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D8.7 Report on monitoring implementation and data collection process in medium-commercial and residential. Lesson learnt and related guidelines

T8.2 Demonstration of diagnostics of medium-scale commercial and residential PV plants

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Summary

The present deliverable details the monitoring implementation and data collection from small and mid-size PV systems. The deliverable explains what data is being monitored, how it is used, how it is being monitored, stored, shared, any data quality procedures, and any lessons learnt during the implementation of the monitoring guidelines set out in deliverable 8.6.

Monitoring information has been collected in operational conditions from heterogeneous portfolios of small and mid-size PV plants for the assessment of developed innovations in WP2, WP3 and WP4 for a better modelling, diagnostics and field testing.

Five main portfolios will be used (portfolios 1 to 3 correspond to large PV plants, which are the object of another task and deliverable):

- PORTFOLIO 4: provided by MLS on residential PV systems, including PV output measurements and self-consumption / self-sufficiency.
- PORTFOLIO 5: provided by CEG on demo sites 1 and 2.
- PORTFOLIO 6: provided by CNR on mid-size PV systems.
- PORTFOLIO 7: provided by CYT on 80 PV systems installed on buildings.
- PORTFOLIO 8: provided by CYT on BIPV and bifacial PV plant.

This deliverable D8.7 is an output of task T8.2.2.

Document Information

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1.1 Description of the deliverable content and purpose

This document contains monitoring information in operational conditions from heterogeneous portfolios of small and mid-scale PV/BIPV plants for the assessment of developed innovations in WP2, WP3 and WP4 for a better modelling, diagnostics, and field testing.

Five main portfolios will be used for the validation of the developments (innovations) done:

- PORTFOLIO 4: provided by MLS for the assessment of diagnostics of a portfolio of medium-scale commercial and residential PV systems based on energy meter measurements. Monitoring data from over 10,000 PV installations across Central Europe, Portugal and UK.
- PORTFOLIO 5: Demo sites 1 and 2, provided by CEG for the assessment of predictive maintenance of batteries based on digital twin approach: (1) Demo site 1 -– iSARE will be held at iSare, a 400kW microgrid designed to test new energy solutions, where CEG will install a Li-ion battery (around 100kWh); and (2) Demo site 2 – CEGASA a Li-ion battery, around 30kWh. In both cases, batteries will be equipped with required condition monitoring to validate the digital twin approach.
- PORTFOLIO 6: provided by CNR on mid-size PV systems.
- PORTFOLIO 7: provided by CYT on 80 PV systems installed on buildings for the assessment of modelling of small PV systems, soiling and snow.
- PORTFOLIO 8: provided by CYT on BIPV and bifacial PV plant for the assessment of modelling of bifacial BIPV and demonstration of the BIPV digital twin.

Each of these five portfolios has their own section on where the data being monitored, how, why, any quality checks and the data uses are all discussed.

1.2 Reference material

This deliverable follows on from Deliverable *D8.6: Monitoring guidelines and specific monitoring and validation plan for demonstration of modelling, diagnostics and field testing of medium-commercial and residential PV plants*. It shows the result of the monitoring implementation.

The deliverable makes multiple references to other tasks of which the data portfolios will be used in the demonstration of. More information on these tasks can be found in the Project Management Plan:

- WP10/D10.4 Project Management Plan - second draft

1.3 Relation with other activities in the project

Table 1.1 depicts the main links of this deliverable to other activities (work packages, tasks, deliverables, etc.) within SERENDI-PV project. The table should be considered along with the current document for further understanding of the deliverable contents and purpose.

Table 1.1: Relation between current deliverable and other activities in the project

Project activity	Relation with current deliverable
T1.1	T1.1 describes all the data provided by the partners and the project KPIs that will be used for measuring the impact of the project innovations.
T2.2	The specific measurement and validation plan for the assessment of the modelling of energy losses due to soling, snow and degradation processes to be developed in T2.2 is described in section 2.1.2 of D8.6.
T2.3	The specific measurement and validation plan for the assessment of the modelling of new BIPV technologies, to be developed in T2.3 is described in section 2.1.1 of D8.6
T2.6	The specific measurement and validation plan for the assessment of commercial modelling solutions to be developed in T2.6 is described from sections 2.1.3 to 2.1.6 of D8.6
T3.2	The specific measurement and validation plan for the assessment of the specific data analytics for new BIPV technologies to be developed in T3.2 is described in section 2.2.1 of D8.6.
T3.4	The specific measurement and validation plan for the assessment of the fault diagnosis toolbox for improved O&M in medium size commercial, residential PV plants and aggregations to be developed in T3.4 is described in section 2.2.5 of D8.6
T3.6	The specific measurement and validation plan for the assessment of the battery digital twin to be developed in T3.6 is described in section 2.2.4 of D8.6
T3.7	The specific measurement and validation plan for the assessment of integration of new data analytics in the commercial solutions to be carried out in T3.7 is described from sections 2.2.6 to 2.2.9 of D8.6
T4.5	The specific measurement and validation plan for the assessment of the field and lab testing for batteries to be defined in T4.5 is described in section 2.3.1 of D8.6
T7.4	Collaborative platform for design, simulation and monitoring data analytics. The results from this deliverable will be used to facilitate the collaboration with external stakeholders.
T8.2	The section 3 of D8.6 describes the detailed technical design of monitoring activities to be developed in T8.2.

1.4 Abbreviation list

Table 1.2: Abbreviation list

Abbreviation	Meaning
API	Application Programming Interface
BIPV	Building-integrated photovoltaics
BMS	Battery Management System
EMS	Energy management System
GHI	Global Horizontal Irradiation/Irradiance

GTI	Global Tilted Irradiation/Irradiance
IPP	Independent Power Producer
QCP	Quality Control Procedure
QoS	Quality of Service
SoC	State of Charge
SoH	State of Health

2 INTRODUCTION

2.1 Portfolios

This deliverable will discuss the monitoring implementation and data collection for the five following portfolios for small and mid-size PV plants for the assessment of developed innovations in WP2, WP3 and WP4 for a better modelling, diagnostics and field testing:

- PORTFOLIO 4: provided by MLS for the assessment of diagnostics of a portfolio of medium-scale commercial and residential PV systems based on energy meter measurements. Monitoring data from over 10,000 PV installations across Central Europe, Portugal and UK.
- PORTFOLIO 5: Demo sites 1 and 2, provided by CEG for the assessment of predictive maintenance of batteries based on digital twin approach: (1) Demo site 1 -– iSARE will be held at iSare, a 400kW microgrid designed to test new energy solutions, where CEG will install a Li-ion battery (around 100kWh); and (2) Demo site 2 – CEGASA a Li-ion battery, around 30kWh. In both cases, batteries will be equipped with required condition monitoring to validate the digital twin approach.
- PORTFOLIO 6: provided by CNR on mid-size PV systems.
- PORTFOLIO 7: provided by CYT on 80 PV systems installed on buildings for the assessment of modelling of small PV systems, soiling and snow.
- PORTFOLIO 8: provided by CYT on BIPV and bifacial PV plant for the assessment of modelling of bifacial BIPV and demonstration of the BIPV digital twin.

Each section will detail the data available, where, and how it can be accessed, and for which demonstrations the data will be used.

2.2 Innovations in Work Packages 2-4

ANNEX I: SUMMARY TOOLS - INNOVATIONS - PORTFOLIOS IN MEDIUM AND RESIDENTIAL PV PLANTS, extracted from D8.6, summarizes the innovations to be developed in WP2, WP3 and WP4, the developers of each innovation and the selected Portfolios where they will be demonstrated.

2.2.1 Work Package 2 - Advanced modelling for small and mid-scale PV systems

Forecasting for residential PV and BIPV systems has different challenges compared to larger systems. Smaller PV systems are often shaded by surrounding objects, however details on these shading objects are not available. Furthermore, even basic information about these systems (such as tilt and azimuth) is often missing. The aggregated PV power output of many small systems in the distribution grid is estimated with different methods by grid operator. Therefore, we will apply the models that learn shading/azimuth configuration from the large data pool of PV power production of residential PV systems (Saint-Drenan, et al., 2015; Killinger, Reich, Dirnberger, & Reise, 2017).

Besides the portfolios used for the demonstration, the developers will use data provided by the partners (see WP1 – Task 1.1) to develop and test their developments, based on defined criteria, like: availability of data (weather, production), completeness of the description of the plant, type (ground-mounted, roof-mounted, etc.).

The WP2 innovations for medium-commercial and residential PV plants to be developed and demonstrated in SERENDI-PV project are:

- Modelling of small PV/BIPV systems.

