EU PVSEC

22 — 26
September

BEC —
Bilbao Exhibition Centre

Bilbao —
Spain

EU PVSEC 2025

42nd European
Photovoltaic Solar Energy
Conference and Exhibition

Conference Highlights

Robert Kenny

European Commission Joint Research Centre

EU PVSEC Technical Programme Chair

EU PVSEC

FACTS & FIGURES | Presentations

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EU PVSEC Programme - Distribution of Presentations per Type

1000+
PRESENTATIONS

CONFERENCE PLENARIES & ORALS
349

CONFERENCE VISUALS
562

OPENING & CLOSING
6

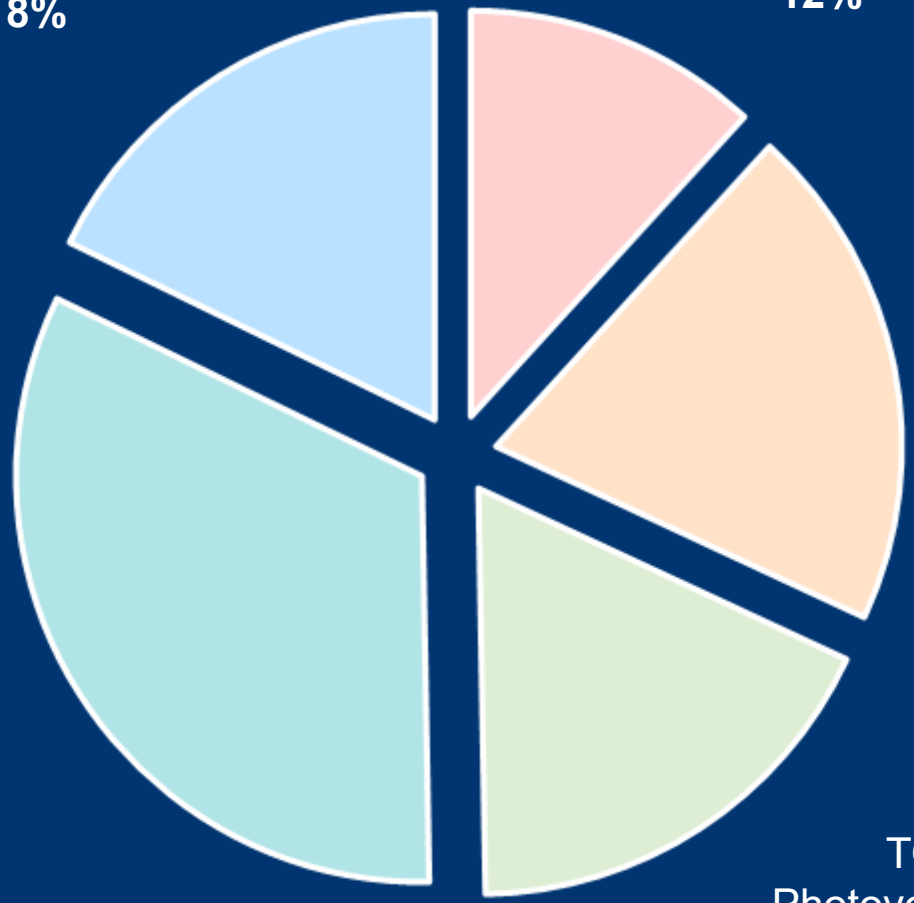
4
PANEL DISCUSSIONS WITH
29
PANELISTS

PARALLEL EVENTS
110

INDUSTRY SUMMIT
44

FACTS & FIGURES | Presentations

EU PVSEC Scientific Conference Programme - **Distribution of Presentations per Topic**



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FACTS & FIGURES | Participants

