Shingled bifacial photovoltaic modules

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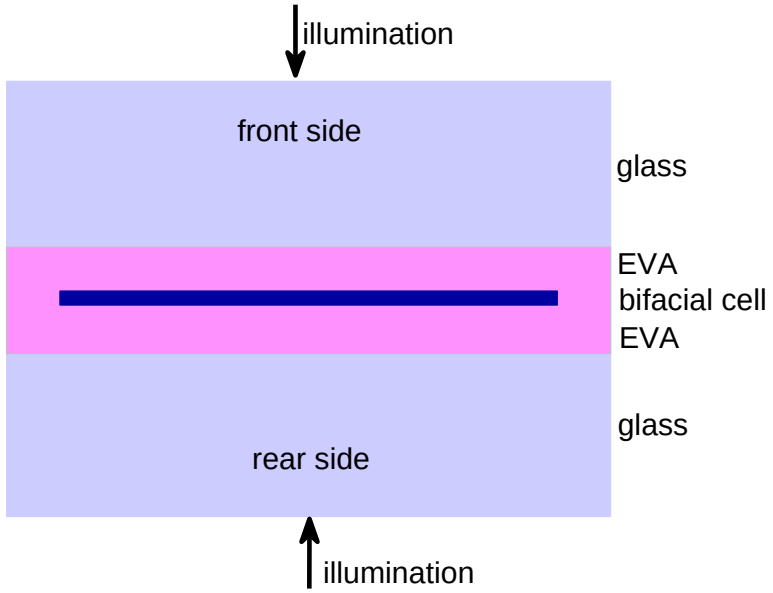
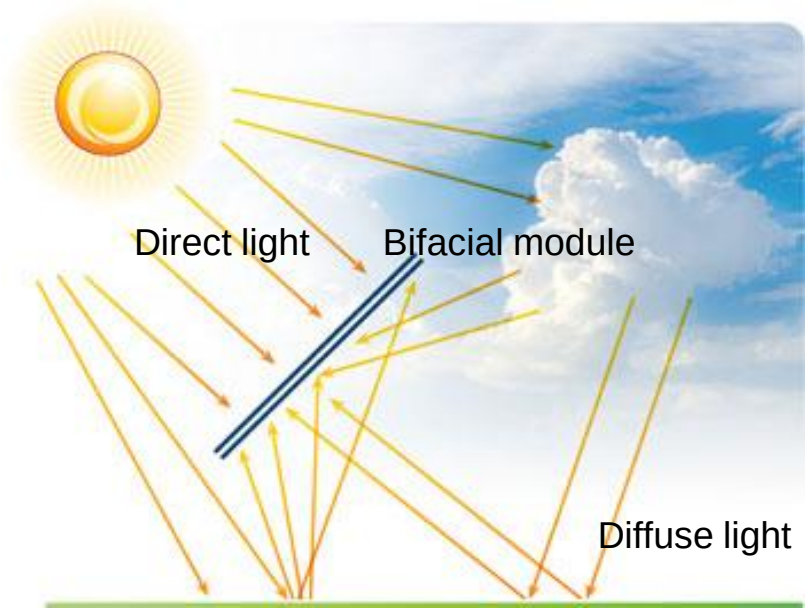
Introduction

Double-glass bifacial PV modules:

- Higher energy yield: 10-20% gain is achievable in outdoor conditions by using albedo from surroundings.
- Improved reliability (double-glass)
- Levelized cost of electricity (LCOE) can be reduced





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Introduction

Bifacial PV module performance and challenges:

- Key performance indicator for bifacial PV modules
  - Module front side power
  - Rear side current response (bifaciality)
- Key challenges
  - Measurement and characterization methods
  - Higher optical and electrical losses compared to monofacial modules.
  - Bifacial solar cells and modules are measured, rated and sold at front side power only.
- For wide acceptance of bifacial PV technology, losses in bifacial modules must be minimized

