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MASS AND POWER SCALING OF HALEU FUELED HEAT-PIPE NUCLEAR REACTORS FOR SELECTED LUNAR BASE SCENARIOS

Abstract

Nuclear energy is a key enabling technology for long duration, deep space missions that require reliable, constant and dense power supply (>10 kWe), regardless the environmental conditions. Lunar habitats and In Situ Resource Utilization (ISRU) are two examples of space applications that would benefit from the use of nuclear reactors due to the long duration of lunar night, that makes challenging the use of solar panels, fuel cells or batteries as primary energy sources. This paper aims at providing key figures of merit (mass and power mainly) for a Heat-Pipe Reactor (HPR), an advanced and proved nuclear reactor concept for which a feasible deployment is expected in a medium-term timeframe. The use of Heat-Pipes, as cooling mechanism, allows to simplify the design decreasing the number of active components (e.g., pumps). This also improves the system reliability and reduces the need of maintenance. Differently from most of the scientific research concerning space nuclear reactors, this work considers the use of High Assay Low Enriched Uranium (HALEU). The reduced amount of fissile material contained in HALEU fuel allows to align to the strict nuclear regulations, eliminating the proliferation issue. A nuclear power system has been outlined following the principles of simplicity, safety and redundancy. The electrical power needs for different crewed lunar bases scenarios (from basic science to ISRU driven scenario) were firstly identified and different electricity transport technologies (cables, radio-waves and lasers) have been analyzed, each featured with specific efficiencies and power to weight ratios. The electrical power needs impact on the overall system mass. For each scenario the mass of the major system's components has been estimated. The study results provide a review of pros and cons of energy conversion and transmission subsystem components for an HPR. The major outcome of this research is an overview of mass and power performances of an HALEU nuclear reactor for lunar base application. These information are relevant for the overall mission system architecture, laying the foundation for trade-off analyses among the different

energy sources.