



IEA PVPS Task 13: Quality, Durability and Integration of PV in Different Environments & Applications

Ulrike Jahn, Task Manager IEA PVPS Task 13

2021 NIST/UL Workshop on PV Materials Durability, 07 December, 2021

IEA PVPS TCP in a nutshell



- 32 members - 27 countries covering 5 continents, European Commission, 4 associations
- A truly global and unbiased network of PV expertise
- Representing main stakeholders in R&D, industry, implementation and policy
- Covering a large majority of worldwide production, applications and markets
- *Mission: “To enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems”*



8 Active PVPS Tasks...



- Task 1 - Strategic PV Analysis and Outreach
- Task 12 - PV Sustainability
- **Task 13 - Performance, Operation and Reliability of Photovoltaic Systems**
- Task 14 - Solar PV in the 100% RES Power System
- Task 15 - Enabling Framework for the Acceleration of BIPV
- Task 16 - Solar Resource for High Penetration and Large-Scale Applications
- Task 17 - PV and Transport (new 2018)
- Task 18 - Off-Grid and Edge-of-Grid Photovoltaic Systems (new 2019)

IEA PVPS Task 13 History and Future



Task 2: 1994-2009 Performance and Reliability of Photovoltaic Systems

- PV performance database
- PV performance figures

Task 13: 2010-2014

- + Performance and reliability of components
- + Testing and standards

Task 13: 2014-2017

- + Economical aspects and business models
- + Yield prediction & uncertainties
- + Failure detection and statistics

Task 13: 2018-2021

- + New module and system designs
- + Field testing
- + O&M practice
- + Risk assessment & mitigation

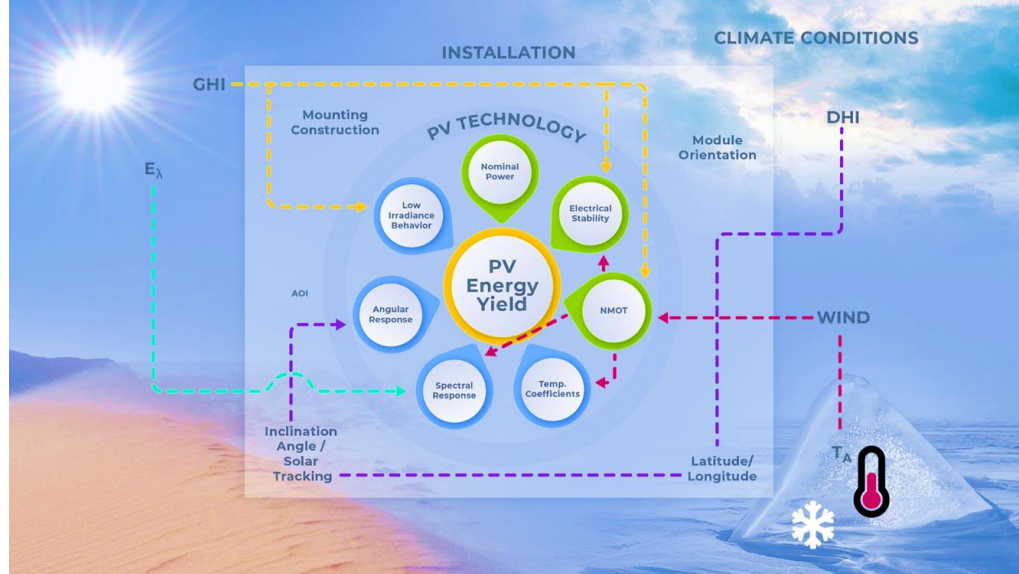
Task 13: 2022-2025

- + New materials & applications (IPV)
- + Digitalization
- + Climate/environment specific design/testing
- + Techno-Economic key performance indicators
- + Second Life PV
- + PV & storage



1. Quality assurance
 - Climatic energy rating of PV modules
 - PV system qualification
2. Durability
 - PV module and system failures
 - Technical risks in PV systems
3. Integration of PV in different environments

1. Climatic Energy Rating of PV Modules



PVPS

Inputs:

- PV module performance for variable temperature and irradiance
- Time series of climate data
- Site conditions and mounting

Model:

- Temperature effects
- Low irradiance effects
- Incidence angle effects
- Spectral effects

CSER

1. Climatic Energy Rating of PV Modules



The climatic energy rating of a PV module is described by the dimensionless parameter "Climate Specific Energy Rating (CSER)", which can be interpreted as PV module performance ratio (MPR).

$$\text{CSER} = \frac{\text{Calculated energy yield of the PV module for a specific climate and for specific mounting conditions}}{\text{Theoretical energy yield assuming continuous operation at STC efficiency}} = \frac{E_{MOD,Year} / H_{P,Year}}{P_{MAX,STC} / G_{REF,STC}}$$

- $E_{MOD,Year}$ = Calculated energy output [kWh/year]
- $H_{P,Year}$ = Global in-plane irradiation [kWh/m²/year]
- $P_{MAX,STC}$ = Nominal output power of PV module [W]
- $G_{REF,STC}$ = 1000 W/m²

CSER <1: Energy yield losses compared to operation at STC efficiency

CSER =1: Operational efficiency of the PV module conforms to its STC efficiency

CSER >1: Energy yield gains compared to operation at STC efficiency

1. Energy Rating Methodology of IEC 61853 Series



IEC 61853-1 (2011)

Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating

IEC 61853-2 (2016)

Photovoltaic (PV) module performance testing and energy rating – Part 2: Spectral Response, Incidence Angle and Module Operating Temperature Measurements

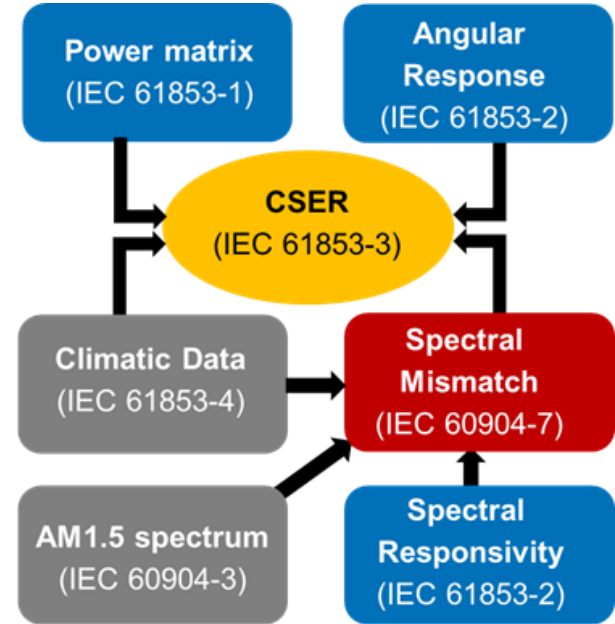
IEC 61853-3 (2018)

Photovoltaic (PV) module performance testing and energy rating – Part 3: Energy Rating of PV Modules

IEC 61853-4 (2018)

Photovoltaic (PV) module performance testing and energy rating – Part 4: Standard reference climatic profiles

PVPS



1. Energy Rating Methodologies for PV Modules



IEC 61853 series “Photovoltaic (PV) module performance testing and energy rating”: Results from indoor and outdoor measurements are used in a time-step simulation with tabulated climate data sets (hourly values).