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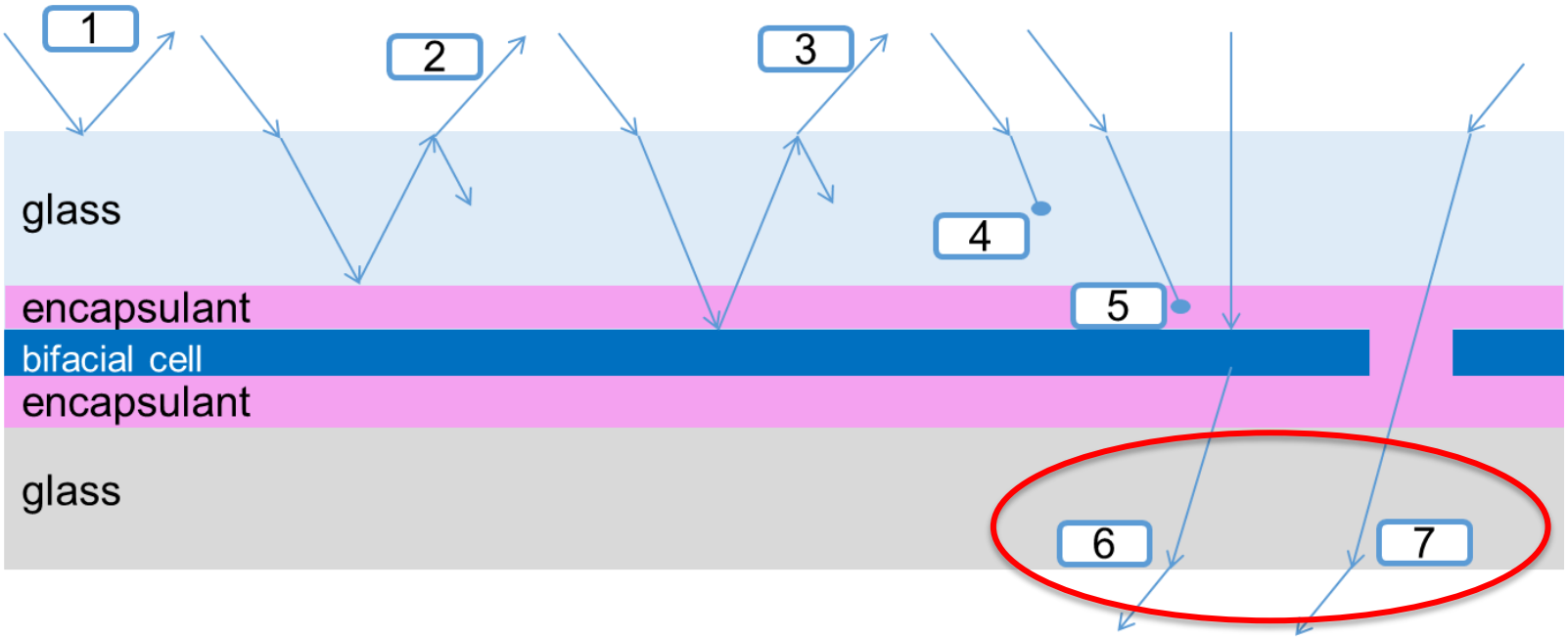
Losses in bifacial modules: optical

- Reflection (1, 2 and 3) and absorption (4 and 5): same as standard glass/backsheet modules
- Long wavelength light transmission through bifacial cell and rear glass (6)
- Transmission through cell-gap area (7)



