TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

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AUTONOME PROVINZ BOZEN SÜDTIROL
PROVINCIA AUTONOMA DI BOLZANO ALTO ADIGE

PV 4.

eurac research

Role of Digitalization in Operation and Maintenance of PV Plants: breaking silos

David Moser
Institute for Renewable Energy
Bolzano
Italy

IEA PVPS

The Quest for Quality: towards reliable and bankable solar PV

Literature on quality

O&M Best Practice Guidelines Version 4.0

At the O&M and Asset Management 2019 conference in London, SolarPower Europe launched Version 4.0 of the O&M Best Practice Guidelines. This new version builds

05/12/2019

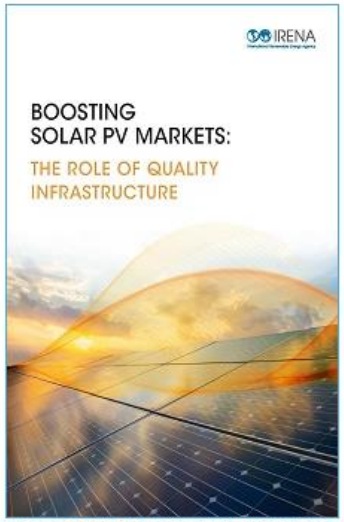
Asset Management Best Practice Guidelines Version 2.0

SolarPower Europe has launched Version 2.0 of the Asset Management Best Practice Guidelines. Building on a successful Version 1.0 published in December 2019, this update

Engineering, Procurement & Construction Best Practice Guidelines Version 1.0

SolarPower Europe has launched the Engineering, Procurement and Construction (EPC) Best Practice Guidelines. Following a year of intensive work, we are very proud to present

24/11/2020

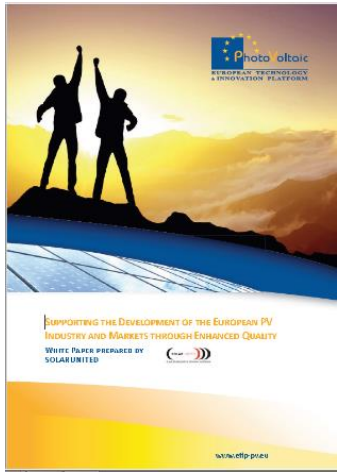


Boosting global PV markets: The role of quality infrastructure

SolarPower Europe

PhotoVoltaic
EUROPEAN TECHNOLOGY & INNOVATION PLATFORM

International Energy Agency
Photovoltaic Power Systems Programme



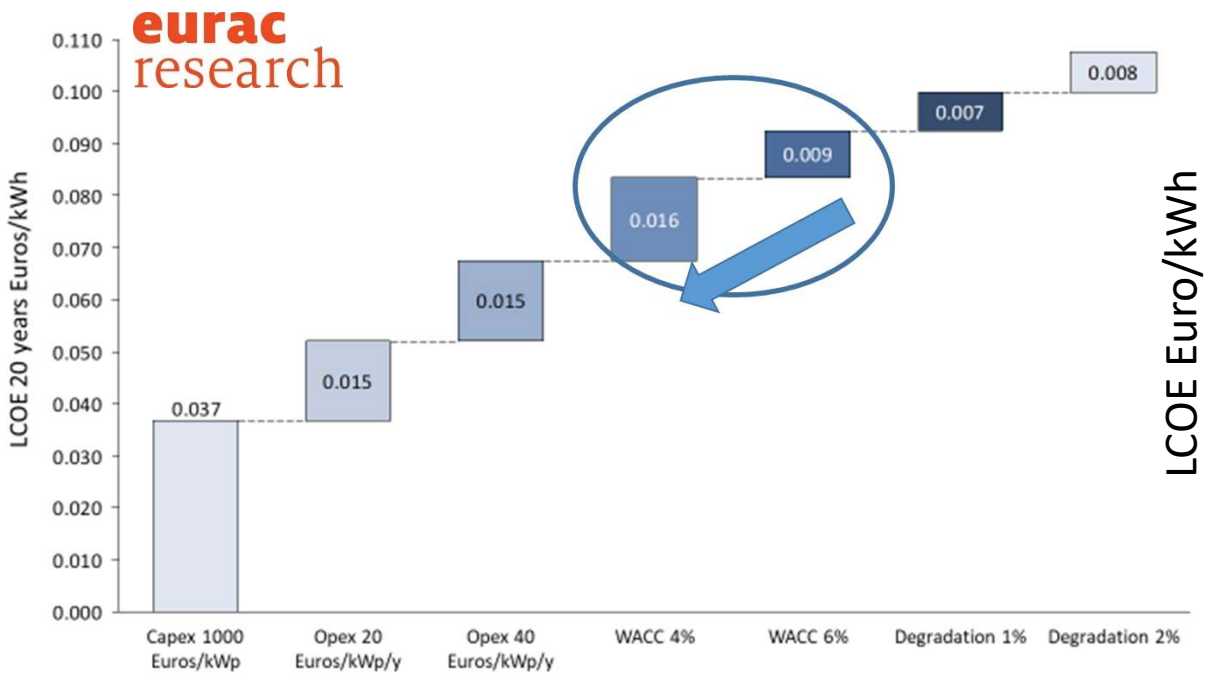
IRENA
International Renewable Energy Agency

