IEA PVPS Task 13
Activity 2.4: Digitalisation in the PV sector

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Intersolar EU 2024, 18 June 2024

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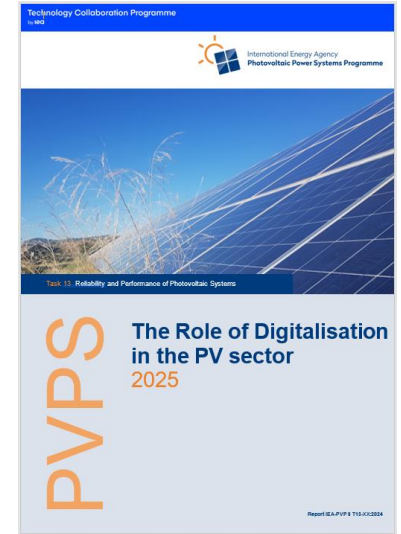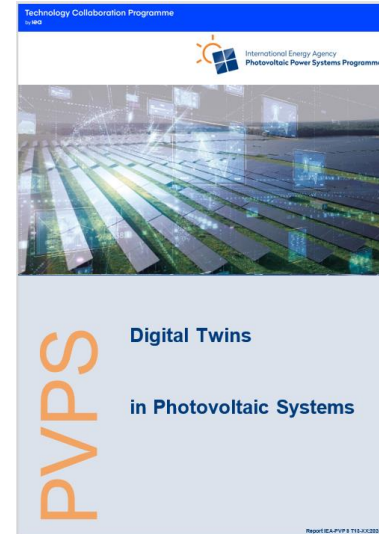# Activity 2.4: Digital Integration and Digital Twinning

Activity Focus:

- Digital twinning of PV systems, definitions, ontologies, and data models

- Digitalisation in PV systems from design phase through operation until end of lifetime

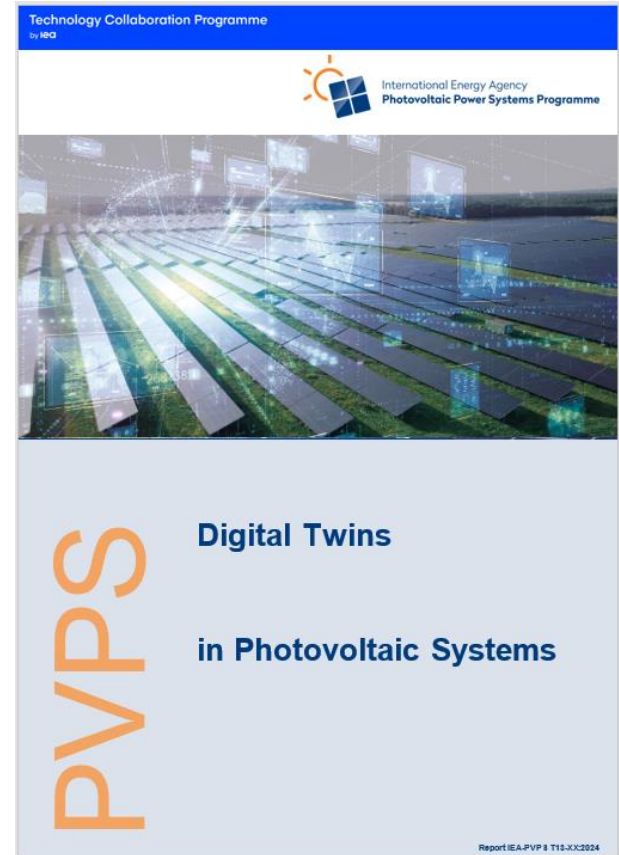- Integration of data along the PV system value chain

Reports:

- Digital Twins in Photovoltaic Systems

- The Role of Digitalisation in the PV Sector

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International Energy Agency
Photovoltaic Power Systems Programme

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Digital Twins

in Photovoltaic Systems

Report IEA-PVP S T10-XX:2024

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Task 13: Reliability and Performance of Photovoltaic Systems

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The Role of Digitalisation in the PV sector
2025

