This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement N952957.
The information reflects only the project's view and the Commission is not responsible for any use that may be made of the information it contains.

TRUST-PV: Performance and reliability of solar PV power plants

10 May 2022

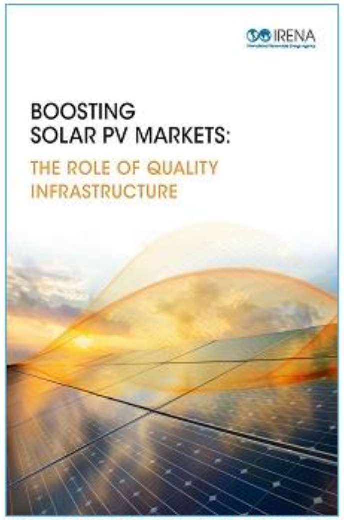
David Moser

Institute for Renewable Energy

eurac research

TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

THE QUEST FOR QUALITY



Boosting global PV markets: The role of quality infrastructure

SolarPower Europe

PhotoVoltaic EUROPEAN TECHNOLOGY & INNOVATION PLATFORM

IEA PVPS

IRENA International Renewable Energy Agency

SOLARUNITED

TRUST-PV PROJECT

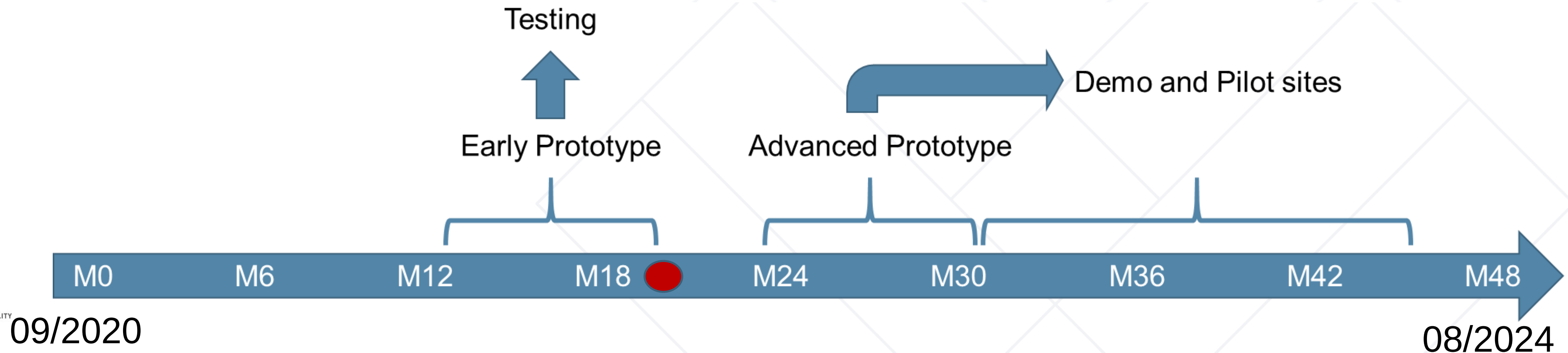
TRUSTPV Proudly powered by the European Union's Horizon 2020 Research and Innovation Programme.

Project Coordinator eurac research

3E, above, BayWa r.e., covestro, endurans solar, enel Green Power, eurac research, FOSS Research Centre for Sustainable Energy

HUAWEI, imec, inaccess, INNOSEA An LOC Company, PVcase, Raptech, Reuniwatt, saidea

SolarPower Europe, Solar Monkey, Statkraft, TU Delft, TÜVRheinland® Precisely Right.



TRUSTPV SOLAR PV, PERFORMANCE & RELIABILITY

EXPECTED RESULTS

LAYER 1 – COMPONENT

RESULTS

R1 Sustainable O&M & grid friendly PV components

R2 Application & climate-tailored testing beyond existing standards

R3 Context-sensitive PV Plant components benchmarking

LAYER 2 – SYSTEM

RESULTS

R4 More accurate energy yield prediction

R5 Progressive repowering

R6 BIM / augmented reality for improved skills of O&M operators

R7 Wireless Sensor Networks

R8 Automated fault diagnostic based on combined image analysis (IR/EL/UV) & electrical signatures

R9 Large database for failure rates calculation, mitigation measures & failure rate reduction based on CPN methodology including grid

R10 Decision support platform from fab to field

LAYER 3 – POINT OF CONNECTION / PV FLEET

RESULTS

R11 Fully felxible & interoperable PV systems

R12 Advanced forecasting

R13 Digital twin concepts

OBJECTIVES

TRUSTPV's RESULTS ENABLE THE ACHIEVEMENT OF OBJECTIVES

1. Increase P&R & lifetime of system components.
2. Increase the knowledge on the performance & establish cost effective fault diagnostic models of medium size commercial-resitential systems.
3. To increase the design accuracy & the reliability & performance of utility – large commercial systems.
4. To combine all the information coming from various stakeholders along the whole PV value chain into a platform for enhanced decision-making.
5. To allow higher PV penetration levels by improving the operational stability at the point of connection and ensure grid friendliness.
6. To increase the sustainability of utility – large commercial systems through progressive repowering interventions.

