NASA SBIR 2005 Phase I Solicitation

**X3.02 Energy Storage**

*Lead Center: GRC*

*Participating Center(s): JPL, JSC*

All exploration missions require advanced primary and rechargeable energy storage devices that are high-density, have long-life capability, and have the ability to function at extreme temperatures. The energy storage requirements vary significantly from a few watt-hours (astronaut equipment) to hundreds of kilowatt-hours (human outposts), depending on the mission. Similarly, power requirements also vary from a few watts (astronaut equipment) to several kilowatts, depending on the mission (human rovers, human outposts, and crew exploration vehicles).

Advanced energy storage devices, such as primary batteries, rechargeable batteries, fuel cells, and flywheels are required to enable future robotic and human exploration missions. Advanced primary batteries are required for applications such as astronaut equipment, communication devices, *in situ* resource utilization systems, sensor networks, etc. Advanced rechargeable batteries are required for solar powered landers and rovers, solar powered human outposts, astronaut equipment, and spacecraft. Primary fuel cells are required for crew exploration vehicles and rovers. Regenerative fuel cells provide an enabling, mass-efficient solution for surface electrical energy storage for future long-duration human exploration of the lunar and Mars surfaces. Flywheels provide an effective solution to meeting peak power requirements when used in hybrid systems with battery or fuel cell systems providing the base power, and offer the capability of integrated power and attitude control.

Energy Storage devices are needed for EVA and EVA accessory applications as well as vehicle and base back-up or peaking power applications. Areas of emphasis include advanced battery materials and cell designs with the potential to achieve the performance and safety advancements required for manned applications. Hybrid systems consisting of fuel cells, batteries, flywheels, and/or ultra capacitors are of interest. Also sought are high energy density fuel cell reactant storage innovations compatible with the performance and safety goals specified herein. Micro and nano-engineered materials are an area of emphasis for all of these applications. Proposals addressing micro-batteries, and integrated power generation and storage are sought.

Primary and rechargeable lithium-based batteries with advanced anode and cathode materials and advanced liquid and polymer electrolytes and solid-state systems are of particular interest. Technology advancements that contribute to the following performance goals are sought: specific energy >180 Wh/kg, calendar life (>15 years), and a wide operating temperature range (-60°C to 60°C). Primary batteries with the following performance targets are of interest: low temperature operation capable of delivering >30% of their ambient temperature capacity at temperatures as low as -100°C, specific energy: >400 Wh/kg, long calendar life >15 years, and high rate capability >C/10.
Fuel cell (FC) and regenerative fuel cell (RFC) systems with power capabilities in the range of 100-1000 watts and 2-10kW are of interest. Technological advances are sought that FC/RFC based systems with the following characteristics: specific energies: FC >1500 W/kg, RFC >600 Wh/kg. Efficiencies: FC>70% at 1500 W/kg, RFC >60% at 600 Wh/kg, and lifetimes: FC >10,000 hours, RFC >1500 cycles. Concepts that incorporate passive operation and advanced reactant storage options (example: H₂, O₂) are sought.

Advanced fuel cell development should include proton exchange membrane fuel cells (PEMFC - high and low temperature), regenerative fuel cells (RFC), and solid oxide fuel cells (SOFC). PEMFC areas of emphasis include long-life stacks and systems with emphasis on gravity-independent water management within the stack or elsewhere in the system, passive water separators, and passive reactant recirculation devices. RFC areas of emphasis include long-life, high-efficiency PEMFCs and electrolyzers. SOFC areas of emphasis include the capability to utilize CO/CO₂ and methane fuels for power generation.

Flywheel technology areas of interest are: system configuration concepts for high specific energy (>100Wh/kg for systems >500Whr and >50Wh/kg for systems 600 Wh/kg, and/or concepts that integrate energy storage, momentum storage, and spacecraft structure are sought.