absorbed into the battery electrolyte. This project will develop an iron-air proof of concept rechargeable battery, the first step in the commercialization of this promising, low-cost battery chemistry.