Report IEA-PVP S T10-XX:2024
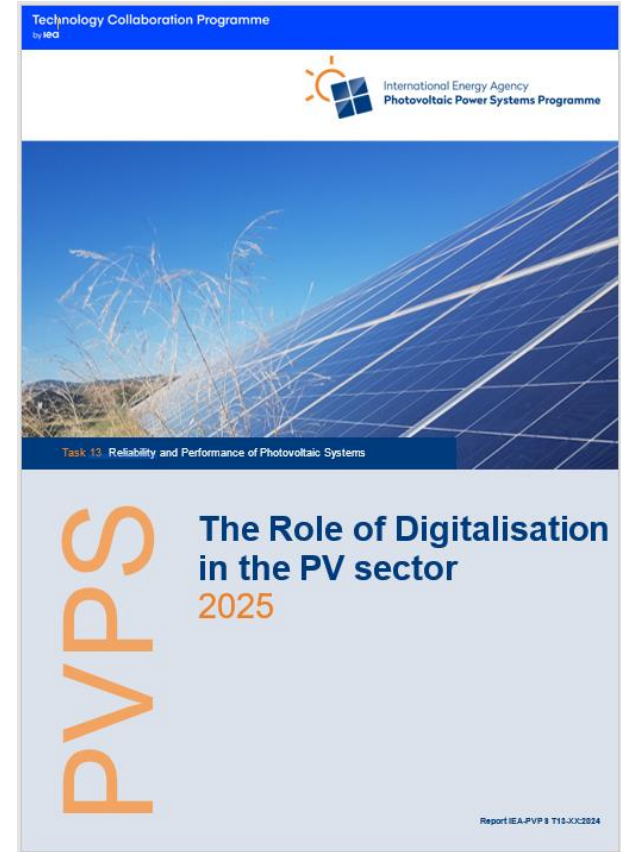
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"Digital Twins in Photovoltaic Systems"

- Aimed towards researchers in the PV sector

- Attempts to find a consensus for the definition of "digital twin" in PV

- Discusses the concepts of data flows, open and FAIR data, ontologies

- Pros, cons, strengths and weaknesses of different forms of digital twins

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International Energy Agency
Photovoltaic Power Systems Programme

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Digital Twins

in Photovoltaic Systems
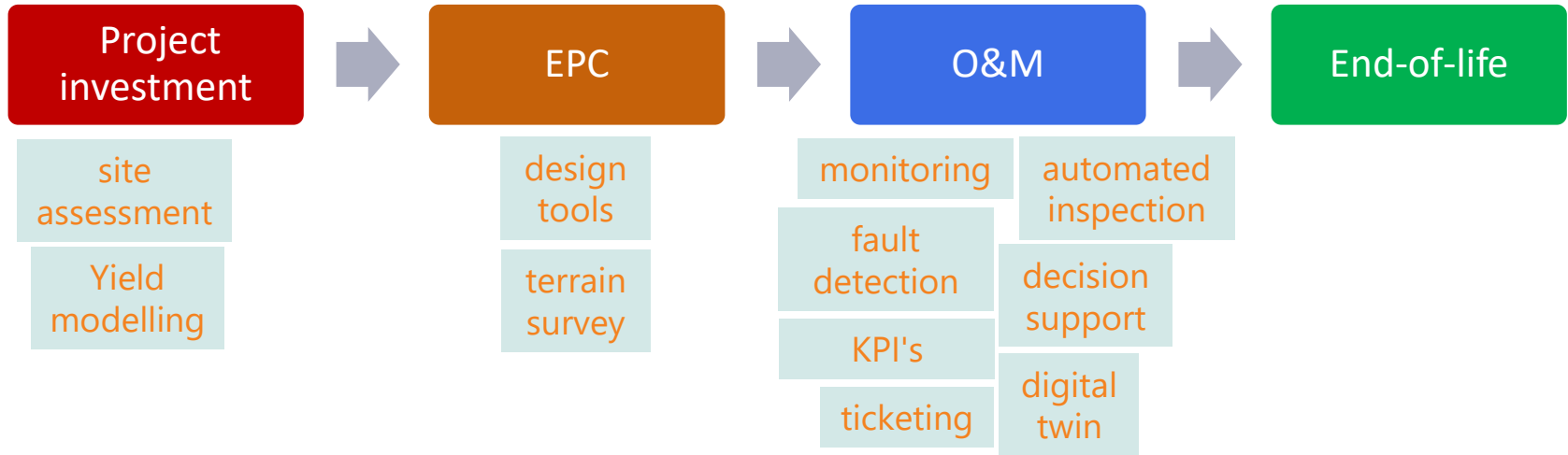
Report IEA-PVP S T13-XX:2024

