DEVELOPMENT OF STANDARDISATION METHODS FOR ECO-DESIGN AND ENERGY LABELLING OF PHOTOVOLTAIC PRODUCTS

Second Stakeholder Meeting

Hybrid, Brussels, July 3rd 2025

Supported by CINEA

European Commission

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Gobierno de España – Vicepresidencia Tercera del Gobierno – Ministerio para la Transición Ecológica y el Reto Demográfico – Ministerio de Ciencia e Innovación

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AGENDA

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01
WELCOME

1.1 WELCOME

- Over 130 people are registered to the project.
- Over 70 people have registered to attend this meeting.
- The meeting will be recorded for the purpose of analysing in detail the outputs and discussions. Consent was given when registering.

1.2 GROUND RULES FOR THE MEETING

- Video is not allowed. Please, switch off your cameras.
- Use the chat to send your questions and comments but remain muted until given the floor.
- When participating, first indicate name and institution. Please, be concise.

02

POLICY BACKGROUND & PROJECT OVERVIEW

2.1 TIMELINE

In **2017** the EC launched a **feasibility study** for the application of various policy tools to PV products and a technical preparatory study.

At present, **final drafts** are being prepared on:

- Potential Commission Regulation (EU) laying down the **Ecodesign requirements for PV modules and PV inverters**.
- Potential Commission Delegated Regulation (EU) with regard to **Energy Labelling of PV modules.**

More info at:

https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12819-Ecodesign-European-Commission-to-examine-need-for-new-rules-on-environmental-impact-of-photovoltaics_en

https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12820-Energy-labelling-European-Commission-to-examine-need-for-new-rules-on-environmental-impact-of-photovoltaics_en

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2.2 SYNERGY BETWEEN THIS STUDY AND THE POLICY WORK

- Unclear timeline for the policy work → **in any case it is seen as not feasible to include the considerations/findings of this study, due to the exploratory nature of the study, and its long duration.**
- This study has the **ambitious target** to developed standardised testing methods on aspects so far not covered: bifaciality and, in particular, long-term performance.
- This 'normative research' study will feed/be in **synergy with any (ongoing) standardization work**, obviously taking into account the specificities of PV modules on the EU market.
- The considerations/findings of the study could be reflected in the **future standardisation request in support to the Ecodesign/Energy Labelling Regulation**.

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2.3 PROJECT OVERVIEW

- **CINEA service contract** CINEA/2023/OP/0009/SI2.908958 "***Development of standardisation methods for eco-design and energy labelling of photovoltaic products***".
- Development of **standardisation (pre-normative) methods** related to:
  - Calculation and testing of the **Energy Yield (EY) of bifacial PV devices**.
  - Measurement and testing of the **long-term degradation of the PV modules' performance.**
- Both methods shall be relevant for the **potential implementation** in the ecodesign and energy label measures on PV modules.

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2.3 PROJECT OVERVIEW

- ❑ Duration **36 months**, from December 2023 to November 2026.
- ❑ **Consortium**:
  - TÜV Rheinland Italia
  - German National Metrology Institute - PTB
  - National Renewable Energy Centre (Spain) – Fundación CENER
- ❑ **CINEA**'s project is supported also by the EC´s DG for
  - Research and Innovation (**DG RTD**)
  - Internal Market, Industry, Entrepreneurship and SMEs (**DG GROW**)

2.3 PROJECT OVERVIEW - ROLES AND RESPONSIBILITIES

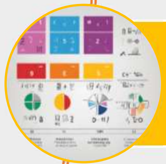
	Testing activities	Methodology development
Energy Yield bifacial PV modules	PTB Physikalisch-Technische Bundesanstalt Braunschweig und Berlin Nationales Metrologieinstitut	PTB Physikalisch-Technische Bundesanstalt Braunschweig und Berlin Nationales Metrologieinstitut; CENER National Renewable Energy Centre
Long-term PV performance degradation	TÜVRheinland® Precisely Right.; CENER National Renewable Energy Centre	TÜVRheinland® Precisely Right.; CENER National Renewable Energy Centre

2.3 PROJECT OVERVIEW – WORK PACKAGES

The project is divided in **four work packages**:

1. Work methodology and work plan development, and contract management.

2. **Testing plan design and execution.**



3. Preparation of standardised methods.

4. Stakeholder consultation.

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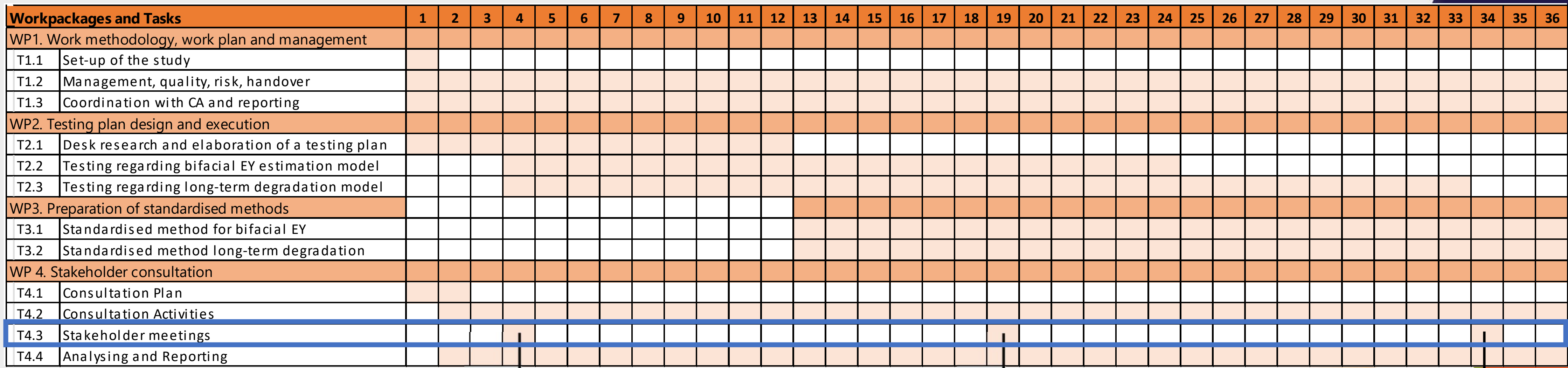
2.3 PROJECT OVERVIEW – GANTT CHART



1st stakeholder meeting (April 2024)
- Project's presentation
- Methodology and Testing plan proposal

2nd stakeholder meeting (July 2025)
- Findings on WP2
- Testing plan and results so far

3rd stakeholder meeting (Sep 2026)
- Draft final report

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2.4 STAKEHOLDER CONSULTATION ACTIVITIES

- **Feedback to 1st stakeholder meeting** received from 4 institutions.
- **Online questionnaire** available between 13/05/2024 and 24/06/2024.
- 16 replies:
  - Manufacturer: 9
  - Consultant: 1
  - NGO: 1
  - Research institution: 1
  - Other: 4

2.4 STAKEHOLDER CONSULTATION ACTIVITIES - ONLINE QUESTIONNAIRE

Bifacial energy yield study:

- General agreement with the **pre-selected modules**.
- Suggestions to the **methodology** to consider backside shading, albedo and different mounting configurations (for/against).
- Suggestions to the **testing plan** with regard to duration (from weeks to 1 year) and aspects to consider (long-term and partial shading behaviour, performance under low light conditions, etc).
- Suggestions to consider feedback from **real PV plants** and studies on **bifaciality** and **emerging technologies**.

2.4 STAKEHOLDER CONSULTATION ACTIVITIES - ONLINE QUESTIONNAIRE

Long-term degradation rate study:

- General agreement with the **pre-selected modules**.
- **Relevant variables** for the selection of modules include presence of UV blocker encapsulant, frame/frameless, glass thickness, number of busbars, etc.
- Suggestions to the **testing plan** to consider tests in available standards, including UVID and LETID, and mechanical stress, and tests duration recommendations (2 months to 2 years).
- Suggestions to the **methodology** include the consideration of different mounting configurations and climatic conditions.
- The methodology needs to be **easily implemented by most laboratories**.

2.4 STAKEHOLDER CONSULTATION ACTIVITIES - ONLINE QUESTIONNAIRE

Long-term degradation rate study:

- Most significant **failure modes** identified: delamination, electrical failure, discoloured encapsulation, UVID, DH and TC.
- General agreement on the **two different degradation rates**.

03

QUESTIONS & ANSWERS – INTRODUCTION

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04

ENERGY YIELD OF BIFACIAL PV MODULES

4.1 OBJECTIVE AND OVERVIEW

➢ Calculation and testing of the **Energy Yield (EY) of bifacial PV devices**.

WP2 Testing plan design and execution:

- T2.1 Desk research and elaboration of a testing plan
- T2.2 Testing activities to define a standardised method for calculating and testing the yield of bifacial modules

WP3 Preparation of standardized methods:

- T3.1 Preparation of a standardised method for calculating and testing the yield of bifacial modules

4.1 OBJECTIVE AND OVERVIEW

- **Energy Yield of monofacial devices** calculated after **EN IEC 61853 Standard series** "*Photovoltaic (PV) module performance testing and energy rating*" for six climatic zones defined in Part 4. Three of them represent the European climate conditions best: subtropical arid, temperate continental and temperate coastal.
- **Energy Yield of bifacial devices** are not yet covered by Energy Rating standards.
- Therefore, a simple **transitional method** is used until a more sophisticated method has been developed in this project:

$$\mathrm{EY}_{\mathrm{bifi}} = EY_{\mathrm{mono}} \cdot (1 + \varphi_{P\mathrm{max}} \cdot 0.135)$$

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4.1 OBJECTIVE AND OVERVIEW

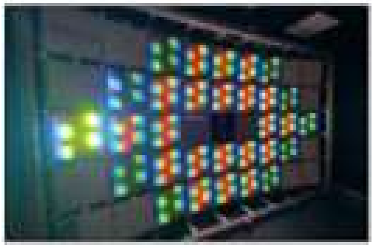
- **Extend Energy Rating calculation to support bifacial modules**.
- Methodology will be as similar as possible to the monofacial one (IEC 61853-3).
  - **New mounting configurations** (as discussed in IEC 61853-3 PT).
  - **Extended datasets** (IEC 61853-4) for in-plane irradiance (G, Gλ).
  - **Extended power matrix** (IEC 61853-1) if necessary, plus **bifaciality**.
  - **Extended tests** regarding Part 2 (a_r, SR, u_0 and u_1).
- **Assess the ability** of the methodology to differentiate and classify bifacial devices.
- **Check tolerances and uncertainties**.
- Aim is to make it easy to be **implemented by Market Surveillance Authorities**.

4.1 OBJECTIVE AND OVERVIEW

- **Amendments to IEC 61853** are under development by a group of experts of the **IEC TC 82 WG 2** to include bifacial devices in the Standard series' scope.
- All four parts of the Standard series are under revision.
- **If you are interested in contributing to one of the project teams, please contact: stefan.riechelmann@ptb.de.**
- **IEC 61853-3 has been submitted for circulation as committee draft (CD) two weeks ago.**
- Currently, work continues on -1 and -4 parts of the standard.

4.2 TESTING PLAN DEFINITION

Measure the **Energy Rating (ER) input parameters** of at least five bifacial PV devices from different manufacturers, according to the **modified procedures** of the IEC 61853 Standard series **Parts 1 and 2, at PTB**.

Power matrix (Part 1)	Spectral response measurements (Part 2)	Angle of incidence measurements (Part 2)	Temperature coefficients (Part 2)
Extended matrix (*Tmod* = 15-75°C and *Gmod*=100-1300 W/m^2) + bifaciality φ_{Pmax} measurements	Front side and rear side *SR* of the bifacial modules measured using an LED-based solar simulator	Front side and rear side *AOI* of the bifacial modules have been measured	Temperature coefficients measured by a testing configuration analogous to monofacial devices
			

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4.2 TESTING PLAN DEFINITION – NEW MOUNTING CONFIGURATIONS

New mounting conditions in IEC 61853-3:

Table 1: Overview of the four different settings for typical PV module mounting conditions.

