› BIGEYE

simulation under shadow conditions | Dr. A.R. Burgers

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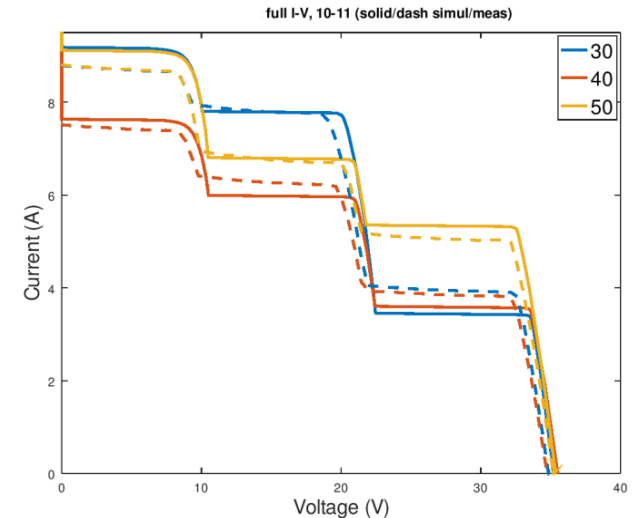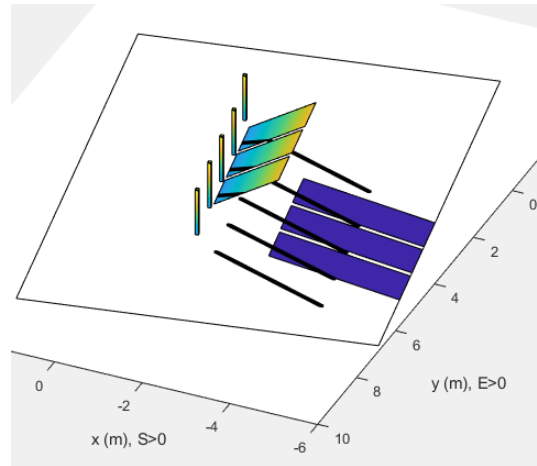
Use button 'Pictures' 📷 to change background
Text-only start sheets can be added using 'New slide/Nieuwe dia'

SHADING IN BIFACIAL PV SYSTEMS

- › Complex geometries
- › Partial shading of modules and cells
  - › Complex IV characteristics
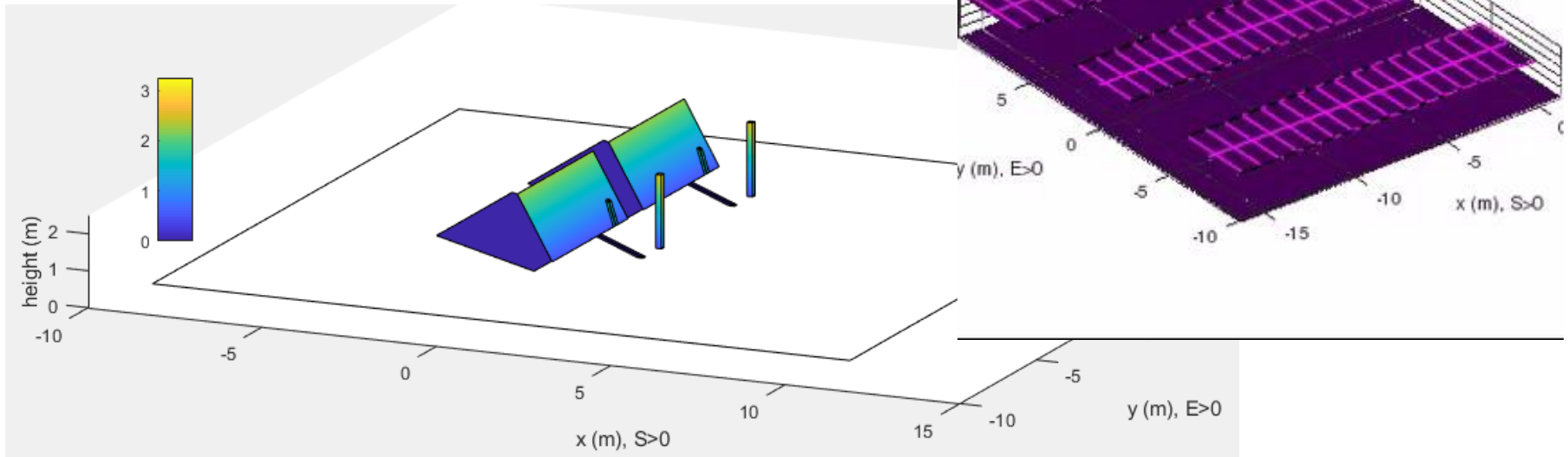- › What is the impact on system performance?


