



# SERENDI-PV: Smooth, Reliable and Dispatchable integration of PV in European Energy grids



SERENDI-PV project has developed innovations to improve lifetime, reliability, performance and profitability of PV generation: (pillar 1)

SERENDI-PV has focused on “new PV technologies” (Bifacial, Floating, BIPV) and on special loss mechanisms (soiling, snow and long-term degradation).

- Accuracy of the **PV energy yield modelling** on these “New PV Technologies” and loss mechanisms has been enhanced in the frame of the project. Uncertainties and their impact on assessed energy yields and financial figures are also better addressed, at both system and portfolio levels.
- SERENDI-PV has improved **fault detection and diagnostic** toolboxes for PV plants, leveraging SCADA, advanced field inspections and data analytics. Also, it has developed novel digital twins for PV inverters and batteries, providing useful information to optimize maintenance activities.
- **In-field quality control and testing hardware** has been developed. Low-uncertainty procedures to measure PV module aging, evaluate string PV inverters and battery performance have been developed for the bifacial and floating PV plants. Dedicated soiling kits and I-V tracers to optimize O&M strategies, have been developed

Besides, SERENDI-PV project has developed innovations to improve the high-penetration of the PV generation in the grids with improved stability: (pillar 2)

- SERENDI-PV has **improved the nowcast and forecast accuracy** (intra-hour, intra-day and day-ahead prediction horizons of Global Horizontal Irradiation and PV power output). It also improved forecasting during extreme weather conditions (soiling, snow and fog) as well as improved forecasting on New PV technologies applicable for a single or a portfolio of PV power plants.
- The project presents innovations to **increase the utilization of PV data and controllability** to provide grid operators with grid information as well as ancillary services.

An academic-industry collaborative platform focused on solar PV (COPLASIMON), serves as a hub for researchers, industry specialists, and stakeholders. It fosters research-driven partnerships to advance solar energy solutions, drive innovation in the field, and showcase the tools developed in the project to facilitate collaboration and research.

In the last year of SERENDI-PV, the maturity (TRL 7-8) of the project’s innovations will be demonstrated: their applicability and performance in operational PV plant environment, at real-life temporal and spatial scale will be validated. In total, fifteen demo sites are involved: from small-scale PV systems to multi-MW PV plants; from component/pilot level, up to district/grid level demos; from standard PV technologies, to emerging ones (bifacial, floating and BIPV).

The Innovations / exploitation results developed for each of the topics above mentioned are the following:

## PILAR I

Improve lifetime, reliability, performance and profitability

### PV energy yield modelling

- ER2\_1:** Algorithms for improved yield modelling of standard and innovative PV systems (bifacial PV, floating PV, BIPV systems), soiling, snow and ageing (degradation)
- ER2\_2:** Load profiles generation for self-consumption evaluation
- ER2\_3:** Modelling of uncertainty and variability and implementation into financial models
- ER2\_4:** Analytically tracking uncertainty propagation in financial models with probability density functions
- ER2\_5:** A novel approach to better model and take into account the long-term evolution of the solar resource in its long-term solar resource assessments

### Fault detection and diagnostic / digital twins

- ER3\_1:** Algorithms for specific data analytics for monitoring and diagnostics of PV systems (Bifacial PV, floating PV, BIPV), soiling, snow and ageing (degradation)
- ER3\_2:** IR imaging-based analytics - ASPIRE
- ER3\_3 – ER3\_5:** Digital twins: Inverte, Battery, BIPV
- ER3\_6:** Estimation of Junction Temperature of semiconductors (TJ) using a detailed Thermal Physical Model
- ER3\_7:** I-V curve based diagnostic tool

### In-field quality control and testing procedures & hardware

- ER4\_1:** On-site testing equipment:
  - Capacitive I-V tracer at 1,500V
  - Soiling measurement kits (2)
  - Operating conditions measuring kits
- ER4\_2:** On-site procedures for:
  - identification of incorrect data from PV power plants
  - calibrating bifacial reference modules
  - measuring the I-V curve of bifacial PV modules
  - field testing of PV inverters
  - field testing of batteries
- ER4\_3:** Lab-testing procedures for:
  - soiling analysis and cleaning assessment
  - predictive degradation/ageing of modules (facility + procedures)
  - Hardware in the Loop (HIL) Platform for testing large inverters

## PILAR II

Improve the high-penetration of the PV generation in the grids with improved stability

### Improved the nowcast and forecast accuracy

- ER5\_1:** Improved forecast accuracy: “intra-day”, “day-ahead”, “intra-hour”
- ER5\_2:** Forecast model accounting for soiling / dust, snow and fog
- ER5\_3:** Forecast model for bifacial and floating PV
- ER5\_4:** Forecast for residential PV - estimation for PV configuration
- ER5\_5:** Forecast uncertainty evaluation for different geographical scales (spatial PV power averaging)
- ER5\_6:** Definition of portfolio forecast (concept of virtual PV power plants)
- ER5\_7:** Forecast PV production and electricity consumption

### Increase the utilization of PV data and controllability

- ER6:** High PV grid penetration and energy management. Digital solutions:
  - Automated data model integration framework for PV integration and communication in DSO data systems
  - Implementation of IEC61850 for data communication on MV/LV grid
  - Digital twin of the grid with high PV contribution
  - Real time commitment dispatch and IT system for down FCR participation of PV plants (without storage)
  - Service system for aggregating anonymous data for the monitoring and management of distributed generation systems
  - Operation of PV ensuring active power reserve available to provide ancillary services - grid connected
  - Real-time Control and Marketing System enabling the participation in ancillary services by a pool of PV plants

### Collaborative database

- ER7:** Collaborative database, modelling & monitoring platform:
  - Collaborative platform for the management of technical specifications of PV components
  - Public database of solar resource and weather data

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