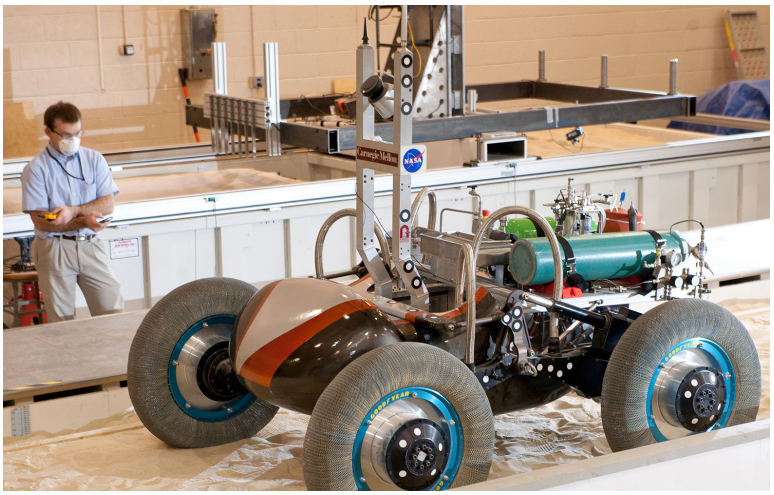
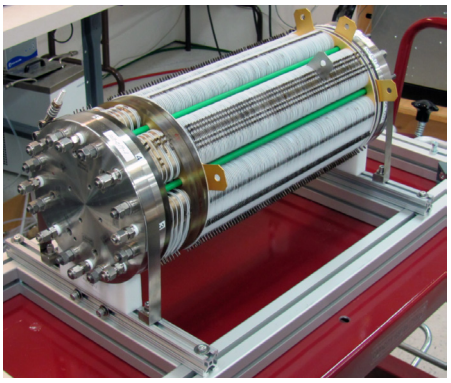
National Aeronautics and Space Administration

Power for Journeys and Discoveries in Space





Left: Powering Scarab with a non-flow-through fuel cell. Right: ASPS's 3-kilowatt fuel cell stack.

Future robotic and human space explorers will need low-cost, abundant, reliable power as they journey far from Earth and make discoveries on other worlds. In addition to solar power for electric spacecraft propulsion, they will need power to keep their life support, maintenance, and repair systems working reliably. They also will need power for surface vehicles; for excavating, collecting, and analyzing samples; and for conducting science experiments. Power will have to be available at "night," during eclipses, and for up to 8 hours at a time for activities outside the spacecraft.

The Advanced Space Power Systems Project (ASPS) funded by NASA's Game Changing Development Program is developing advanced battery and fuel cell technologies to provide this vital power. In 2012, ASPS also built a refueling station for a fuel-cell-powered city bus and held events to inspire Ohio students. ASPS is a nationwide effort of NASA centers and contractors, other Government agencies, universities, and manufacturers. It is led by NASA's Glenn Research Center.

Advanced Lithium-Ion Batteries

NASA needs large-format lithium-ion (Li-ion) batteries (stacks of many connected cells) because they produce more energy without increased weight. However, these batteries can cause fires, and existing electrolytes (the charged liquid or gel in a battery) are flammable. Also, existing Li-ion batteries cannot provide enough energy in the small packaging needed for future space applications. ASPS is developing and testing advanced Li-ion batteries that can work in the harsh environment of space, provide very high energy from lightweight cells, and use electrolytes that suppress fires.

ASPS has tested flame-retardant electrolytes and is developing ways to mass-produce advanced anodes and cathodes (the positively and negatively charged electrodes of the battery).