	Setting 1	Setting 2	Setting 3	Setting 4
Description	closed rack	open rack	vertical	tracking
Inclination angle β_j	20°	20°	90°	variable
Orientation	Equator	Equator	front to East, rear to West	East/West




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4.3 NEW PV REFERENCE CLIMATES

- **Updated datasets** for rear-side irradiance and new mounting configurations.
- Selection of **three new locations** in Europe for energy rating specific climates.

Standard Reference Climate Profile (EN IEC 61853-4)	
Temperate continental	Relevant for Europe
Temperate coastal	Relevant for Europe
Subtropical arid	Relevant for Europe
Subtropical coastal	
Tropical humid	
High elevation (above 3000m)	

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4.3 NEW PV REFERENCE CLIMATES

Date, yyyy-mm-dd

Local solar time

Ambient temperature, T_{amb} (°C)

Wind speed at the module height, v ($m \cdot s^{-1}$)

ECMWF's ERA5

Sun elevation (°)

Sun incidence angle to the normal of the module, θ (°)

Global horizontal irradiance, Gh ($W \cdot m^{-2}$)

Direct horizontal irradiance, Bh ($W \cdot m^{-2}$)

CMSAF SARAH-3

+ Spectral Irrad

Global in-plane irradiance, G ($W \cdot m^{-2}$)

Direct in-plane irradiance, B ($W \cdot m^{-2}$)

New columns for the new mounting configurations and the front and rear side of the bifacial devices

Spectrally resolved global in-plane irradiance integrated in 32 spectral bands, R ($W \cdot m^{-2}$)

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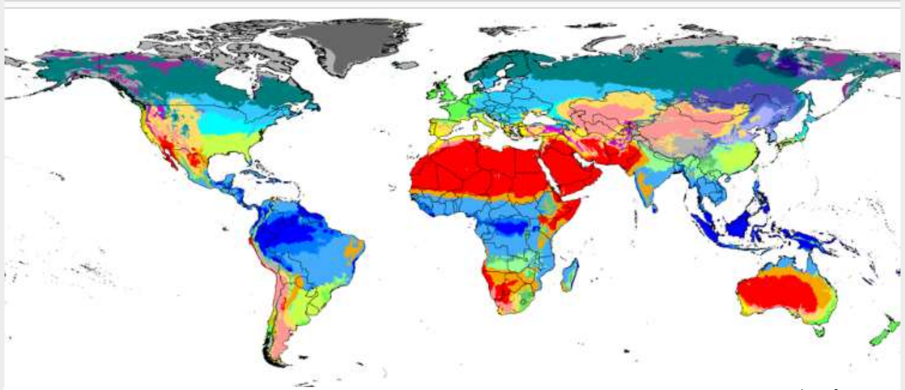
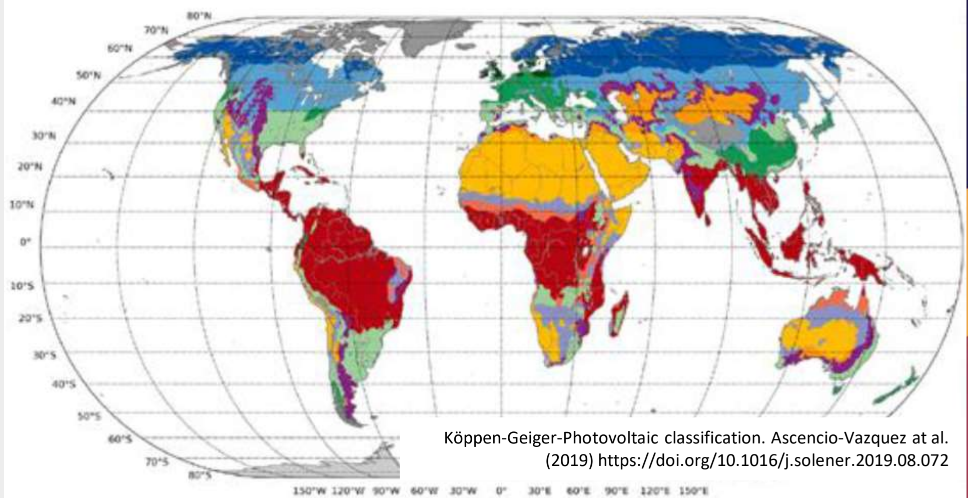
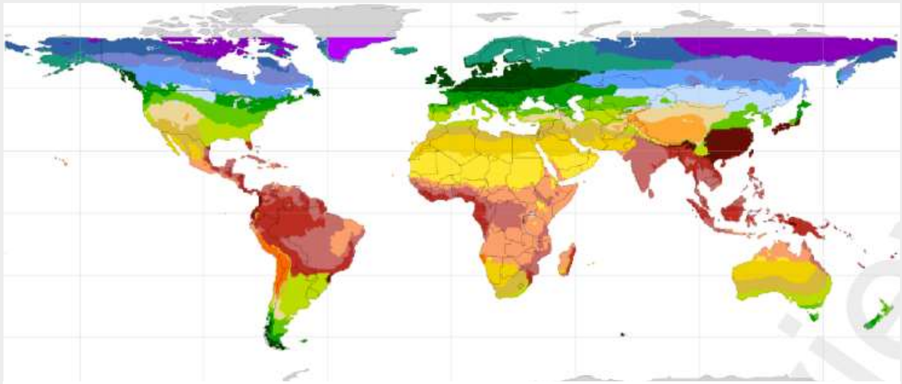
4.3 NEW PV REFERENCE CLIMATES



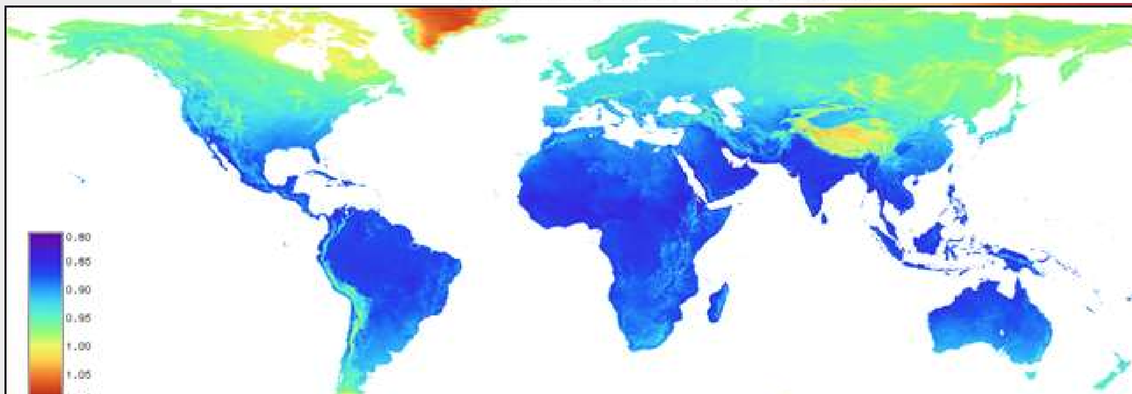
Köppen-Geiger classification



Köppen-Geiger-Photovoltaic classification. Ascencio-Vazquez at al. (2019) https://doi.org/10.1016/j.solener.2019.08.072



Triana de las Heras et al. (2024) SSRN http://dx.doi.org/10.2139/ssrn.4905242



cSi PV performance (without spectral effects) Huld, 2018

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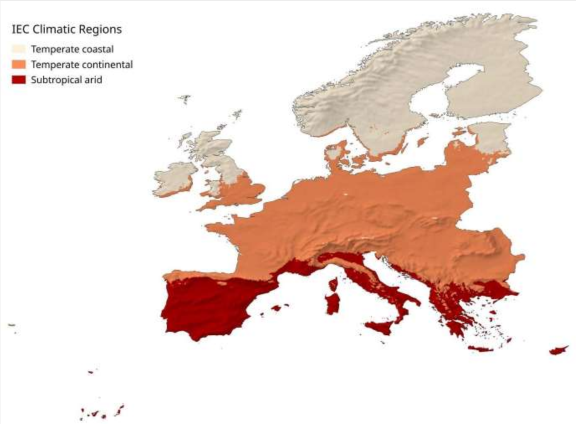
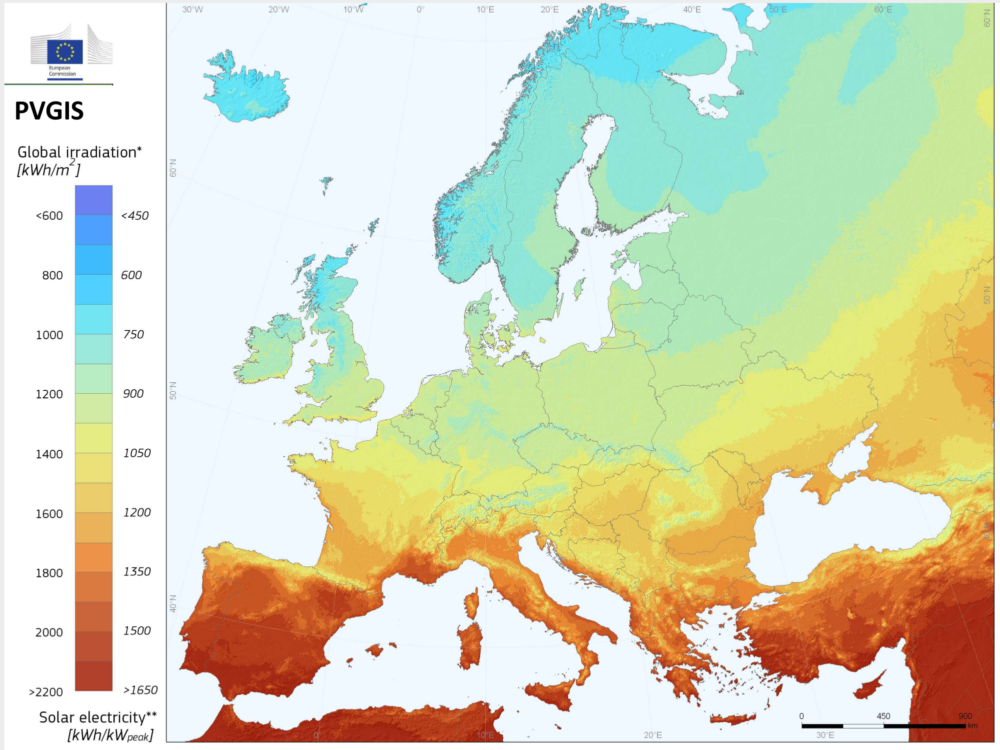
4.3 NEW PV REFERENCE CLIMATES – RELEVANT FOR EUROPE

Geographical distribution in Energy Label proposal





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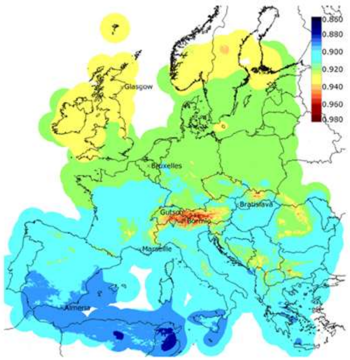
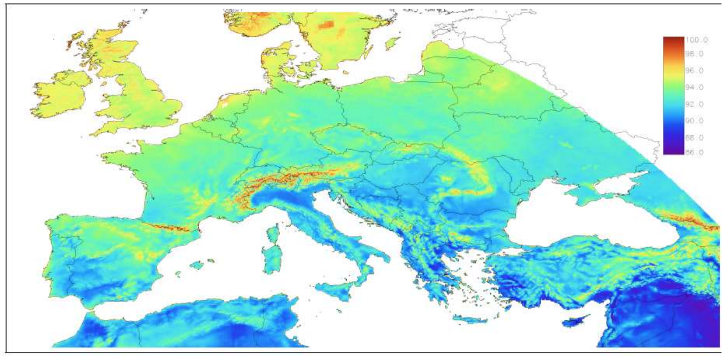
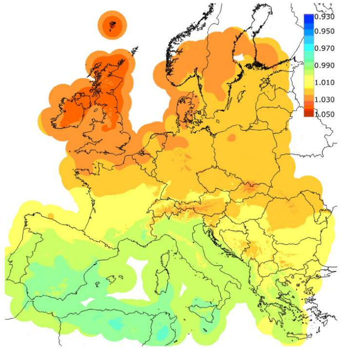
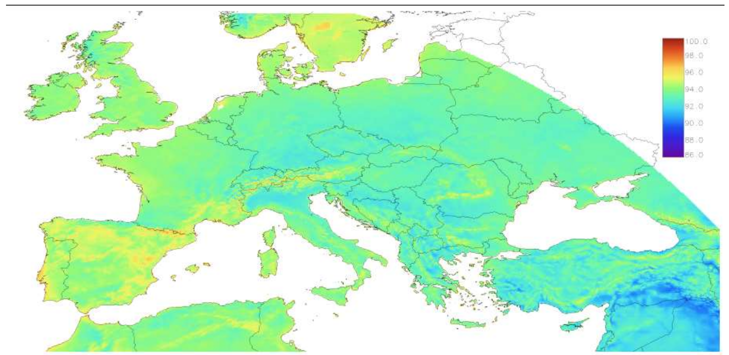
4.3 NEW PV REFERENCE CLIMATES – RELEVANT FOR EUROPE

Geographical estimated PV performance of various technologies.