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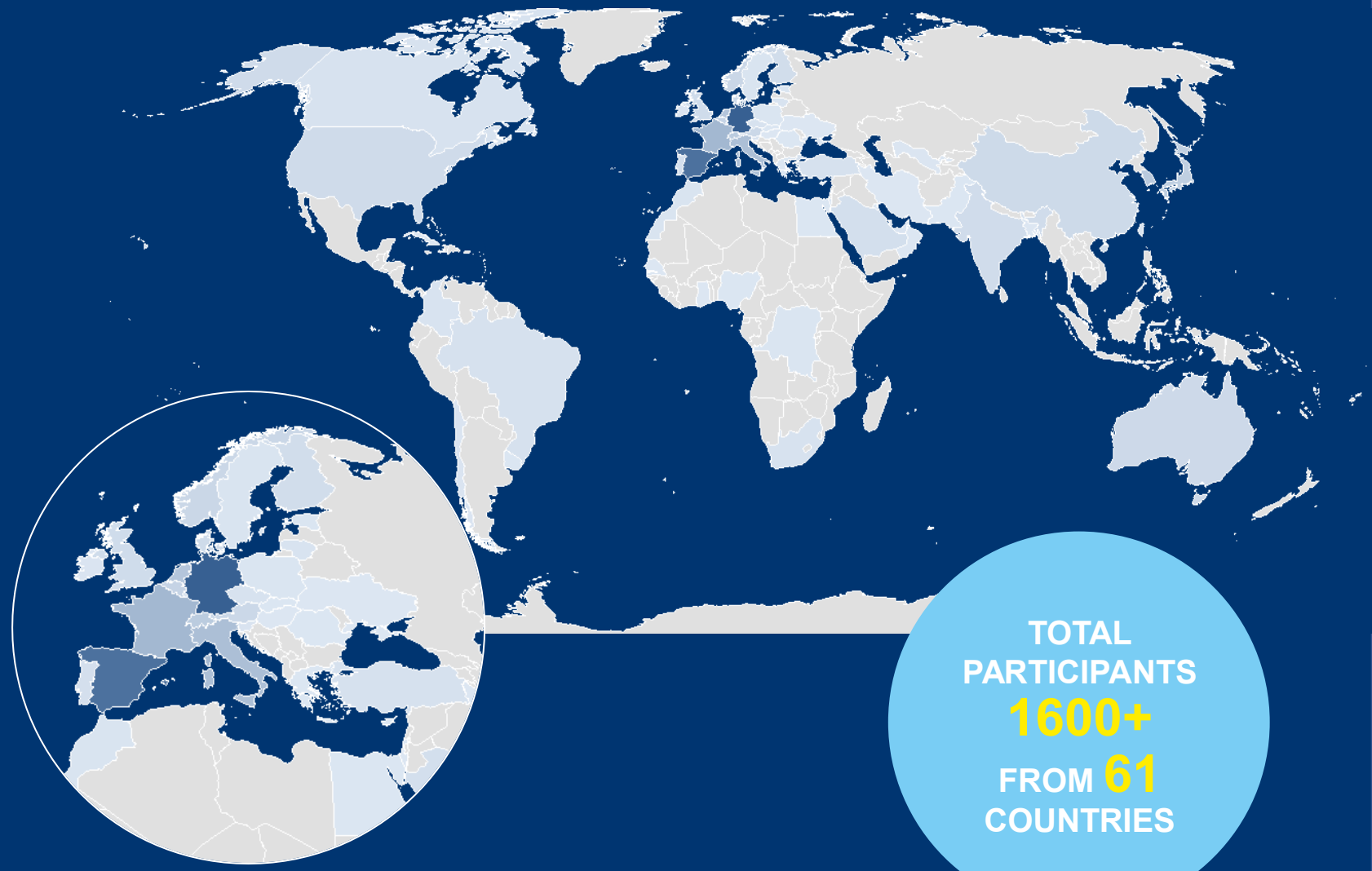
Participants by Countries
Top 10

No	Country	Participants
1	Germany	310
2	Spain	270
3	France	108
4	Italy	90
5	The Netherlands	76
6	South Korea	67
7	Switzerland	62
8	Japan	55
9	Belgium	44
10	Norway	35



TOTAL PARTICIPANTS
1600+
FROM 61 COUNTRIES

Plenary Session *"PV Everywhere"*

OPENING
Monday, 22 Sept. 2025

Welcome Messages

Becquerel Prize Ceremony

Moderated Panel Discussion *"Solar in Turbulent Times: Global Dynamics and the Way Forward"*

Key Note Speech *"The Dual Face of Global Solar Growth"*

PANEL DISCUSSIONS

BO.13 Reliability and Bankability in PV
"The rapid developments of PV technology require increased attention to be paid to reliability testing."

CO.7 Challenges and Opportunities of PV up to 2030
"PV Technology is already reliable and cost effective, and even though improvements are welcome, key blockages are storage and grid strengthening. AI and robotics are essential to meet the scale of developments needed."

DO.13 Scalability and Manufacturability Prospects in Europe for New Technologies
"The prospects for reaching the 30GW target for PV module manufacturing in Europe were discussed and policy measures proposed."

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KEY MESSAGES

Cross-cutting themes emerged throughout the programme, showcasing how solar technologies can be applied everywhere, from traditional to emerging fields.

- Sustainability and circularity remain central, with research focused on reducing material use, such as replacing silver with copper, and advancing end-of-life management of modules.
- Ensuring long-term stability and predictable energy yield is equally essential, with studies of degradation mechanisms such as UVID carried out.
- The role of AI across the PV value chain is rapidly expanding, from design to operations and maintenance, including drone applications.

