The Outdoor Bifacial PV Testing Facility and Technical University of Denmark

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The Outdoor Bifacial PV Testing Facility at Technical University of Denmark

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Background: Since summer 2018, European Energy A/S and DTU have measured the performance of bifacial PV strings mounted on trackers and fixed tilt systems located in Northern Europe (55.6° N, 12.1° E). A new publically funded project is underway with the intent to evaluate in-house and commercially available bifacial PV performance models. The facility includes several sub-systems where the conditions known to affect bifacial performance are varied including tracker spacing (GCR), albedo (ρ) and module tilt (θ).

Equipment and Layout
- Monofacial and bifacial strings of similar front side power mounted side-by-side.
- Horizontal East-West (HSAT) trackers (x8) and south facing 2V racks with adjustable tilt angle (x8).
- Tilted single axis trackers (x2) and dual axis tracker (x1).
- Multiple ground covers under test:
  - Seasonal grass
  - Coarse sand
  - Medium-size gravel
  - White polymeric tarp
  - μ-structured reflector
  - GHI (broadband)
- Tcell
  - Cell temperature (Tcell)
  - DHI (broadband)
- Multiple ground covers under test:
  - DHI (spectral)
- Coarse sand
- Multiple ground covers under test:
  - PV electrical parameters
- GHI (broadband)
- Horizontal East

Sensors and Detailed Monitoring
- Monitoring independent of inverter measurements
- DC Power meters with isolated surface mount resistors and digital filtering
- Spectroradiometers for diffuse and beam measurements (300-1100 nm) for investigation of spectral effects.
- Solar radiation Measurements include:
  - DNI (spectral)
  - DNI (broadband)
  - DHI (spectral)
  - DHI (broadband)
  - GHI (broadband)

Albedo sensors at four locations around the facility.

Tracker error monitor for single axis trackers.

Albedo of grass as measured by Class A pyranometers vs. Class C photodiodes.

Performance Modeling
We are using the onsite meteorological data as inputSs to bifacial PV models. The model’s output is then compared to our electrical measurements. View factor models under consideration currently include MoBiDiG (ISC Konstanz), PVsyst, and SAM. Ray trace models currently being tested include Zemax and Radiance.

Measured Model Outputs
- DC+AC power
- Transposed irradiance
- Cell temperature (Tcell)

Obtain Model Outputs
- Solar radiation
- Albedo (ρ)
- Shade Scene, tracker features

Compare to Field Measurements
- Plane of array irradiance (front and rear)
- Tcell (currently only mono-f)

Model Assumptions

Measured vs. Measured power of four rows of 25° fixed tilt bifacial systems mounted on seasonal grass over 6 months (Jan. - Jul. ’19).

Distribution of back of module irradiance on the center module within the ‘2V’ module string during a clear sky conditions (ρ = 20%, θ = 25°). Both the top [left] and bottom [right] modules in the 2V configuration are shown.

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