IEA PVPS TASK 13 WORKSHOP MUNICH, 30 MAY 2017

# Review and Analysis of Technical Assumptions Used in PV Financial Models

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# Outline

- Introduction
- Technical Assumptions used in PV Financial Models
  - PV Plant Design
  - Procurement Process
  - Plant Construction
  - Plant Acceptance
  - O&M
- Long-Term Yield Estimates & Their Level of Confidence
- Conclusions

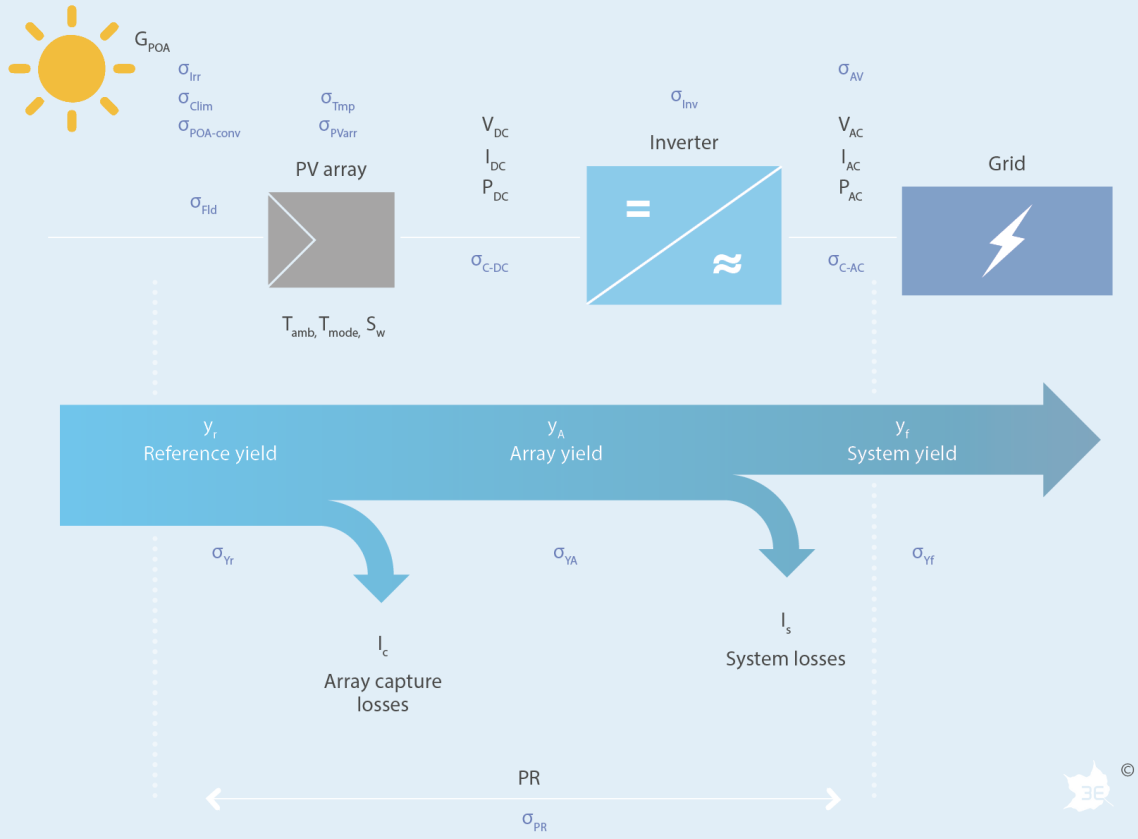
# Introduction

- Survey of current practices (questionnaire)
  - 84 PV projects
  - 9 countries
  - Different business concepts
- Complemented with:
  - Results from the Solar Bankability project [1]
  - General & public domain industry knowledge

[1] The Solar Bankability project is funded by the European Union's Horizon 2020 research and innovation programme under the grant agreement No 649997.

