(The following article appeared in the October 1990 issue of *Ad Astra*, the official magazine of the National Space Society.
To return to The Space Settlement Institute website (www.space-settlement-institute.org), click *here*.
For more information about the origin of the Power Tower concept and the image used in the article, see the Midnight Sun *page*.)

BACK OF THE
ENVELOPE

Power Tower

By Alan Wasser

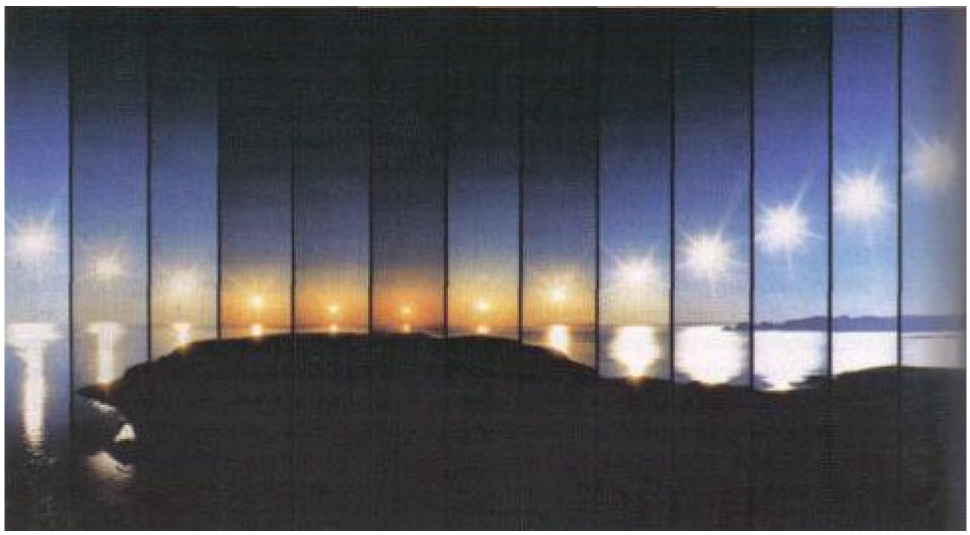
Now that there seems to be a consensus emerging that solar power satellites should be made primarily from lunar materials, the next question is: why not start with a solar power collection system on the Moon, and just beam back the power?

The primary answer has been that a solar power collector on the Moon could only be half as efficient as it would be in orbit, as it would be in darkness during the two-week lunar night. That answer turns out to have a very promising exception.

Earth-based assumptions may have kept us from realizing that there are two places on the Moon where sunlight is available almost all the time: above the lunar poles. Of course, a horizontal plain of lunar surface at a pole would get virtually no sunlight at all, but a tower of solar cells built on top of the highest hill at the pole would get perpetual sunlight except during lunar eclipses.

Over the course of a lunar day (approximately one Earth month), the Sun, while staying low in the sky, would seem to revolve all the way around a tower on a polar mountaintop, such as the rim of the Peary crater. If it were important to keep the same side facing the Sun, the tower would have to turn itself around once each month, but whether it turned or not, it would get continuous sunlight.

Images of the feeble "midnight Sun" around Earth's poles spring to mind—sunlight much too frail to be useful for solar power. But there is a crucial difference. On Earth, sunlight at or near the poles has been filtered and weakened by the long diagonal trip through Earth's thick atmosphere, while tropical sunlight has a much shorter atmospheric passage. But the Moon has no atmosphere, so even when the Sun just clears the lunar horizon, the sunlight over a lunar pole should be as strong as sunlight over the lunar equator. Even the seasonal effects produced by Earth's 23.5 degree axial tilt would be almost eliminated by the fact that the Moon's axial tilt is a scant 1.5 degrees.



A composite photograph of the midnight sun in Norway, taken every hour over the course of one summer day, is the best Earth analogy to the constant sunlight available at the lunar poles.

The question of which type of solar power collector to use at the lunar poles will require study. The first question is whether it can be designed to use radiation from any side, or must revolve to face the Sun. Most likely, the bulk of the tower would stand still while some small part revolved. The most obvious example is a giant tower covered with solar cells. Another option would be a tower of huge cylindrical lenses made of lunar glass, stacked end on end as high as possible, perhaps in multiple concentric stacks. The lenses would work together to focus the Sun's rays on a vertical tube-shaped collector in the central core, either a thermodynamic or solar cell.

Whatever method is eventually selected, the weak lunar gravity and absence of wind or earthquakes would make it possible to build a gigantic lunar polar solar power tower to a height that would be unthinkable on Earth.

