This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 691768

Installation and execution of monitoring of BIPV systems

Project report

NOBATEK, TECNALIA

March 2018

www.pvsites.eu

Summary

This document reports the completion of the installation of monitoring equipment in the demonstration sites of the PVSITES project for the assessment of the baseline situation (meaning before installation of BIPV systems).

Moreover, at this stage of the project, the BIPV systems are not yet installed in the demonstration sites. Therefore, the monitoring infrastructure specifically associated to the BIPV performance assessment is not yet installed. As a result, the present document exposes only the monitoring infrastructure which is planned for the reporting period (after installation of the BIPV systems).

Acknowledgements

The work described in this publication has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 691768.

The present report was mainly prepared by PVSITES project partner NOBATEK, with additional contributions from TECNALIA. The report was originally submitted to the European Commission as Project Deliverable D8.10 in March 2018.

Disclaimer

About the PVSITES project

PVSITES is an international collaboration co-funded by the European Union under the Horizon 2020 Research and Innovation program. It originated from the realisation that although building-integrated photovoltaics (BIPV) should have a major role to play in the ongoing transition towards nearly zero energy buildings (nZEBs) in Europe, the technology in new constructions has not yet happened. The cause of this limited deployment can be summarised as a mismatch between the BIPV products on offer and prevailing market demands and regulations.

The main objective of the PVSITES project is therefore to drive BIPV technology to a large market deployment by demonstrating an ambitious portfolio of building integrated solar technologies and systems, giving a forceful, reliable answer to the market requirements identified by the industrial members of the consortium in their day-to-day activity.

Coordinated by project partner Tecnalia, the PVSITES consortium started work in January 2016 and will be active for 3.5 years, until June 2019. This document is part of a series of public reports summarising the consortium's activities and findings, available for download on the project's website at www.pvsites.eu.

The PVSITES consortium:

Tecnalia Research & Innovation	CTCV	FormatD2
Onyx Solar	Flisom	Vilogia
BEAR-iD	Cricursa	R2M Solution Research to Market
Nobatek	CEA	CADCAMation
Film Optics	Acciona Infraestructuras	WIP - Renewable Energies

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1 EXECUTIVE SUMMARY

1.1 Description of the deliverable content and purpose

This deliverable is one of the documents associated to the task 8.4 "Monitoring of installations" and specifically related with subtask 8.4.1 "Detailed technical design of monitoring" and task 8.4.2 "Monitoring and evaluation of the baseline of the buildings". It reports the completion of the installation of monitoring equipment in the demonstration sites for the assessment of the baseline situation meaning before installation of BIPV systems. The document also provides a short synthesis of the main lessons learnt through these activities as regards to what was planned initially in the M&V plans provided in D8.8 "Specific monitoring plan for every demo site". Moreover, at this stage of the project, the BIPV systems are not yet installed in the demonstration sites. Therefore, the monitoring infrastructure specifically associated to the BIPV performance assessment is not yet installed. As a result, the present document focuses only on description of the monitoring infrastructure which is planned for the reporting period (after installation of the BIPV systems).

The general monitoring guidelines have been previously delivered in D8.7 for the PVSITES project.

The Measurement & Verification (M&V) plans have been defined and described for each pilot in D8.8 with a common agreement on the monitoring strategy (what will be measured, which measurement devices will be used, which are the responsibilities of each stakeholder…). Once this is agreed, the second step is to proceed to the installation of the monitoring infrastructure and initiate the process of data collection. Such is the purpose of this present document D8.10 that reports what has been achieved so far in terms of measurement deployment in all the pilot sites of the PVSITES project.

In the first part of the document (Chapter2), the general objectives of the monitoring are reminded taking into account all the requirements coming from the other activities conducted within the project and especially the WP6 "Building Energy Management System for different building uses" requirements.

Chapter 3 reports the completion of the installation of monitoring equipment for the assessment of the baseline situation providing some illustrations of the concrete implementation in the different pilot sites. This chapter also reports the main lessons learnt so far regarding the monitoring infrastructure implementation.

Chapter 4 describes the measurement plan which is envisioned for the BIPV performance assessment during the reporting period (after BIPV installation). This chapter will be updated in next deliverables once the BIPV installation has been completed.

Chapter 5 provides concise conclusions and identify the future steps attached to monitoring activities.

1.2 Relation with other activities in the project

Table 1.1 depicts the main links of deliverable D8.10 to other activities (work packages, tasks, deliverables, etc.) within PVSITES project.

Table 1.1 Relation between D8.10 and other activities in the project

Project activity	Relation with current deliverable
D2.1	D2.1 describes the technical specifications for PVSITES BIPV modules and their manufacturing processes. It also proposes a first monitoring approach and lists the parameters to be measured in order to assess the BIPV system performance.
D8.1	D8.1 provides a pre-dimensioning of BIPV systems for every demo site. This is the main input for the M&V plan definition.
D8.3	D8.3 delivers the final design of the BIPV systems for each demo site.
D8.7	D8.7 introduces a first framework for the M&V Plans to be considered within PVSITES (monitoring guidelines).
D8.8	D8.8 specifies the Measurement and Verification Plans to be deployed for each pilot site and establish the specific details associated to each demonstration building.
D8.9	D8.9 provides an analysis of the data collected during the baseline period (before installation of the BIPV systems) for each pilot site in order to establish the energy consumption baseline to be compared to the new consumptions after renovation.
WP6	Task 8.4 feeds in the planning tool developed within WP6 (Building Energy Management System for different building uses) with data measured on site (data series of PV production, solar radiation)
WP3 and WP4	Simulation tasks conducted within WP3 and WP4 provide expectations in terms of BIPV impact on energy demand of the demo sites. These simulations will be compared with real measurements collected within demonstration activities.

1.3 Reference material

D2.1 “Technical specifications for BIPV modules”, deliverable of the PVSITES project delivered at M06.

D8.1 “Energy audit of buildings and identification of BIPV possibilities in every demo site”, deliverable of the PVSITES project delivered at M15.