# Technical Assumptions Used in PV Financial Models

## Energy flow from sunlight to consumer of electrical power:




Several sub-models & assumptions

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**Uncertainties**

# Technical Assumptions Used in PV Financial Models

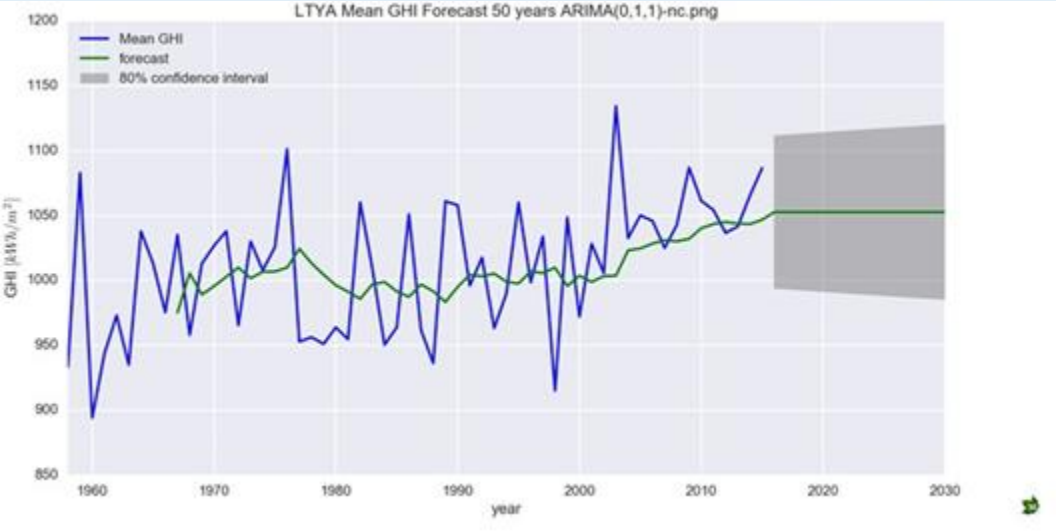
## Weaknesses when dealing with technical assumptions and risks in PV financial models:

| PV plant design | Procurement process | Plant construction | Plant acceptance | Operations & Maintenance |
|---|---|---|---|---|
| • Solar Resource<br>• P50/P90<br>• Degradation behavior<br>• Availability | • Technical specifications<br>• Specific requirements<br>• Factory inspections<br>• Product testing | • Transportation & handling<br>• Storage of components on-site<br>• Construction supervision | • Protocol for visual inspection<br>• Relevant equipment (IR / EL)<br>• Provisional acceptance<br>• Protocol for data collection and KPIs calculation | • Monitoring capabilities<br>• Preventive & corrective maintenance protocols<br>• Relevant equipment (IR / EL) |

# Weaknesses: PV Plant Design

## Solar Resource Assessment

Effect of long-term trends in the solar resource is often not fully accounted for

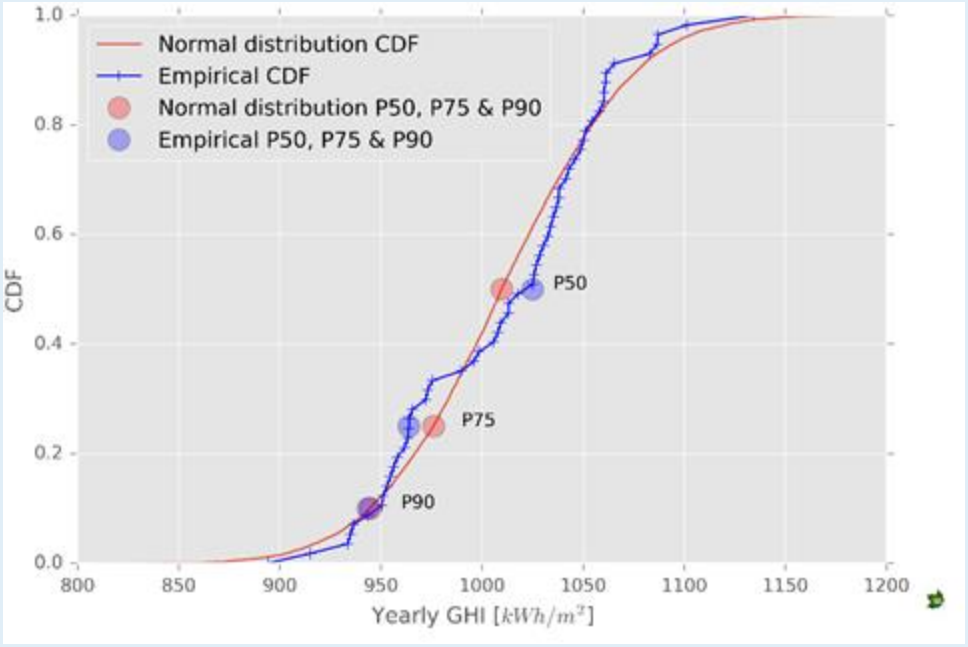



Forecast of future long-term irradiation based on the average of 32 meteo stations in the Netherlands

# Weaknesses: PV Plant Design

## Uncertainties calculation

Exceedance probabilities (e.g. P90) are often calculated assuming a normal distribution for all elements contributing to the overall uncertainty




Cumulative distribution function for the long-term (58 years) GHI average of 32 meteo stations in NL

# Weaknesses: PV Plant Design

- Incorrect **degradation rate** and inaccurate rendering of the system **behavior over time**