SOLARUNITED

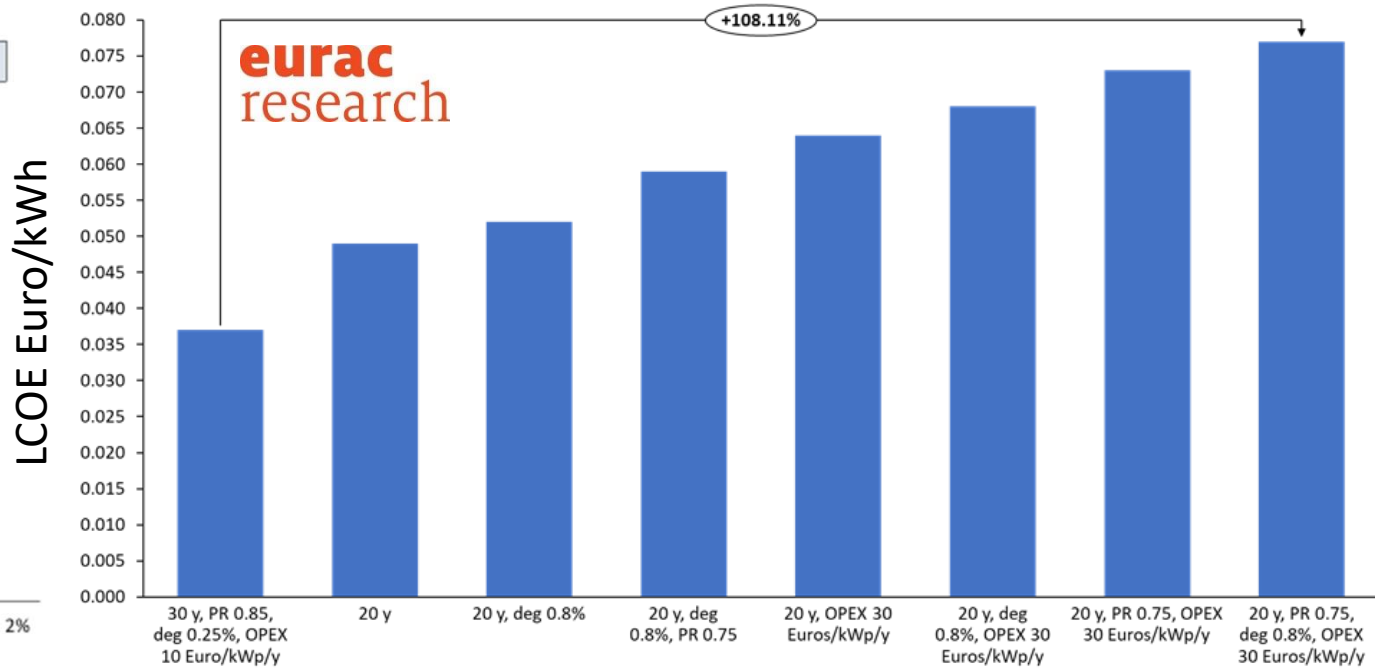
PVQAT
International PV Quality Assurance Task Force

Quantifying «quality»

Derisking



Impact of reliability on LCOE



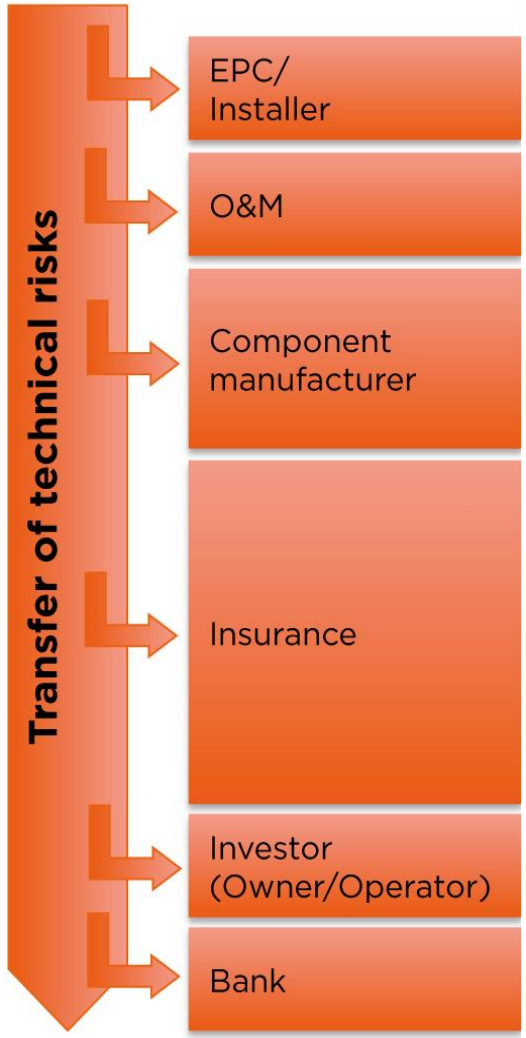
Drivers for cost-effective increase of performance and reliability:

- Common nomenclature / dictionaries
- Risk framework and guidelines
- A value-chain approach

For all these drivers digitalisation is key

Impact of weighted average cost of capital, capital expenditure, and other parameters on future utility-scale PV levelised cost of electricity, Eero Vartiainen, Gaëtan Masson, Christian Breyer, David Moser, Eduardo Román Medina, PIP 2019 https://doi.org/10.1002/pip.3189

Stakeholders' needs



short defect warranty periods, minimum of additional guarantees and warranties, high sale price with low OPEX (short time horizon)

manage all the conflicting requirements for a long period of time. The best condition for O&M operators is in fact in the presence of long defect warranty period and low sale price to allow for higher OPEX.

Limit their liability to product guarantees and warranties

limit their liability to failures PV plants, which meet technical market standards and are maintained on a regular basis

long defect warranty periods, performance guarantees, reasonable low CAPEX and OPEX, high long-term plant performance and lifetime (ideally above the initial prediction).

projects with a 10-15 year financing period and PV plant performance which can also be slightly below prediction.