D8.3 “Design pack for every demo site”, deliverable of the PVSITES project, in preparation, to be delivered at M18.

D8.7 “Common monitoring guidelines”, deliverable of the PVSITES project delivered at M15.

D8.8 “Specific monitoring plan for every demo site”, deliverable of the PVSITES project delivered at M20.

D8.9 “Report on the baseline assessment of the demo sites”, deliverable of the PVSITES project, to be delivered at M27.

D3.7 “Report on simulation work, c-silicon based BIPV elements”, deliverable of the PVSITES project delivered at M23.

D4.4 “Results of modelling at element and building level, CIGS products”, deliverable of the PVSITES project delivered at M27.

D8.2 “Result of modelling and BIPV strategies for every demo site”, deliverable of the PVSITES project, to be delivered at M28.

1.4 Abbreviation list

BCC:	Building Control Center
BEMS:	Building Energy Management System
BIPV:	Building-Integrated Photovoltaics
EHG:	Ecole Hôtelière de Genève
ESCo	Energy Services Company
EV:	Electrical Vehicle
IPMVP:	International Performance Measurement and Verification Protocol
M&V:	Measurement and Verification
PV:	Photovoltaics
WP:	Work Package

2 REMINDER ON MONITORING OBJECTIVES AND PROTOCOL USED

The two main objectives of the monitoring activities within the PVSITES project are the following:

- Assess the impact of BIPV technologies on the building performances
    - In terms of energy performances
    - In terms of indoor environmental conditions
- Assess the BIPV performance once integrated in the demo buildings meaning in real conditions.

In addition to these fundamental objectives, the monitoring should also feed WP6 activities and development of the Building Energy Management System (BEMS) by providing data for establishing managing strategies as regards to the loads profiles of the different buildings. In order to cover this aspect, requirements coming from WP6 have been considered and when possible implemented through the monitoring infrastructure deployment.

Finally, WP8 “Large scale demonstration and assessment of BIPV systems in real buildings” and monitoring activities will also allow comparison between measurements collected and simulated data in order to assess the performance gap associated to the BIPV technologies, identify the sources of the gap when possible and conduct corrective actions to reduce this gap.

In order to answer to these objectives, a chronological procedure has been proposed for the implementation of the monitoring program of the PVSITES project. In D8.7, generic guidelines are provided supporting the monitoring and evaluation approaches that are to be followed by each pilot site of the PVSITES project. These guidelines define a set of actions and steps proposed as a common performance evaluation process to be implemented. The guidelines are based on two main items:

- A monitoring procedure providing a very detailed process made of several steps and requirements.
- The IPMVP protocol as the framework for the monitoring programme content, ensuring both quality of the assessment to be done and homogeneity between each pilot site.

Following this first step, Measurement and Verification plans (M&V plans) have been defined and are provided in D8.8 following the general guidelines. These M&V plans go deeper into details for the measurement implementation site by site. D8.8 describes also the responsibilities assigned to each stakeholder of the demo sites leading to a clear distribution of roles within the monitoring process.

In accordance with these M&V plans, the measurement devices have been selected, purchased, installed and commissioned for each pilot.

It should be reminded that the Building Control Center (BCC) of ACCIONA is used within the monitoring process to recover, store and manage all the monitored data coming from all the demonstration sites according to the scheme of Figure 2.1:

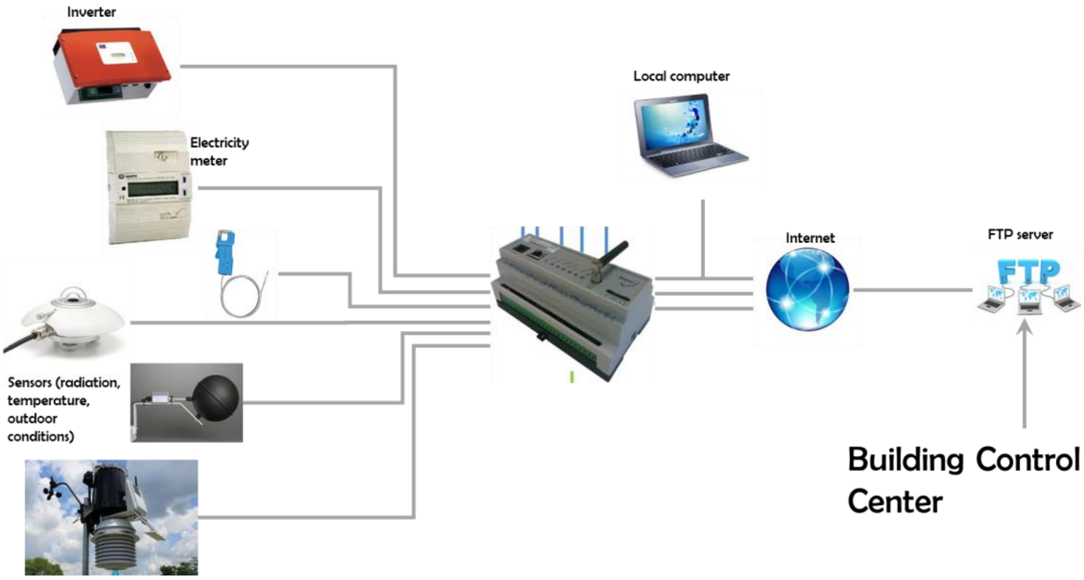


Figure 2.1 General communication concept between the monitoring infrastructure on site and the BCC

Once the data are collected by the gateways locally installed on site and sent to the dedicated ftp server, the BCC developed by ACCIONA gathers the data from the ftp server and performs an aggregation to make these data available for other users (BEMS developed by TECNALIA) according to the scheme displayed in Figure 2.2.

