Compact Fission Battery for Lunar Night Survival, J. C. Kennedy, B. T. Rearden, D. J. Rhodes, and A. J. Fallgren X Energy, LLC., 801 Thompson Ave., Rockville MD. 20852. (Contact: john.kennedy@x-energy.us)

X Energy, LLC (X-energy) presents a compact design concept for fission surface power (FSP) to support lunar exploration and prospecting throughout the lunar night and permanently shadowed regions (PSRs). The 1-10 kWe "fission battery" will support 24/7 operation of rovers and other equipment under the harsh thermal, illumination and plasma environments on the lunar surface. Its compact size and weight facilitate launch, landing and surface transport within the framework of existing aerospace technology.

The design is down scaled from a 40 kWe design presently being developed in a joint venture between Intuitive Machines and X-energy (IX), under NASA's FSP Phase 1 award. We open this presentation with an overview of the 40 kWe baseline design concept and related enabling technologies (e.g., X-energy's proprietary TRISO-X fuel), and discuss key differences in the smaller survive the night unit.

The 40 kWe baseline is designed to support sustained robotic and human activity for 10+ years of autonomous operation. We discuss how this pilot FSP design project, and its follow-on demonstration in Phase 2, will pave the way – in both the technical and regulatory sense – toward expanded nuclear power capabilities on the Moon and in space. The presentation addresses the planned site setup and application on the lunar surface, and touches into envisioned future integration into a lunar surface power grid. We also provide an overview of the supply chain developed for this effort, and the primary T/MRL challenges.

The survive the night fission battery, in the 1-10 kWe range, supports most planned near-term NASA activities, such as survive the night capabilities and exploration of PSRs. It applies to all upcoming uncrewed missions, as well as the early stage of upcoming crewed missions [1]. Its power system leverages well-established design concepts proven by NASA's successful Kilopower experiment. At this scale of size, power and technological maturity, it is feasible to develop a generic nuclear fission battery that could be duplicated as needed to support a variety of near-term lunar surface exploration missions. While the baseline design includes a limited degree of mobility (i.e., transferred from one site to another), this smaller unit could be integrated with a rover to travel across large distances, day or night, and facilitate prospecting for water and other volatiles, as well as potential structural material distributions in the lunar regolith. Such prospecting activities are considered the key to initializing sustained human activity on the lunar surface and are anticipated to continue well into the future as lunar activity transitions from scientific exploration to a hub of self-sustaining commercial endeavors. The compact structure also allows for easier launch under more mature lunar lander technology (e.g., Nova-C lander by Intuitive Machines). Lastly, we review the advantages of a controllable nuclear reactor system over the classic RTG approach, both of which compete for the ~1 kWe design space.

This presentation will conclude with an overview of the unique capabilities of X-energy's R&D team. A verified and validated Multiphysics tool suite and its expert users enable rapid de-sign prototyping for advanced nuclear systems. We discuss how these tools and related design processes support the fine balance between agile workflow and nuclear industry level quality (NQA-1). The high degree of computational fidelity allows X-energy to build confidence in the un-precedented level of autonomous operation in these first-of-a-kind space nuclear systems.

[1] D. M. Bushnell, R. W. Moses and S. H. Choi, Frontiers of Space Power and Energy, NASA/TM–20210016143 (2021).

[2] G. Sanders and J. Kleinhenz, In Situ Re-source Utilization (ISRU) Envisioned Future Pri-orities, ISRU Tech Review, Houston, TX (2022).

[3] J. Scott, NASA's Technology Priorities for Lunar Surface Power, Advanced Space Power Systems for Deep Space Exploration (2022).