Sandia PV Array Performance Model (SAPM): Alternative procedure for energy yield modelling. Algorithm defines equations for I-V curve parameters I_{sc} , I_{mp} , V_{mp} and V_{oc} . Outdoor measurements are used to calibrate the modelling parameters.

ISE Model: Alternative procedure for energy yield modelling. Modelling is based on historical meteorological data and information from the PV module datasheet.

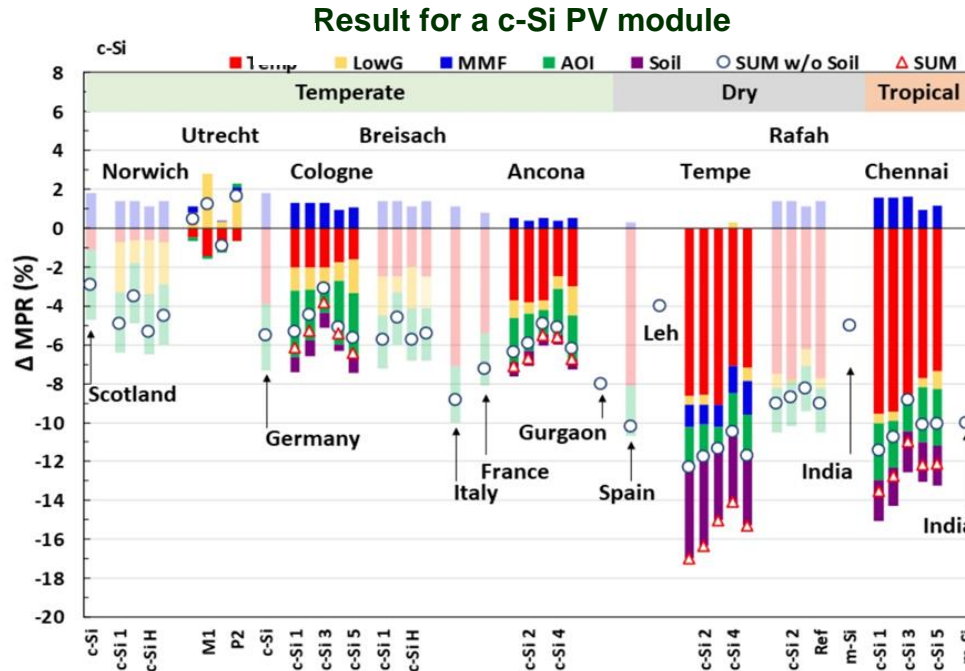
TÜV Rheinland Linear Performance Loss Analysis (LPLA): No energy yield modelling, but irradiance weighting of PV energy yield performance indicators. Breakdown of performance losses into thermal, spectral, angular and electrical.

1. Linear Performance Loss Analysis (LPLA)



PV module performance ratio (MPR)

$$MPR_{LPLA} = 1 + \Delta MPR_{TEMP} + \Delta MPR_{SMM} + \Delta MPR_{IAM} + \Delta MPR_{LOWG} + (\Delta MPR_{SOIL})$$



MPR depends on:

- Temperature (**Temp**)
- Low irradiance (**LowG**)
- Mismatch factor (**MMF**)
- Angle of Incidence (**AOI**)
- Soiling (**Soil**)

MPR provides:

- a realistic estimate of the performance of a PV specific technology at various climate conditions
- estimates of various PV technologies at a specific climate zone

1. Summary



Results have been published in an IEA report:

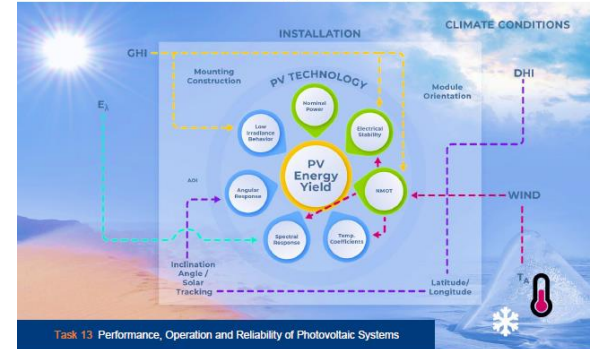
IEA-PVPS T13-20:2020

- 25 Authors from 12 countries
- 166 Pages
- 86 Figures
- 21 Tables
- 183 References

Free download:

<https://iea-pvps.org/key-topics/climatic-rating-of-photovoltaic-modules/>

Technology Collaboration Programme
by IEA



PVPS

**Climatic Rating of Photovoltaic Modules:
Different Technologies for
Various Operating Conditions
2020**

Report IEA-PVPS T13-20:2020

1. Benefits of On-Site Inspection



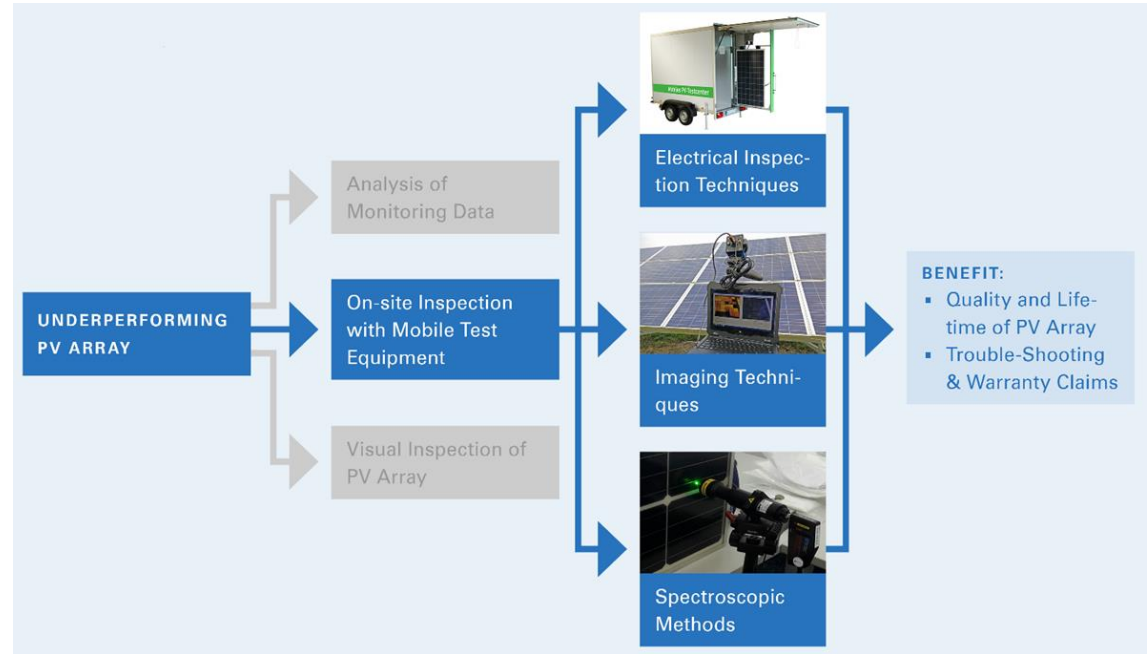
Particular strength:

- Inspection is performed without dismantling and shipping the PV modules to a test laboratory



Avoid transport risks and a long downtime of the PV system

- Results are available immediately



- Targeted quality assurance ⇒ Choose combination of suitable inspection methods

1. Benefits of On-Site Inspection



Range of detectable failures with mobile test equipment:

- Performance variation (shading, soiling, misalignment)
- Cabling or combiner box issues (open circuit failure, resistive losses)
- Insulation failures (ground faults)
- Induced degradation (PID, LeTID)

PV string
level

- Performance variation (electrical mismatch)
- Underperforming electrical output power
- Cell cracks
- Interruptions in the cell interconnection circuit
- Bypass diode failure
- Localized heating (i.e. hot-spot, solder joint issues, cell cracks)
- Degradation monitoring (crack propagation, polymer ageing)
- BOM issues (polymeric footprint)

PV module level

PVPS

1. Electrical Inspection Methods & Detectable Failures



Daylight I-V measurement of PV strings and PV modules



- Output power degradation
- Cabling issues
- DC wiring losses
- Shading and soiling effects
- Electrical mismatch of PV strings
- Bypass diode failures
- PID / LeTID on PV string level

Dark I-V measurement of PV strings and PV modules



- DC wiring losses
- Electrical mismatch of PV strings
- Bypass diode failures
- PID on PV string level

PVPS

PV module characterization with mobile PV test centre



- Output power degradation
- Resistive losses
- Cell cracks
- Interruptions in the cell interconnection circuit
- Bypass diode failures
- Induced degradation (PID, LeTID)

PV plant testing vehicle for PV strings



- Performance ratio (PR) of PV power plant
- DC wiring losses
- Inverter efficiency losses
- Shading effects during the day
- Soiling & snow coverage effects
- Electrical mismatch of PV strings

1. PV module characterization with mobile test centre

- PV modules to be dismantled, but still short downtime of the PV system



Inspection range:

- I-V curve measurement @ 1000 W/m² with solar simulator
- EL inspection
- IR inspection
- Dry/wet insulation test
- Bypass diode test

Detectable failures:

- Output power degradation (i.e. PID, LeTID)
- EL imaging: Cell cracks, interruptions in the cell interconnection circuit
- IR imaging: Heat generation due to high contact resistance
- Bypass diode failure
- Insulation resistance failure

1. Theoretical Measurement Uncertainties



Manufacturers of Mobile Test Centres state a measurement uncertainty of $u[k=2] = \pm 3\text{-}5\%$ for the measurement of $P_{\max, \text{stc}}$ of crystalline silicon

Contributions	Example of $P_{\max, \text{stc}}$ uncertainty of an ISO 17025 accredited test laboratory	Typical $P_{\max, \text{stc}}$ uncertainty in the field with a mobile test centre
Temperature uncertainties		
Temperature sensor	0.18°C (RTD)	0.5-1°C (IR sensor)
Temperature stability	0.5°C (climatised dark room)	1-2°C
Temperature non-uniformity	0.5°C (climatised dark room)	1-2°C
Irradiance uncertainties		
Calibration of reference device	0.5% (primary ref cell)	2-3% (secondary calibration of ref. module)
Spatial non-uniformity	1% (class A+)	1-2%
Spectral mismatch	0.5% (spectral MM correction)	0.5-3%
Combined expanded P_{\max} uncertainty ($k=2$, >95%)	$\pm 1.6\%$	$\pm 2.7\text{-}4.8\%$

1. Imaging Techniques & Detectable Failures



Drone-mounted electroluminescence & thermal infrared imaging of PV arrays



- Cabling issues
- Combiner box issues
- Cell cracks
- Bypass diode failures
- Interruptions in the cell interconnection circuit
- Induced degradation (PID, LeTID)

UV fluorescence imaging



- Cell cracks
- Distinction between older and younger cell cracks
- Differentiation of used encapsulation and backsheet materials

Daylight electroluminescence imaging



- Cell cracks
- Interruptions in the cell interconnection circuit
- Cabling issues
- Combiner box issues
- Induced degradation (PID, LeTID)
- Bypass diode failures

Advanced outdoor photoluminescence imaging of PV modules



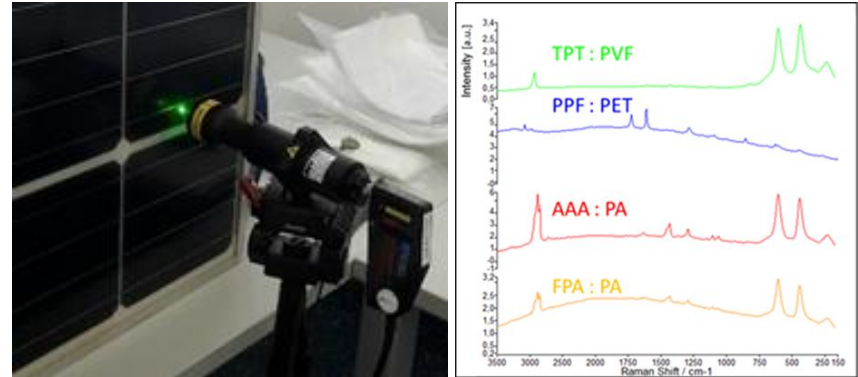
- Cell cracks
- Interruptions in the cell interconnection circuit
- Induced degradation (PID, LeTID)
- Bypass diode failures

1. Spectroscopic Methods for Polymeric Materials



- Non-destructive material analysis without dismantling PV modules
- Identify the polymeric compounds of PV modules (encapsulants, backsheets)
- **NIR and Raman spectroscopy:** Identify the encapsulant in the PV module
- **FTIR spectroscopy:** Identify the polymeric backsheet, detect surface degradation effects (e.g. oxidation, hydrolysis)
- **NIR spectroscopy:** Determine the entire composition of the multilayer backsheet composite

Raman spectroscopy



Detectable failures:

- Polymer degradation
- Differentiation between different types of encapsulation and backsheet materials

1. Summary of On-Site Inspection Methods



Primary inspection method	Application					
	Inspection focus		Ambient requirement		Electrical disconnection of PV string or PV module	
	PV string	PV module	Day-time	Night-time	YES	NO
Daylight I-V measurement	X	X	X		X	
Dark I-V measurement	X			X	X	
PV plant testing vehicle	X		X		X	
Electrical impedance spectroscopy	X		X		X	
Thermal infrared imaging ¹	X	X	X			X
Nighttime electroluminescence imaging ¹	X	X		X	X	
Daylight electroluminescence imaging	X	X	X	X	X	
UV Fluorescence imaging		X	X	X		X
Outdoor photoluminescence imaging		X	X			X
Spectroscopic methods for polymeric materials		X	X	X		X

1) Partially covered in this report in chapter “Drone-mounted EL & IR inspection”. For more details see:

U. Jahn, M. Herz, M. Köntges, D. Parlevliet, M. Paggi, I. Tsanakas, J. S. Stein, K. A. Berger, S. Ranti, R. H. French, M. Richter and T. Tanahashi, "Review on Infrared and Electroluminescence Imaging for PV Field Applications: Report IEA-PVPS T13-10:2018", ISBN 978-3-906042-53-4, 2018

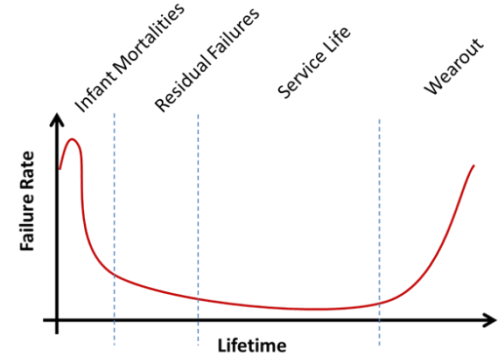
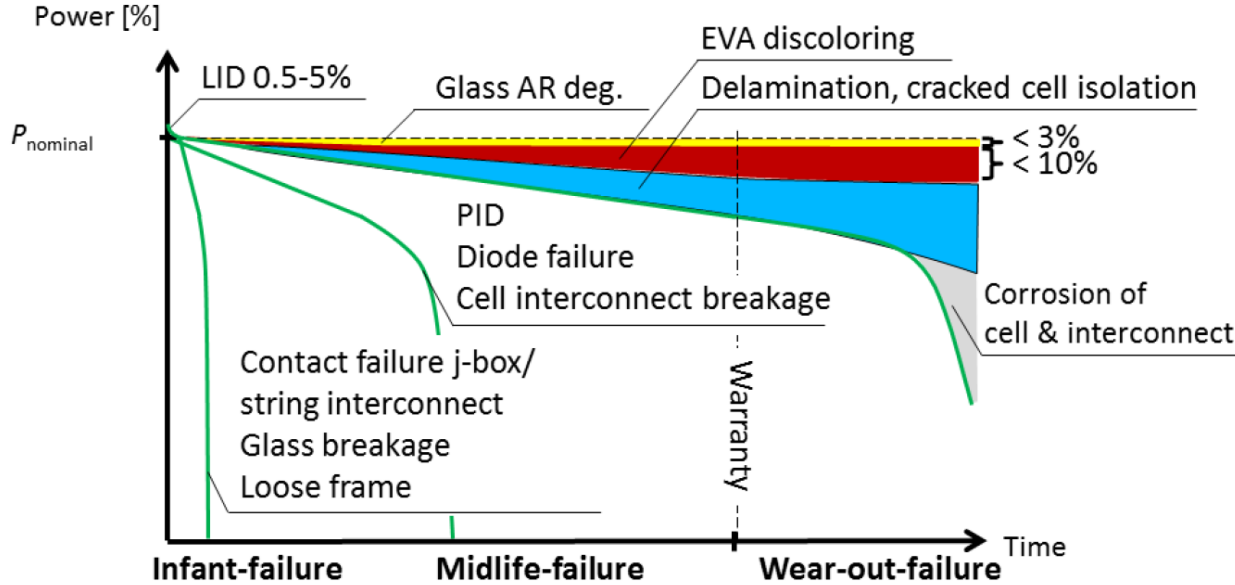
1. Conclusions



Quality assurance to increase lifetime and reliability

- Many degradation modes are directly linked to polymer degradation and material interactions with polymer components.
- Testing of new materials, encapsulants and PV modules!
- PV modules and systems designed for specific environmental conditions
- Increasing recyclability and reparability of PV modules (Gernot Oreski's talk)
- Deployment and validation of field inspection tools for all emerging PV applications.

2. Durability: Failure Scenarios of c-Si PV Modules



Köntges et al. (2014) IEA-PVPS Task 13 Report on "Review of Failures of Photovoltaic Modules"

Module lamination

Material degradation

Component selection

PVPS

Mostly avoidable: Extensive R&D, quality and reliability testing needed

Can be delayed to some extent with proper stabilization

2. PV Failure Fact Sheets (PVFS)



Aim

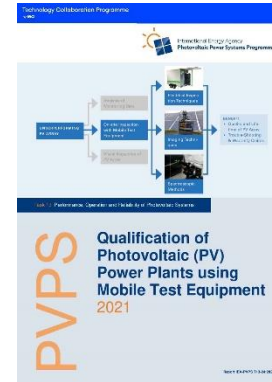
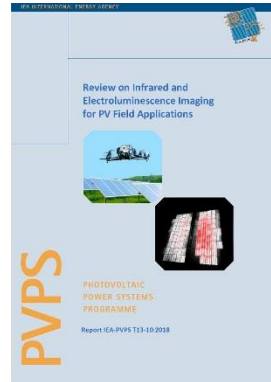
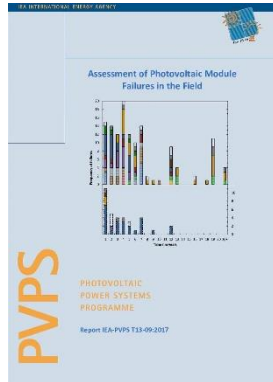
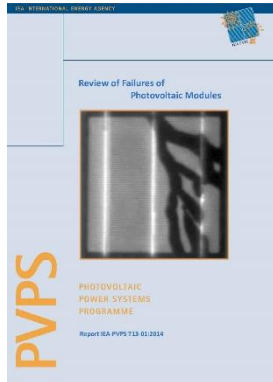
Brief description of failures with examples, an estimation of risks and suggestions for mitigation measures.

Target audience

PV planners, installers, investors, independent experts and insurance companies.

Approach

Summarise the key aspects described in IEA PVPS Task 13 technical reports.



2. PVFS List



- COMPONENT
- DEFECT
- APPEARANCE
- DETECTION
- ORIGIN
- IMPACT
- MITIGATION
- EXAMPLES

30 PV Failure Fact Sheets

FAILURES	PV MODULE	FAILURES	CABLE AND INTERCONNECTOR
PVFS 1-1	Cell cracks	PVFS 2-1	DC connector mismatch
PVFS 1-2	Discolouration of encapsulant or backsheet	PVFS 2-2	Defect DC connector/cable
PVFS 1-3	Front delamination	PVFS 2-3	Insulation failure
PVFS 1-4	Backsheet delamination	PVFS 2-4	Thermal damage in combiner box
PVFS 1-5	Backsheet cracking	FAILURES	MOUNTING
PVFS 1-6	Backsheet chalking (whitening)	PVFS 3-1	Bad module clamping
PVFS 1-7	Burn marks	PVFS 3-2	Inappropriate/defect mounting structure
PVFS 1-8	Glass breakage	PVFS 3-3	Module shading/gure
PVFS 1-9	Cell interconnection failure	FAILURES	INVERTER
PVFS 1-10	Potential induced degradation	PVFS 4-1	Overheating (temperature derating)
PVFS 1-11	Metallisation discolouration/corrosion	PVFS 4-2	Incorrect installation
PVFS 1-12	Glass corrosion or abrasion	PVFS 4-3	Complete failure (not operating)
PVFS 1-13	Defect or detached junction box		
PVFS 1-14	Junction box interconnection failure		
PVFS 1-15	Missing or insufficient bypass diode protection		
PVFS 1-16	Not conform power rating		
PVFS 1-17	Light induced degradation in c-Si modules		
PVFS 1-18	Insulation failure		
PVFS 1-19	Hot spot (thermal patterns)		
PVFS 1-20	Soiling		

<https://iea-pvps.org/research-tasks/performance-operation-and-reliability-of-photovoltaic-systems/documents/>

2. PVFS 1-03: Front delamination



- COMPONENT
- DEFECT
- APPEARANCE
- DETECTION
- ORIGIN
- IMPACT
- MITIGATION
- EXAMPLES

Component	Module	PVFS
Defect	Front delamination	1-3
Appearance	Any local separation of the layers between (i) the front glass and the encapsulant or (ii) the cell and the encapsulant, visible as bubbles or as bright, milky area/s. It may appear continuous or in spots. The position and size of the delamination or bubble depends on the origin and progress of the failure.	