Advanced Fuel Cells

NASA needs reliable, maintenance-free fuel cells that can use reactants stored at high pressure and that can operate with leftover fuels, but existing fuel cells cannot operate reliably enough for NASA's needs. Also, the most promising fuel cells—Proton Exchange Membrane (PEM) cells—have not yet been proven to operate well in a space environment.

game changing development

The fuel cells used on Earth react with oxygen from the air and use air to remove the water produced by the reaction. In space, another way is needed to remove the water. ASPS developed and is testing non-flow-through (NFT) PEM fuel cells and passive water-feed electrolyzers. The electrolyzers produce oxygen and hydrogen for fuel and can operate without air or gravity. The fuel cell uses a novel membrane to wick water away—like some fabrics wick sweat away from the skin.

NFT fuel cells promise to be more reliable and smaller because they have no moving parts. They can be assembled into systems with fewer components, which also reduces size and weight. In 2012, ASPS tested a 125-watt NFT fuel cell on Scarab, a four-wheeled robot that is demonstrating how future rovers might travel and drill samples on extraterrestrial surfaces. Scarab used power from the fuel cell stack for maneuvers in Glenn's Simulated Lunar Operations (SLOPE) Facility.

Having demonstrated that this NFT technology can work on a small rover, ASPS is building bigger systems for bigger applications. A 1-kilowatt, 40-cell stack is scheduled to provide more power for rovers, and a 3-kilowatt system—the largest ever built—will provide enough electrical power for a planetary lander or a habitat. The goal is a system that can provide 10,000 hours of reliable electrical power while producing pure water for the spacecraft's environmental control and life support system.

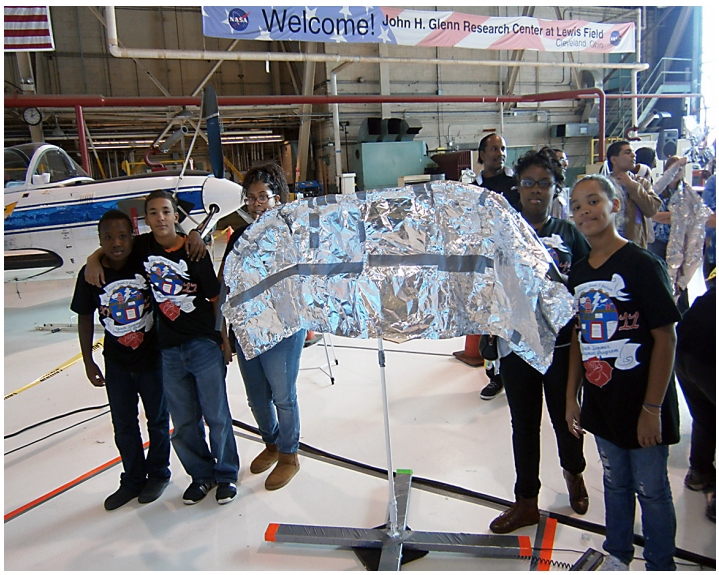
Making Hydrogen To Fuel City Buses

Hydrogen-fueled bus.

Working with Greater Cleveland's Regional Transit Authority and others, Glenn applied NASA's fuel cell technologies to a safer way to refuel hydrogen-powered vehicles. It is the first refueling station in Ohio that uses electrolysis to make hydrogen fuel onsite—avoiding the need to transport extremely flammable hydrogen gas. The hydrogen sensors used in the station were developed from NASA's space launch system research.

The station uses electricity to split Lake Erie water into hydrogen and oxygen gases through electrolysis. The hydrogen gas is stored in tanks until it is needed. Then the PEM fuel cell that powers the bus combines the hydrogen with oxygen from the air to produce electricity. The only byproduct is water, which goes out the tailpipe.

Inspiring Students



Foil "solar array" created by students.

Inspiring students to pursue science, technology, engineering, and mathematics, ASPS has involved students in several activities. At Glenn's Young Astronaut Day event, students competed to create the best aluminum foil "solar array"—the winner had the most surface area when the array was rolled out and the smallest mass and volume when it was rolled up.

The Game Changing Development (GCD) program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

For more information about GCD, please visit
http://gameon.nasa.gov/

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