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TOPIC 1: SILICON MATERIALS AND CELLS

Enhancements in IV measurement procedures

- Michael Rauer, Fraunhofer ISE: 1AO.4.5 *Universal Contacting Approaches for the Characterization of Solar Cells*
- Shuai Nie, UNSW: 1AO.4.6 *Contact-Free J-V: a Simple Technique for Universal State-of-the-Art Solar Cells*

Replacement of critical by sustainable materials:

- Reduced Ag consumpion e.g. by replacing by Cu (plating)
- In-free SHJ solar cells and Pero-Si tandems

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TOPIC 1: SILICON MATERIALS AND CELLS

Great advance in understanding of UV induced degradation and Hydrogen related degradation

- Excellent PLENARY by Bram Hoex (presenting for Muhammad Umair Khan), UNSW: 1CP.3.5 *Understanding the Root Cause of UV-Induced Degradation in TOPCon and PERC Solar Cells*

Further high quality orals:

- Christina Hollemann, ISFH: 1AO.4.2 *Mitigating UV-Induced Degradation: Impact of PECVD and PEALD AlOx Layers Deposited in a Tube-Type Direct Plasma-Enhanced Chemical Vapor Deposition System*
- Hugo Lajoie, CEA: 1AO.4.3 *New Insights on UV-Induced Degradation of SHJ Solar Cells*
- Byungsul Min, ISFH: 1BO.3.6 *UV Stable Passivation Stack with Plasma-Enhanced Atomic Layer Deposition of Aluminum Oxide from an Industrial Tube-Type Direct Plasma-Enhanced Chemical Vapor Deposition System*
- Wolfram Kwapil, Fraunhofer ISE: 1AO.5.6 *Impact of Illumination on Solar Cell Properties: Insights into Atomic Hydrogen Release*

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TOPIC 1: SILICON MATERIALS AND CELLS

Advances in TOPCon and SHJ technology → Pushing the Limits of Performance

- Fantastic keynote lecture (PLENARY) on heterojunction solar cells by Dr. Guangtao Yang, Trina: 1CP.1.1 *Silicon Surface and Interface Study for >27% Efficient SHJ Solar Cell*
  - Deep insight into technological aspects eg. influence of rear side polishing on cell performance
  - Very high efficiencies for both-sides contacted HJT > 27%
  - Issues with CAPEX, sustainibility (Ag, In)
  - Pero-Si tandem cells on large area and modules

Late News Presentation on 27.8% efficient back contact silicon solar cells by Hua Wu, Longhi: 1DO.9.1 *Hybrid Interdigitated Back Contact Silicon Solar Cells with Superior Efficiency*

Late News Presentation as TOPCon for Bottom Solar Cells in Pero-Si Tandem devices by Jana Polzin-Isabelle Polzin, Fraunhofer ISE: 1DO.9.3 *Silicon Solar Cells – From High Efficiency Single-junction to Bottom Cells in Two-Terminal Perovskite-Silicon Tandem Devices*

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TOPIC 1: SILICON MATERIALS AND CELLS

Further high quality orals:

- Hua Wu, Longhi: 1DO.9.1 *Hybrid Interdigitated Back Contact Silicon Solar Cells with Superior Efficiency*
- Daming Chen, Trina: 1AO.5.1 *Large Area i-TOPCon Solar Cells with 25.9% Record Efficiency*
- Maysa Sarsour, UNSW: 1AO.6.1 *Evaluating Silicon Heterojunction Solar Cell Stability under Industrial Illuminated Hydrogenation Conditions*

Bottom cell optimization for Pero-Si tandems

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TOPIC 2: THIN FILMS AND NEW CONCEPTS

A lot of focus on the long-term stability improvement and upscaling of tandem devices based on a variety of materials (hence not only pero-Si).

Many companies (e.g. Hanwha Q-cells, Oxford PV, Microquanta Seminconductor, Jinko Solar, Longi, etc. non-exhaustive list) presented impressive results on industrial size single-junction pero modules and pero-based tandem modules. A highlight here was the plenary talk from Hanwha Q-cells showing a record large area (M10) pilot-scale Pk/Si tandem cell of 28.6% efficiency.

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TOPIC 2: THIN FILMS AND NEW CONCEPTS

In the field of pero-Si tandems, there is clearly more focus on improving the stability of the tandem devices than before with many contributions doing in-depth investigations into the different degradation mechanisms that can occur in pero-Si tandems.

In this respect, 2DO9.5 presented a consensus statement about reliability testing of perovskite-based tandems that is endorsed by specialists worldwide from both industry and research and presents a kind of minimum that should be done in terms of testing and reporting concerning the stability and lifetime of perovskite-based tandem devices.

More and more advanced characterization methods for perovskite and perovskite - silicon tandem solar cells are being used, hyperspectral imaging methods identify non-uniformities by layer for processing development.

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TOPIC 2: THIN FILMS AND NEW CONCEPTS

Another clear trend is that pero-TOPCon cells are nearing the same record efficiencies as pero-Heterojunction cells. A highlight talk here was the certified 34.22% efficiency perovskite/ topcon tandem solar cell(1cm2) by Jinko Solar 2CO2.1

Another highlight was the 30.5% triple junction pero/pero/silicon cell by EPFL (2CO2.3)

In the field of perovskite single junction devices, 2DO.7.3 showed perovskite devices with remarkable reliability, withstanding 4 years of outdoor exposure. The degradation mechanism is attributed to the diurnal behaviour, also verified and replicated with indoor experiments.

2AO3.6 investigated experimental degradation and recovery of perovskite solar cells, improving the comprehension of instability's dynamics, to extend the lifetime of devices.