- Incorrect **availability assumptions** used to calculate the initial yield for the project investment financial model as opposed to the O&M plant availability guarantee

# Weaknesses: Procurement Process

- **Technical specification** of the PV plant components usually consists only of a high-level description
- Project **specific requirements** such as salt-mist, ammonia or resistance to PID, with the relevant IEC certification testing, are not always specified
- Lack of specifications requiring **factory inspection or product testing**

# Weaknesses: Plant Construction

- Absence of standardized **transportation & handling protocol**
- Inadequate quality procedures in component **un-packaging** and handling during construction
- Lack of **construction supervision**

# Weaknesses: Plant Acceptance

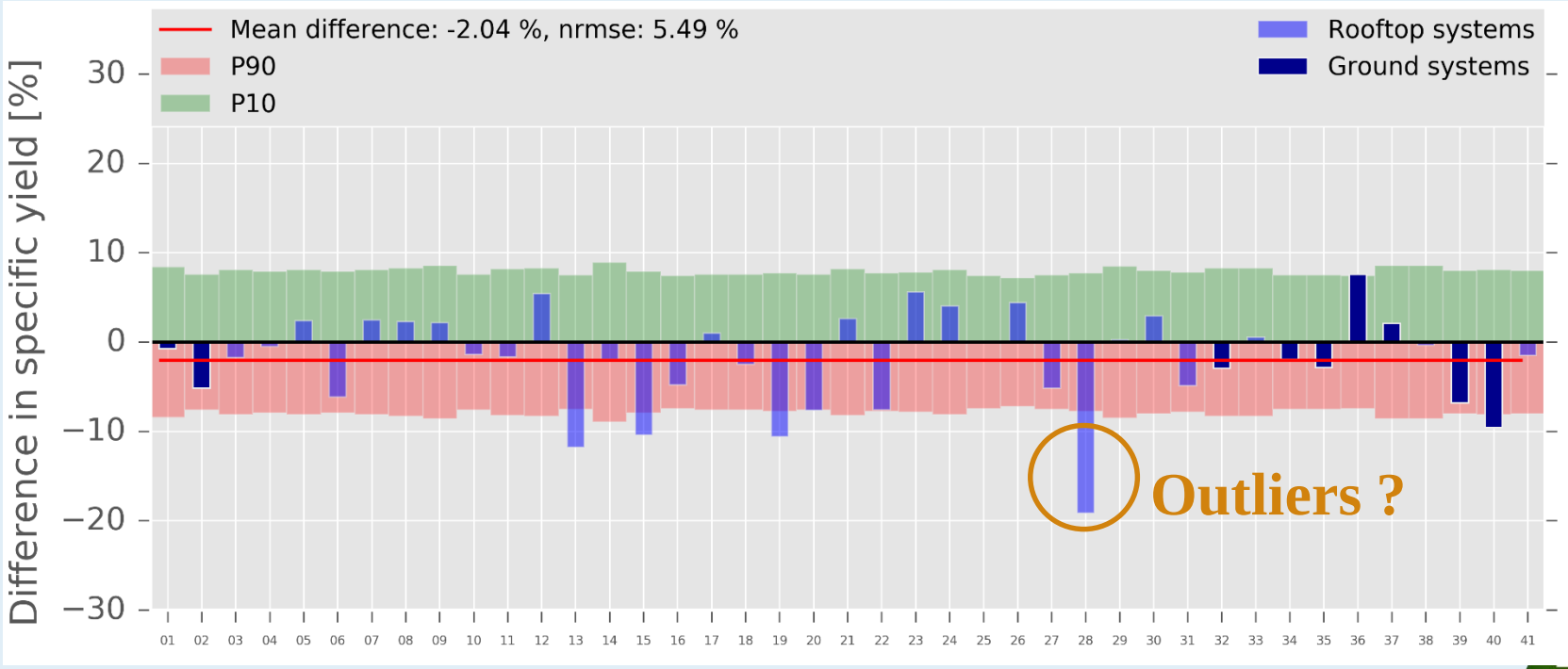
- Inadequate **protocol for data collection, KPIs calculation and visual inspection**
- Lack of **relevant equipment (IR / EL)**
- No short-term performance test at **provisional acceptance**

# Weaknesses: O&M

- Selected **monitoring system** is not capable of **advanced fault detection** and identification
- Missing or inadequate **maintenance of the monitoring system**
- **Preventive & corrective maintenance protocols**
- Inadequate or absent **relevant equipment (IR / EL)**

