# Space Fission Reactor Power Systems
## *The Technology and Applications*

February 2003

In addition to developing advanced technologies that can be used to meet future national energy needs here on Earth, the U.S. Department of Energy (DOE) also works cooperatively with the National Aeronautics and Space Administration (NASA) to develop advanced energy technologies to support space exploration in the 21st century. Nuclear energy systems, including both radioisotope and fission systems, are attractive for space applications in that they are long-lived, operate independently of sunlight, and can perform in the harsh environments of space. This fact sheet provides a brief introduction to the characteristics of fission power systems and a look at some of the future applications they potentially could support.

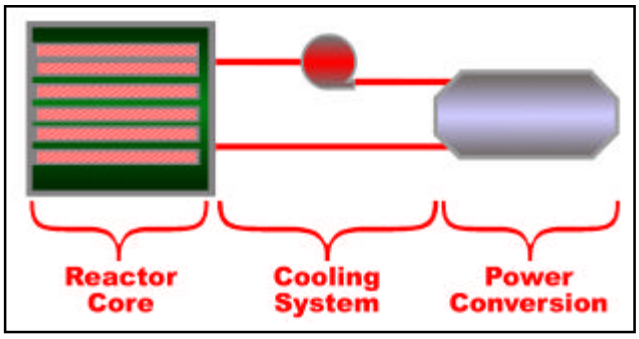
### What is a Space Fission Power System?

A space fission power system is a device designed and engineered to generate power for space applications using a reactor to fission, or split, uranium atoms. During the fission process, a neutron strikes a uranium atom, causing it to release energy as it splits into smaller atoms, called fission products. The released thermal energy (heat) is then converted into electricity through a conversion system to power the spacecraft. This fission process can be sustained and controlled to provide power at needed levels in a continuous manner in a reactor system.

Space reactors are designed differently than terrestrial reactors. They are much smaller (typically on the order of 10,000 times smaller for near-term space applications). They also are designed to remain in a "cold", inactive state until arriving at a designated startup location in space and receiving a command signal to initiate operation, a design feature that would enhance system launch and operations safety. For more information on safety of these systems, please see the related fact sheet "Space Fission Reactor Systems: Their Use and Safety."

### How does a Space Fission Power System Work?

Space fission reactor systems generate thermal (i.e., heat) energy. This heat will be converted into electricity for various uses. Although the design of a space fission power system is complicated, the basic theory on which it operates is fairly simple. To generate electrical power, there are only three basic subsystems: (1) a controlled fission reactor core to produce heat, (2) a cooling loop that removes the heat from the core, and (3) a power conversion subsystem that receives the heat from the cooling loop and converts a portion of it into




*Subsytems of a Fission Power Reactor Unit*

electrical power. The reactor itself can be built using different forms of uranium fuel arranged in a geometric configuration that depends on the control system for the reactor. Similarly, gases or liquid metals can be used as the coolant to flow through the reactor core and remove heat (unlike reactor systems on Earth, water cannot be used as a coolant). Different power conversion technologies can be used to convert the heat into power. Since all the heat energy is not converted into electricity, radiators are used to remove the excess thermal energy into space. A radiation shield is used to protect electronics and other sensitive equipment from radiation emitted from the reactor during operation. In the final design, the specific combination of technologies will depend on their compatibility and requirements placed on the system.

## For Which Space Exploration Applications Can Space Fission Power Systems be Used?

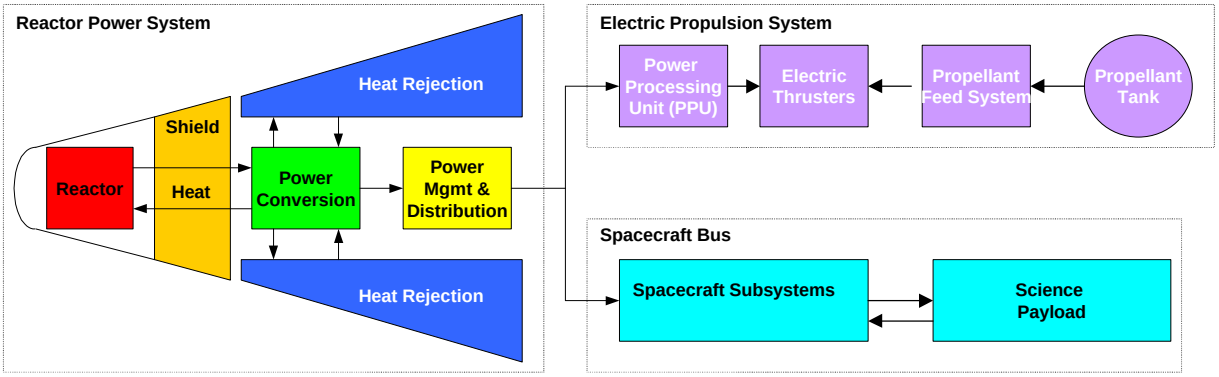
Although space fission reactors are significantly smaller than those used on Earth, they can still be used to generate abundant power in space. Space fission systems would be ideal for exploration missions requiring higher power than currently available, on the order of many kilowatts of electricity and up, where other energy systems cannot be used or are not adequately effective. Additionally, nuclear fission power for spacecraft would allow a change in approach to outer Solar System exploration by making it possible to: (1) propel spacecraft directly to the planets in ways not possible today, and perform orbital maneuvers once there; and (2) provide ample electrical power to operate advanced scientific instruments and transmit the resulting data to Earth. This new technology would enable multi-destination missions capable of entering into orbit around one body, conducting observations, and then departing to a new destination on a voyage of exploration which could last many years. These systems could also provide a sustained, power-rich environment for robotic exploration missions on other planets. Ultimately, space fission systems could be used to provide transport for and sustain life during human exploration missions that might take place in the 21st century.

## How Can a Space Fission Power System be Used to Provide Propulsion?

Space fission power systems can be used as the power source to provide large amounts of electricity for electric propulsion systems, or the heat generated by the fission process can be used directly to heat a propellant and create thrust. The first application is typically called nuclear electric propulsion (NEP), and the second, nuclear thermal propulsion. NEP systems, NASA's current design focus, do not produce much thrust over a short time period, but are extremely efficient when it comes to using the propellant. Consequently, fission propulsion systems can provide thrust over an extremely long time period. The propellant atoms are ionized, or stripped of electrons, using the electricity produced by the fission power system. Because these electron-stripped atoms, called ions, have a positive electric charge, they can be accelerated by magnetic or electrified grids out the exhaust of this ion engine at very high exhaust velocities. This highly efficient propulsion system is the key to travel across the vast distances of the Solar System.

## Space Fission Power Systems—Energy for 21st Century Space Exploration

Space fission power systems are capable of providing the energy needed to support 21st century space exploration. NASA and the Department of Energy are committed to providing safe, reliable nuclear power technology to enable and enhance the peaceful exploration of the Solar System.




*Components of a Nuclear Electric Power and Propulsion System*

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