- Modelling of soiling
- Modelling of snow

2.2.2 Work Package 3 - Data analytics for small/mid PV systems

The reality of small and mid-scale PV systems is different than for large PV systems. SERENDI-PV will demonstrate the monitoring services for medium size commercial and residential PV plants at a relatively low cost. The analytical tools will be based on PV power production readings from the energy meters typically available at time intervals of several minutes.

The analytical tools will aim at identification of issues such as shading, missing data/losses, underperformance. We will also demonstrate a concept of comparing real power production to expected PV power production. The expected PV power production will be calculated by the different PV simulation tools and the solar & metrological data or data measured at powerplant (if available). The data analytics will be applied to indicate irregularities in the production data or data measured at powerplant (if available). Datasets on timescales of months to years can also be analyzed to detect long-term trends of production decrease or the increase in 'faults' such as erroneous data (using outlier detection methods), enabling the identification of PV installations at risk of either breaking or not being able to cope with sufficient for the demand.

Further to the comparison of expected versus actual production, these large datasets, with many data points both temporally and spatially, can be used to detect underperforming PV installations based on the performance of 'nearest neighbors' installations, i.e. based on similar size, age, current weather conditions etc (Leloux, Navarte, & Desportes, 2020; Alcaniz, Nikam, Snow, Isabella, & Ziar, 2022). This work will look to integrate tools developed previously into monitoring platforms.

The WP3 innovations for medium-commercial and residential PV plants to be developed and demonstrated in SERENDI-PV project are:

- Specific data analytics for small PV/BIPV systems.
- Specific data analytics for soiling
- Specific data analytics for snow
- PV inverter efficiency characterization
- BIPV digital twin
- PV Battery digital twin

2.2.3 Work Package 4 - Field and lab testing

The objective of this WP is to increase PV project's quality & lifetime, to reduce their performance uncertainty and to improve bankability of the new PV technologies through quality control procedures (QCP) in the field and in the lab, including equipment and procedures.

The WP4 innovations for medium-commercial and residential PV plants to be developed and demonstrated in SERENDI-PV project are:

- Batteries: New procedures for batteries field testing. characterization in the field of battery cycle efficiency and state of health (SoH)

3 PORTFOLIO 4: MYLIGHT PORTFOLIO

3.1 Portfolio description

PORTFOLIO 4 provided by MLS for the assessment of diagnostics of a portfolio of medium-scale commercial and residential PV systems based on energy meter measurements. Monitoring data from over 10,000 PV installations is available.

MyLight Systems is a manufacturer of smart solar self-consumption management systems. MLS monitors energy consumption and production data from over 10,000 residential installations across Western Europe (mostly France with a few installations in Italy, Switzerland and Belgium, Portugal and UK). There are a wide range of installation monitoring time ranges – from several years to several days. There are also various power capacities, with most of the installations being from 3 to 6 kWp.

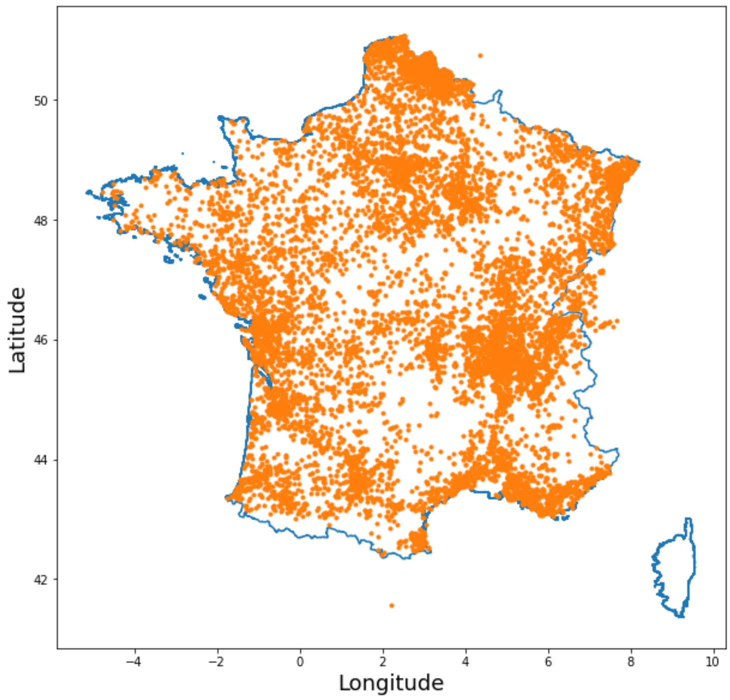


Figure 3.1: Mylight Systems Installations Locations in France as of June 2022

Repartition of MLS Installations across France as of June 2022. There is a significant coverage across the country (except the famous “diagonal du vide” (empty diagonal), a region of low, sparse population stretching from the south-west to the north-east of France, as well as in the mountainous Alps region in the southeast).

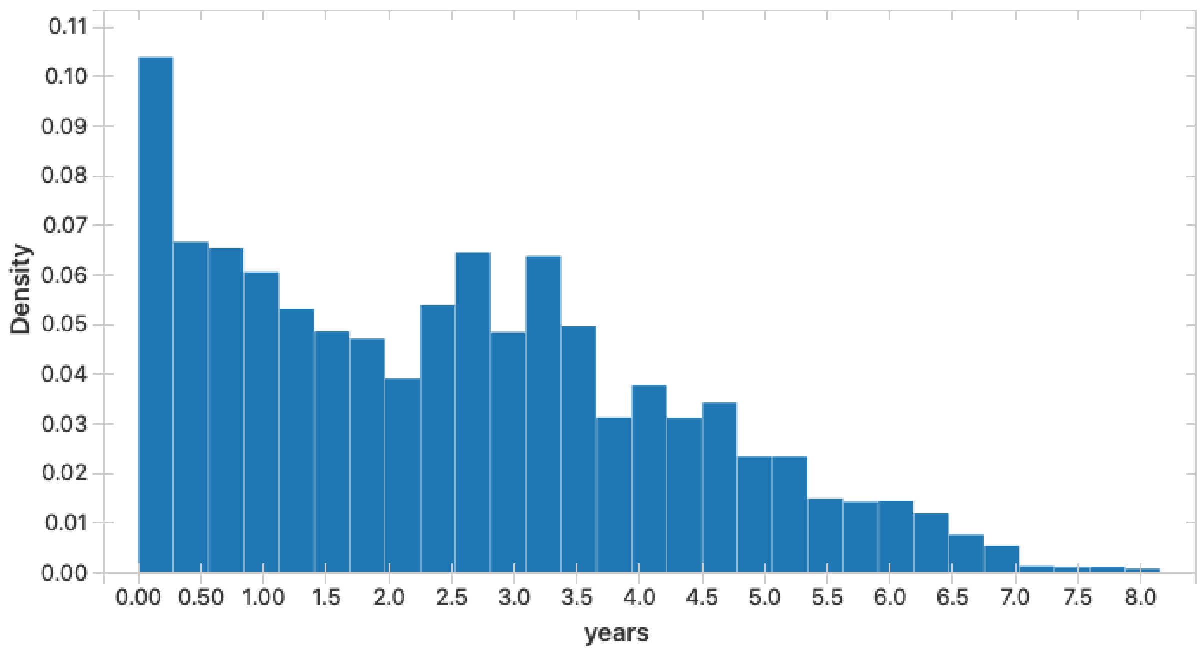


Figure 3.2: Age of Mylight Installations

The histogram shows the age in years of the installations (and hence the amount of data available) for all of the Mylight Systems installations.

