PVgnosis: Diagnosis, maintenance and operation of PV plants

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Consortium, Funding Agencies and Duration

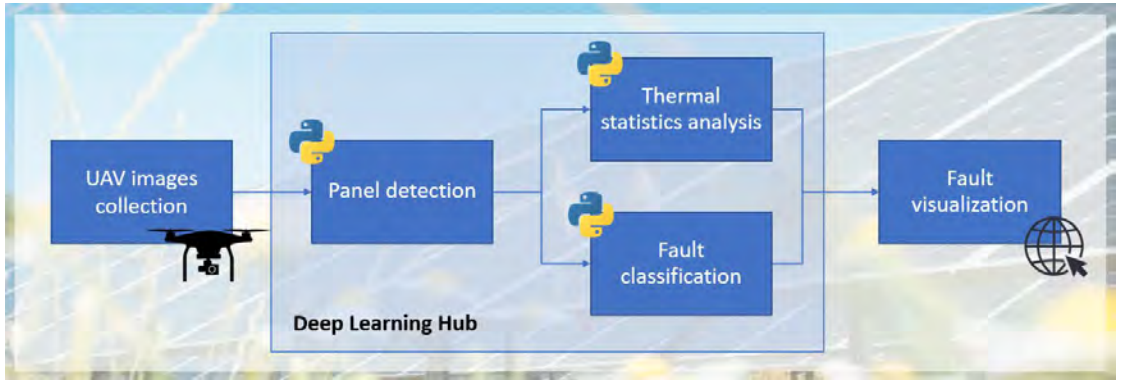
Organisation	Funding Agency	Contract Number	Duration
CERTH	General Secretariat for Research and Innovation (GSRT)	PVgnosis/5075007	3/12/2020 – 31/07/2023
University of Cyprus	Cyprus Research and Innovation Foundation (RIF)	P2P/SOLAR/0818/0007	01/11/2019 – 31/05/2023
ENGAIA	General Secretariat for Research and Innovation (GSRT)	PVgnosis/5075007	3/12/2020 – 31/07/2023
Checkwatt	Swedish Energy Agency	2019-004730	01/01/2020 – 31/12/2022

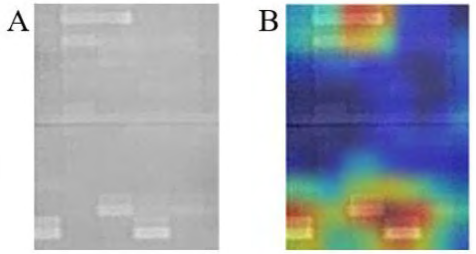
Scientific, technical, commercial challenges addressed

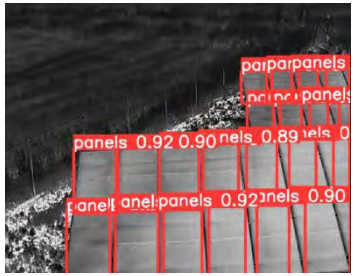
- **Project Objectives**
  - Create an advanced **operation and maintenance framework** for photovoltaic (PV) systems
  - Develop a **software platform** and associated tools for advanced **diagnosis, predictive maintenance and intelligent visual inspection** of PV plants
  - Advance the **PV inverter** with new operational functionalities based on advanced control schemes to support the operation of **smart grids**
  - Design **fault diagnosis schemes** to improve the maintenance and lifetime of **PV inverters**

