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POWER MANAGEMENT AND DISTRIBUTION FOR LIFE SUPPORT TECHNOLOGY AND SYSTEMS OF MICROGRID TO SUSTAIN FIRST MARS COLONY

Abstract

The first crewed mission to Mars requires advanced understanding of power management and distribution for the arrival of machines and settlement of humans on the Red planet. In the past few decades, researchers from NASA and other organisations have made great advancements in outlining the power systems, technologies, and materials involved in operating Martian habitat (Cataldo, R. L., 1998; Hew, Y. et al, 2018;).

Power Management and Distribution (PMAD) requires critical analysis on the materials, mass, and deployment of technologies involved in settlement operations over time. A lack of understanding of systems involved in PMAD stifles the planning of human and machine activities for space colonization and exploration. Knowledge gaps on the energy required to operate systems and subsystems impose uncertainties and challenges in the short and long-term design, engineering, and planning of settlements beyond Earth.

PMAD estimates, mass ratios, and systems involved in previous studies have a fair degree of inaccuracy and tend to focus on power storage, transmission, and sources. Rather than defining the system-level specifications and requirements from a multidisciplinary approach, research studies tend to emphasize the long term plan with prolonged human operations in deep space, introducing risks to human physical and mental health.

For these reasons, our objective is to conduct a comprehensive study on PMAD and microgrid to support systems and organisms during the first human mission on Mars. After outlining a comprehensive settlement layout, we will analyze power distribution and management during a simulated round trip six-man mission enabled with on-orbit staging with Starship. With up to three kWe-size nuclear fission reactors, PMAD energy estimates of settlement operations include pressurization, heating, hydrogen fuel cell water production, agriculture, waste and water management, Sabatier reactor, nitrogen generator and compression, habitat appliances, communication, EVAs, feedstock storage tanks and facilities, and lighting to improve efficiencies and power budgets of the settlement operating capacity.

Finally, in quantifying the energy budget for life support technologies, we derive baseline reference for engineers to compare energy system requirements with the value of proposed innovations. by engaging with leaders from industry, academia, and government to help better define energy and system requirements, researchers develop one of the most accurate and detailed estimates for the microgrid for the first Martian colony. PMAD estimates can be used as a reference to guide decision making of power and financial budgets, policies, cost estimations, and planning involved in enabling the first colony on Mars.