	Huld at al 2013	Huld at al 2016
cSi		
CdTe		

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4.4 PV TECHNOLOGY SELECTION

Selection Criteria:

- As much different market-relevant technologies as possible.
- Broad range of Bifi factor.
- No samples with NDA, preferably purchased at a distributor.
- Readily available in small batches in Germany.

Module	Technology	φ_{Pmax} (%)
M1	Heterojunction, n-Type	88
M2	Crystalline Silicon TOPCon, white	76
M3	Crystalline Silicon TOPCon, transparent	80
M4	Crystalline Silicon TOPCon, fullblack	73
M5	PERC frameless	70
M6	IBC (Interdigitated back contact)	41

Pre-selection:

Module	Technology	φ_{Pmax} (%)
M1	Heterojunction, n-Type	90
M2	TOPCon	85
M3	PERC frameless	85
M4	PERC Ga-doped	70
M5	PERC Bo-doped	70
(M6)	IBC (Interdigitated back contact)	?

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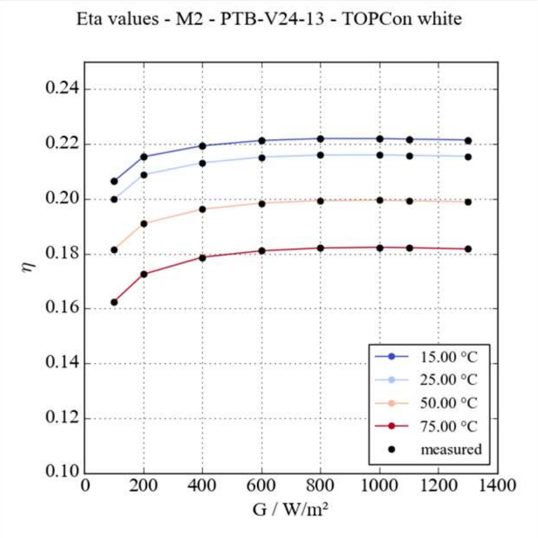
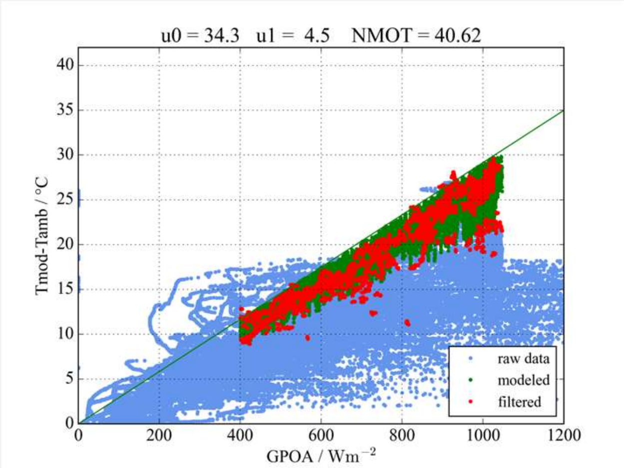
4.5 FIRST RESULTS

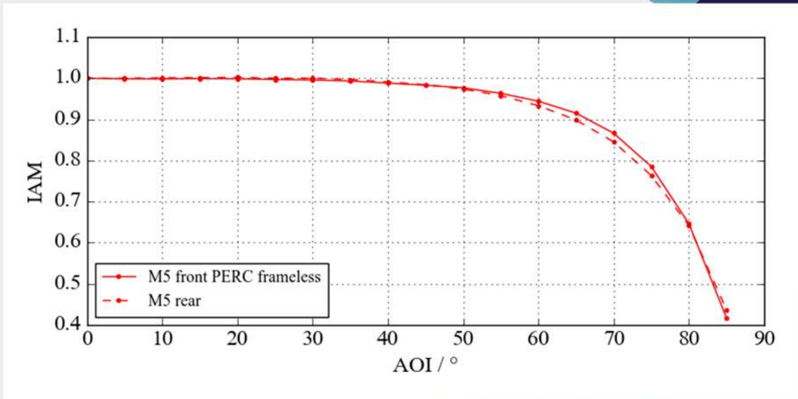
Module	STC	φ_{Pmax}	GT Matrix	SR	AOI	Wind coefficients
M1, HJT	✓	✓	✓	✓	✓	✓
M2, TOPCon, white	✓	✓	✓	✓	✓	✓
M3, TOPCon, transparent	✓	✓	✓	✓	✓	✓
M4, TOPCon, fullblack	✓	✓	✓	✓	✓	ongoing
M5, PERC frameless	✓	✓	✓	✓	✓	ongoing
M6, IBC	✓	✓	✓	✓	✓	ongoing
M7, TOPCon, monofacial	✓	✓	✓	✓	✓	ongoing

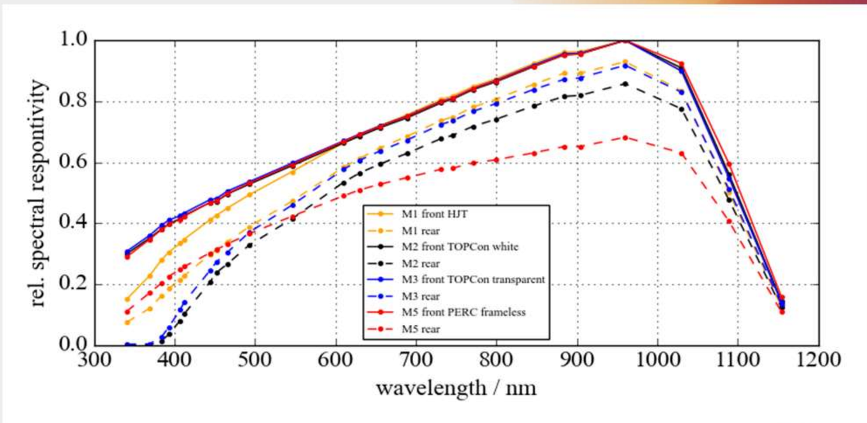
4.5 FIRST RESULTS

Example of the measurements performed so far by PTB









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4.5 FIRST RESULTS

Preliminary results with new mounting conditions in IEC 61853-3

Temperate coastal	Setting 1 Rooftop	Setting 2 Ground-mounted	Setting 3 Vertical E/W	Setting 4 Tracking
M1, HJT	0.962	1.046	1.832	1.070
M2, TOPCon, white	0.979	1.052	1.739	1.071
M3, TOPCon, transparent	0.973	1.049	1.766	1.071
M4, TOPCon, fullblack	0.984	1.053	1.709	1.072
M5, PERC frameless	0.994	1.062	1.714	1.079
M6, IBC	0.958	0.998	1.342	1.014
M7, TOPCon, monofacial	0.973	0.975	0.963	0.981

Subtropical arid	Setting 1 Rooftop	Setting 2 Ground-mounted	Setting 3 Vertical E/W	Setting 4 Tracking
M1, HJT	0.919	1.059	1.675	1.042
M2, TOPCon, white	0.919	1.036	1.574	1.019
M3, TOPCon, transparent	0.919	1.044	1.603	1.028
M4, TOPCon, fullblack	0.926	1.037	1.552	1.021
M5, PERC frameless	0.922	1.025	1.542	1.007
M6, IBC	0.921	0.985	1.257	0.980
M7, TOPCon, monofacial	0.919	0.922	0.913	0.926

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4.5 NEXT STEPS

1. Finalize the **wind coefficients** measurements during summer.
2. Analyse relevant **feedback received within IEC TC 82/WG2** of bifacial energy yield method included in IEC 61853-3 ED2 (CD).
3. Work on **IEC 61853-1** (GT matrix measurements).
4. Work on IEC 61853-4 (standard reference climatologies) to develop three **new climatic datasets relevant for Europe**.
5. Perform studies regarding **module temperature under bifacial illumination** and **bifaciality under different irradiance conditions**.

05

QUESTIONS & ANSWERS – ENERGY YIELD OF BIFACIAL PV MODULES

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06

LONG-TERM PV PERFORMANCE DEGRADATION RATE

6.1 OBJECTIVE AND OVERVIEW

➢ Measurement and testing of the **long-term degradation of the PV modules' performance** (including monofacial and bifacial devices).

WP2 Testing plan design and execution:

- T2.1 Desk research and elaboration of a testing plan.
- T2.3 Testing activities to define a standardised method for the assessment of the long-term degradation of PV modules' performance.

WP3 Preparation of standardized methods:

- T3.2 Preparation of a standardised method for assessing the long-term degradation of PV modules' performance.

6.2 TESTING PLAN DEFINITION

Identification of specific **failure modes** and most severe **degradation modes** per technology and EU reference climates

Identification **of sequences of tests**

Adjustment of selected tests to the **EU reference climates**

Consideration of the effect of **environmental** and **internal stress factors**

- Ability to deliver **different degradation rates** for the same PV module under different stress conditions.
- **Easy to implement** by manufacturers & Market Surveillance Authorities.
  - Characterization & stabilization requirements.
  - Testing sample selection.
  - Overall duration.

Assumption:
Modules in the PV market have passed type approval and safety standard tests.

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6.2 TESTING PLAN DEFINITION

Relevant Standards	• Performance (**IEC 61215 series**) and safety (**IEC 61730**) qualification Standards with **increased severity**. • **IEC TS 63209-1** extended stress testing. • **IEC TR 63279** sequential and combined accelerated stress testing. • **IEC standardisation initiatives** focused on LETID and UVID and combined tests (Damp Heat, Thermal Cycling and UV exposure).
Testing protocols	• PVEL's PV module Product Qualification Programme and Reliability Scorecard. • TÜV Rheinland's Extended Bankability Testing. • NREL's Qualification Plus Testing. • Fraunhofer's PV Durability Initiative.
Transitional method	• **Default values**: Si-based modules **0.7%/year,** thin-film modules **1%/year.** • **Estimated values**: 5 years data, 2 mounting configurations and 2 locations per reference climate.