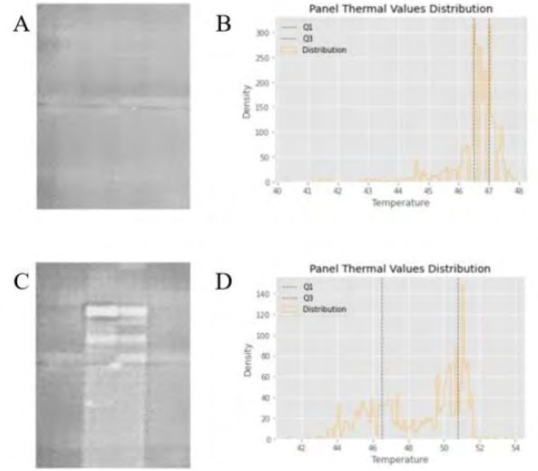
Key outcomes, results and benefits

- **A deep learning framework for improving solar panel defects using drone imagery**
  - A novel approach for identifying and categorizing solar panel problems (hot spots, diode faults, off-line panels) utilizing **UAVs** that can take **RGB** and **thermal** photos. The suggested method is divided into four primary stages: thermal statistics analysis using **machine learning**, panel identification using **CNN** based on YOLOv5 architecture, panel classification using an EfficientNet classifier, and picture preparation using **computer vision** techniques.



