Uncertainty evaluation of PR measurement

with focus on meteorological parameters

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HUKX

Sensor Technology

Introduction

Kees VAN DEN BOS

- Co-founder / director Hukx
- Pyranometer technical expert, metrology expert (ISO / IEC 17025)
- Participant standard development IEC 61724 (PV system performance monitoring)
- Project leader standard development ISO 9901, 9847 (pyranometer best practices and calibration)

Hukx: a leading innovator

Solar radiation
sensors

Calibration
services

This presentation: utility-scale PV performance monitoring

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PV monitoring system

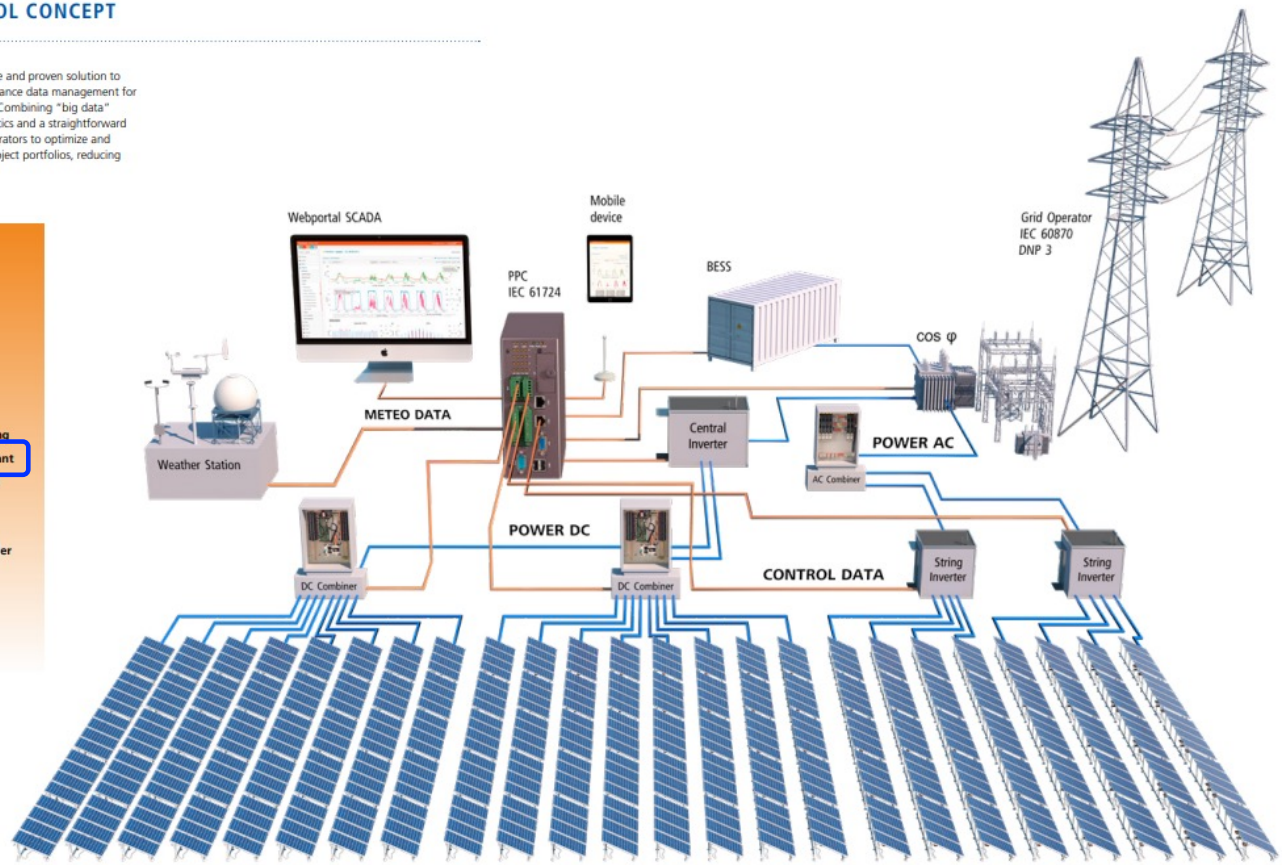
MONITORING AND CONTROL OF UTILITY SCALE PHOTOVOLTAIC SYSTEMS

DAQ AND CONTROL CONCEPT

Gantner provides a comprehensive and proven solution to the growing challenge of performance data management for utility-scale PV project portfolios. Combining "big data" processing with easy-to-use analytics and a straightforward user interface enables project operators to optimize and control the performance of PV project portfolios, reducing O&M costs and LCoE.

INTELLIGENT SOLUTIONS

- AC/DC Combiner
- BESS
- Data Logger
- DNP3/IEC 60870
- Environmental Monitoring
- IEC 61724-1:2017 compliant
- Independent Monitoring
- Made in Germany
- Meteo station
- PPC Power Plant Controller
- RAS
- SCADA
- VDE-AR-N 4110
- VDE-AR-N 4120
- Worldwide Service
- Web Portal (SaaS)



Gantner instruments

1500 V in stock

PV monitoring system

PV Performance Monitoring

Purpose:

- Measurement of Performance Ratios, PR
- PR = Electrical output / (solar input*module efficiency)

- main KPI of PV system

Progress and questions

Progress in the past years

- ISO / IEC standardization: pyranometers
- IEC standardization: PV performance testing
- Better accuracy instruments

Questions still open

- Best practices (instruments, maintenance, responsibilities, data analysis)
- Uncertainty evaluation of PR

