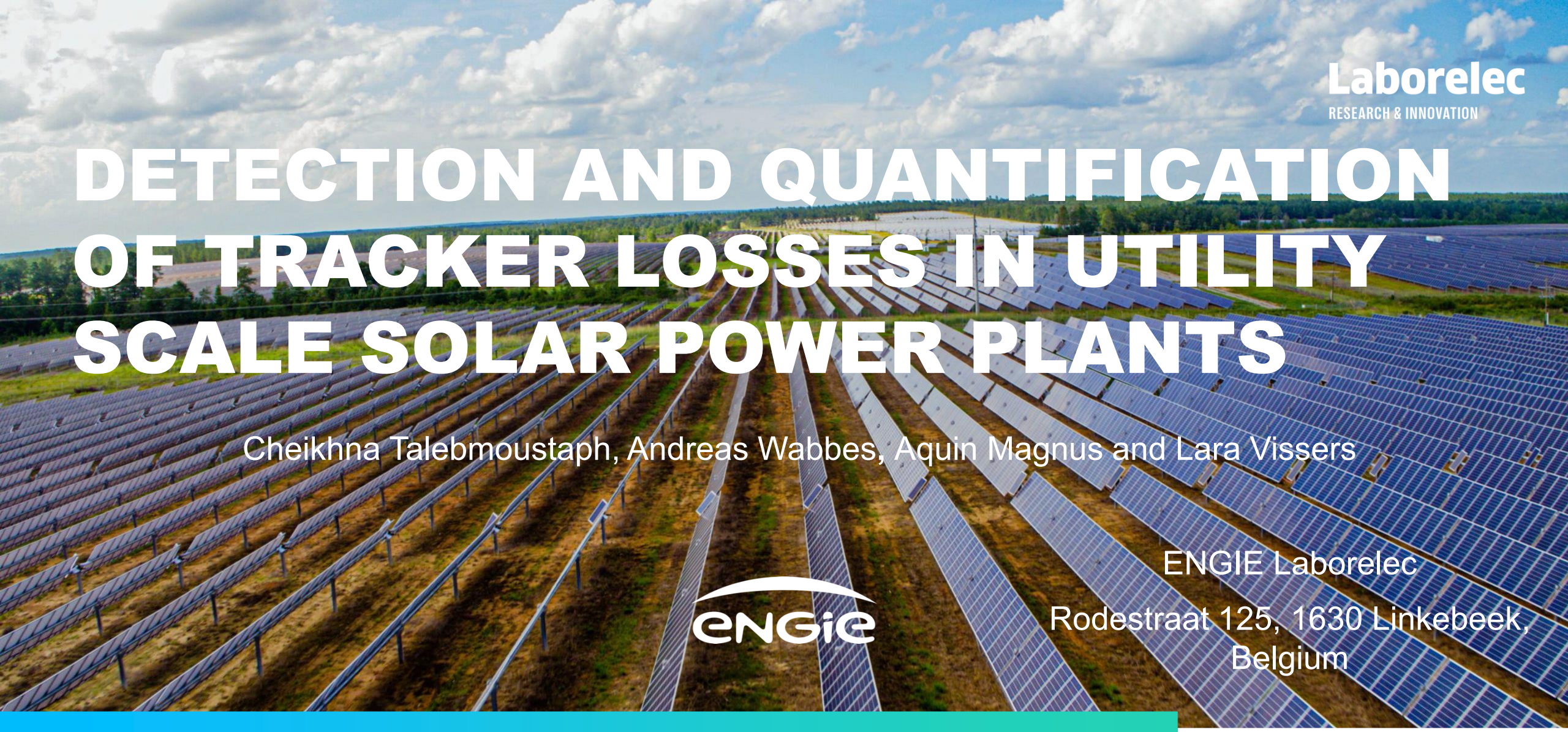


Laborelec
RESEARCH & INNOVATION

DETECTION AND QUANTIFICATION OF TRACKER LOSSES IN UTILITY SCALE SOLAR POWER PLANTS

Cheikhna Talebmoustaph, Andreas Wabbes, Aquin Magnus and Lara Vissers

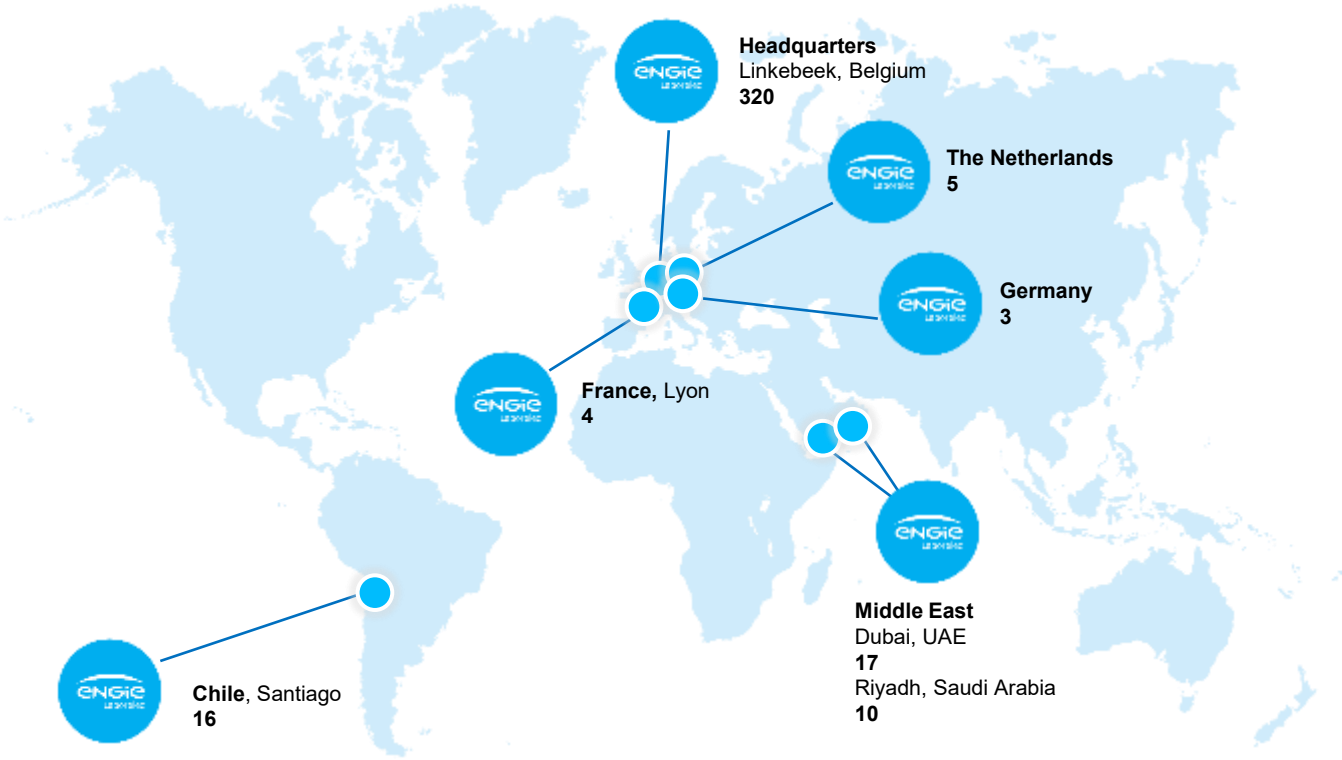
ENGIE Laborelec

Rodestraat 125, 1630 Linkebeek, Belgium

PUBLIC | RESTRICTED | INTERNAL | SECRET

Laborelec: A research centre supported by a unique and multi-located group of experts

- Laborelec is a **leading centre of expertise and research** in the area of electrical energy technologies with its headquarter in Belgium and 6 subsidiaries on 3 continents.
- Supporting the **energy transition** and accelerating the **net zero carbon journey**.
- With a **highly qualified workforce** of over 379 colleagues (PhDs, engineers, specialist technicians) from 23 different nationalities.