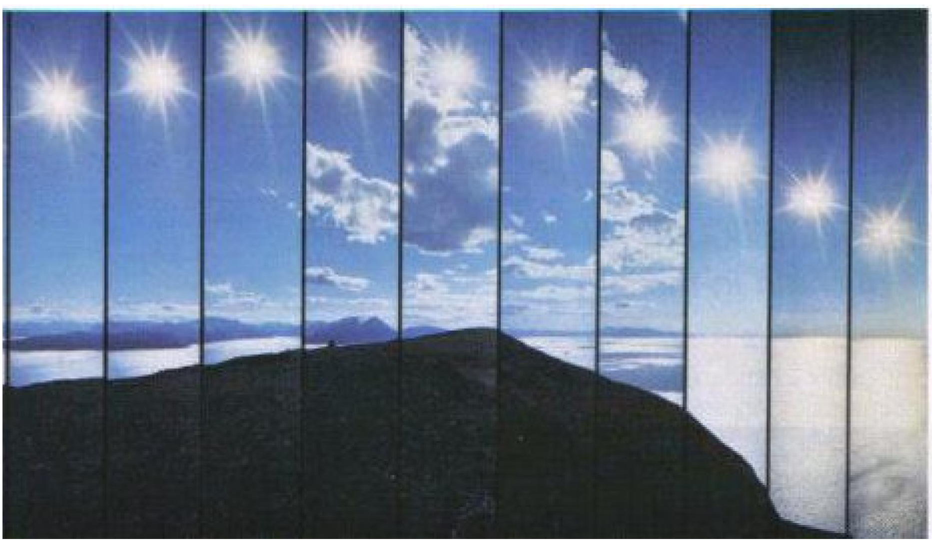
There are many advantages of collecting solar power on the Moon rather than in orbit. First is saving the cost of launching tons of materials from the Moon and, perhaps more of a problem, catching the material in space. The work of processing and construction would be easier in the low gravity of the lunar surface than in zero gravity. Even the problem of what to do with waste products is much easier on the Moon, as are the problems of housing and shielding workers.

How best to beam the power back to Earth is the area that will require the most additional study. In the *Report of the NASA Lunar Energy Enterprise Case Study Task Force, July 1989,* David Criswell of the University of California, San Diego, offers an interesting proposal. He suggests a phased array system of multiple low-intensity microwave beams from the sides of the Moon that would appear to merge into a single large synthetic aperture. The beams would converge, focused somewhat like a spotlight, and "each beam can be fully controlled in intensity across its cross-sectional area to a scale of a few hundred meters at Earth," efficiently delivering safe economical electrical power to Earth rectennas as small as 200 meters in diameter. Presumably, the Criswell system would work equally well if moved from the edges of the Moon to the top and bottom of the Moon. (Actually, transmitters aimed at the Earth should be located at least 7 degrees in toward the lunar equator from the poles to allow for the apparent tilting known as libration of latitude.)

Beaming the power back to Earth could be either direct or via relay satellites. Of course, the turning Earth would constantly present a different face to the lunar transmitters, necessitating multiple reception sites on Earth if direct transmission is used. While this could be a drawback, it would also have the economic benefit of allowing sale of the power to the highest bidder, worldwide.

Alternatively, or more likely in addition, the lunar transmitters could beam to a ring of relay satellites or microwave reflectors in high Earth orbit, allowing constant supply to a single point on Earth.

Of course, the polar towers can also supply beamed power via relay satellites in lunar orbits to installations elsewhere on the Moon, especially when they are in darkness. After the towers are operating, the industrial base that built them and the power they offer could be used for processing lunar materials for solar power satellites, helium-3 mining, mass-drivers, etc. In fact, lunar operations would almost certainly be the first beneficiaries of power from the towers, well before the beam to Earth is fully functional.



Incidentally, Criswell' s analysis of a lunar power system shows that it is very promising, even though he starts from the assumption that "a given lunar base is adequately illuminated only 13.25 of the 29.5 days of the lunar month" and therefore calls for "large mirrors" to be "placed in orbit about the Moon and oriented to reflect sunlight to the bases."

The lunar polar location would also be ideal for the humans who would operate the power towers. The high altitude polar locations would have the advantage of being the best places on the Moon for thermal stability, since they are the only places where there is sunlight and shade available all the time. A polar habitation, being continuously warmed on one side and cooled on the other (except for the brief period when it is in the shadow of the tower), could probably keep its inside at room temperature by means of its exterior coloration and some simple heat circulating scheme, rather than the elaborate, expensive and vulnerable air conditioning and heating equipment needed elsewhere on the Moon. The psychological benefits of avoiding two weeks of darkness are not insignificant either.

Conveniently located between the polar hills are valleys and crater bottoms that should be among the coldest places in the Solar System, as they never see any sunlight at all. There may well be frozen water or other volatiles in those valleys, and they may be useful in other ways, such as for super conductive power storage installations.

The polar sites even allow easy access to areas on the side of the Moon that is hidden from Earth, which might be valuable for many reasons, including astronomy and waste disposal.

Although multiple solar power collectors could be built on high ground within each lunar polar region, the highest would inevitably shade the lower ones once each month. That fact, and the many advantages of the poles, put a very big premium on being the first to claim the highest hilltops in the polar regions, and on discouraging others from moving in and building taller towers, shading yours.

As I write this, the Iraqi invasion of Kuwait and subsequent conflict in the Persian Gulf have caused world oil prices to surge, and the world' s dependence on oil is beginning to be felt as it hasn' t been since the 1970s. A recent report in *The New York Times* also notes that "Electricity use, up by 50 percent since the first oil crisis in 1973, will continue to grow strongly in the next few decades ... but the source of the new supplies is not clear, the experts say, given concern about environmental damage from fuel burning [and skepticism about] a rebirth of the nuclear industry."

It is clear that the world absolutely must have vast amounts of environmentally acceptable power soon, no matter what it costs, and solar power from space seems the only serious contender. The question is, who will build the power source and reap the incredible riches the world will pay for that power in the 21st century? ☙

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