LIQUID SOLAR ARRAY

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ABSTRACT

PV concentrators appear to offer significant potential savings in cost over flat plate semiconductor PV systems. Due to the exponential growth of photovoltaics, prices for PV systems have rapidly declined in recent years. However, they vary by market and the size of the system. This potential advantage derives from the trading of large areas of high grade semiconductor and glass (silicon) for similar areas of cheap acrylic plastic in the form of a thin Fresnel lens or a thin glass mirror, plus a small area of PV cells (typically silicon) and a tracking mechanism. However, to date the potential savings have not yet been realized due to complexities arising mainly from the mass of the physical structure needed to provide adequate support for the concentrator, cells and tracking mechanism in adverse weather conditions.

This paper shows a means whereby all major limitations, and costs, may be considerably reduced by adopting a configuration, termed the "Liquid Solar Array" (LSA) where each element of a floating array comprises a raft supporting a solar tracking lens and partially-submerged water-cooled PV cell assembly. An important feature of the LSA is that the lens can be submerged in windy conditions thereby reducing structural requirements in comparison to PV (land-based) concentrator cell arrays.

Keywords: *- Photo Voltaic, Liquid solar array, cell array*

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1. INTRODUCTION

A solar array is a loosely defined term referring to a group of photovoltaic solar panels or cells that convert sunlight to electricity, arranged and linked in such a way as to operate as a single unit. The term can also refer to a similar set of reflecting mirrors used for directing and focusing sunlight onto such a group of photovoltaic units. A solar array can be relatively small, such as a group of panels on the roof of a single family home, or very large, such as an array covering several acres, containing hundreds or even thousands of individual panels.

In the strictest sense of the term, even some individual solar panels are technically solar arrays. A typical solar panel is made up of several photovoltaic cells linked together and bound, or contained, within a single unit. The word array is not generally used in this manner, however, and a solar array is usually regarded as a group of solar panels, which can vary widely in size and shape. A typical solar array is composed of solar panels of one type, but this does not necessarily have to be the case.

Photovoltaic cells are the basis for most solar arrays. These devices convert sunlight into electric current, and can generate substantial amounts of electricity in large enough numbers. In the late 20th and early 21st century, it became more common for energy and environmentally conscious homeowners to install residential solar arrays in an effort to mitigate their energy costs.

2. POTENTIAL OF PV CONCENTRATORS

The main potential advantage of PV concentrators over one-sun flat plate PV derives from reducing costs by trading large areas of high grade semiconductor-under-glass (silicon) for similar areas of cheaper materials, such as acrylic plastic in the form of a thin Fresnel lens or a thin glass mirror, needing only a small area of PV cells. The light is concentrated so the area of silicon typically required is reduced 50 to 200 fold for a given output.

Silicon cells in concentrator systems are quoted as low as US$0.20 per watt; however, difficulties arise from the lens or mirror structure that focuses the light onto these economical cells as the structure needs to be substantial. Added to this is the cost of the tracker that, along with the structure, needs to withstand winds of at least 150 km/hr in many locations. Table 1 (Appendix 1) gives the approximate forces to be expected at different wind speeds, using Bernoulli's formula.

Thus it may be seen that the structure must withstand pressure of 120 kg/m^2 if exposed to winds of 150 km/hr. If exposed to wind forces at only 60 km/hr, the peak forces per square metre acting on the structure are reduced to 20 kg/m^2, thus if the effective pressure could be reduced, there would be less need for such a substantial structure and tracking mechanism. Around one sixth of the strength and mass should be possible without compromising performance.[1].

The concept of employing the lowest costing transparent elastomers as pottants, by permitting UV sensitivity, requires in turn the need for an outer cover material that is both UV screening and naturally weatherable. For a superstrate design, this is provided by glass, which is also the module structural panel.[2]

3. SOLUTION

By arranging the PV concentrators in an array that is placed on water rather than on land, a simple solution has been realised that gives efficient cooling of the PV cells and allows a lighter structure to be used, resulting in major cost savings. A buoyant raft comprising moulded plastic members supports a tracking mechanism and light weight lens as shown in Figure 1. The lens system can be rotated into the water at any time that wind-speeds exceed some threshold, or according to weather predictions and thereby obviate the need for the large area components to withstand high winds. An array of such rafts and immersible collectors might be termed a liquid solar array (LSA).

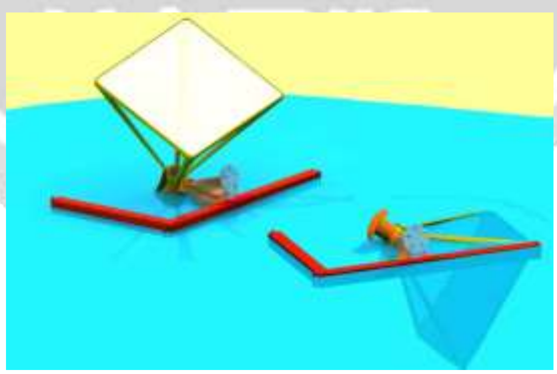

Figure 1 Collector in operating and protected positions.

With such a design the lens and its supports can be very light – as little as 3 or 4 kg for a square metre of Fresnel lens with its frame (versus 20 kg/m^2 for a standard concentrator). So the mass of the moving components is greatly reduced. Hence the tracking motor drive is also reduced in size and power.