379
COLLEAGUES

23% **77%**

Power networks

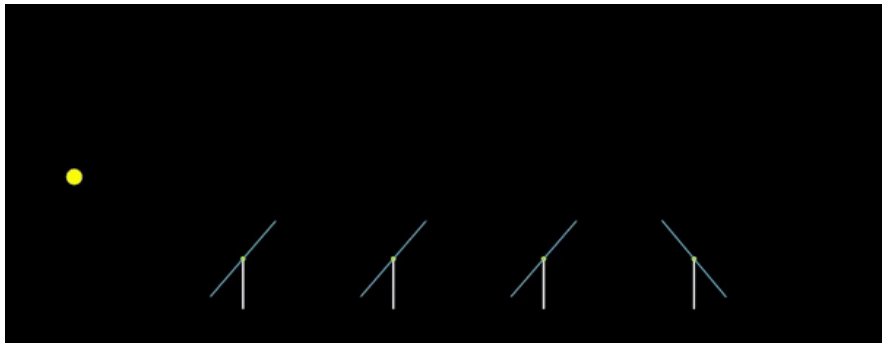
Nuclear

Thermal

Renewables

CCS

Introduction

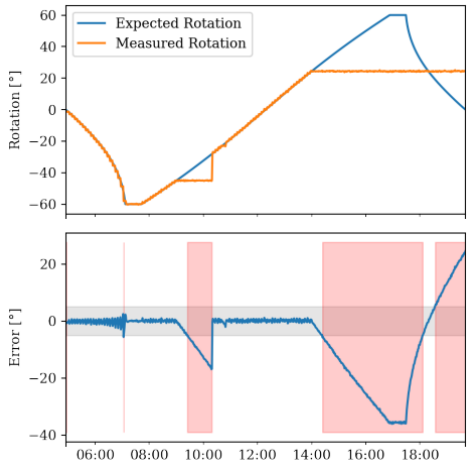


- Over 725 GW of new tracker installations expected between 2024–2030[1].
- Faults - like misalignment, communication errors, or mechanical failures - can cause a tracker to lose up to 50% of energy.
- These losses impact financial performance and contract compliance

Two main tracker fault (stall) detection methods :

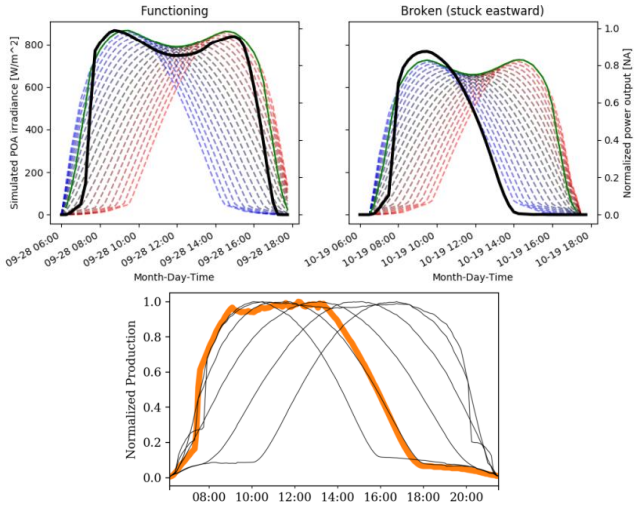
Tracker angle-based methods[3]

Use tracker position data to detect misalignment



Production timeseries-based methods[2,3,4]