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BIGEYE: ENERGY YIELD OF BIFACIAL SYSTEMS

‹ Full 3D geometry
  ‹ PV sheds
  ‹ Diffuse reflectors
‹ Bifacial, partially transparent, modules
‹ Single Axis Tracking (SAT)

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Total W/m2 (azi=61,hgt=0.8,beam=0.0,diff_hor=0.4)

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BIGEYE: MODELS

› Deals with self shading, end of shed effects.
  › 3D view factor numerical approach
› From GHI, DHI timeseries
› Thermal model: $T_{cell} - T_{ambient} = f(G_{fr,POA}, G_{re,POA}, U_{wind})$
› Cell IV, partial shading
› Mismatch in IV on cell, module, string level.

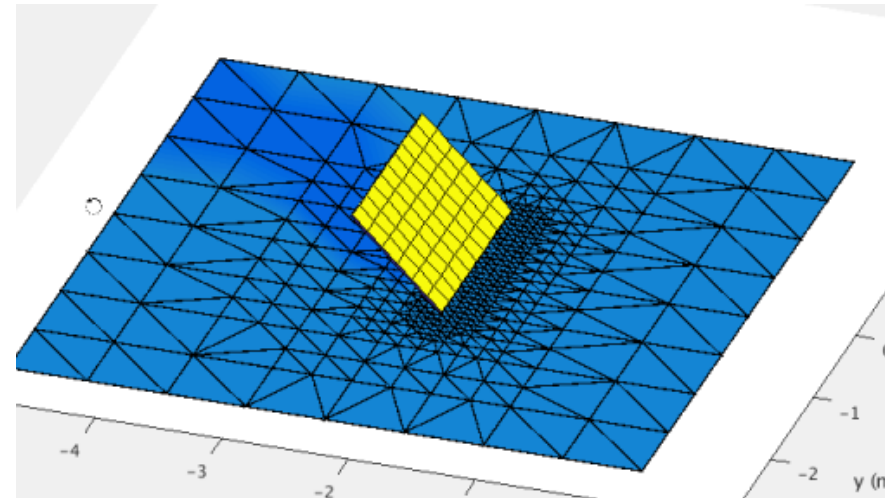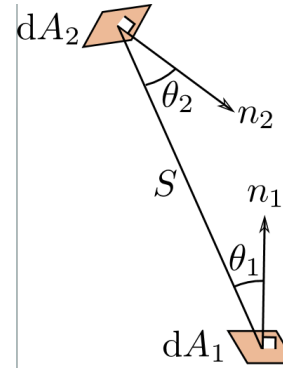shaded sky dome+horizon irradiance @ 500.0 W/m2
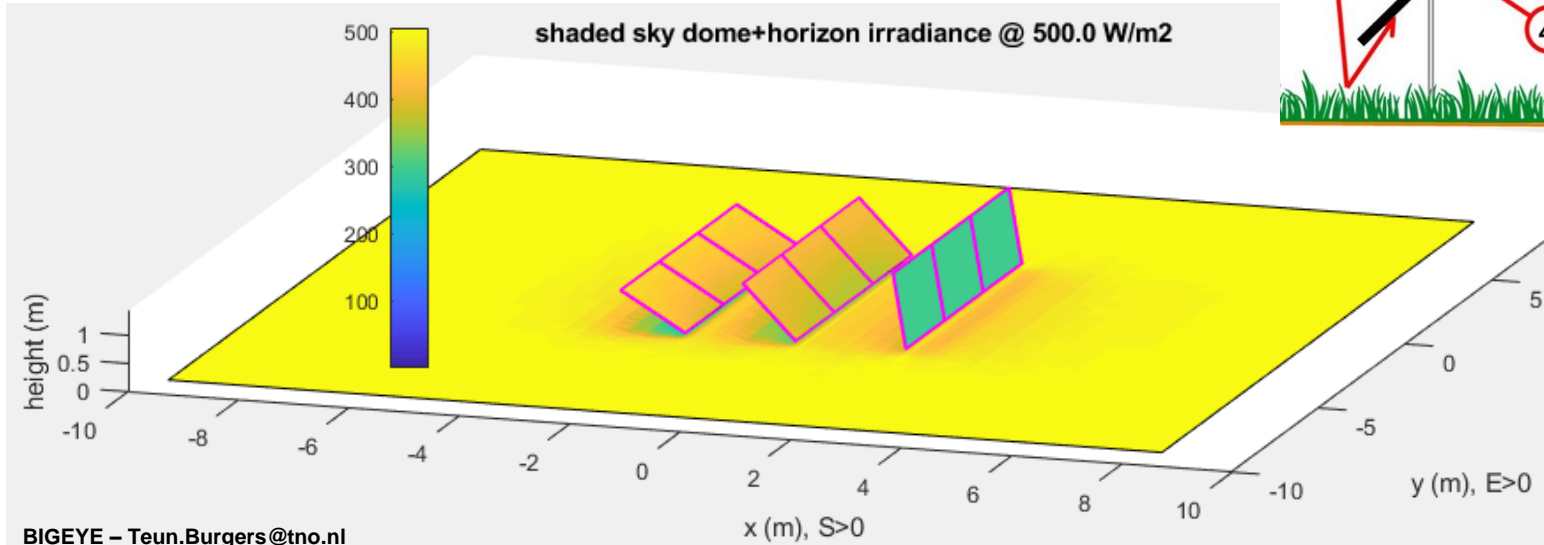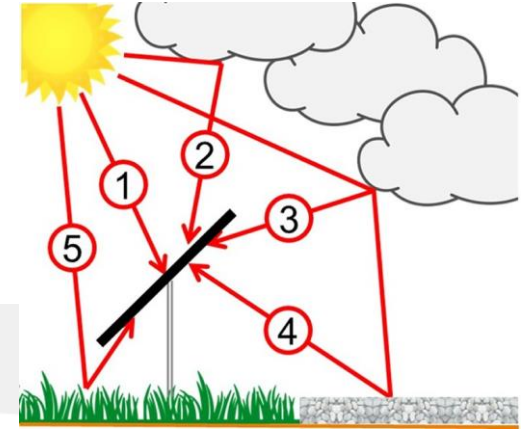
3-D VIEW FACTORS