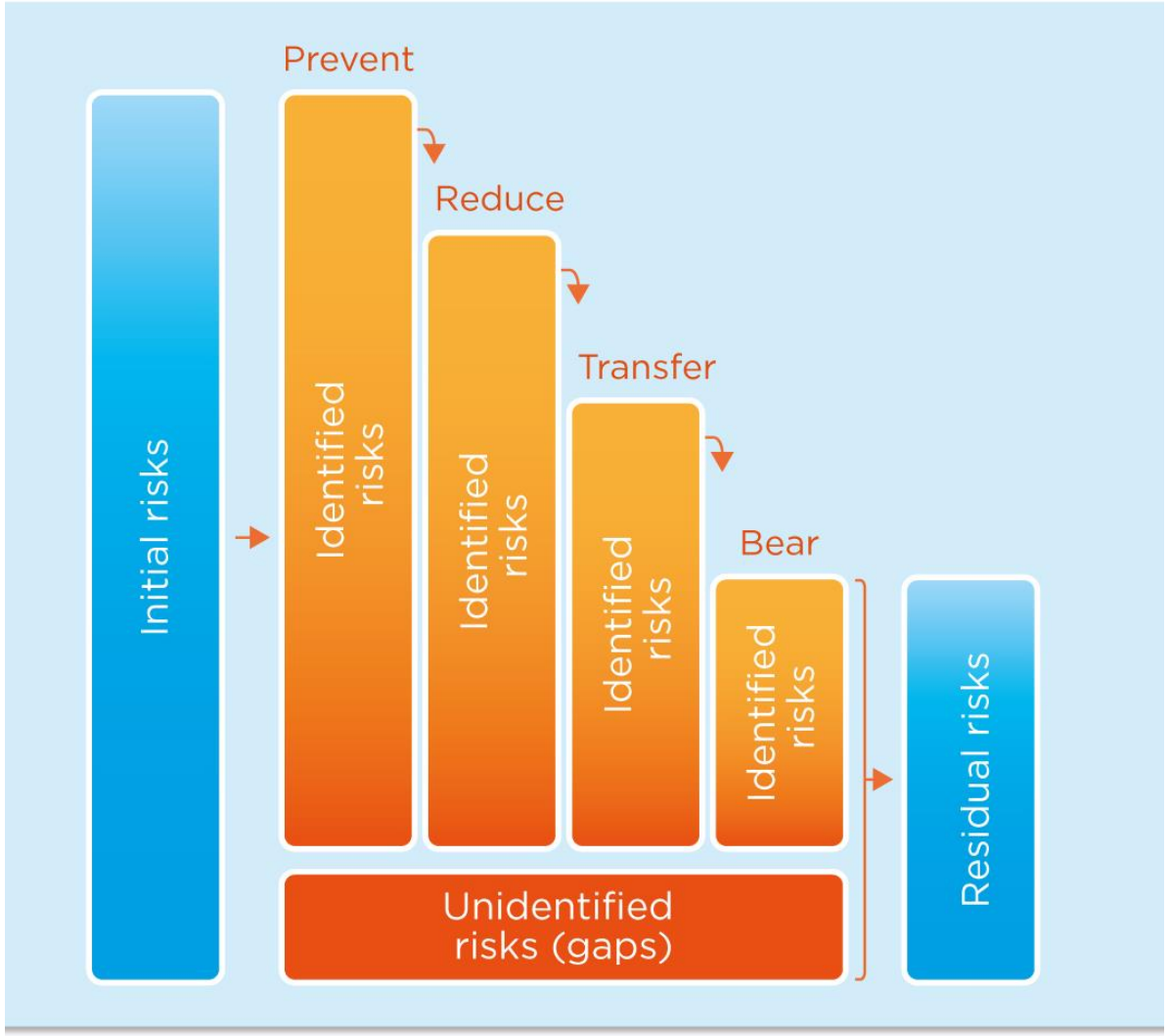
Data availability

Bankability and quality must be data-driven

Large datasets are available:
- Procurement / Testing
- Monitoring
- Field inspection
- Ticketing O&M
- Insurance claims
- Third party inspections

HOWEVER

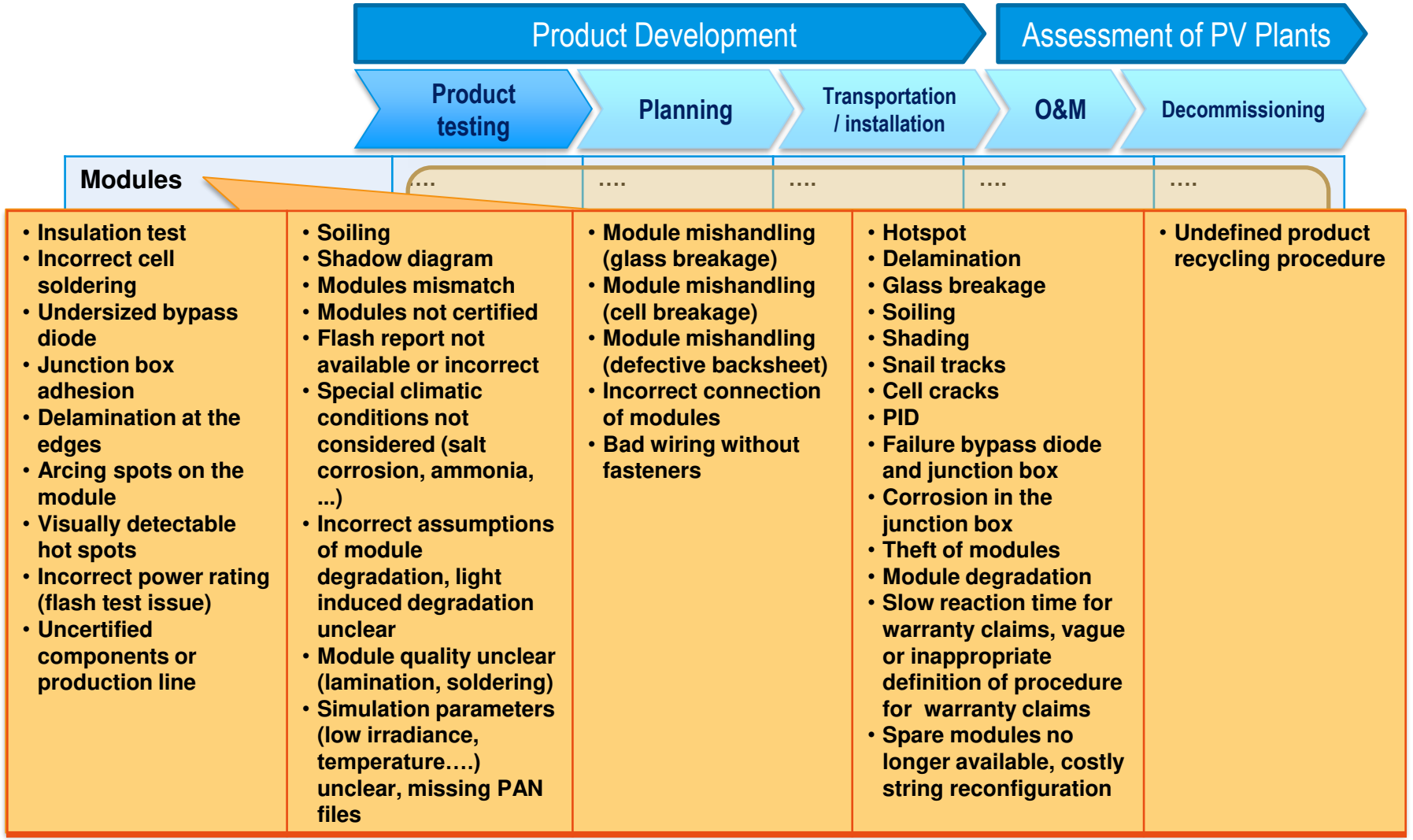
These datasets are rarely:
- Organised
- Interoperable and digitalised
- Rely on interlinked digital platforms



