Farming the sun's energy

Using large arrays of collectors to make electric power from the energy of sunlight begins to seem a practical possibility

by Dietrick E. Thomsen

Up to now the major direct use of solar energy has been the photosynthesis process of green plants. Man's major fuels come from deposits laid down by that process, and as everyone knows, the supply is running out. Everyone also knows that alternate power sources are needed. One now gaining new attention is the direct conversion of solar energy to power.

A large research and development effort is going into the application of nuclear fission and nuclear fusion to power needs. Fusion is still in the future. Fission is with us, but it is not proving as economical as some of its ardent supporters had hoped it would be. Meanwhile more and more scientists and engineers are beginning to believe that solar conversion will account for a significant portion of the world's future power needs.

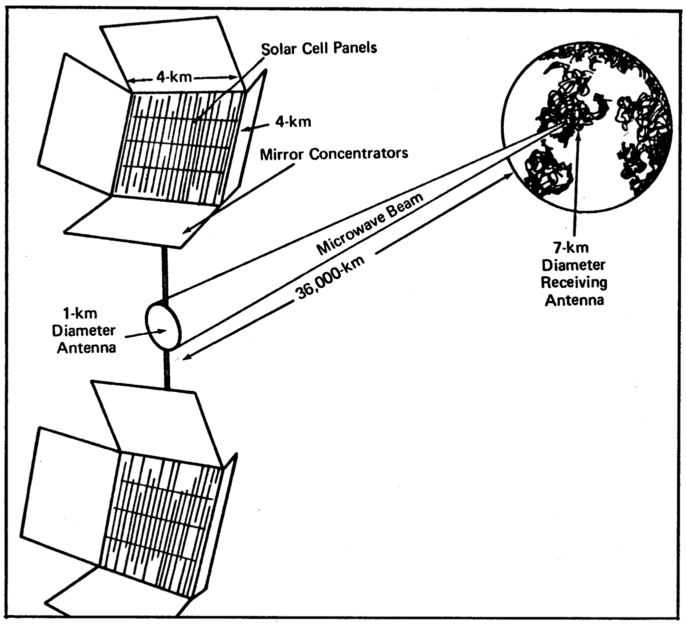
Solar energy received attention in President Nixon's energy message to Congress of June 4, 1971. As a result, a Solar Energy Panel was set up by the National Science Foundation and the National Aeronautics and Space Administration. The panel has solicited suggestions and comments on current work from researchers in the field and intends to digest the material into a report that it hopes to submit to the President through the Office of Science and Technology by early summer. Meanwhile, the NSF budget for solar conversion research, which stood at $1.4 million in fiscal year 1972, is raised to $4 million in the fiscal 1973 request.

The idea of using other and more efficient methods than that of the green plants to convert solar energy is not new. For a long time solar-energy conversion has had an obligatory place in "World of Tomorrow" brochures and comic books. The usual picture showed a glassy dwelling in a kind of bastard Bauhaus style with a handy-dandy home solar-energy unit mounted on the roof. This image led to an impression that solar energy was a small-unit operation suitable for underdeveloped countries with plenty of sunlight and not much else. There is little R&D capital in underdeveloped countries, and they are not yet very frantic for power, so there has not been any feeling of public urgency about the development of solar conversion.

What has changed the atmosphere lately is not only the fuel crunch in the developed countries but also the possibility of putting together large-scale units, solar-energy "farms" that would compete with power stations in the megawatt range and higher. There are proposals for building such collectors both on the ground and in orbit, and there has been a grant of money for a pilot demonstration.