Analyse power output patterns to identify anomalies

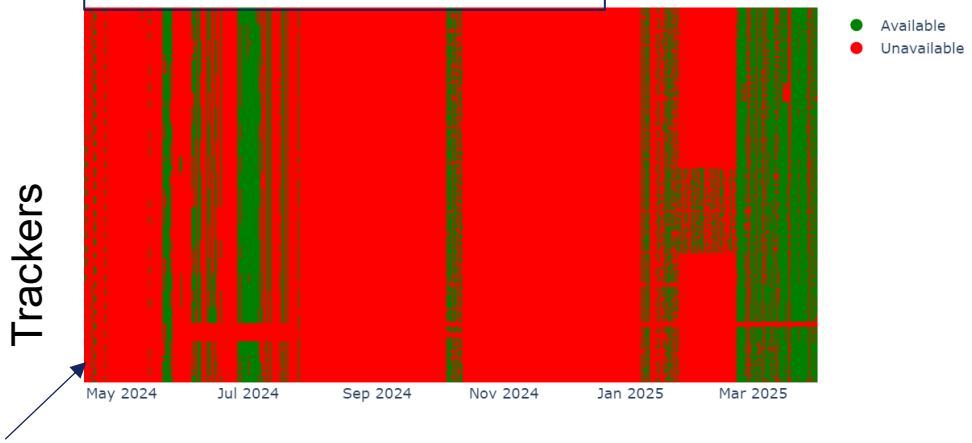


1 : Innovation driving change in solar tracker market. PV Magazine, September 2024
2 : Ruth & Muller, Prog. Photovolt. Res. Appl., 2018
3 : Anderson et al., IEEE JPV, 2021
4 : Zgraggen et al. ACPHMS, 2022

Challenges of angle-based approaches

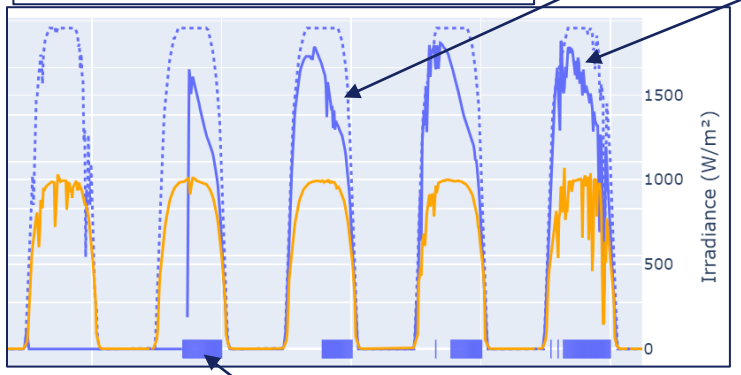
- Method uses tracker data (both actual angle and setpoints)
- Multi-step approach to make sure that most possibilities are covered:
  - Actual angle vs setpoint
  - Setpoint vs median(setpoints)
  - Setpoint vs modelled theoretical angle (e.g. Pvlib)

1 : Tracker data availability

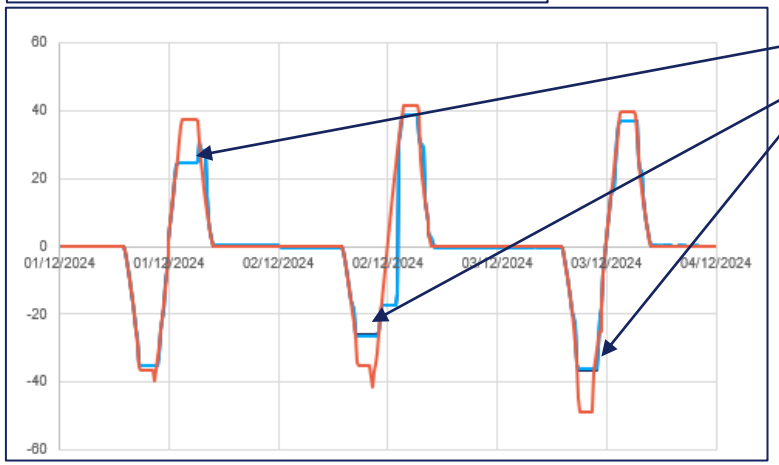


Each horizontal line represents a tracker

2: Link tracker events with production (mapping)



3 : Communication issues



Com outage ? Motor stopped ?