Technical risks framework: towards a standardised approach to quality

Risk matrix: taxonomy

The importance of using common dictionaries



Risk matrix: taxonomy

The importance of using common dictionaries

Failure appearance in PV plant

Creation of ticket in SCADA system

Classification of failure according to TRUST PV's Risk Matrix

Resolution of failure

Statistical analysis of failure (CPN)

Workflow
Failure categorization

Risk Matrix Update

Components

Grid	Weather station, Communication & Monitoring
Interconnection	Mounting Structure
Inverter	System
Module	Transformer

MANDATORY OPTIONAL

failure_id	Component	Subcomponent	failure	Description	Cause	Origin	Accountability	Detection
grid.02	Grid	Entire grid	Limitation of deliverable power			Operation		Warning O&M platform
inv.11	Inverter	Entire inverter	Overheated inverter		Ventilation issues	Operation		Warning inverter
mod.01	Module	Backsheet	Chalking			Operation	Insurance	Visual inspection
mount.12	Mounting Structure	Tracking system	Tracking failure		Storm	Operation		

340 failures listed

Ticket Alignment

Status update:
24,780 tickets of 86 PV plants aligned

Statkraft enel Green Power BayWa r.e.

Economic impact of failures

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Cost-based Failure Modes and Effects Analysis (FMEA) for PV

New metrics

CPN: metric that allows for
- **Comparison between asset within the same PV plant portfolio (AM, O&M)**
- **Evaluate best strategies in EPC, O&M**
- **Act as a link between the various phases of the value chain**

a) Economic impact due to downtime and/or power loss (kWh to Euros)
- Failures might cause downtime or % in power loss
- Time is from failure to repair/substitution and should include: time to detection, response time, repair/substitution time
- Failures at component level might affect other components (e.g. module failure might bring down the whole string)

→ Income / savings reduction

+

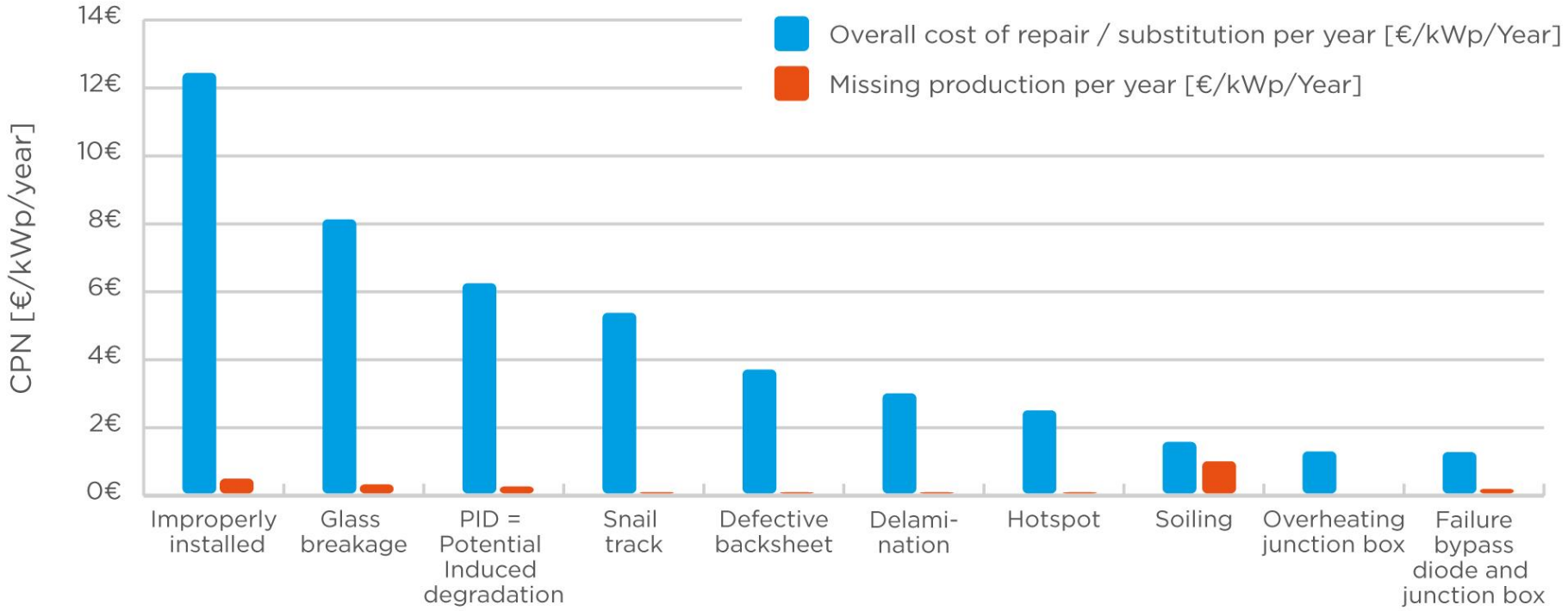
b) Economic impact due to repair/substitution costs (Euros)
- Cost of detection (field inspection, indoor measurements, etc)
- Cost of transportation of component
- Cost of labour (linked to downtime)
- Cost of repair/substitution

→ O&M cost increase
Reserves decrease

CPN Results - Components and Market Segments

- PV modules - Utility scale

Scenario based results!

