Solar Energy: A Feasible Source of Power?

Hopes for utilizing solar energy on a large scale have never materialized in the past. Recent discussions of how to meet growing national energy needs have focused on fission breeder reactors and fusion reactors as the best long-range replacements for fossil fuels and have usually dismissed solar energy altogether.* However, a new proposal for a solar energy system has been attracting considerable attention among Washington officials. The proposed system would capture the sun's energy extremely efficiently by means of specially coated collecting surfaces, which would be heated by the resulting super "greenhouse" effect to temperatures as high as 540°C; the heat energy would be collected and stored in a thermal reservoir, to which conventional steam boilers, turbines, and electrical generating equipment would be attached. Although several key questions remain to be answered, preliminary calculations indicate that such a system may well be technically and economically feasible.

The proposed new solar energy system was designed by two astronomers, Aden B. Meinel, director of the Optical Sciences Center of the University of Arizona at Tucson, and his wife, Marjorie. Their system, which would operate at much higher temperatures than those of earlier solar energy schemes, would attain a 25 to 30 percent overall efficiency of conversion of incident sunlight to electricity.

In the relatively cloudless deserts of the southwestern United States, the solar energy flux reaching the earth's surface averages about 0.8 kilowatt per square meter for the middle 6 to 8 hours of day during most of the year. An ordinary black surface absorbs most of this energy, but much is reemitted as thermal radiation. It is the spectral differences between the incident and reemitted radiation that makes efficient use of solar energy possible. The incident energy flux has a maximum at a wavelength of about 0.5 micrometer, near the center of the visible region—0.4 to 0.7 micrometer—but the flux decreases rapidly toward the red end of the spectrum. The thermal reemission is mostly in the infrared with a peak near 5 micrometers at the temperatures envisioned for the collecting system. Hence highly selective coatings that are black in the visible and are poor emitters in the infrared are able to absorb essentially all of the incident sunlight but give off almost nothing.

There appear to be many ways of making suitable coatings from layers of thin films deposited on a steel collecting surface by evaporation techniques. One type of coating developed recently by Bernard Seraphin at the University of Arizona depends on the intrinsic properties of materials. An example of this type of coating consists of a semiconductor material that is opaque to visible light but transparent to infrared; underneath the semiconductor layer would be another layer of a material, such as gold, which has a very low emissivity in the infrared. Because of the transparency of the semiconductor to infrared radiation, the composite coating would act like a mirror—a desirable property because high reflectivity corresponds to low emissivity—in the infrared.

Other more sophisticated coatings involve interference phenomena. Layers of a metal and of a completely transparent material, such as quartz, can be alternated with thicknesses adjusted to the wavelength of the reflected light, so that the coating absorbs visible light well but is a good mirror in the infrared or ultraviolet.

The collecting surfaces in the proposed system would be enclosed in a vacuum to eliminate convective cooling. Liquid sodium would be pumped through channels in the steel to transport the heat to a tank containing a eutectic mixture of molten salts, which, like a giant water-ice system, can maintain a constant temperature over a wide range of energy storage. The molten salt system would provide a reservoir from which energy could be drawn by the steam turbine as required, so that operation overnight and for short periods of cloudy weather would be possible. According to the Meinels' estimates, about 8 square kilometers of collecting surface and a 50-million-liter thermal storage tank would be required for the equivalent of a 1000-megawatt generating plant— a size comparable to nuclear power plants being built today. The largest question as to the technical feasibility of the proposed system appears to concern the durability of the thin film coatings.

Solar energy systems have no fuel costs, but they require higher initial investments in equipment than do other energy systems. In addition, the cost of manufacturing thin film coatings on a large scale has always been prohibitive in the past, because of the high vacuum and large currents required. Recently, however, large continuous evaporators have become available and are now used to coat such products as architectural glass. If a commitment were made to utilize solar energy on a sufficient scale, so that a large manufacturing plant could be built to produce the collecting surface, then, Meinel estimates, the unit costs should decrease to the point that electricity from solar energy would be economically attractive—in the range from 5 to 10 mils per kilowatt-hour, exclusive of distribution costs. Comparable figures for fossil fuels range from 1.5 to 5 or more mils per kilowatt-hour at present. Although in this country solar energy plants would be restricted to the southwestern deserts, developments in cryogenic or superconducting power transmission lines could make the power available to a larger region.

Solar energy systems are environmentally attractive, because they do not contribute to air pollution, and because they avoid the radioactivity hazards of nuclear power systems. However, solar energy systems would still require cooling water for the steam turbines, so that thermal pollution would potentially still be present. Meinel envisions dual-purpose plants that could use the waste heat for industrial or agricultural purposes, or for running evaporators to produce fresh water by desalinization.

It is still too early to make accurate assessments of the economic feasibility of solar energy, but the prospects appear to be encouraging enough to warrant further research. Similar economic questions remain to be resolved about breeder reactors, and fusion power systems have yet to be proved scientifically feasible, so that solar energy must be considered a significant, if still uncertain, alternative for future power needs.

—Allen L. Hammond

* See, for example, a speech by Glenn T. Seaborg, U.S. Atomic Energy Commission, at a forum on Energy, Economic Growth and the Environment, Washington, D.C., 21 April 1971.