> Infinitesimal view factors between elements dA_1 and dA_2

$$F_{1\rightarrow 2} = \frac{\cos\theta_1 \cos\theta_2}{\pi s^2} dA_2$$
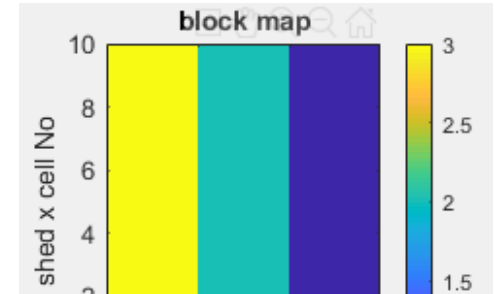
> Exchange over a larger area by integration

$$F_{1\rightarrow 2} = \frac{1}{A_1} \int_{A_1} \int_{A_2} \frac{\cos\theta_1 \cos\theta_2}{\pi s^2} dA_2\, dA_1$$

> Invalid when sizes A_1, A_2 large compared to S

> Refine mesh: combine good accuracy with limited computational effort

BIGEYE: TOWARDS AN IV CURVE

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- Irradiance on PV surface
  - sub solar cell spatial resolution to resolve shades

- Cell IV: curve per cell, including reverse characteristic

- Block IV:
  - 6x10 module: typically 3 bp diodes, each 2x10 cells
  - Series connect IV of cells in block
  - Apply (ideal) bypass diode characteristic
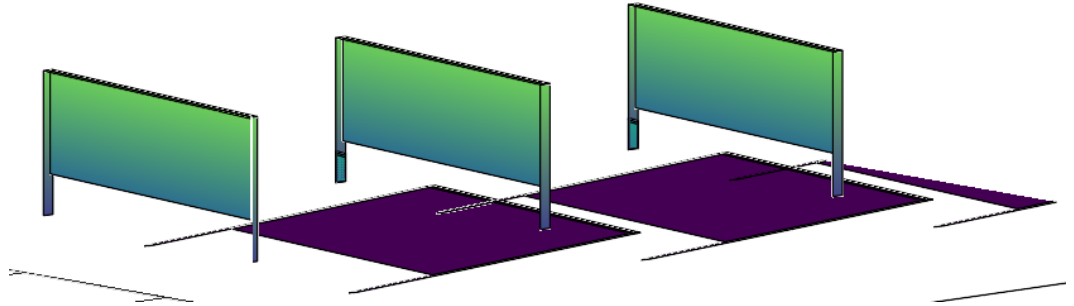
- String IV
  - Series connect IV of blocks
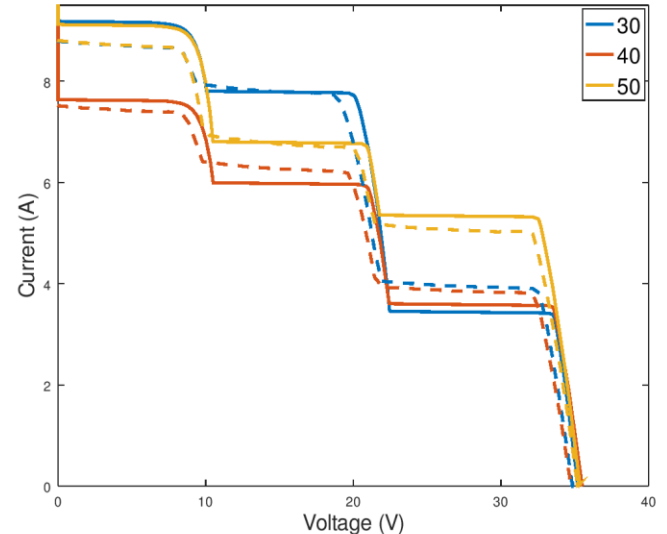
BIFACIAL VERTICAL PV

› E/W facing PV
› Shades cast by frame


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IMPACT OF SHADING ON YIELD

> Different local optima in the P(V) curve
> Large voltage jumps associated with the optima
> Mpp tracking algorithms in optimizers and inverters:
>> Local mpp tracking with high frequency
>> Global mpp search with low frequency
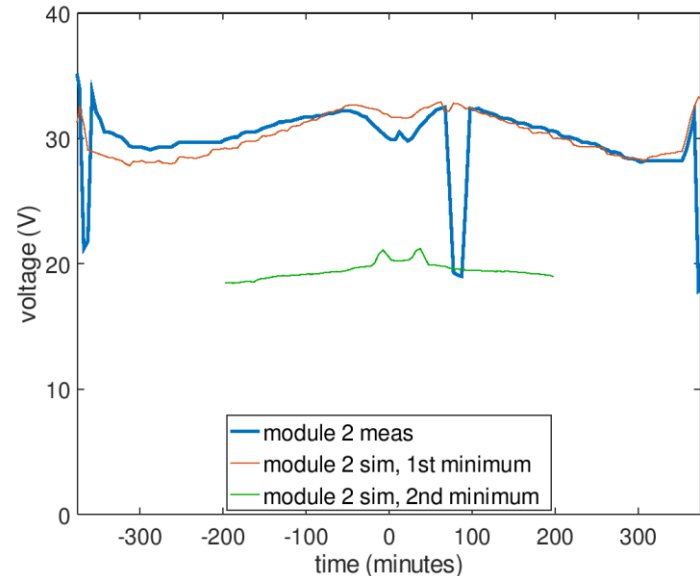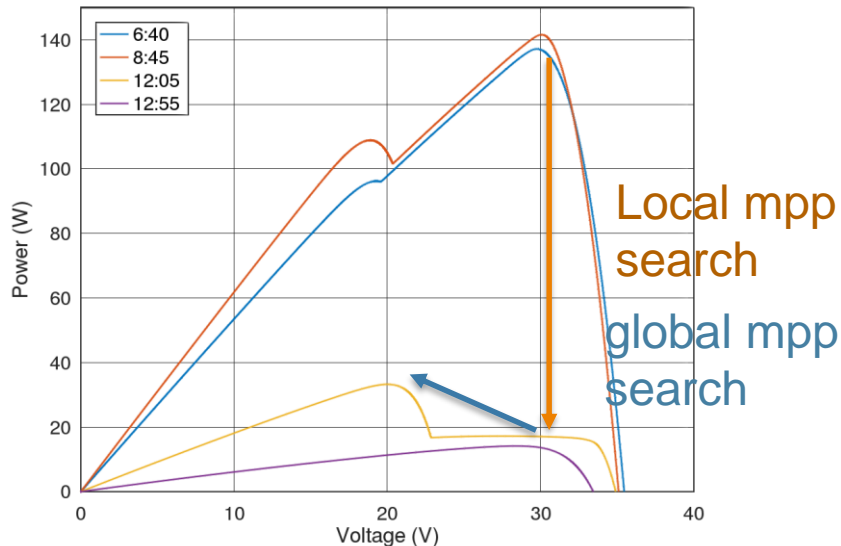
BIFOROT VALIDATION