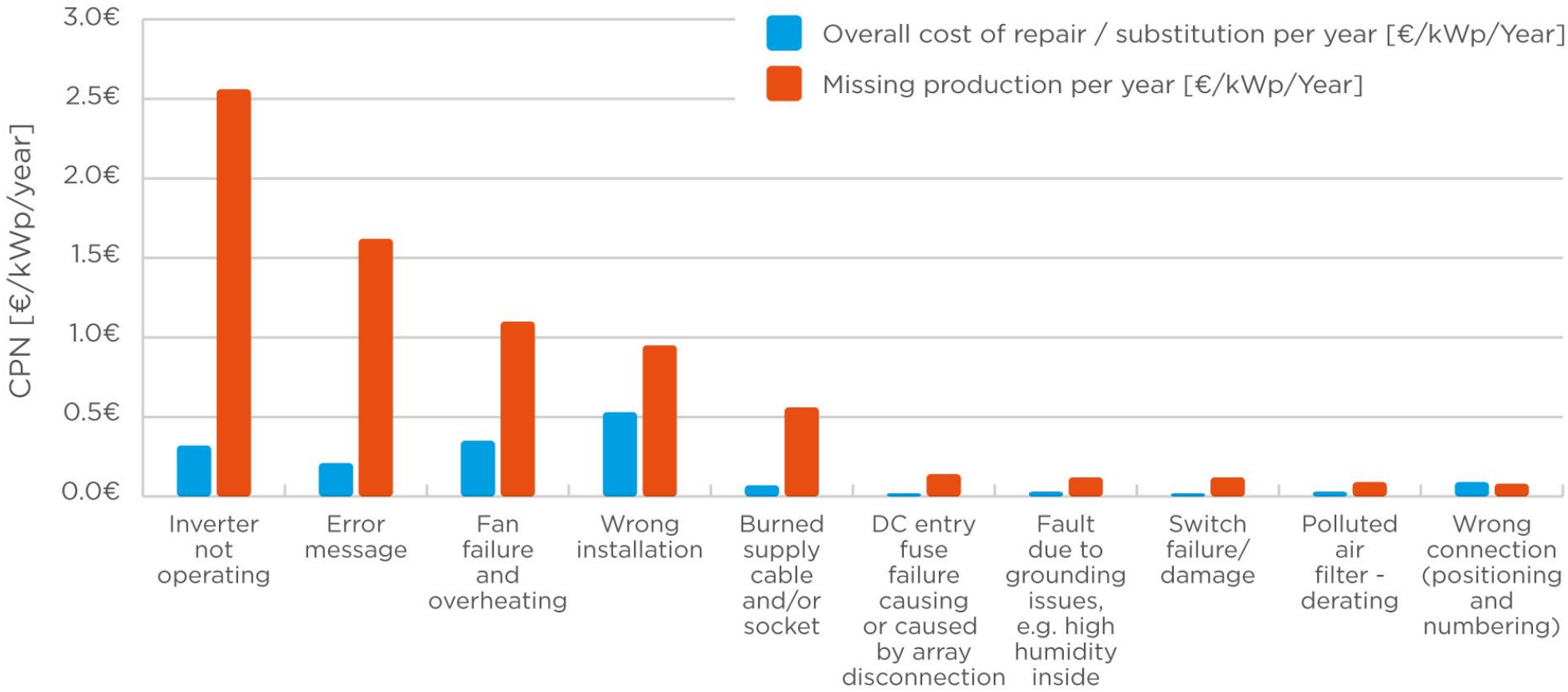


- Highest risk consists of a group of installation failures (mishandling, connection failures, missing fixation, etc.)
- Variety of failures detected by different techniques (VI, IR, EL, IV-Curves)

CPN Results - Components and Market Segments

Scenario based results!

- Inverters



Economic impact of failures

Treaceability

When a failure occurs, e.g. performance deviation beyond allowed threshold or inverter error code generated.
An alarm is triggered

Acknowledgement of the fault by the O&M Contractor.
A maintenance ticket is opened

The technician arrives on-site with all the tools and spare parts needed to fix the problem

Problem fixed and acknowledged by the O&M Contractor.
The maintenance ticket is closed

failure time | acknowledgement time | intervention time | resolution time

Detection time

Time that it takes to detect the occurrence of a problem

Response time

Time that it takes to organise the repair or substitution

Repair time

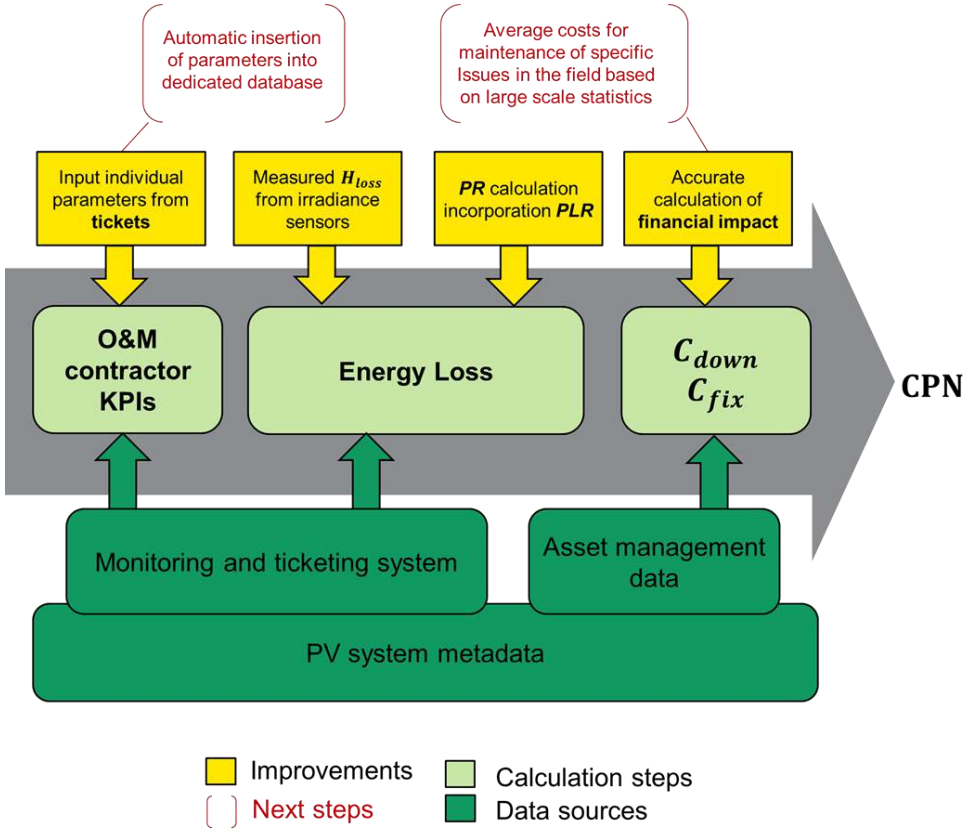
Time that it takes the technician to fix the problem

