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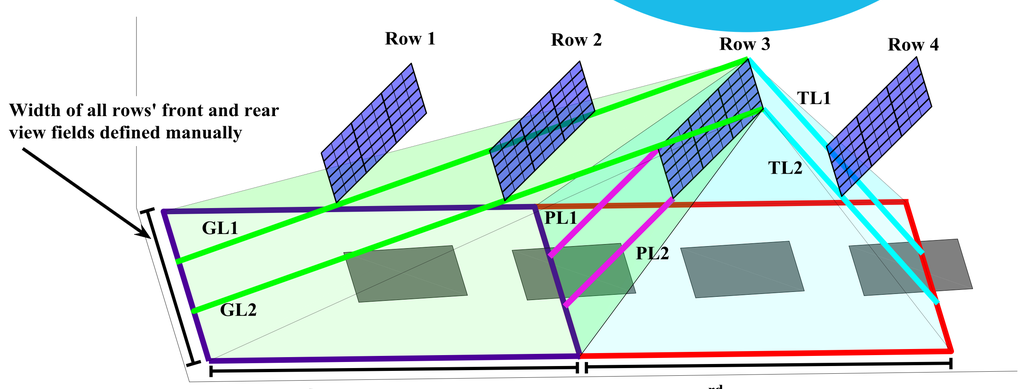
Simulating the Influence of Field Design on LCOE of a Fixed-Tilt Bifacial PV Power Plant

Energy Yield Modelling

- Methodology paper submitted to “Solar Energy” journal, entitled “Simulating the energy yield of a bifacial photovoltaic power plant”.
- Focus on holistic modelling of absorbed irradiation
- Module rows can mutually influence each other’s energy yield.
- 3-D simulation of casted shadows
- Ground-reflected irradiation is calculated using the theory of view factors on module string level.
- Shaded module strings do not contribute to electricity generation.
- Consideration of electrical efficiency’s temperature dependency



Length of 3rd row's front view field defined by green (GL1, GL2) and pink (PL1, PL2) lines

Length of 3rd row's rear view field defined by turquoise (TL1, TL2) and pink (PL1, PL2) lines

Case Study Based on Bifacial PV Power Plant “La Hormiga” (2.5MW), San Felipe, Chile

- Capacity: 72 270W bifacial modules in landscape format (4 rows, 6x3 modules in each row), 19.44kW$_{dc}$ in total (capacity reduced in order to save computation time)
- Lifetime: 30 years, interest rate: 2.74%
- Ground reflectivity: 25% (dry grassland)
- Cost categories: modules, inverters, installation’s labour & equipment, operation & maintenance (annual increase by 2%), building land (leasing rate increases by 2% annually) and mounting (depends on installation height)

Results

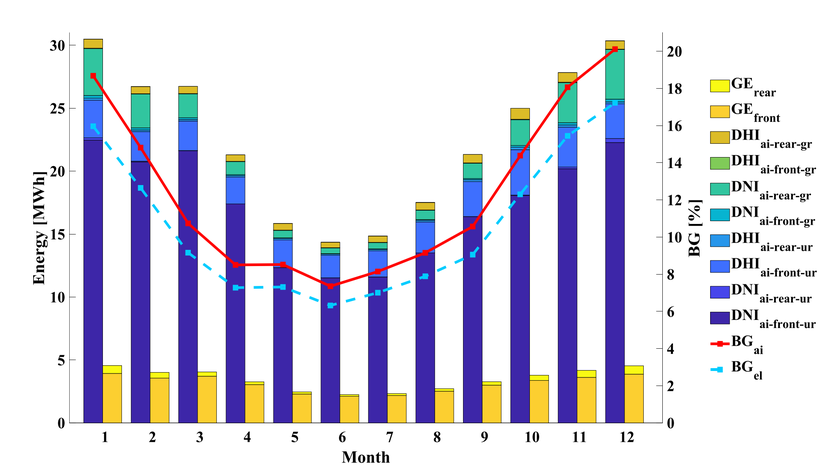


Figure 1: Simulated absorbed irradiation, generated electricity, BG_{ai} and BG_{el}

