The Outdoor Bifacial Test Facility at 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 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 (β).

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_{max}) and voltage (V_{max}) measurements on 64 individual strings.
- Measured Model Inputs:
  - DNI, DHI, Albedo, GHI, Tamb and Windspeed
  - PV electrical parameters
  - Shade Scene, tracker features

Performance Modeling
- We are using the onsite meteorological data as input 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.

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

Compare to Field Measurements
- DNI and DHI, Albedo, GHI, Tamb and Windspeed
- PV electrical parameters
- Shade Scene, tracker features

Obtain Model Outputs
- Simulate structural geometry
- Obtain bifacial power
- Compare to field measurements

Distribution of back of module irradiance on the center modules within the '2V' module string during a clear sky conditions (top (left) and bottom (right) modules in the 2V configuration are shown.

Albedo sensors at four locations around the facility.
- Albedo meter (Class A)
- Albedo meter (Class B)
- Albedo meter (Class C)

Tracker error monitor for single axis trackers.

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

Solar radiation Measurements include:
- DNI (spectral)
- DNI (broadband)
- GHI (spectral)
- GHI (broadband)

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- Startak

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