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TOPIC 2: THIN FILMS AND NEW CONCEPTS

In the field of compound semiconductors, there were many presentations on alternative materials for perovskite in tandems. In this way, first monolithic (AgCu)(InGa)Se2 on Si tandem cells were demonstrated as well as 16.1% semitransparent Ag doped Cu(InGa)S2 sulfide top cells.

An exciting highlight in this field was 2BO8.2 in which UPC Barcelona achieved 18% efficiency under indoor lighting for kesterite solar cells with alkali doping

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TOPIC 3: PHOTOVOLTAIC MODULES

“Reliable packaging to Maximize the energy yield from high efficiency cells”

big theme: Optimizing module materials and packaging for long lifetime and predictable energy yield from high efficiency cells. The industry and research community are moving quickly to assess and improve reliability.

- Understanding, accelerated testing, and mitigating UV-ID in n-type cells and modules
- How do you develop accelerated tests for constantly changing BOMs - new encapsulants, new metallization, thinner glass, and high efficiency cells

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TOPIC 3: PHOTOVOLTAIC MODULES

- Degradation and metastability in packaged perovskite tandems - understanding energy yield and realistic degradation rates
- Characterization out of the lab and into the field and factory - accurate outdoor performance, online quality control measurements for encapsulant cross linking
- Reducing silver content and metallization temperatures - reliability of low temperature and low silver metallization
- Developing glass qualification requirements to minimize breakage

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TOPIC 4: PHOTOVOLTAIC SYSTEMS

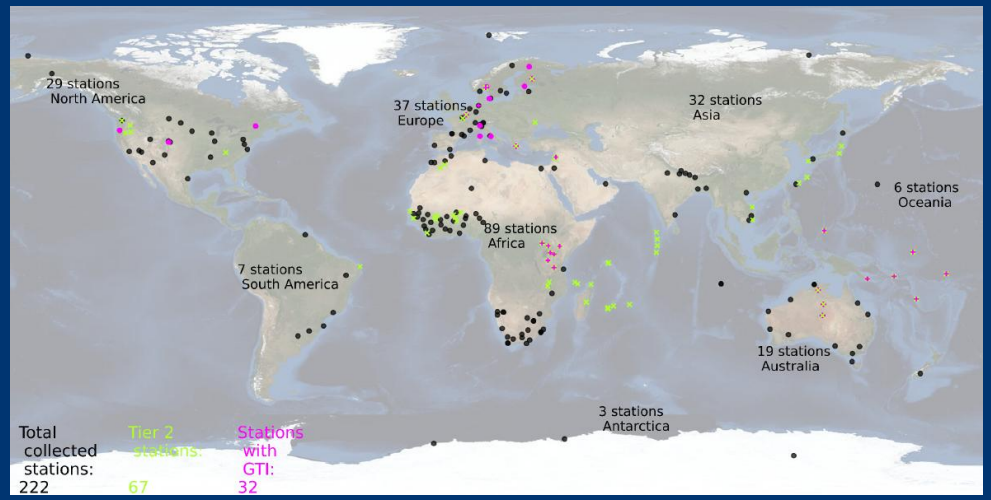
Advances in O&M of PV systems

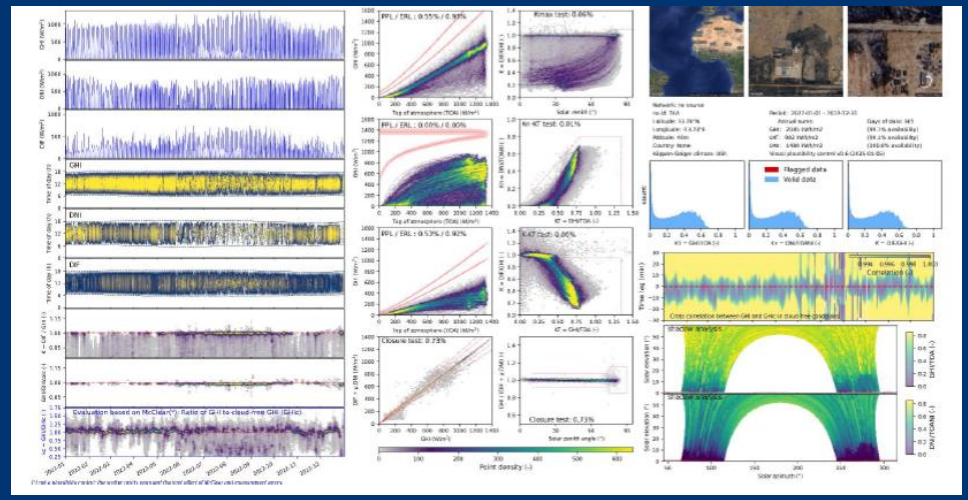
(4CV.1) focuses on fault detection, cleaning optimization, soiling (and snow 4CO.8), UAV for autonomous monitoring and digital twin.

