# BIGEYE: Accurate energy yield prediction of bifacial PV systems

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## Motivation

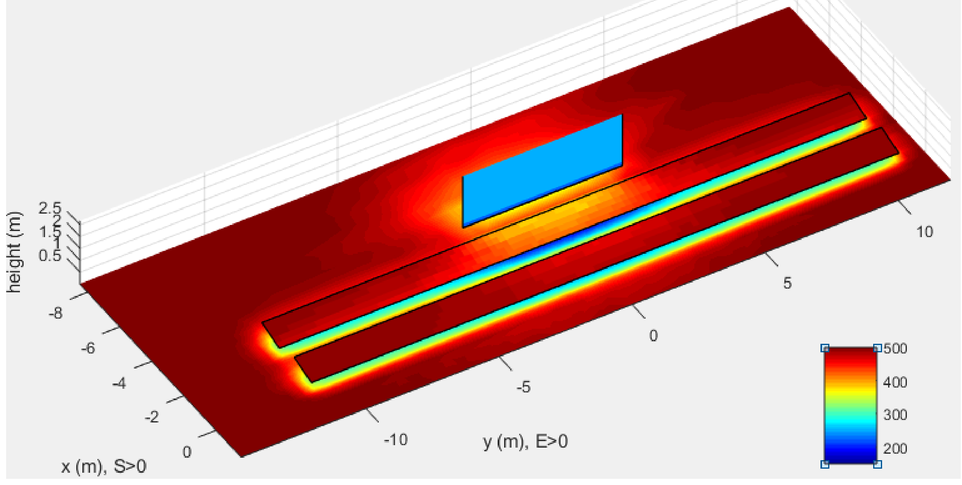
- Give stakeholders trust in
  - bifacial plant design
  - lower cost of electricity generation by bifacial PV
  - the anticipated return on investment
- Through accurate kWh predictions
  - at specific locations
  - based on (hourly resolved) climate data

## Flexible geometry

- Sheds:
  - arbitrary positions and tilt
- Diffuse reflection
  - from ground and walls
- Single Axis Tracking (SAT)

## Proven

- Based on earlier versions[1]
- Benchmarked[2]




- Sky irradiance on a configuration of 2 sheds and a single diffuse reflecting wall behind those sheds

## Irradiation model

- Direct radiation components
  - beam, circumsolar
  - sky dome
  - horizon brightening/darkening
- Indirect, using full 3D view factors
  - diffuse reflection of the ground
  - diffuse reflection of other reflective surfaces
  - adaptive meshing
- Account for shading effects in all components

## Meteo and module optics

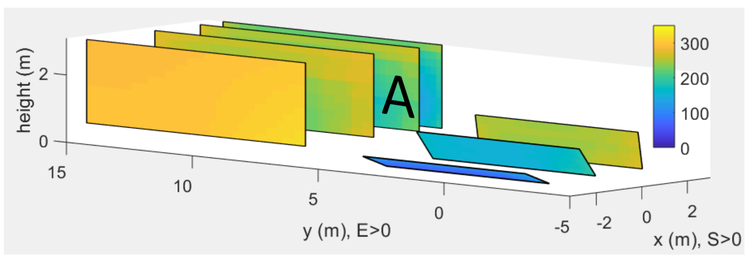
- Perez model
  - for single shed, front and rear side
  - circumsolar (CS) component
  - horizon brightening or darkening
  - account for shading in CS and horizon
- Module optics:
  - AOI modifiers
  - homogeneous transparency

## Cells, blocks, strings

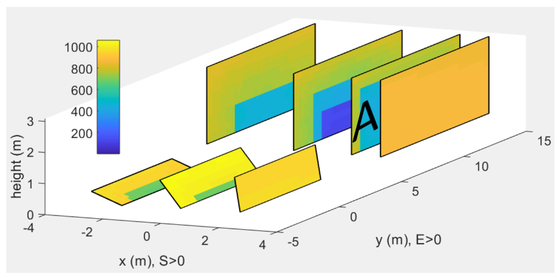
- Cell I-V from front- and rear irradiance and module thermal properties
- Block:
  - set of cells protected by by-pass diode
- Partial shading on cells
  - has impact on block output,
    - then on string output
  - effects handled with Rodrigo's model[3]