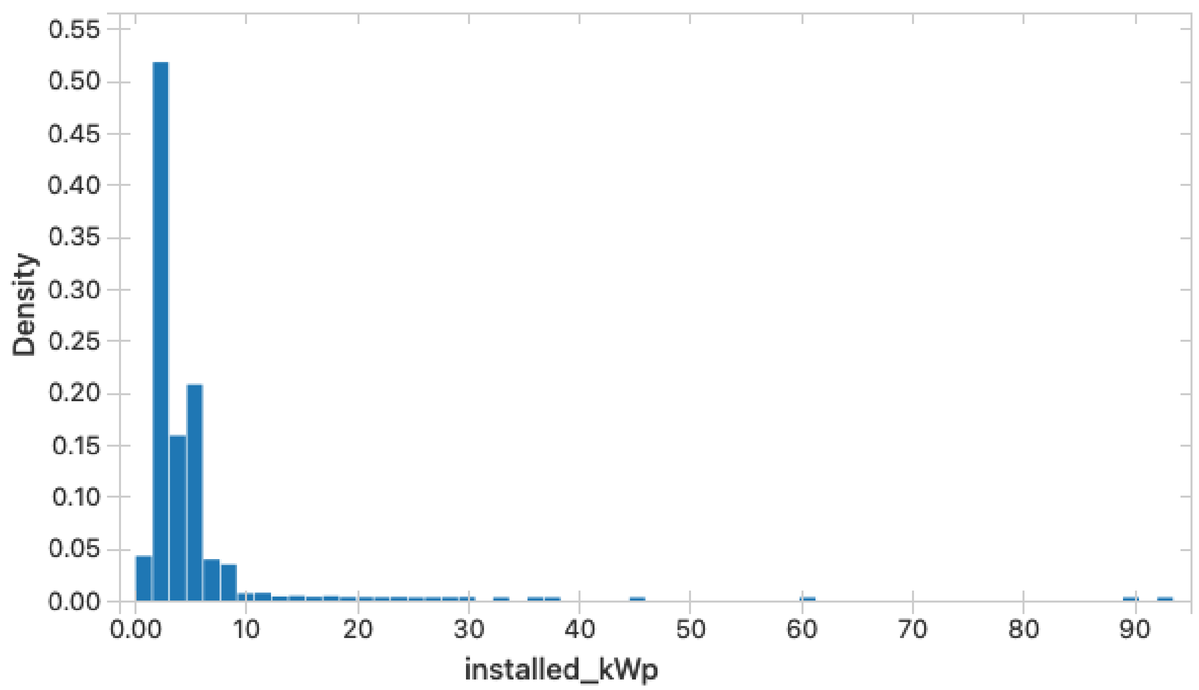


Figure 3.3: Installed power (kWp) of Mylight Installations

The above histogram shows the distribution of installed power in kilowatt peak for all the Mylight Systems Installations. The vast majority of the installations are between 3 and 6 kWp. There are also (very few) much larger installations.

3.2 Monitoring Data

Figure 3.4: MLS Installation

Example of various household devices and the PV installation attached to the MLS control box (in the basement) from which the data is then sent to MLS´ servers.

3.2.1 Data Set and granularity

Data is stored and available at a range of granularities. Raw data is available at 30 second, 1 minute, 150 second or 5-minute granularity (according to year collected as the update frequency has been changed, that is, the more recent installations have a lower frequency. There are also some older installations with 10-minute granularity). On arrival, all data is aggregated to either 5 minutes, 15 minutes or 1 hour and stored.

At each time-step, for the installation **photovoltaic production,** in addition to the **energy consumption of each device** being monitored in the residence (for example, washing machine, water-heater), a value is received for each of the following:

- Energy (Ws)
- Active power (W)
- Reactive power (W)
- Index (Counter)
- Power Factor

3.2.1.1 Storage

The data is stored in several locations depending on its granularity.

3.2.2 Metadata

There is a range of metadata available for each installation:

- Coordinates (latitude, longitude)
- Modules (number of modules installed)
- Module Power (the power of each module)
- Power capacity (the installed power capacity in kWp)
- Orientation (Not always and often wrong)
- Inclination (Not always and often wrong)
- Tariff data (Off peak hours etc)

This data has various purposes. The coordinates, the installed power, and the orientation and inclination are used to either calculate or get (via an API) the irradiance and the expected energy production of the installation. This can then be used for planning energy consumption (scheduling water heating during the hours of most production [also taking into account the tariff data]) or for detecting underperformance (the actual production << the predicted production). The work in WP2 is based around modelling, whilst WP5 is forecasting.

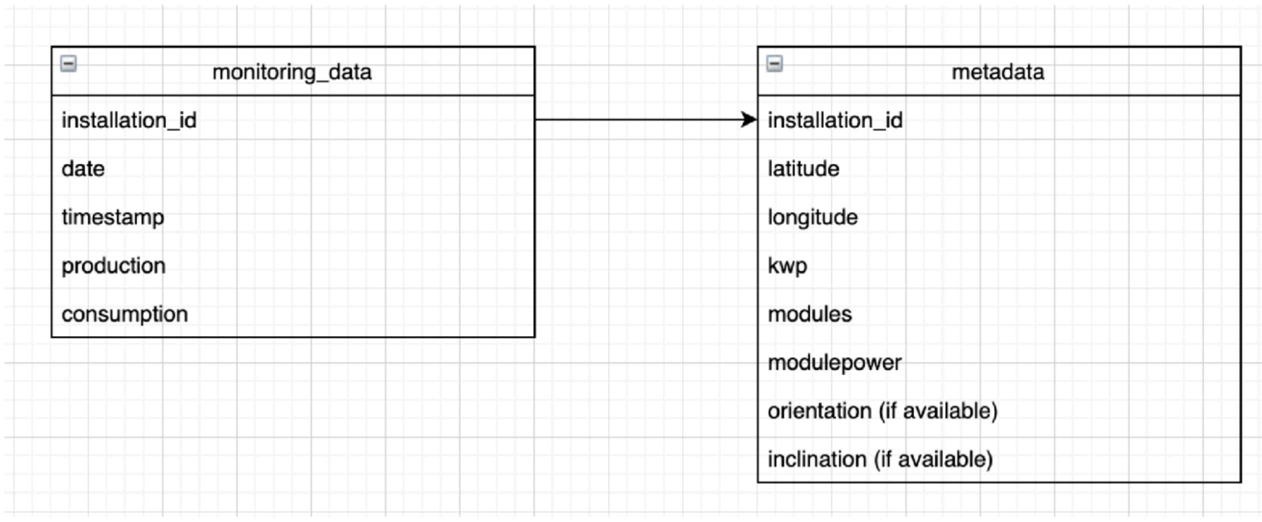


Figure 3.5: Schema of MLS Data

3.2.3 Data Quality

All streaming data is constantly analysed for anomalous values. Batches of data are routinely tested for a range of possible problems:

a) installation errors (where the photovoltaic installation has been incorrectly installed),

b) configuration errors (where the monitoring system has been incorrectly configured) or

c) general data errors (anomalous values, missing data, etc).

3.2.3.1 Defect Tests – Installation errors

These tests detect problems linked with the physical installation of the photovoltaic system and consumption monitoring system. Photovoltaic modules and the accompanying production and consumption data monitoring systems are often unintentionally incorrectly installed. For example, a frequent error is the ‘upside-down’ connection of current measuring clips which can either give a negative reading for a positive current or for non-amperometric clips, a value of zero will be returned when negative values are not detected.

3.2.3.2 Defect Tests – Configuration errors

On the other hand, even if the installation of all hardware was successful, the setup process can also cause problems. The conversion factors of the sensors or their calibrations are usually a source of failures in the configuration of the monitoring system. In the case of BIPV, by identifying which appliances are consumer appliances, which are production appliances, and depending on the monitoring system installed, a variety of other parameters, mistakes can be made that lead to the data being received from an energy-consuming appliance, such as a heater of water, are identified as the energy production of the photovoltaic installation.

3.2.3.3 Defect Tests – Data errors

"Data” errors refer to all problems with the actual data itself, ranging from anomalous/extreme values (outliers), missing data, or the results of disconnections which can range from all data being received at a later time to all the past data being “totaled” into one value giving a large peak. There can also be “duplicate” values received that can be slightly different to each other but contain measurements from overlapping intervals.

These types of errors must be detected and accounted for. This is particularly important for the billing.

Detecting these types of errors (installation, configuration, and data) is further complicated by the accumulation of errors. Several different types of errors within the same installation can make individual errors virtually impossible to diagnose, or at least much more advanced and time-consuming techniques are needed (or even human intervention which for thousands of installations may be little realistic).