IEC 61724

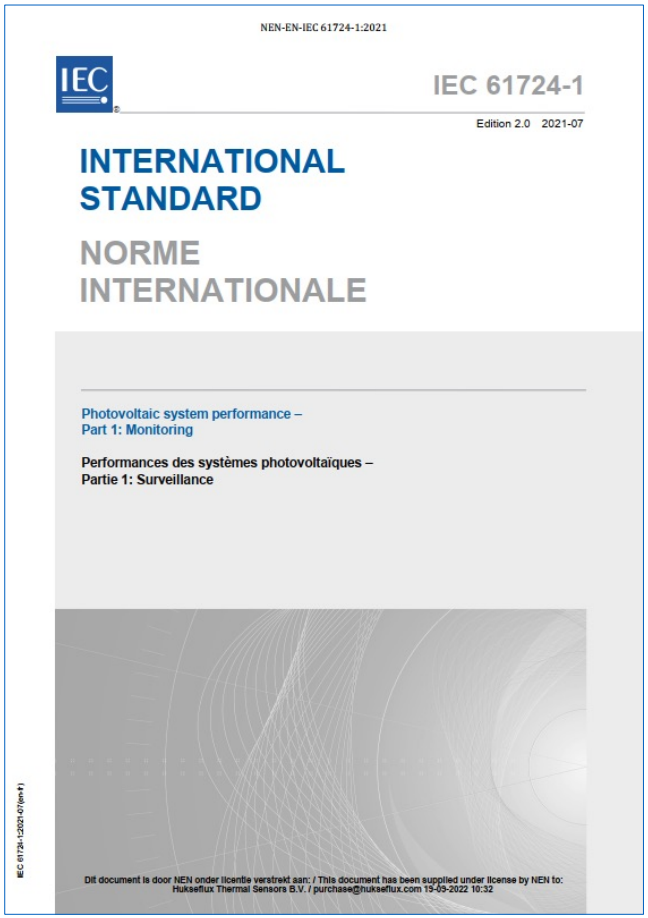
Group of 3 standards

-1: monitoring (general theory)

-2: one- two day evaluation for commissioning

-3: one-year long evaluation during operation

-2 and -3: PR



Capabilities

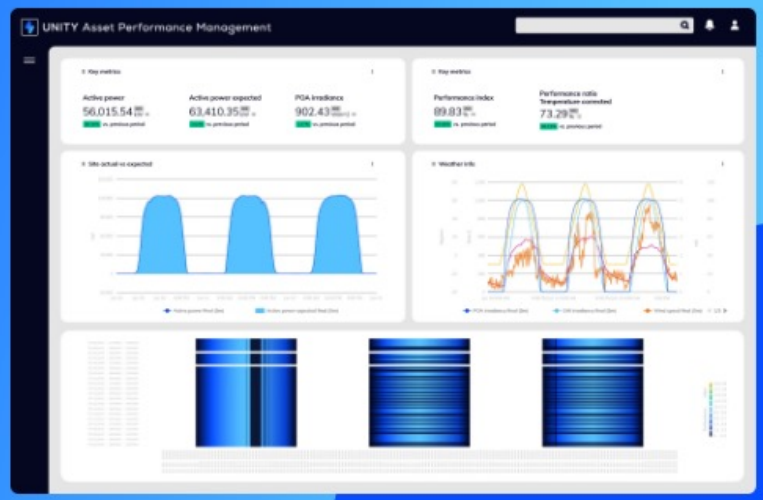
Asset Performance Management

SOLARGIS

- One integrated solution
- Asset hierarchies
- Role-based dashboards
- Event management
- Reports & data warehouse
- Performance analytics
- Data cleaning

Performance analytics

Optimize your renewable energy assets with advanced insights and automated fault detection. Configured with standard metrics such as Availability Factor and Performance Ratio, along with proprietary KPIs, performance analytics offer predictive and prescriptive capabilities. Machine learning and AI detect changes or abnormal operations, providing comprehensive insights for performance analysis.



Takeaways:

- IEC has always been working on accuracy
- Now attempt to quantify
- PR measurement uncertainty is large, probably larger than 3 %
- Meteorological measurements are a significant cause of uncertainty

- Following slide: uncertainty reduction in IEC 61724

	1998	2017		2021	
IEC	No Classes	Class A	Class B	Class A	Class B
POA	PV ref cell	PV ref cell	PV ref cell	PV ref cell	PV ref cell
	Pyranometer	Pyranometer Class A ventilated	Pyranometer Class B	Pyranometer Class A heated	Pyranometer Class C
	5 % accuracy	3 % accuracy	8 % accuracy	2 % cal uncert	3 % cal uncert
GHI	Not required	Pyranometer Class A ventilated	Pyranometer Class B	Pyranometer Class A heated	Pyranometer Class C or satellite
		3 % accuracy	8 % accuracy	2 % cal uncert	3 % cal uncert
Calibration	No requirement	1 x /yr	1 x / 2 yr	1 x / 2 yr	Manufact. ecc
Cleaning	No requirement	1 x / wk	1 x / 2 wks	1 x / wk	User decision
Others	PV Temp	PV Temp, wind sp-dir, soiling, rain	PV Temp	PV Temp, wind sp-dir, soiling, rain	PV temp

