SOLAR TECHNOLOGY

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SUMMARY: This paper discusses recent developments made in various applications of solar energy. It is found that almost all these applications are emulative of marine and polar arganisms which have built-in system enabling them to utilize solar energy very efficiently. Careful study of marine life should therefore be of benefit in developing more efficient and simpler solar systems at shorter time lags.

Key words: Solar energy, solar technology.

INTRODUCTION

During 1988 we published several papers describing the cost - effectiveness of renewable energy systems (RES) (1-4). It was firmly established in the sepublications that there exists a real need to bring down the initial capital investment (ICI) with the paradox of simultaneously increasing average lifetime - efficiency (ALTE) and operational lifetime (OLT) of these systems.

In view of the fact that RE technologies are witnessing radical developments in their manufacturing and system design, this adds further requirement that an RES should recoup its investment in a period normally not exceeding four years in case the system is replaced by a more functional one.

This technical paper aims at reviewing some of recent advances made to improve durability and efficiency of RES that cost less to produce.

TRANSPARENT INSULATION MATERIALS (TIM)

RES are made of host of materials that are often than not incompatible (1-3). Incompatibility results from material: material, material: environment, material: fluid (if any) and material: material: environment: fluid interactions. Present authors have shown unequivocally that different materials have different comfort levels exactly like human beings do. Placing a material outside its comfort zone puts it under permanent stress that will lead eventually to its premature failure.

As RES are designed to utilize uncontrollable energy resources there exists no guarantee that these systems will always be placed within their comfort zones.

In order to surmount these problems the use of TIM has been introduced (5). These materials have different configurations such as films, foils or honeycombs. In some cases the inclusion of air bubles is done so that TIM become effective thermal insulators as well. Being transparent TIM allow solar radiation in but deny heat escaping out due to their insulating properties.

Surprisingly, the use of TIM in RES has taken so much time in view of their long established merit in providing comfortable living conditions for marine species. For example, the most widespread means of reducing specific gravity in enidarians is the configuration of their connective tissue which produces transparent gellike tissue to make the body lighter and in more harmony with the prevailing marine environment.

This provides an example of natural utilization of solar energy in marine environments that are extensible and adaptable to RES. Only recently such adaptation has been made as summarized below.

Solar Water Heaters, SWHs

TIM have been used in SWHs to replace the glazing covering material. It is noticeable that these materials are analogous not only to marine species, but also to polar bear hair (5). This hair has a transparent shaft which can trap ultraviolet light and aim it toward the skin. This natural solar collector of the polar bear can convert part of the solar radiation into heat with an efficiency exceeding 95 percent. It was found by Grojean in Canada (5) that individual polar bear hairs are actually colorless, not white. They look white because of the scattering effect of incoming radiation. The black skin absorbs the scattered radiation and converts it into heat. Also, it is interesting to note the high degree of compatibility of appearance of polar bear and environment (transparent hair that looks white living on ice that is colorless but deceptively looking white). RES need to be further developed to reach this degree of compatibility.

It is interesting that some RE designs have been developed as an off-shoot of those designs of the polar bear fur and some marine species.

For example, solar collectors were filled with hair-like transparent materials. Experimental results show that the efficiency of these collectors are upped to 50%. Not only efficiency is up, but also need to use tracking devices has almost been eliminated. This is because these systems can utilize the UV radiation which is able to pierce the clouds. In Germany, the use of a fluorine-bearing transparent polymer (Miraflow) has been developed by Bomin Solar Company (6). This material allows UV and IR rays to pierce through clouds and heat up enclosed water.

Solar Ponds

A TIM is being used in a large scale such as in solar ponds to heat water and generate electricity (6). A very similar application has been reported in Australia in 1986 (7). In this system fresh water (not salty water as with conventional solar ponds) covering 600m^3 will have the top 13 cm covered with a honeycomb structure of a transparent insulation plastic with a thin-layer

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coverage of a UV - resistant material with surface of water itself having a coverage of silicone oil to reduce evaporation losses similar to (gel - coat in marine organisms). Solar radiation will penetrate the transparent plastic materials and heat up water for industrial and electricity-generation applications. Surprisingly, such improvements have lagged for long times when model natural systems exist.

Passive design of buildings

The use of TIM has not been confined to solar collectors, but also to heating building components. One interesting material is silica gel which, besides being transparent, is porous and is formed as monolithic tiles (7,9). Silica gel is now being experimented for heating Trombe wals with the gel used as a cover. Initial results are encouraging; yet efforts have still to be made to reduce water absorption of silica gel (may be a gel will do).

POWER - GENERATION

Photovoltaics (PV)

The deceptive white color of ice and polar bear hair resulting from internal reflections of light has been utilized in developing PV arrays. One company in the Federal Republic of Germany has just developed a PV array that has a blackish background due to such light reflections. This helped to bring efficiency to 18% as claimed by the manufacturer.

A major technological advance has been reported recently (6) wherein an experimental device called a "mechanically-stacked multijunction solar cell" can convert a phenomenal 31 percent of the light striking into electricity. It is predicted that efficiency would eventually reach 35% i.e. comparable to conventional power-generation systems.

The availability of PV systems is very much dependent on availability of solar insulation. Surprisingly, there seems to be no reports of possible inclusion of light-generating systems during night hours in emulation of the phenomenon of bioluminescence, in which emission of light during night hours is possible. Chemiluminescence is known also to convert chemical energy to radiant energy directly and virtually at 100 percent efficiency (10). This way if a PV system is coupled to radiated energy at night hours and during cloudy days the energy resources will be available for longer periods and hence the efficiency of RES systems will be increased especially that the conversion of chemical energy to radiant energy is extremely efficient. This is in emulation of some marine organisms that radiate light such that it matches the intensity of sunlight penetrating from above, or those organisms which exhibit a 24-hours rhythm of light intensity, highest at night and lowest during the days.

Solar Electricity Generating Systems (SEGS)

Some marine organisms possess true light organs (11). These consist of lens, reflectors, pigments (if any) and light emitting organs. This is not a widely different arrangement from SEGS in which solar insulation is relected to a central collector wherein superheated steam is generated for electricity production (not light production as in marine organisms).

Recent efforts are directed towards simplifying the design and construction of REGS. One effort to reduce the concentrator cost is through production of innovative stress heliostat design in which glass is replaced by a polymer film mirror. It is envisaged that future developments will bring SEGS closer to that existing in marine organisms.

CONCLUSION

Recent developments of new applications of solar energy depend on the use of innovative transparent and insulative materials. These developments are bringing these systems to close resemblance of marine and polar organisms. These organisms have solar - utilizing mechanisms characterized by their simplicity, functionality, harmony with local environment and self-controlling qualities. If solar systems developed by mankind are to be cost - effective, durable and efficient emulation and adaptation of natural systems is recommended as has been recently practiced.

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