2. PVFS 1-03: Front Delamination



- COMPONENT
- DEFECT
- APPEARANCE
- DETECTION
- ORIGIN
- **IMPACT**
- MITIGATION
- EXAMPLES

Component	Module	PVFS
Defect	Front delamination	1-3
Impact	Delamination or bubbles do not automatically pose a safety issue, but they can result in reduced insulation of the component and increased safety risk when they form a continuous path between electric circuit and the edge due to possible water ingress. Moisture in the module will decrease performance due to an increase of series resistance affect long term reliability and in some cases also the structural integrity of the module. Moreover, delamination at interfaces in the optical path will result in additional optical reflection and subsequent decrease in current. This can be the origin of current mismatch . If the mismatch is significant, it will trigger the bypass diode and cause further power loss. The inverter might also shut down due to leakage current's leading to a further performance loss. Manufacturing related delamination issues often affects a relevant percentage of modules within the same production batch and consequentially has a big impact on system performance.	

- **Failure with an impact on safety**
Failure which can lead to a danger for who is working on or staying close to a PV system.
- **Failure with an impact on performance**
Failure which impacts negatively the energy production of a PV system.

2. PVFS 1-03: Front Delamination



- COMPONENT
- DEFECT
- APPEARANCE
- DETECTION
- ORIGIN
- IMPACT
- MITIGATION
- EXAMPLES

Component	Module			PVFS 1-3
Defect	Front delamination			
	Safety:		Performance:	

No unique rating is possible → Spectrum covering typical field observations

RATING SYSTEM

Safety category	Description
	Failure has no effect on safety.
	Failure may cause a fire (f), electrical shock (e) or a physical danger (m) if a follow-up failure and/or a second failure occurs.
	Failure can directly cause a fire (f), electrical shock (e) or a physical danger (m).

Ref: 'Review of failures of photovoltaic modules', Report IEA-PVPS T13-01:2014

Performance category	Description	
	The defect has no direct effect on performance.	no loss (0%)
	The defect has a minor impact on performance.	below detection limit <2-3%
	The defect has a moderate impact on performance.	within warranty (<0.7-1%/year)
	The defect has a high impact on performance.	out of warranty (>0.7-1%/year)
	The defect has a catastrophic impact on performance.	catastrophic loss (>3%/year)

Ref: 'Silicon solar module visual inspection guide: Catalogue of Defects to be used as a Screening Tool', K. Sinclair, M. Sinclair, <https://www.engineeringforchange.org/wp-content/uploads/2017/09/Solar-PV-Product-Visual-Inspection-Guide.pdf>

2. PVFS 1-03: Front Delamination



- COMPONENT
- DEFECT
- APPEARANCE
- DETECTION
- ORIGIN
- IMPACT
- MITIGATION
- EXAMPLES

Encapsulant delamination in uncritical position. [SUPSI]	Encapsulant delamination from cell caused by production process. [SUPSI]	Encapsulant delamination from cell along grid fingers and bus bar. [38]	Encapsulant delamination from glass (spotted due to glass texture) along the bus bars. [37]	Encapsulant delamination along a cell crack. [46] (see also PVFS 1-1)	Encapsulant delamination near cell edges in combination with cell browning. [38]
Delamination in front of cell in the centre of the module. [40] (see also FS 1-2)	Delamination at module insert connections of a glass/glass module (junction box). [SUPSI]	Delamination at cell edges. [16]	Encapsulant delamination at borders. [37]	Encapsulant delamination along a bus-bar in a cell close to the module edge. [40]	Encapsulant delamination from glass (spotted due to glass texture) at the edge of the cell. [37]
Delamination creating a continuous path between electric circuit and the edge. [40]	Delamination with corrosion. [1] (see also FS1-11)	Delamination caused by detachment of backsheet with exposure of encapsulant from the back. [SUPSI]			

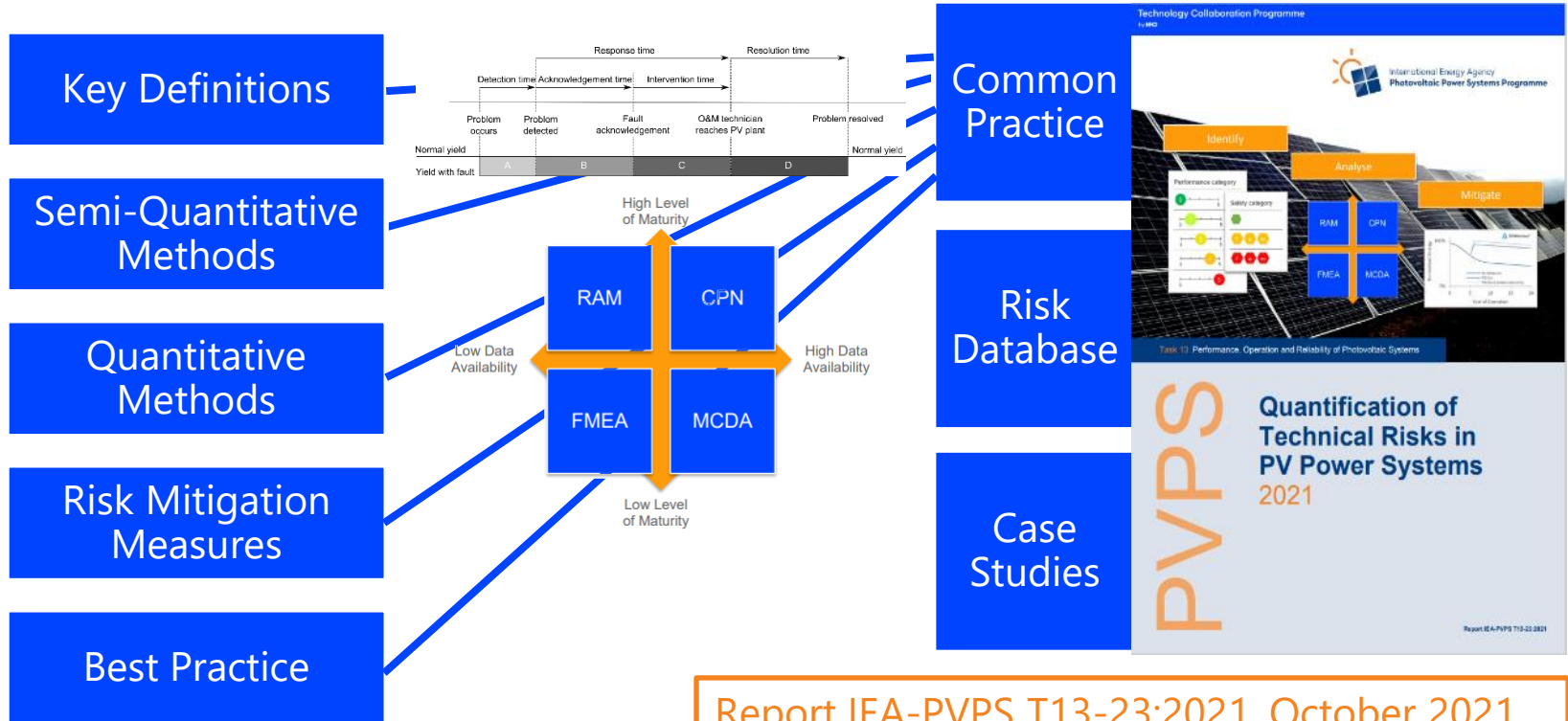
- The pictures are taken from literature or case studies and give only a partial picture of the situation. They are used to explain the potential levels of impact.
- The Rating is based on an expert assessment.
- Power loss is estimated/measured on the component level.