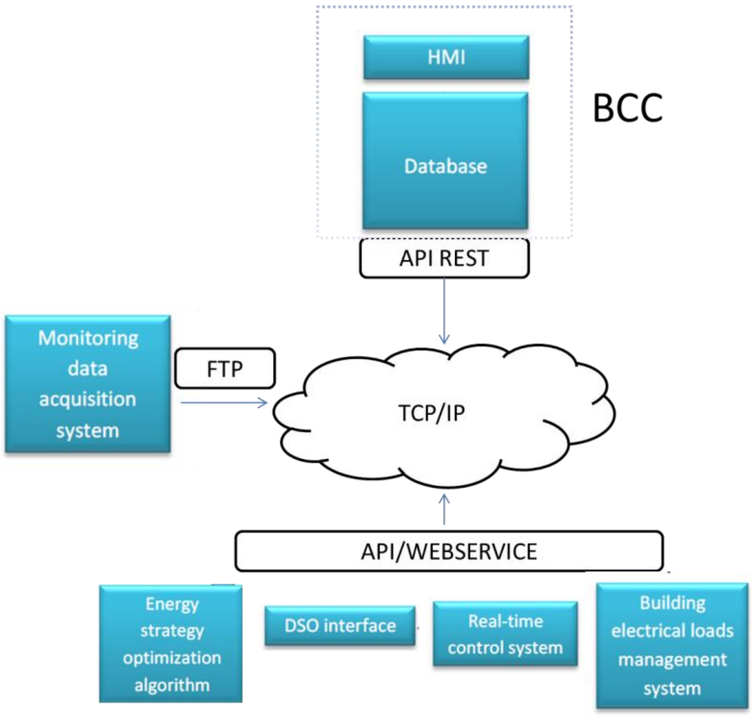


Figure 2.2 BCC integration in the PVSITES Architecture.

3 REPORT ON MONITORING INFRASTRUCTURE DEPLOYMENT FOR THE BASELINE SITUATION ASSESSMENT

This chapter reports the monitoring equipment installation in the pilot sites of the PVSITES project: It gives the main steps of the implementation, provides some photos testifying the installation and includes technical documentation related with devices selected for monitoring purposes.

The following table summarises the dates of installation of the monitoring equipment (for several pilots, the installation has been done in two or three stages).

Table 3.1 Dates of installation of monitoring equipment

Pilot site	Installation of monitoring devices
#1 Format D2	Installation done in one go March 2017
#2 EHG	Installation done in two stages June 2017 January 2018
#3 • CARPORT EMPA • CARPORT EKZ	• No installation performed so far (waiting for progress on the carport construction from FLISOM side). Monitoring installation planned in April 2018 • No installation performed. Data are available from the solar and weather station already present on site
#4 CRICURSA	Installation done in two stages March 2017 July 2017
#5 VILOGIA	Installation done in two stages April 2017 October 2017
#6 TECNALIA	Installation done in three stages April 2017 October 2017 March 2018

Concerning the pilot site#3, the carport initially planned for the demonstration has been replaced by two alternative carports:

- The first one is a new carport built at EMPA facilities,
- The second one is a new carport built at EKZ facilities (EKZ is the local electricity provider for the Zürich canton).

In order to comply with the monitoring budget, it has been decided to install a detailed monitoring instrumentation for the carport that is built in EMPA facilities. And FLISOM will take care of the monitoring of the carport built in EKZ facilities to get basic information. In that frame, and for EKZ carport, data from an existing weather station are collected and will be used for analysis of BIPV production.

3.1 Demo 1 – Format D2 house (Stambruges, BELGIUM)

Table 3.2 provides the list of monitoring devices that have been installed in FD2 house.

Table 3.2 Measurement devices installed in FD2

Equipment installed	Parameters measured or function
1 weather station Vaisala WXT536[1] on the roof of the house	Temperature Relative Humidity Atmospheric pressure Wind speed and direction at the location of the BIPV Rain intensity Hail intensity
1 pyranometer Kipp&Zonen SMP6-First Class[2] installed on the roof of the building with same orientation as the roof	Global Inclined Solar radiation
1 gateway WebdynSun[3]	Collects data from the pyranometer
1 mini-PC	Collects data from the weather station and allows remote maintenance of the whole system

Moreover, in order to have an accurate follow-up of the heating consumption of the house and in addition to the measurements conducted on the electrical line dedicated to heating space, a manual follow-up of the wood consumed has been implemented with the building owner through a monthly weighing of the wood used.

Table 3.3 summarises the measurement devices that were already in place in the building before the project and that are part of the whole monitoring infrastructure used within the project.

Table 3.3 Existing measurements devices already installed on site

Parameters	Target	Scale	Means of measurement
Indoor environmental parameters	Temperature	Each room of the house	Temperature sensors already on site (locations of the sensors are displayed on Figure 3.1)
	Relative humidity	Each room of the house	Humidity sensor already on site
Energy consumptions	Heating consumptions: -Wood -Electricity	Building	Separate electricity meters already on site + manual follow-up of the wood consumed (monthly weighing)

[1] Technical information: https://www.vaisala.com/en/products/instruments-sensors-and-other-measurement-devices/weather-stations-and-sensors/wxt530

[2] Technical information: http://www.kippzonen.com/Product/358/SMP6-Pyranometer#.WrNAmpeDPgc

[3] Technical information: https://www.webdyn.com/photovoltaic-plant-monitoring-webdynsun/?lang=en

	Electricity consumptions per electrical usage: -Lighting -Ventilation -DHW -plugs and others (deduced from the general counter and the other usages)	Building	Separate electricity meters already on site. The global architecture of the electricity measurement infrastructure of the house is provided in Figure 3.2.
	DHW consumptions	Building	Thermal energy meter attached to the heat pump already on site

