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A HIGH - FIDELITY PARAMETRIC STUDY OF A PHOTOVOLTAIC AND BATTERY SYSTEM FOR LUNAR NIGHT SURVIVAL

Abstract

The survival of lunar surface missions during the prolonged lunar night period relies on efficient energy management systems. This paper presents a high-fidelity parametric study of a photovoltaic (PV) and battery system designed to provide power to an end-system during the lunar night on the surface of the Moon along with supporting its operations during the day. The study investigates various system parameters, including PV panel characteristics, battery capacity and heating power for its survival, and energy management strategies, while assessing the performance of the system in terms of energy density. Additionally, the impact of selenographic latitudinal variation on the total mass was examined along with the quantification of effects such as state-of-charge (SOC),depth of discharge (DOD) and mission lifetime in the subsystem sizing.
The outcomes of the parametric study provide insights into the system's performance, specifically in terms of energy density, resulting in the polar regions as the most promising areas for operation. The minimum operating battery temperature during the night was found to be one of the main drivers in terms of total system mass, with locations below 70^o latitude resulting in more than 70% of battery discharge power dedicated to its own thermal management. Additionally, the maximization of specific energy for a given end-system power demand was observed to be dependent on the location under examination and the amount of power demanded. These findings guide the design and implementation of PV and battery systems for lunar night survival, contributing to the advancement of energy storage and management technologies for sustainable and long-duration exploration of the Moon.