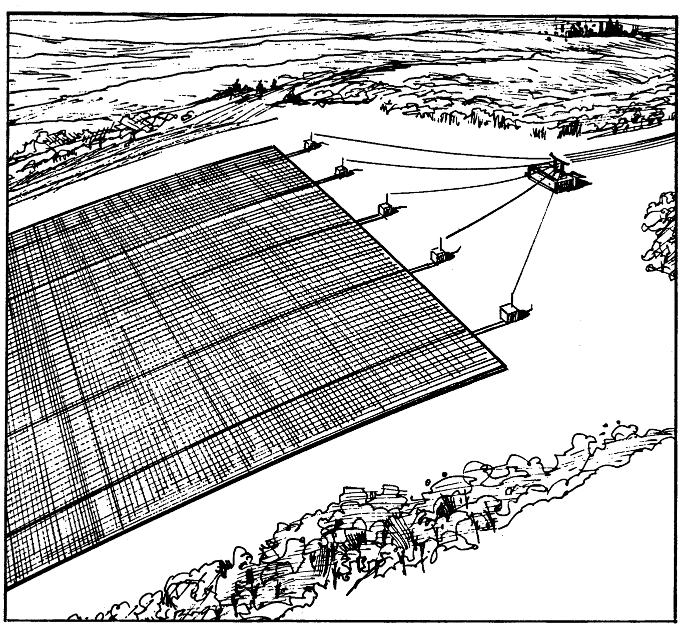
Basically there are two nonphotosynthetic ways to use solar energy: concentrate the rays and use them to heat something and eventually boil water to run a turbine or use the photovoltaic effect. The photovoltaic effect depends on the ability of certain crystals to generate an electrical potential, a voltage, that will drive a current when light shines on them.

The solar cells that NASA uses to power satellites are photovoltaic cells. Fabricating them, notes William R. Cherry of the Goddard Space Flight Center, is painstaking skilled handwork more like making jewelry than manufacturing a product. But satellite power requirements are low, and NASA can afford to pay heavily per kilowatt. Cherry estimates that oriented space solar arrays like the large Apollo Telescope Mount cost about $2 million per kilowatt. "It's still pretty much a space application," he says, "but I think it's going to change."



Arthur D. Little, Inc.

Conception of a 10,000-megawatt orbital power plant.



W. R. Cherry

A square-mile array of photovoltaic collectors.

To make feasible large solar units requires developing ways to mass produce the photovoltaic material. Cherry believes that this can be done, and that demand will stimulate the necessary development work. Similarly, he thinks demand will stimulate development of large hardy batteries to store part of the output so that the station could supply power steadily at night and on cloudy days.

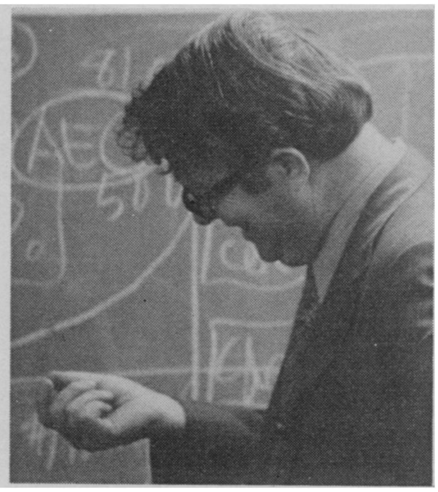
Given suitable economic developments Cherry figures the cost of construction and 20 years of operation of a one-square-mile station to be $100 million. If the plant were in the southwestern United States where the sun shines 70 percent of the daytime, it would generate at least 210 million kilowatt-hours per square mile per year. If the power were sold for three cents a kilowatt-hour (about twice today's rates), says Cherry, the gross return over 20 years would be $126 million.

A plant of this size would be feasible only in the Southwest. Around Washington, D.C., for example, there isn't enough sun. Still, in the East and other parts of the country Cherry believes that rooftop units would be possible as auxiliaries to public power systems. The rooftop installations would be especially useful, he thinks, in heating and cooling of buildings, activities that throw heavy peak loads on public power systems.

Related to this idea is the work of Maria Telkes at the University of Pennsylvania. She is developing heating and cooling units that use the heat of fusion of substances called eutectic salts to store heat or "cold" so that the unit can operate continuously at a steady power rate while responding to fluctuating demand for heat or cooling.