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6.2 TESTING PLAN DEFINITION

Research projects	• International PV Quality Assurance Task Force (PVQAT). • Durable Module Materials Consortium (DuraMAT). • Photovoltaic Collaborative to Advance Multi-climate Performance and Energy Research project (PV CAMPER). • Solar PV, performance and reliability project (TRUSTPV).
Experts expertise	• Scientific papers (long-term performance monitoring at different climatic conditions & modelling approaches). • Meetings with various experts (IEA T13 experts, Fraunhofer ISE, Sandia National Laboratories, NREL TÜV Rheinland Cologne and Shangai, CSEM, SUPSI, etc).
Project team expertise	• TÜV Rheinland and CENER accredited laboratories and experience. • Members of IEC Standardisation Committee for PV, TC 82 WG 2. • Experience in the detection and identification of failures, as well as in the development of stress tests.

6.2 TESTING PLAN DEFINITION – FEEDBACK FROM EXPERT MEETINGS

Complexity:

- Difficult to propose something useful for all technologies.
- Degradation mechanisms are very different and often differ between generations.
- New technologies and BOM have shown different degradation mechanisms.

Quantification:

- Available standards provide a pass/fail criteria but not calculate quantitative numbers.

Modelling:

- Arrhenius kinetics to model the effect of temperature in an exponential way.
- Other stress factors (humidity, moisture, oxygen, light, mechanical load, etc..) need other approaches.
- Coffin-Manson is more suitable to model behaviours that depend on temperature variation (thermal fatigue).

6.2 TESTING PLAN DEFINITION – FEEDBACK FROM EXPERT MEETINGS

Outdoor performance data:

- Comparison with outdoor data is crucial.
- Various experts could share outdoor monitored data but the climatic conditions should be representative of European climates.

Indoor data:

- Analyse results and data of test plans like IEC 61215, IEC TS 63209-1, IEC 61730 to identify the most critical stress factors.
- Analyse results of PV modules already tested in TÜV and CENER's laboratories following these testing sequences.

6.2 TESTING PLAN DEFINITION - DEGRADATION MECHANISMS

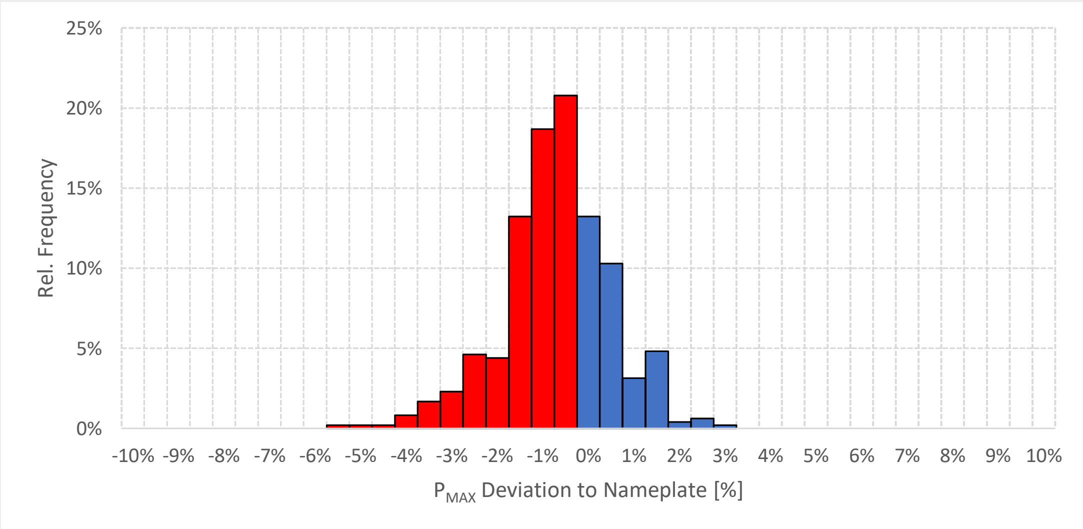
Type	Affected component	PV technology affected	Type of test
Thermal degradation	Cell	All	Thermal cycling
Light induced degradation (LID)	Cell	All	LID (high dose)
Potential induced degradation (PID)	Cell	P-type c-Si	PID
Light and temperature induced degradation (LETID)	Cell	PERC	LETID
Thermo-mechanical stress	Cell, front and back sheet, glass	All, glass-glass	Mechanical stress + thermal cycling
Diffusion processes (water, oxygen ingress)	Contacts, wires, polymers	All	Damp heat
UV induced degradation	Front and back sheet	HJT	UVID

6.2 TESTING PLAN DEFINITION - DEGRADATION MECHANISMS

DATA FROM CERTIFICATION PROJECTS (400 samples)

#	Company	Characteristics	Power Labelling [W]	Pmpp [W]	Vmpp [V]	Impp [A]	Voc [V]	Isc [A]	FF [%]	Difference
1		mono cut-cell c-Si module, 132 pcs	605	594.9	40.2	14.8	47.5	15.6	80.5	-1.67%
2		mono cut-cell c-Si module, 132 pcs	605	593.1	40.3	14.7	47.5	15.5	80.8	-1.97%
3		mono cut-cell c-Si module, 132 pcs	605	593.3	40.2	14.8	47.4	15.5	80.6	-1.93%
4		mono cut-cell c-Si module, 144 pcs	570	567.9	44.2	12.8	51.8	13.5	81.1	-0.37%

TÜV Rheinland Data



6.2 TESTING PLAN DEFINITION - DEGRADATION MECHANISMS

Main tests of IEC 61215:

- **Damp heat:** temperature and humidity
- **PID:** potential induced degradation
- **LETID:** Light and temperature induced degradation
- **Temp cycles:** temperature cycles
- **UVID:** UV light induced degradation

TÜV Rheinland Data

Power loss (%) - ΔP

- **Technologies**:
  - PERC
  - TOPCon
  - Back Contacted
- **Structure**:
  - G/G (glass-glass)
  - G/BS (glass-backsheet)

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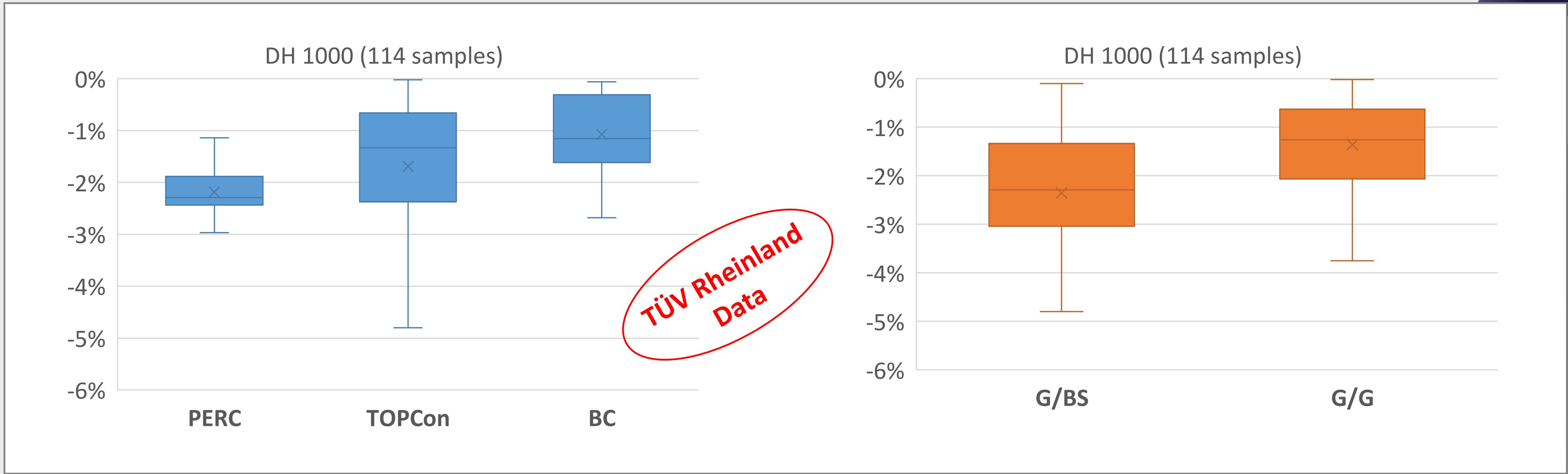
6.2 TESTING PLAN DEFINITION - DEGRADATION MECHANISMS

Damp heat



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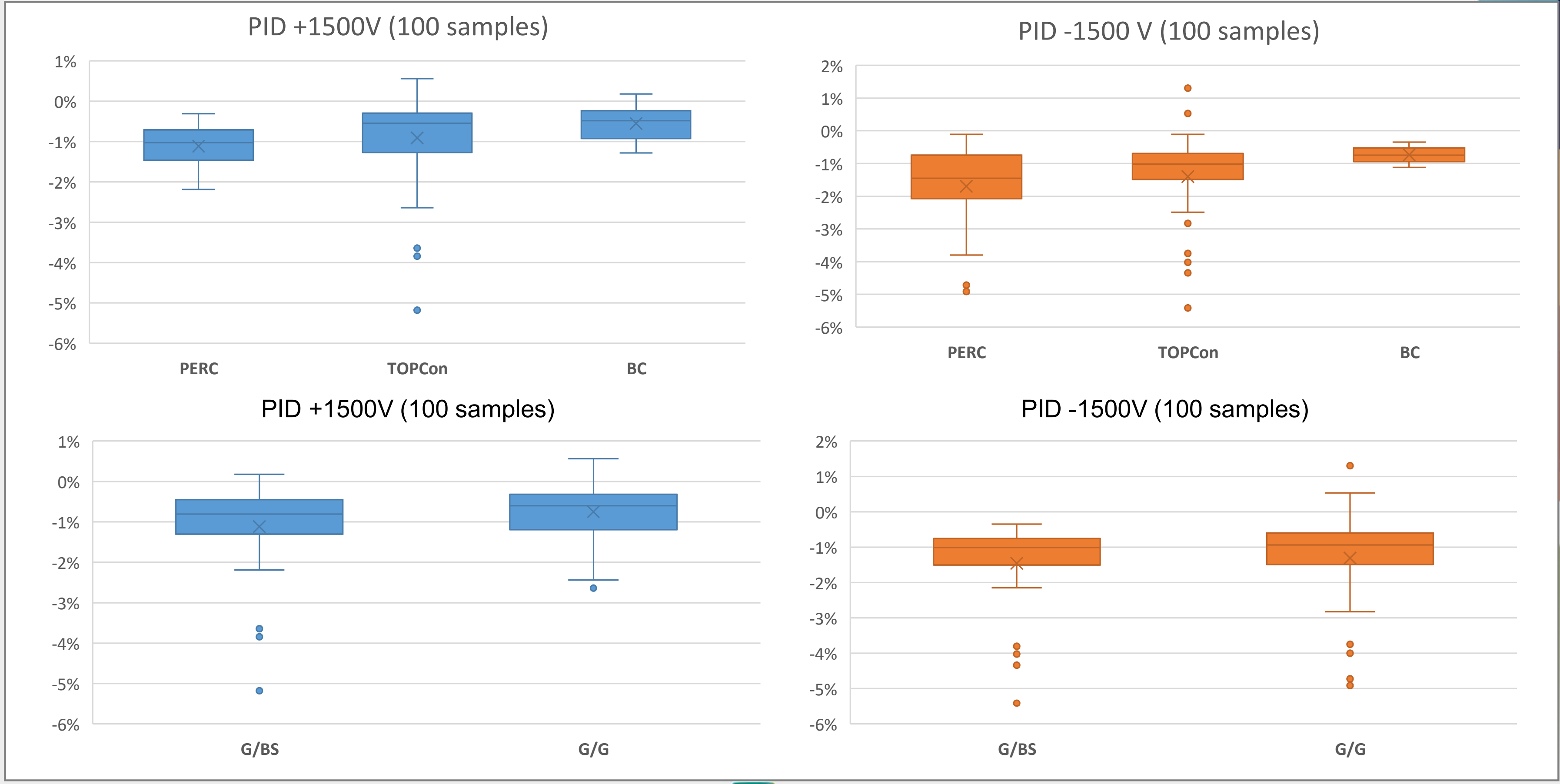
6.2 TESTING PLAN DEFINITION - DEGRADATION MECHANISMS

