Bifacial PV cell with reflector for stand-alone mast for sensor powering purposes

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Bifacial PV cell with reflector for stand-alone mast for sensor powering purposes

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Motivation
Bifacial solar-cell modules can provide a price advantage in production relative to normal solar-cell modules if the effective light collecting area can become twice the area of a normal single-sided solar-cell module of the same size. This can only be achieved by designing an adequate low cost reflector. Particularly, a design which is optimized for local winter conditions has our highest interest.

We intend to use ray-tracing to model and optimize the interaction between the vertical bifacial solar-cell module and vertical reflector designs.

In this work, we demonstrate results on simulating the power gain, using the bifacial PV cell mounted with a retroreflector relative to a bare bifacial PV cell of same size. We will insert solar data into the model. Finally, we will present our first measurements from a prototype of the bifacial PV cell with the retroreflector.

In Fig. 1(a) the length of the bifacial PV cell is twice the depth of the retroreflector. This allows the PV cell to collect light, which otherwise could escape the retroreflector. The angles of the two mirrors relative to the PV cell are ±45 deg. As illustrated in Fig.1(a) the length of the bifacial PV cell is twice the depth of the retroreflector. The PV-cell and the retro reflector are surrounded by air only. The path of the incoming light is modelled by two ray paths. Either direct incidence of light onto the PV cell or via a reflection in the retroreflector onto the PV cell.

The simulations do include optical losses at reflections at the mirrors (95%) and absorption in dielectric media, such as the covering laminar protecting the PV cell. Two solar models are used: Solar model I has a constant radiance as long as it is above the horizon, while solar model II uses solar irradiance measurements, obtained from a solar station (see Fig.1(c)).

The results
In Fig 2(a) and Fig 3(a) the normalized irradiance collected by the bifacial PV cell with the retroreflector is simulated at the latitude of Copenhagen (55.676°N), and at three dates: The 23rd of June (red), the 10th of April and the 21st Dec. In Fig. 2(b) and Fig.3(b) and the simulations for the bare bifacial PV cell is plotted as a function of azimuth angle as well, and at the same conditions as Fig.2(b). In Fig 2 the solar model I is used while in Fig 3 the solar model II is used. In the table the power collected through the entire days with solar model I are listed.

In Fig 4 measurements of photovoltaic current from the prototype (Fig.1(d)) of the bifacial PV cell with the retroreflector are plotted as a function of azimuth angle.

<table>
<thead>
<tr>
<th>Date</th>
<th>Bifacial PV with reflector</th>
<th>Bare bifacial PV cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>June (23/6)</td>
<td>0.328</td>
<td>0.424</td>
</tr>
<tr>
<td>April (10/4)</td>
<td>0.348</td>
<td>0.347</td>
</tr>
<tr>
<td>Dec (21/12)</td>
<td>0.237</td>
<td>0.102</td>
</tr>
</tbody>
</table>

Conclusion
An optical raytracing model has been presented to the bifacial PV-cell with a without a retroreflector. The reflector improve the performance of the bifacial PV cell during winter. We have also present our first data from the corresponding prototype.

Outlook
The model will be developed further in the near future, to include diffuse light, more solar data and different reflector configurations.