Terrestrial Applications of Bifacial Photovoltaic Solar Panels

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Abstract: - Bifacial Photovoltaic solar cells (so-called transparent bifacial photovoltaic solar cells) offer additional absorption by rear side, which is a significant advantage over ordinary Photovoltaic solar cells. A range of experiments have been done on bifacial photovoltaic panels in terrestrial application. This paper represents several of its applications that may inspire novel design for upcoming researches.

Key-Words:- Photovoltaic, solar cells, absorption, terrestrial, panels

1 Introduction

Ordinary PV cells are usually laminated by a transparent material on front surface and opaque material on rear surface. They absorb solar radiation on front surface, that's why electrical conductor material is partially printed on front side, but full coverage at rear side.

Bifacial Photovoltaic solar cells offer additional absorption by rear side, which is promising advantage in contrast with ordinary Photovoltaic cells. More solar absorption leads to more electricity production but, desires some modification on configuration of cell and lamination. Fig 1 represents cell configuration of monofacial and bifacial cells.

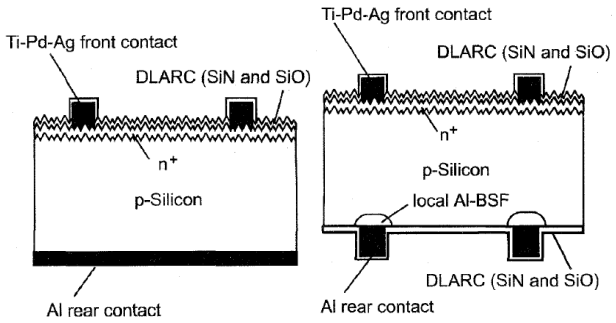

Fig 1. Schematic of monofacial (left) and bifacial (right) photovoltaic cell [1]

2 Classification of applications

Terrestrial applications of bifacial solar photovoltaic panels could be classified regarding the physical attitude of the system, properties of the components and installation as well. Fig 2 demonstrates the classifications.

3 Installation attitude

Since bifacial panels can absorb solar radiation from both sides, it provides a multiple choice to install it vertical, horizontal or tilted with different azimuth angle.

T.Joge et al. [2] studied the effect of azimuth and elevation angle (tilt angle) on solar absorption bifacial panel in contrast with mono-facial one. Their research represents higher yearly electrical power generation by bifacial panel rather than mono-facial panels; especially in cloudy day. It shows little dependence to module orientation angle.

T. Uematsu et al. [3] continued research on vertical installed bifacial PV panels and result indicates more electrical output than mono-facial panel by optimum tilt angle (30^{o} for Japan) and not much dependence on orientation.

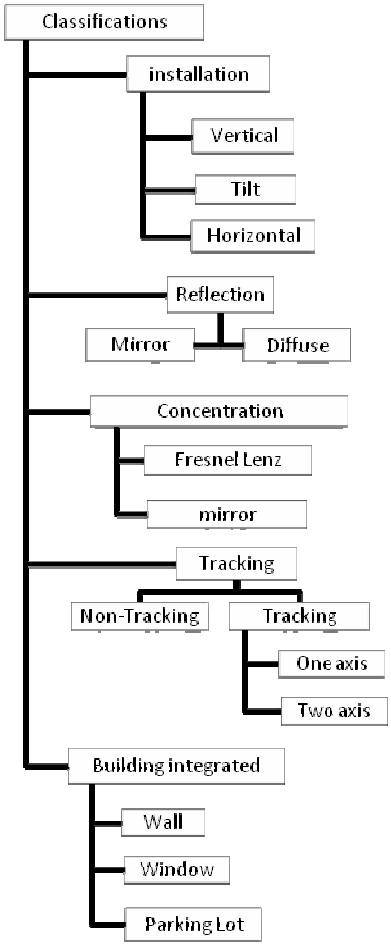

Fig 2. Classification of specifications of bifacial PV module at terrestrial applications

4 Reflectors

Though few researches offered vertical installation without backside reflector [2,3], the others spent effort on utilizing various types of reflectors because, back side absorption is the privilege of bifacial panels in contrast with monofacial ones. It inspires the idea of substituting high cost photovoltaic material by low cost reflectors.

A.Moehlecke et. Al [4] placed a diffuse reflector to return solar beam radiation to the back surface of bifacial PV cells (Fig 3). They introduced the white color reflector as the best diffuse one with 75% reflection performance.