LAYER 1 | COMPONENTS

RESULT | 1

O&M and grid-friendly solar PV components.

Read more »

RESULT | 2

Application and climate-tailored testing beyond existing standards

Read more »

RESULT | 3

Context-sensitive PV plant components benchmarking based on monitoring data from over 6 GW of PV plants under operation and Big Data analytics.

Read more »

- Antireflective coatings with improved performance
- O&M-friendly solar PV modules considering the needs of O&M contractors such as reduced weight and reduced number of failures
- Inverter enabling semi-automated field inspection combined with UAV and forecasting
- Innovative PV modules passive cooling
- Power Plant Controller enabling grid friendliness

Inverter enabling semi-automated field inspection - EL

Reverse Power flow on the string is required during EL

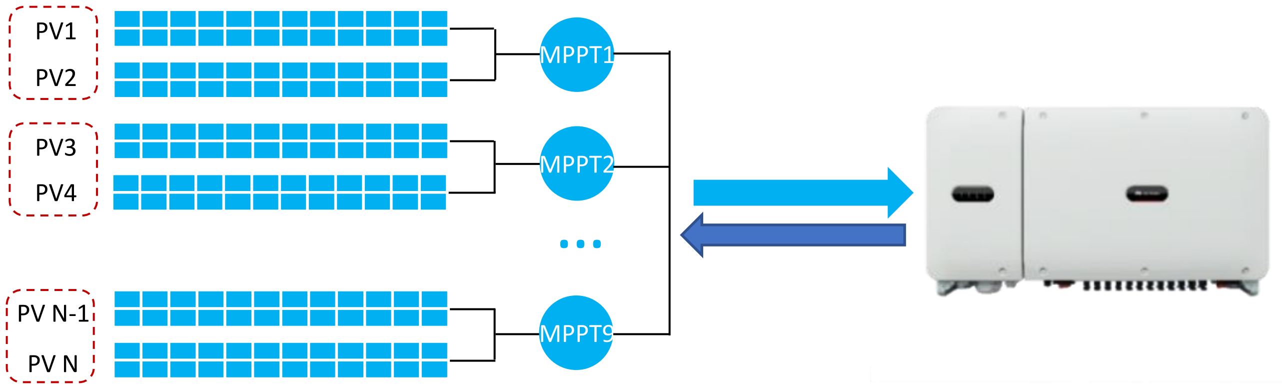
In order to provide the conditions for Electroluminescence (EL) the hardware of the current Huawei‘s standard string inverters must be upgraded as there is no reverse energy flow possible via the MPPT

TRUST-PV Innovation-enabled Potential

Within H2020 TRUST-PV, Huawei is researching and assessing the best ways to combine EL in an integrated-inverter-level solution (software & hardware based)

EL is enabled without extra/external hardware or cabling reconfiguration – cost-effective and user-friendly

EL Enabled Inverter with Integrated Solution – No extra equipment needed



- **Latest version based on a prototype with embedded hardware for final definition of the EL operating conditions (necessary string voltages, currents and reverse power)**

- **Latest EL software has both APP and MODBUS capabilities to ease the control management**

TRUSTPV SOLAR PV, PERFORMANCE & RELIABILITY HUAWEI eurac research above

Inverter enabling semi-automated field inspection - EL

Electroluminescence Functionality tested in the field

- Confirmation of functionality
- Special considerations for Bi-facial modules necessary
- Next steps: combination with UAV and forecasting to find best weather for flying

Available soon!

LAYER 1 | COMPONENTS

RESULT | 1

O&M and grid-friendly solar PV components.

Read more »

RESULT | 2

Application and climate-tailored testing beyond existing standards

Read more »

RESULT |

Context-sensitive PV plant components benchmarking based on monitoring data from over 6 GW of PV plants under operation and Big Data analytics.

Read more »

