NASA SBIR 2015 Phase I Solicitation

H8 High Efficiency Space Power Systems

Lead Center: GRC

This topic solicits technology for power systems to be used for the human exploration of space. Power system needs consistent with human spaceflight include:Â

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- Fuel cells compatible with methane-fueled landers, and electrolyzers and fuel cells compatible with materials extracted from lunar regolith and/or the Martian soil or atmosphere.
- Nuclear fission systems to power electric spacecraft and/or surface space power systems.
- Photovoltaic technology to power electric spacecraft.

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Solid oxide technology is of interest for fuel cells and electrolyzers to enable:Â

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- The operation of fuel cells using hydrocarbon reactants, including methane and fuels generated on-site at the Moon or Mars.
- Electrolysis systems capable of generating oxygen by electrolyzing CO_2 (from the Mars atmosphere, trash processing, life support, or volatiles released from soils), and/or water from either extraterrestrial soils, life support systems, or the byproduct of Sabatier processes.

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Both component and system level technologies are of interest.

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Technologies to enable space-based nuclear fission systems are sought for three power classes:Â

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- Kilowatt-class to support robotic missions as precursors to human exploration.
- 10 kWe-class power conversion devices and 400-500K radiators to support large surface power and 100 kWe-class electric propulsion vehicles.

- 100 kWe-class power conversion devices, >500K radiators, and high temperature fuels, materials, and heat transport to support MW-class electric vehicles.

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Photovoltaic (PV) technologies are sought to provide lower-cost power systems with particular emphasis on high power arrays to support solar electric propulsion spacecraft on deep space missions.Â Â Â

Subtopics

H8.01 Space Nuclear Power Systems

Lead Center: GRC

Participating Center(s): JPL, JSC, MSFC

NASA is developing fission power system technology for future space exploration applications using a stepwise approach. Initial small fission systems are envisioned in the 1 to 10 kWe range that utilize cast uranium-metal fuel and heat pipe cooling coupled to static or dynamic power conversion. Follow-on systems could produce 10s or 100s of kilowatts utilizing a pin-type uranium fueled reactor with pumped liquid metal cooling, dynamic power conversion, and high temperature radiators. The anticipated design life for these systems is 8 to 15 years with no maintenance. Candidate mission applications include power sources for robotic precursors, human outposts on the moon or Mars, and nuclear electric propulsion (NEP) vehicles. NASA is planning a variety of nuclear and non-nuclear system ground tests to validate technologies required to transfer reactor heat, convert the heat into electricity, reject waste heat, process the electrical output, and demonstrate overall system performance.Â

The primary goals for the early systems are low cost, high reliability, and long life. Proposals are solicited that could help supplement or augment the planned NASA system testing. Specific areas for development include:Â

- 800-1000 K heat transport technology for reactor cooling (liquid metal heat pipes, liquid metal pumps).
- 1-10 kWe-class power conversion technology (thermoelectric, Stirling, Brayton).
- 400-500 K heat rejection technology for waste heat removal (water heat pipes, composite radiators, water pumps).

The early systems are expected to provide the foundation for later systems in the multi-hundred kilowatt or megawatt range that utilize higher operating temperatures, alternative materials, and advanced components to improve system performance. Specific areas for development include:Â

- 100 kWe-class power conversion technologies.
- Waste heat rejection technologies for 500 K and above.
- High temperature reactor fuels, structural materials and heat transport technologies.Â

H8.02 Solid Oxide Fuel Cells and Electrolyzers

Lead Center: GRC

Participating Center(s): JSC

Technologies are sought that improve the durability, efficiency, and reliability of solid oxide systems. Of particular interest are those technologies that address challenges common to both fuel cells fed by oxygen and hydrocarbon fuels, and electrolyzers fed by carbon dioxide and/or water. Hydrocarbon fuels of interest include methane and fuels generated by processing lunar and Mars soils. Primary solid oxide components and systems of interest are:Â

- Solid oxide cell, stack, materials and system development for operation on direct methane in designs scalable to 1 to 3 kW at maturity. Strong preference for high power density configurations.

- Cell and stack development capable of Mars atmosphere electrolysis should consider feasibility at 0.4 to 0.8 kg/hr O_2; scalable to 2 to 3.5 kg/hr O_2 at maturity. CO_2 electrolysis or co-electrolysis designs must have demonstrated capability of withstanding 15 psid in Phase I with pathway to up to 50 psid in Phase II.

Proposed technologies should demonstrate the following characteristics:Â

- The developed systems are expected to operate as specified after at least 20 thermal cycles during Phase I and greater than 70 thermal cycles for Phase II. The heat up rate must be stated in the proposal.
- The developed systems are expected to operate as specified after at least 500 hours of steady state operation on propellant-grade methane and oxygen with 2500 hours expected of a mature system. System should startup dry but after reaching operating conditions an amount of water/H_2 consistent with what can be obtained from anode recycle can be used. Amounts must be justified in the proposal.
- Minimal cooling required for power applications. Cooling in the final application will be provided by means of conduction through the stack to a radiator exposed to space or other company proposed solution.
- Minimal power (heating plus electrolysis) required for CO_2 electrolysis applications.
- Demonstrate electrolysis of the following input gases: 100% CO_2, Mars atmosphere mixture (95.7% CO_2, 2.7% N_2, 1.6% Ar), 100% water vapor, and 0.7 to 1.6:1 CO_2:H_2O mass ratio. A final test using pure CO_2 of 500 hours (or stopping at 40% voltage degradation) is required. Description of technical path to achieve up to 11,000 hrs for human missions is requested.Â

H8.03 Advanced Photovoltaic Systems

Lead Center: GRC

Participating Center(s): JSC

Advanced photovoltaic (PV) power generation and enabling power system technologies are sought for improvements in capability and reliability of PV power generation for space exploration missions. Power levels for PV applications may reach 100s of kWe. System and component technologies are sought that can deliver efficiency, cost, reliability, mass and volume improvements under various operating conditions, in extreme environments, and over wide temperature ranges.

PV technologies must enable or enhance the ability to provide low-cost, low mass and higher efficiency for power systems with particular emphasis on high power arrays to support solar electric propulsion missions. Areas of particular emphasis include:Â

- Advanced PV blanket and component technology/ designs that support very high power and high voltage (> 200 V) applications.
- PV power generation (cell, interconnect, and small self-deployable arrays) for CubeSat/ small satellite applications.
- PV module/ component technologies that emphasize low mass and cost reduction (in materials, fabrication and testing).
- Improvements to solar cell efficiency that are consistent with low cost, high volume fabrication techniques
- Automated/ modular fabrication methods for PV panels/ modules on flexible blankets (includes cell laydown, interconnects, shielding and high voltage operation mitigation techniques).
- Integrated PV system including cells, blanket, array, inverters, interconnect technologies, storage, structures, etc. with a balance-of-components while matching specifications of various systems.
- Simulated PV capability that take optimizes system components, ensures compatibility of modules/inverters, and takes temperature extremes and unique aspects of the space environment into account including radiation tolerance.

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract.Â