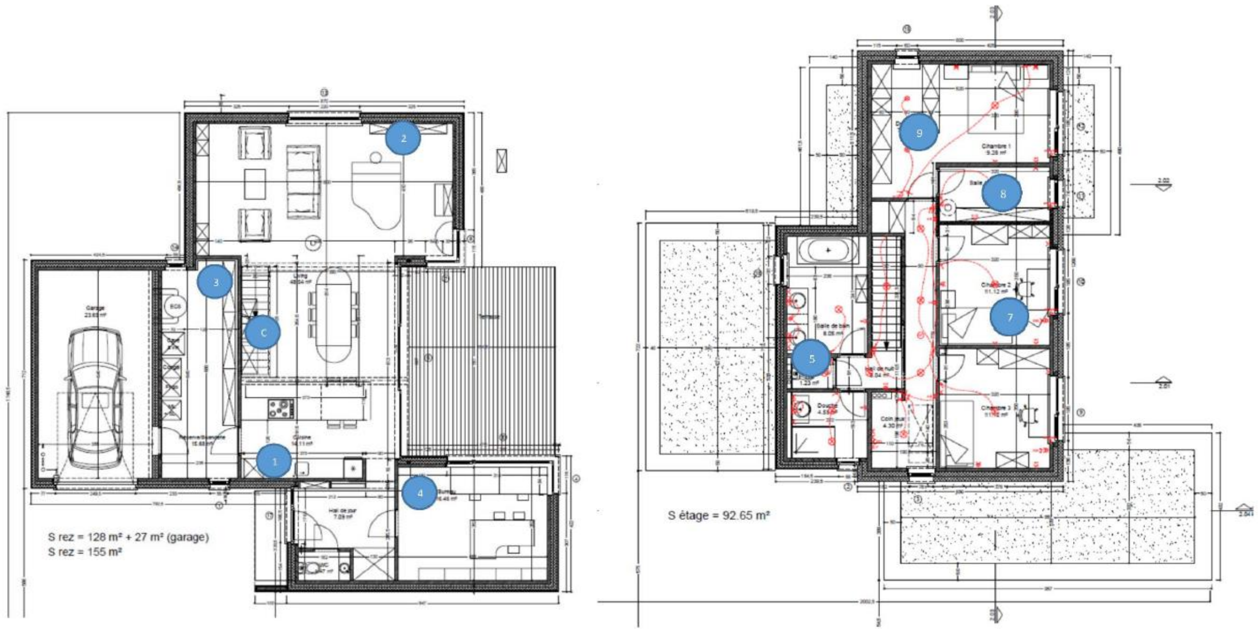


Figure 3.1 : Temperature and Humidity sensors location (first floor on the left, second floor on the right)

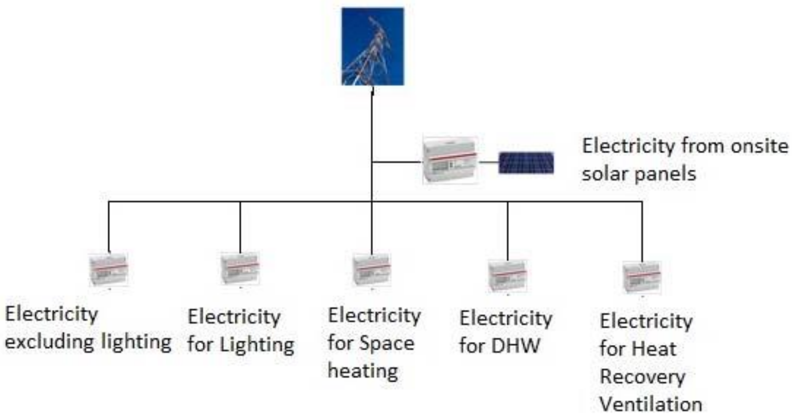


Figure 3.2 Global architecture of the electricity measurement infrastructure already installed on site

This measurement infrastructure together with the devices installed additionally allows to cover the whole M&V plan defined for the PVSITES project.

The following figures show some photos of the weather station after installation.

Figure 3.3 Weather station and pyranometer installed on Format D2 house

Moreover, in order to be compliant with the BIPV system that will be installed in the house, an adjustment has been conducted on the electrical installation of the house. A new three-phase general electricity meter has been installed on site (Figure 3.4) in order to address the future electrical configuration of the house after BIPV installation. The meter includes a channel measuring the electricity coming from the grid and as well a measurement channel measuring the electricity sent to the grid. The connexion of this meter to the monitoring infrastructure has been implemented through the WebdynSun gateway according to the scheme displayed in Figure 3.5 to collect the data directly and send them to the BCC.

Figure 3.4 Photo of the new three-phase general electricity meter installed in the FD2 house

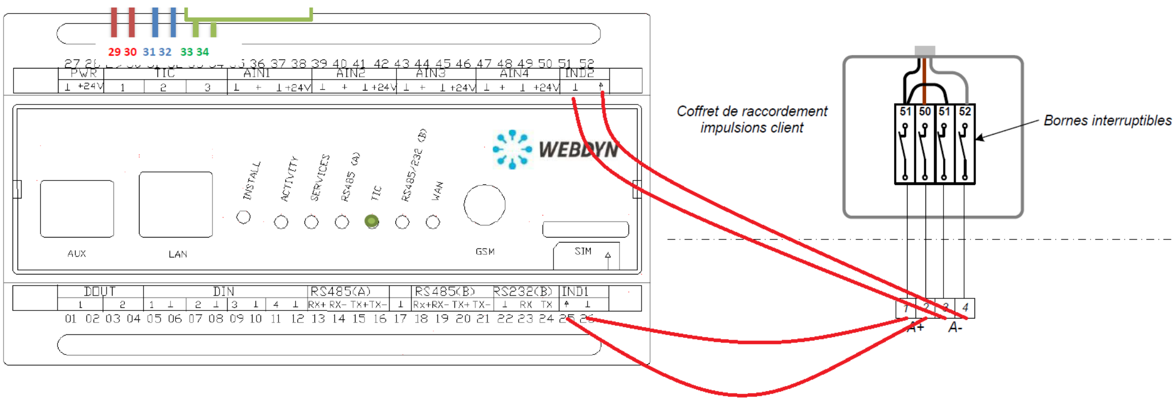


Figure 3.5 Connection of the new general electricity meter to the monitoring infrastructure

