The Outdoor Bifacial PV Testing Facility and 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 publicly 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 ρ ≈ 20%
  - Coarse sand ρ ≈ 28%
  - Medium-size gravel ρ ≈ 26%
  - White polymeric tarp ρ ≈ 76%
  - μ-structured reflector ρ ≈ 63%

Sensors and Detailed Monitoring
Max-power current (I_m) and voltage (V_mp) measurements on 64 individual strings.

Four panels with 10 individually measured 5” mono-Si cells for studying distribution of rear side irradiance.

Performance Modeling
We are using the onsite meteorological data as inputs 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
Simulation
Compare to Field Measurements
- DC+AC power
- Plane of array irradiance (front and rear)
- Tcell (currently only mono-f)

Model Assumptions
- DHI, DNI, Albedo, GHI, and Windspeed
- PV electrical parameters
- Shade Scene, tracker features

Measured Model Inputs
- Integrals, DNI, DHI, GHI, and fixed tilt bifacial view factor models under various scene, tracker features, and BSDFs.

Spectroradiometers for diffuse and beam measurements (300-1100 nm) for investigation of spectral effects.

Albedo sensors at four locations around the facility.

Tracker error monitor for single axis trackers.

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