PID

TÜV Rheinland Data



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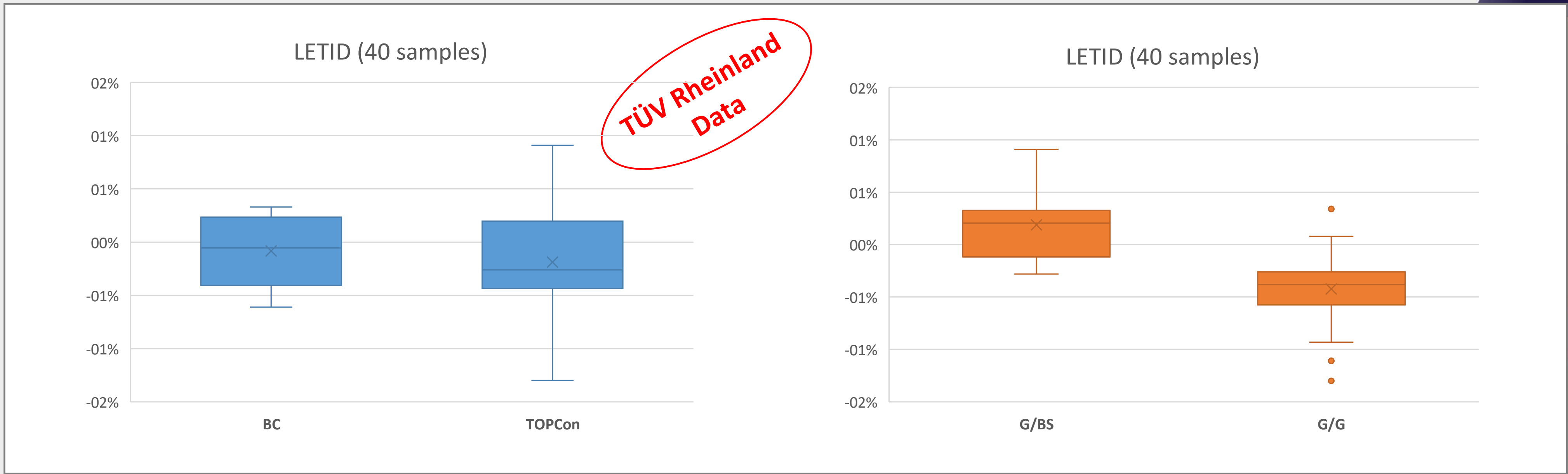
6.2 TESTING PLAN DEFINITION - DEGRADATION MECHANISMS

LETID



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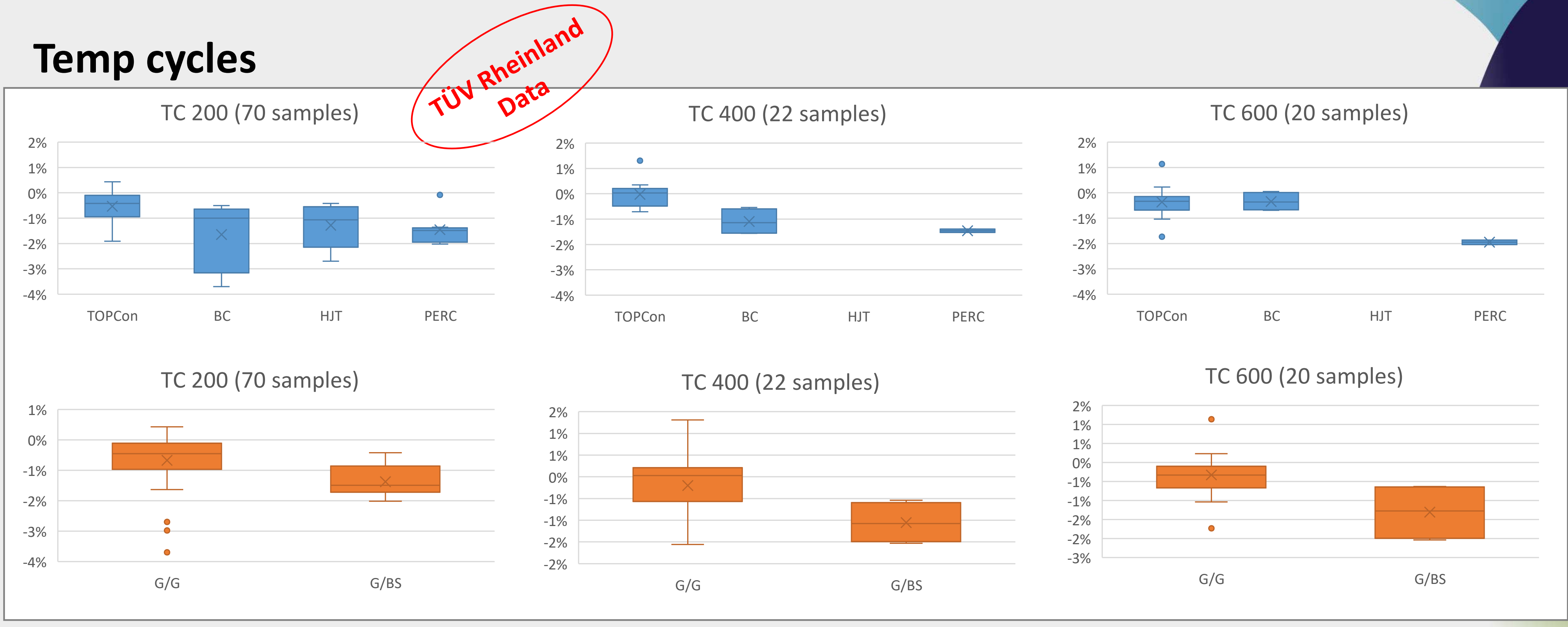
6.2 TESTING PLAN DEFINITION - DEGRADATION MECHANISMS

Temp cycles



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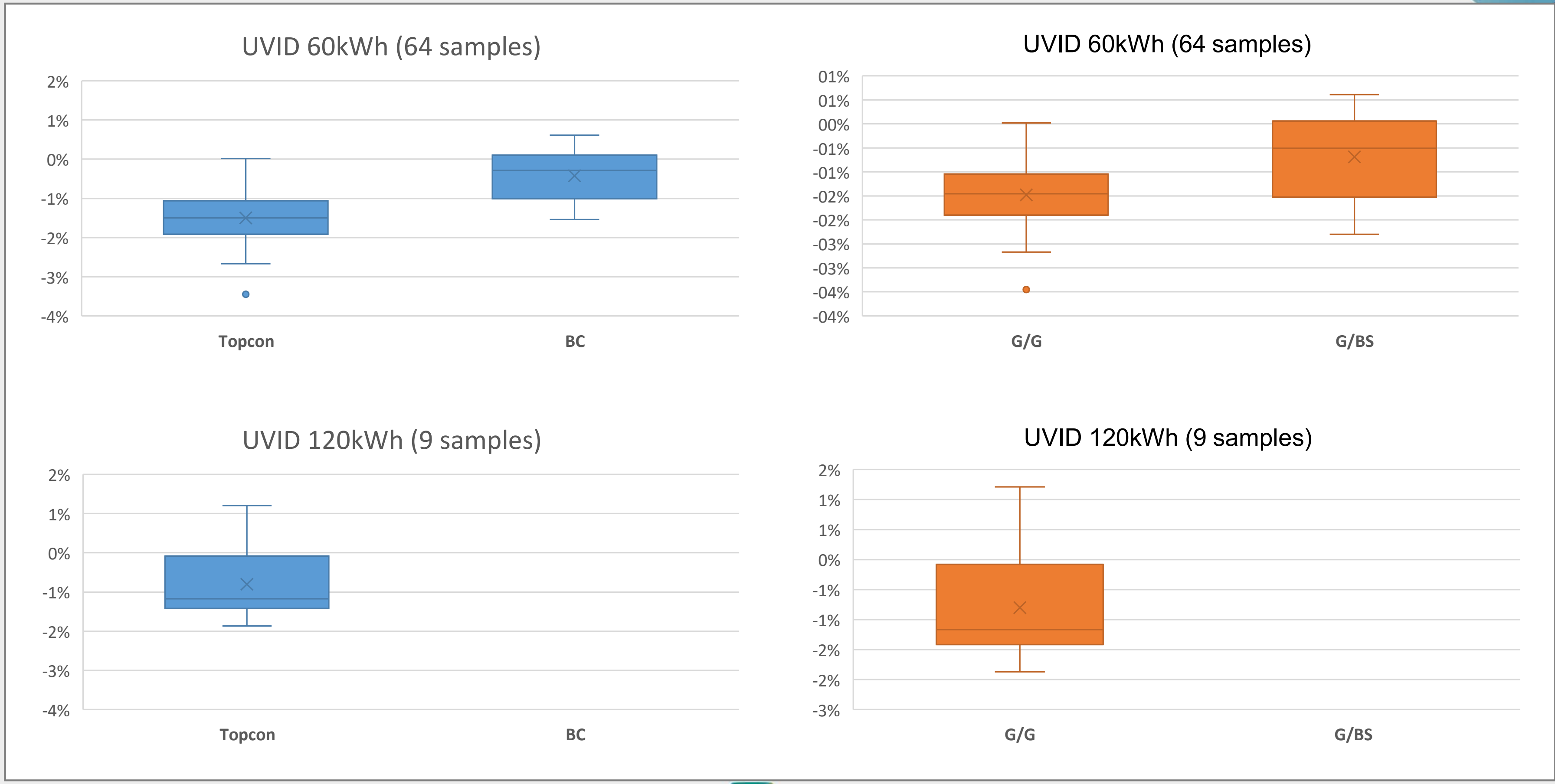
6.2 TESTING PLAN DEFINITION - DEGRADATION MECHANISMS

UVID

TÜV Rheinland Data



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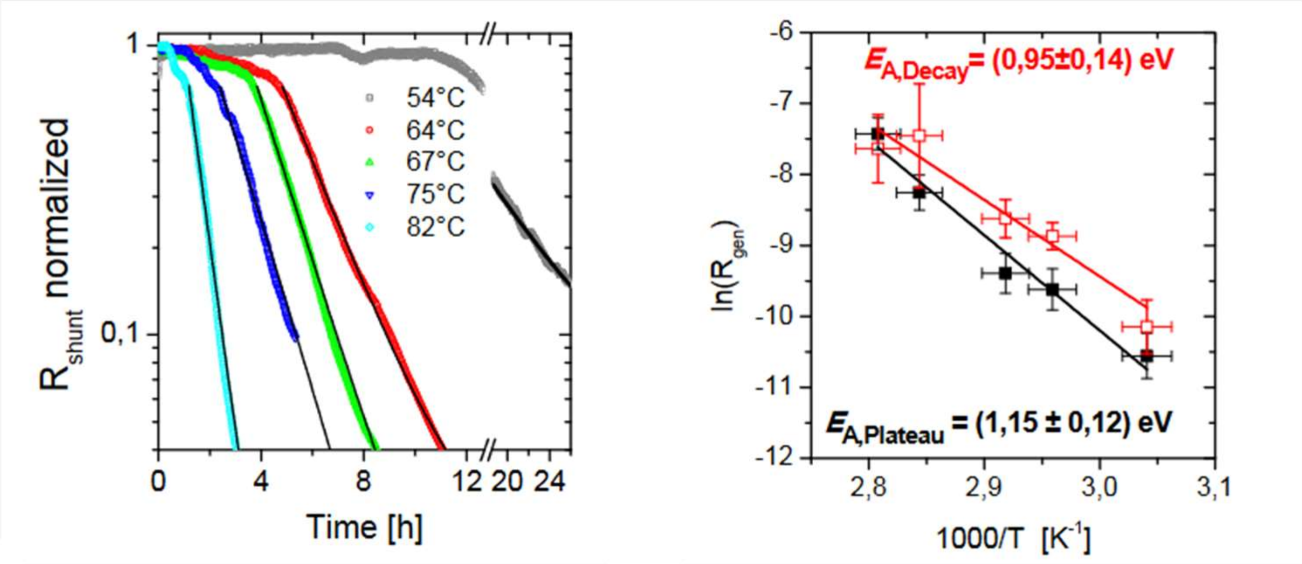
6.2 TESTING PLAN DEFINITION - DEGRADATION MECHANISMS