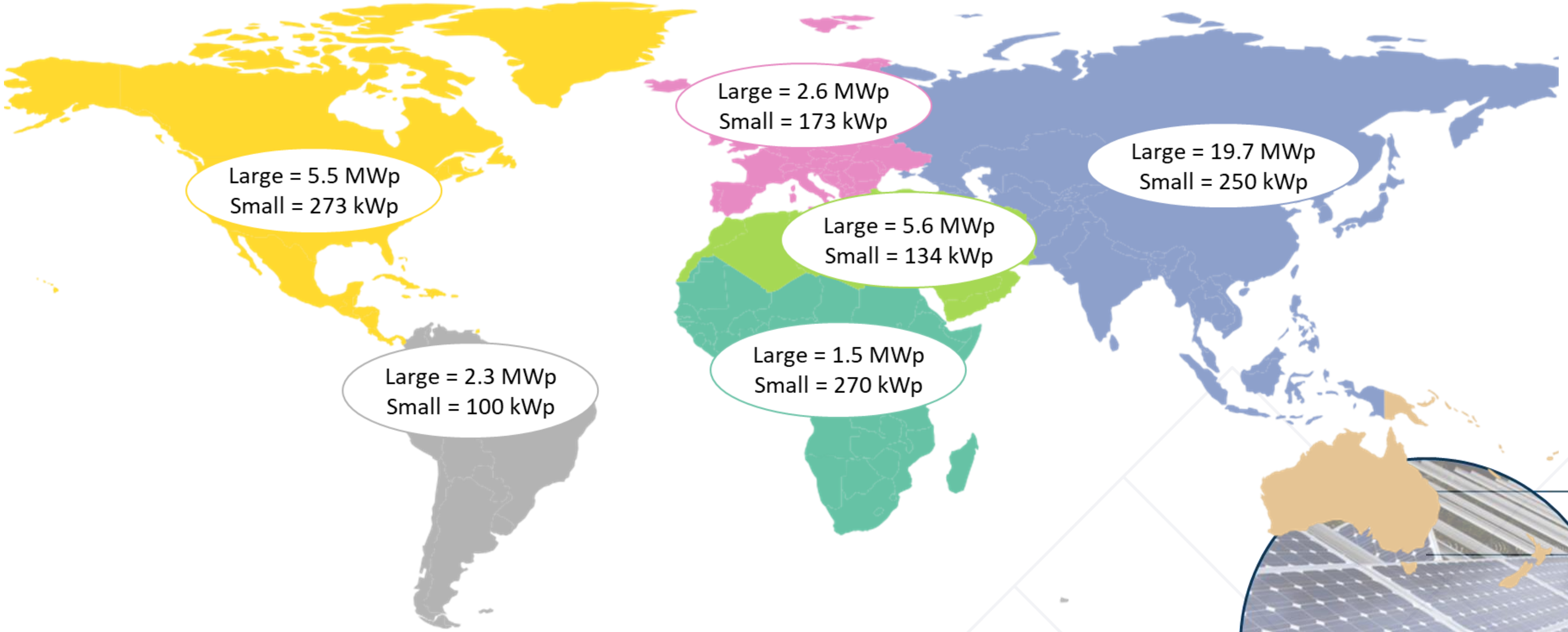
enel	BayWa r.e.	3E	Statkraft	INNOSEA
PV component failure data O&M ticketing data	Monitoring and as-built information Asset management data	Monitoring and as-built information	PV component failure data O&M ticketing data	Monitoring data from Floating PV plants

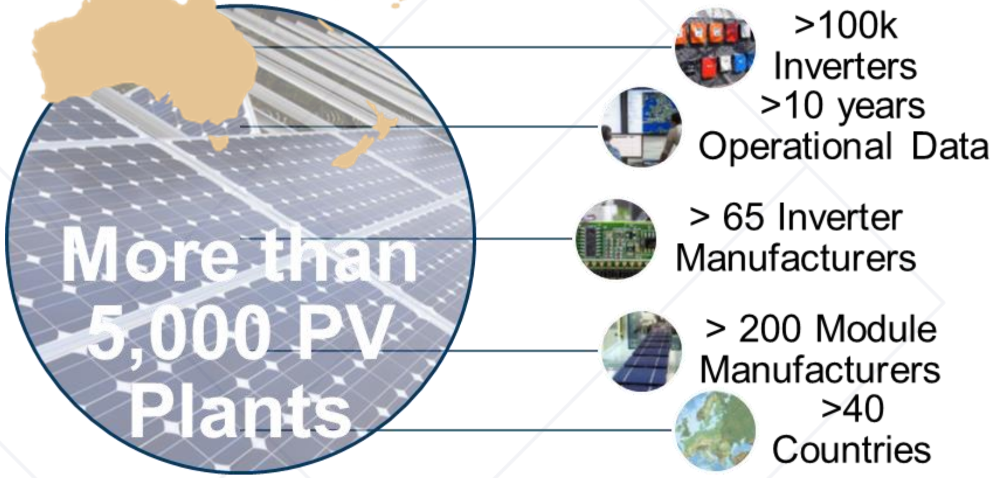
- More than 7 GW of connected assets
- Metadata
- Monitoring data
- O&M data