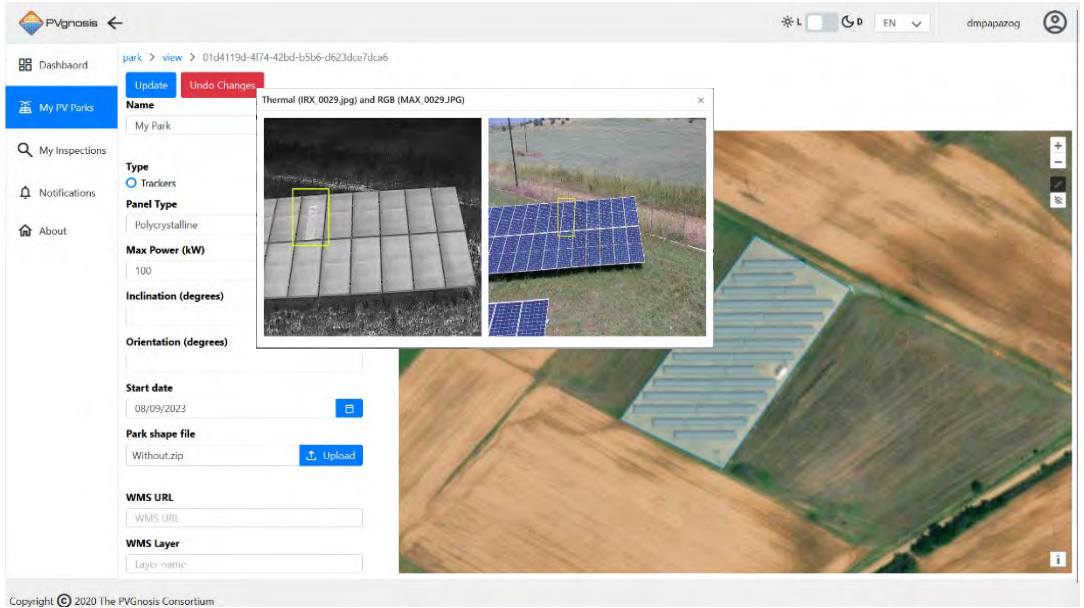


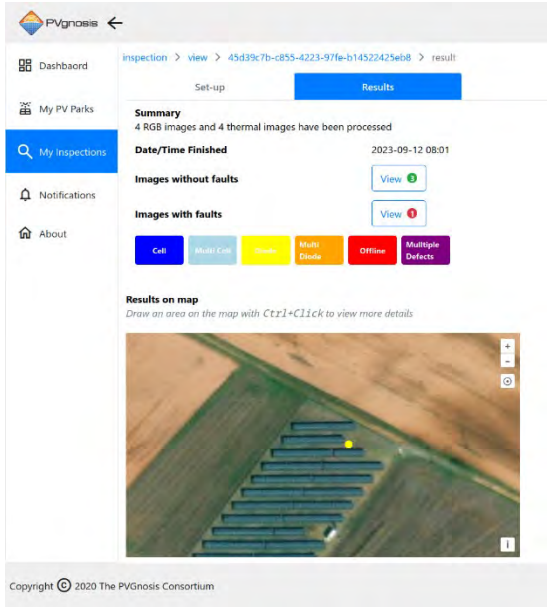


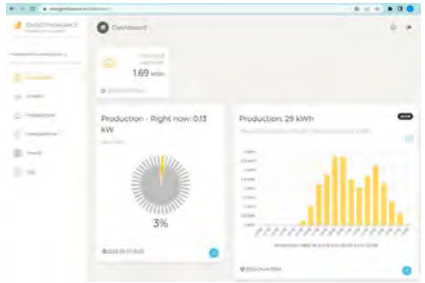


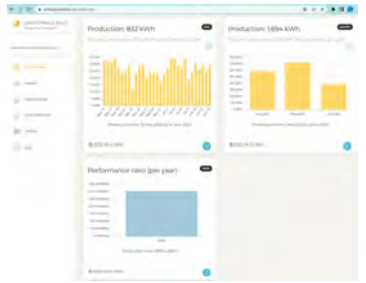
Key outcomes, results and benefits

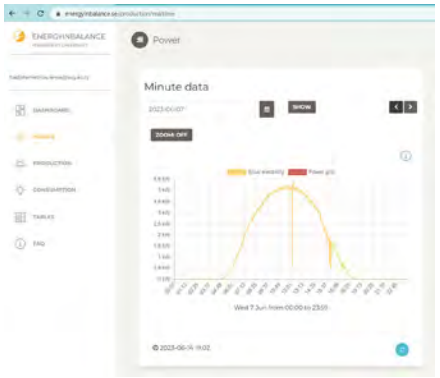
- **A web platform for PV plants maintenance and monitoring**
  - The PVgnosis web application is an advanced interactive admin console for inspecting Photovoltaics panels for a range of possible defects. It integrates IoT measurements (energy production, solar radiation, temperature etc.) as well as the deep learning models to provide a visualization and predictive maintenance framework that supports the operation of the PV parks, reducing costs and maximizing revenues.