Why is this important

PV system performance monitoring

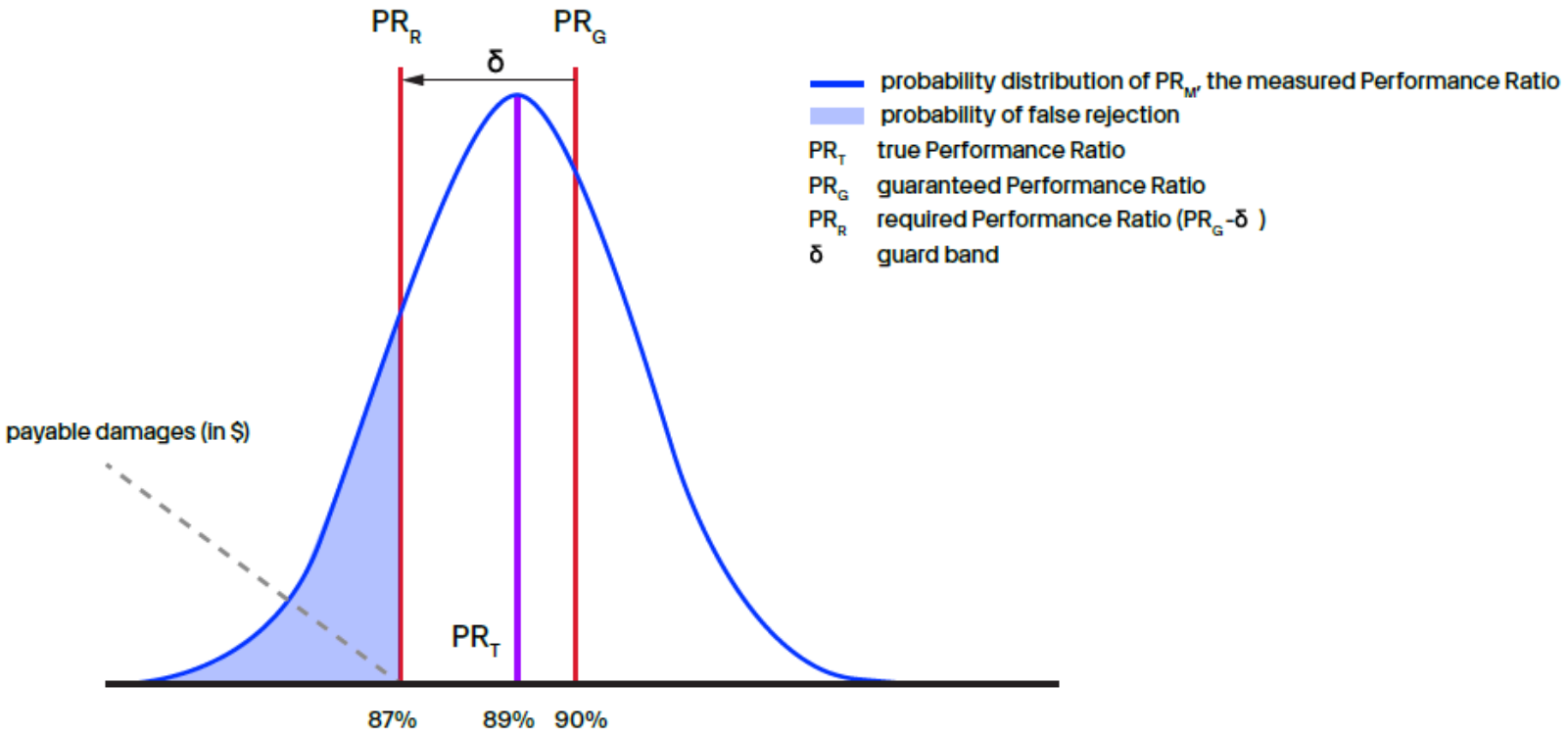
– Is part of acceptance testing
– COMING UP: is part of financial auditing of the owner

Uncertainty of performance ratio translates to financial risk

– Unnecessary / unjustified penalties
– Under-valuation of assets

Risks in Testing: Measurement Uncertainty

– If you allow PRr, with a high test uncertainty, you have a high risk (blue area)



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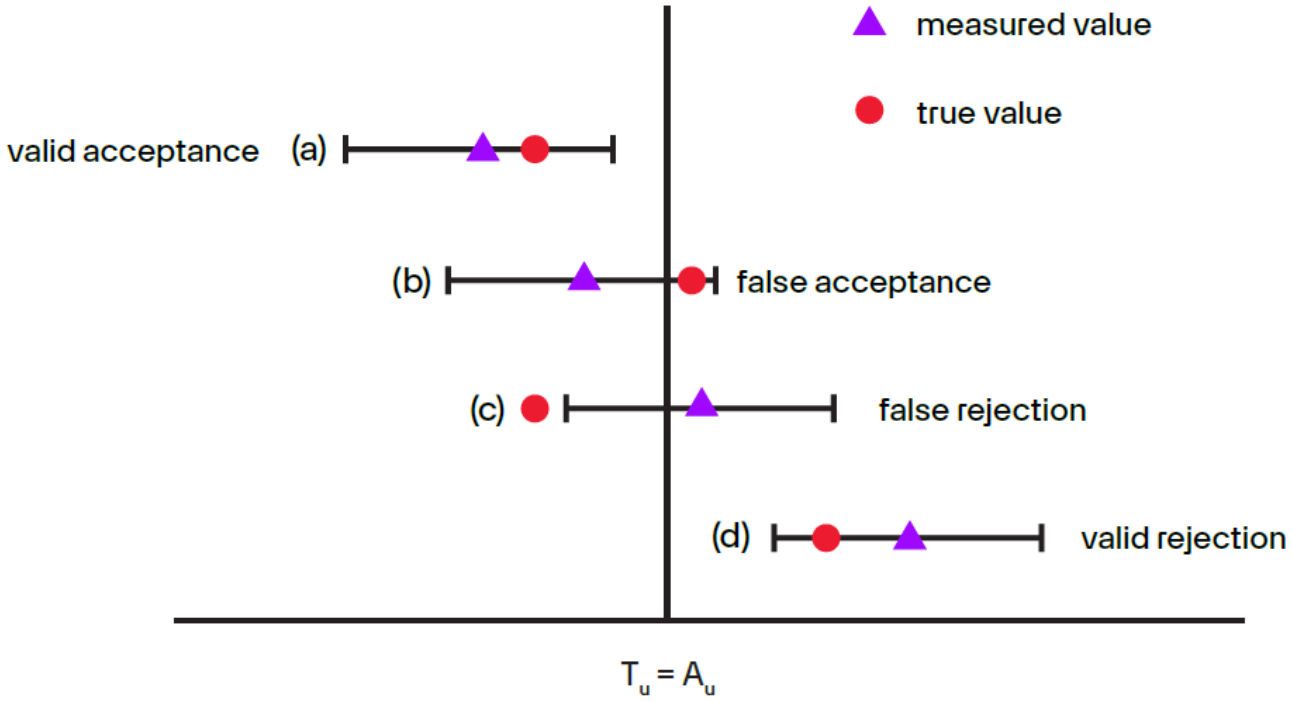
PV system performance testing: Risks