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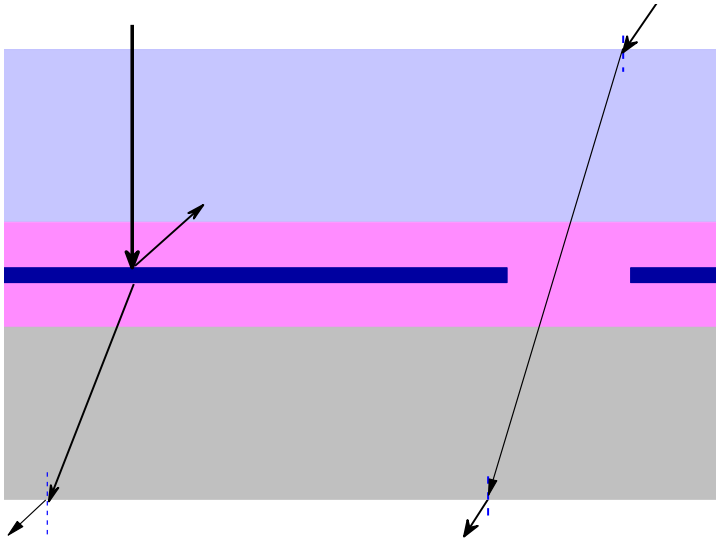
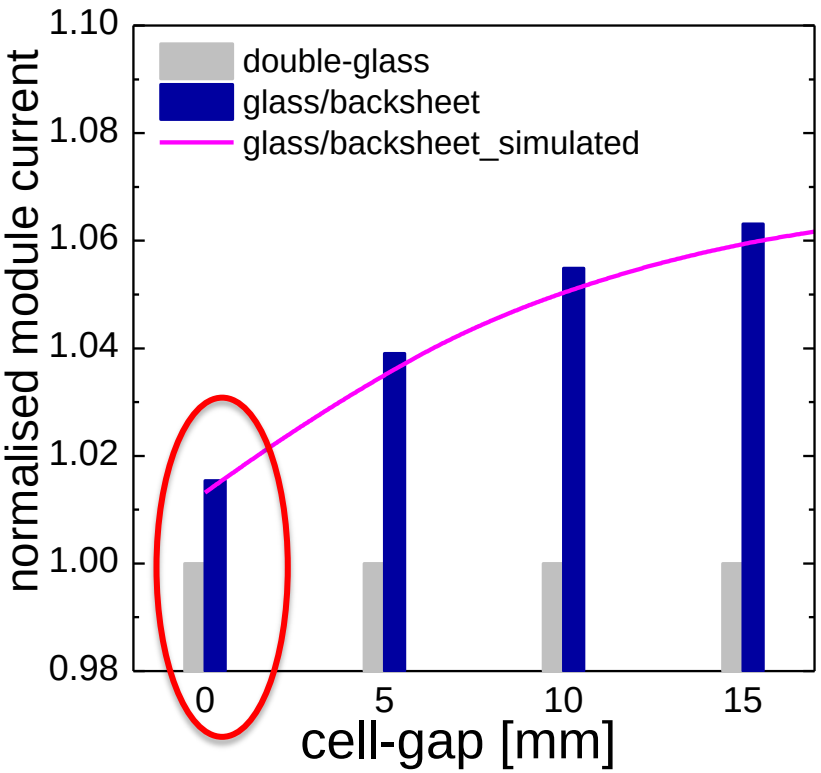
Losses in bifacial modules: optical





- Bifacial cell transmittance losses: ~1.30% compare to the glass/backsheet structure.
- Cell-gap losses: 2-3% compared to glass/backsheet modules.