"The Role of Digitalization in the PV Sector"

- Aimed towards stakeholders from PV industry (e.g., EPC, O&M, asset owners/managers)

- Discusses the role of digitalisation in PV

- Considers the full value chain from design and O&M to end-of-life

- Highlights the need for integration of data along the value chain: breaking silos

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Important but specific focused developments

Project investment	→	EPC	→	O&M	→	End-of-life

Project investment
- site assessment
- Yield modelling

EPC
- design tools
- terrain survey

O&M
- monitoring
- automated inspection
- fault detection
- decision support
- KPI's
- digital twin
- ticketing

- Advanced tools under development that leverage the power of digitalisation and AI/ML
- Most efforts focused on the O&M phase
- Advanced tools in Design/EPC and auxiliary services (irradiance/weather data)
- BUT: developments happen in silos
  (different responsible entities): data silos remain issue

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TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

To enable digitalization, common dictionary is needed

TRUSTPV
SOLAR PV, PERFORMANCE & RELIABILITY

TRUST-PV Risk Matrix:

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

Same failure appears in many different ways!

INTERACTIVE

1. choose your COMPONENT

COMPONENT

2. choose your SUBCOMPONENT

SUBCOMPONENT

3. choose your FAILURE/EVENT

FAILURE/EVENT

https://trust-pv.eu/reports/risk-matrix/

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

Lindig et al, PIP,
https://doi.org/10.1002/pip.3637

eurac research · Statkraft · BayWa r.e. · TÜVRheinland

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Data integration & common nomenclature enable efficiency and new tools
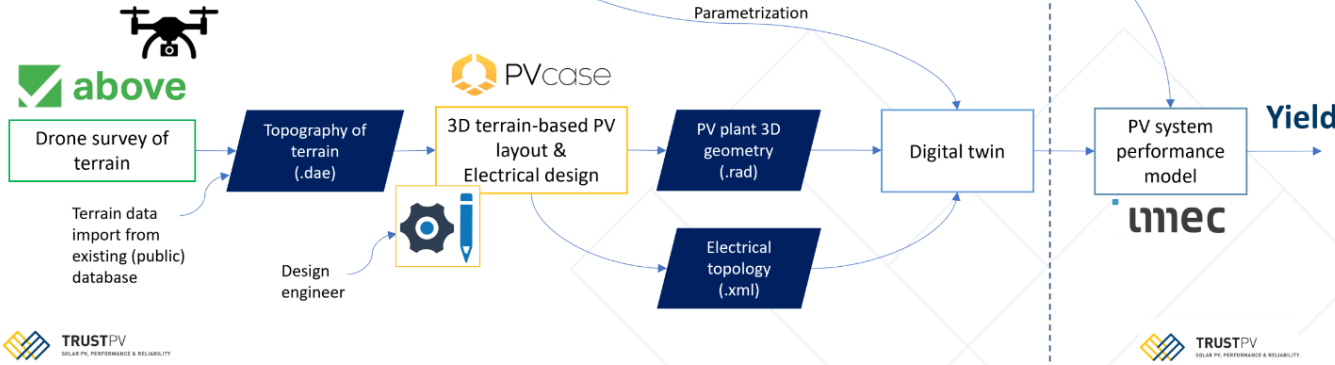

Project investment → EPC → O&M → End-of-life

data handover across phases!
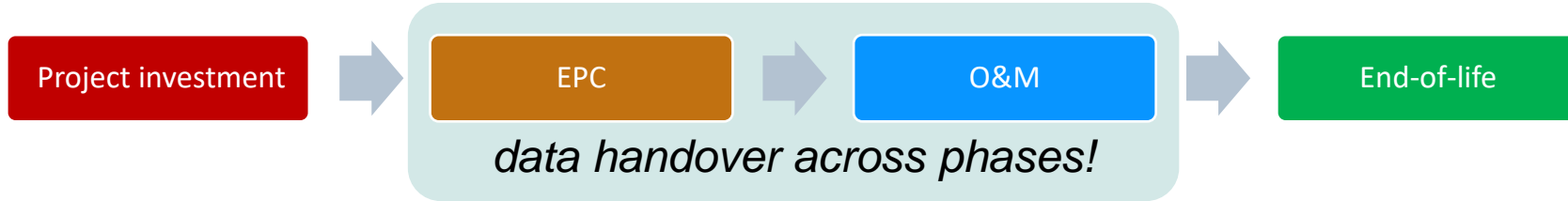
DIGITAL TWIN CREATION WORKFLOW: NEW PV PLANT

*Input from datasheets, external databases, manufacturers, BIM...