- Risk: false acceptance
- Risk: false rejection



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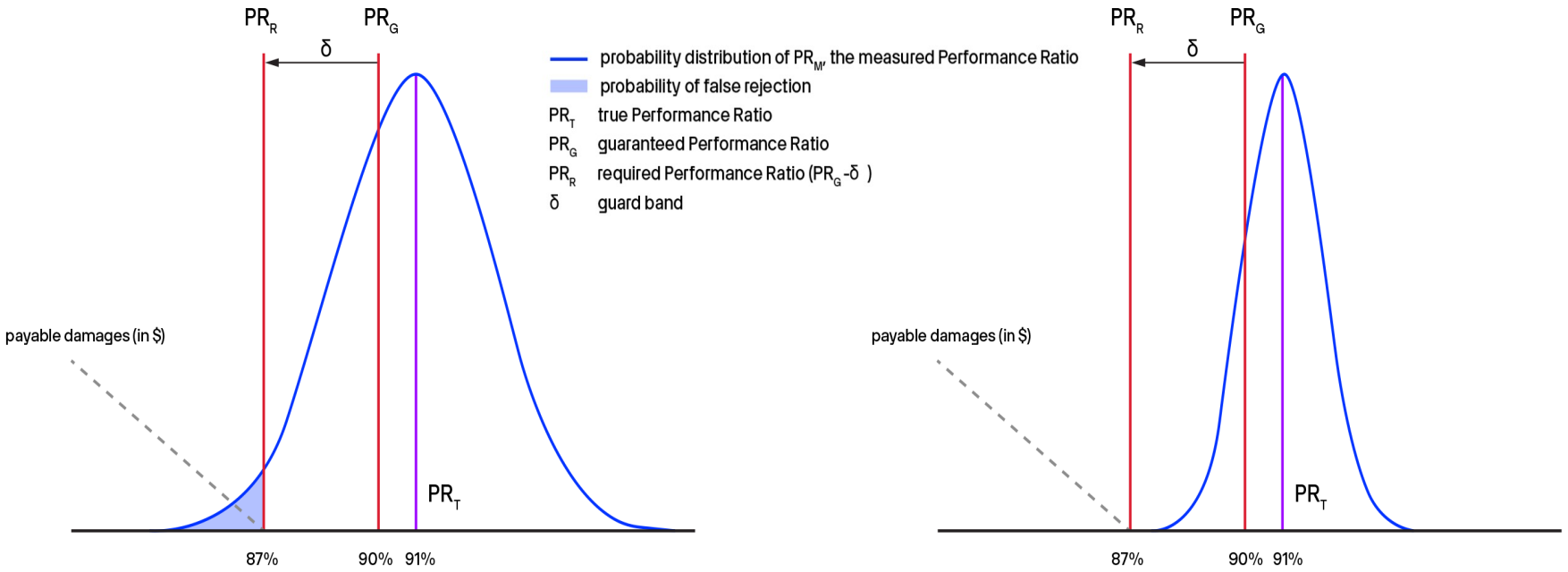
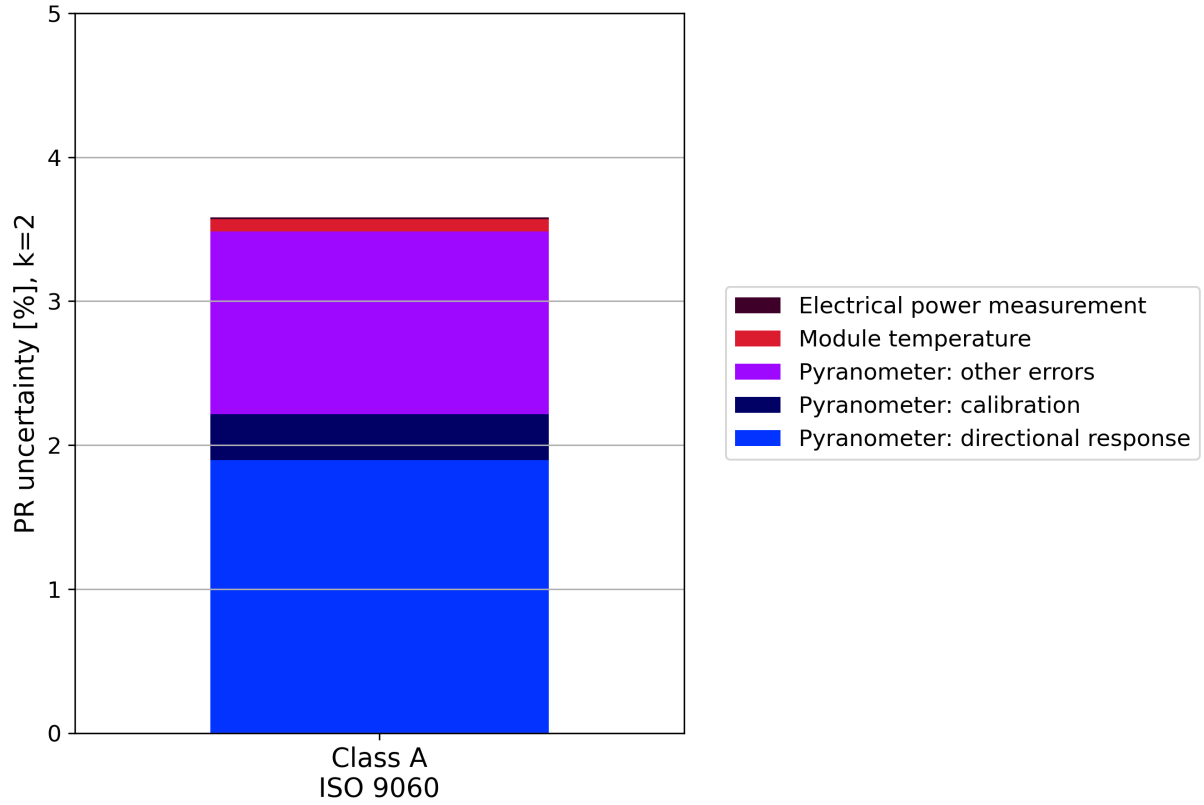
Risks in Testing: better measurement uncertainty, lower risk



Ideal PV system: uncertainty in PR Measurement during 1 yr use: Pyranometer Class A minimum specs, calibration 2 % per IEC



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Takeaways: invest in high accuracy PR

High accuracy measurement: benefit for EPC and owner!

