LUNAR NIGHT SURVIVAL AND OPERATION UTILIZING COMMERCIAL RADIOISOTOPE HEATERS AND ELECTRIC GENERATORS. C. G. Morrison, Astro Nuclear Engineer USNC-Tech, c.morrison@usnc-tech.com

Introduction: Atomic batteries possess one million times the energy density of state-of-the-art chemical batteries and fossil fuels. Atomic batteries are enabling for locations that do not have access to the sun or other energy sources. Relevant use cases on the Moon include surviving the lunar night, exploring permanently shadowed regions, cave exploration and process heat for ISRU. USNC-Tech is maturing a patented (PCTUS2116982, PCTUS2116980) atomic battery technology and is actively engaging the government, science communities, commercial companies, regulatory agencies, and manufacturing partners to achieve a commercial product.

The challenges in production and the complexity of containing nuclear material have limited the application of atomic batteries. Traditional atomic battery solutions focus on the high-performance but expensive special nuclear material Plutonium-238. The cost, necessarily controlled nature, and limited supply of Pu-238 prevent widespread commercial use.

Atomic batteries are manufactured using natural non-radioactive precursor material embedded within an encapsulation material. The precursor material is then activated or "charged" inside a radiation source and packaged. This concept is known as a Chargeable Atomic Battery or CAB.

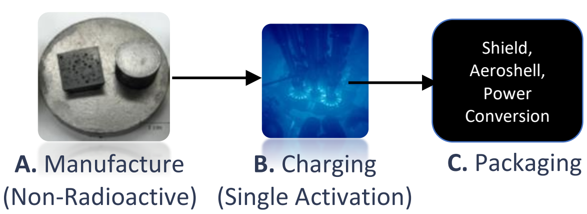

Fig 1. CAB Manufacturing Process

CABs can be manufactured in existing facilities and have a path toward a prototype using available technologies and facilities. For watt-scale batteries, the process can be demonstrated to a TRL of 6 with a ground demonstration and licensing in the next two years, focusing on a circa 2024 flight demo.

CAB Product: A CAB Unit is a cylindrical heterogeneous ceramic with an outer wall and a filling, as shown in Figure 2. The wall is composed of encapsulation material, and the filling is composed of an activation target material known as a precursor material. Multiple CAB units are integrated into a stack. The stack is integrated into a system that could include an x-ray shield, power conversion, thermal management, and aeroshell.

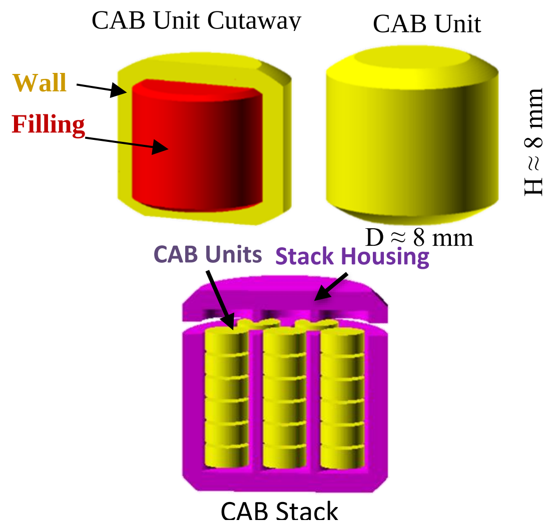

Fig 2. CAB Technology for a Lunar Heater

The encapsulation method is used with different types of isotopes. CAB units are tailored to meet the half-life, x-ray shielding, and power density needs of different science and commercial customers.

Table 1. Radioisotopes

Precursor	Radioisotope	Half-life [yr]
^{6}Li	^{3}H	12.3
^{169}Tm	^{170}Tm	129 days
^{59}Co	^{60}Co	5.7
^{151}Eu, ^{153}Eu	^{152}Eu, ^{154}Eu	11.0 (avg.)

Science Mission Applications: USNC-Tech is developing a 1 to 100 W modular thermal heater unit to enable lunar night survival for landers, rovers, and science payloads as soon as 2024. We are also evaluating electric power conversion options looking at 1 to 5 watt thermoelectric systems and 40-100 W electric Stirling systems. We want to engage with science customers at LEAG to determine needs within the science community for these ideas

Conclusions: CAB technology isn't as high performance as Pu-238. However, CAB technology can provide many of the same benefits. Interested parties are encouraged to reach out to the author.