High spatial- and temporal-resolution performance modeling and comparison to field measurements

Christopher E. Valdivia, A. C. J. Russell, T. J. Coathup, N. Anderson, E. Hussary, K. Pollak

enurgen Inc., Ottawa, Ontario, Canada | chris@enurgen.com | https://enurgen.com

Challenges:

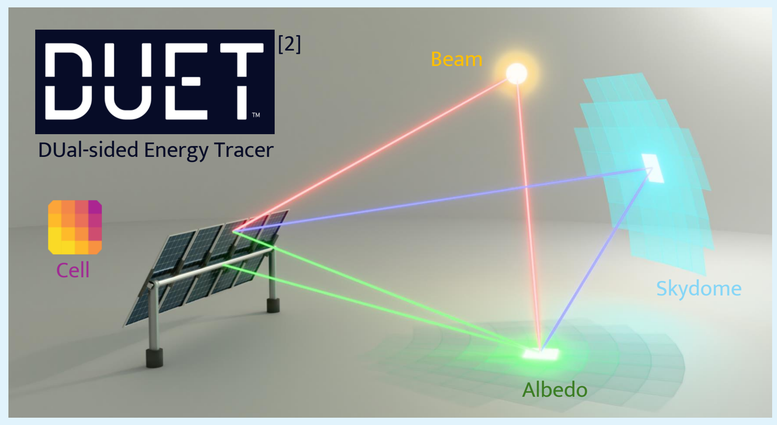
- Persistent 7-13% P50 under-performance [1]
- Minutely system behavior
- Bifacial performance accuracy
- Precise and flexible modeling with full optimization

Objectives:

- Model-to-field accuracy & precision in face of spatial and temporal variability
- Reduce uncertainty: eliminate empirical factors
- Reproducibility: physical inputs

Model Continuity:

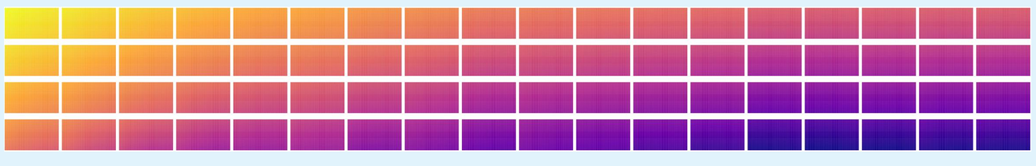
- Apply model across entire plant lifecycle
- Real-time performance baseline
- Accurate power profile forecast
- Expandable as plant grows or is retrofitted



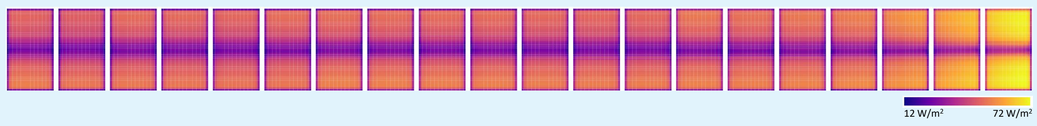
Irradiance

- DUET generates 2D profiles, every timestamp
- Captures spatial and temporal variability
- Model-to-measurement fit is sensitive to 3D sensor position
- Impacted by shading environment, including racking details

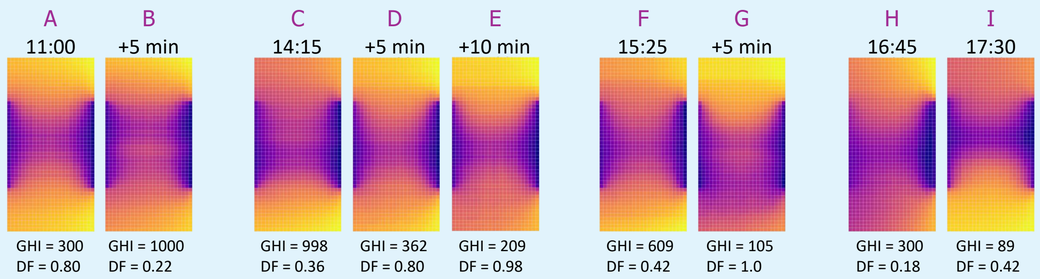
Front Irradiance (4L Table)