In order to have a complete monitoring infrastructure and collect the data remotely, the following configuration is used:

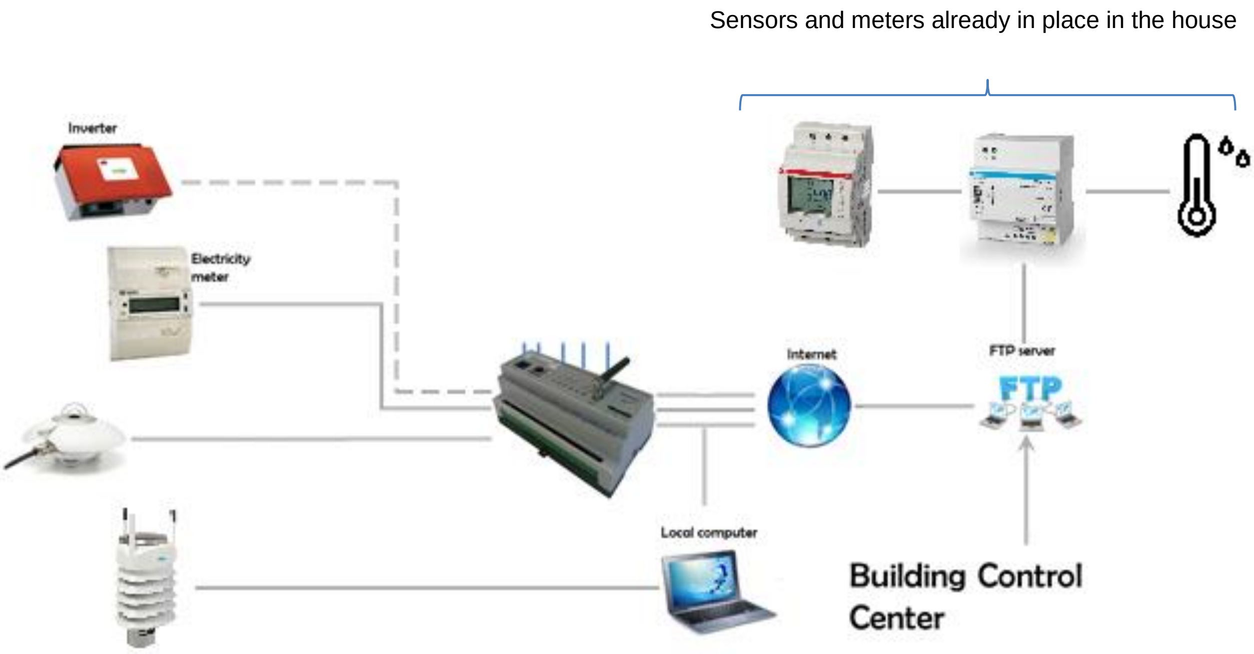


Figure 3.6 General monitoring infrastructure for FD2

Annex 1 (paragraph 6.1) provides the list of data which are collected for FD2, the date from which the data are available and the sample frequency of each data.

3.2 Demo 2 – EHG (Genève, SWITZERLAND)

EHG site has entered late in the project and the installation has been conducted in two stages (first intervention in June 2017 and second intervention in January 2018).

Table 3.4 provides the list of monitoring devices that have been installed in the EHG site.

Table 3.4 Monitoring devices installed in EHG site

Equipment installed	Parameters measured or function
1 weather station Vaisala WXT536 on the roof of pavilion 2	Temperature Relative Humidity Atmospheric pressure Wind speed and direction at the location of the BIPV Rain intensity Hail intensity
2 pyranometers Kipp&Zonen SMP6- First Class	Global solar radiation measured in the planes of the PV cells (vertical position, east and west oriented and free of shadow in both pavilions)
3 wireless T/RH sensors WebdynThyg[4]	Indoor air temperature and relative humidity into 1 classroom of each pavilion located behind the wall on which the BIPV system will be installed (in order to assess a potential impact of the BIPV on the general conditions)
2 surface temperature sensors connected on datalogger Hobo[5] (Pt1000)	Indoor surface temperature
2 gateways WebdynSun	Collect data from the 2 pyranometers
1 gateway Webdyn RF WM-Bus[6] with deported antenna of 10m	Collects data from the indoor conditions sensors
1 mini-PC	Collects data from the weather station and allows remote maintenance of the whole system

Moreover, the general EHG electricity consumption (for the whole block of 3 buildings) is provided by the EHG energy supplier, SIG, with a 15 min sample rate. This data is automatically collected on the FTP server once a day for the previous day.

The following photos illustrate the installation of monitoring devices in the building.

[4] Technical information; https://www.webdyn.com/radio-sensor-webdynthyg/?lang=en

[5] Technical information: http://www.onsetcomp.com/products/data-loggers/u12-012

[6] Technical information: https://www.webdyn.com/meter-datalogger-webdynrf-wmbus/?lang=en


