Home Generation of Power by Photovoltaic Conversion of Solar Energy

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The economic and technological feasibility of the home generation of electric power by means of the photovoltaic conversion of solar energy is examined in the light of extensive solar insolation data and advances in solar cell technology.

SINCE the demonstration of a high-efficiency silicon solar cell in 1954 for the direct conversion of solar energy into electricity by means of the photovoltaic effect, there has been a great deal of hope and speculation that some day the device might prove to be a useful source of electric power. The list of potential applications of the solar cell now extends from the cordless electric clock (requiring 12 milliwatts of power) to the power sources for ion-propelled space vehicles (requiring megawatts of power). Until recently, however, the device has found only limited use in either the novelty field (e.g., civilian portable radios) or applications where power must be made available regardless of other considerations (e.g., the power source for satellite instrumentation).

One of the most inviting of the possible applications is that of providing the electric energy required for the operation of individual households. It is the purpose of this article to demonstrate the economic feasibility of this possibility in the light of comprehensive solar irradiation data and present-day solar cell technology.

THE ECONOMICS OF HOME POWER GENERATION

THE STAFF of the General Electric Laboratory considered in some detail the economic problem of the production and *in situ* use* of electric energy generated by means of the photovoltaic conversion of solar radiation.[2] The system considered consisted of: (1) a cylindrical parabolic mirror having a solar radiation concentration factor of 20, and which could be manually tilted to follow the seasonal changes in the altitude of the sun; (2) a 5% efficient photovoltaic cell; and (3) a lead–acid storage system capable of storing a 4-day supply of energy. The system would be used where the short-term average daily isolation is equal to or greater than 0.3 kw-hr per day per square foot.

The conclusion of the study was that to be competitive with power delivered to the home by conventional transmission lines (having a value of $0.04 per kw-hr) the total system must cost no more than $1.81 per square foot of mirror aperture. This total cost would be divided between the three major components as follows:

Aluminum mirror (1 square foot of aperture)	$0.40
Battery to store 0.06 kw-hr	1.00
Photovoltaic cell (1/20 square foot)	0.40
TOTAL	$1.80

At the time of writing the approximate costs of these items to the consumer were

Aluminum mirror	$0.40
Battery	6.00
5% efficient silicon cell (at $360 per square foot)	18.00
TOTAL	$24.00

Two further studies by individual members of the staff further clarified the problem. The first[3] pointed out that for northern latitudes, nearly half of the total insolation during the winter was diffused radiation and hence would not be focused by the mirror. Furthermore, it pointed out that the 4-day storage supply was optimistic and that an 8-day supply would be more realistic.

The second study was more encouraging. Douglas[4] described a storage system which would sell for about $0.42 per 0.015 kw-hr (i.e., one day's production from 1 square foot of aperture) of storage capacity.

While these initial studies were enlightening, it was obvious that two points needed further investigation before definite conclusions could be reached as to the economic feasibility of the proposed system. Both points centered around a more thorough examination of solar weather at various geographical locations.

The first problem is concerned with examining the insolation at various locations in order to assign a monetary value to the energy produced by the proposed system. The second problem is concerned with the reliability of the system. For such a power plant to be accepted by homeowners, it would be necessary that the plant be nearly 100% reliable. Thus, it is necessary that a storage scheme be found to provide this reliability. In addition to the reliability requirement, the storage system must be available to the consumer at a reasonable price.

* The use of solar cells to generate power at a large central station power plant has never been seriously considered. The cost of electric energy delivered to the home is determined primarily by the cost of distribution. Since the solar cell generator is recognized as being expensive in comparison to conventional generators, there would be no point in such a system. Likewise, home power plants that are tied in with distribution lines such as suggested by L. J. Giacoletto[1] have no economic justification.

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