J. P. Singh, et al. *IEEE Journal of Photovoltaics,* vol. PP, pp. 1-9, 2015.

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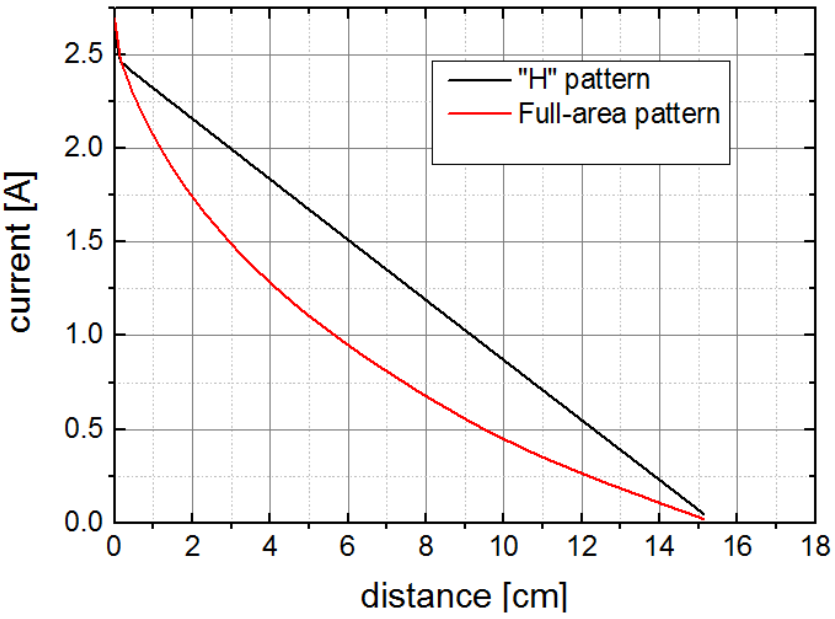
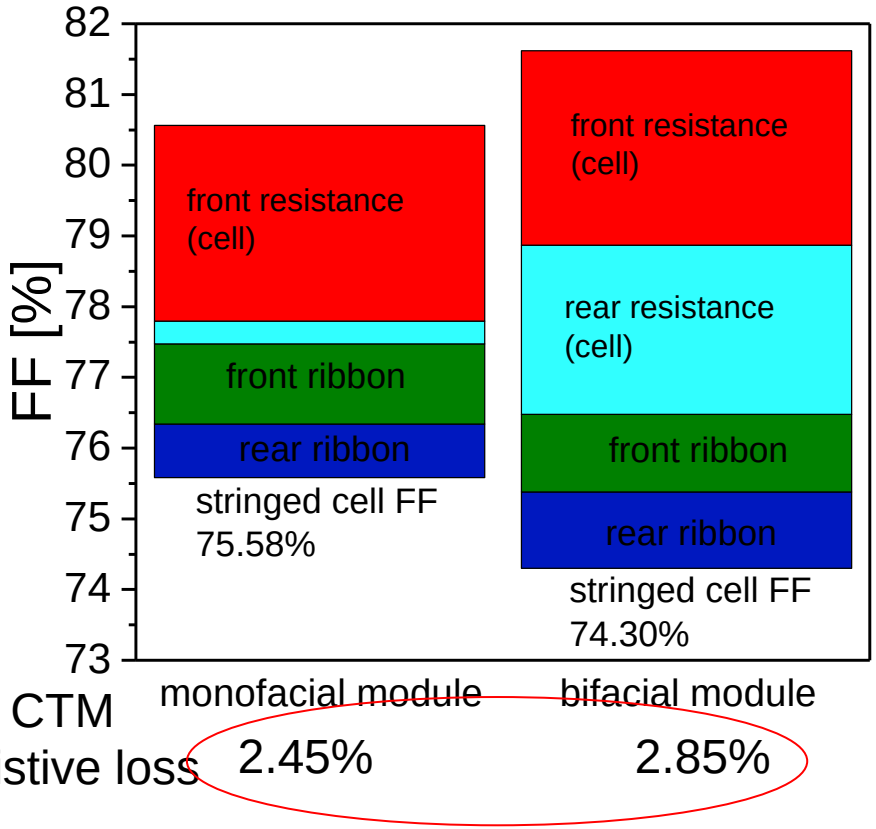
Losses in bifacial modules: resistive





- Current flow pattern is different for monofacial and bifacial cells
- Higher resistive losses in bifacial modules are mainly due to rear side cell and ribbon resistances.