- Set-up at Zurich University of Applied Science
- Simulation programs
    - PVsyst
    - MoBiDig (ISC)
    - BigEYE (ECN.TNO)

- Conclusions from the comparison [1]
    - The three simulation tools
        - give similar results
        - are in agreement with the experiment
    - bifacial yield modeling is reaching a stage of maturity.

[1] Accuracy of Simulated Data for Bifacial Systems   with
    Varying Tilt Angles and Share of Diffuse Radiation,
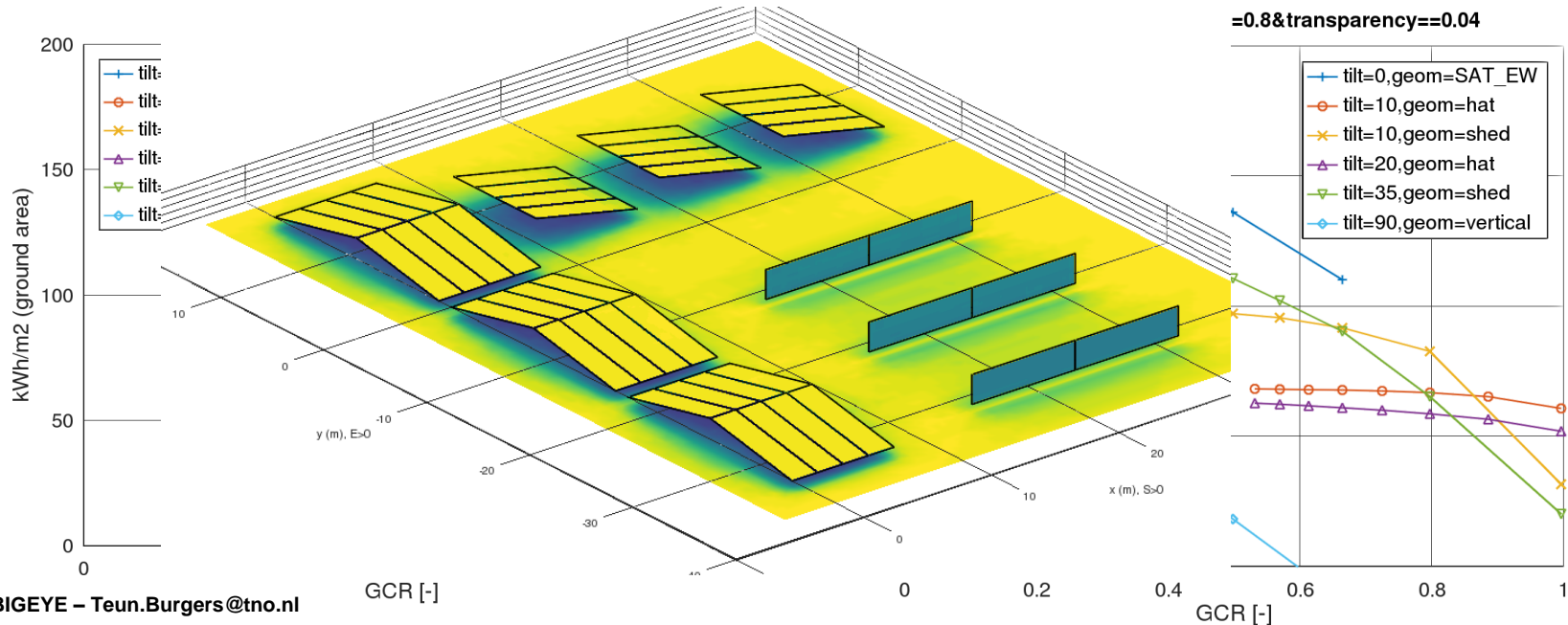   Hartmut Nussbaumer et Al, submitted to Solar Energy
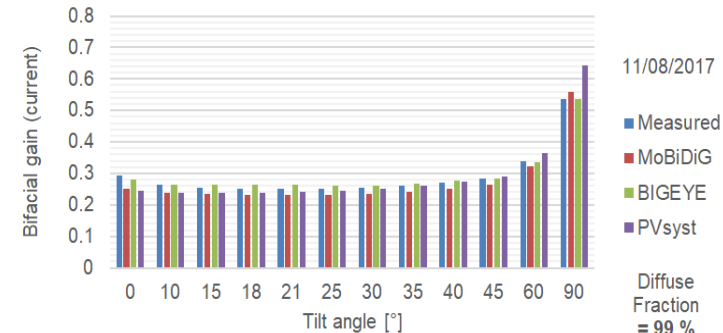
BIGEYE VALIDATION: HOPEWELL SITE (NC)