- Lower risk of damages in acceptance testing
- Fairer test
- Lower safety margins for PV system design
- Pyranometer is weakest link in PR, easiest to improve

- Later benefit for owner in asset valuation and O & M

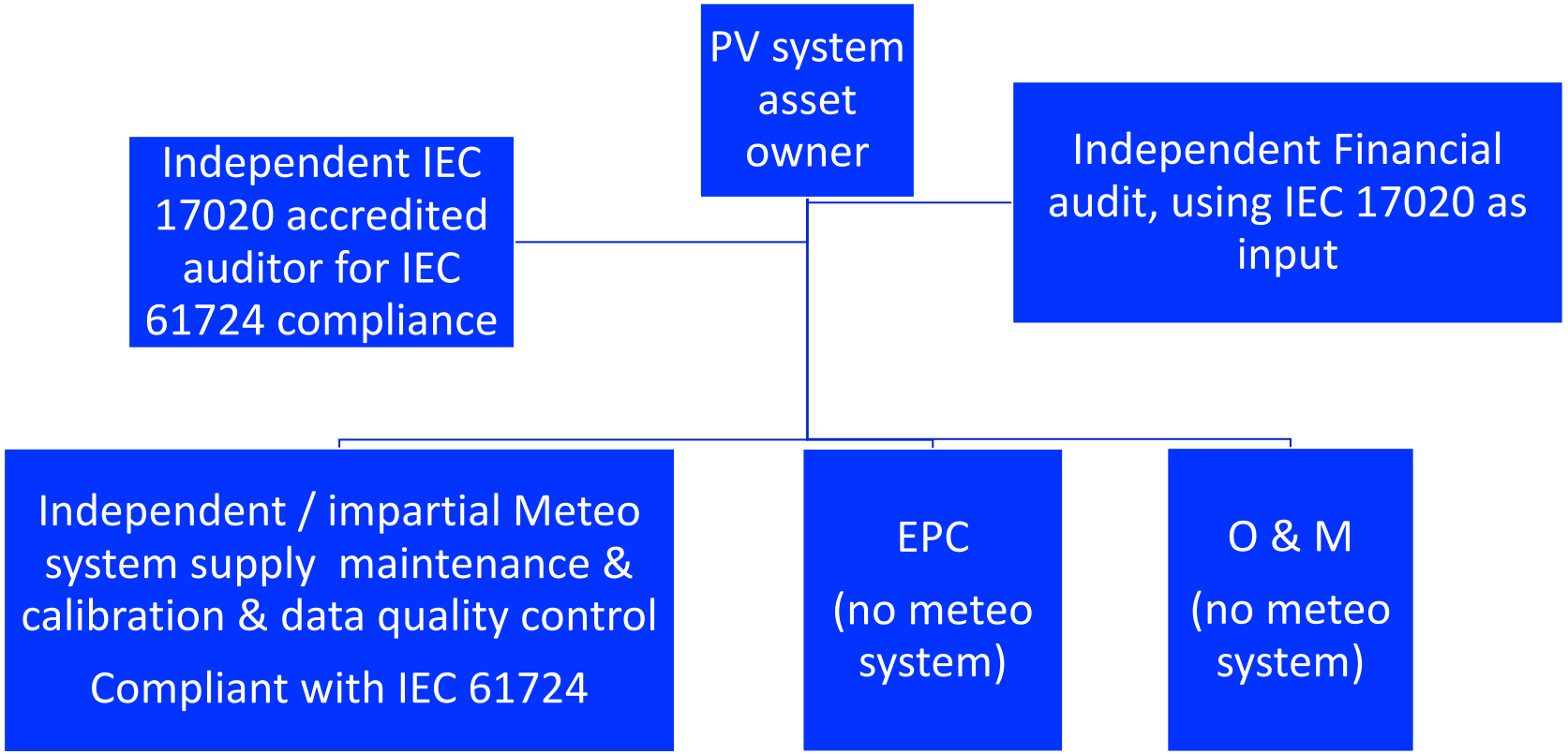
The real world: systematic errors

Previous analyis assumed statistical errors only

- No cleaning of pyranometer dome
- Software manipulation
- PV module temperature measurement

- Results may be manipulated
- Owners ask for Impartiality?

Impartiality for PV system performance monitoring?



