Future NASA science objectives will include missions such as Earth Orbiting, Venus, Europa, Titan, Lunar Quest and Space Weather. Under this subtopic, proposals are solicited to develop energy storage and power electronics to enable or enhance the capabilities of future science missions. The unique requirements for the power systems for these missions can vary greatly, with advancements in components needed above the current State of the Art (SOA) for long life, high reliability, low mass/volume, radiation tolerance, and wide temperature operation.

### Energy Storage

Future science missions will require advanced primary and secondary battery systems capable of operating at temperature extremes from -100°C for Titan missions to 400°C to 500°C for Venus missions, and a span of -230°C to +120°C for Lunar Quest. In addition, high energy-density rechargeable electrochemical battery systems that offer greater than 50,000 charge/discharge cycles (10 year operating life) for low-earth-orbiting spacecraft, 20 year life for geosynchronous (GEO) spacecraft, are desired. Advancements to battery energy storage capabilities that address one or more of the above requirements for the stated missions combined with very high specific energy (>200 Wh/kg for secondary battery systems) and energy density, along with radiation tolerance are of interest.

In addition to batteries, other advanced energy storage/load leveling technologies designed to the above mission requirements, such as flywheels, supercapacitors or magnetic energy storage, are of interest. These technologies have the potential to minimize the size and mass of future power systems.

### Power Management and Distribution (PMAD)

The "New Frontiers in the Solar System: An Integrated Exploration Strategy" ([http://www.nap.edu/catalog.php?record_id=10432](http://www.nap.edu/catalog.php?record_id=10432)), the 2006 Solar System Exploration Roadmap ([http://nssascience.nasa.gov/about-us/science-strategy](http://nssascience.nasa.gov/about-us/science-strategy)) and the Science Plan for NASA's Science Mission Directorate ([http://nssascience.nasa.gov/about-us/science-strategy](http://nssascience.nasa.gov/about-us/science-strategy)) all describe the need for radioisotope power systems (RPS) for planetary exploration. In conjunction with the RPS, intelligent, fault-tolerant PMAD technologies are needed to efficiently manage the system power for these deep space missions. Advances in electrical power technologies are required for the electrical components and systems for these future platforms to address program size, mass, efficiency, capacity, durability, and reliability requirements. Of importance are expected improvements in energy density, speed, efficiency, or wide-temperature operation (-125°C to over 450°C) with a number of thermal cycles. Advancements are sought for power electronic devices, components and packaging for Venus type missions with power ranges of a few watts for minimum missions up to a few kilowatts for large missions.

For the lower power applications (up to 20 watts), NASA desires to build smaller spacecraft types carrying smaller instrument packages. However, power requirements to accommodate these instruments and spacecraft systems will not necessarily shrink in a similar fashion as spacecraft size. Therefore, power management technologies are sought that are compatible with small spacecraft geometries and sizes. These Electrical Power Systems should be compatible with Space Plug and Play (SPA) architectures.

Overall technologies of interest include:
• Intelligent, fault-tolerant electrical components and PMAD systems
• High temperature devices and components (up to 450°C)
• Advanced electronic packaging for thermal control and electromagnetic shielding
• Plug and Play compatibility for low power applications

Power Conversion and Distribution relevant to Command, Data Handling, and Electronics, will be covered under subtopic S3.01.

Power Storage for Terrestrial Balloons will be covered under sub-topic S3.07 Terrestrial and Planetary Balloons.

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II, and when possible, deliver a demonstration unit for NASA testing at the completion of the Phase II contract. Phase II emphasis should be placed on developing and demonstrating the technology under relevant test conditions. Additionally, a path should be outlined that shows how the technology could be commercialized or further developed into science-worthy systems.

Other subtopics, which could potentially benefit from these technology developments include O5 - Low-Cost and Reliable Access to Space (LCRATS), S5.05 - Extreme Environments Technology, and S5.01 - Planetary Entry, Descent and Landing Technology. Battery development could also be beneficial to X6.02 - Advanced Space-rated Batteries, which is investigating some similar technologies in the secondary battery area but with very different operational requirements. Power Management and Distribution could be beneficial to X8.05 - Advanced Power Conversion Systems AND Management and Distribution (PMAD), which is investigating similar technologies, but with very different power levels.