Power Requirement Estimation of a Preliminary Lunar Base

Micah Boudreau[1], Andrew Dean[1], Paula do Vale Pereira[1], Marcel Otto[2], Abhilash Prasad[2], Augusto Delavald Marques[2], Zamir Londono[2], Al-Muthanna Al-Ani[2], Jayanta Kapat[2]

Affiliations: 1: *MISSION Lab, University of Central Florida* 2: *CATER, University of Central Florida*

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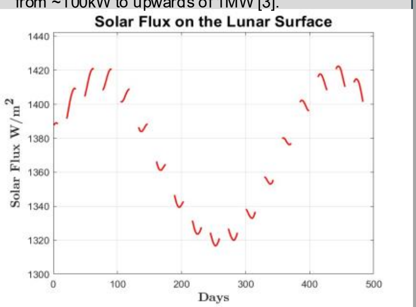
Title or Text

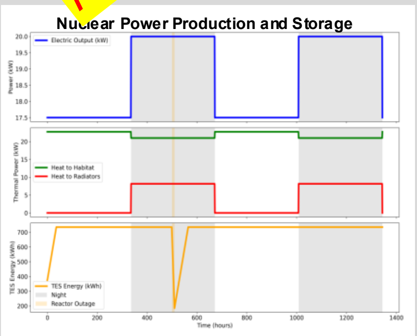
To size the power output of a lunar molten salt reactor (MSR), we first require an estimate of how much power the fission reactor must supply to the base. Power estimates must consider a variety of different factors including the location, number of crew, and activities/operations of the base. Estimates have remained relatively consistent over the past decades for power requirements to sustain one human life, at about 2 kWe for a closed system, excluding food importation. To consider the power requirements for food cultivation, more research is needed to obtain accurate power needs; here, we assume a conservative, 10 kWe per person to be sufficient. Rought estimates place housekeeping power requirements in the range of 45-55 kW to maintain critical sub-system functionality [1]. Various science experiments will undoubtably be performed, yet the specifics of the experiments are unknown, thus we assume a power budget for lunar science of 30 kW. The current estimate places a 4-person closed system base at roughly 133 kW. Current literature states a fission reactor design is capable of producing 40 kWe and 175 kWth [2]. This thermal heating may be taken advantage of by our MSR design where a thermal efficiency of approximately 53% is required to fully power a 4-person lunar base. Similar literature reports requirements of an inital lunar base to be on the order of 100kW, with ISRU capable bases approaching requirements of 500 kW or more [3]. NASA has also become interested in ways to scale up an initial lunar base from ~100kW to upwards of 1MW [3].



Introduction

Nuclear power has become the most promisingcandidate to fulfill the power needs of a base on theMoon. Compared to nuclear options, Photovoltaicarrays require a larger amount of available energystorage. This is because the base would have toendure the 14-day lunar night without any solarpower generation.

$$q''_L = q''_s \frac{1AU}{r_L}$$



Power Flowchart Rationale

Text

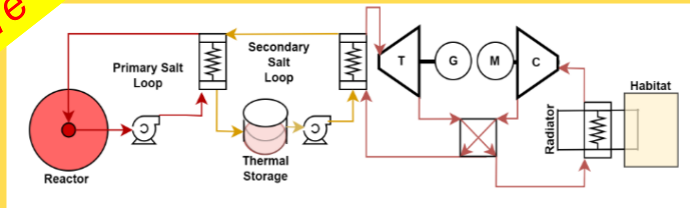


Image credit: NASA

South Pole-Aitken Basin

The most likely location for a lunar base is within the South Pole-Aitken Basin (SPA). This area is rich in rare-earth elements as well as craters that are never exposed to the sun and reach temperatures lower than 27K. Some of these dark craters hold water ice that could be mined and used as drinking water for the crew. The ice could also be made into H2 and O2 and used as rocket fuel. Outside of these dark craters, surface temperatures can reach as high as 394K during the lunar day and as low as 140K at night.

References

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[2] Oleson, S., and others. “A Deployable 40 kWe Lunar Fission Surface Power Concept.” Paper presented at the Nuclear and Emerging Technologies for Space (NETS-2022) meeting, Cleveland, OH, May 8-12, 2022. NASA Glenn Research Center, Cleveland, OH. NASA Technical Report 20220004670.

[3] Hickman, J. Mark, and others “Design Considerations for Lunar Base Photovoltaic Power Systems,” NASA Technical Memorandum NASA-TM-103642 (E-5823), prepared for the 21st Photovoltaic Specialists Conference (IEEE), Kissimmee, FL, May 21-25, 1990