→ Digitalisation becomes a necessity

Digitalisation as THE driver for quality

Process digitalisation

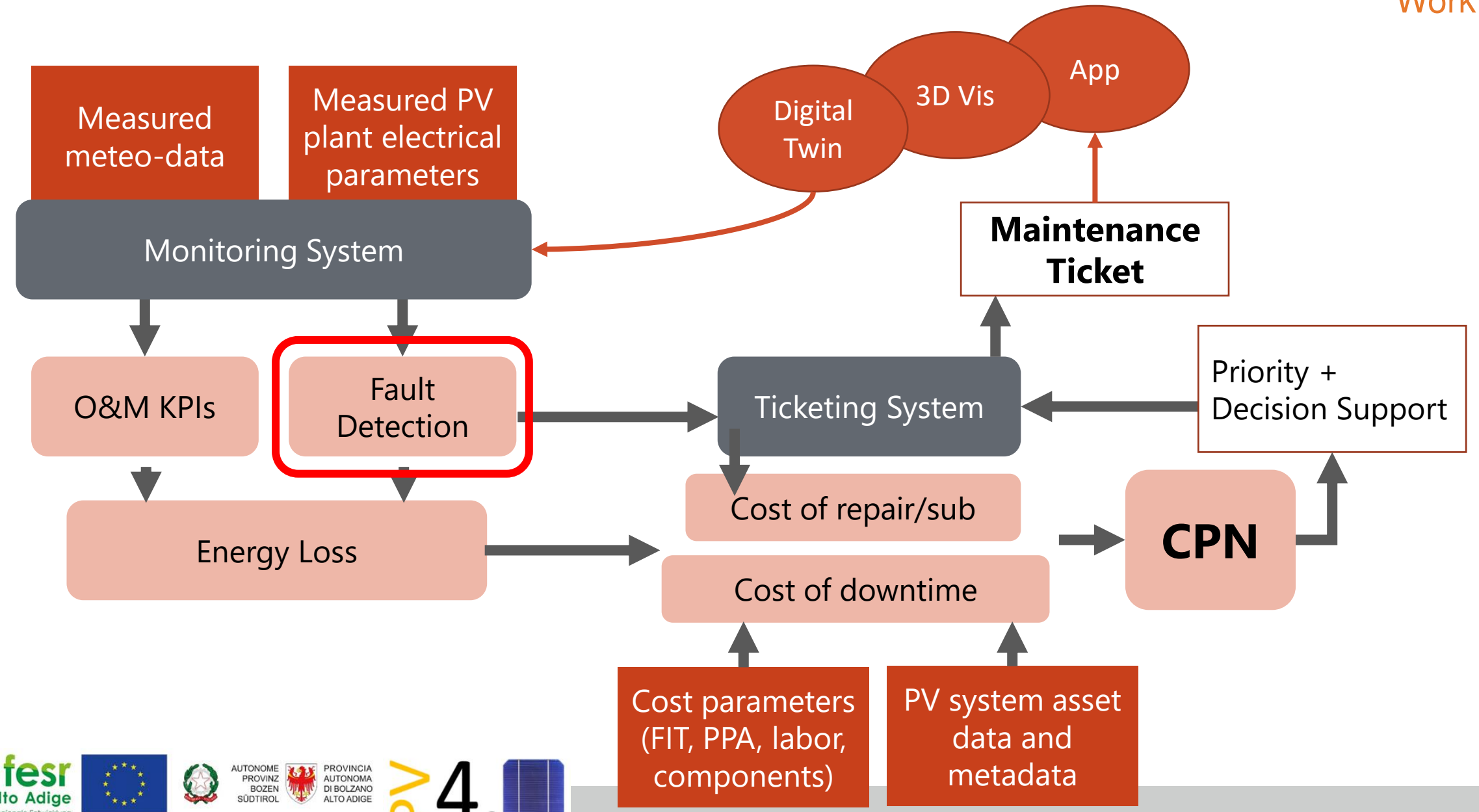
Full integration of monitoring platforms and ticketing systems



- Creation of standardised metadata (PV passport)
- Development of an automated and therefore time-efficient solution for extracting key parameters from maintenance tickets to gain statistical insights from a large number of PV plants.
- Development of a software tool for field technicians that would allow the precise and error-free recording of standardised parameters for the calculation of the O&M contractors KPIs necessary for an efficient implementation of the methodology
- The O&M field practices must definitely move away from a manual input of tickets in text format and adopt a more standardised approach when human intervention is limited

Process digitalisation

Workflow



A value-chain approach

Needs and definitions

Virtual construction of a facility prior to its actual physical construction

(reduce uncertainty, improve safety, work out problems, and simulate and analyze potential impacts)

Bridge the information loss associated with handling a project from design team, to construction team and to asset owner/operator

Dynamic information about the asset

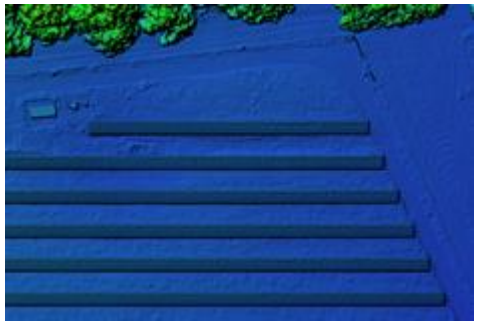
(Configuration changes, sensor measurements, control signals)

