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Options for Affordable Planetary Fission Surface Power Systems

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Nuclear fission systems could serve as "workhorse" power plants for the Vision for Space Exploration. In this context, the "workhorse" power plant is defined as a system that could provide power anywhere on the surface of the moon or Mars, land on the moon using a Robotic Lunar Exploration Program (RLEP)-developed lander, and would be a viable, affordable option once power requirements exceed that which can be provided by existing energy systems.

A primary impediment to the use of surface fission systems is perceived development cost. The assumption is that because a system is "nuclear", it must be inordinately expensive to develop and utilize.

It is true that high power, cutting edge nuclear systems and facilities are expensive. For example, the 400,000 kWt, sodium cooled Fast Flux Test Facility (FFTF) was capable of burning mixed actinide fuel and had elaborate experimental capabilities, including large in-core test positions and hot cells. The facility cost $3B (FY06) to complete. The Tennessee Valley Authority recently estimated that a single new terrestrial nuclear power plant (3,800,000 kWt / 1,371,000 kWe) would cost $2.2B (FY06) to complete. The high power, fast-spectrum Prometheus-1 NEP system for the prevoiously proposed Jupiter Icy Moons Orbiter mission was designed to use refractory metals, a new fuel/clad system, and have a 20 year life. Cost estimates for that power system exceeded $3B.

In contrast, the required thermal power for a surface fission system had been identified as <400 kWt, roughly 1/10,000th that of a terrestrial power plant. Surface fission systems of this type may not require use of refractory metals, and could be designed to have system operating environment similar to that of highly-developed terrestrial systems. Lifetime requirements could also be quite reasonable. Qualified fuel forms could be used.

A viable space reactor design must be safe and have adequate performance. Once those criteria are met, cost becomes the primary driver. This paper will discuss several attributes that could enable affordable surface fission power systems.

1. Design the system to fit on an RLEP-developed lander.
3. Use only well-characterized materials with irradiation databases; eliminate all refractory or exotic materials from the system.
4. Use fuel that is readily available or has been previously qualified.
5. Avoid extreme lifetime requirements.
6. Design the system to remain below the radiation damage threshold of materials.
7. Minimize the need for new nuclear infrastructure.
8. Use simple, robust radiation shield designs.

9. Design system to allow testing in operational US facilities (e.g. ATR, HFIR, ACRR).
10. Simplify instrumentation and control (self-regulation, lifetime).
11. Reduce system complexity.
12. Leverage off ongoing "balance-of-plant" development programs, e.g. Stirling engine development activities within NASA, industry and the DoD.