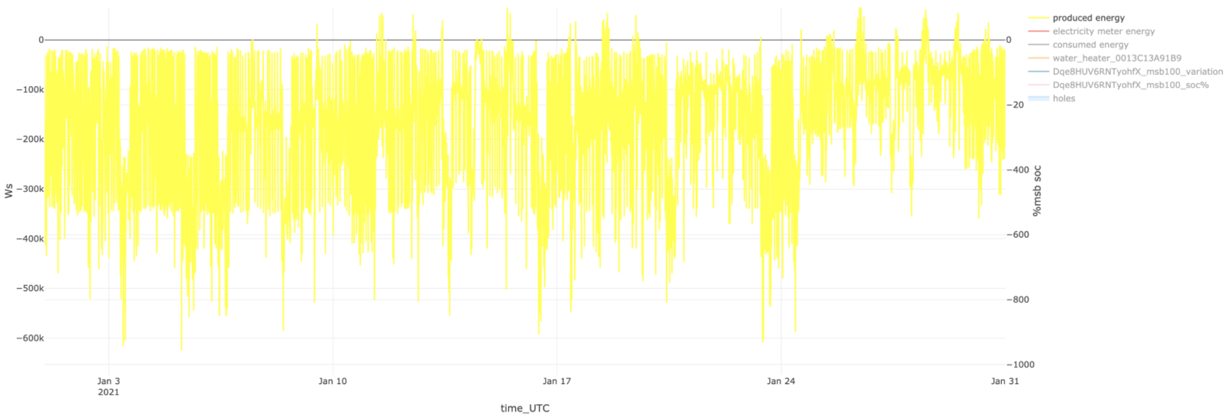


Figure 3.6: Installation problem example

Simple example of a problematic installation that MLS commercial tools should be capable of detecting. The y-axis is energy (Ws) and the x-axis is UTC time. As can be clearly seen, the production is always negative (except for the a few points). Although initially this could be understood as an inverted amperometric clip on the production source, the curve does not resemble a production curve, and so it is likely an inverted amperometric clip on a measuring source that has been mislabelled as production**.**

3.2.4 Data Limitations

Although all effort has been made that the data provided is as reliable and as accurate as possible, there still may be one or two faults (i.e. anomalous values). However, with each update of our data test suite, we re-analyze the data and remove any defect sites.

3.2.5 Data Access

Currently, 18 months of aggregated production and consumption data for ~700 sites at 5 minutes granularity are available.

The data is available as one large csv, or as one csv for each site. The data is stored in an azure blob for which a unique token and instructions to access will be provided by contacting one of the persons at Mylight Systems that are involved in the SERENDI-PV project: J. Reed or C. Salperwyck.

In the near future the data will be made available at closer to real time. It is undecided as to how to do this currently.

3.2.6 Monitoring Installation Improvements (Lessons learnt)

In previous iterations of the monitoring hardware's firmware, if ever data packets were not received for whatever reason (e.g., disconnection), the resulting data would be incomplete as the missing data packet would contain energy consumption for a given time interval that is now unknown. In order to fix this, the concept of the Index was introduced. The index is a continuous counter that increases with consumption and decreases with injection. In case of disconnection, the net energy that is consumed or injected is now known. This indexing also helps with our monitoring of the current status of the virtual battery of the client as it is important to keep track of the exact energy consumed and injected.

Similarly, the installation and configuration process are constantly being improved thanks to feedback from our error tests. The process is becoming more rigorous and possible errors are brought up before they become a problem, resulting in less errors overall.

3.3 Demonstration Objectives

The main objective of MLS portfolio is to demonstrate the range of modelling, data analytics and fault detection algorithms and methods developed in WP 2 and 3 on a large dataset of small residential PV installations. There are two main themes across these two work packages; the first is to be able to accurately predict short- and long-term energy production based on meteorological conditions, and the second is to be able to accurately detect and diagnose the under- or defective- performance of a solar panel installation compared to an expected production based on current meteorological conditions and the installations metadata (inclination, orientation etc).

With this in mind, this portfolio will serve to demonstrate (see Annex I):

- Long-term modelling developed in WP2, and short-term forecasting in WP5.
- That the analytics and fault detection algorithms and methods developed can accurately identify and diagnose periods of underperformance or defectiveness due to multiple factors including soil, shading, snow, bad installation/configuration, or defective equipment. This will be done by comparing the excepted production based on simulation, and then comparing the modelling vs the current production

The validation plan must validate the following points:

a. Detection of snow and soiling
b. Detection of underperformance
c. Detection of degradation
d. Detection of erroneous data
e. Accurately predict short- and long-term energy production

This gives rise to the following KPI's:

1. Better detection of pre-defined snowy intervals
2. Better detection of pre-defined dust intervals
3. Better identification of predefined periods of underperformance
4. Better identification of problematic installations (see example above)
5. Better identification of anomalous values
6. Better identification of all data gaps
7. Better prediction accuracy on short term (< 24h) production

4 PORTFOLIO 5: CEGASA PORTFOLIO

4.1 Portfolio description

4.1.1 Demo site 1

CEGASA has installed a Li-ion battery, of around 100 kWh, in iSARE facilities with the required monitoring condition to validate the digital twin.

iSare is a pioneering infrastructure which seeks to promote technologies and solutions in the field of smart grids:

- Power generation capacity of 400 kW.
- Remotely managed loads, accumulators and generators system that can operate connected to the electricity distribution network or as standalone (island).
- Several technologies, renewable energy production sources and conventional generation sources are used in an integrated manner, setting up smart management and storage systems of overall electrical energy.

Figure 4.1: ISARE Facilities

4.1.2 Demo site 2

A PV installation with the following characteristics will be implemented in CEGASA premises:

- At least 10 KW of PV will be installed in the factory roof.
- Inverter: solar tripower 20000TL-30
- Battery: eBick 280 PRO. The installation will be modular, it will be possible to install different number of modules, according to the needs.
- Battery inverter: the installation will be adjusted for an easy interchange in order to validate different inverters.
- An EmControl will be used as EMS

4.2 Monitoring Data

4.2.1 Data Set and granularity

All the variables necessary to perform the validation of the digital twin model and the QC Procedures (cell voltage, current, temperature, SoC, state) will be downloaded at the required frequency.

The main variables to be monitored will be:

- Voltage
- Current
- Temperature
- SoC
- Battery state (SoH)
- Minimum cell voltage
- Maximum cell voltage

4.2.2 Data Quality

Data will be collected at a frequency high enough to allow validation of the Digital Twin, considering the limits of the cloud and the communications system. This sampling time is expected to be no less than 1 second and no more than 5 seconds (between 1 and 5 seconds).

The communication protocol between the information producer and the cloud platform will be message-oriented, based on a reactive architecture (e.g. MQTT or Kafka). In this way, there is no need for pooling type communication between both of them, alleviating the information transfer. In any case, QoS mechanisms will be implemented to avoid losing messages in case of unstable communications.

The treatment applied to the collected data depends on the specific application for which they are collected. In the case of Digital Twin validation, the sampling frequency should be high enough to have a good accuracy, so no aggregation function will be performed. Filtering will be performed to avoid outliers that could be recorded.

Once the batteries to be used for monitoring have been installed, no additional equipment is required. A computer with internet access will be connected directly to the BMS master of the battery. This will allow to acquire all the information and modify any parameter in real time.

4.2.3 Data access

Data from the battery monitoring system will be shared with partners who require it for their tasks within the project.

Any other partner wishing to access the data should contact one of the persons at CEGASA that are involved in the SERENDI-PV project: M. Puente, A. Urkitza or I. Cantero.

4.3 Demonstration Objectives

The monitoring data will allow the assessment of preventive maintenance, based on digital twin approach (WP3 innovation), and the assessment of the new lab and on-site Quality Control Procedures (QCP) of the batteries (WP4 innovation)

The data will be used in comparisons with predicted data, used for tests of various developments and algorithms.

5 PORTFOLIO 6: CNR PORTFOLIO

5.1 Portfolio description

CNR (Compagnie Nationale du Rhône) is the first French IPP with 100% renewable energy portfolio. Concessionary of the French state for the Rhone River. CNR's portfolio contains PV plants with different technologies and various capacity.

PORTFOLIO 6 provided by CNR is composed of one small BIPV asset from CNR portfolio: SANT PV plant.

Table 5.1: Technical summary SANT PV Plant

Name	SANT
Technology	BIPV on an agricultural warehouse
Power [kWp]	250
Number of modules	925
Number of inverters	4
Module power [Wp]	270
Module inclination [°]	15
Commissioning date	01/05/2018
GPS	43.55, 3.655

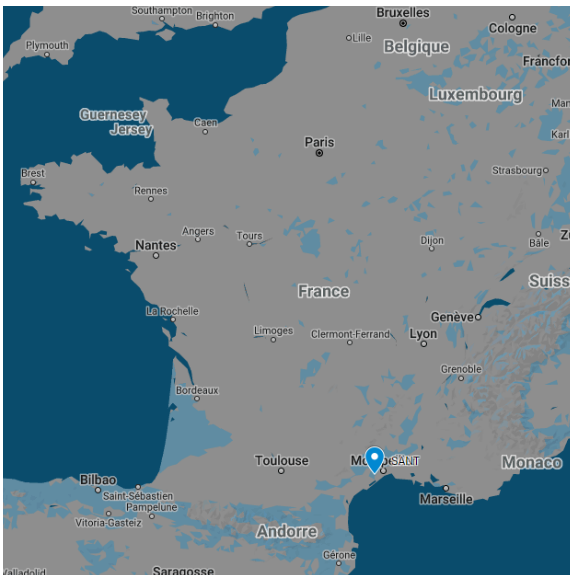


Figure 5.1: SANT PV Plant location

Figure 5.2: SANT PV Plant aerial and on-site view

5.2 Monitoring Data

5.2.1 Data Set and granularity

This dataset used to manage the assets and production follows up:

Table 5.2: SANT PV Plant Data

Source	Variable
Weather station	Irradiation (in the plane of modules)
	Ambient temperature (measured with a PT100 for temperature)
Inverter (Delta RPD M50A)	AC/DC current, voltage and power (string level)
	DC power
	AC power
Delivery point	AC power

The data set is stored and available at a granularity of 10'.