Data driven and AI based O&M (4CO.9) including a medicine-like workflow in Autonomous multi-AI agent system for health monitoring: a fully automated O&M pipeline with field robotics (4CO.9.4 D. Moser, EURAC)

PV Everywhere from space to agricultural applications like integration in vineyards (Mo, Opening plenary) and many other **integrated options** as we have seen throughout the week. On Thursday (4DO.4) agriPV, noise barriers and floating integrated systems. AgriPV technologies (4DO.2), BIPV

PV needs solar energy. **Solar resource and forecasting** (Mo, 4AO.7-9 & Tu 4BV.3). Shortly IEA PVPS T16 will publish minute irradiance data, some including GT over 220 stations worldwide with. Same format and quality controlled. (*Worldwide solar radiation measurement database with quality-control added value*, Anne Forstinger CSP Services, 4AO.7.1)





(4BV.3). Poster winner 4BV.3.12 *Advancing Very Short-Term Solar Irradiance Forecasting in Africa: A Low-Cost Sky Imaging and Machine Learning-Based Approach*, implications for PV deployment and grid integration (Martin Ansong, KIT). Runner-up 4BV.3.25 *Evaluating the Suitability of Köppen-Geiger Climate Classifications for Photovoltaic Systems: Micro-climate Analysis and Risk Assessment Maps,* with worldwide distribution of humidity related risk assessment for PV performance (Pavan Kumar Panda, Anhalt University of Applied Sciences).

Integrated PV

BIPV (4BO.16) examples of coloured modules (which was main topic of the poster session along with fire concerns of BIPV, 4BV.4), lightweight solutions (4BO.5) and modelling partial shading effects 4BO.17.1, *Modelling partial shading at the cell level on PV modules,* Jean-Paul Calin, ENSTA) and 4BO.17.3, *Comparing the energy yield and degradation rates of smart PV modules compared to conventional PV system designs in shaded urban scenario's,* Youri Blom, TU DELF.

AgriPV 4DO.2 the room was fully packed showing the interest in the topic. 5 talks were on new ways of sharing light (2 spectral splitting before the PV conversion, 2 semitransparent PV modules both c-Si and CdTe, 1 on downshifting encapsulate) + 1 new AgrivPV like application with Algae instead of crops.

4DO.4 also included AgriPV and **Others types of integration like noise barriers and floating.** In addition to performance other aspects like (*Hydrological and ecological effects on floating PV,* Konstantin Ilgen, FHO ISe) have been highlighted this week

4DO4.2

BOS and tracking systems (4DO.1) focused on backtracking strategies and terrains with complex topography.

4DO.1.4

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TOPIC 4: PHOTOVOLTAIC SYSTEMS

Reliability of PV systems

Several presentations focused long-term monitored degradation, failure modes and degradation modes identification techniques (non-destructive, aerial images, AI-based)

4BO.6.1 *Three decades, three climates: insights and lessons on PV reliability*. Good BOM offer very high reliability in power production, with 30-35 years old modules showing 0.24% degradation rate per year.

4BO.6.3 *Non-destructive detection of water ingress in solar modules using NIR spectroscopy* (Oleksandr Mashkow HI ERN) proved near-infrared absorption (NIRA) technique to detect water ingress in modules in the field, which correlated with the module degradation.

4BO.7.2 *Robust PV performance loss rate calculation for high latitudes* (Lauri Karttunen, Meteo Inst Helsinki) and 4BO.7. 3 *Detailed analysis of degradation rates of operating PV assets in tropical climate conditions* (Xioaqi Xu, Seris Singapore) Performance loss rates reported for high latitudes and tropics based on solid data sets. PLR in the tropics -1.4%/year

4DO.3.6 PV system design and assessment highlighted how inverter safety issues are extremely important and how more research about inverter safety and reliability is needed.

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TOPIC 5: PHOTOVOLTAICS IN THE ENERGY TRANSITION

Main topics of interest :

- Flexibility
- Artificial intelligence
- EoL management

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TOPIC 5: PHOTOVOLTAICS IN THE ENERGY TRANSITION

5.1 Grid Integration and Flexibility Enablers (2 sessions)

- Smoothing effect related to different orientations of PV systems in a given area allows 10 to 15% additional hosting capacity of the distribution grid compared to the conservative calculation that consists in summing the AC power. Such accurate calculation enabled by high resolution large area images and LIDAR and induces therefore very low costs.

5.2 Sustainability of PV (4 sessions)

- New inventories LCI and LCA for emerging technologies even though lack of data for perovskites, LCA showing a way for low environmental Impacts with technology improvement and localisation. / Technological improvements will contribute to the reduction of environmental Impact / Grid Efficiency has an Impact on the environmental Footprint.
- Manufacturing optimization / Reuse & recycling: results from the perspective of economic performance – would it convince manufacturer to consider it if economic benefit ?
- EoL Management /recycling -> emerging field attracting lots of activities / mainly EU projects (EVERPV / ICARUS / QASAR) – highlight on polymer, interesting question came up and to be debated for the next decade: is it worth it to consider polymer (EVA/ backsheet) recycling ?
- Major progress in methodology and indicators to assess sustainable design & circularity and improve transparency recyclability index, technical recyclability, digital passport)

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TOPIC 5: PHOTOVOLTAICS IN THE ENERGY TRANSITION

5.3 Scenarios for Renewables, Policy, Global Challenges (1 session)

- wide scope of contributions on the way to massive, medium- to long-term PV deployment -> should not be taken for granted despite positive projections since there can be limiting factors such as public acceptance / regulatory restrictions and effect of climate change

5.4 Costs, Economics, Finance and Markets (1 session)

- Annual installed capacity over 400 GWp / total cumulative installed capacity worldwide over 2.1 TWp / Clear mismatch between PV module installations rate worldwide and PV module production rate leading to bunch of inventories and drastically reduced prices.

