EPRI-NASA-CenterPoint Energy Lunar Surface Power System Project

Eva Gardow, BSME '82 and Joseph Potvin, BSEE '06 MSEE '09 PhD '18 work at the Electric Power Research Institute (EPRI). EPRI is a research organization that advances safe, reliable, affordable, and clean energy. Eva and Joe worked together on a project supporting the National Aeronautics and Space Administration (NASA) Artemis Campaign with the local Houston, TX utility, CenterPoint Energy. NASA is a customer of CenterPoint Energy.

The purpose of the Artemis Campaign is to explore the Moon for scientific discovery, technology advancement, and to learn how to live and work on another world. NASA is an independent agency of the U.S. federal government responsible for the civil space program, aeronautics research, and space research. A specific Artemis Campaign project is to develop a Lunar Surface Power System (LSPS), which plans to include power sources and loads connected by a distribution system.

EPRI worked on the fundamental design and risk analysis regarding designing and building an electric distribution system on the moon. EPRI managed one analysis and performed two others for the developing LSPS. The initial project was to answer fundamental questions on system configuration, whether to design an AC or DC system, voltage level, and identify a better choice of copper or aluminum wiring. The other two projects addressed Standards for the electric system components and the other on how best to assess electric system Reliability.

These analyses were predicated on the extreme environment of the moon that makes the design, construction, and operation of an LSPS challenging. Moon temperatures ranges from -180°C at night to +120°C during the daytime. A Lunar day is approximately 27.3 Earth days, with periods of darkness near the equator of over 300 hours. Fortunately, in the South Pole region, locations have sunlight for much of the lunar day. Other lunar conditions that need to be considered in the design include lunar dust, known as regolith, as well as a vacuum environment, and space radiation. Regolith is a dusty material that has a fine particle structure, is abrasive, and susceptible to becoming electrostatically charged.

The initial work performed analysis on the fundamental design of a power distribution system for the lunar surface. The recommendation for the LSPS is for an alternating current (AC)

system with a frequency of 60 Hertz and a voltage level of 13.8 kilovolts using aluminum cabling for a 1 megawatt module to be deployed initially in the south polar region of the moon.

Regarding Standards, EPRI evaluated known distribution system, electrical component Standards to determine their applicability to the lunar extreme environment. The Standards reviewed address components that are designed and manufactured for terrestrial environments. It was determined that there is no existing guidance on how electric system components would need to be designed for use in a lunar environment.

EPRI also assessed the LSPS Reliability using a Probabilistic Risk Assessment (PRA) model to comprehend the risks and inform the challenges in both the design phase and during operation of the LSPS. A PRA provides the tools to assess the impact of the lunar extreme environment on the LSPS to verify that the LSPS meets the reliability targets.

The full Standards report titled: Extreme Environment Power Systems Standards: Evaluation and Gap Analysis is available for download by clicking on the title and the full Reliability report titled: Proposed Risk Management Methodology to Assess Reliability for a Lunar Surface Power System is available for download by clicking on the title.