2. Quantification of Technical Risks in PV Power Systems



Review methods to compare and assess common practice

PVPS



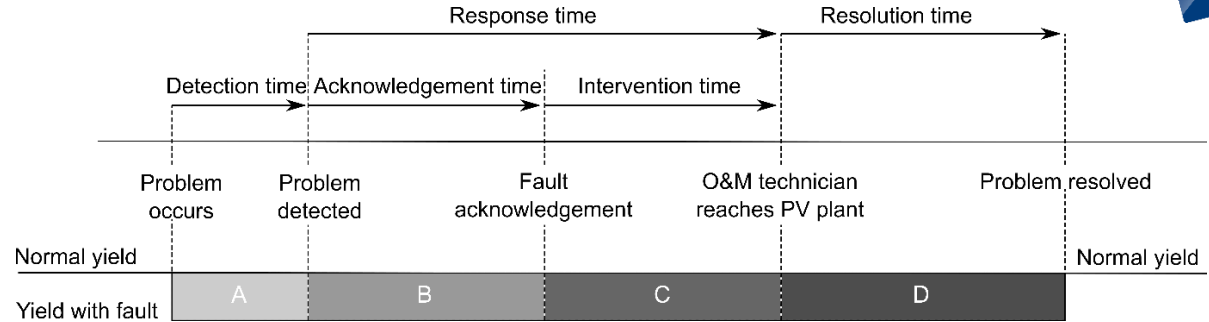
Report IEA-PVPS T13-23:2021, October 2021

2. Quantification of Technical Risks in PV Power Systems



Common Practice

Key Definitions



Report IEA-PVPS T13-25, ISBN 978-3-907281-13-0, 2021.

Technical risk: The probability of problems multiplied by the consequences of its failure

Reliability: The probability that a component performs its intended function

Energy Yield: The electrical energy generated by a power plant

Yield Loss: Not-generated energy caused by a problem

Failure rate: It indicates how many objects fail on average in a period of time

Detection time: How long a problem exists before it is noticed

Response time: Time between when the problem is detected and the corrective action starts

Resolution time (repair time): time to resolve the fault from the moment of reaching the plant

2. Quantification of Technical Risks in PV Power Systems

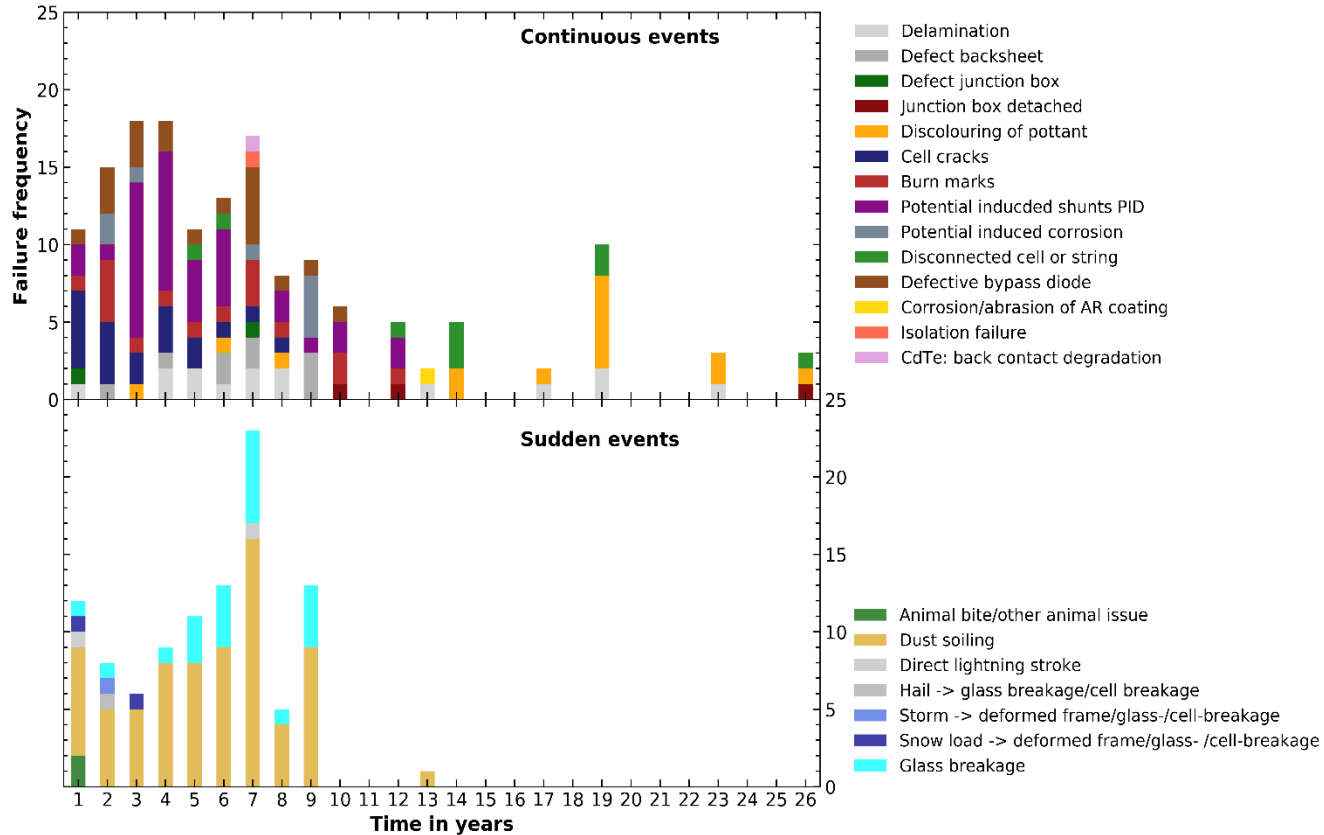


Risk Database

PV Failure Degradation Sheets

- The main results of the last report remain true.
- PID effects, cell cracks and defective bypass diode failures** seem to dominate the failure statistic in the **first seven years**.
- Additionally, the failure type **“burn marks”** have been detected more frequently.