TRUSTPV
SOLAR PV, PERFORM

CONTEXT SENSITIVE BENCHMARKING

World map with average plant DC capacity per world region

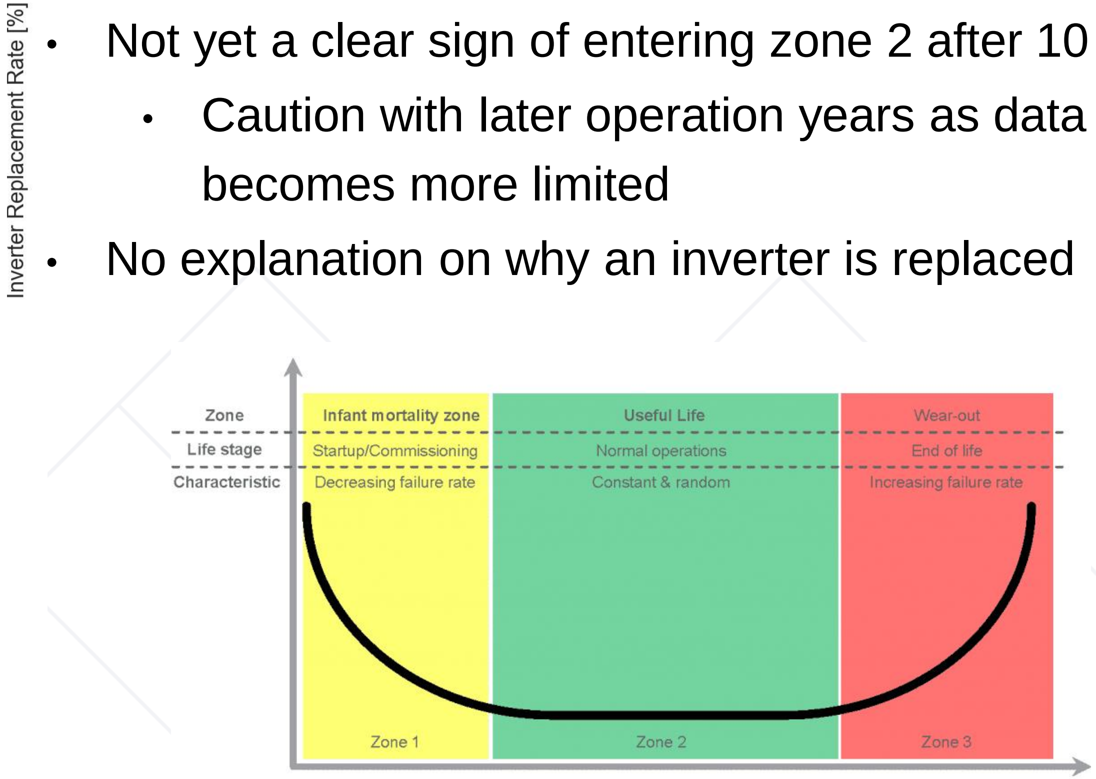




TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

CONTEXT SENSITIVE BENCHMARKING:
Inverter replacement rate

- Bathtub curve based on actual measured big data
  - One of the first of its kind for inverters
- Not yet a clear sign of entering zone 2 after 10 years
  - Caution with later operation years as data size becomes more limited
- No explanation on why an inverter is replaced



TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

LAYER 2 | SYSTEM

RESULT | 4

More accurate energy yield prediction for PV systems with novel technologies and system layout.

Read more »

RESULT | 5

Progressive Repowering.

Read more »

RESULT | 6

Augmented Reality for improved skills of O&M operators and disruptive concepts for PV systems engineering.

Read more »

RESULT | 7

Wireless Sensor Networks using Narrowband Internet of Things (IoT) and 5G technology for on-site sensors such as energy meters for combined AI – physics based diagnostic

Read more »

RESULT | 8

Automated fault diagnostic based on combined image analysis (PL/IR/EL/UV) and electrical signatures

Read more »

RESULT | 9

Large database for failure rates calculation, mitigation measures and failure rate reduction functional to a fully integrated CPN methodology including grid and novel PV plant design

