RADIOISOTOPE FUEL SELECTION STUDY FOR STELLAR NUCLEAR'S RHU

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MOTIVATION

Current Radioisotope Heater Units (RHUs) have relied on Pu-238, which is practically unavailable in Europe [1]. The primary European alternative, Am-241, suffers from low specific power and restricted production capacity [2] . To address this, **Stellar Nuclear is developing isotope-agnostic, composite-based heat sources.** This study evaluates alternative radioisotope fuel candidates for a new RHU prototype.

RADIOISOTOPE HEATER UNITS

Passive, autonomous heat sources utilizing radioisotope decay

Functional without direct solar exposure (night, eclipse, shadow)

Suitable for missions beyond the asteroid belt with low solar irradiance

Provide supplementary thermal regulation to protect temperature-sensitive components

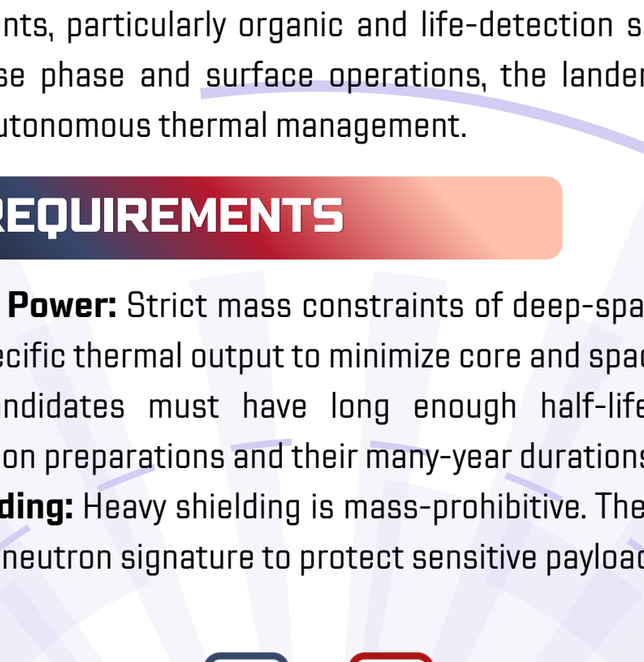


MISSION USE CASE: L4 ENCELADUS

Exploring Saturn's moon Enceladus (9.5 AU) involves a thermally hostile environment (below −200 °C) where solar power is non-viable. To protect sensitive scientific instruments, particularly organic and life-detection sensors, during the long-duration cruise phase and surface operations, the lander requires reliable, fully passive, and autonomous thermal management.

ISOTOPIC REQUIREMENTS

- **High Specific Power:** Strict mass constraints of deep-space landing systems require high specific thermal output to minimize core and spacecraft weight.
- **Longevity**: Candidates must have long enough half-lifes to accomodate prolonged mission preparations and their many-year durations.
- **Minimal Shielding:** Heavy shielding is mass-prohibitive. The fuel must exhibit a low gamma and neutron signature to protect sensitive payload electronics.



ISOTOPE ANALYSIS

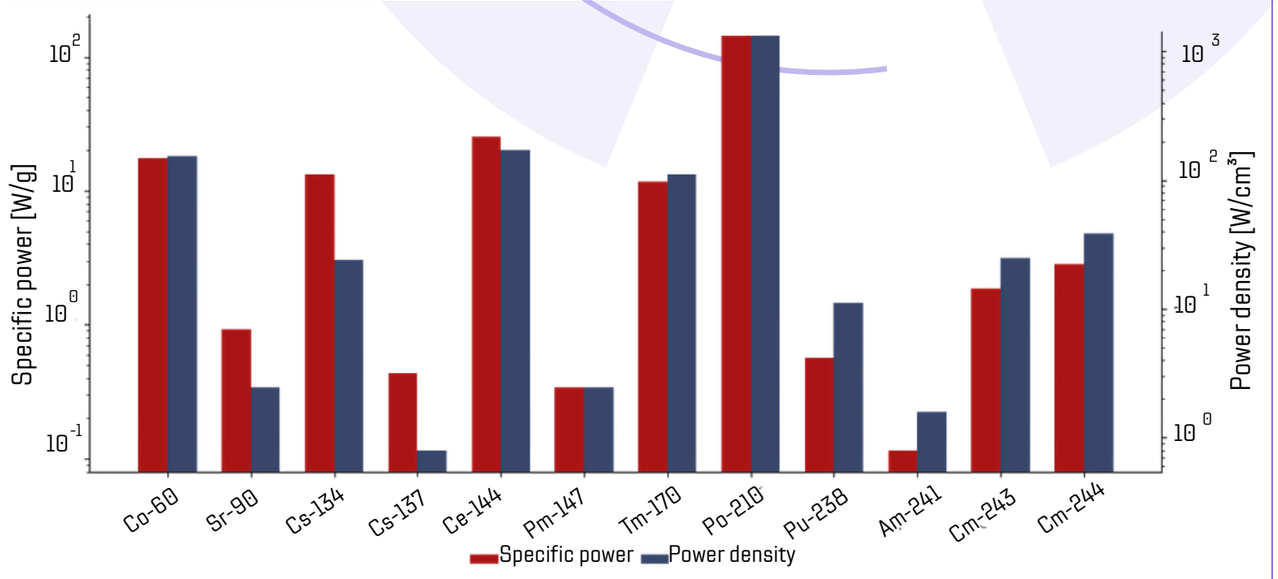


Figure 1. Theoretical Thermal Performance of Evaluated Candidates calculated with IAEA nuclear decay data [3].