5.2.2 Metadata

There is a range of metadata available for this installation:

- Coordinates (latitude, longitude)
- Number of Modules
- Module Power
- Installed capacity
- Orientation
- Inclination

This metadata has been used to forecast the production.

5.2.3 Data quality

There are periods with lack of data due to operational issues (communication problem, material failure, etc…). Most of the time, the recovery is done within 1 week. Longer duration of the issues may be possible on several plants (material replacement…).

In particular, in the case of the SANT PV plant, there is no AC/DC data since June 21 due to inverters failure.

5.2.4 Data access

The historical data is available since the date of commissioning mentioned above (01/05/2018).

CNR is flexible about the interface for sharing one-time data if it respects data privacy. If the receiver had any preference, we could consider it and apply it as well as possible. In other case CNR has an external exchange interface that could be used.

The format available are as following:

- csv
- xlsx
- pdf as reports

5.3 Demonstration objectives

The main objective is to provide a plant for the project and the partners demonstrations in the range of medium-commercial and residential. SANT is representative of French agricultural warehouses PV installations.

The PV plant has faced defective equipment (4 inverters) between June 21 and June 22. SANT faces standard soiling since the commissioning.

Consequently, this study case is suitable for the consortium to demonstrate:

- The modelling tools developed by the partners can accurately predict the solar energy production in the short and long-term (WP2)
- That the analytics and fault detection algorithms and methods developed by the partners can accurately identify and diagnose periods of underperformance or defectiveness due to multiple factors including soil, bad installation/configuration, or defective equipment (WP3).

Figure 5.3: SANT PV Plant inverters and module soiling

6 PORTFOLIO 7: CYTHELIA PORTFOLIO ON COMMERCIAL BUILDINGS

6.1 Portfolio description

The portfolio 7 is a set of installations composed of around 300 PV plants installed on commercial buildings. These installations belong to one of the customers of Cythelia for whom Cythelia is providing supervision services.

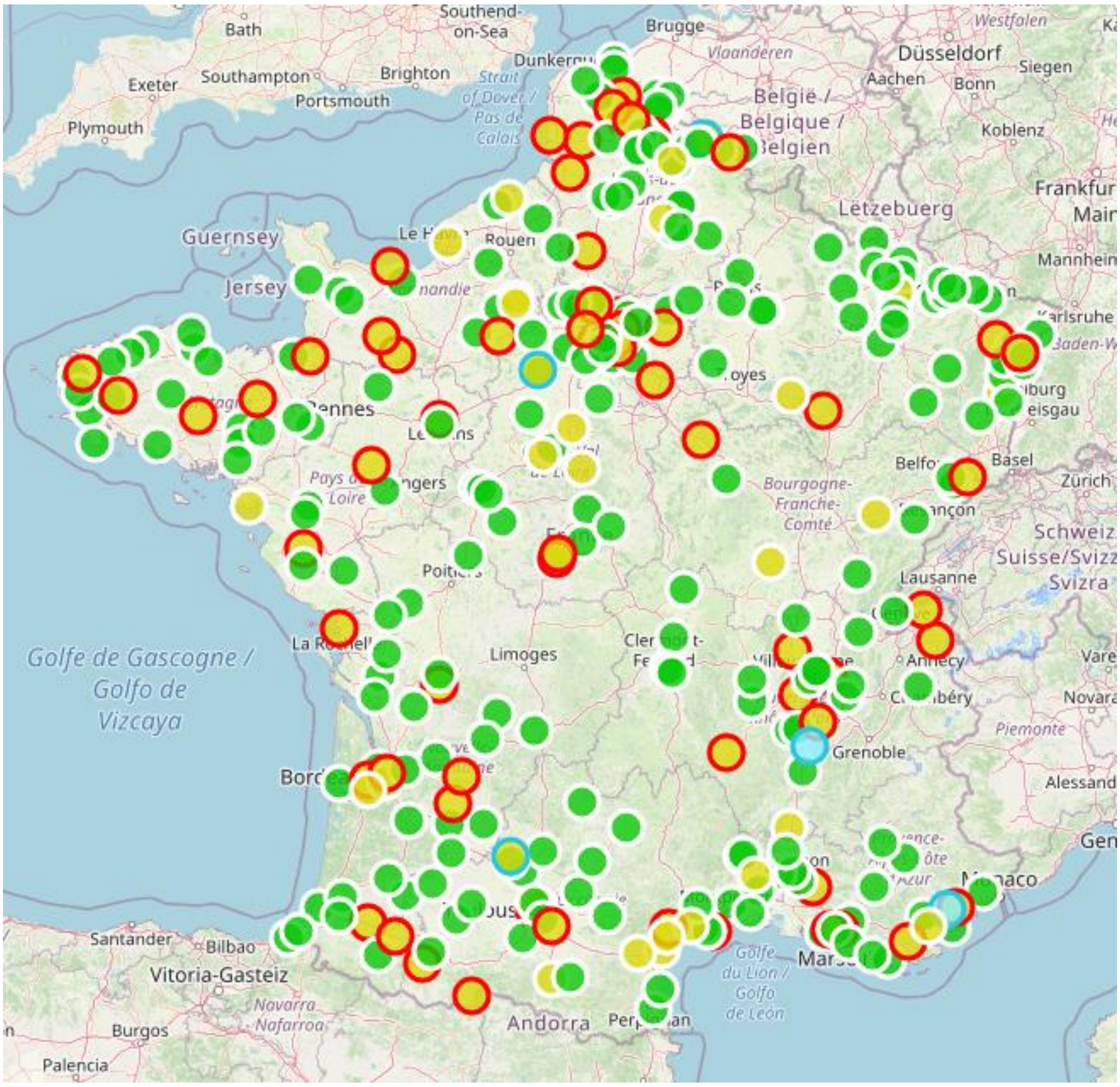


Figure 6.1: PV plants on commercial buildings (Cythelia)

Each point represents one installation (green: no default; yellow: default flagged by the system; blue: not monitored).
All the plants are in self-consumption mode.

An example of load and production curves is shown in next figure. The self-consumption is “total”, as no injection into the grid is allowed. The PV production (in green) is therefore curtailed and cannot be higher than the site consumption (in red).

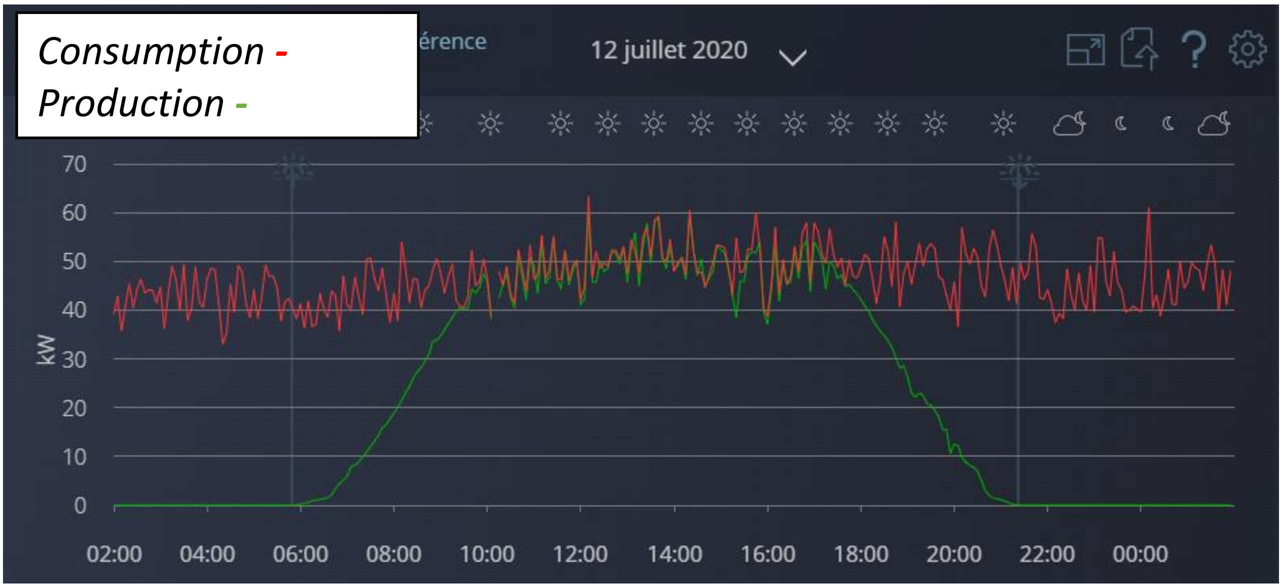


Figure 6.2: Example of self-consumption PV plant

By the end of the year 2022, 274 plants will have at least one year of data. The average installed power is 141 kWp, but, as shown in the graph below, most of the plants have an installed capacity comprised between 75 and 80 kWp.

