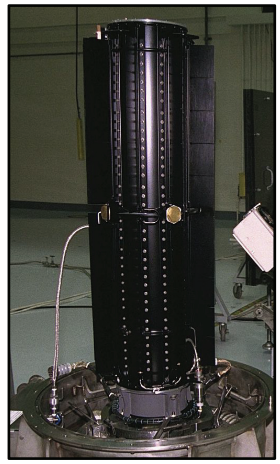
National Aeronautics and
Space Administration

NASAfacts

Next Generation Radioisotope Thermoelectric Generators

Radioisotope Power Systems (RPS) have been a trusted source of safe, reliable, long-lived electrical power and heat for space exploration missions bound for destinations across the solar system—and beyond—for more than six decades.



GPHS-RTG for Cassini.
Credit: NASA

NASA missions have used several generations of RPS, developed and built by the U.S. Department of Energy (DOE), to meet their scientific and operational needs. Most of these missions flew various evolutions of Radioisotope Thermoelectric Generators (RTGs). This type of space nuclear power system converts heat into electricity without using moving parts.

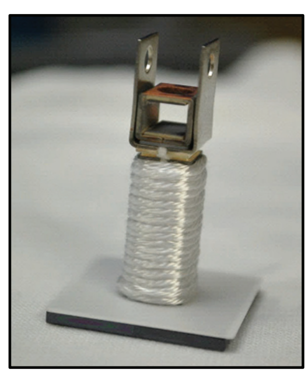
Recent science mission concept studies of long-duration voyages, to challenging space environments such as the outer solar system, have identified a clear need for higher power levels than what can be easily provided by the current flight system, the Multi-Mission RTG (MMRTG), that is providing power for NASA's Curiosity and Perseverance rovers on Mars.

To meet this future demand, the NASA-DOE RPS Program has initiated a project to revive and revitalize the General Purpose Heat Source-RTG (GPHS-RTG) used with great success by missions such as Galileo to Jupiter, Cassini to Saturn, and New Horizons to Pluto and the Kuiper Belt.

Known as the Next Generation RTG, this power system builds upon the successful technical heritage of the GPHS-RTG and provides more than twice the power of an MMRTG (an estimated 245 watts electric per unit), with a significantly slower power degradation over time, thus providing more energy at the end of a long cruise to Uranus or Neptune, for example.

Applying Proven Materials

RTGs produce power by converting heat from the natural decay of radioisotope materials into electricity. Each RTG consists of two major elements: a heat source that contains the plutonium dioxide fuel (which consists mostly of plutonium-238), and solid-state thermocouples that convert the plutonium's decay heat energy into electricity.



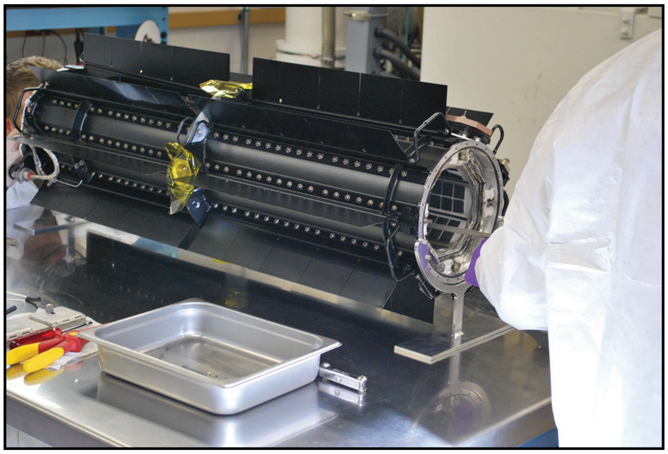
SiGe Unicouple.
Credits: DOE/INL

Conversion of heat directly into electricity is a scientific principle discovered two centuries ago. German scientist Thomas Johann Seebeck observed that an electric voltage is produced when two dissimilar, electrically conductive materials are joined in a closed circuit and the two junctions are kept at different temperatures. Such pairs of junctions are called thermoelectric couples (or thermocouples).