- **Damp heat and PID:** 3 temperatures for calculation of activation energy E_A
- **Temperature cycles:** theoretical estimation following IEC 62892 approach
- **LETID and UVID**: minor contribution



Source: Mario Bähr and Kevin Lauer / Energy Procedia 77 (2015) 2 – 7

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6.3 TESTING SEQUENCE

PID				Damp heat				UVID	Outdoor exposure
Power loss & Shunt resistance				Power loss at 1000h, +500h				Power loss (& Pass/Fail ?)	Power loss every 3 months
Measurements at: 85% RH, 1500 V for 96h/temp.				Measurements at: 85% RH for 2000h/temp.				Dose (kWh/m²): 200*	Cologne (1106 kWh/m²) Pamplona (1519 kWh/m²)
Temp. (°C)	65	75	85	Temp. (°C)	65	75	85	Duration is chamber dependent	Duration of at least 1 year
3 modules				**3 modules**				**1 module**	**2 modules**

* UV dose to be confirmed

2 control modules + 1 spare module

Initial measurements

1. Stabilization → 2. Performance (EL, IV) → 3. Insulation test → 4. Wet leakage current test

PID (T1, T2, T3)
- CENER
- 288 h, 12 days

Damp heat (T1, T2, T3)
- TÜV : 2 Temps
- CENER : 1 Temp
- 6000 h, 250 days

Estimation of the Activation Energy

UVID
- Chamber based
- TÜV : 50% modules
- CENER : 50% modules

Outdoor exposure
- At least 1 year
- TÜV : 1 module
- CENER : 1 module

Final measurements

1. Stabilization → 2. Performance (EL, IV) → 3. Insulation test → 4. Wet leakage current test

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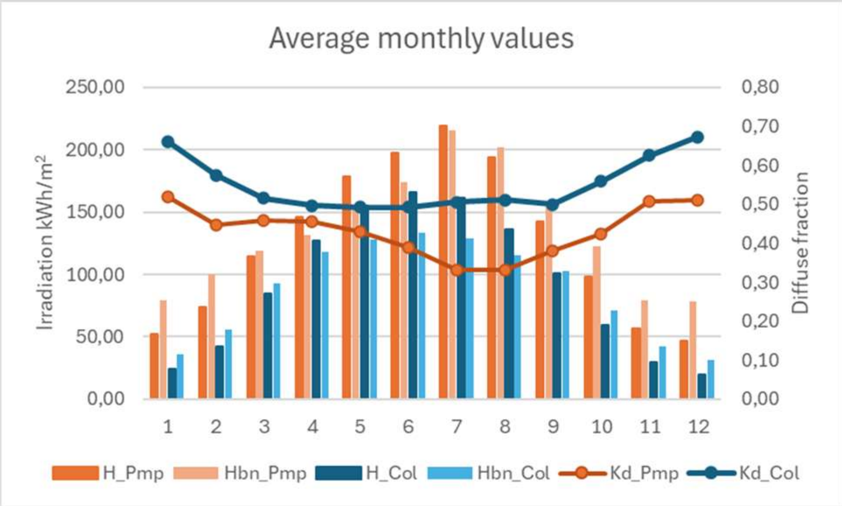
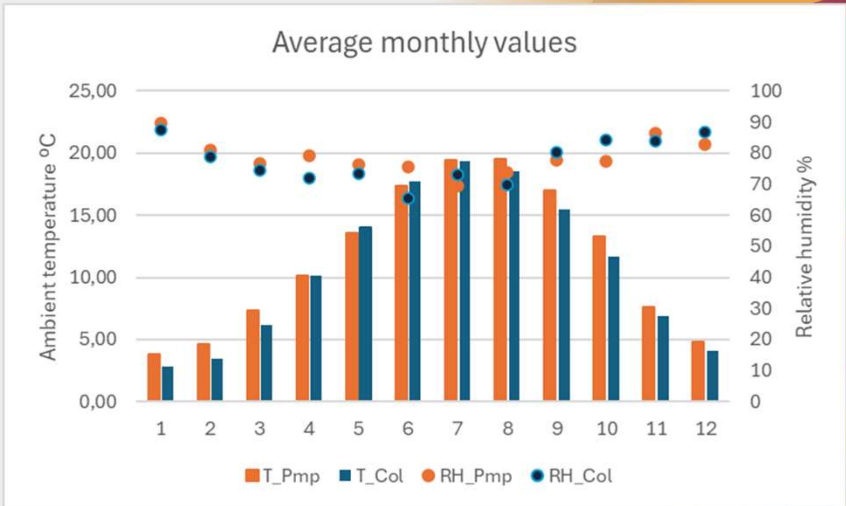
6.3 TESTING SEQUENCE – OUTDOOR EXPOSURE

Outdoor exposure
Power loss every 3 months
Cologne (1106 kWh/m^2) Pamplona (1519 kWh/m^2)
Duration of at least 1 year
2 modules



Pamplona compared to Cologne:

- 37% higher global horizontal irradiation (H)
- 53% higher beam normal irradiation (Hbn)
- 12% lower diffuse fraction (kd)
- 6% higher ambient temperature (T)
- 2% higher relative humidity (RH)



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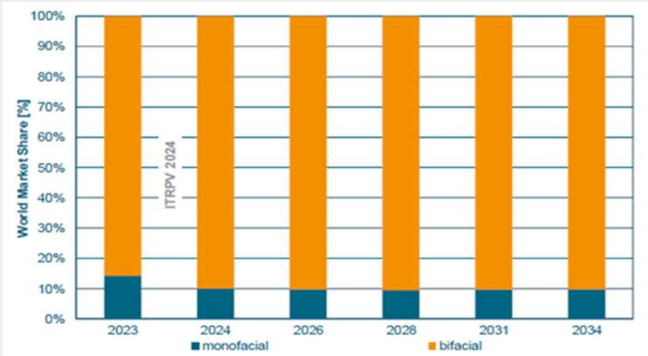
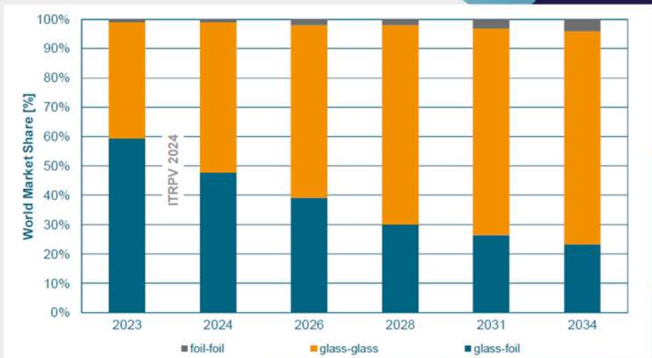
6.4 PV TECHNOLOGY SELECTION

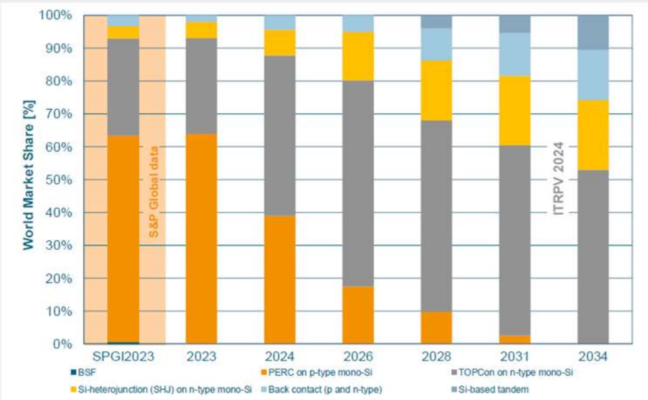
- Layout (G/G, G/BS)
- Monofacial or Bifacial
- V system
- Type of encapsulant
- Cell technology



Market dominated by bifacial cells



Evolution towards glass-glass



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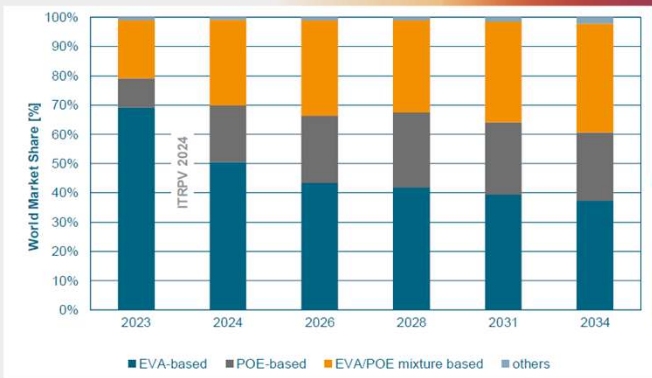
TOPCon n-type expected to dominate the market (followed by Si-Heterojunction n-type and Back contact)

POE and EVA/POE are increasing their market share



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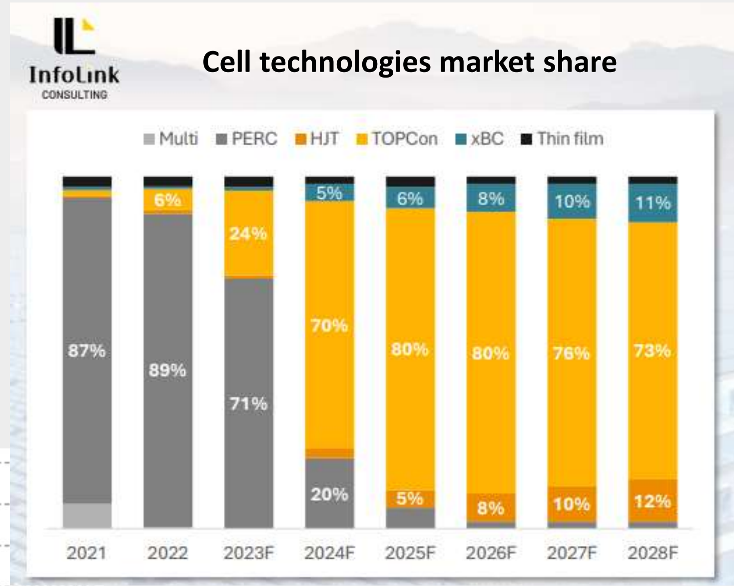