PVPS



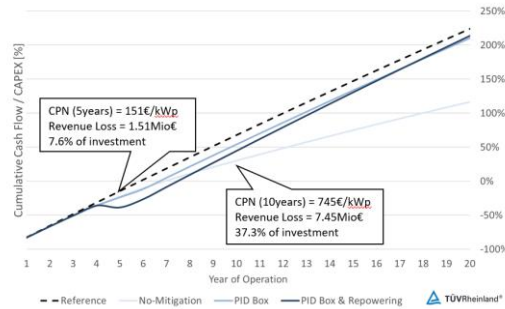
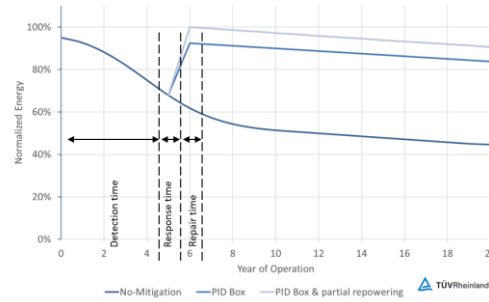
2. Quantification of Technical Risks in PV Power Systems



Assess the economic impact of risks and the effectiveness of mitigation measures

Risk Analysis

Cost-Benefit Analysis



Common Practice

Risk Database

Case Studies

The image shows the cover of the report 'Quantification of Technical Risks in PV Power Systems 2021'. The cover features a blue header with the 'Technology Collaboration Programme' logo and the 'International Energy Agency Photovoltaic Power Systems Programme' logo. Below the header is a flowchart with three main stages: 'Identify', 'Analyse', and 'Mitigate'. The 'Analyse' stage is further divided into 'RAM', 'CPN', 'FMEA', and 'MCDA'. A small line graph is also visible on the right side of the cover. The title 'Quantification of Technical Risks in PV Power Systems 2021' is prominently displayed in the center. The 'PVPS' logo is on the left, and the report number 'Report IEA-PVPS T13-23:2021' is at the bottom right.

2. Conclusions



Quantification of Technical Risks in PV Power Systems

- Data-driven approach for predictive/corrective maintenance actions required.
- Database/design tool for material and component selection for specific climatic conditions of PV systems (SRIA for 2030).
- Data-driven evaluation of techno-economic performance indicators is a significant key to take decision support on LCOE to the next level.

Technical Reports (2018-2021)



Technology Collaboration Programme
Level 1

Table 1: Performance, Operation and Reliability of Photovoltaic Systems

PVPS Uncertainties in Yield Assessments and PV LCOE 2020

Report IEA-PVPS T10.02.2020

Technology Collaboration Programme
Level 1

Table 7: Performance, Operation and Reliability of Photovoltaic Systems

PVPS Climatic Rating of Photovoltaic Modules: Different Technologies for Various Operating Conditions 2020

Report IEA-PVPS T10.03.2020

Technology Collaboration Programme
Level 1

Table 11: Performance, Operation and Reliability of Photovoltaic Systems

PVPS Assessment of Performance Loss Rate of PV Power Systems 2020

Report IEA-PVPS T10.05.2020

Technology Collaboration Programme
Level 1

Table 13: Performance, Operation and Reliability of Photovoltaic Systems

PVPS Bifacial Photovoltaic Modules and Systems: Experience and Results from International Research and Pilot Applications 2021

Report IEA-PVPS T10.06.2021

Technology Collaboration Programme
Level 1

Table 15: Performance, Operation and Reliability of Photovoltaic Systems

PVPS Performance of New Photovoltaic System Designs 2021

Report IEA-PVPS T10.08.2021

Technology Collaboration Programme
Level 1

Table 17: Performance, Operation and Reliability of Photovoltaic Systems

PVPS Designing New Materials for Photovoltaics: Opportunities for Lowering Cost and Increasing Performance through Advanced Material Innovations 2021

Report IEA-PVPS T10.09.2021

Technology Collaboration Programme
Level 1

Table 19: Performance, Operation and Reliability of Photovoltaic Systems

PVPS Qualification of Photovoltaic (PV) Power Plants using Mobile Test Equipment 2021

Report IEA-PVPS T10.10.2021

Technology Collaboration Programme
Level 1

Table 21: Performance, Operation and Reliability of Photovoltaic Systems

PVPS Service Life Estimation for Photovoltaic Modules 2021

Report IEA-PVPS T10.11.2021

Technology Collaboration Programme
Level 1

Table 23: Performance, Operation and Reliability of Photovoltaic Systems

PVPS Quantification of Technical Risks in PV Power Systems 2021

Report IEA-PVPS T10.12.2021

Technology Collaboration Programme
Level 1

Table 25: Performance, Operation and Reliability of Photovoltaic Systems

PVPS Guidelines for Operation and Maintenance of Photovoltaic Power Plants in Different Climates 2021

Report IEA-PVPS T10.13.2021

3. Integration of PV



“PV going everywhere”

