NOVEL BUILDING INTEGRATED SOLAR CONCENTRATORS

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ABSTRACT

In developed countries 60% of the electricity consumed is attributable to commercial and public buildings. Even in the UK, the solar energy incident on buildings is more than 7x the electrical energy they consume. This represents a problem (the management of solar heat gain and glare) but also an opportunity that may be taken advantage of using complementary concentrator technologies. We are investigating conventional geometric and luminescent concentrators that may be combined to optimally harvest the direct and diffuse components of sunlight within a double glazed window unit.

The conventional geometric concentrator employs an array of linear Fresnel lenses in the form of a power generating blind focusing the light onto light-bars, which serve as secondary concentrators, to couple the light to high efficiency solar cells located in the window frame. The modules resemble Venetian blinds as illustrated in Figure 1, which eliminate the direct component of sunlight, but also provide a view through the window. In addition they transmit a significant fraction of the diffuse sunlight, which has been scattered in the atmosphere and is incident over a wide range of angles, for glare-free natural interior illumination, even when the sun faces the window. This eliminates the need for interior lights when the blind is working. Furthermore, these solar tracking, transparent, building integrated solar concentrators (BISCs) can be considered as highly effective "solar blinds" since they shield the interior from direct sunlight, which is converted to electricity, thereby protecting the building from excessive heating and reducing the need for expensive air-conditioning.

However, this concentrator can only harvest the direct component of sunlight and it has long been recognised that in many developed countries the diffuse component can be greater than the direct [1]. The highest building integrated photovoltaic power generation density will therefore be achieved by making optimal use of both the diffuse and direct components of sunlight. The conventional BISCs described above only harvest the direct sunlight and we have therefore developed a transparent luminescent solar concentrator (LSC), see e.g. [2], which can be added to the window glass to harvest the significant short wavelength fraction (< 450nm) of the diffuse sunlight to which the eye is insensitive. A prototype is illustrated in Figure 2.

We have developed ray-tracing software, which utilizes constructive solid geometry to allow the interrogation of complex geometries, to optimise the designs of the light-bar and transparent LSC. Initial results suggest that optical efficiencies around 50% are achievable for the light-bar and that the combined system can achieve power conversion efficiencies of over 25% under standard AM1.5g illumination.

It is expected that the full integrated system would produce 2 to 3 times the electricity of current building integrated PV systems based on 2nd generation thin or semitransparent a-Si or CIS cells [3], in addition to making more effective use of the solar spectrum. Our calculations suggest that the system would enable a typical office building behind a south facing wall, even in London, to be electrically self sufficient for much of the year.

Figure 1. Impression of a BISC Venetian blind

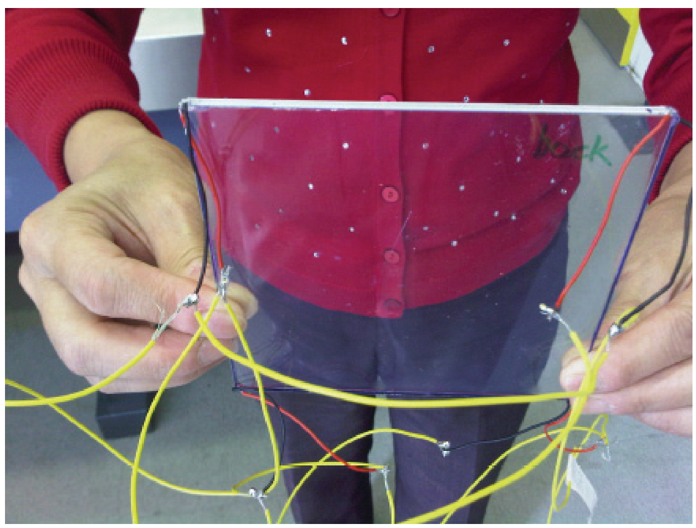

Figure 2. A prototype transparent LSC

References

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