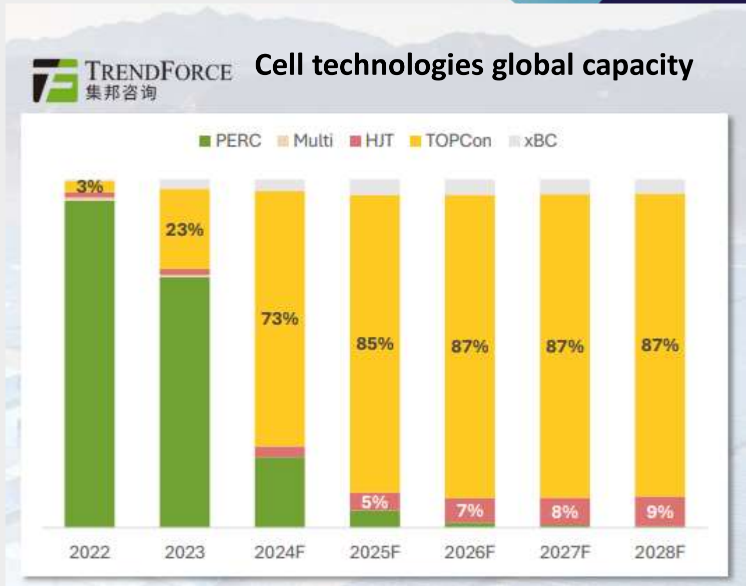

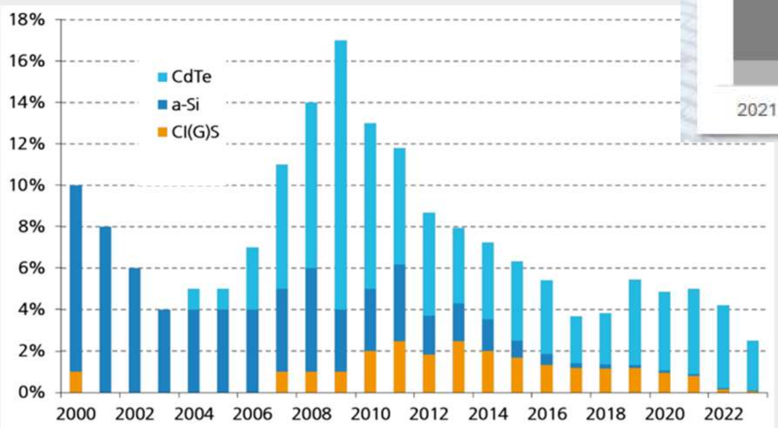

Market share of Thin-film technologies (Source: Fraunhofer ISE)

6.4 PV TECHNOLOGY SELECTION

Pre-selection:

Module	Technology	Dimension
M1	Heterojunction, n-Type	< 2 m
M2	Crystalline Silicon TOPCon, n-Type	< 2 m
M3	Mono-crystalline Silicon PERC p-type Ga dopped	< 2 m
M4	Mono-crystalline Silicon PERC p-type Bo dopped	< 2 m
M5	Interdigitated back contact	< 2 m
M6	Thin-film (CdTe)	< 2 m
M7	Thin-film (CGIS or amorphous silicon)	< 2 m
M8	Tandem perovskite (if available)	< 2 m

Selection:

- 1 HJT (G/BS)
- 4 TOPCon (2 G/G – 2 G/BS)
- 2 PERC (G/BS)
- 1 IBC (G/BS)

6.4 PV TECHNOLOGY SELECTION

Module	Technology	Monofacial /Bifacial	Layout	Front	Rear	Diodes	P_{STC} (W)	Efficiency (%)
M1	Heterojunction	Monofacial, 88 half-cut cells	G/BS	Glass 3.2 mm with ARC	High resistance polyester	4	450	21.61
M2	PERC mono	Monofacial, 120 half-cut cells	G/BS	Glass 3.2 mm with ARC	Plastic backsheet	3	450	20.79
M3	PERC mono	Monofacial, 120 half-cut cells	G/BS	Glass 3.2 mm with ARC	Plastic backsheet	3	460	21.26
M4	TOPCon mono	Monofacial, 108 cells	G/BS	Glass 3.2 mm with ARC	Plastic backsheet	3	450	22.52
M5	TOPCon-n mono	Monofacial, 120 half-cut cells	G/BS	Glass 3.2 mm with ARC	Plastic backsheet	3	500	23.09
M6	TOPCon-n	Bifacial, 120 cells	G/G	Glass reinforced 2 mm	Glass 2 mm	3	475	21.94
M7	TOPCon-n	Monofacial, 144 cells	G/G	Glass semi tempered 1.6 mm	Glass semi tempered 1.6 mm	3	440	22.53
M8	IBC	Monofacial, 108 cells	G/BS	Glass 3.2 mm with ARC	Plastic backsheet	3	455	22.29
M9	Heterojunction		G/G	Glass	Glass			

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6.4 PV TECHNOLOGY SELECTION

Module	Technology	Monofacial /Bifacial	Layout
M1	Heterojunction	Monofacial, 88 half-cut cells	G/BS
M2	PERC mono	Monofacial, 120 half-cut cells	G/BS
M3	PERC mono	Monofacial, 120 half-cut cells	G/BS
M4	TOPCon mono	Monofacial, 108 cells	G/BS
M5	TOPCon-n mono	Monofacial, 120 half-cut cells	G/BS
M6	TOPCon-n	Bifacial, 120 cells	G/G
M7	TOPCon-n	Monofacial, 144 cells	G/G
M8	IBC	Monofacial, 108 cells	G/BS
M9	Heterojunction		G/G

Test	Number of modules	Total modules	TÜV	CENER
PID	3	24 (27)	0	24 (27)
Damp heat	3	24 (27)	16 (18)	8 (9)
UVID	1	8 (9)	4 (5)	4 (4)
Outdoor exposure	2	16 (18)	8 (9)	8 (9)
Control	2	16 (18)	8 (9)	8 (9)
Spare	1	8 (9)	0	8 (9)
	12	**96** (108)	**36** (41)	**60** (67)
	96 (108)	Numbers in () if M9 is purchased		

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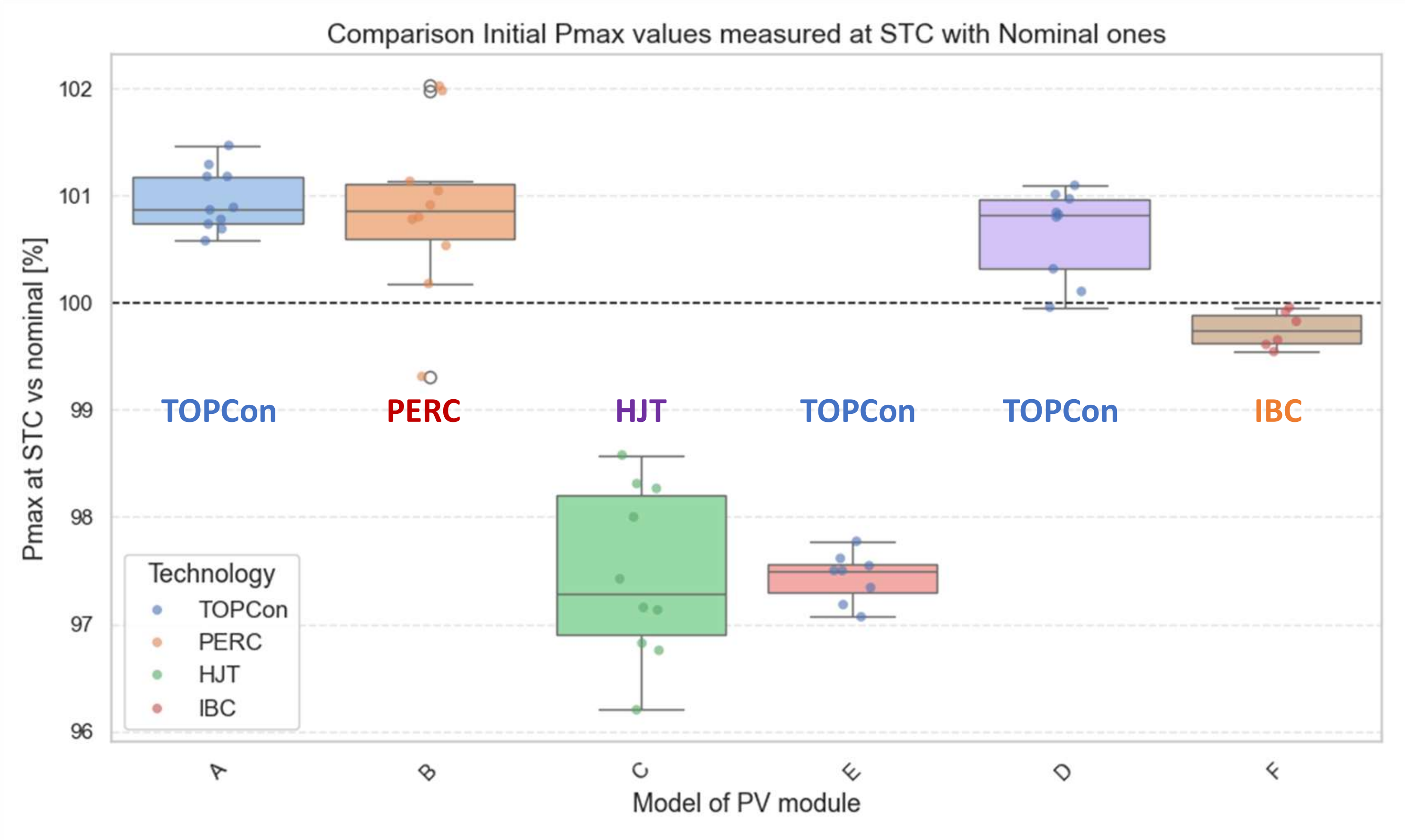
6.5 FIRST RESULTS

Maximum Power @ STC (MQT06.1)



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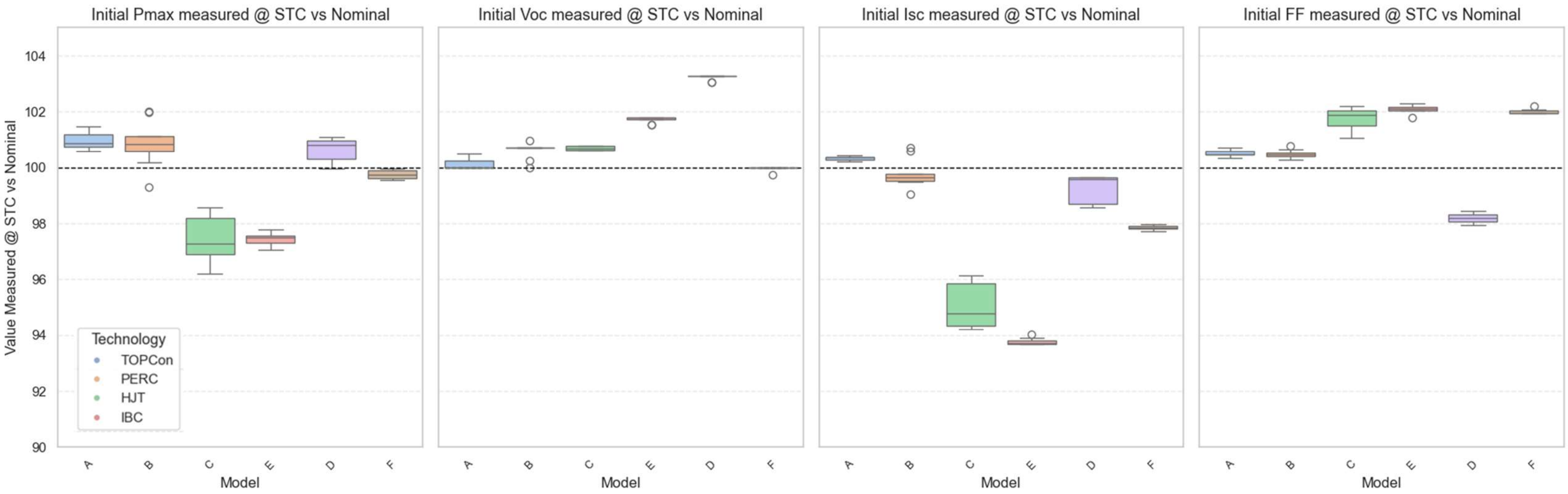
6.5 FIRST RESULTS

Maximum Power @ STC (MQT06.1)