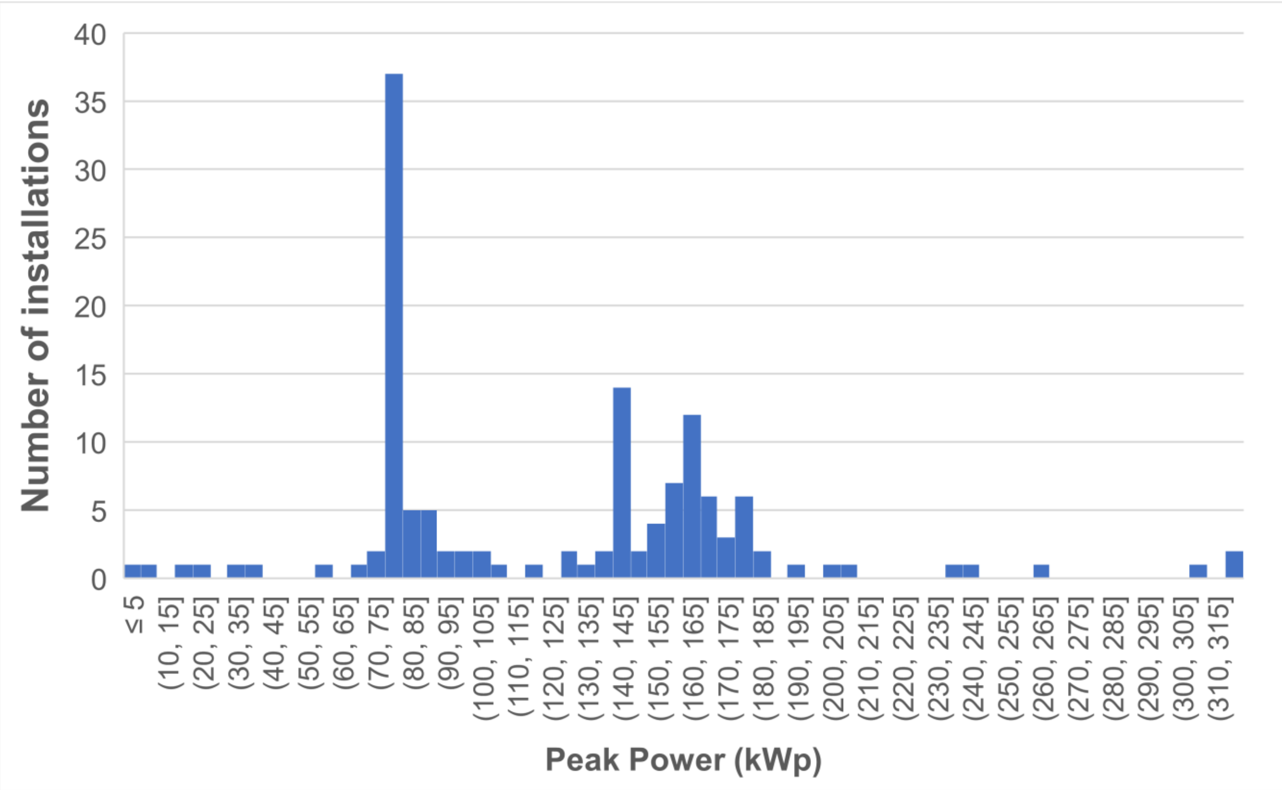


Figure 6.3: Distribution of installed power (Cythelia)

135 plants out of the 274 have an irradiance sensor installed.

6.2 Monitoring Data

6.2.1 Data Set and granularity

The monitored data are DC and AC productions collected by the inverters.

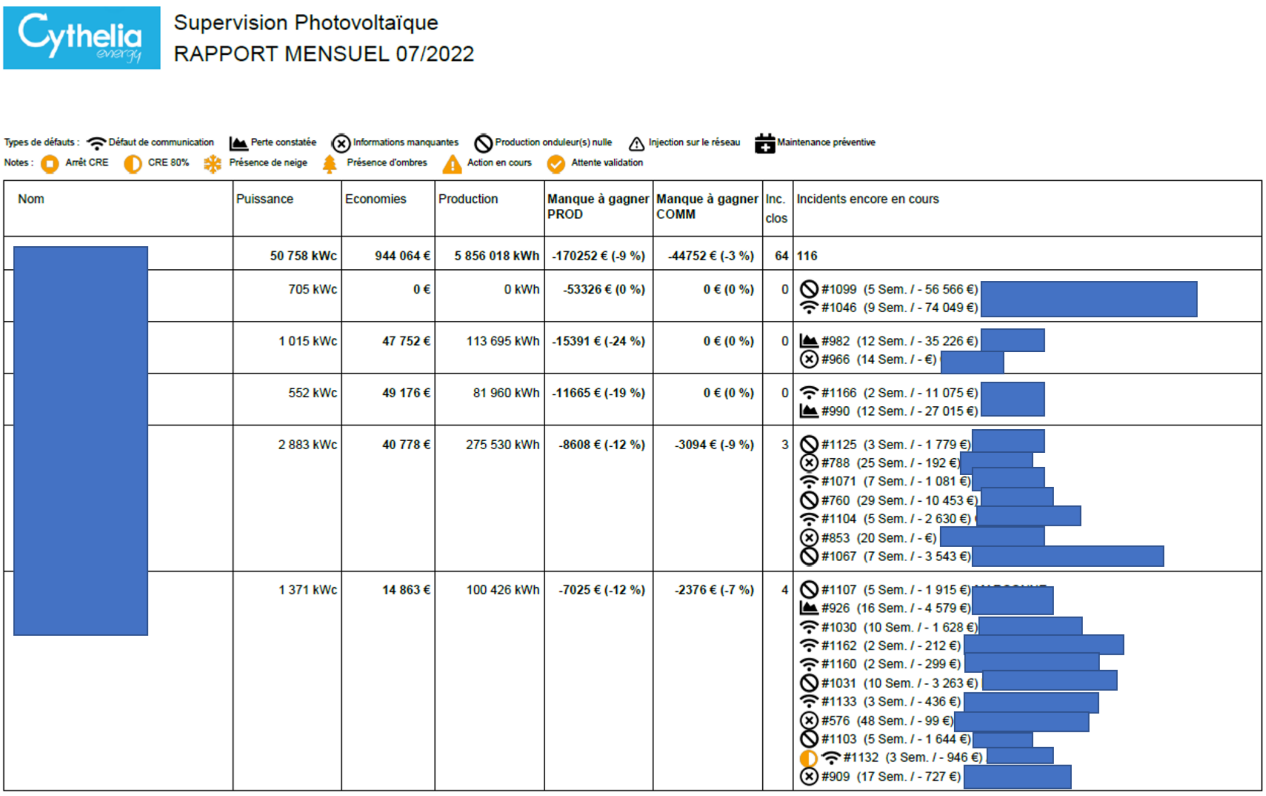
The granularity is dependant of the sizing (small/large inverters).

6.2.2 Data access

The data of the clients´ PV plants are confidential and cannot be shared with other SERENDI-PV partners. They will only be used by CYTHELIA for development and validation purposes of their innovations on WP2 and WP3, as it was described in D8.6 (included a summary in annex I).

6.2.3 Data quality

The control of the quality of the data is to be performed. Procedures will be implemented to check missing data, no production and abnormal low-production periods. This information is already flagged in the supervision system, as it is shown in the extract of a monthly report.