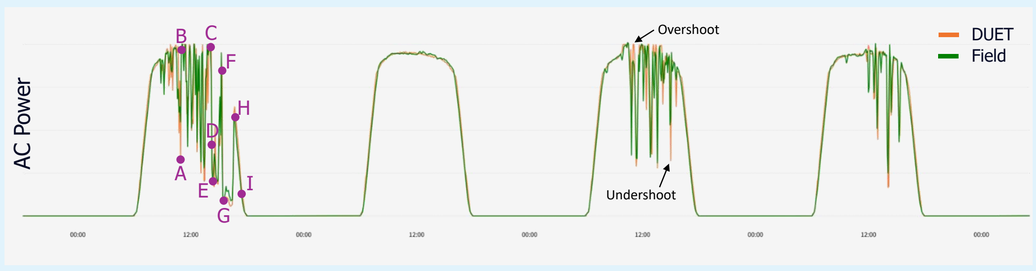


Rear Irradiance (1P Table)

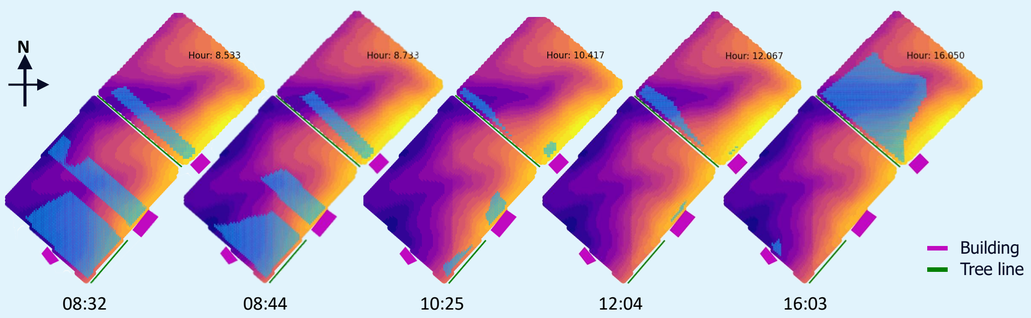


Rear Variability



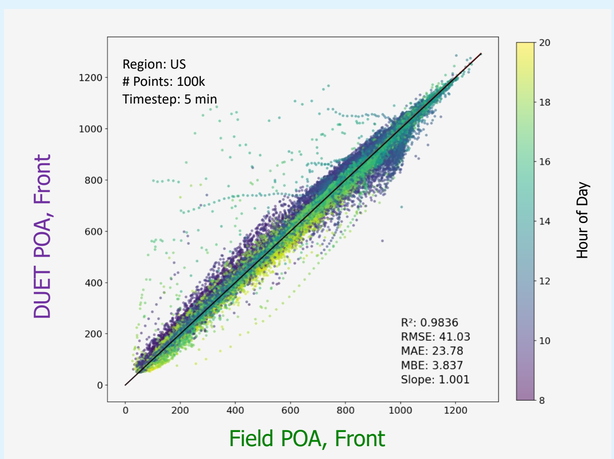


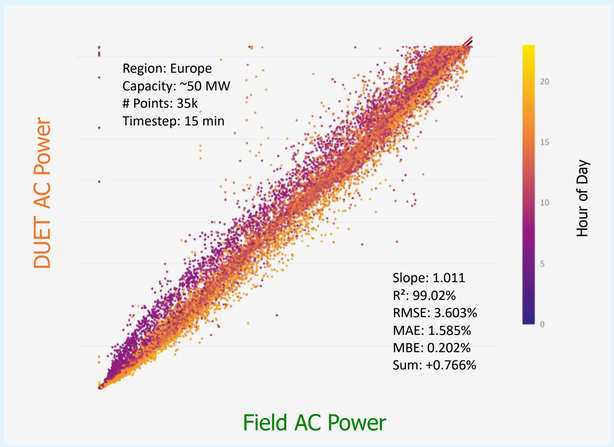
Near Shading & Terrain

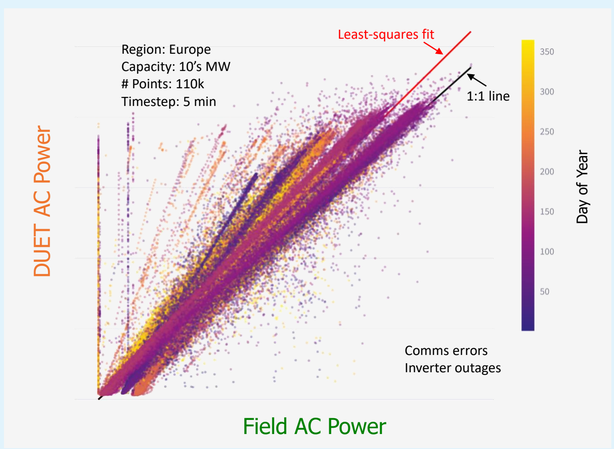


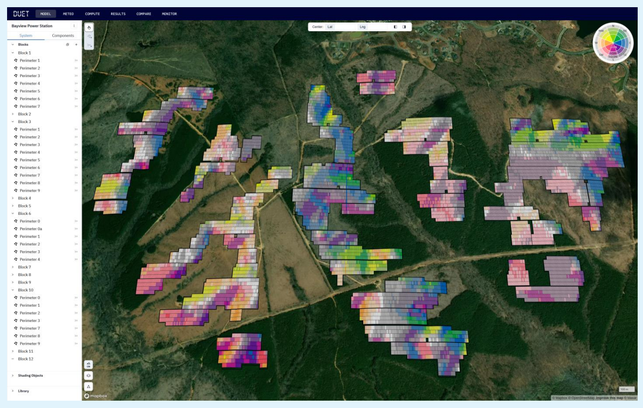
Model vs Field: Energy Yield

- Detailed system layout
- Each block is independent
  - equipment
  - environmental data
- In-app comparison of DUET results to other simulations and field data

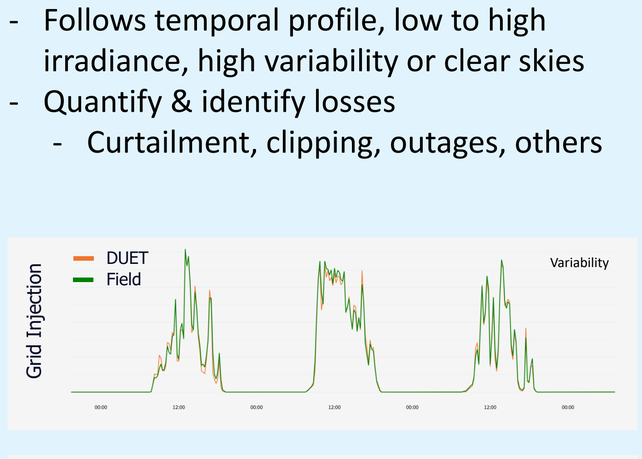








- Follows temporal profile, low to high irradiance, high variability or clear skies
- Quantify & identify losses
  - Curtailment, clipping, outages, others



Modeling:

- Plant optimization, reporting, lifetime projections
- Optimization includes bifacial parameters
- Realign P50 performance expectations
- Informs project financing
- Quantifies retrofit benefits

Operations:

- Continuous performance baseline
- Early identification of performance deviations
- Quantify and project losses
- Locate root causes and propose solutions
- Production forecasting

Transactions:

- Commissioning & capacity tests
- EPC hand-over analysis
- Record of performance deviations and resolutions
- Digital asset follows physical asset after acquisition

[1] kWh Analytics, *2022 Solar Generation Index* report, https://www.kwhanalytics.com/sgi.
[2] A. C. J. Russell, C. E. Valdivia, C. Bohémier, J. E. Haysom, K. Hinzer, *DUET: A novel energy yield model with 3-D shading for bifacial photovoltaic systems*, IEEE J. Photovoltaics, 12(6), 1576-1585 (2022). DOI: 10.1109/JPHOTOV.2022.3185546.

We proudly acknowledge support from:
uOttawa mitacs NCFDC NSERC CRSNG Government of Canada Gouvernement du Canada