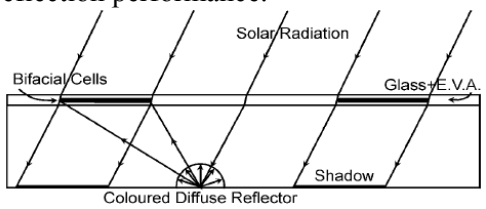

Fig 3. bifacial PV equipped with diffuse reflector [4]

Simultaneous to above mentioned research, T. Uematsu et. al [5] placed a v-groove reflector with 88% reflection efficiency at the back and they left gap between bifacial PV and top glazing to maximize uniform solar gain via multi reflection by top glazing (Fig 4).

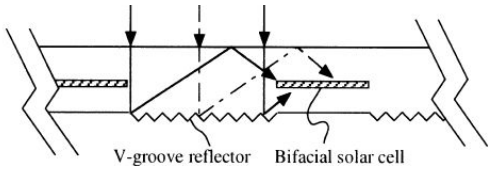

Fig 4 Bi-PV equipped with v-groove reflector [5]

5 Concentration

Ugur Ortabasi [6] is pioneer of researcher on applications of bifacial PV. He introduced 20X (20 sun) concentration system.

In this system, top mounted Fresnel lenses focus parts of solar radiation on front side of bifacial PV and the rest on reflector, to reflect on rear side of bifacial PV. Fig 5 demonstrated the schematic of the system.

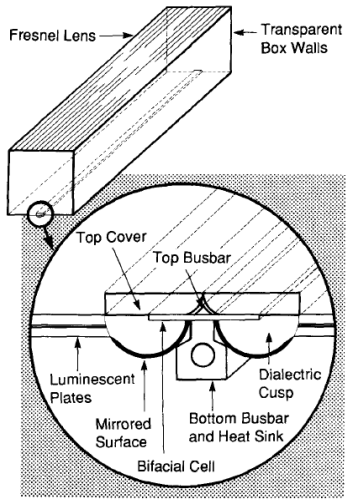

Fig 5. 20X Fresnel lens bifacial PV solar collector[6]

He proposed the feasibility of low concentration Pi-PV (2X or 3X) that has been pursuit by himself 9 years later [7]. In 1997 he introduced 2X bifacial PV solar collector panels, which has been inspired by his previous research. In latest design, he eliminated the top covering Fresnel lens. It reduces the solar gain, but, he could avoid high temperature (85^{oC}) that he faced on his old design. High temperature slashes the efficiency and life time of bifacial PV either.

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In 2003 T.Uematsu et al [3] introduced an static concentrator flat plate solar panel equipped by bifacial PV and V-groove reflector (Fig 6).

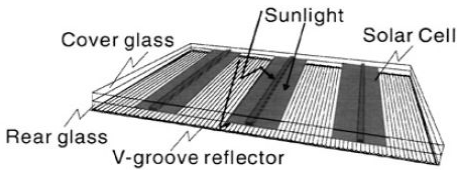

Fig 6. static concentrator flat plate solar panel [3]

It considers as low concentrator and the distance of bifacial PV from V-groove reflector affects the concentration ratio.

In 2007 B. Robles-Ocampo et al [8] have done experiment on a low concentration bifacial PVT panel. Their system has been equipped by 3 reflectors and it could absorb 1X solar beam radiation on front surface and 1X on rear side, which leads to 40%increase electrical energy production (Fig7).

Fig 7. 1X bifacial PVT solar collector [8]

In 2009 Vladislav Poule et al. [9] constructed a 5X bifacial PV panel. This panel absorbs 1X by front surface a 4X by rear side. They could increase energy gain 300% compare to the fixed monofacial panels. This panel could withstand up too 200^{oC} (Fig8).

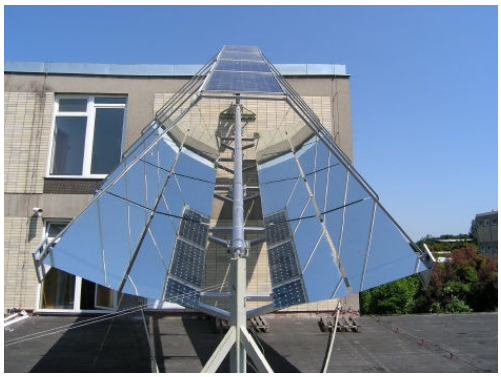

Fig 8. 1X bifacial PVT solar collector[9]

5 Tracking

Tracking system is not compulsory for all bifacial PV solar collectors. Low concentration bifacial PV will operate without tracking system [3, 4, 5, 8] with acceptable efficiency.