The Next Gen RTG will employ heritage Silicon Germanium (SiGe) unicouples using a design that was successfully utilized in the Multi-Hundred Watt-RTG (MHW-RTG) that has operated for more than 45 years aboard Voyager 1 and 2, as well as the GPHS-RTGs flown by Galileo, Ulysses, Cassini, and New Horizons.

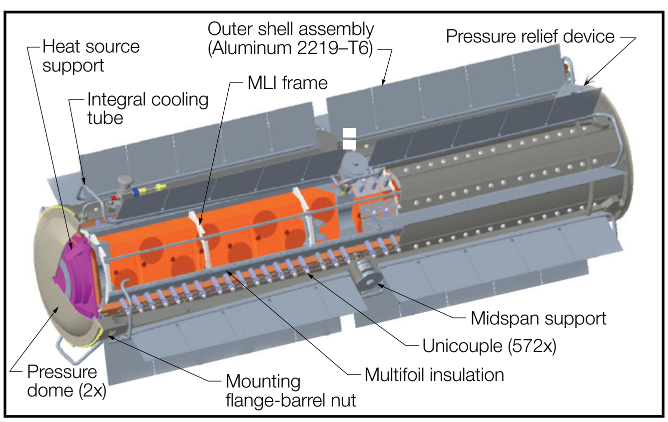
An Evolutionary Production Process

To support expected mission needs, the Next Gen RTG project will deliver three variants of RTGs. The first variant, known as Mod 0 ("mod zero"), is an in-depth refurbishment of a single legacy GPHS-RTG unit. This effort leverages "off-the-shelf" hardware to provide a flight unit ready for mission use prior to the delivery of new Next Gen RTG flight hardware (Mod 1). The Mod 0 unit will provide GPHS-RTG-like power—estimated at 290 Watts electric—based on the use of 18 legacy GPHS modules dependent on mission conditions



Next Gen RTG Mod-0 Inspection. *Credits: DOE/INL*

Next Gen RTG Mod 1 will be a build-to-print reproduction of the GPHS-RTG with minimal modifications required for the use of 16 GPHS modules, and replacement of obsolete components. NASA's Glenn Research Center and DOE's Idaho National Laboratory, with Aerojet Rocketdyne as an industry partner, will deliver a Mod 1 flight unit in the 2030 timeframe. Next Gen Mod 1 will require restart of the SiGe unicouple production line. In addition, the manufacturing capability to produce the Multi-Layer Insulation (MLI) package together with overall system assembly will be re-established.



Next-Gen RTG Mod 1 Concept. *Credit:Aerojet Rocketdyne*

System Performance

Designed for operation in the vacuum of space, the Next Gen RTG Mod 1 contains a total of 21.2 pounds (9.6 kilograms) of plutonium dioxide fuel, which initially provides approximately about 245 watts of electricity from 4,000 watts of thermal power when exposed to deep-space environments. Mod 1 will be about 16.6 inches (42.2 centimeters) in diameter (fin-tip to fin-tip) by 44.9 inches (114 centimeters) tall, with a mass of about 122.8 pounds (55.7 kilograms).

Number of GPHS modules	16
Thermoelectric material	SiGe unicouple
Number of thermocouples	572
Beginning of life power (watts)	245
Estimated end-of-design life power (watts)* at 17 years	177
Beginning-of-life (BOL) system efficiency	6%
BOL specific power (watts/kilogram)	4.4
Load voltage (volts)	30
Mission usage	Space vacuum
*Design life includes three years of fueled storage before launch	

Enhanced Power to Explore

In parallel with this Mod 1 generator production, the RPS Program will conduct a technology maturation effort to increase the efficiency of the RTG thermoelectric couples. Once the higher efficiency technology design has matured sufficiently for flight qualification, it could be integrated into the Next Gen RTG Mod 1 design to increase overall Next Gen RTG power performance.

By building upon the historic design heritage and demonstrated performance of the GPHS-RTG, the Next Gen RTG will continue to provide NASA with the power to explore for decades more to come.

For more information about radioisotope power systems, visit **rps.nasa.gov** or write to **NASA-RPS@mail.nasa.gov**.