## Example: varying pitch, size and tilt angle of sheds

rear side: total irradiance

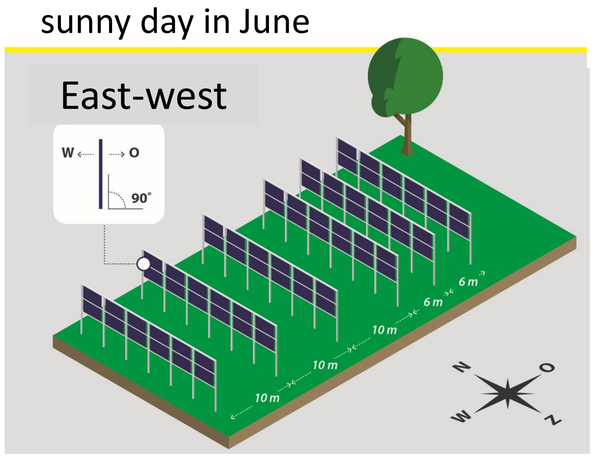


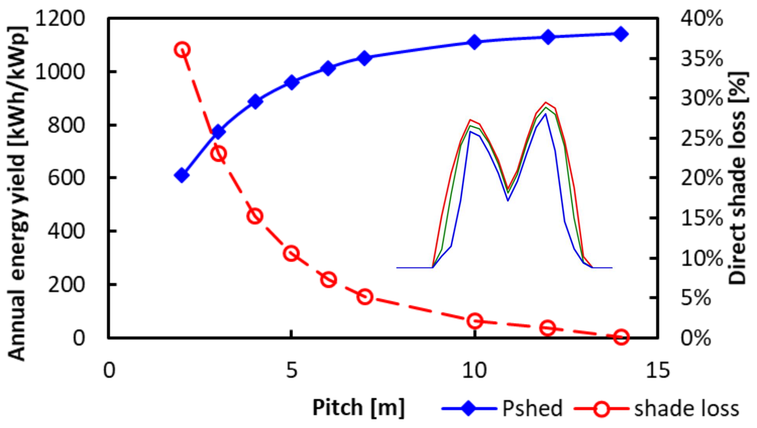

front side: total irradiance




## Example: varying pitch for vertical PV system

- 6 sheds consisting of 6x2 bifacial modules
- n-PERT modules, 300 Wp, with 75% bifaciality factor
- landscape, ground clearance 1 m
- location: Petten, the Netherlands
- inset: daily yield for three pitches, sunny day in June

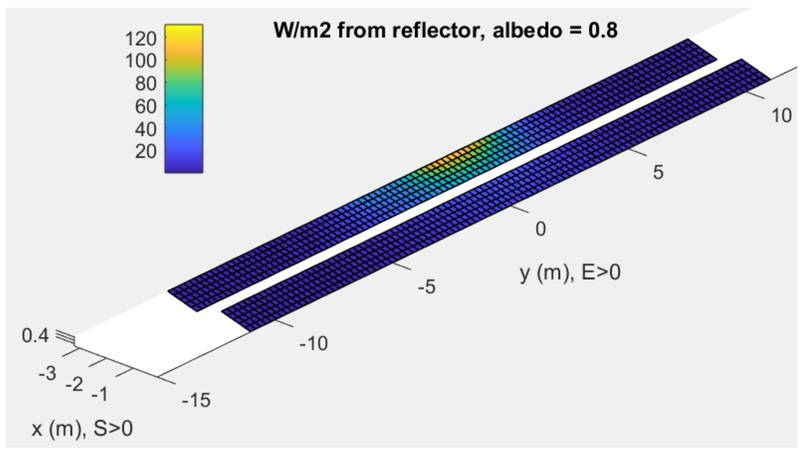



- Large pitch: 1140 kWh/kWp
- Below 5-7 m, energy yield decreases rapidly
- Direct shading is dominant factor ~65% of total loss
- Less sky contributions (view factor limitations) and less ground reflection amount to 35% of yield loss

## Reflecting wall impact

See figure on top right of poster




- Wall limits view of sheds on sky:
  - diffuse sky irradiance reduced near wall
- Wall diffusely reflects sky- and beam it receives:
  - adds to irradiance on sheds

## Acknowledgements

project Biface: Netherlands Enterprise Agency, www.rvo.nl
solar-era.net, www.solar-era.net
project BING: TKI Solar Energy, www.tkisolarenergy.nl

1. G.J.M. Janssen et al., Energy Procedia **77** (2015) 364
2. M. Klenk, biforot project, this workshop
3. Rodrigo et al., Solar Energy **93** (2013) 322