NASA Regenerative Fuel Cell Development Status Update. I.J. Jakupca[1] , P.J. Smith[2], K.P. Cain[2] [1]Fuel Cell Technology Lead, National Aeronautics and Space Administration (NASA), Glenn Research Center (GRC), 21000 Brookpark Road, Cleveland, OH 44135, [2]Photovoltaic and Electrochemical Systems Branch, NASA GRC, (Contact: ian.j.jakupca@nasa.gov)

The specific energies (W·hr/kg) of currently available energy storage technologies impose unacceptable mass penalties on lunar missions, especially systems designed to support a persistent human lunar surface presence during the lunar night. The National Aeronautics and Space Administration (NASA) funds research into multiple technologies to minimize this mass penalty and satisfy as many mission requirements as possible. This includes the electrochemical regenerative fuel cell (RFC) technology based on the hydrogen (H_2) / oxygen (O_2) couple.

This presentation provides a summary into the status of the RFC project funded by the Space Technologies Mission Directorate (STMD) Game Changing Development (GCD) program office. The RFC project is tasked to advance the RFC energy storage technology from a Technology Readiness Level (TRL) 3 to TRL 5 by designing, developing, and demonstrating via ground-test, a subscale (100 W_{Net} / 36.6 kW·hr_{Net}) automated RFC system within a thermal-vacuum (TVAC) facility that simulates the temperature and pressure environment of an equatorial lunar landing site. This system design must be extensible to a full scale system of 7 kW_{Net} / 2.6 MW·hr_{Net}. Minimum success criteria requires that the system fully supports the external load profile(s) throughout the simulated lunar nights within the thermal-vacuum chamber, illustrate a specific energy of at least 320 W•hr/kg, and complete at least one full lunar day-night cycle within the thermal-vacuum chamber. For reference, the state-of-the-art (SOA) packaged Li-ion battery systems have a specific energy of approximately 160 W•hr/kg (576 kJ/kg) at the time of this publication.

While developing the ground-test system, the RFC project identifies technology gaps that must be addressed to implement this technology on the lunar or Mars surfaces. Ongoing efforts reveal a range of technology gaps with a wide distribution of difficulties to address these gaps. Select component gaps discussed include sensors, pumps, water purifiers, power electronics, storage tanks, electrochemical stacks, passive humidification control devices and safety devices. The system-level technology gaps identify insufficient test data on life, durability, and reliability at both the component and sub-system levels. This data gap increases technical risks associated with system design and packaging.

The RFC project continues to assess developing technologies for viability and potential inclusion into the RFC demonstration system. Alternative compression technologies, water sanitization technologies, and thermal management technologies are examples of near-term technologies being assessed. Long-term system assessments include alternative reactant combinations, multiple system integration within a habitat, and requirement sensitivity to landing site locations.