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Meteorological measurements

Why heat pyranometers

2 pictures

- On right efffectiveness against frost
- Next page effectiveness against dew

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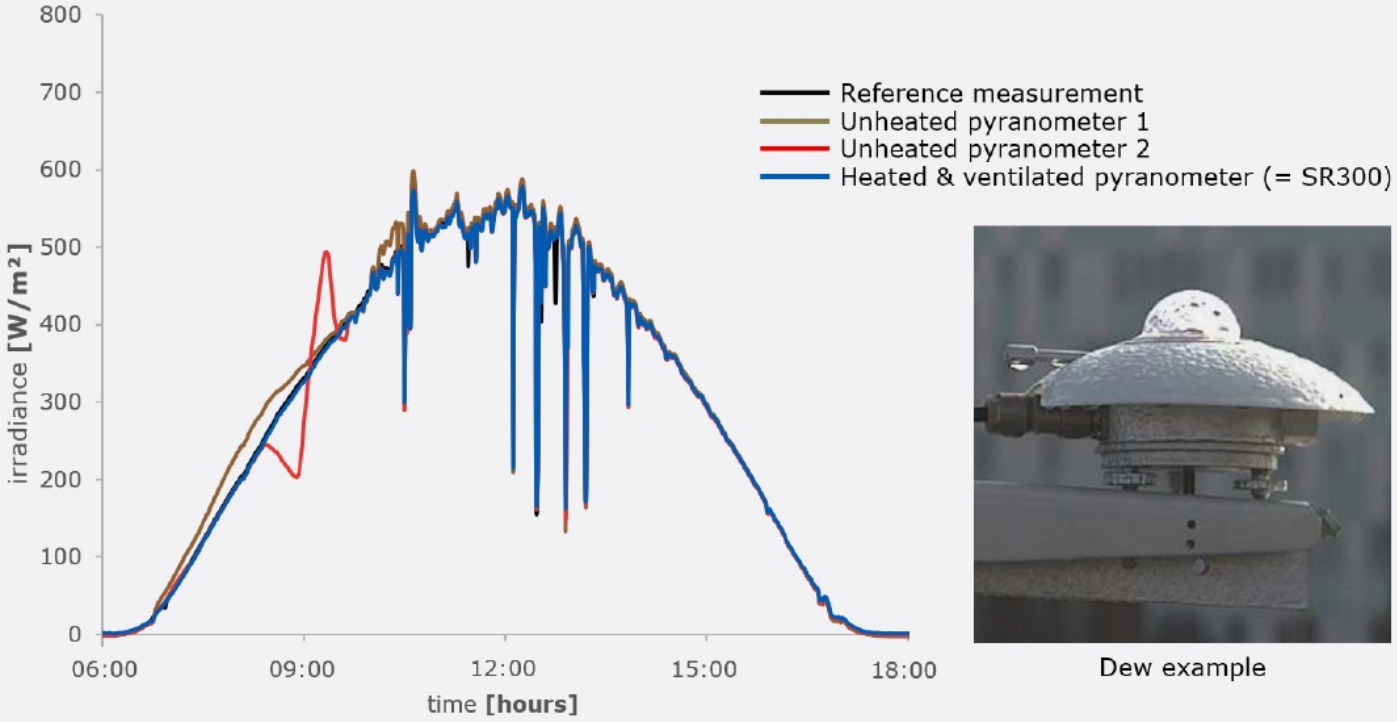
What happens if pyranometers are not heated? Red line shows error in morning



Dew example

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Independent testing setup (NLR roof)

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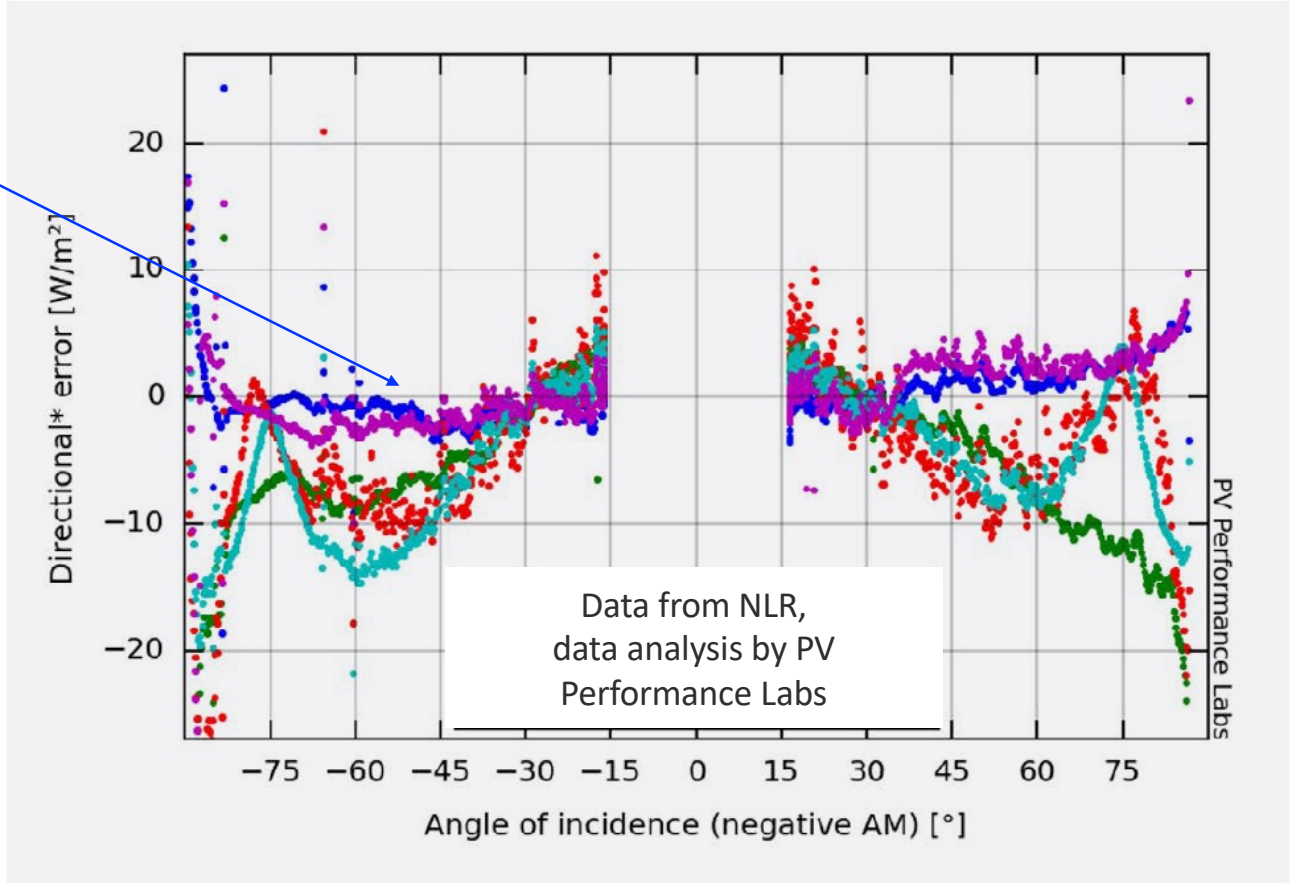
NRL pyranometer comparison: error relative to reference