5.6 Societal Challenges; Citizens' Participation, Awareness (1 session)

- data and analysis in gender aspects are emerging in PV! (poster session) + Highlight on innovation in education! On example that targets students & skilled workers -> mobile Lab for advanced experimental training PV-related to bring skills and characterization tools everywhere.

PARALLEL EVENTS

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PARALLEL EVENTS

- Perovskite Innovation Roundtable: Driving EU Leadership in Perovskite Innovation
- Women in PV presents: Leading with Inclusion – Embracing the 6 Traits of Inclusive Leadership
- Unlocking the Potential of Integrated Photovoltaic Systems - European R&D Approach
- Why Do PV Plants Perform Lower than Expected? (Estimating losses by backtracking algorithms in undulating terrain & Analysis of the loss chain and identification of deviations from initial expectations)
- PV Made in the EU: How Do Companies Die and How Can They Thrive?


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GEOPOLITICS & PV MANUFACTURING CHALLENGES
China Scale Dependency ?
EXHIBITION
FORUM
INDUSTRY
SUMMIT
The road to a
sustainable future

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INDUSTRY SUMMIT

Industry Summit Opening (session I)

Session Title: Solar PV production in Europe - the way forward

Moderators: Begoña Molinete, Walburga Hemetsberger

Key Takeaway:

This session discussed the state of play of European manufacturing projects and whether there is enough European support. It was clear that political support is further lacking – only 3 Member States have developed schemes to support European manufacturing. While the Net Zero Industry Act is helpful to diversify supplies, it will not particularly support European manufacturing.

All panellists agreed that apart from further policy support (financing, derisking) collaboration is the way forward.

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INDUSTRY SUMMIT

Session II
Session Title: International corporations in the light of changing geopolitics
Moderators: Radovan Kopecek, Puzant Baliozian

Key takeaway:
EU machine builders are still supporting mostly Indian but also US and EU projects with their technology and expertise. The major arguments for choosing EU tech are quality, training, support and low OPEX.

Session III
Session Title: PV Systems: How do we get the produced electricity in Europe into the grid?
Moderators: Catarina Augusto, Peter Fath

Key Takeaway:
Hybrid PV + storage systems (co-located or distributed) are essential for integrating PV into electricity grids. Storage adds flexibility and stabilizes the grid, making it a cornerstone of resilient energy systems; while the technology is mature, scalable and bankable revenue models remain the key gap for widespread deployment.