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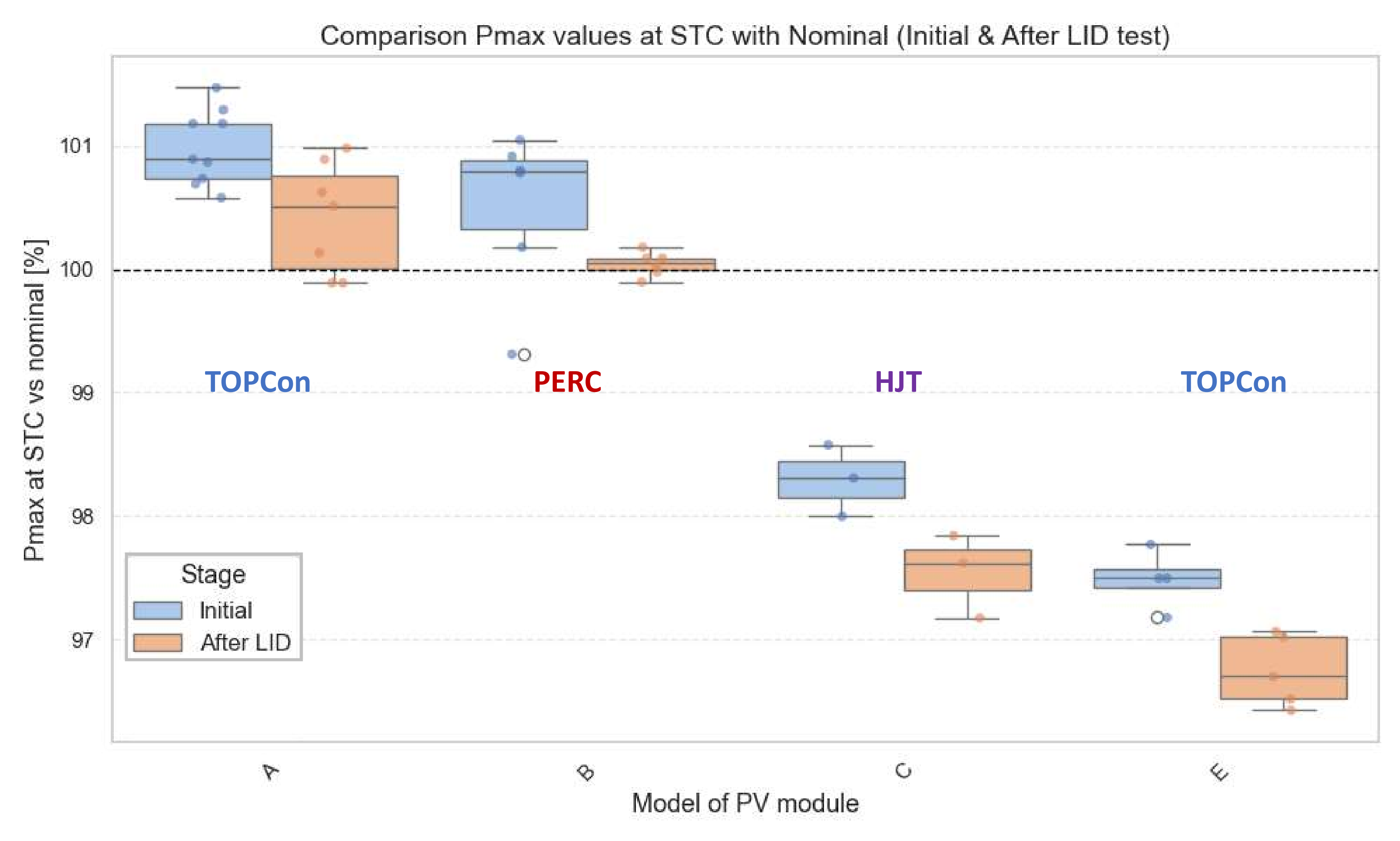
6.5 FIRST RESULTS

Outdoor exposition
> 20 kWh/m² **(MQT08)**



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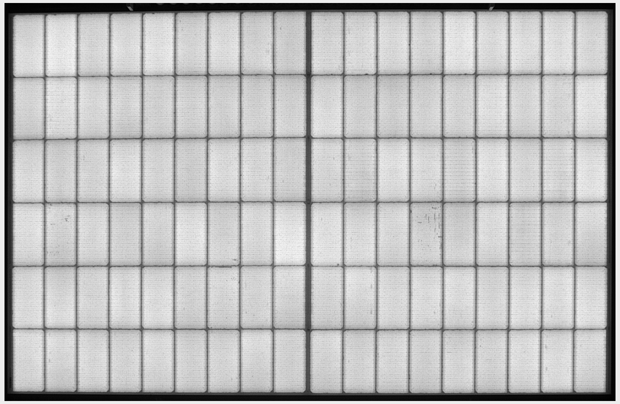
6.5 FIRST RESULTS

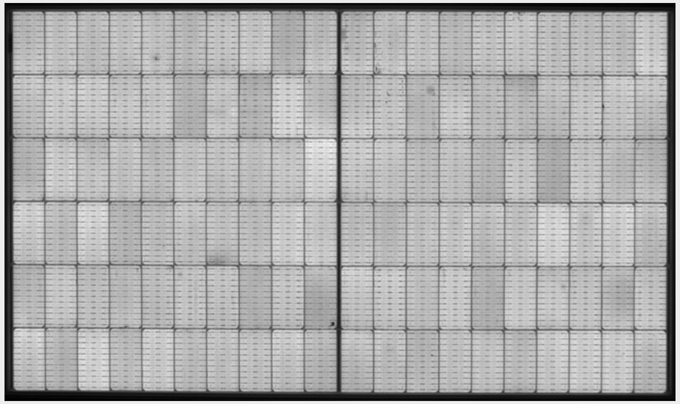
Electroluminescence Test (EL)

EL Images @ Isc & 10%*Isc

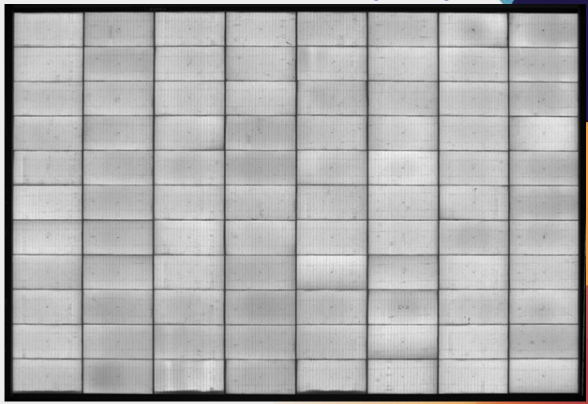
Model – A (TOPCon)



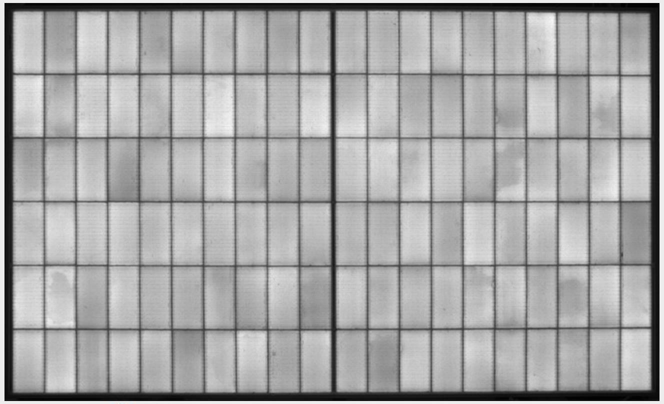
Model – B (PERC)



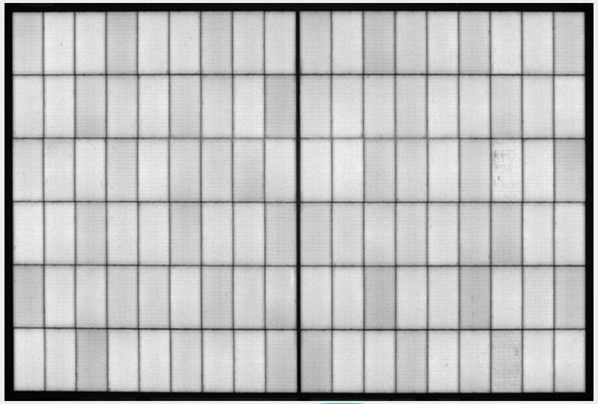
Model – C (HJT)



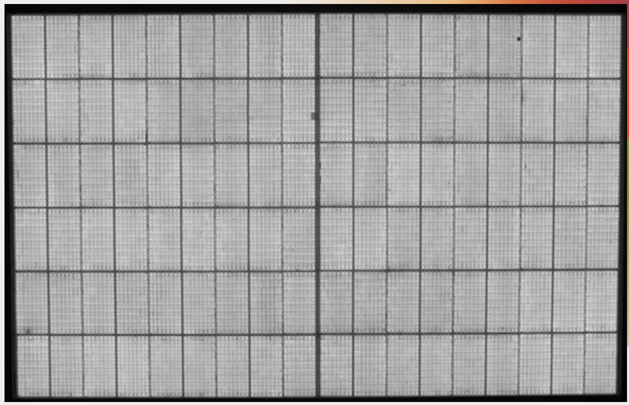
Model – D (TOPCon)



Model – E (TOPCon)



Model – F (IBC)



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6.6 NEXT STEPS

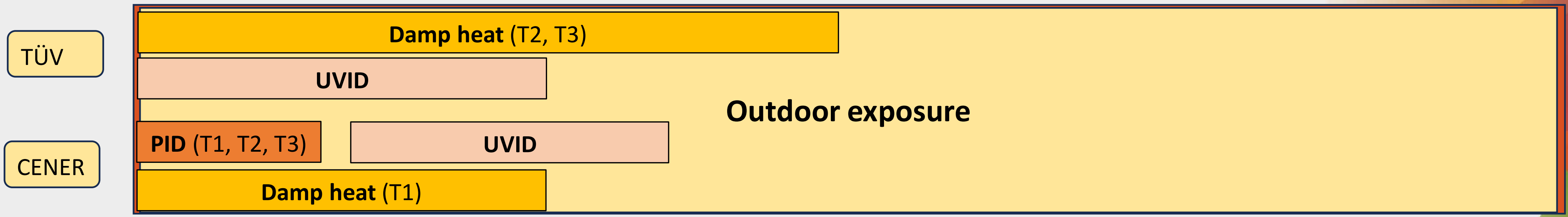
1. Finalize the purchase of PV modules (HJT G/G).

2. Finalize stabilization of all the modules.

Initial measurements

1. Stabilization → 2. Performance (EL, IV) → 3. Insulation test → 4. Wet leakage current test

3. Start with the testing sequence.



4. Long-term PV degradation modelling.

Estimation of the Activation Energy

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07

QUESTIONS & ANSWERS – LONG-TERM PV PERFORMANCE DEGRADATION RATE

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08
NEXT STEPS

NEXT STEPS – STAKEHOLDERS' FEEDBACK

- ❑ **Written comments and feedback** are welcome. Please send them to info@ecodesign-pv-testing.eu. **Deadline August 3rd 2025**.

- ❑ **Next stakeholder meeting:**
  - **Third meeting** on September 2026.
  - Final results and conclusions. Draft final report.

- ❑ Dates, invitation to meetings and further stakeholder consultation activities will be communicated to the **registered stakeholders** and published on the project's website https://ecodesign-pv-testing.eu/.

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QUESTIONS & ANSWERS

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CLOSURE

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- **Minutes and slides** of this meeting will be available shortly in https://ecodesign-pv-testing.eu/documents/.

Development of standardisation methods for eco-design and energy labelling of photovoltaic products

Home The Study Register Meetings Documents Contact

- **Project updates** will be published on the website and sent to the registered stakeholders. To register, please visit https://ecodesign-pv-testing.eu/register/.

What's new

03/06/2025: Invitation to the second stakeholder meeting taking place in Brussels on July 3rd, from 10:00 to 13:00 CET (UTC+2). It will be possible to join the meeting online. Please, register here indicating participation in person or online.

02/08/2024: Join us at the parallel event "***Ecodesign and Energy Label for PV Products: Present and Future***" organized at the **41st European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC)** on Monday 23rd September 2024 at 15:15 to know more about this project and the European Commission's initiatives.

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Thank you for your attention

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