Medium, to high concentrators strongly rely on tracking accuracy, that maximizes the solar gain, but imposes thigh investment and maintenance cost.

20X Fresnel lens bifacial PV introduced by Ugur Ortabasi et Al. [6] in 1988 requires one axis tracking system, but in 1997 they introduced a non-tracking 2X bifacial PV. This system shows significant economical advantage in contrast with ordinary flat plate panels, and less complexity in component that leads to reduction in initial cost rather than their pioneer design in 1988 (Fig 9).

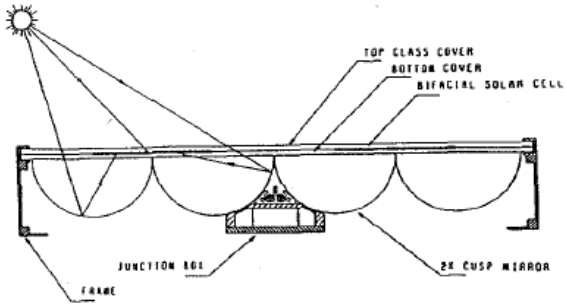

Fig 9. 2X nontracking bifacial PVT solar collector [6]

6 Building integration

Bifacial PV could be invested to residential area such as, window integrated, wall integrated and parking lot integrated.

In wall integrated bifacial PV, cells partially cover panel and they are placed with an offset distance from wall. So, a portion of solar radiation hits the cells, and the rest penetrated through transparent encapsulation and reflects by wall to the rear side of cells, it accompanies to produce more electrical energy (Fig. 10).

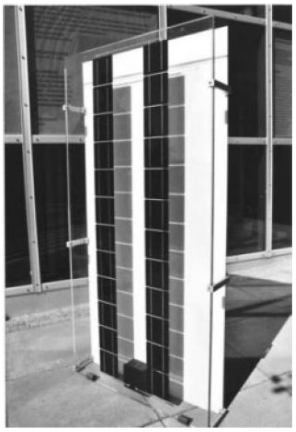

Fig 10. Wall integrated bifacial PV panel [10]

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Bifacial PV as a window integrated panel has to functions:

1- Produces electricity.
2- Permits faint solar beam penetrates to interior area for lightening the residential or commercial area (Fig. 11).
3-

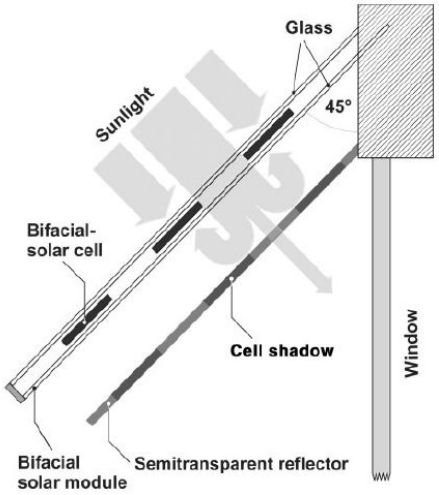

Fig 11. Window integrated bifacial PV panel [10]

Parking integrated bifacial PV is a novel investment on open area parking lots.

The advantage of bifacial PV panels over normal PV panels is that it provides shadow for vehicles and absorbs reflected sunshine from back side reflector, which leads to higher electricity production (Fig 12).

Fig 12. Parking lot integrated bifacial PV panel [10]

7 Summary

The most significant advantage of bifacial PV cells reveals in flat plate and low concentrations solar collectors, that they represent significant increscent in electrical energy production with negligible increase at investment cost.

Dual surface absorption PV panel offers vide range of applications specially as a building integrated component. They can produce energy (electricity) from exterior walls, windows, open area parking lot and roof as well. Bifacial PV provides shading and faint light penetration. Bifacial PV could be considered as an architectural and HVAC synergy component.

At this stage, research on static flat plate bifacial panels would result to higher market share rather than conventional PV panels, because of their extra electricity production from rear surface.

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