Blue and purple pyranometers outperform the rest (the closer to zero, the better)



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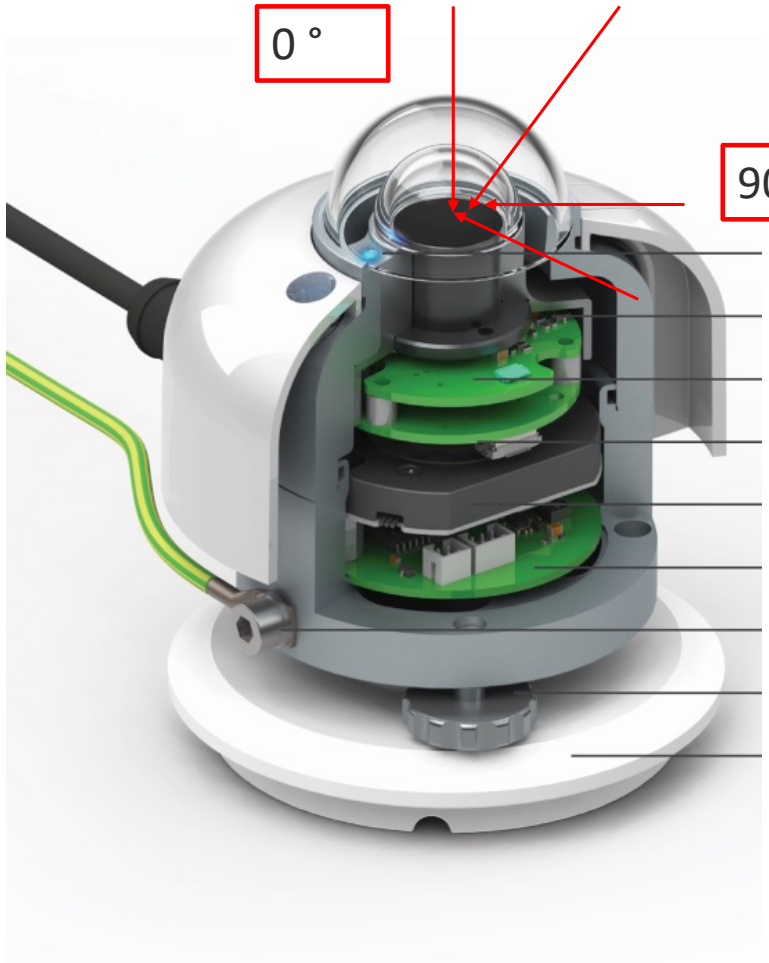
Directional response (zenith and azimuth)



Azimuth: North, West, South, East

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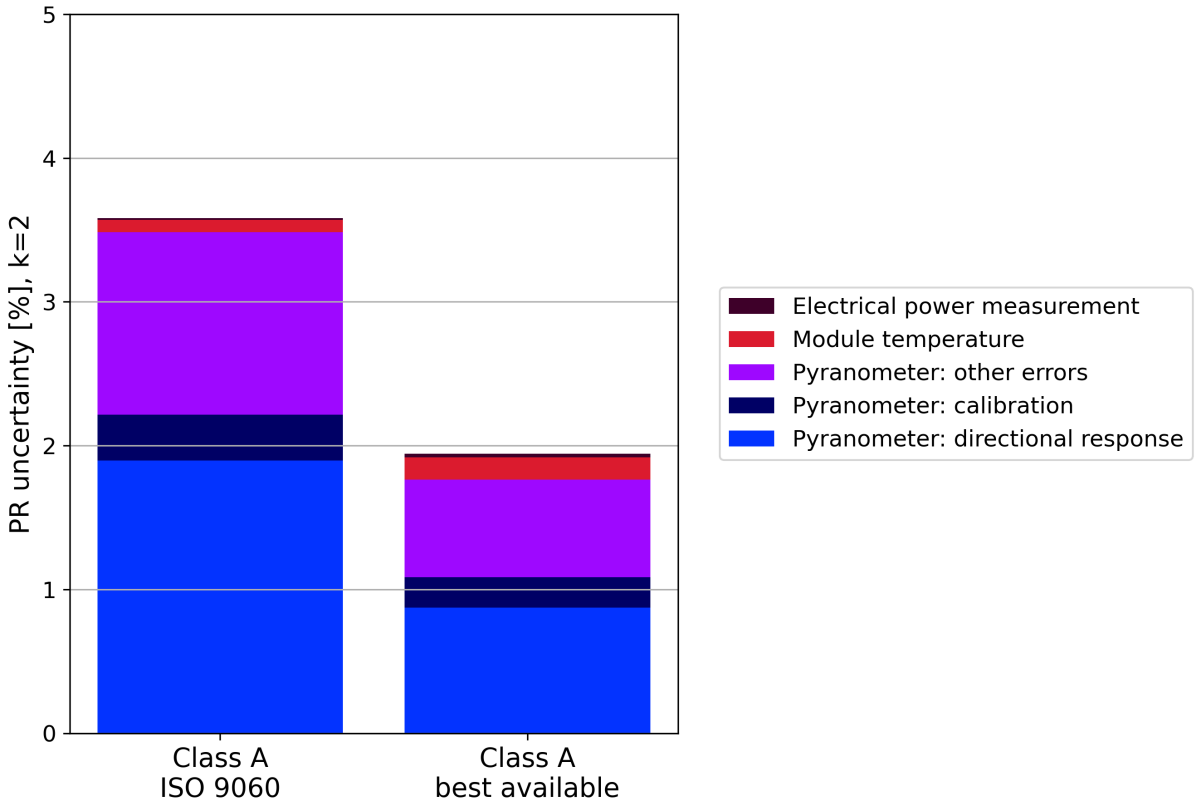
Ideal PV system: uncertainty in PR Measurement – best available pyranometer – much better PR accuracy