Supervision Photovoltaïque
RAPPORT MENSUEL 07/2022

Types de défauts : Défaut de communication; Perte constatée; Informations manquantes; Production onduleur(s) nulle; Injection sur le réseau; Maintenance préventive
Notes : Arrêt CRE; CRE 80%; Présence de neige; Présence d'ombres; Action en cours; Attente validation

Nom	Puissance	Economies	Production	Manque à gagner PROD	Manque à gagner COMM	Inc. clos	Incidents encore en cours
	50 758 kWc	944 064 €	5 856 018 kWh	-170252 € (-9 %)	-44752 € (-3 %)	64	116
	705 kWc	0 €	0 kWh	-53326 € (0 %)	0 € (0 %)	0	#1099 (5 Sem. / - 56 566 €) #1046 (9 Sem. / - 74 049 €)
	1 015 kWc	47 752 €	113 695 kWh	-15391 € (-24 %)	0 € (0 %)	0	#982 (12 Sem. / - 35 226 €) #966 (14 Sem. / - €)
	552 kWc	49 176 €	81 960 kWh	-11665 € (-19 %)	0 € (0 %)	0	#1166 (2 Sem. / - 11 075 €) #990 (12 Sem. / - 27 015 €)
	2 883 kWc	40 778 €	275 530 kWh	-8608 € (-12 %)	-3094 € (-9 %)	3	#1125 (3 Sem. / - 1 779 €) #788 (25 Sem. / - 192 €) #1071 (7 Sem. / - 1 081 €) #760 (29 Sem. / - 10 453 €) #1104 (5 Sem. / - 2 630 €) #853 (20 Sem. / - €) #1067 (7 Sem. / - 3 543 €)
	1 371 kWc	14 863 €	100 426 kWh	-7025 € (-12 %)	-2376 € (-7 %)	4	#1107 (5 Sem. / - 1 915 €) #926 (16 Sem. / - 4 579 €) #1030 (10 Sem. / - 1 628 €) #1162 (2 Sem. / - 212 €) #1160 (2 Sem. / - 299 €) #1031 (10 Sem. / - 3 263 €) #1133 (3 Sem. / - 436 €) #576 (48 Sem. / - 99 €) #1103 (5 Sem. / - 1 644 €) #1132 (3 Sem. / - 946 €) #909 (17 Sem. / - 727 €)

Figure 6.4: extract of a monthly report of the supervision system

6.3 Demonstration objectives

The main objective of this portfolio is to demonstrate:

- The models developed in WP2, especially those regarding BIPV (Task 2.3.3)
- The data analytics performed in WP3: PV inverter efficiency characterization (Task 3.3)

The large number of plants in this portfolio makes it relevant for the BIPV modelling, as different types of systems and shadow scenes could be found in it. Similarly, several types of inverters (both manufacturers and models) are found in this portfolio, and it can reasonably be assumed that the sizing parameters (like the ratio between the PV installed power and the nominal power of the inverter, or the voltage of the strings) are somehow different.

7 PORTFOLIO 8: CYTHELIA´s BUILDING

7.1 Portfolio description

On his new offices building, Cythelia has built a BIPV plant with the following characteristics:

- 70 kWp bifacial modules installed on
    - Carport and sunshade: 40 kWp
    - Trackers located on the roof: 30 kWp
- Each module is equipped with a micro-inverter for the DC/AC conversion and injection to the grid

The plant has been commissioned in 2021, but the connection to the grid is effective only since April 2022.

The produced electricity is consumed by the building. The production not consumed is sold to the grid, in 2 steps:

- Electricity is sold to the neighbouring buildings within a collective self-consumption scheme (or energy community). This operation is being setup and should be operational in the coming months.
- If there is still extra-production, it is sold to the grid at a regulated tariff.

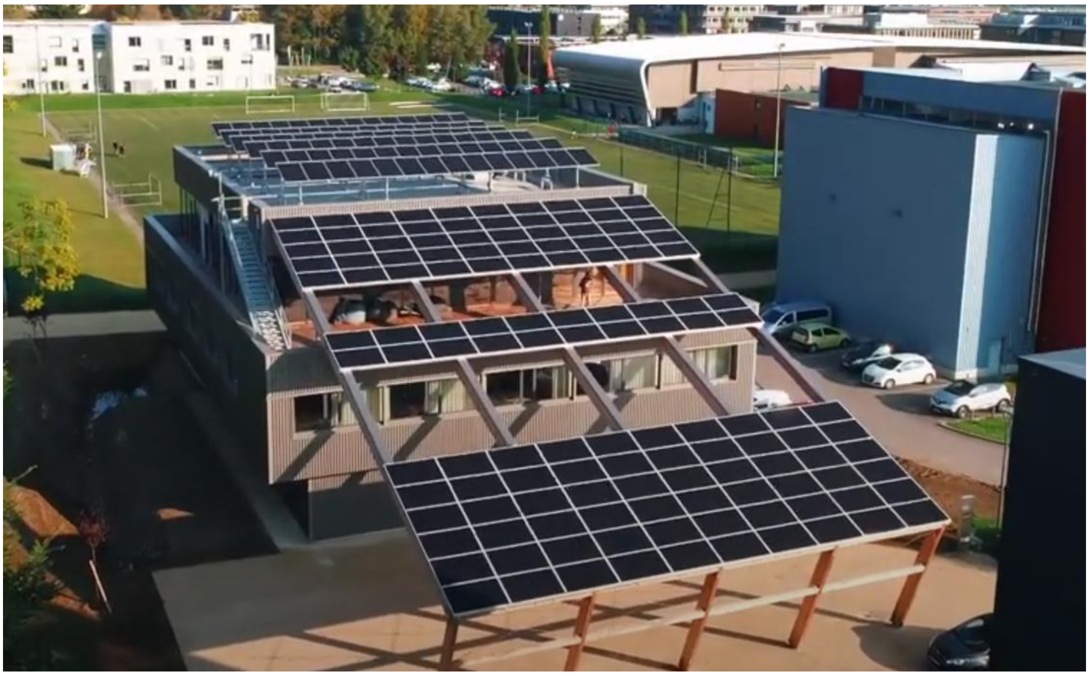


Figure 7.1: Cythelia building with PV Installation

The modules on the roof are mounted on horizontal 1-axis trackers aligned on East-West axis. They are not aiming at producing a lot more electricity than standard titled south-facing modules, but they allow easy changes of the tilt of the modules, which is an important parameter in bifacial gain modelling.

Figure 7.2: PV modules on trackers (roof part of the Cythelia installation)

7.2 Monitoring Data

7.2.1 Data Set and granularity

AC production data are available at module level, at a 10-minute time resolution, since April 2022.

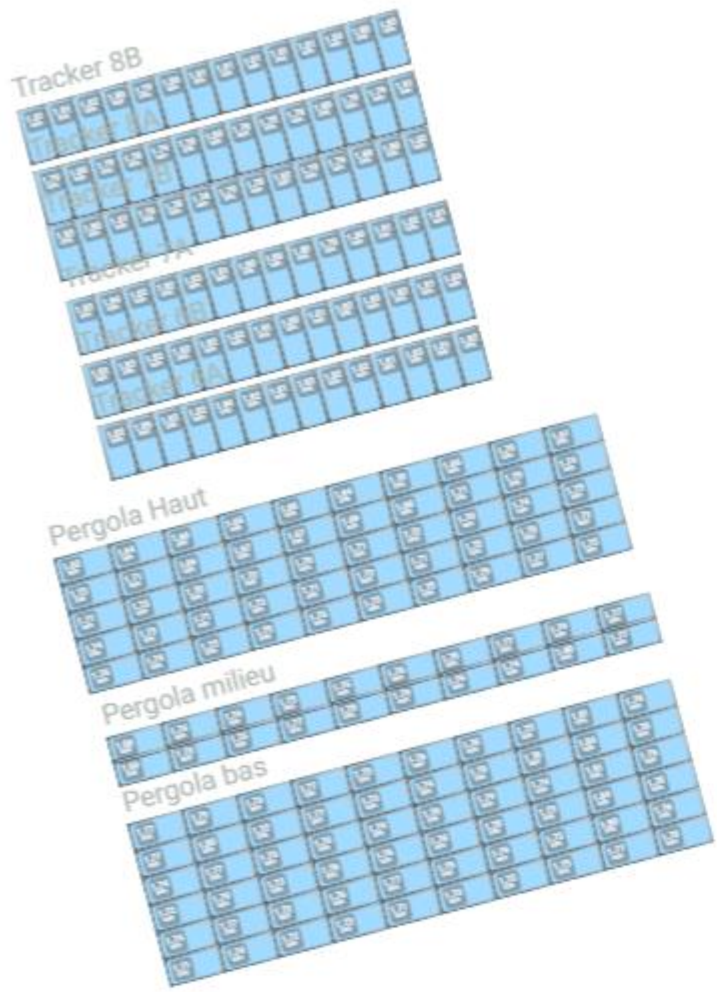


Figure 7.3: Daily AC production per module (Cythelia Installation)