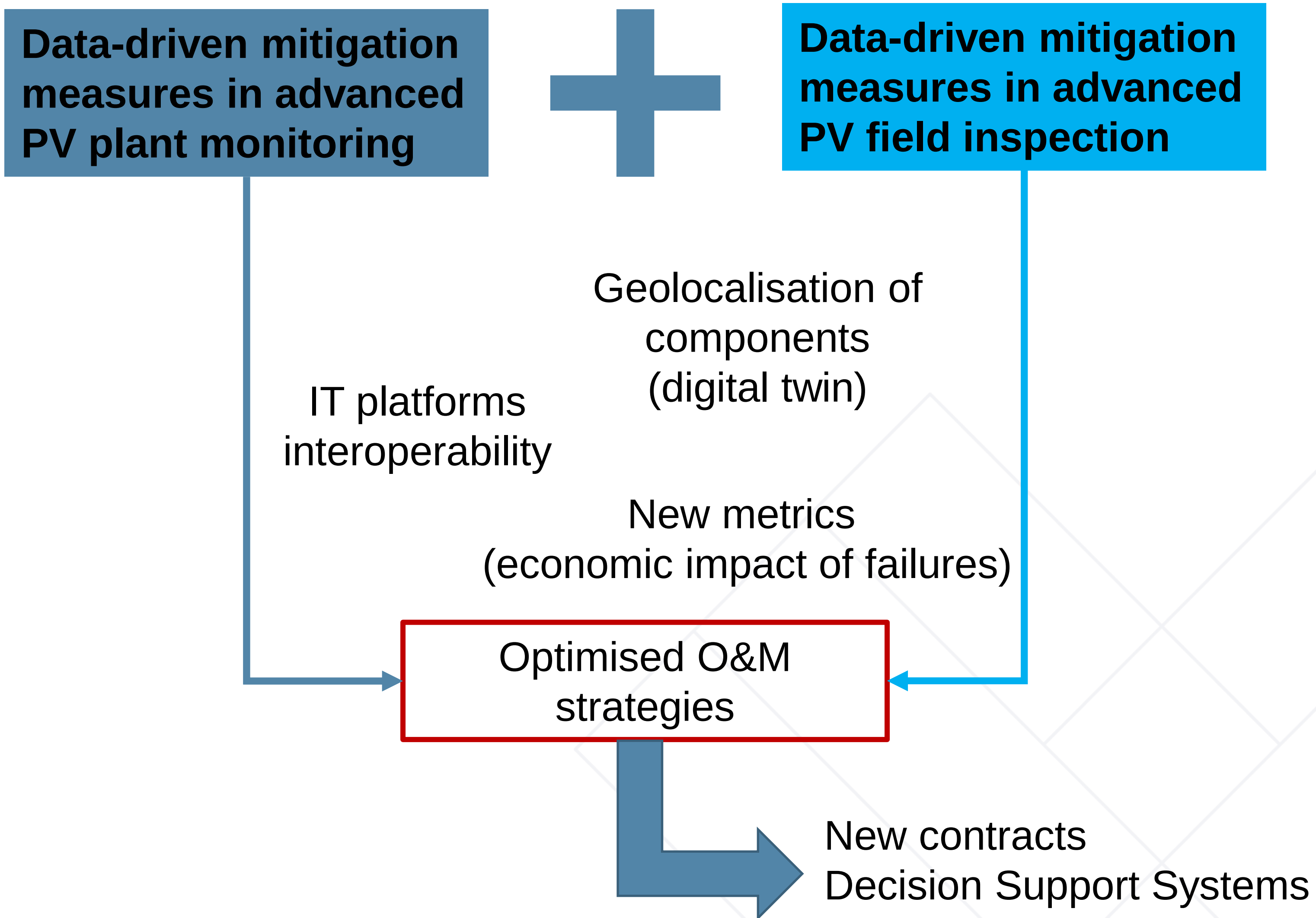
Read more »

RESULT | 10

Decision support platform from fab to field

Read more »

DATA DRIVEN QUALITY MANAGEMENT



RISK MATRIX: TAXONOMY (OR ONTOLOGY)

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)

Risk Matrix Update

COMPONENT
SCROLL CHOICES BELOW
(VIEWER WILL SELECT ONE FROM BELOW & 'CLICK')

MODULE

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

FAILURE ID
SCROLL CHOICES BELOW
(VIEWER WILL SELECT ONE FROM BELOW & 'CLICK')

MOD.14

Mod.1
Mod.2
Mod.3
Mod.4
Mod.5
Mod.6
Mod.7
Mod.8
Mod.9
Mod.10
Mod.11
Mod.12
Mod.13
Mod.14
Mod.15
Mod.16
Mod.17
Mod.18
Mod.19
Mod.20
Mod.21
Mod.22
etc.....

RESULT: SUB COMPONENT/FAILURE/DESCRIPTION
RESULT WINDOW BELOW
(ONLY ONE RESULT WILL BE SHOWN AS THERE IS ONLY ONE RESULT PER FAILURE ID)

SUB COMPONENT: CELL
FAILURE: Breakage
DESCRIPTION: Cell cracks of type B and C, power is not necessarily down to zero