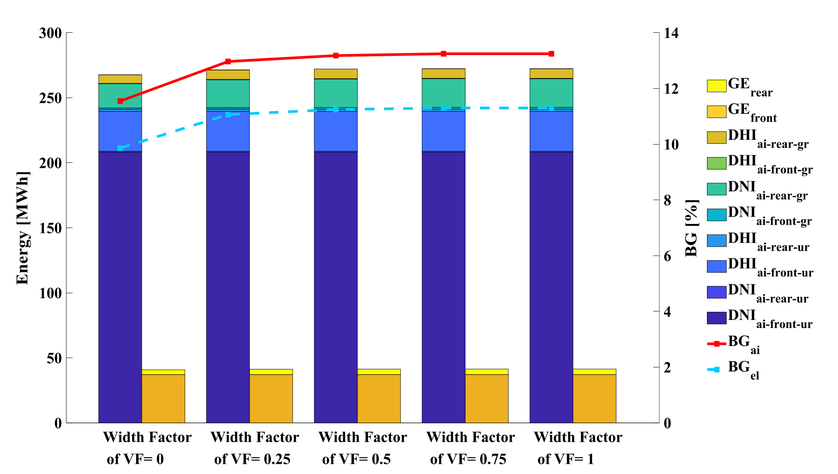


Figure 2: Impact of the view fields’ width (corresponding to the building land’s width) on the annual energy yield.

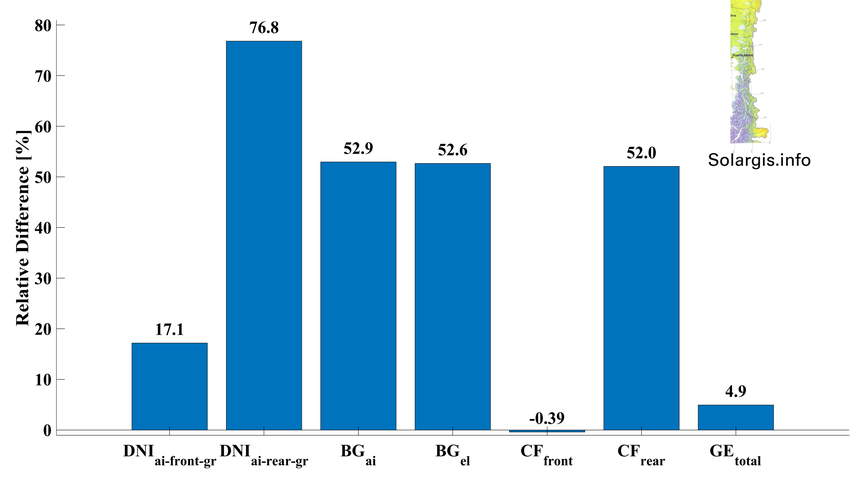


Figure 3: Relative difference of selected parameters based on two scenarios: 1. Casted ground shadows do not exist, 2. Casted ground shadows do exist.

Indicies: GE: Generated electricity, DHI: Diffuse horizontal irradiation, ur: unreflected, gr: ground-reflected, BG_{ai}: Bifacial gain in absorbed irradiation, BG_{el}: bifacial gain in electricity generation, CF: capacity factor

Variation of module elevation and row spacing @ slope= 25°. View field’s width extended by 50% to both sides of a module row.

Figure 4: LCOE. The red cross indicates the PV field’s configuration yielding minimal LCOE.

Figure 5: BG_{el}.

Figure 6: Specific electricity yield (regarding front-side capacity) over lifetime.

Figure 7: Cost breakdown of PV power plant's configuration achieving $LCOE_{min}$.

Conclusions

Energy Yield

- Presented methodology determines the composition of absorbed irradiation and the impact of casted ground shadows on total energy yield.
- Increasing the width of building land results in an asymptotical increase of energy yield.
- For validation, the specific electricity generation of 52 days was compared with “La Hormiga” generation data of 2017 → overestimation by the model of 6%.

LCOE

- The PV field’s configuration yielding minimal LCOE does not correspond to the configuration with maximal electricity generation.
- A slight increase of row distance does pay off both economically and energetically, since self-shading is reduced; a further increase does not pay off economically since building land is associated with costs.
- A slight enhancement of building land’s width does pay off economically.

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