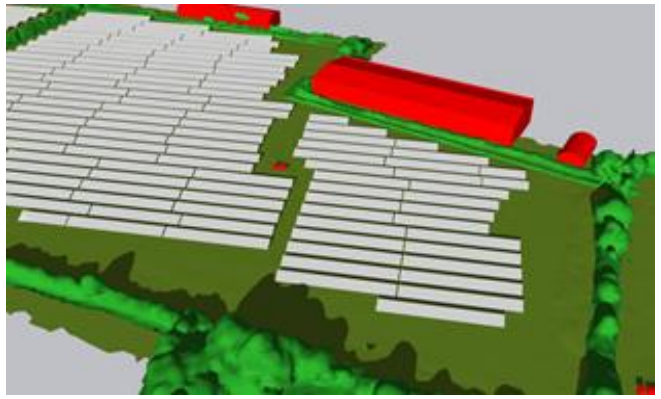
PV BIM = Digital repository to facilitate the storage, modification and exchange of all PV asset information throughout the entire PV lifecycle

Digital Twin = parametrized 3D model, containing all physical information needed to simulate the behavior and performance of the real PV plant it represents

Process digitalisation

Digitalised PV plant





Drone survey of existing site

Imagery

Very accurate ground-control

Photo-grammetry

3D model

Ground topography

Tree shading geometry

Building geometry

Post-processing

PV table geometry

Automation

PV module geometry

Raw 3D geometry (.dwg or .dae)

Process digitalisation

Digitalised PV plant

Raw 3D geometry from drone survey (.dwg or .dae)

Electrical layout Information (.dwg)

Generation of full PV model of existing site from drone survey and electrical layout

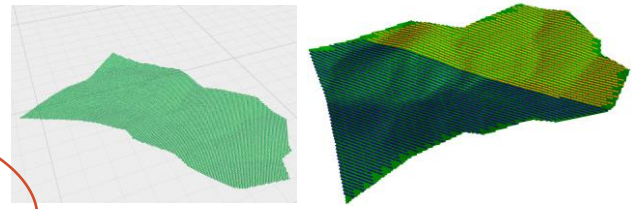
Ground topography

Tree shading geometry

Building geometry

PV table geometry

PV module geometry



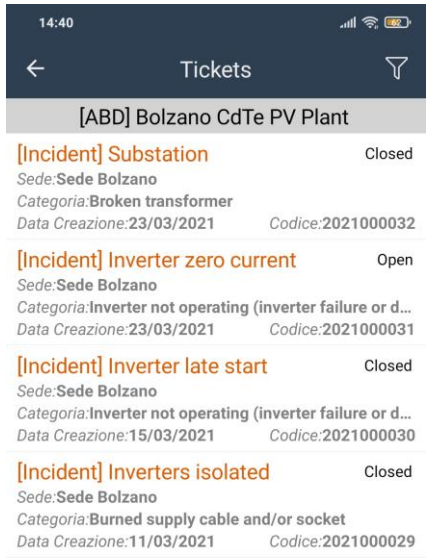
PV 3D geometry (.rad)

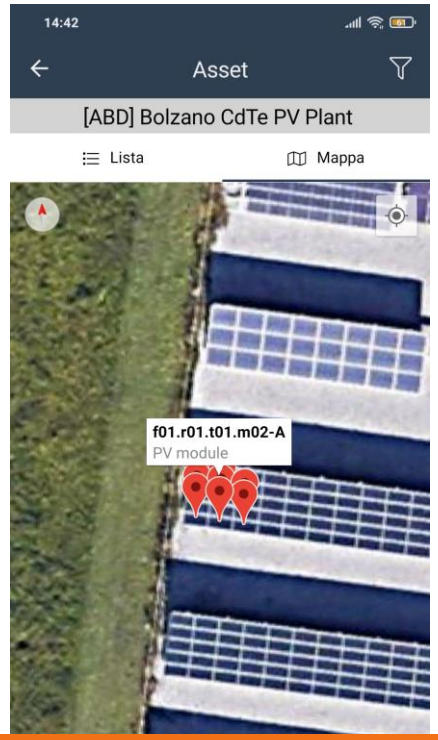
Electrical hierarchy (.xml)

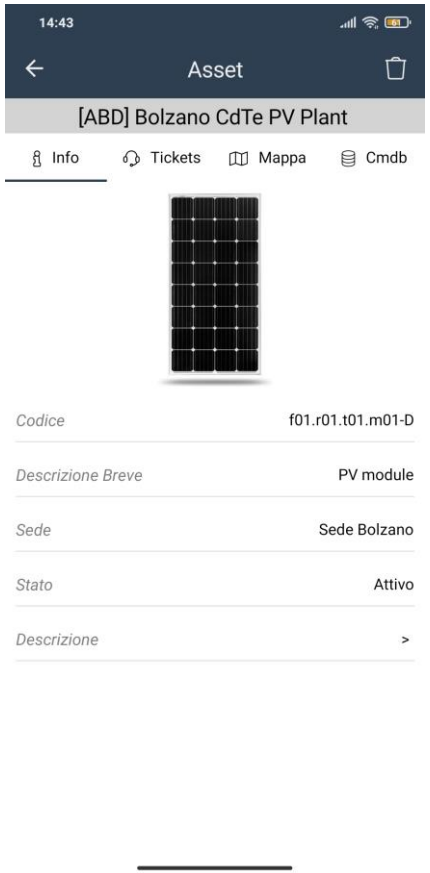
PV system performance simulation

Process digitalisation

Digitalised PV plant







Component geolocalised
History / logging at component level
Integration in digital platforms
Common nomenclature: statistics
Suggestions on actions
H&S / skills management