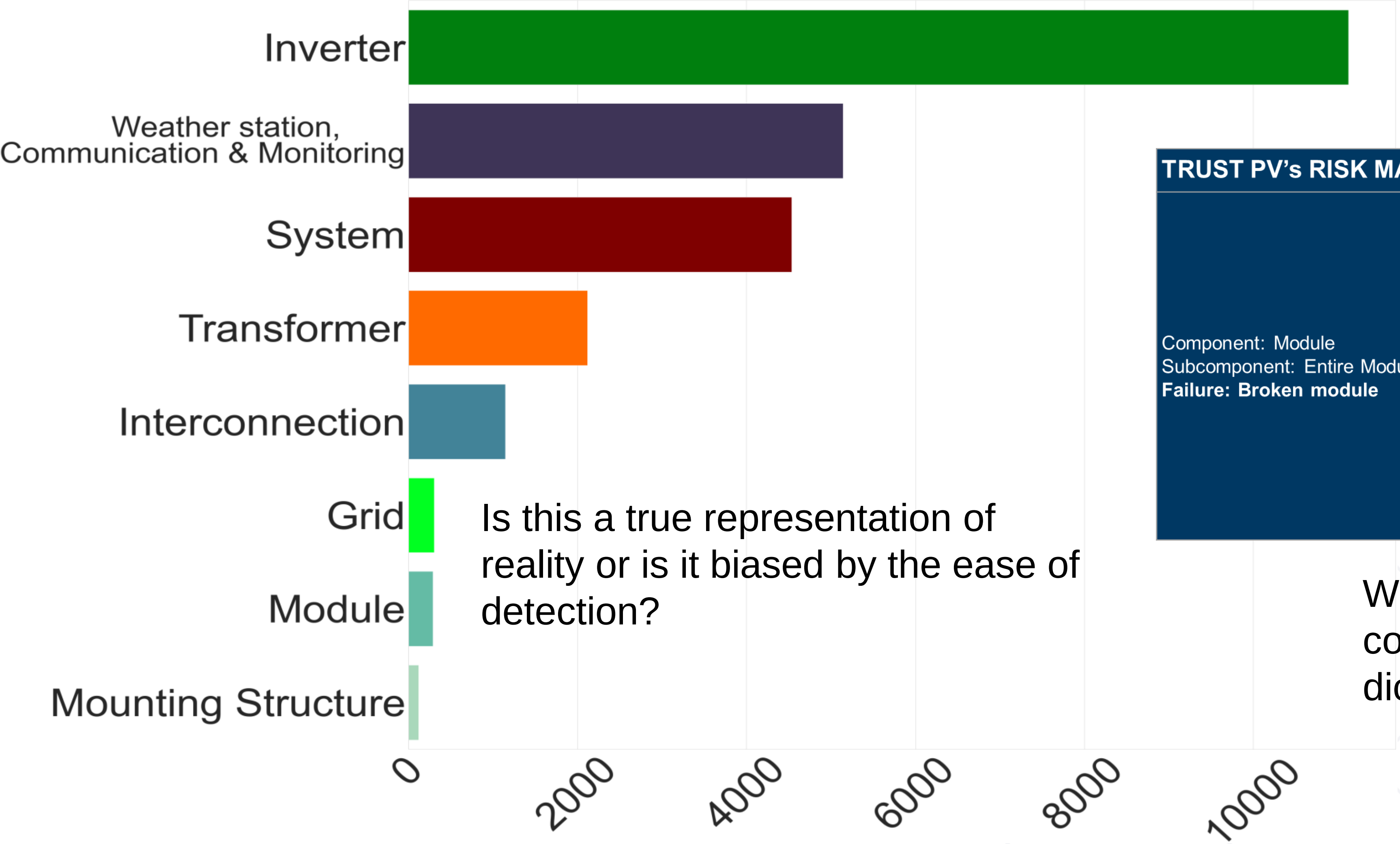
Ticket Alignment

>30,000 tickets of >100 PV plants aligned

INNOSEA An LOC Company · Statkraft · enel Green Power · BayWa r.e.

Available soon at www.trust-pv.eu

RISK MATRIX



Is this a true representation of reality or is it biased by the ease of detection?

TRUST PV's RISK MATRIX	O&M TICKETS
Component: Module Subcomponent: Entire Module **Failure: Broken module**	Damaged PV Module Found broken panel Faulty panel Isolated broken panels 2 broken panels found at string X PV panel outage String isolated due to broken panel Damaged panel Damaged module Broken module Faulty module Module broken Smashed module

What is the level of detail at component level? Need of common dictionary

LAYER 3 | POINT OF CONNECTION

RESULT | 11

Fully flexible and interoperable PV plants solutions

Read more »

RESULT | 12

Use of forecasting for advanced diagnostic and grid dispatch

Read more »

RESULT | 13

Enhanced Digital Twin concept

Read more »

VALUE CHAIN APPROACH: management, sharing and federation of PV asset information throughout the lifecycle

