Ambi PV
Adapted Modules for Bifacial Photovoltaics

Project duration: from 10.2019 to 09.2022
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Publishable Summary

The project Ambi PV focused on new interconnection approaches for bifacial solar cells. The higher current in bifacial modules causes increased ohmic power losses which can be addressed by advanced interconnection techniques such as wired interconnection, shingling, 1/2 cells or combined approaches. The following interconnection technologies are investigated, including related optimizations of the cell/module materials and lay-outs:

- A new wire-based concept for the interconnection of bifacial IBC (Interdigitated Back Contact) cells .
- Two shingling interconnection approaches for PERX cells, based on electrically conductive adhesives (ECA) and seamless soldering.

Each of these approaches has specific challenges which are not only related to the interconnection process but also to the respective module and cell design. So, the mechanical stress due to e.g. bending of the laminate will affect the interconnection of shingled cells in a different way than wire connected ones. The tensile or compressive stress on an ECA glued interconnection will be different if the cell matrix is embedded along the neutral fiber in a glass/glass- or in a glass/backsheet- module. Therefore, a fully parametrized thermo-mechanical FEM model which can be easily adapted to varying material properties was implemented. The simulation results showed that most of the internal stresses in the ECA interconnect and the adjacent silicon cells are due to material contraction and expansion induced by temperature changes. The influence of design parameters (joint thickness, joint width, cell overlap was investigated, and under thermal loading conditions each of the joint design parameters (joint thickness, joint width, cell overlap) showed a significant influence where the results indicate that an increase in joint thickness leads to the most significant improvement regarding the reduction of stresses. Additionally, double glass designs and encapsulant films with lower stiffness also showed a beneficial effect and a reduction of mechanical stresses on the interconnection and the solar cell.

For the three interconnection approaches different levels of readiness have been achieved within Ambi PV:

Seamless Soldering: A bifacial mini-module demonstrator with seamless soldered cells with < 3 % CTM loss without breakage after production was built. This design has around 3% more active cell area with seamless soldering layout. The targeted bifaciality factor of 90% could not be achieved with the p-PERC cells from an external supplier that were finally used, since their bifaciality level of a good 60% was significantly lower than the 90% of the planned PERT cells. However, this is due to the cells and is not related to the interconnection.

ECA shingled modules: Shingled mini-modules with an efficiency of 19% could be reached.

However, the project work was focused on R&D to minimize CTM losses and used bifacial Bison (n-PERT) cells with 19.5% initial cell efficiency. Using the same shingling and module processes and extrapolating to 22.5% efficient Topcon cells yields a prediction of >20.5%.

Wire-based IBC interconnection: Demonstration modules with an efficiency on 22.5% on cell level and a bifaciality factor of 0.73 on module level have been reached. The design showed 33% less silver consump¬tion than standard Zebra cells. A reliable (1% power loss after TC200 and no power loss after DH2000) interconnection approach was developed which shows promising series resistance and performance.

Finally, within Ambi PV also a thermal model for bifacial modules was developed and applied to various solar module types. The model was successfully verified by experimental results. The temperature model is set up in a Matlab environment, that allows extremely fast processing of very large data volumes. Thus, measurement data from a solar module can be imported over the entire year. Climate data from weather station next to the system are also imported for precise further processing.

The results of Ambi PV will provide a sound basis for further decisions and deliver material for dissemination and publication.

Project consortium

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Participating countries and financing:

Country	**Number of organisations involved**	**Project costs in EUR**	**Public funding in EUR**
Austria	1	183 851	145 869
Switzerland	1	129 634	120 040
Germany	2	274 313	227 544
Israel	1	237 783	237 783
Total	*5*	***825 581***	***731 236***

Funding agencies involved and contracts

Funding Agency	Contract N° and Title
FFG	837780 Adapted Modules for Bifacial Photovoltaics
SFOE	SI/502052-01 Ambi PV II: Adapted Modules for Bifacial Photovoltaics
PTJ	032EE1036 Adapted Modules for Bifacial Photovoltaics
ETN	EFO 0007 Adapted Modules for Bifacial Photovoltaics
Ministry of Energy	AGREEMENT NO. 219-11-082 “High-Efficiency p-PERT Bifacial Cell, as the Core Component for Bifacial Advanced Modules