INPUT

Component properties
Material properties

Meteorological data

DIGITAL TWIN CREATION

above

Drone survey of terrain

Terrain data import from existing (public) database

Design engineer

Topography of terrain (.dae)

PVcase

3D terrain-based PV layout & Electrical design

Parametrization

PV plant 3D geometry (.rad)

Electrical topology (.xml)

Digital twin

PV system performance model

imec

Yield

TASK 2.1 REPORT

Automated PV digital twin-based yield simulation framework
March / 2022 (Updated in March 2023)

www.trust-pv.eu

How does digitalization realize its full potential?

For digitalization to realize the full potential there remain several hurdles:

- Data and tools should be **integrated** across phases of the PV value chain

- The **digital twin** concept ideally spans the full value chain

- All data flows should be **machine readable** and **human readable**

- This requires **common nomenclature** (ontology/dictionary) to be adopted: **Data models**

- **From early design to O&M and beyond!**

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Why do we need data models?

"A digital twin is a virtual representation of

   - a PV system or systems,

   - **at the appropriate level of detail,**

   - that can span its lifecycle,

   - is updated from real data,

   - and uses simulation, machine learning or reasoning

to help decision making."

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Importance of Information models for DT

- Digital twinning involves creating a virtual representation or replica of a physical object – a PV system

- A standardized (PV-) Information Model represents the data and structure of the object or system being twinned. Consists of Entities, attributes, and relationships that define the digital twin and how it is organized.

- PV Information Model enables data management, analysis, interoperability and simulation in the context of digital twinning applications

- Ontologies are also being used in digital twinning, going a step further (machine reasoning)

- Semantics turn data into information

- FAIRification of data

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Vision: (PV-) Federation of Trust

Interoperability	Trust	Data Value
• Data Models & Formats • Data Exchange APIs • Provenance and traceability	• Identity Management • Access & usage control/policies • Trusted Exchange	• Metadata&Discovery protocol • Data usage Accounting • Publication and Marketplace services

Vision: (PV-) Federation of Trust

- Federation of Trust with authentication (e.g. Eduroam, internet2 and GEANT)

- DTs use "Simulation as a service", e.g. also from agricultural- and other domains (APV, PV+Storage etc.)!

- PV "data as a service"

- Standardized access to information from adjacent domains (geospatial, weather, buildings, forecast etc.) via APIs

- Federated learning within data spaces

- GDPR compliant

- An "End to data silos"

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Digitalizing the Energy System

"

A European framework for sharing data to support innovative energy services

Opportunity / issue: The key enabler for a digitalised energy system is the availability of, access to, and sharing of energy-related data.

Aim: To facilitate the development of innovative energy solutions and novel and inclusive services that will support grid developments, engage consumers/prosumers and lower bills, and further the integration of the energy market.

Means: Develop a European framework for sharing energy data. Establish a **common European data space for energy**.

Approach: Harmonizing the European Data Markets in line with sector-specific legislation.

European Commission

Rolf Riemenschneider, Head of Sector IoT, European Commission, 2023

"

OEDI
Open Energy Data Initiative
U.S. DEPARTMENT OF ENERGY

search energy data   Search

https://data.openei.org/

gaia-x

The energy data space

The path to a European approach for energy

Digitalisation workstream

The aim of the Digitalisation Workstream is to ensure that the solar sector in Europe takes the opportunities arising from the digitalisation of the energy system. This means promoting data-driven solutions to integrate solar, storage, and other DER devices into the electricity system and unlocking their flexibility potential. At the same time, it means ensuring high levels of cyber security in the face of increasing reliance on data.

SolarPower Europe members in the workstream contribute to solar deployment by supporting the design, development, construction and maintenance of solar power plants.

SolarPower Europe

ETIP Photovoltaics

Roadmap 7

Digitalisation of PV systems

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Source middle right: https://gaia-x.eu/wp-content/uploads/files/2021-06/Gaia-X_Data-Space-Energy_Position-Paper.pdf

Thank you!

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