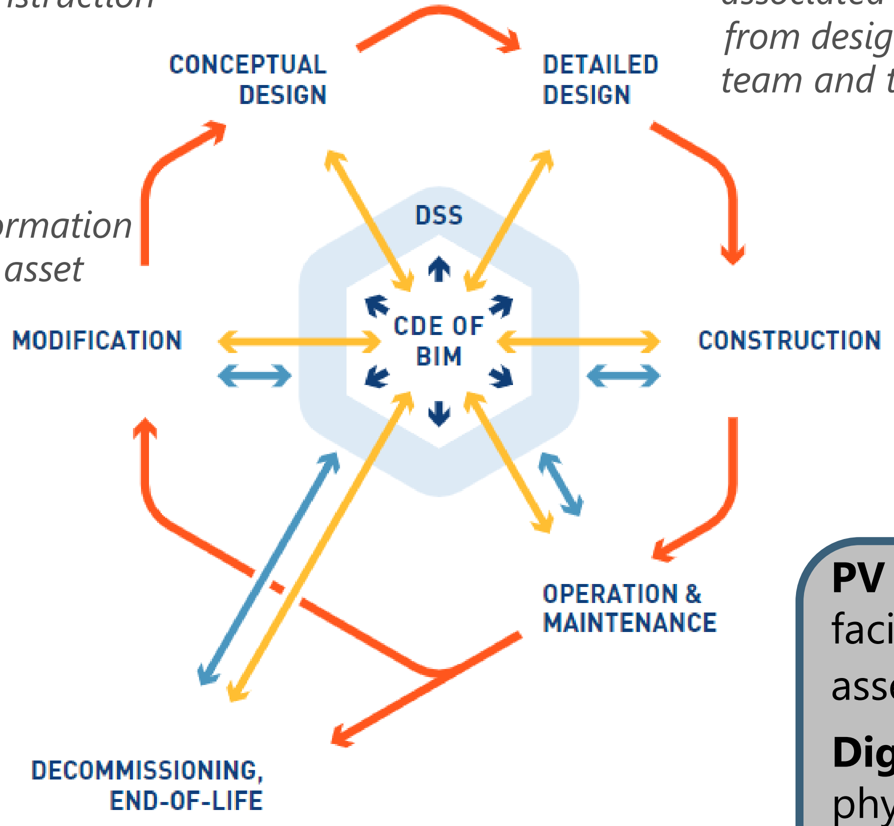
Report available

Virtual construction of a facility prior to its actual physical construction

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

- 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**)



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

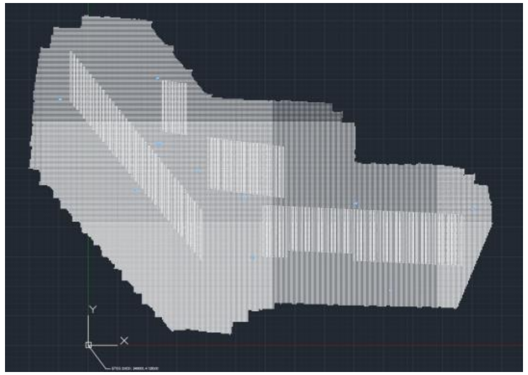
TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

SOLAR PV, PERFORMANCE & RELIABILITY

AUTOMATED DIGITAL TWIN CREATION

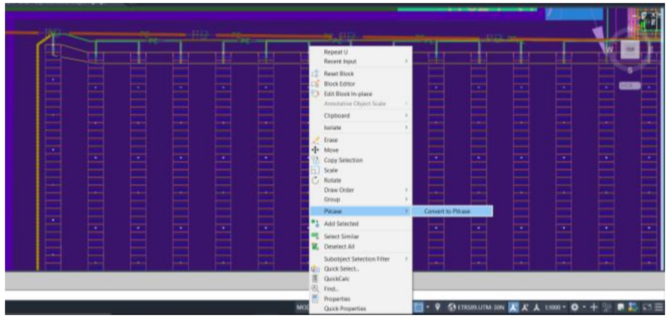
Drone survey → AutoCAD 3D

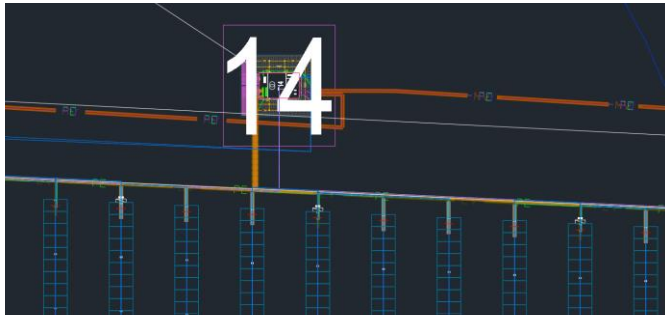
above



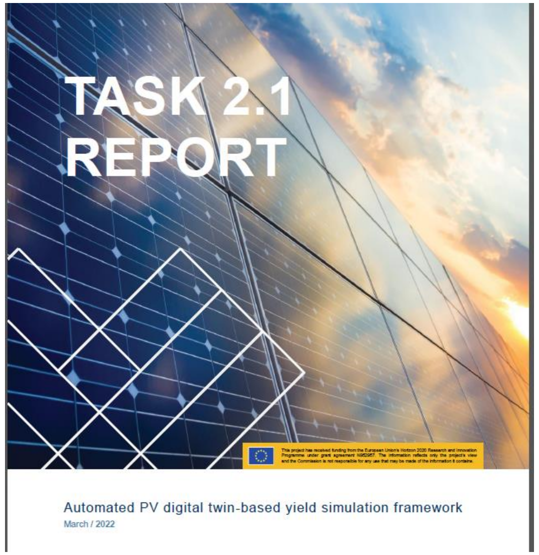
PV design software: electrical devices + connections