- Site visit: regular com outages

➢ Need for an additional method

Methodology – Combiner box comparison approach

- Captures trackers stall events
- Simple daily comparison of combiner power timeseries on individual inverters using shape parameters
- No use of a theoretical pattern

Limitations

- Clear-sky points only in V1
- Cannot detect fleet-wide issues (no absolute reference)
- Requires multiple combiner boxes per inverter

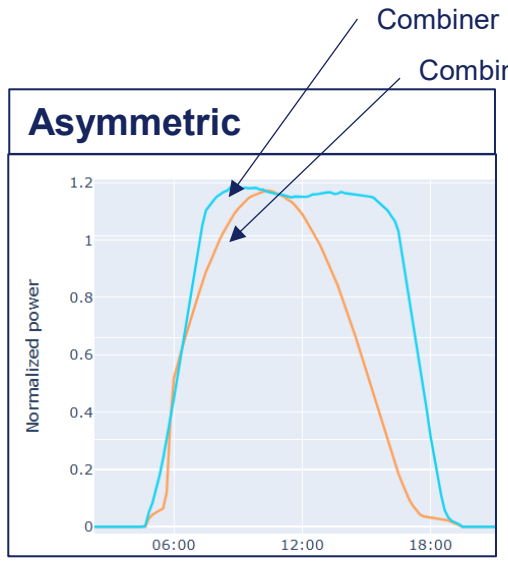
STEP 1
Characterize Daily Power Curves

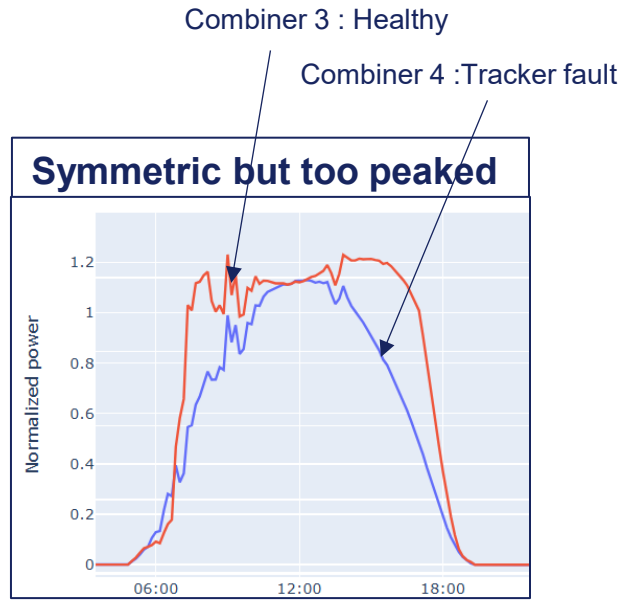
↓

STEP 2
Identify Best Reference

↓

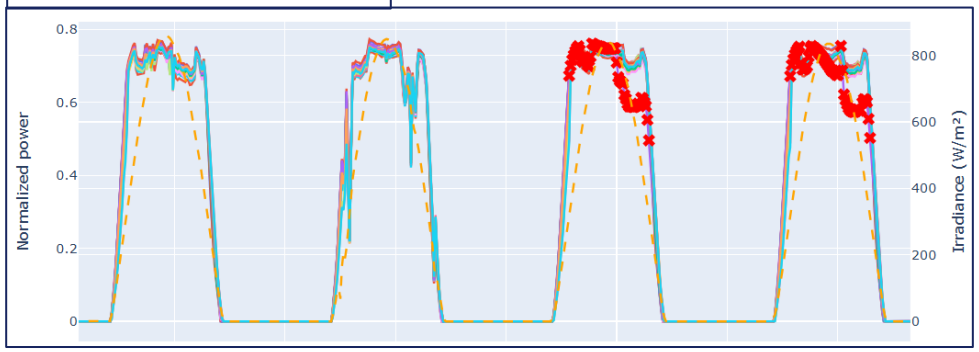
STEP 3
Detect Anomalies



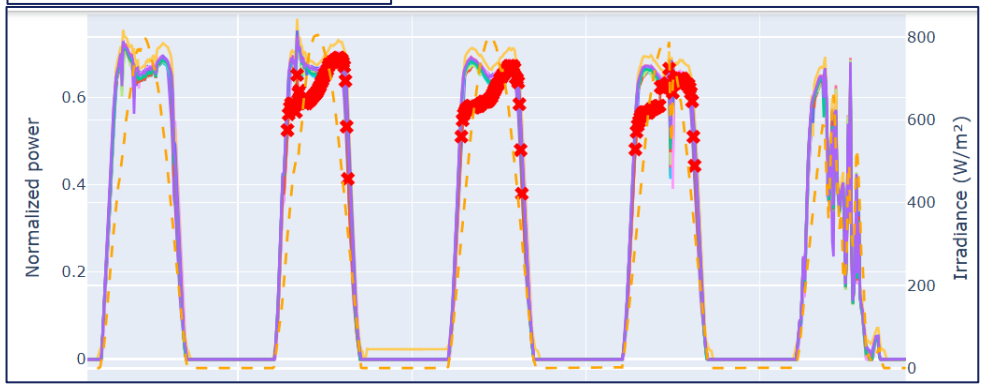


Results (validated on more than 2GW)