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Effect of soiling on PR

- Systematic underestimation of irradiance
- 1 % / wk soiling rate is not uncommon

- Higher PR

PV Module temperature sensors compared

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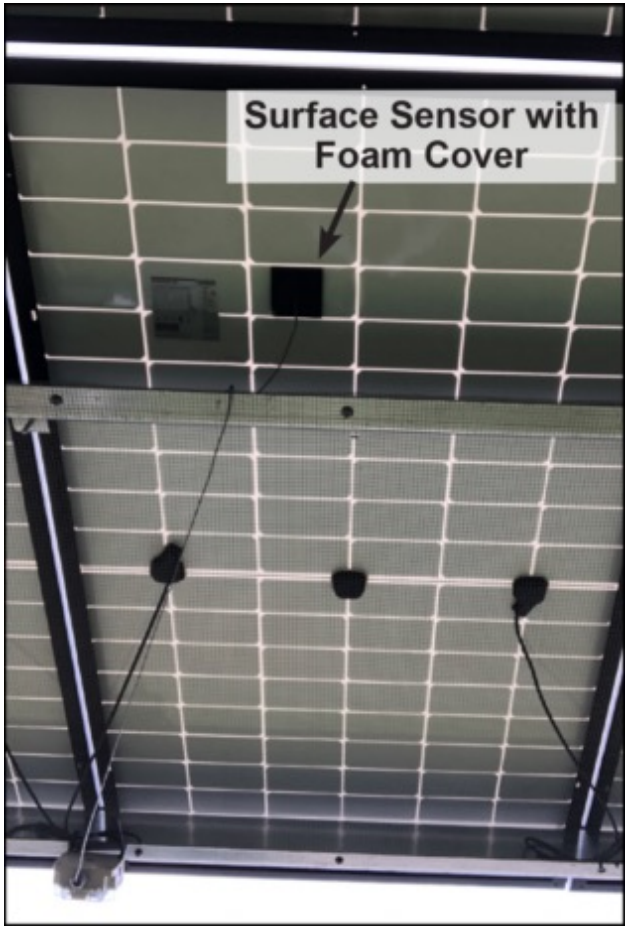
Insulated sensor? (advertised on internet)



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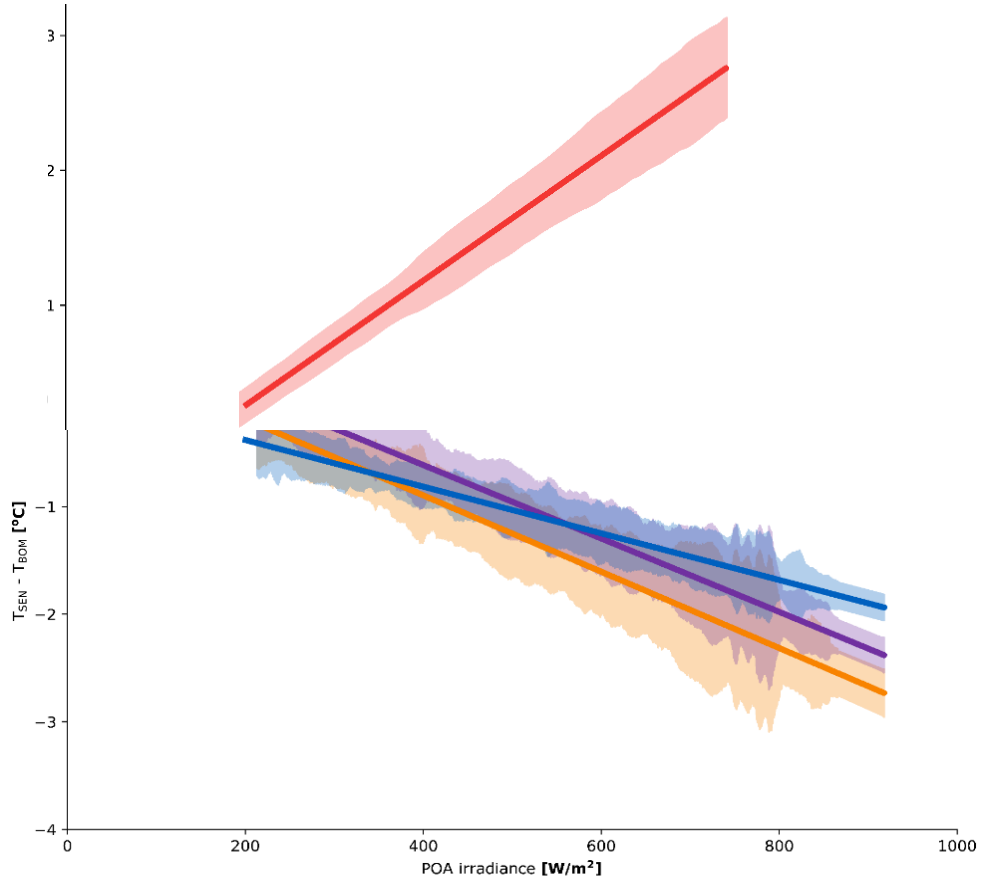
Total result: PR 1 % improved



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Work in progress: Solar radiation scale change

- 0.3 % scale change expected in 2027
- W/m^2 will go down
- PR will go up

- Who is in charge: PMOD Switzerland / METAS

Assistance requested

– IEC TC 82 / WG3

– Hukx: Excel and Python code for PR uncertainty evaluation
– Review, improvement

What may we do for you?

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