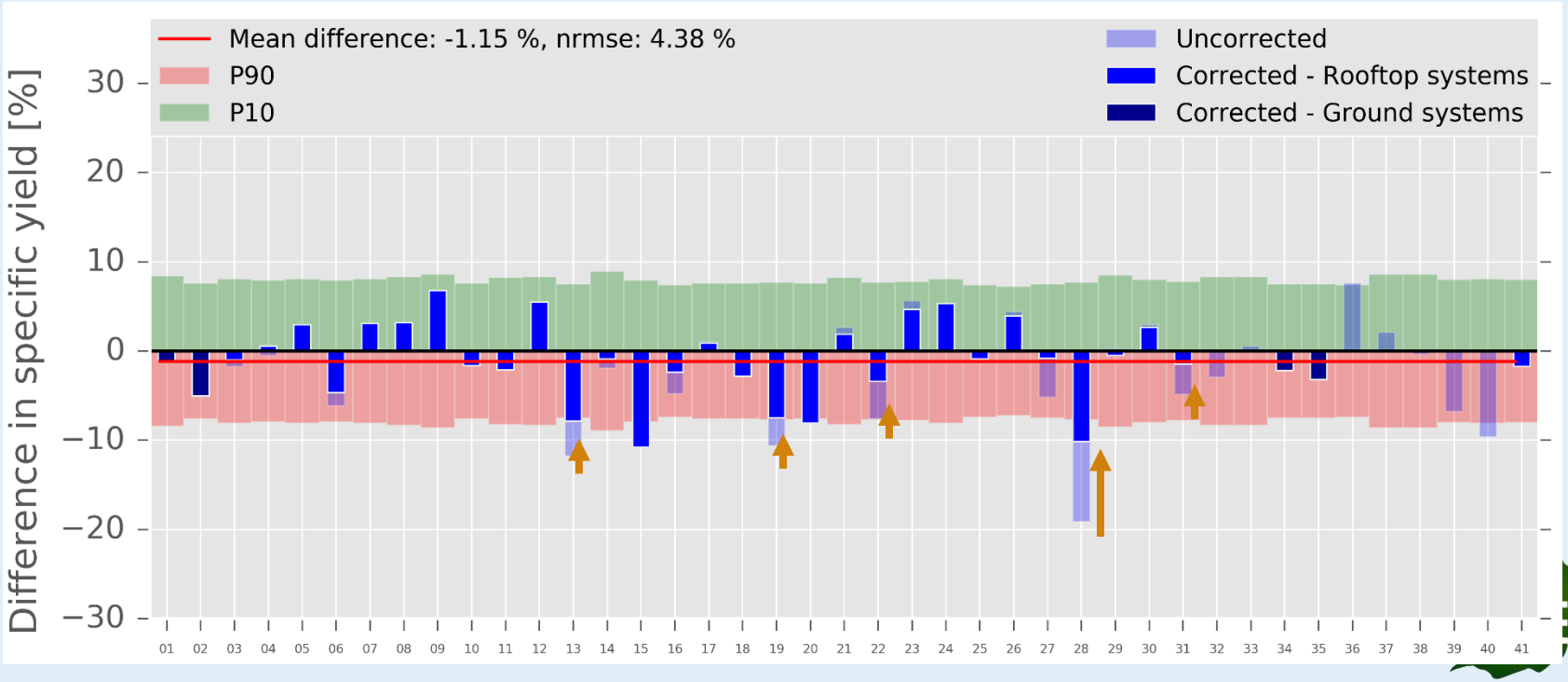
# Long-Term Yield Estimates & Their Level of Confidence

## Initial P50 and P90 yield estimates vs actual electricity production for a portfolio of 41 PV plants



# Long-Term Yield Estimates & Their Level of Confidence

- Deviations below the confidence margin (P90) disappear after correction
- 1.13% over-estimation (or under-performance?)



# Long-Term Yield Estimates & Their Level of Confidence

- Results at **plant level**:
  - For most of the PV plants across the analyzed portfolio the actual electricity production during first year of operation lies **within expected uncertainty ranges**
  - Actual **availability is lower than initial estimates** in LTYA

# Long-Term Yield Estimates & Their Level of Confidence

- Results at **portfolio level**:
  - The **yield is slightly lower than initially estimated** during the design phase **(-1.15%**)
  - The dispersion **(nRMSE) is around 4.4%** for the analyzed portfolio
  - These deviations are typically expected to be mainly due to the **variability of the solar resource** and **other site specific losses** that are not precisely modelled during the design phase

# Conclusions

- Main areas of weakness in a PV project:
  - **Inaccurate assumptions** for the future behavior of the PV plant
  - Lack of methods to **enable these assumptions** during design, building, commissioning, and O&M
  - **Lack of quality control throughout the plant's life**
- Focus on the technical aspects of the EPC and O&M scopes of work to manage the technical risks linked to the CAPEX and OPEX of PV investments

  … **Mitigation measures** (next presentations)

# Thank you

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