PVcase





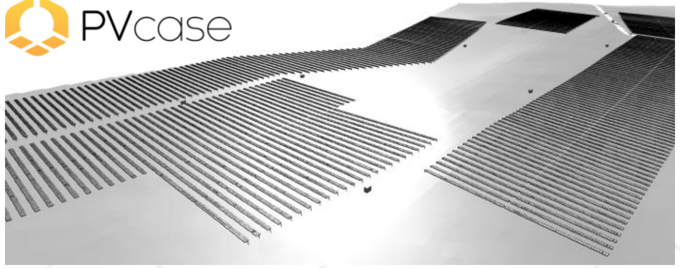
Functional Digital twin vs as-built



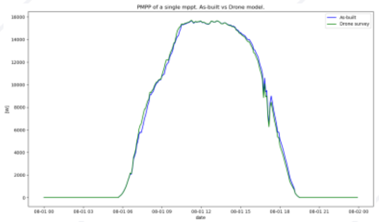
Available soon

Functional digital twin

PVcase



imec



TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

CONCLUSIONS

TRUST-PV is developing:

- Approaches to ensure and measure quality of components, systems and projects
- New metrics to quantify the impact of decisions taken over the lifetime of a PV project
- Methodologies to break silos between stakeholders by evaluating the impact of decision taken during a phase on the next phases and developing O&M friendly components
- Interoperable digital solution to carry information along the value chain (eliminate work repetition)
- Standardisation of data format and collected data (metadata / PV plant passport, product data, monitoring data, ticketing, common dictionaries, etc)

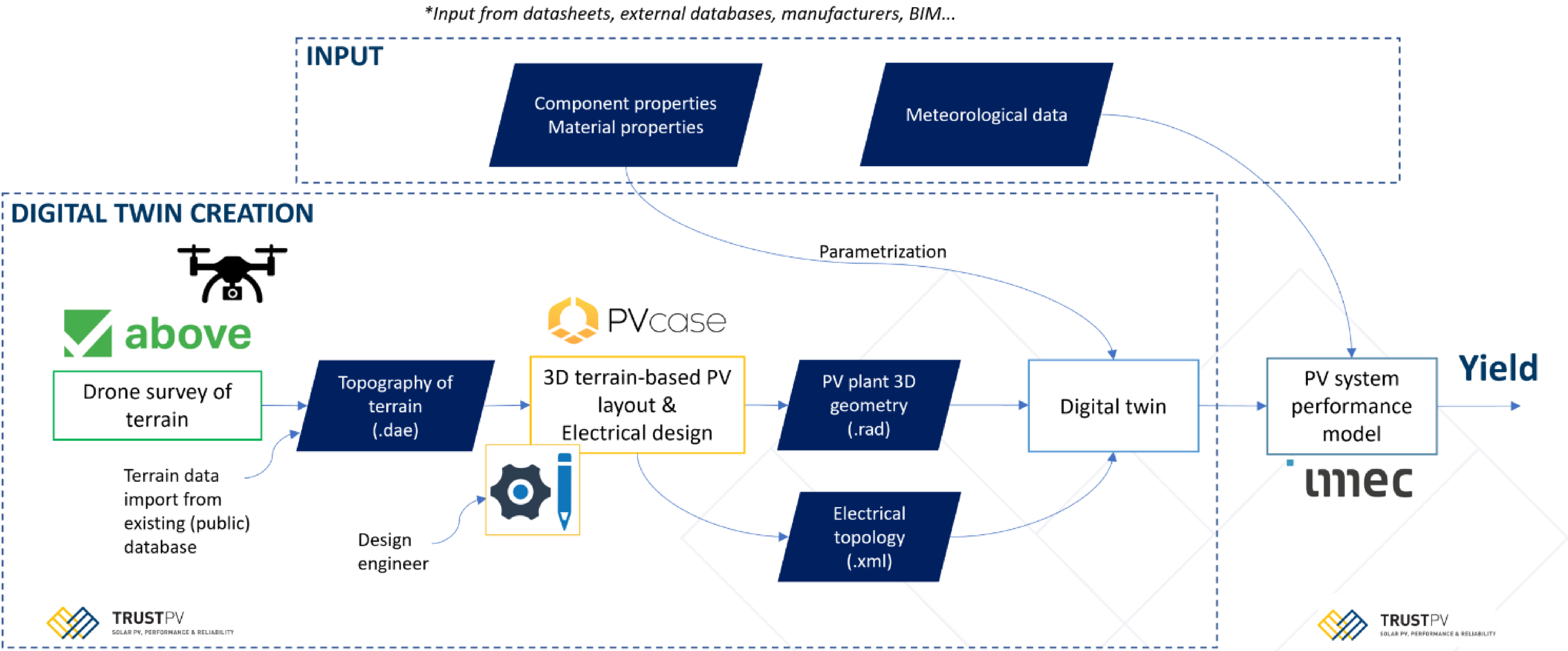
Solar bankability must be based on hard facts / data and is an approach that heavily relies on data / quantification of quality

THANK YOU!

PROJECT PARTNERS

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement N952957.
The information reflects only the project's view and the Commission is not responsible for any use that may be made of the information it contains.

DIGITAL TWIN CREATION WORKFLOW: NEW PV PLANT



DIGITAL TWIN CREATION WORKFLOW: EXISTING PV PLANT