Another significant advantage of this approach is that the system is likely to survive coastal cyclonic conditions that are expensive to manage with existing solar collectors and wind farms, leading to lower insurance costs for the LSA.

4. SHADING AND DIRT

Photovoltaic cell electrical output is extremely sensitive to shading. When even a small portion of a cell, module, or array is shaded, while the remainder is in sunlight, the output falls dramatically due to internal 'short-circuiting' (the electrons reversing course through the shaded portion of the p-n junction). If the current drawn from the series string of cells is no greater than the current that can be produced by the shaded cell, the current (and so power) developed by the string is limited.[2].

5. COMPARISIONS

The comparisions between Floating Solar Power System and Ground Solar System are as follows:-

	Floating Solar Power System	Ground Solar System
1.	Naturally cooling. Therefore improve power production (panels better when they are cooled).	Cooling is slow.
2.	It shades the water limit algae growth.(Reduce evaporation of water 70%evaporation reduce).	N.A
3.	Life span is less.	More life span.
4.	Moving parts: More function and wear and tear of mechanical parts.	No moving parts.
5.	Initial capital cost more by considering motors initial installation on water etc.	Less capital cost
6.	More operating cost.	Less operating cost.
7.	No effect of dust.	Due to dust the system is affected.

6. APPLICATIONS

Most coastal areas and inland reservoirs within 35 degrees of the equator could be suitable for application of the LSA.

The basic requirement is a protected area of water between one and ten metres deep (with some flexibility). About 25 square metres of water area is required for each kilowatt of electrical output if using silicon concentrator cells of 19% efficiency (at 40 degrees C). Where suitable bodies of water are already available, and the sunlight availability is over 2000 hours per year the LSA system could offer an extremely competitive source of raw electric power. Lesser hours of sunlight give higher power costs but in many situations this m likewise, in some good solar situations, custom built ponds may be economically feasible. In ea self is not consumed or changed at all, so multiple usage of the water is possible (drinking, aquac

Given that the basic one square metre module of this system will generate about ll systems should still have good economics. Thus the LSA would suit farm or village scale p to 20 kW nearly as well as 1GW systems. Bigger is generally better.

If contributing to a national power grid, the LSA component would be most effectiv ndreds of systems each of about 10-100 MW, as this would be least affected by local cloud. One requires about 2.5 km^2 of water area (1.6 x 1.6 km).

Lens $25

Moving Structure $25

PV Assy. $30

Tracking $20

Raft $20

Total

7. ADVANTAGES

1.Photovoltaic cells used are naturally cooled by convection of the water to give top silicon efficiency.

2.Structure & Concentrator lens can be made from very light-weight, low cost plastics as they are protected from extreme weather forces.

3.Minimal land & setup cost (dual use of water).

8. DISADVANTAGES

1.The sun doesn't shine 24 hours a day. When the son goes down or is heavily shaded. Solar PV panels stop producing electricity.

2.The primary disadvantages of solar power is that it obviously cannot be created during the night.

3.Solar panels energy output is maximized when the panel is directly facing the sun.

4.This means that panels in fixed location, such as the building above will see a reduced energy production when sun is not at an optimal angle.

9. COST

The costs is about US$1.35 per watt are likely to be achievable at low levels of production (including installation, mounting and wiring). Figure 2.below gives an impression of the costs of each component for a higher mass production case (using well known silicon concentrator cells).

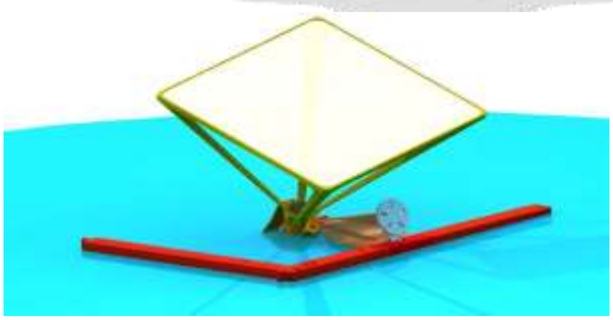

Figure 2. A mass production cost estimate, giving about US$1 per watt.

This case results in costs around $1 per watt or 5 cents per kwhr. Estimates for higher volumes indicate that $0.70 per watt, or less, is possible with silicon concentrator cells. Note that these are not hopeful, long-term projections, but estimates based on the costs of similar existing components that are available now. In all estimates the PV cells are assumed to cost more per unit area than existing one-sun mono-crystalline cells. If one were to assume that high production volumes will drive technological improvements in the LSA system, such as the incorporation of multi-junction PV cells and lightweight composites, the cost of DC power could go below US$0.50 per watt in the long term (or two cents per kwhr in excellent locations).

10. CONCLUSION

The results shown in this paper indicate that the major cost drivers for concentrated solar electricity collectors can be considerably reduced by this technique of selective immersion of the concentrator. The LSA design effectively addresses the 'Achilles Heel' of conventional PV concentrators – their sensitivity to extreme weather. The LSA design is working with nature to accommodate these extreme conditions economically.

Given that a prototype shows that this economical assembly works with good efficiency and that its components are readily available, making the costs highly predictable, it should be considered that the LSA cost estimates are both credible and achievable with relatively little effort.

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