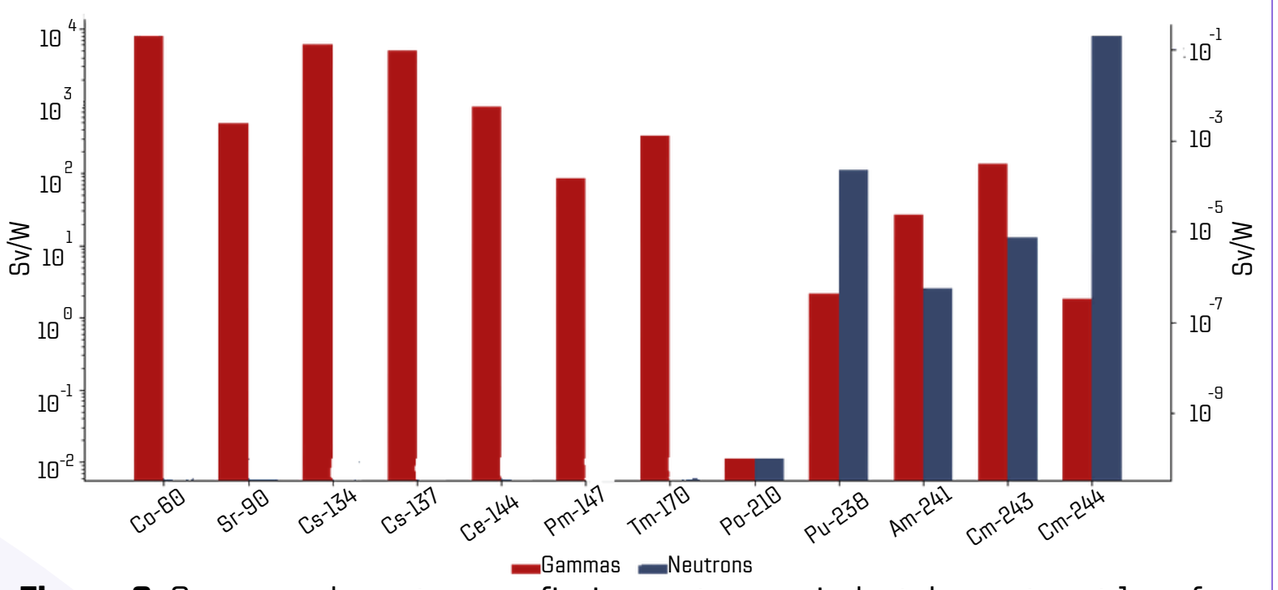


Figure 2. Gamma and spontaneous fission neutron equivalent dose rates at 1 cm from an unshielded point source (normalized to 1 W_{th}). Effective doses were calculated from SCALE/IAEA decay data using ICRP 119 conversion coefficients.

CONCLUSION AND FUTURE WORK

This study demonstrates that the European alternative fuel landscape extends significantly beyond Am-241. While Pu-238 remains the optimal baseline, Cm-243 ranks second overall, outperforming Am-241. Among beta emitters, only Sr-90 proves viable due to the prohibitive radiation profiles of others.

Future research will evaluate candidate production and supply chains before transitioning to system-level RHU modeling of total mass against net thermal output and analyzing the physical impacts of fuel chemical forms, pellet porosity, and (alpha, n) reactions.

Isotope	Power	Longevity	Radiation	Summary
Co-60	3	6	11	20
Sr-90	8	4	5	17
Cs-134	4	8	10	22
Cs-137	10	3	8	21
Ce-144	2	9	9	20
Pm-147	11	7	4	22
Tm-170	5	11	6	22
Po-210	1	10	7	18
Pu-238	9	2	1	12
Am-241	12	1	2	15
Cm-243	7	4	3	14
Cm-244	6	5	12	23

Isotopes are ranked from 1 (best) to 12 (worst). The 'Summary' column displays the sum of these three ranks, where the lowest total represents the most balanced and best-performing fuel overall.

REFERENCES

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[3] Livechart - Table of Nuclides - Nuclear structure and decay data [online]. IAEA, 2026. Available from: https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html

STELLAR NUCLEAR

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