S. Guo, J. P. Singh, I. M. Peters, A. G. Aberle, and J. Wong, *Solar Energy*, vol. 130, pp. 224-231, 2016

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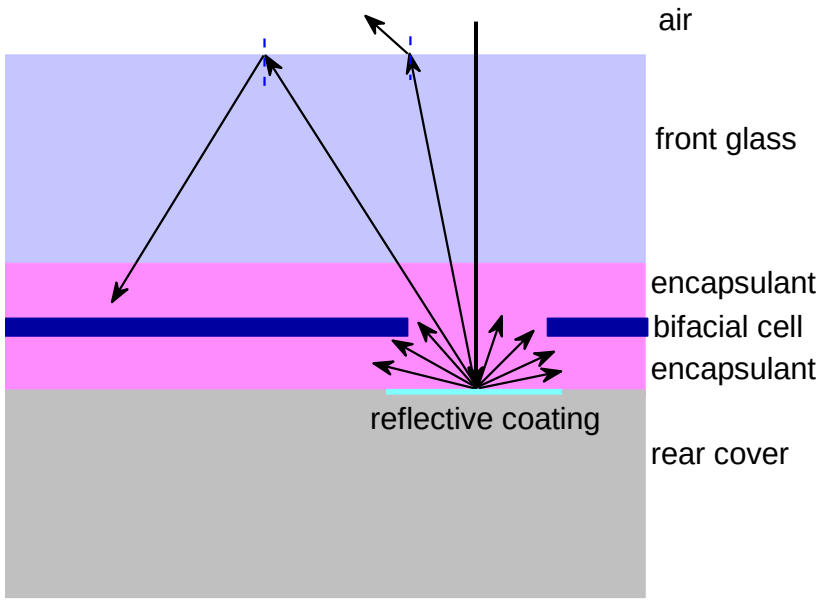
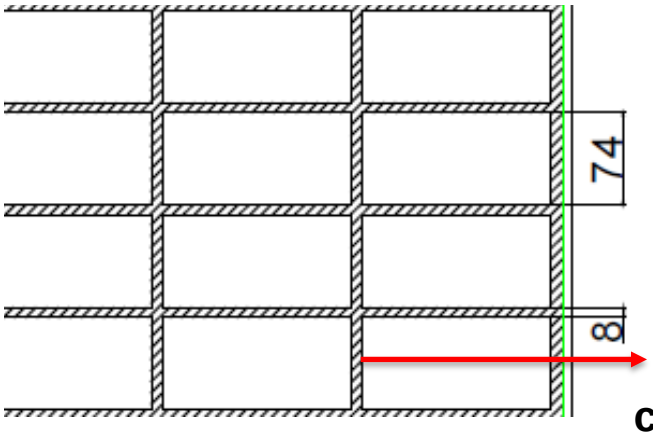
Approaches for loss reduction#1



- Selective white reflective coating in the cell-gap region
- Half-cut cells
- Additional issues with glass alignment and stringing.
- Bifaciality reduces (5-7%)



white reflective coating (cell-gap)

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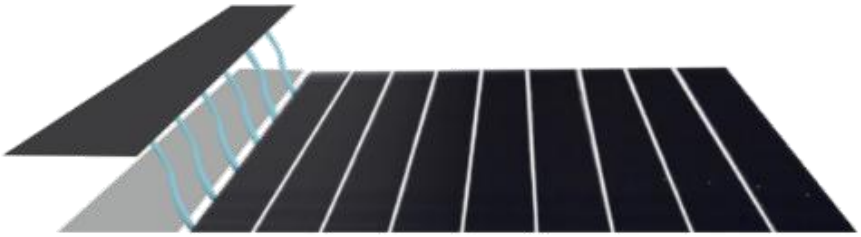
Approaches for loss reduction#2

Shingled bifacial PV modules

- Recently, shingled concept becoming popular for monofacial modules: high power density
- Shingled type interconnection is suitable option for bifacial modules
  - Minimizes the optical and resistive losses
  - High power density, further reducing the module cost.



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Shingled bifacial module: design optimization

- In-house developed simulation tool **Griddler** is used for simulations of shingled and standard interconnections of bifacial cells.
- First, bifacial cells were optimized for grid metallization (number of fingers, busbar width, etc.).
- Same cell parameters were used except the cell metallization (optimized for shingled interconnection).
- The shingled bifacial interconnection design is optimized for
  - number of cell cuts
  - cell-overlap

