SPACE SOLAR POWER

Japan Looks for Bright Answers to Energy Needs

A massive solar array to beam energy back to Earth is still a dream, but feasibility studies are moving ahead on several continents

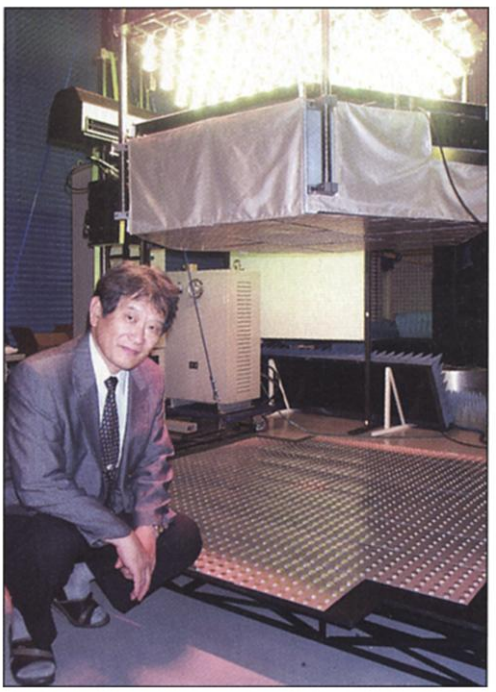
UJI, JAPAN—The bank of halogen lights mounted on a rack in a nondescript laboratory building here at Kyoto University isn't there to illuminate the room. Instead, it's part of a technology that space radio scientist Hiroshi Matsumoto believes will eventually light up the world. After years of neglect, the idea is also starting to shine more brightly in the eyes of government officials in Japan and elsewhere around the world.

Demonstrating the technology to a visiting reporter, Matsumoto switches on the light, which strikes an array of photovoltaic cells. The generated electricity is converted to microwaves, which are transmitted across a meter or so of air to collectors. They convert the energy back into electricity that powers up tiny light-emitting diodes. "The technology demonstrably works," says Matsumoto, who dreams of several square kilometers of solar panels in a geostationary orbit beaming back energy for use on Earth. Such a scheme, he says, "is the only way we can guarantee the energy needed to support a steady increase in living standards for the world's growing population."

This science fiction–like vision has been around for decades, and it enjoyed a brief day in the sun during the oil shortages of the 1970s. But it's only recently that the giggles of skeptical colleagues are being replaced by signs of respect—and money—from government agencies.

Japan's National Space Development Agency (NASDA) earlier this year commissioned two industrial groups to develop competing proposals for a space solar power test satellite that could be launched within this decade. "The agency and the aerospace industry are extremely interested in this project," says Masahiro Mori, NASDA's space solar program manager. Japan's Ministry of Economy, Trade, and Industry (METI) is separately funding a study of a commercial space solar power plant that is expected to trigger additional funding. "We consider this a possible future energy option," says Junya Nishimoto of METI's space industries office. And this year Matsumoto received $3.5 million from the Ministry of Education, Culture, Sports, Science and Technology to build a facility to test microwave antennas and receivers. Matsumoto estimates that in the last decade Japan has spent $10 million to $20 million, not including salaries, on both wireless power transmission and space solar power.

Interest in space solar power is picking up in other countries as well. The French space agency, CNES, is watching the installation of the first operational wireless power transmission system on remote Réunion Island in the Indian Ocean for clues about its use as a power source for robots on Mars or the moon. In September, a committee of the U.S. National Research Council (NRC) said that a fledgling NASA program on space solar power deserves at least enough funding to do some serious research. "I am confident that with this positive peer review we will be able to move ahead with this research," says John Mankins, director of the NASA program, which has spent $22 million in the past 2 years.



Powerful idea. Hiroshi Matsumoto has built a prototype of an orbiting solar power system in his laboratory at Kyoto University.

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Some doubt that space solar power will ever prove economically competitive for terrestrial use. "The tasks are formidable, and [at present] it's not clear that you can identify a path that you know will solve the technology problems," says Richard Schwartz, an electrical engineer and dean of engineering at Purdue University in West Lafayette, Indiana, who chaired the NRC panel. Schwartz, who remains neutral on the question of putting a solar power plant in space, nevertheless believes that an increased investment could bolster work on photovoltaics, robotics, and wireless power transmission.

The concept of generating power from space goes back to Nikola Tesla, who in 1899 tried unsuccessfully to illuminate isolated homes by beaming energy from a tower set up in Colorado Springs, Colorado. In the 1960s, William Brown, an engineer at Raytheon Co., powered a small helicopter hovering above a transmitting array, and Peter Glaser, a mechanical engineer in Boston, proposed the idea of space-based solar arrays beaming energy to Earth (*Science*, 22 November 1968, p. 857). Since then, scientists have tried to show that the physical constraints are not insurmountable. In 1983 and again in 1993, Japan's Institute of Space and Astronautical Science transmitted microwave beams from one rocket to another, confirming that atmospheric scattering is negligible. It has also been shown that microwaves below 10 gigahertz suffer minimal damping from atmospheric water vapor.

Although the NRC committee agrees with Matsumoto that the basic concept has been proven, it noted that "providing space solar power for commercially competitive terrestrial electric power will require breakthrough advances in a number of technologies." There's also the problem of getting the necessary equipment into space. Both NASA and NASDA have programs to develop low-cost launch technologies based on either reusable rockets or inexpensive expendable rockets. Both will probably be needed to build a workable power grid: The NRC committee estimates that it would take 1000 space shuttle payloads to deliver the necessary material, an order of magnitude more than the number of missions needed to construct the international space station. Without breakthroughs in launching technology, space solar power "would be impractical and uneconomical for the generation of terrestrial base load power due to the high cost and mass of the components and construction," the NRC report concludes.

But enthusiasts see that long list of challenges as a rallying cry, not a signal to retreat. "It may take 2000 years, but humans are destined to civilize space," says Matsumoto, who also chairs NASDA's space solar power advisory committee and is an adviser to the METI program. "And this will be one of the enabling technologies."

–DENNIS NORMILE