Desert PV



© IEA PVPS Task 13

Vehicle integrated PV



© Sono Motors

Agri PV



© SolarPower Europe

Building integrated PV



© Ertex Solar

PV in transport infrastructure



© AIT

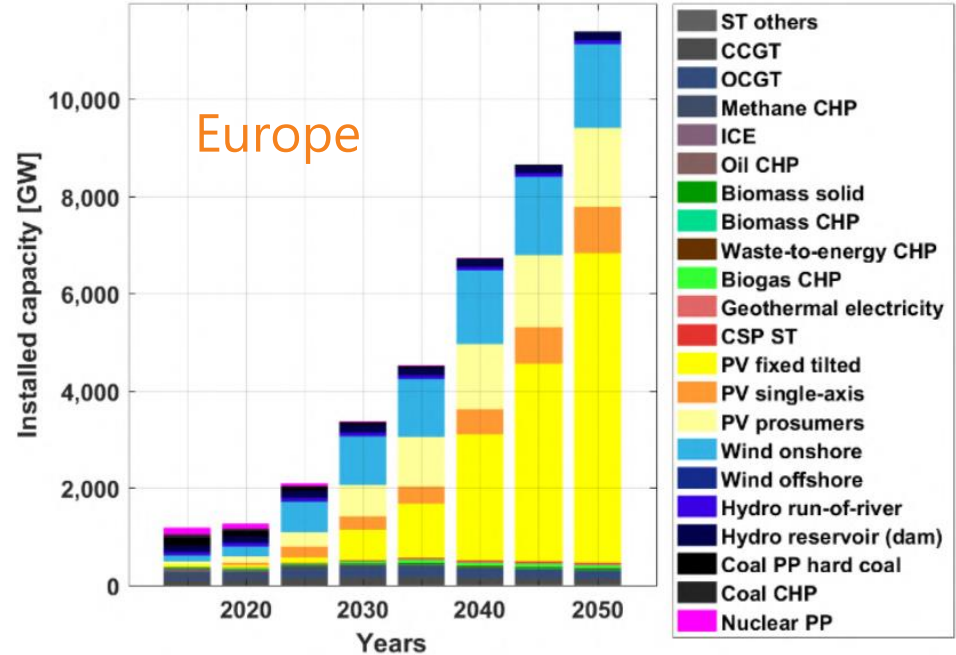
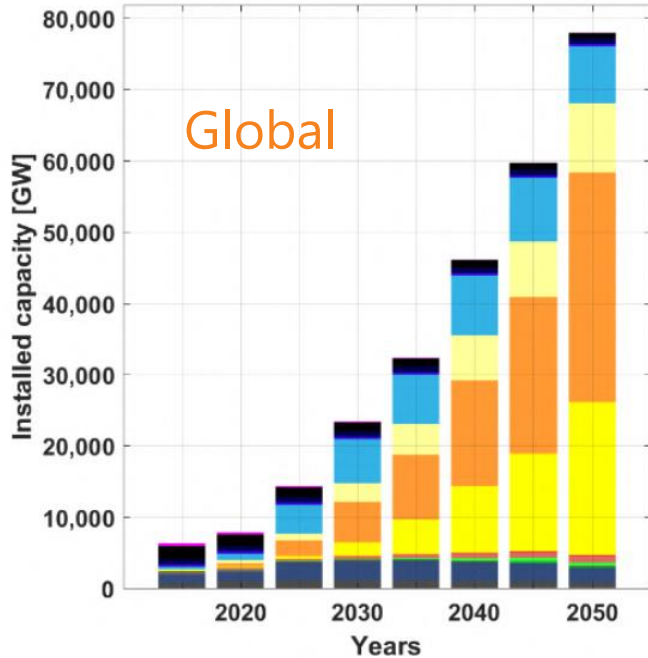
Floating PV



© Baywa r.e.

3. Installation of PV

We will install TW of solar PV capacity - and we will not clear natural vegetation to do it!!



3. Integration of PV - Agrivoltaics



BayWa r.e.



PVPS

Next2Sun

Research & Innovation for A-PV

- Investigate and identify the most appropriate use cases based on climate and local agricultural needs.
- Integrating rainwater harvesting for use in optimized irrigation strategies.
- Matching the lighting conditions to the needs of the plants
- Proposed KPIs: crop yield and photovoltaic yield

Land cover type	Proportion (%)	Total (km ²)
Arable land and permanent crops	25	1 471 684
Pastures and mosaics	17	985 102

3. Integration of PV - Floating



Research & Innovation for F-PV

- Application in damp, corrosive environments and under the effect of constant movement.
- System design for wave classes > 0.5 m
- Highly accurate yield predictions including the effects of cooling and motion (mismatch losses).
- Design of floating offshore PV systems for use in conjunction with an offshore wind farm.

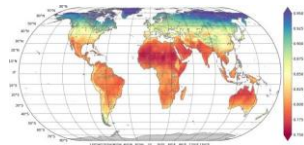
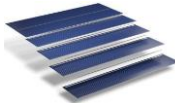
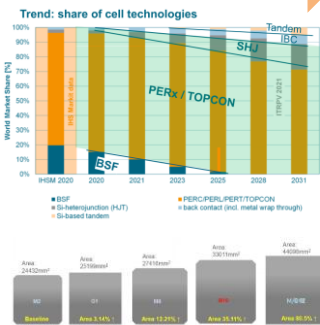
Land cover type	Proportion (%)	Total (km ²)
Water bodies	3	152 629

IEA PVPS Task 13 New Work Programme 2022-2025



Task 13: Reliability and Performance

- + New materials & applications (IPV)
- + Climate/environment specific design/testing
- + Techno-Economic key performance indicators
- + Digitalization
- + Second Life PV
- + PV & storage



Subtask / Activity

Subtask 1: Reliability of novel PV materials, components and modules

- ST1.1 Degradation modes in new PV cell and module technology
- ST1.2 Performance and Reliability of Second Life PV
- ST1.3 Impact of Testing Strategies including application specific load conditions
- ST1.4 Reliability of PV+Storage

Subtask 2: Performance and Durability of PV Applications

- ST2.1 Floating PV
- ST2.2 Agrivoltaics
- ST2.3 Bifacial Tracking Systems
- ST2.4 Digital Integration and Digital Twinning
- ST2.5 Module Power Electronics Performance and Shading

Subtask 3: Techno-Economic Key Performance Indicators

- ST3.1 Severe weather and its impact on PV performance
- ST3.2 Guideline for the optimisation of KPIs for specific climatic or environmental conditions
- ST3.3 Impact of decisions in PV projects economic KPIs
- ST3.4 Mapping economic and reliability KPIs

Acknowledgements



Main and contributing authors:

Gernot Oreski, Polymer Competence Center Leoben GmbH, Leoben, Austria
Werner Herrmann, TÜV Rheinland Group, Cologne, Germany
Magnus Herz, TÜV Rheinland Group, Cologne, Germany
Gabi Friesen, University of Applied Sciences and Arts of Southern Switzerland (SUPSI), Mendrisio, Switzerland
Gabriele Eder, Österreichisches Forschungsinstitut für Chemie und Technik, Vienna, Austria
Ioannis Tsanakas, CEA INES – Institut National de l’Energie Solaire, Le Bourget-du-Lac, France
Boris Farnung, Fraunhofer-Institut für Solare Energiesysteme ISE, Freiburg, Germany
Marc Köntges, Institut für Solarenergieforschung GmbH Hameln/Emmerthal, Hamelin, Germany
Tadanori Tanahashi, Fukushima Renewable Energy Institute, AIST, Fukushima, Japan
Karl Berger, Austrian Institute of Technology, Vienna, Austria
Bernhard Kubicek, Austrian Institute of Technology, Vienna, Austria
Oliver Kunz, University of New South Wales, Sydney, Australia
Haitao Liu, Electrical Engineering Institute/Chinese Academy of Sciences, Beijing, China
David Parlevliet, Murdoch University, Western Australia, Australia
David Moser, EURAC Research, Bozen/Bolzano, Italy
Sascha Lindig, European Academy Bozen/Bolzano, Italy
Jan Vedde, European Energy, Birkerød, Denmark
Franz Baumgartner, Zurich University of Applied Science (ZHAW), Switzerland
Karl-Anders Weiss, Fraunhofer-Institut für Solare Energiesysteme ISE, Freiburg, Germany
Laura S. Bruckman, SDLE, Case Western Reserve University, Cleveland, USA
Roger French, SDLE, Case Western Reserve University, Cleveland, USA
Samuli Ranta, Turku University of Applied Sciences, Turku, Finland
Marco Paggi, IMT School for Advanced Studies, Lucca, Italy

Thank You



PVPS

Thank You

Ulrike Jahn, IEA PVPs Task 13 Manager

ulrike.jahn2@vde.com