Electrical parameters of 5-BB bifacial cell

I_{sc} (A)	V_{oc} (mV)	FF (%)	η (%)
9.45	648.0	78.47	19.74

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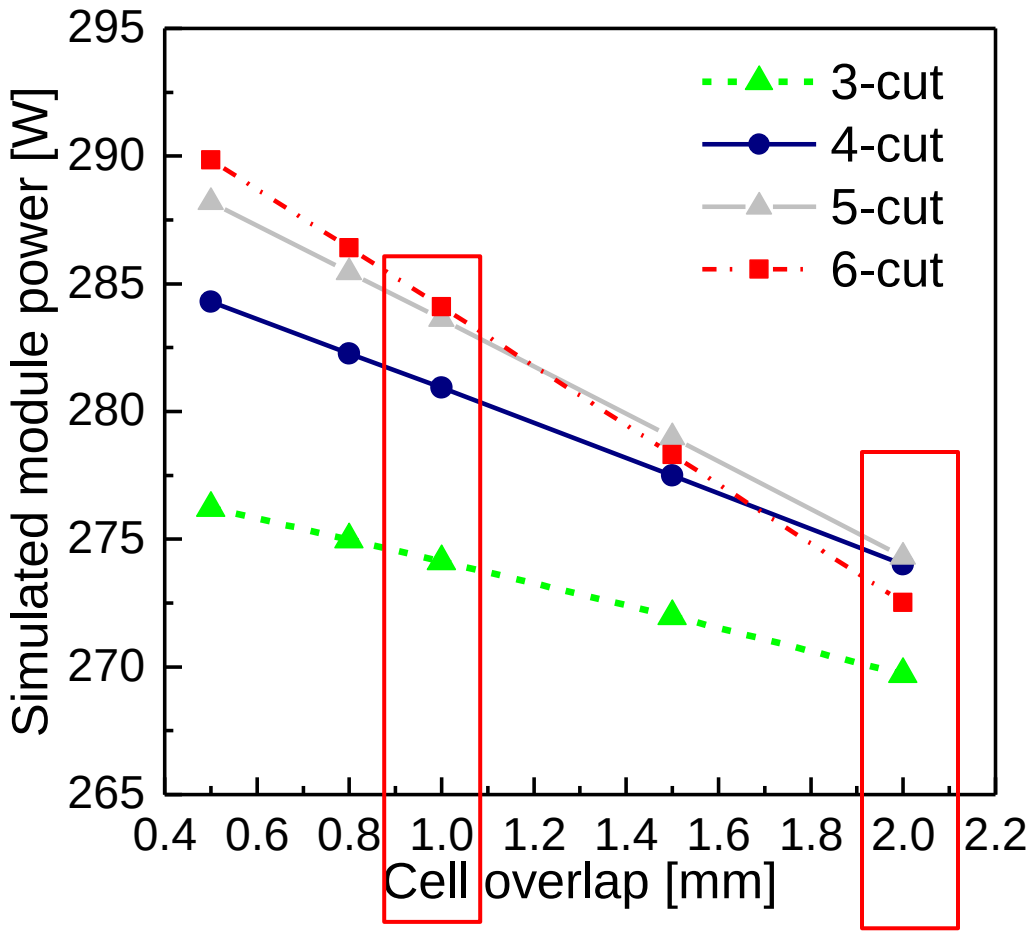
Shingled bifacial module: design optimization



- Number of cell cuts is limited by throughput and cutting losses.
- Cell overlap is limited by lay-up and stringing m/c capability.

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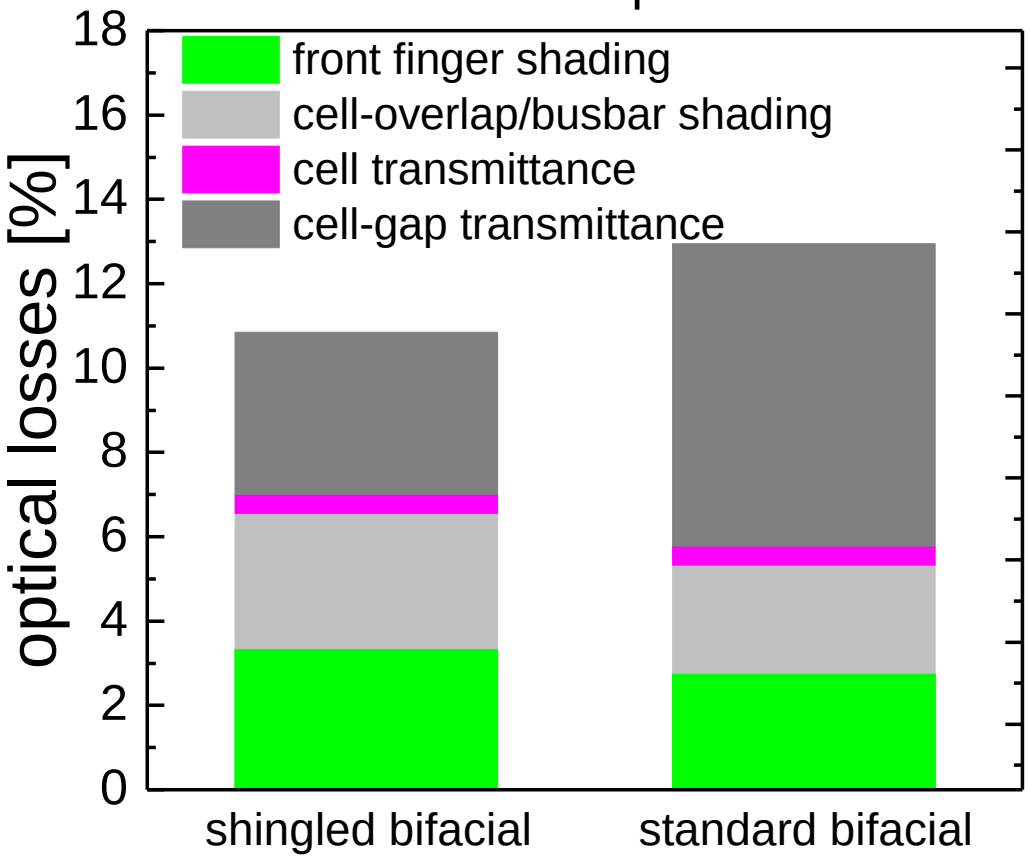
Optical losses: shingled vs standard

