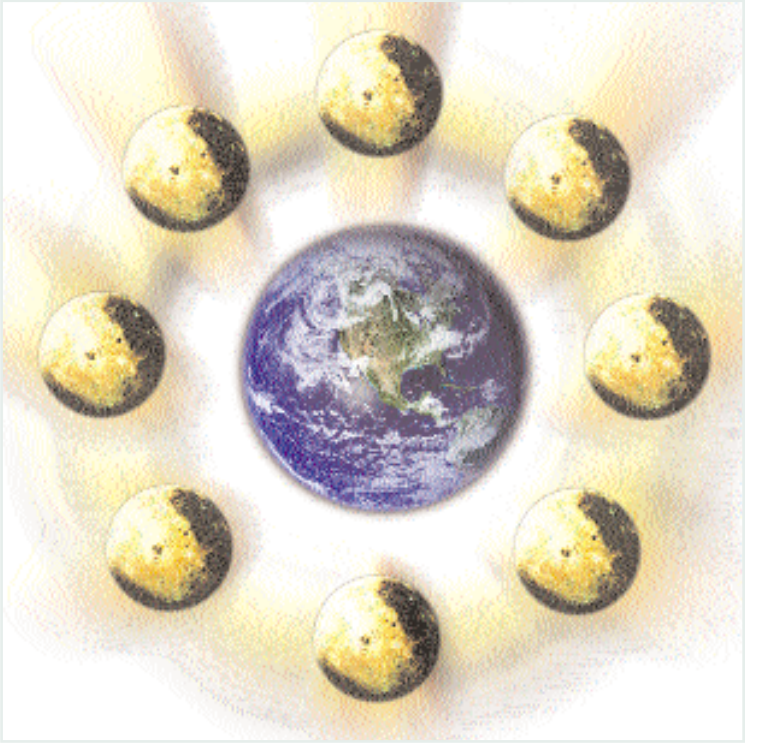
Return to the Moon

"Solar Power via the Moon," which described my proposed Lunar Solar Power (LSP) System, has generated considerable interest since its publication in *The Industrial Physicist* (April/May 2002, pp. 12–15). The article was downloaded more than 18,000 times from the magazine's Web site through late June. Eureka Alert, another Web site, reported more than 5,000 downloads through early June of the American Institute of Physics press release about the article. The Web site for Environmental Data Interactive reported 1,000 downloads of its news article by early May, a record for that site. In all, more than 30 news publications and Web sites reported the LSP article, and by early June, I had received 31 detailed e-mails requesting information, 24 of which expressed support and 7 of which raised concerns. This reply focuses on answering the concerns expressed in those communications.



Steven R. Black/NASA Goddard Space Flight Center

Will the microwave beams "cook" humans and animals?

No. This common concern arises from the everyday use of microwave ovens. Microwave power in an oven has five times or more the intensity of noon sunlight. Power beams can operate at, or less than, one-fifth of the intensity of sunlight or 4% of the intensity in a microwave oven. In addition, the tightly confined beams are directed to receivers, termed rectennas, erected several meters above restricted and fenced industrial zones. Beams can be turned off in a few seconds for unusual conditions. Outside the fenced area and under the rectennas, the microwave intensity will be far less than that allowed for continuous exposure of the general population. Some electronics in the next generation of airplanes and satellites will have to be modified for routine passage through the beams. Passengers and crew in a metal aircraft will be isolated from the direct beams by the craft's fuselage.

Will the tremendous power introduced into the biosphere and atmosphere by the Lunar Solar Power System cause any environmental damage?

No. Unlike any other large-scale terrestrial power system, LSP can be environmentally neutral. Its electric power will be distributed to industry and consumers, and the waste heat will radiate back to space. One-tenth of that level of waste heat will be released into the atmosphere above the thousands of rectennas. Rectenna waste heat can be canceled over the course of the year by painting a portion of each rectenna white and reflecting back to space an equal flow of sunlight.

Is it possible that the power beams might be turned into weapons?