> 1 MW commercial bifacial SAT site
>> With US DoE grant for additional instrumentation and validation
>>> T_{module}, albedo, $G_{POA,fr}$, $G_{POA,re}$
> PV Evolution Labs Cypress Creek Renewables

May,e1: INV07-INV09

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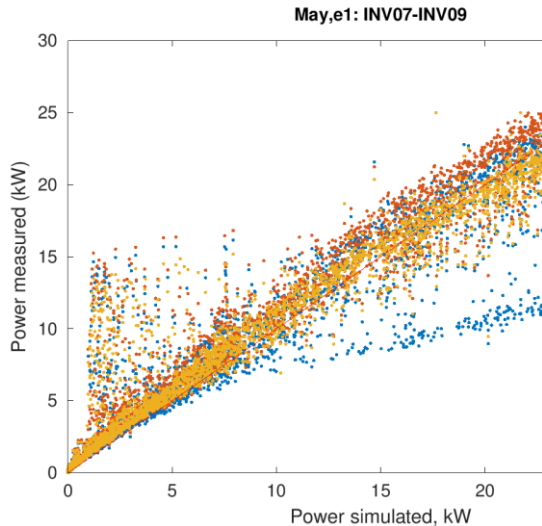
BIGEYE: SYSTEM DESIGN

› Site layout

  › Design e.g. for kWh/m², kWh/kWp

  › With edge effects

  › As function of e.g. albedo, geometry, transparency

=0.8&transparency==0.04

Legend (right plot):
- tilt=0,geom=SAT_EW
- tilt=10,geom=hat
- tilt=10,geom=shed
- tilt=20,geom=hat
- tilt=35,geom=shed
- tilt=90,geom=vertical

SUMMARY

› Versatile

› Accurate, but fast

› Validated
  › In numerous smaller set-ups and projects
  › Bifacial SAT production site to be reported soon.

› Useful for
  › providing reliable data for bankability of bifacial PV
  › Design of complex PV systems
  › Detailed analysis of measurement data

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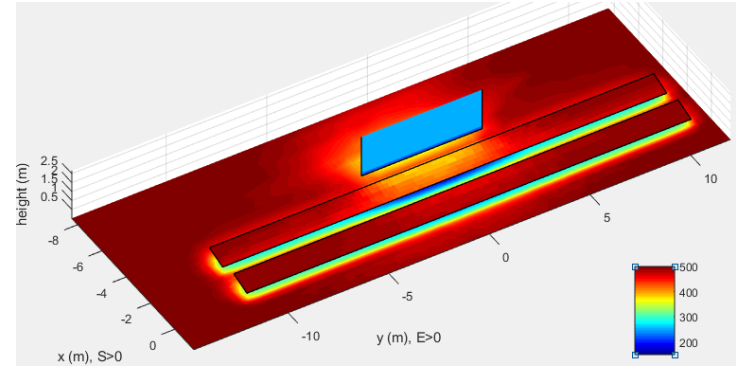
THANK YOU FOR YOUR ATTENTION

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