- Standard bifacial: 5-BB, 0.9 mm ribbon width, 2.5 mm cell-gap, 3 mm string gap.
- Shingled bifacial: 5-cut, 1 mm cell-overlap, 3 mm string-gap
- Shingled module have ~ 2.1% less optical loss



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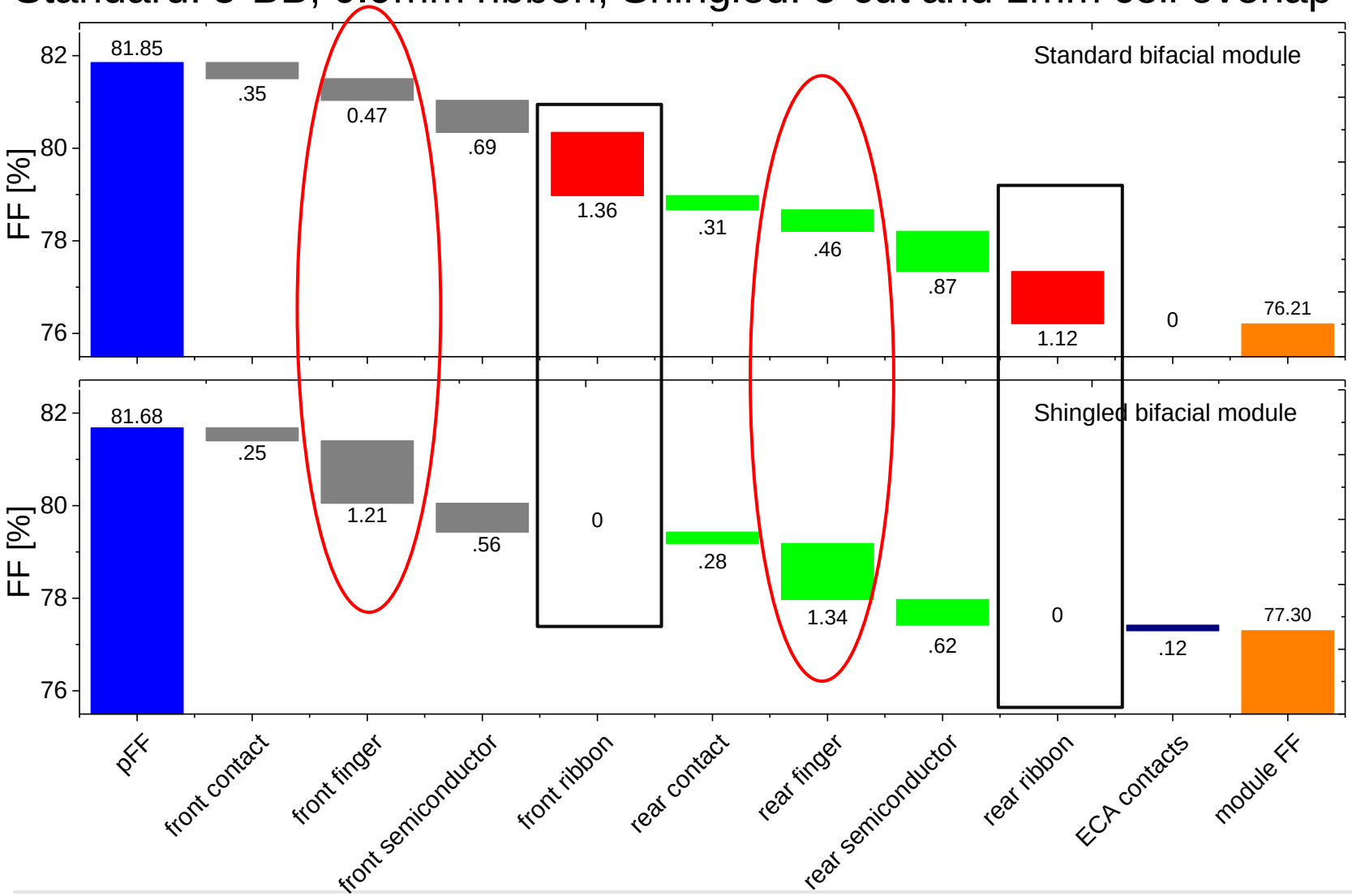
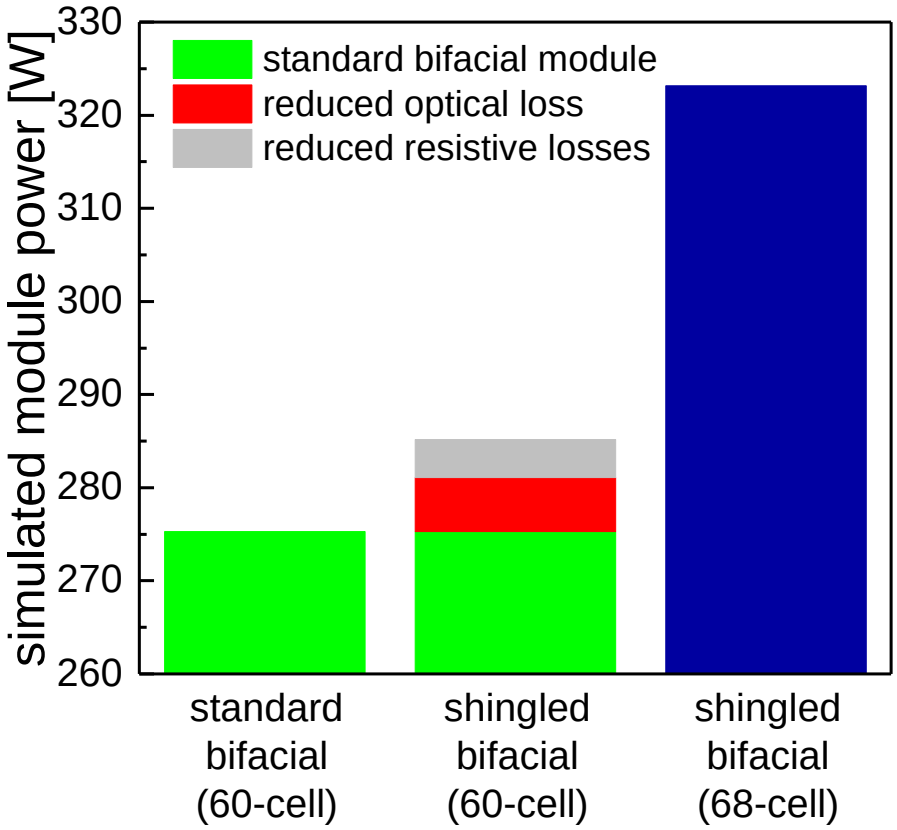
FF losses: shingled vs standard

Standard: 5-BB, 0.9mm ribbon, Shingled: 5-cut and 1mm cell overlap



Shingled bifacial vs standard bifacial

- Bifacial shingled module performance is ~ 3.6% higher
- For the same glass-size, the module power will be even higher (higher packaging density, 68 cells)



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Summary

- Shingled bifacial modules can improve the front side power due to reduced optical and resistive losses: h**igher selling price**.
- Module power can be enhanced further by using more number of cells, further reducing the cost.
- For shingled modules, cell metallization design and modules design should be optimized.
- Module design (cell-cut, overlap) can be optimized by considering the throughput and the performance. (our study:5-cut with 1.0mm)
- Losses in cell-cut process and shingled interconnection (e.g. cost of ECA , alignment) are the main challenges for shingled bifacial modules.

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Thank you for your attention!

More information

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