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Methods of energy production in space

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In order to maintain a spacecraft in a working condition, it needs electricity to keep it warm. Let alone all the power to run scientific instruments and the transmitters to send gathered data home. So, getting enough power in space is a big problem.

If on Earth the main sources of electricity production are made by huge coal and hydroelectric power plants, in space there are a number of restrictions. The main criteria for spaceships and spacecraft delivered by them, are the weight and dimensions. Today, solar panels, radioisotope thermoelectric generators and nuclear reactors are used for the energy production. Each of them has its benefits and drawbacks.

When it comes to using a satellite or a space probe on Earth's orbit, the preference is given to solar panels. For the reducing the cost of the spacecraft launching solar panels are used as it lighter and cheaper than nuclear reactors. The solar panel works by using photons from the Sun to knock electrons free from atoms. These electrons are harvested and provide electricity for a spacecraft to operate.

The situation is completely different for a lander on the planets' surface or probes sent to study the far reaches of the solar system and beyond. The problem is that when such scientific tools are moved off from the Sun, the amount of energy received by the solar panel decreases. This all due to the inverse square law, according to which the intensity I at any distance d is equal to the inverse square of that distance.

$$I = \frac{k}{d^2} \tag{1}$$

k - constant depends on the power of the source.

For example, both Voyager-1 and Voyager-2 are equipped with three radioisotope thermoelectric generators, which contains a small amount of slowly decaying Plutonium-238. While this process is occurring, released alpha-particles, bombard the surface of the container, heating it up, and this heat energy is converted into the electricity. As the amount of usable heat is steadily decreasing over time, the energy will not be enough to power up their transmitters any longer.

Space-based nuclear fission reactors are similar to those used down on the Earth to supply electricity. They use uranium-235 as a fuel for fission reaction, where the nucleus is split, releasing energy.

NASA in 2018 announced that they are working on a new space-based fission reactor technology called *Kilopower*. After ground tests of a new kind of such reactor it is known that it can supply 1000 watts of electrical energy for spacecraft, and up to 10000 watts for installation on the Moon, Mars or even for use in space stations on their orbits.

The reactor consists of an enriched uranium core that is undergoing fission decay. Heat pipes extend out from the reactor and connect to Sterling engines which convert the heat into electrical energy. The whole system is self-regulating. If the reactor overheats, the engines can draw off more power to cool it. If the temperature is too low, the core starts contacting, increasing the rate of fission again.

The next step is to conduct tests in a space. If all goes well, future Moon or Mars explorers will have all the power they need to survive on other worlds, run their science instruments, and transmit the results back home.

Each of those methods has its own implementation depending on the mission: for closed to Sun explorations usage of solar panels is more effective while nuclear power is better in other applications.

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