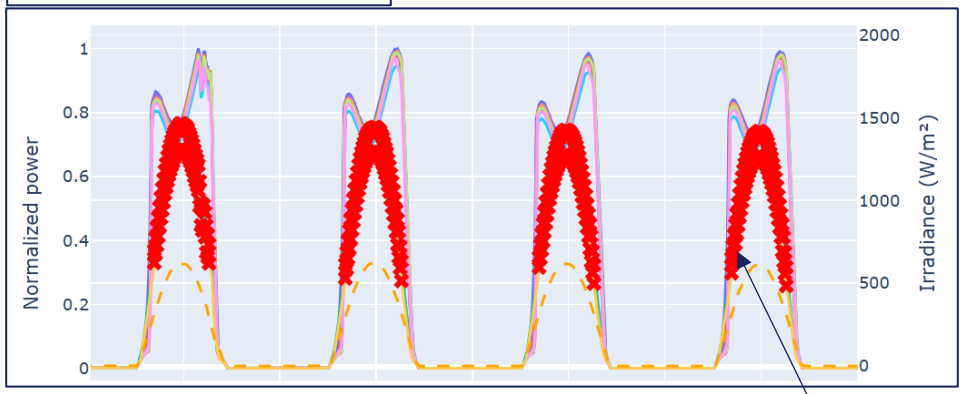
Single-row – Site A



Single-row – Site B

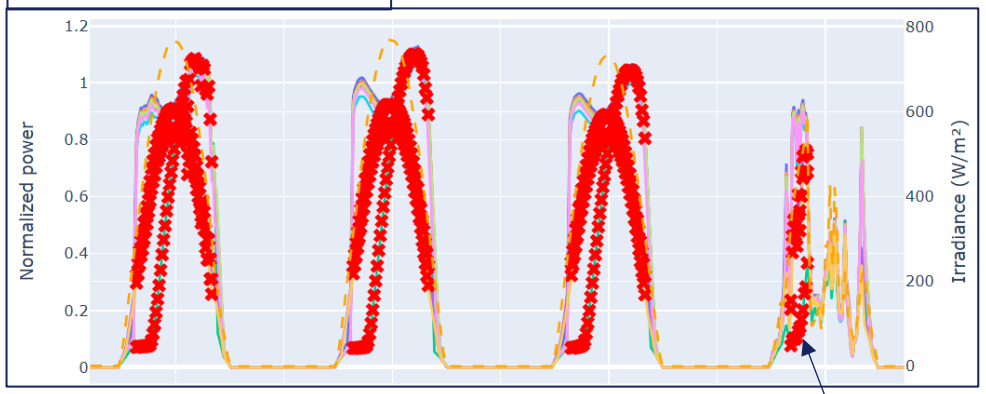


Multi-row – Site C



Tracker stall at 0°

Multi-row – Site D



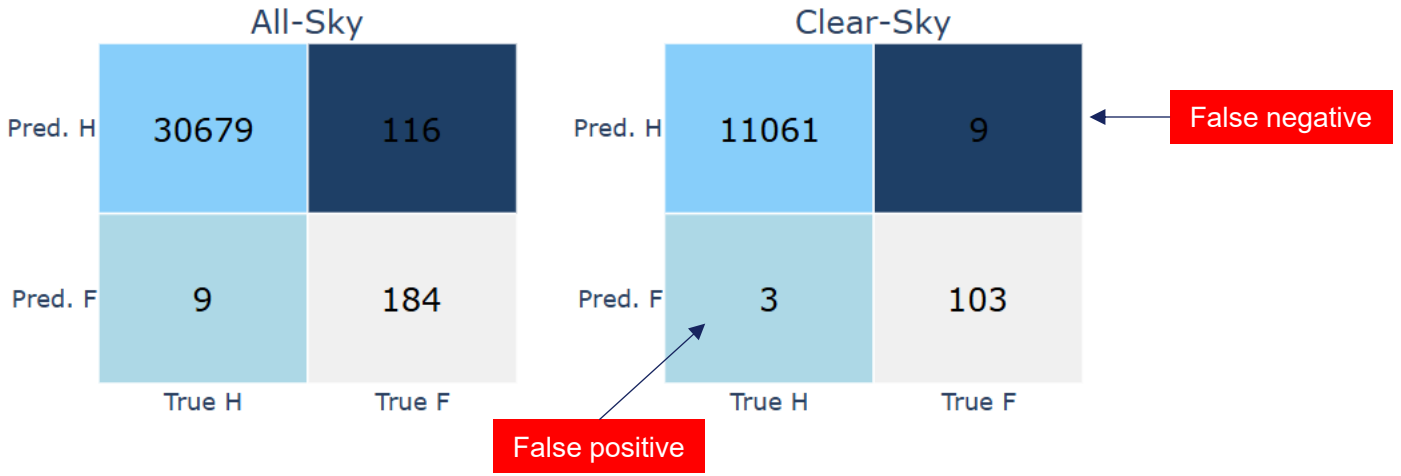
Captures only the clear-sky portion of the day

Validation & sensitivity to cloudy days

- **Dataset from an operational plant**
- **Ground truth source:**
  - Tracker angle monitoring system provides actual tracker positions
  - Malfunction events directly mapped to corresponding combiner boxes
  - Creates validated "true positive" reference for algorithm evaluation

Condition	Precision	Recall	F1-Score
All-Sky	0.953	0.613	0.746
Clear-Sky	0.972	0.920	0.945

➢ What about loss quantification ?