Environmental data are also available at the same time resolution (10-minute). These environmental data include:

- Meteorological parameters:
    - Ambient temperature
    - Precipitation measurement
    - Wind speed and direction
- Irradiance measurement:
    - Horizontal irradiance (GHI): pyranometer[1] + reference cell[2]
    - Irradiance in the plane of the modules (GTI) measured with reference cells:
        - Front side: 2x (1 sensor on the roof + 1 sensor on the carport)

[1] Kipp & Zonen SMP10-V

[2] Ingenieurbüro Si-RS485 (accuracy : Irradiance ±5 W/sqm ±2.5% from value; with temperature compensation, vertical light beam and AM 1.5)

- Back side: 8x (4 sensors on the roof + 4 sensors on the carport)

- Modules' temperature:
  - 2 sensors on the roof
  - 1 sensor on the carport

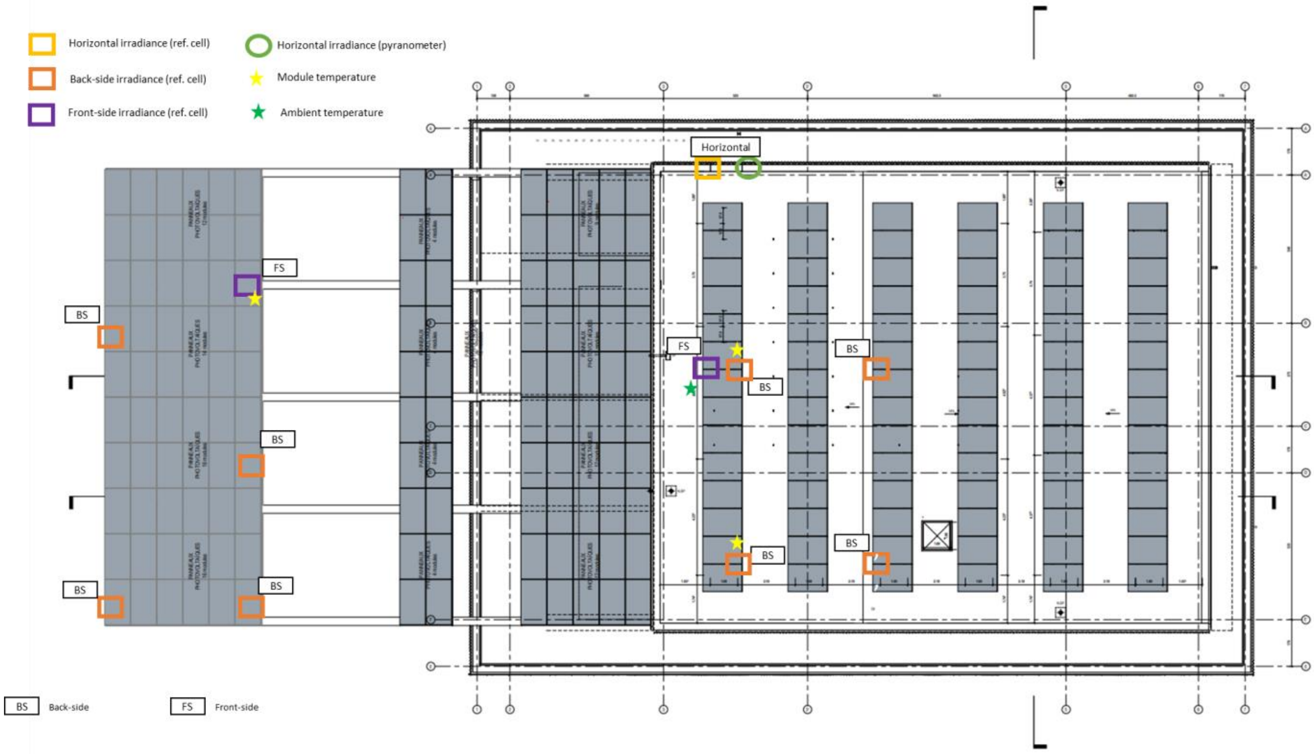


Figure 7.4: Location of the sensors

7.2.2 Data access

The data will be made available to SERENDI-PV partners through the collaborative platform developed in WP7, COPLASIMON. For more information contact the responsible person of CYTHELIA involved in the SERENDI-PV project: I. Lokhat.

7.2.3 Data Quality

The control of the quality of the data is to be performed. Procedures will be implemented to check missing data, no production and abnormal low-production periods.

7.3 Demonstration objectives

The main objective of this portfolio is to demonstrate the innovations developed in WP2, regarding

- Bifacial PV (Task 2.3.1).
- BIPV (Task 2.3.3).

The reasons this plant is relevant to demonstrate such modelling works are summarised in the table below.

Table 7.1: Rationale for this plant as a demonstrator

Bifacial	BIPV
The data are available at module level, and will enable the study of the modules' production according to their position in a row (for bifacial), or according to the surrounding obstacles (BIPV)	
	The plant is prone to shadows caused by the surrounding buildings/plants
One part of the plant is equipped with trackers, allowing tests of different tilts	

Also, this PV plant will be used to demonstrate some innovations developed in WP3, regarding:

- Specific data analytics for small PV/BIPV systems
- Specific data analytics for soiling
- Specific data analytics for snow
- PV inverter efficiency characterization
- BIPV digital twin

ANNEX I summarizes all the innovations that will be tested in this PV plant.

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9 ANNEX I: SUMMARY TOOLS - INNOVATIONS - PORTFOLIOS IN MEDIUM AND RESIDENTIAL PV PLANTS

The relationship between the developments to be demonstrated and the portfolios is as follows: (*this information is extracted from D8.6*)

WP	Tool (if integrated)	Innovation	Developper	MLS portfolio 4	CEG portfolio 5	CNR Portfolio 6 (medium)	Name of Plant	CYT porfolio 7	Name of Plant	CYT porfolio 8
2	LUSIM (LUC)	Modelling of small PV/BIPV systems	LUC	Yes	No					
		Modelling of soiling	LUC	Yes	No					
		Modelling of snow	LUC	Yes	No					
2	EVALUATE (SGIS)	Modelling of small PV/BIPV systems	SGIS	Yes	No	Yes	SANT			
		Modelling of soiling	SGIS	Yes	No	No				
		Modelling of snow	SGIS	Yes	No	No				
2	archelios PRO (CYT)	Modelling of small PV/BIPV systems	CYT		No	To be discussed		Yes	Several customer plants;	Yes
		Modelling of soiling	CYT		No	To be discussed		Yes		Yes
		Modelling of snow	CYT		No	To be discussed		Yes		Yes
2	GreenPlay (MLS)	Modelling of small PV/BIPV systems	MLS	Yes	No					
		Modelling of soiling	MLS	Yes	No					
		Modelling of snow	MLS	Yes	No					
3	LUMONITOR (LUC)	Specific data analytics for small PV/BIPV systems	LUC	Yes						
		Specific data analytics for soiling	LUC	Yes						
		Specific data analytics for snow	LUC	Yes						
3	Solargis Monitor (SGIS)	Specific data analytics for small PV/BIPV systems	SGIS	Yes		Yes	SANT			
		Specific data analytics for soiling	SGIS	Yes		No				
		Specific data analytics for snow	SGIS	Yes		No				

3	archelios PRO (CYT)	Specific data analytics for small PV/BIPV systems	CYT			To be discussed		Yes	Several customer plants	Yes
		Specific data analytics for soiling	CYT			To be discussed		Yes		Yes
		Specific data analytics for snow	CYT			To be discussed		Yes		Yes
		PV inverter efficiency characterization	CYT					Yes		Yes
		BIPV digital twin	TEC							Yes
3	MLS (MLS)	Specific data analytics for small PV/BIPV systems	MLS	Yes						
		Specific data analytics for soiling	MLS	Yes						
		Specific data analytics for snow	MLS	Yes						
3	-	PV Battery digital twin	TEC+CEG		Yes					
4	-	New procedures for batteries field testing	CEG+QPV		Yes					