saidea informatica

eurac research PV 4.0

A value-chain approach

Breaking silos

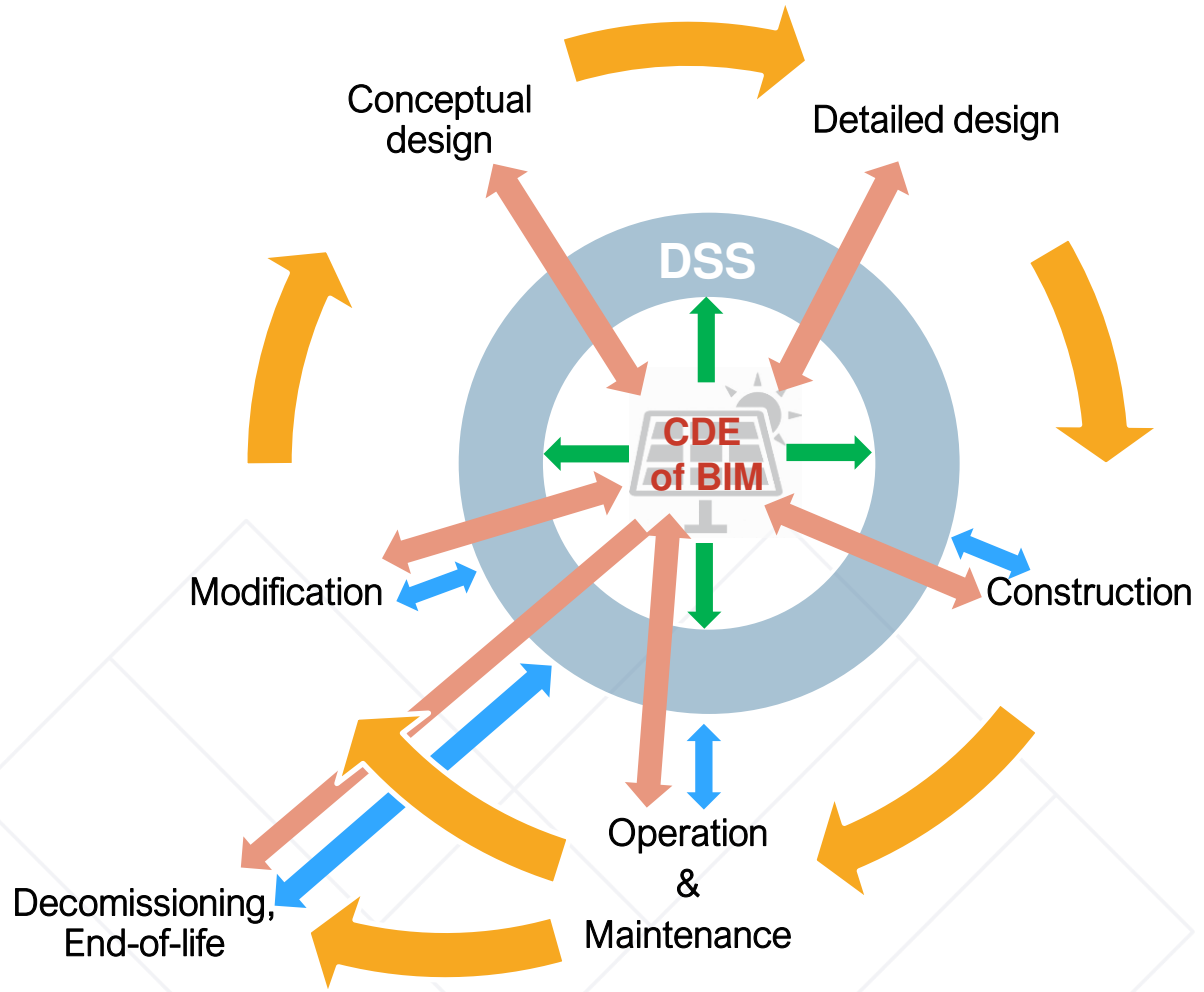
BIM framework for the PV industry

- **Building Information Modeling (BIM) for the management, sharing and federation of PV asset information throughout the lifecycle**

Lifecycle processes request from and provide information to a shared repository or Common Data Environment (CDE)

Advanced digital services request information and perform federation

Advanced digital services interact with lifecycle processes to aid decision making e.g. through a Decision Support System (DSS)



A value-chain approach

Breaking silos

Asset information re-use in the PV industry

- **The information need of several PV system lifecycle stages is investigated (see table)**
  - **It was found that enabling information re-use through BIM can render most services:**
    - More efficient through eliminating work repetition
    - More reliable through using a single, managed source of information

Lifecycle stages	Data elements	Terrain Topography	Drone mapping	PV plant 3D model	Component datasheets	As-built documentation	Expected Yield Simulation	Site Location + Metadata	PV Plant + Metadata	Electrical Layout	Electrical Hierarchy	Weather Data	Component Labelling	PV plant Bill of Materials	PV Module Bill of Materials	Component cost database	Serial Numbers	Operational Data	Long Term Yield Assessment Data	Ticketing Data
	Product Manufacturing & Testing						x		x					x	x	x				
Planning and Design	Creation of a Digital Twin (Existing Plant)	x	x		x	x		x												
	Creation of a Digital Twin (New Plant)	x	x		x			x								x				
	Energy yield simulation using Digital Twin		x	x	x			x	x	x	x	x	x							
	Construction Monitoring	x	x		x	x				x	x		x				x			
	Performance Monitoring		x		x		x	x	x	x	x	x	x				x	x	x	x
	Operation & Maintenance	x	x	x	x	x	x	x	x	x		x						x		x
	Recycling and End-of-Life				x									x	x		x			
	PV Financing						x							x	x	x			x	
	Decision Support System	x	x		x	x	x		x	x	x	x	x					x		x

Conclusions and outlook

- The PV sector must establish approaches to ensure and measure quality of components, systems and projects
- Each PV project must ensure the presence of a reliability plan which is constantly updated and passed along the value chain
- New metrics must be introduced to quantify the impact of decisions taken over the lifetime of a PV project
- Silos culture between stakeholders must change. Decision taken during a phase have an impact on the next phases
- Information must be carried along the value chain (eliminate work repetition)
- Standardisation of data format and collected data (metadata / PV plant passport, product data, monitoring data, ticketing, etc)
- Digital platforms must be interoperable

Bankability must be based on hard facts / data

Solar Bankability is an approach that heavily relies on data / quantification of quality

Digitalisation is the driver that can finally ensure cost-effective increase of quality and reliability

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Stay tuned for the next Task 13 period!

Thank you for your attention

www.eurac.edu/

David.moser@eurac.edu

Decision support system