Figure 3.7 Weather station and pyranometer installed on the roof of Pavilion 2

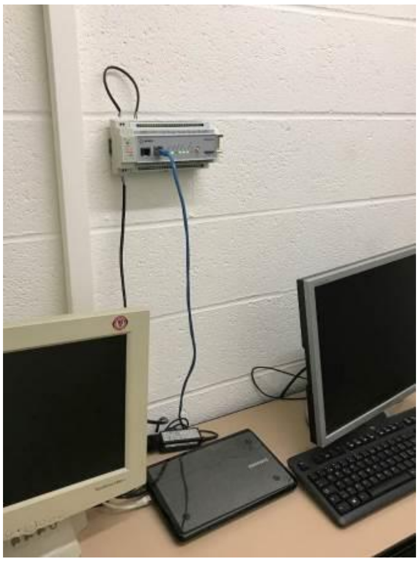
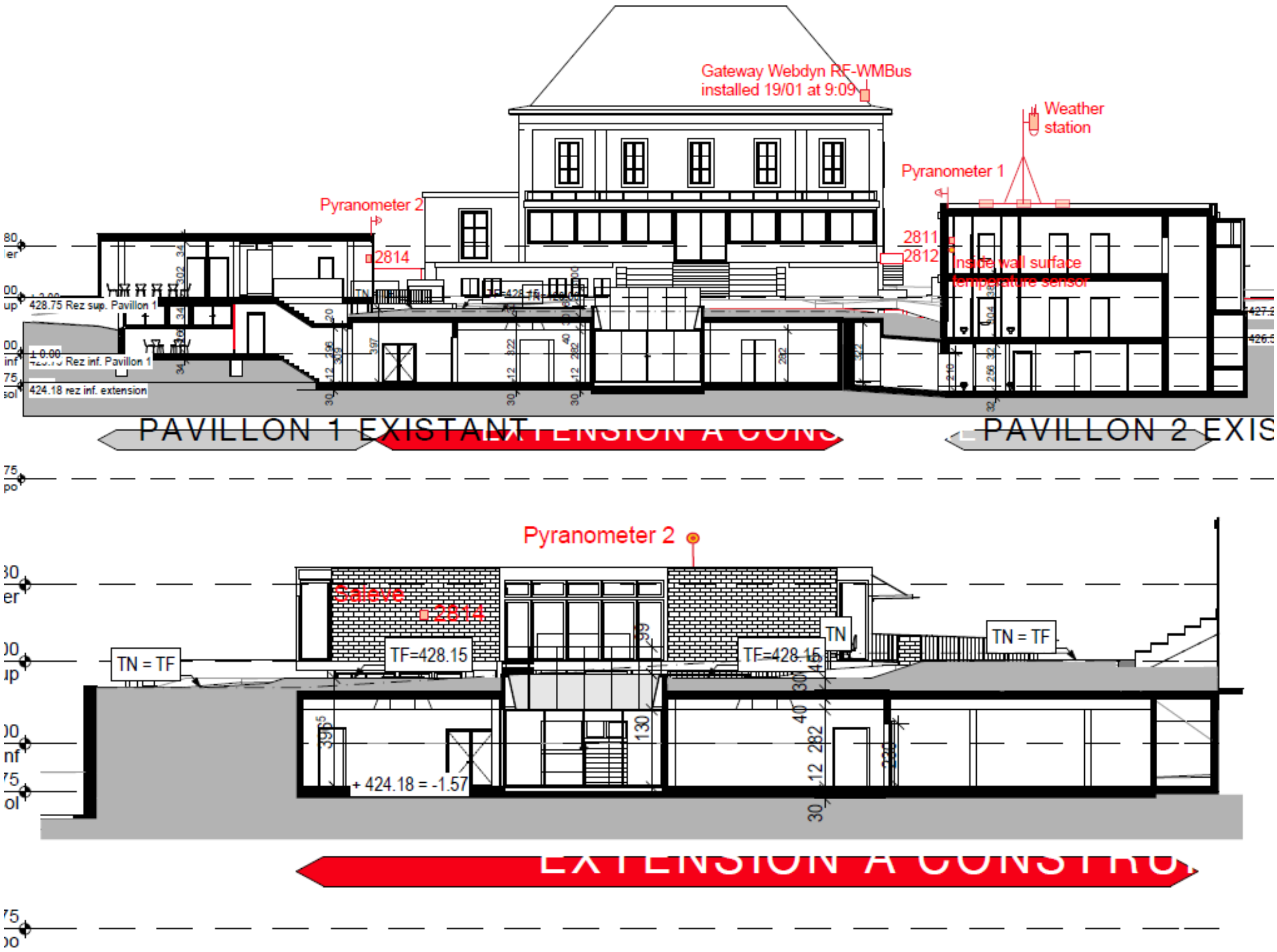



Figure 3.8 Gateway WebdynSun installed in server room on the ground floor of Pavilion 2 (picture on the left) and Gateway WebdynSun installed in ventilation room on the ground floor close to Pavilion 1

Figure 3.9 Wireless T/RH sensors installed in Pavillon & and Pavillon 2

The following pictures provide an overview of the location of the different equipment installed in Pavillon1 and Pavillon2.



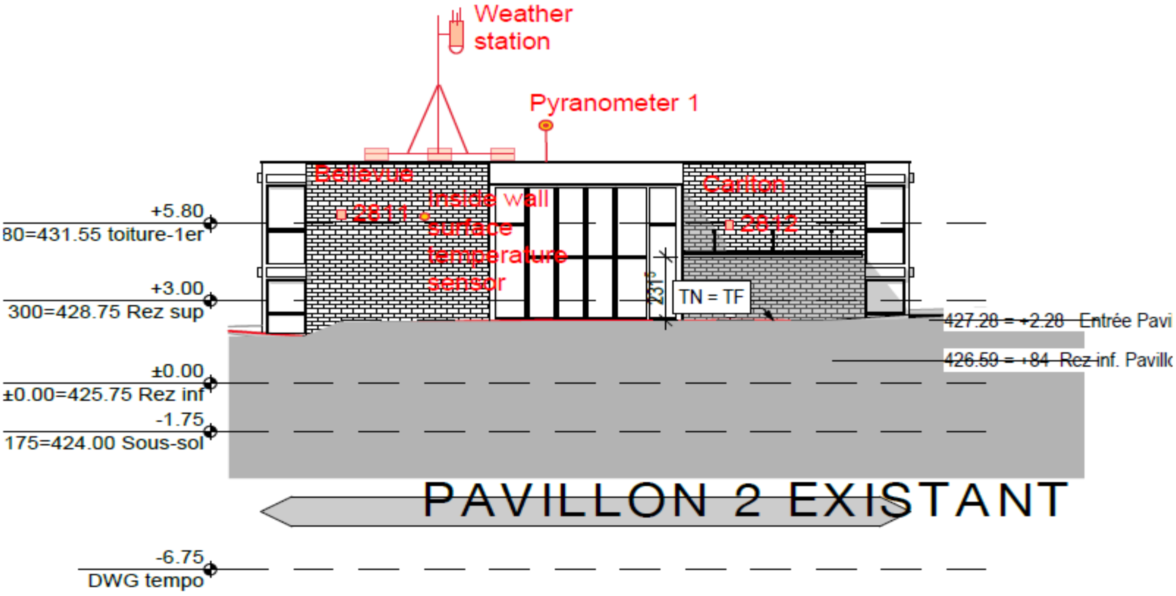


Figure 3.10 Overview of sensors location in both pavillons

Annex 2 (paragraph 6.2) provides the list of data which are collected for EHG site, the date from which the data are available and the sample frequency of each data.