RENEWABLE ENERGY TRAINING
WIP
RENEWABLE ENERGIES
EUROPEAN COOPERATION PROJECTS
CONSULTANCY SERVICES

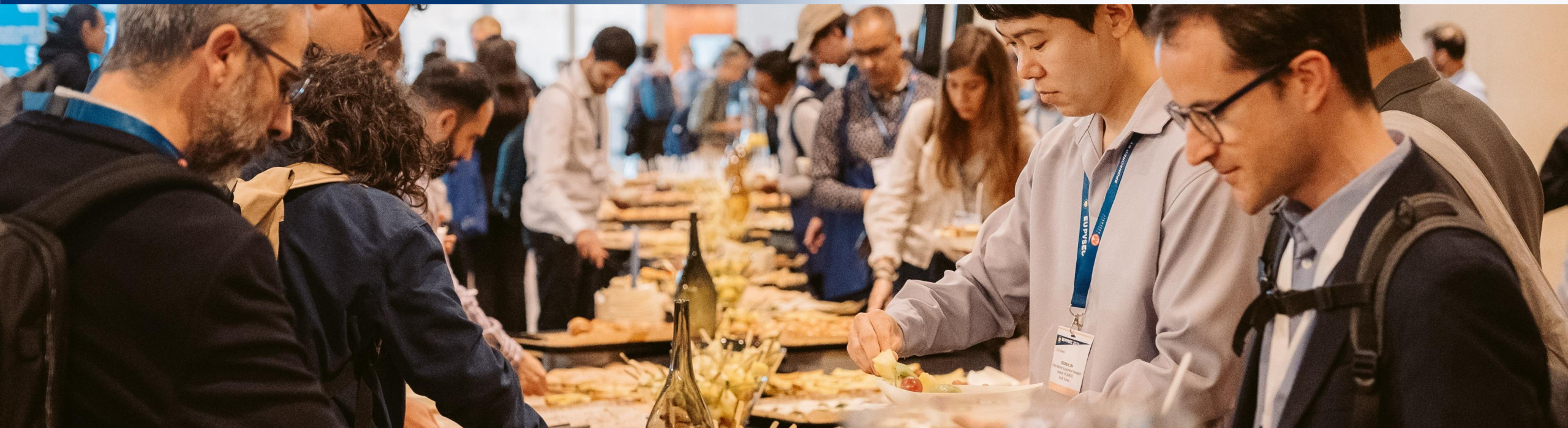
EXHIBITION


STATE
A+A+A++ CLASS
FROM 300 TO 1300 nm
PEROVSKITE
ADVANCED QUALITY
COMPATIBLE WITH
TOPCon
PEROVSKITE
HJT
FOR R&D LABS
HIGH-RESOLUTION EL/PL IMAGING
MULTI-PARAMETER CHARACTERIZATION
ECOSUN NOVA
ECODOME


PERC
TOPCon
HJT
xBC
Perovskites
Tandem


tecnalia
generation

It’s all about networking



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SUSTAINABILITY | at the EU PVSEC

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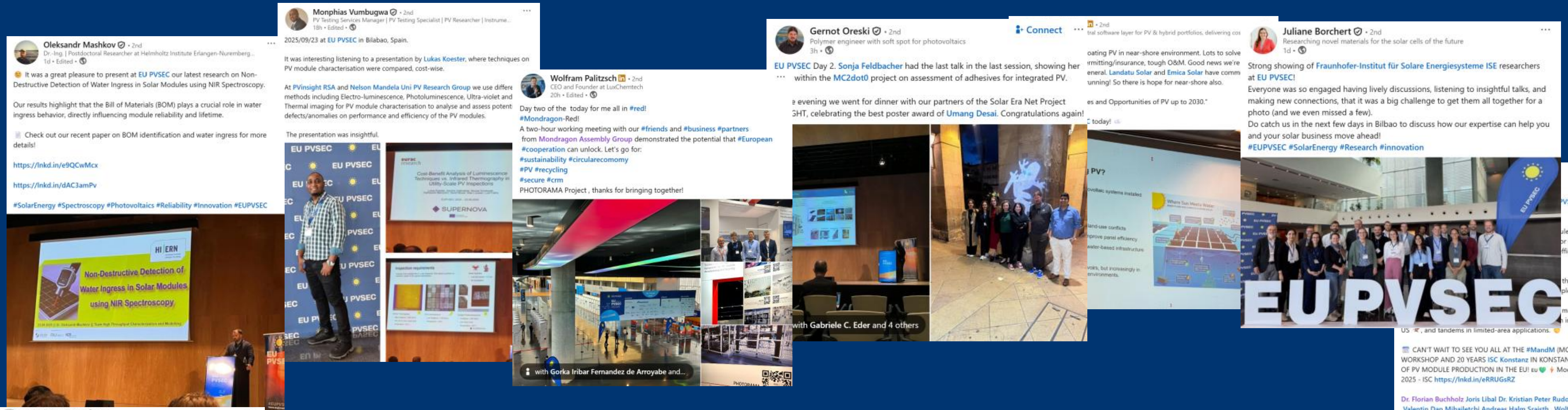
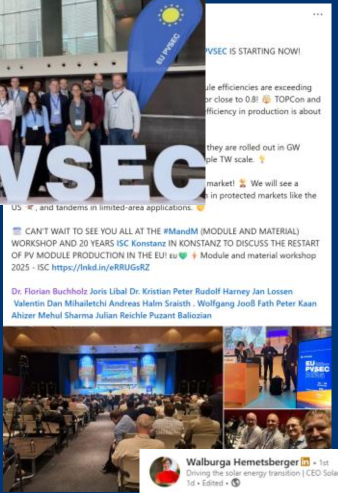
We are committed

→ to minimising our environmental impact.

→ Green Ticket - supporting climate protection projects.

→ Driving sustainable practices in all aspects of the event.