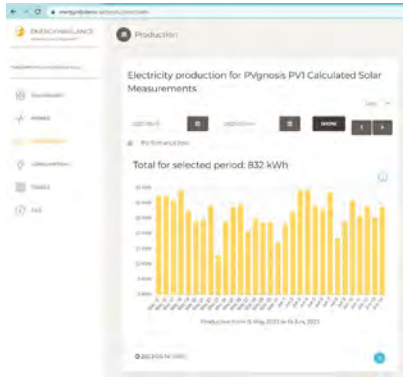










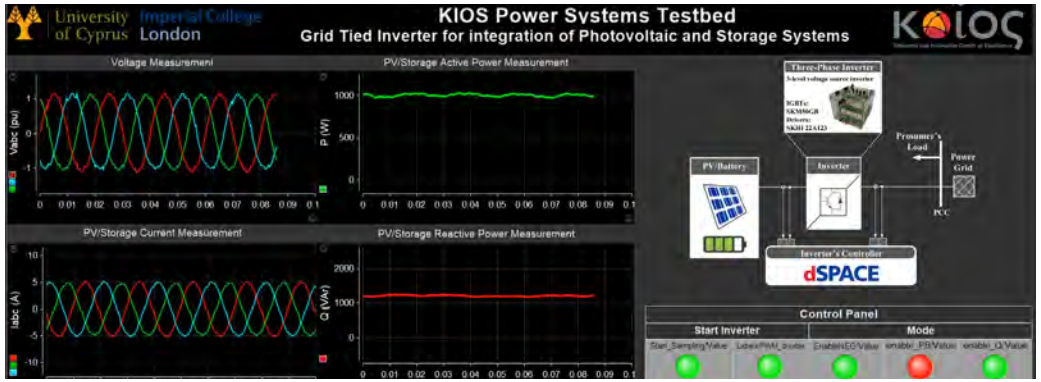


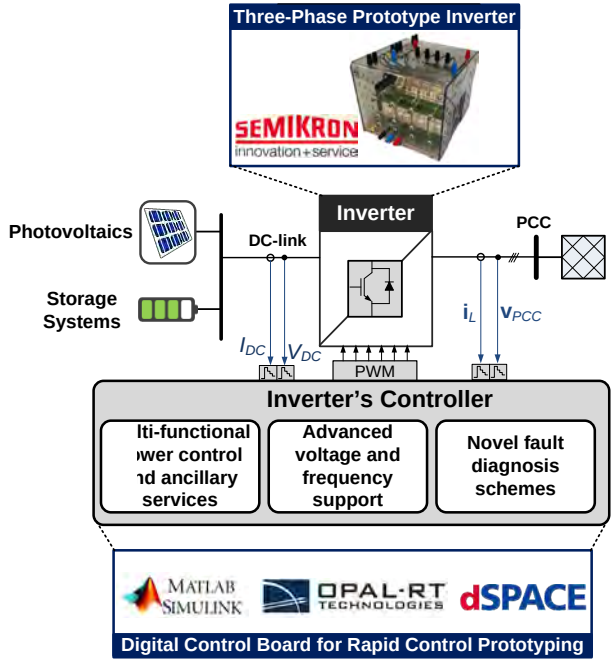
Key outcomes, results and benefits

- **A multi-functional control framework for PV and ESS inverters**
  - PV inverter can operate in a **multi-mode approach** (maximum power, constant power, delta power, reactive support, phase balancing, active filtering, etc.)
  - PV-ESS inverter can provide an **enhanced frequency** and an **optimal voltage** support (tailored for PV-ESS connected at the distribution grid) to **improve the stability of modern power systems**
  - PV inverter can be used for ensuring a unity power factor, phase symmetrized loading conditions, and harmonic distortion elimination to **improve the power quality and PV hosting capacity of distribution grid**
- **An advanced fault diagnosis framework for PV inverters**
  - A novel **fault diagnosis algorithm** can detect and isolate sensors failure (e.g., voltage or current sensors)
  - A **junction temperature control scheme** can prevent overheating of the switching component of the PV inverter during ancillary services provision, for **improving the inverter maintenance** and **extend its lifetime**

Key outcomes, results and benefits

- **A prototype grid-connected PV-ESS inverter has been developed, where the multi-functional control framework and the advanced fault diagnosis scheme has been integrated**





Experiences gained in transnational set-up

- **Global Perspective:** Project partners gain a broader perspective on global markets, regulations, and business practices, which can be valuable for future international endeavors.
- **Legal and Regulatory Awareness:** Understanding and navigating various international laws, regulations, and compliance requirements is a crucial aspect of transnational projects.
- **Adaptability:** Different regions may have unique challenges, opportunities, and unforeseen issues. It is important to understand that and adapt quickly to changing circumstances / environment.
- **Risk Assessment:** Experience in identifying, assessing, and mitigating risks in different international environments is gained through these projects.
- **Market Research:** Conducting comprehensive market research in different regions to make informed business decisions is a crucial part of transnational projects.
- **Stakeholder Engagement:** Building and maintaining relationships with a wide range of stakeholders, including government agencies, R&D institutes, local communities, and NGOs, is a significant aspect of such projects.

Critical factors and lessons learned for future successful transnational R&I projects

- **Positive**
  - Even in a single European market operating under similar conditions and legislation, there are local particularities that should be addressed by those wishing to develop solutions that transcend narrow national boundaries. Partnerships like those of PVgnosis contribute to this goal.
  - **Results should be disseminated to broader audience**. The presentation of the PVgnosis platform in the Agrovoltaics conference is an excellent example of how real users needs can identify the next necessary steps in order to reach the PV market.
  - There are now many possibilities that support true **remote collaboration**. We learned that the hard way because of COVID-19.
- **Negative**
  - There are obstacles in cooperation when different funding Agencies are involved. In the case of PVgnosis, 3 countries and 3 different funding / monitoring Agencies were involved, resulting in a **different project start date and duration** for each participant, which significantly hampered implementation according to the original planning and schedule.
  - There was a need for additional reporting (progress reports) as these had to be submitted both to Solar-Era.NET and to National Authorities.