For EHG site, it is envisioned to self-consume the BIPV production for the electricity loads of Pavilions 1 and 2. In order to feed the BEMS with detailed data, we are currently investigating the way to measure these two buildings separately.

3.3 Demo 3 – Carport at EMPA facilities (Dübendorf, SWITZERLAND)

As already pointed out, there is no power demand directly associated to the carport performance, because it is not illuminated nor has any other permanent power load.

As a consequence, no monitoring device has been installed on this pilot site to measure energy consumption. However, a weather station and 2 pyranometers are planned to be installed on site in order to collect outdoor environmental conditions to be used for BIPV performance assessment. As some changes have occurred for this pilot site (a new carport will be built instead of using an existing one), some delays are observed in the installation of the monitoring devices. NOBATEK is waiting for specific work (basement construction + access to a secured room where monitoring equipment can be installed with network connexion) and choices made by FLISOM and EMPA stakeholders in order to proceed to the installation.

Table 3.5 Monitoring devices installed in EMPA site

Equipment to be installed	Parameters measured or function
1 weather station Vaisala WXT536 close to the location of the carport	Temperature Relative Humidity Atmospheric pressure Wind speed and direction at the location of the BIPV Rain intensity Hail intensity
2 pyranometers Kipp&Zonen SMP6- First Class	Global horizontal measurement on the building roof of neighbor building and other pyranometer for global horizontal measurement on the carport roof.
1 gateway WebdynSun	Collects data from the 2 pyranometers
1 mini-PC	Collects data from the weather station and allows remote maintenance of the whole system

The following figure illustrates the location which is planned for the weather station and the pyranometer installation.

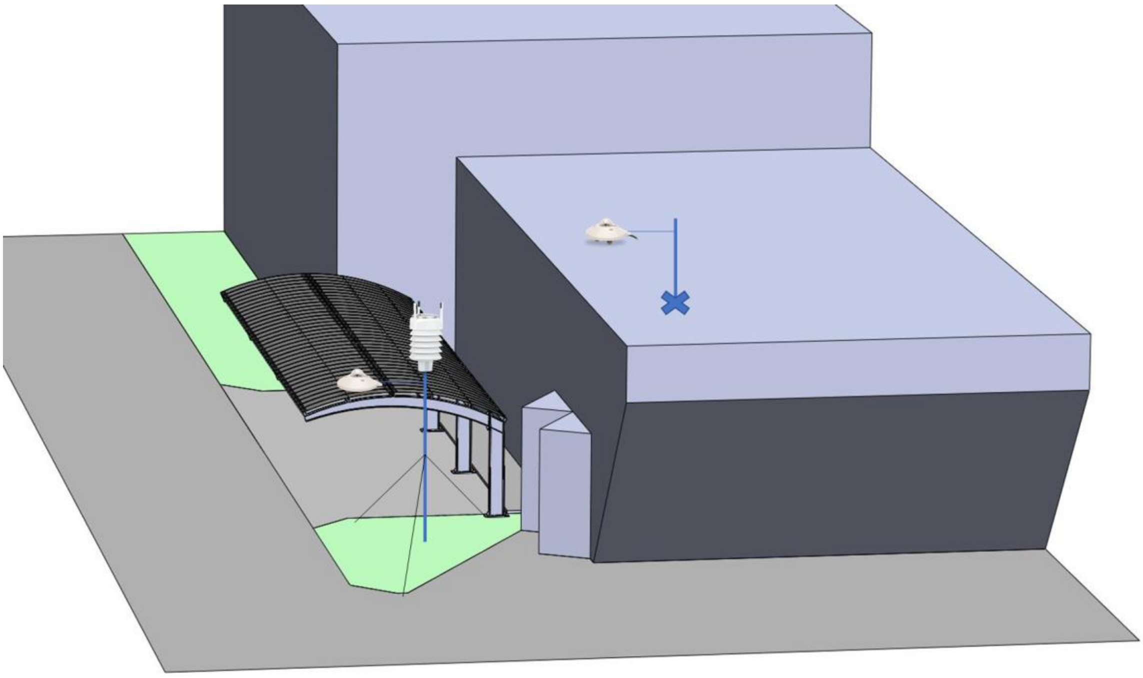


Figure 3.11 Overview of sensors location

3.4 Demo 4 – CRICURSA building (Granollers, SPAIN)

Table 3.6 provides the list of monitoring devices that have been installed in CRICURSA site.

Table 3.6 Monitoring devices installed in CRICURSA site

Equipment installed	Parameters measured or function
1 weather station Vaisala WXT536	Temperature Relative Humidity Atmospheric pressure Wind speed and direction at the location of the BIPV Rain intensity Hail intensity
1 pyranometer Kipp&Zonen SMP6-First Class	Global solar radiation measured in the plane of the PV cells
3 Clamp-on sensors for electricity lines of heating and cooling systems of offices (2levels) and plugs	Energy and power of electricity lines related with heating and cooling systems of offices (2levels) and plugs
3 Pt 1000 sensors	Internal roof surface temperature at the location of the BIPV
3 wireless T/RH sensors WebdynThyg	Air temperature and relative humidity in 3 points under the roof at the location of the BIPV
1 gateway Webdyn RF WM-Bus with deported antenna of 10m	Collects data from the indoor conditions sensors and from electricity meters
1 gateway WebdynSun	Collects data from the pyranometer and Pt 1000 sensors
1 mini-PC	Collects data from the weather station and allows remote maintenance of the whole system

The electricity consumption of the whole CRICURSA building is manually collected from the CRICURSA ESCo Opyce. This data is collected with a 15 min sample rate and manually sent by CRICURSA building manager on a weekly basis.