Heat of fusion is the heat the substance absorbs when it melts or emits when it solidifies. By mixing the proper substances, eutectic salts with various melting points in the range near room temperature can be made. To cool hot air one blows it over solid salt and melts the salt. To heat cold air, one blows it over molten salt and solidifies the salt. Connected with a rooftop solar plant or not, such a system could do much to lessen the load peaks that cause brownouts and failures. Telkes expects to have a demonstration house operating by summer 1973.

Some investigators are not very hopeful that mass production of photovoltaic materials will become economic and therefore see little future for rooftop collectors or large ones such as Cherry proposes. Prominent on this side are Aden Baker Meinel and Marjorie Pettit Meinel of the University of Arizona. Instead of photovoltaics they have been working on dark films that will optimally absorb the solar wave-

D. E. Thomsen

Marjorie and Aden Meinel propose boiling water with the heat of the sun.

lengths that are best for heating. They propose to coat pipes with these films. Above the pipes would be Fresnel lenses, devices similar to diffraction gratings that use diffractive effects to concentrate light on the coated pipe. A long array of this pipe, similar in geometry to Cherry's strips of photovoltaic material, would deliver a hot liquid, probably sodium, to boilers which would drive turbines.

One of the problems is to achieve a high enough operating temperature to be efficient and competitive with other power sources. This works out to be upward of 1,000 degrees F., but the Meinels think they can reach it. Another difficulty is that this kind of system, like all thermal systems, produces waste heat that could be a thermal-pollution problem. The Meinels do not propose to let the waste heat go; they would use it to desalinate water. "After all," says Marjorie Meinel, "the immediate problem in the Southwest isn't power, it's fresh water."

To critics who allege that they propose uneconomic uses of land, Cherry and the Meinels reply that the land they would use is either not now used or is used for low-yield activities such as grazing. Since the collectors would not cover the whole area but would be laid in strips, other activities could continue between the strips. "Navajo sheep could still graze," says Aden Meinel. And Cherry points out that the figures for his hypothetical station give a monetary yield of $2,000 per acre per year over 20 years. "Farm land yielding such a net return is considered premium."

In case the Navajo sheep still don't like it, Peter Glaser, director of research at Arthur D. Little, Inc., proposes putting the collecting station into synchronous orbit. The station would consist of a photovoltaic collector connected to a giant microwave antenna that would convert the power to microwaves and beam it to a receiving area on earth. This arrangement has two basic advantages, according to Glaser. First it would work continuously, doing away with the need to develop jumbo storage batteries. Only at the time of the equinoxes would it pass briefly into the earth's shadow. Second the collecting region on earth would not be geographically tied but could be located near places of maximum use, cutting down transmission problems. Reception of the microwaves would have to be spread over a small area because putting so much power into a narrow beam would heat the receiver intolerably.

The heating aspect of the microwaves leads some people to consider their use unwise, but Glaser does not anticipate serious problems. "I do not mean to suggest that you would want to live in the middle of the [receiving] area," he says, but he figures the flux density arriving at the center of the region would be only about twice the present solar maximum, and it would fall off to the sides. Nevertheless nothing could live there, and wasteland would have to be used: "Perhaps a strip-mined area," Glaser suggests.

The microwave technology needed is more or less already with us. The futuristic parts of Glaser's proposal are again mass production of photovoltaic material and the capability of building such a thing in space. That capability is not yet at hand, but, says Glaser, the proposed space shuttle is a first step toward it.

As the Solar Energy Panel works on a report that, proponents hope, will get the Government moving on an expanded program of R&D in the field, the solar-energy community, as they call it, seems to be infused with more optimism than has been seen there in many years. Even so, there are no claims that solar energy is a utopian solution to all the world's power needs, only a significant portion. The estimates given range up to about 20 percent. □