LSP offers much higher levels of safety than current or projected power systems. Each lunar-based LSP transmitter consists of hundreds of thousands of individual subtransmitters, control circuitry, and reflectors. There can be many quick off-switches on the lunar solar arrays and transmitters, as well as the relay satellites. Beams can be designed to limit the maximum intensity at Earth to ensure that this safety feature cannot be overridden. Control systems also can be designed to feed power only to receivers on Earth that provide guide beams. If the control system fails, the power beam disappears, and negligible power would reach Earth.

Local distribution is a major part of our residential electric bill; how can the LSP System provide lower-cost power?

Household electricity is only a fraction of the total energy (fuels and electricity) used each year. Other indirect energy costs that we pay include the machines that provide energy, the energy needed for our products and services, health and environmental remediation, energy stability, security, and defense. The wholesale price of LSP power to the regional grid can be less than \$0.01/kW·h and could decrease over time. By 2050, this low-cost energy could support most industrial and commercial activities at a third of the cost, or less, of existing thermal-power systems.

Why is the LSP System not operating now? Why are not other nations and companies developing the LSP System?

In its coverage of "Solar Power via the Moon," *National Geographic*'s news Web site interviewed lunar geologist Paul Lowman of the National Aeronautics and Space Administration (NASA). "In principle, it [the LSP System] is perfectly feasible, but the problem is cost," he said. "Criswell's project will need a lot of people up there, and that will be expensive. As far as NASA is con-

cerned, the moon has been scratched off. Scientists' interests have shifted to astrobiology, life on Mars, Europa. Only if carbon dioxide is shown to be escalating global warming will there be pressure to move energy production to the moon." Former astronaut and retired senator John Glenn responded, "Right now we have trouble funding the International Space Station (ISS), with all of its important research projects. To go back to the moon, establish and keep viable bases for power generation, would be a very, very expensive operation. I would rather see more funding to support ISS."

U.S. space programs expend approximately $25 billion annually. A demonstration LSP could be operating within 10 to 15 years for that amount of money and grow rapidly thereafter from commercial investments. All aspects of Earth's existing 14-TW global commercial power system account for approximately 10%, or $4,000 billion, of the annual gross world product. The economic development of 5 billion of Earth's 6 billion people is held back by the high cost of commercial energy. Contrast the statements by Lowman and Glenn to the following from the global-power community.

The 17th World Energy Congress in Houston in September 1998 concluded that "the number one priority in sustainable energy development today for all decisionmakers in all countries is to extend access to commercial energy services to the people who do not now have it and to those who will come into the world in the next two decades, largely in developing countries, without such access."

Maurice Strong, who organized the 1992 United Nations Rio de Janeiro environmental summit, later became chairman of Ontario Hydro, Canada's largest operator of nuclear power plants. In his 2000 book *Where on Earth are We Going?*, Strong says, "I have checked it [the LSP System] out with a number of experts, all of whom confirmed that the idea, which has been mooted for some time, may now be ripe to carry forward. The scale is awesome and the problems to be overcome are clearly daunting, but Criswell makes a persuasive case that it can be undertaken based on existing technology and the expertise acquired through the United States space program. The project would deliver net new energy to Earth that is independent of the biosphere, would produce no CO_2 nor any other polluting emissions, and have minimal environmental impact compared with other energy sources… It [the LSP System] offers a perpetual, nondepleting resource as long as the sun shines and the moon remains in place."

The following additional questions from readers are addressed in the references of my original article.

- Why collect power on the moon rather than on Earth or by satellites constructed in orbit about Earth?
- Why are fission, fusion, wind, and 21 other power options less attractive?
- Are there any examples of the key operating technologies, such as power beaming (yes–planetary radar), rectennas (yes–done in 1975), solar cells on the moon (yes), production of solar cells from lunarlike materials (yes), orbital redirectors (yes), and others?
- What are the key engineering and cost assumptions for the LSP System, the scale of the final system, design options, and the number of people required on the moon, in space, and on Earth?

The LSP System appears exotic to most people focused on developing large commercial power systems. However, ask each of these people the following vital questions, which they have previously avoided:

- How many terawatts of sustainable electric power can your system provide by 2050?
- How will your power system be likely to affect the natural and human-constructed environments?
- How much will your energy cost?
- Will your power system enable humankind to become independent of the biosphere of Earth and enable us to nurture that biosphere and all humans?

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