National Aeronautics and Space Administration

NASA Radioisotope Power Systems Program

Next-Generation RTG Study: Summary 2017

NASAfacts

STUDY OBJECTIVE

Determine the characteristics of a new Radioisotope Thermoelectric Generator (RTG) that would "best" fulfill the needs of future mission concepts being studied by NASA's Planetary Science Division (PSD) into the 2030s, limited to systems that would use thermocouples to convert heat directly to electricity.

For this study, "best" is defined as the confluence of the following factors:

- An RTG that would be useful across the solar system
- An RTG that maximizes the types of potential missions that could be flown: flybys, orbiters, landers, rovers, boats, submersibles, and balloons
- An RTG that has a reasonable development risk and timeline
- An RTG with a value returned to NASA—in terms of significance, worth, and usefulness—that merits a new investment, as compared with retaining existing baseline systems such as the Multi-Mission RTG (MMRTG)

STUDY TEAM

The Next-Gen RTG Study included team members and mission study input from NASA Glenn Research Center, the NASA Jet Propulsion Laboratory, NASA Goddard Space Flight Center, the Johns Hopkins University Applied Physics Laboratory, the Department of Energy, and the University of Dayton Research Institute.

The study team considered and compared 249 solar system mission concepts to 63 different targets, 309 concepts for existing or future RTGs, and 67 candidate thermoelectric materials (38 n-type and 29 p-type), arrayed into 21 possible thermocouple configurations.

KEY FINDINGS

From the numerous broad concepts for RTGs that were studied, three system design concepts for a Next-Generation RTG were recommended for further study and optimization: a Segmented-Modular RTG (SMRTG), a Segmented RTG (SRTG), and a Hybrid-Segmented RTG (HSMRTG), in that order of priority.

The SRTG and SMRTG would operate only in the vacuum of space; the HSMRTG could operate in a planetary atmosphere, such as on Saturn's moon Titan, making it more complex and thus riskier to develop.

The electrical power output of these conceptual systems ranges from 50-500 watts of electricity by utilizing between two to 16 GPHS modules at their core; such a power output range covers both small and large mission concepts, including NASA's Discovery, New Frontiers and Flagship-class missions. Only one version of the SRTG is envisioned, producing between 400-500 W, depending on design choices.

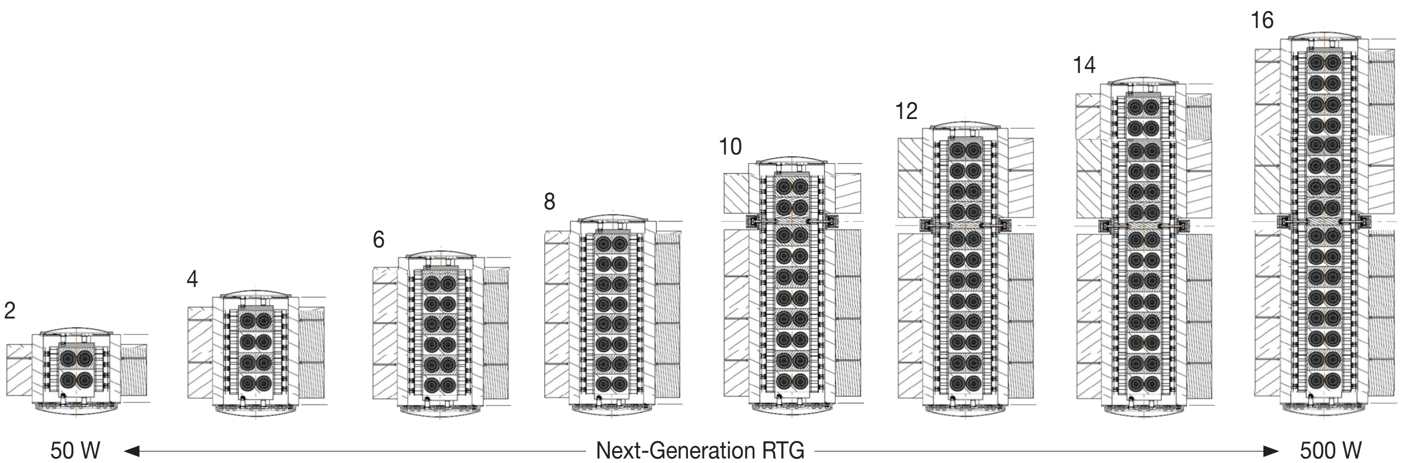
A wide-ranging screening process found that there are at least eight configurations of candidate materials for next-generation thermoelectric couples that are promising enough to merit potential development of a new RTG concept.

Two of the eight top-ranked thermocouples have one element, while two have two segments each, and four have three segments. Given their significantly greater efficiency, these eight varieties of thermoelectric couples have the potential to deliver an RTG with a similar amount of power as the retired General Purpose Heat Source (GPHS)-RTG, ~285 watts, using less than half as much radioisotope fuel (~44 percent).

The eight recommended thermocouple configurations offer predicted efficiencies that range from 11.3–16.5%, the flexibility of operating in a vacuum or argon cover gas environment, desirable sublimation rates below 10^{-6} grams/centimeters^2/hour, and a less than 10% mismatch in the coefficient of thermal expansion between the individual segmented materials (for six of the eight).

The study also produced a set of more than 30 draft technical requirements for the Next-Gen RTG concepts (including performance requirements, physical and structural requirements, and environmental requirements), and it identifies key issues that should be resolved before proceeding, such as the possible need to accommodate a pressure vessel for future "melt probe" mission concepts to explore beneath the ice on Ocean Worlds.

NASA intends to refine the requirements for the RTG concepts through engineering trade studies by the participating NASA centers, DOE, and its national laboratories; to continue to mature the thermoelectric materials and related technologies; and, to work with DOE to seek industrial partners for them to build a system that would meet NASA's requirements, so that a qualified design would be available for flight by 2028.



The Next-Generation RTG study recommends a modular configuration packaged as up to eight variants that would be sized to house between two and 16 GPHS modules as the RTGs heat source. The largest of these concepts would produce at least 400 watts of electricity, would degrade at only ~1.9% per year (leading to significantly higher end-of-mission power), and would weigh less than 132 pounds (60 kilograms).

For more information, visit **rps.nasa.gov**