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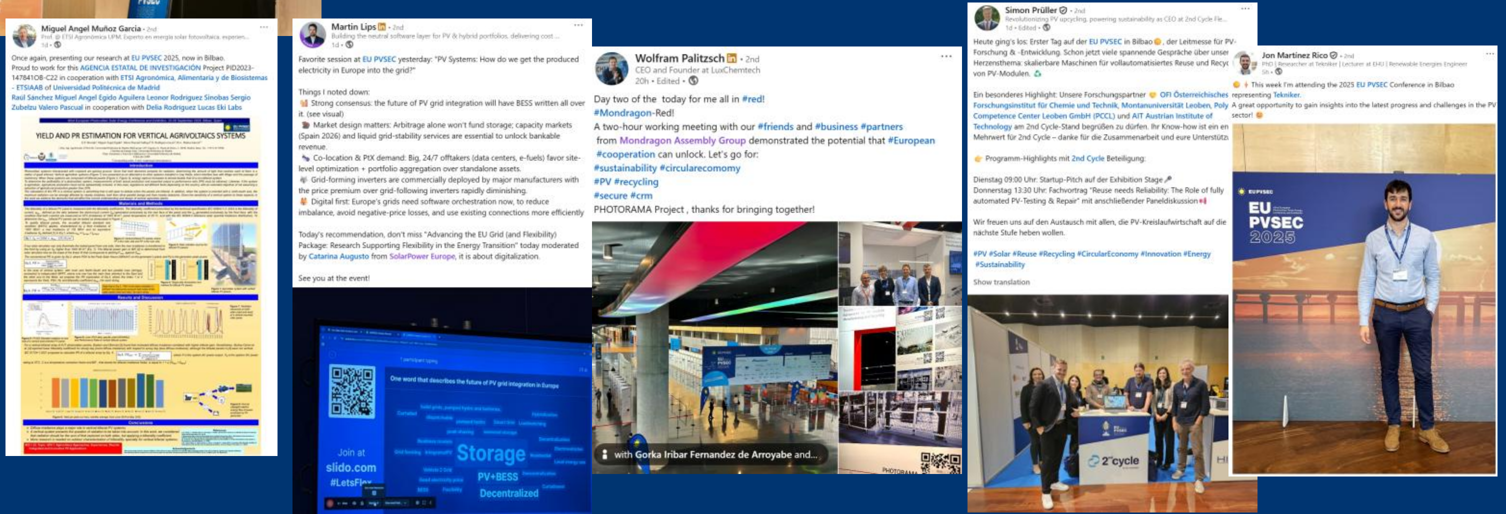
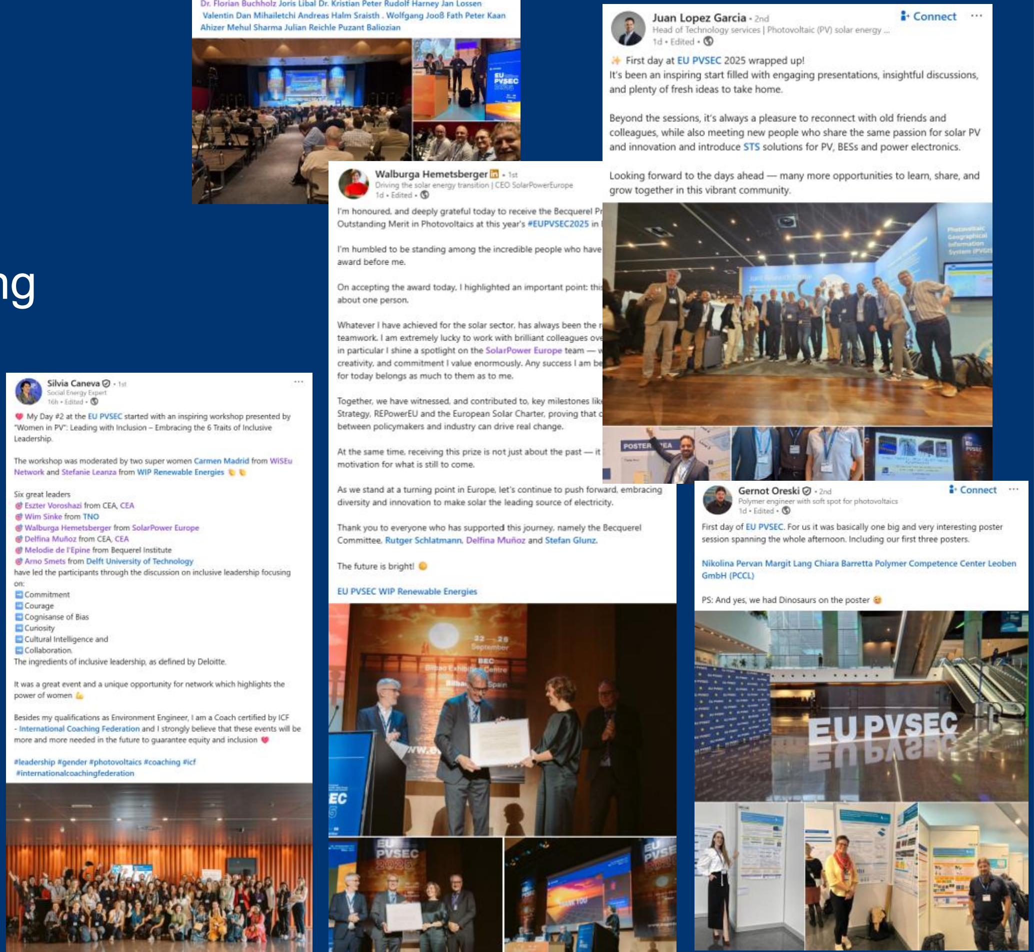
YOU ARE THE EU PVSEC

Let's Grow Together

Share your favourite moments and insights using

#EUPVSEC2025 #EUPVSEC





WE THANK YOU!

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SURVEY

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Check your email

In a few minutes the organiser WIP will send you an email where you will be able to provide your input and insights of the week.

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BILBAO | Great city

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