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Optimisation of Concentrator in the Solar Photonic Optoelectronic Transformer: Comparison of Geometrical Performance and Cost of Implementation

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Abstract. The Solar Photonic Optoelectronic Transformer (SPOT) is one of the components of the SolarBrane, a Building Integrated Photovoltaic (BIPV) system developed by SolarEmpower Ltd. The SPOT employs 2-D linear dielectric totally internally reflecting concentrator (DTIRC) to increase the collection efficiency of the sun's rays and reduce the amount of photovoltaic (PV) material used. In this paper, an optimised DTIRC design for the SPOT, based on the maximum concentration method (MCM), is discussed. Next, the geometrical properties of the optimised DTIRC design are explained and compared to a DTIRC based on the phase conserving method (PCM). A cost analysis of implementing the MCM is also presented. The results obtained from simulations in MATLAB show that the MCM offers higher geometrical concentration gains and at the cost of increasing the concentrator size. The new optimised concentrator offers a lower cost of implementation, shorter payback period and an even higher annual return as compared to the existing design.

Key words

Solar concentrator, dielectric totally internally reflecting concentrator, maximum concentration method, phase conserving method, geometrical concentration gain.

1. Introduction

SolarEmpower Ltd. aims to exploit solar power as well as producing a cheap, cost competitive Building Integrated Photovoltaic (BIPV) system into the PV market. SolarBrane [1] is a BIPV system developed by SolarEmpower Ltd after years of research. It is a static solar device. Unlike conventional solar photovoltaic (PV) systems which only generate electricity, SolarBrane utilises both direct and indirect solar radiations to produce electricity, hot water, space heating, illumination and ventilation for a building which reduces the power consumption of a building [1],[2]. Figure 1 shows the diagram of a SolarBrane.

To reduce the production cost of the system, a solar concentrator is used in the design. A solar concentrator is one of the devices used in the BIPV system that maximizes the collection of solar light and focuses the light to a smaller exit area, at which a PV cell is attached. While traditional solar PVs use a large area of silicon cell, the introduction of a concentrator in the design enables SolarBrane to use approximately 30% of the total silicon whilst maintaining the same output power [1],[2].

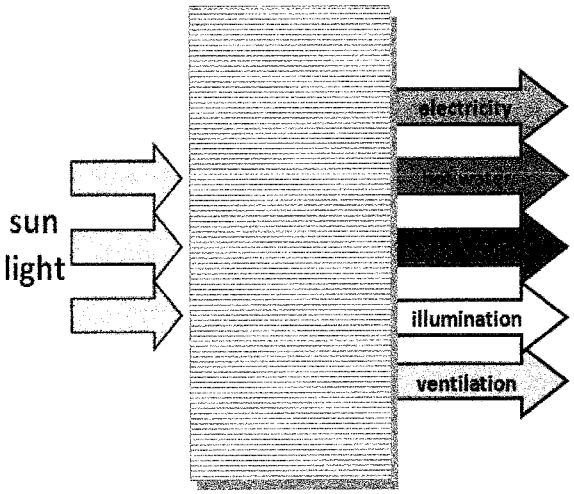

Figure 1: The SolarBrane [1]

An important component of the SolarBrane is the Solar Photonic Optoelectronic Transformer (SPOT). Currently, the optical concentrator incorporated in the SPOT is a 2-D extrusion of a dielectric totally internally reflecting concentrator (DTIRC) profile (see Figure 2) and is deposited on a rectangular PV cell cooled by water or air depending on the application. This concentrator has proven to provide three advantages as compared to alternative optical elements such as a conical