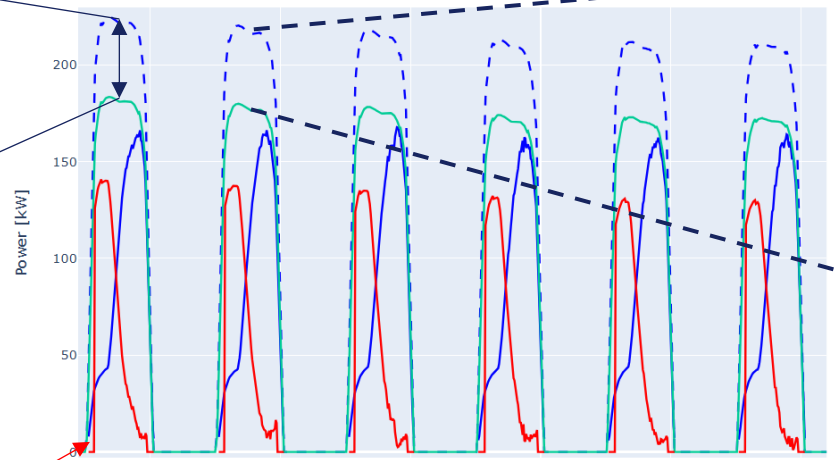


Confusion matrix for tracker issue detection (clear and all-sky days). "Pred." indicates algorithm predictions and "True" represents ground truth from tracker angle analysis. "H" denotes healthy tracker operation (no issues detected) and "F" indicates faulty tracker behaviour (tracking malfunction identified). Values show the number of combiner box-day classifications. Clear-sky : True Positives (103), False Positives (3), False Negatives (9), and True Negatives (11061) .

Loss quantification

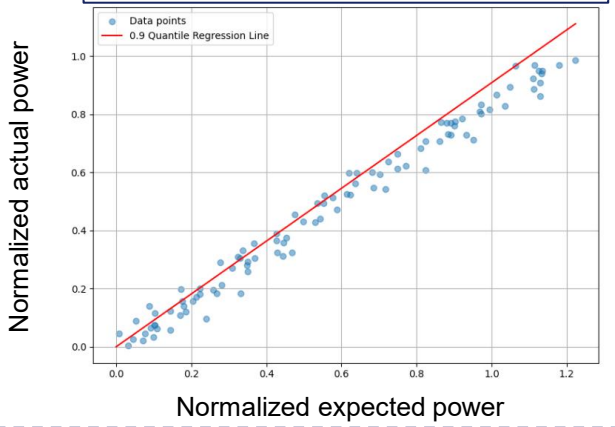
- Expected power based on FID* model to compute losses at multiple levels:
  - Physical 3D-model that can be queried sub-hourly and set-up fast
  - Purely physics-based approach ensures interpretability and compatibility with reporting requirements
  - Rescaling is essential to avoid loss double-counting

- String losses
- Soiling
- As-built
- Etc.



Actual power curve
Modelled Expected power
Rescaled Expected power
Tracker loss curve

Examples of expected power scaling



*FID: Final Investment Decision

Conclusions & Open Questions

Practical method for fleet-scale tracker loss detection using only combiner data

- **Primary objective:**
  - Accurately quantify tracker-related energy losses at the system level
  - Not focused on identifying individual faulty trackers among thousands (e.g. 1 out of 8000 in a single site)
  - Minimize site-level investigation and operational burden

- **Combiner box-based methodology for tracker fault detection**
  - **Flexible implementation:**
    - Use tracker angle data when available
    - Switch to power-based method when angles are missing
  - Achieves high precision (>97%) and strong overall accuracy (F1 = 0.95) under clear-sky conditions, with minor recall degradation on cloudy days due to natural irradiance variability

➢ We aim to support ongoing PVMAC efforts to standardize definitions of underperformance and fault classification

➢ Which strategies (modelling and compliance) can address missing tracker-combiner box-inverter mappings (single and multi-row configurations) and improve spatial fault resolution?

Contact us



Andreas Wabbes
Senior Solar expert ENGIE
andreas.wabbes@external.engie.com



Cheikhna Talebmoustaph
PV Performance lead ENGIE Laborelec
cheikhna.talebmoustaph@engie.com



Lara Vissers
Performance solar engineer ENGIE Laborelec
Lara.vissers@engie.com



Aquin MAGNUS
Research engineer solar and renewable hybrid activities ENGIE Laborelec
aquin.magnus@engie.com



Laborelec

RESEARCH & INNOVATION

laborelec.com