The following photos illustrate the installation of monitoring devices in the building.

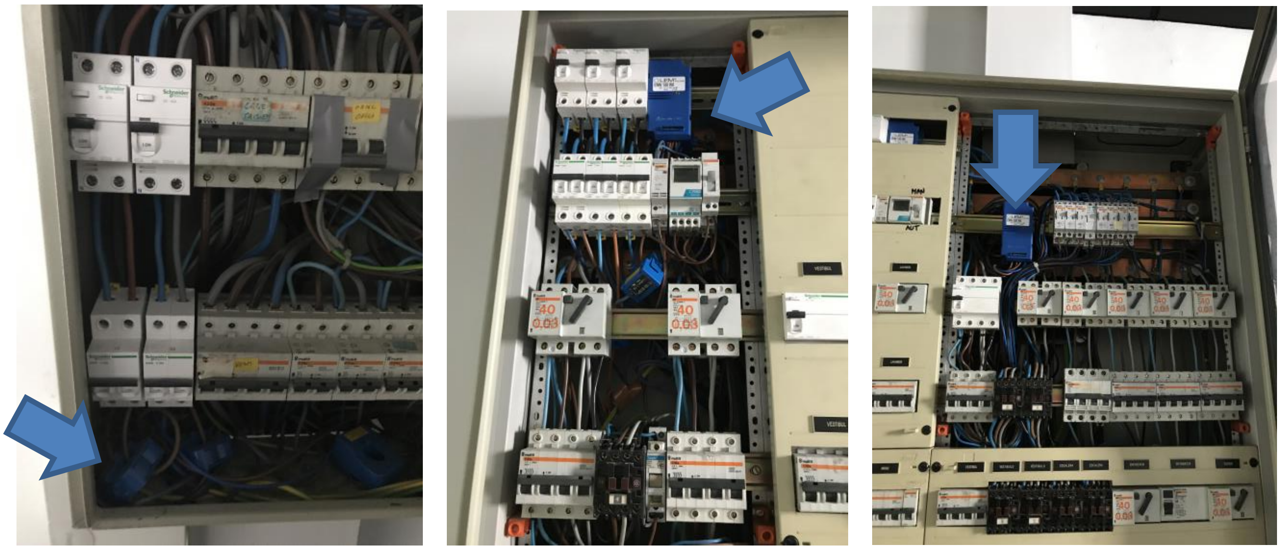


Figure 3.12 Clamp-on sensors installed in the electrical boxes of the CRICURSA building

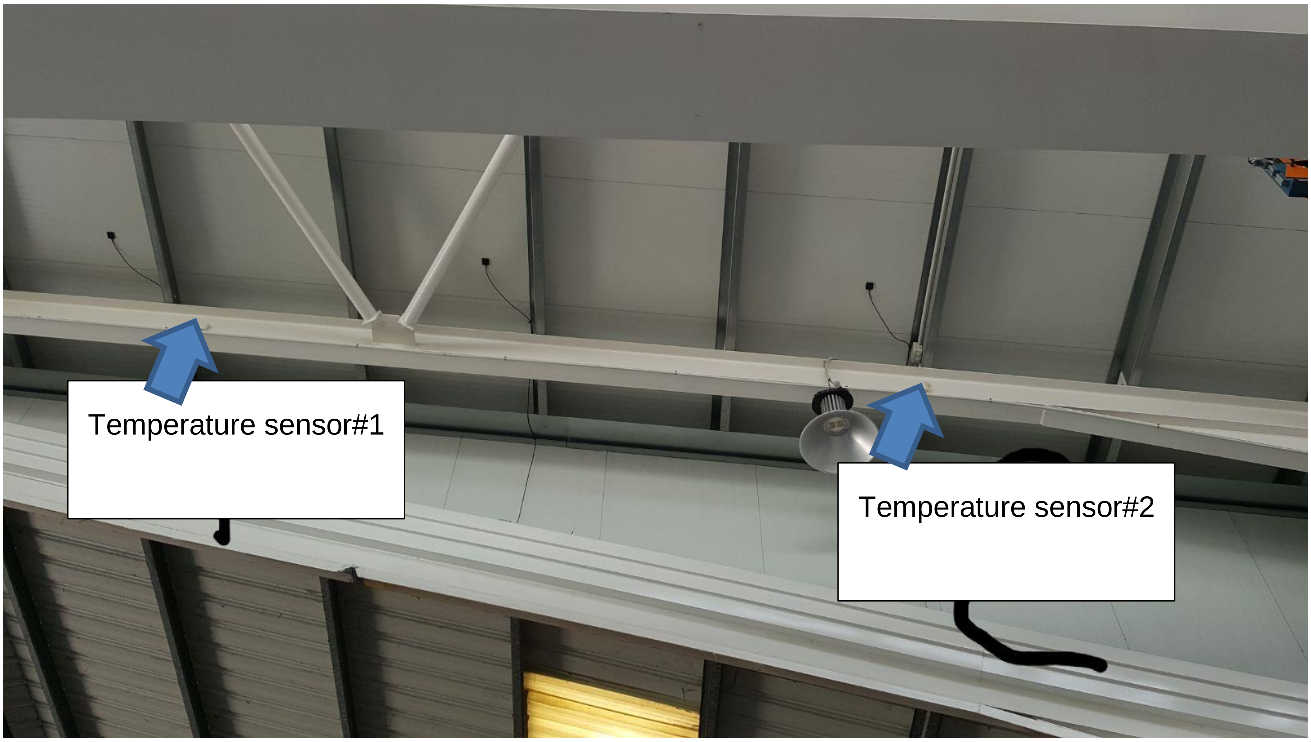


Figure 3.13 Temperature sensors installed in the factory building

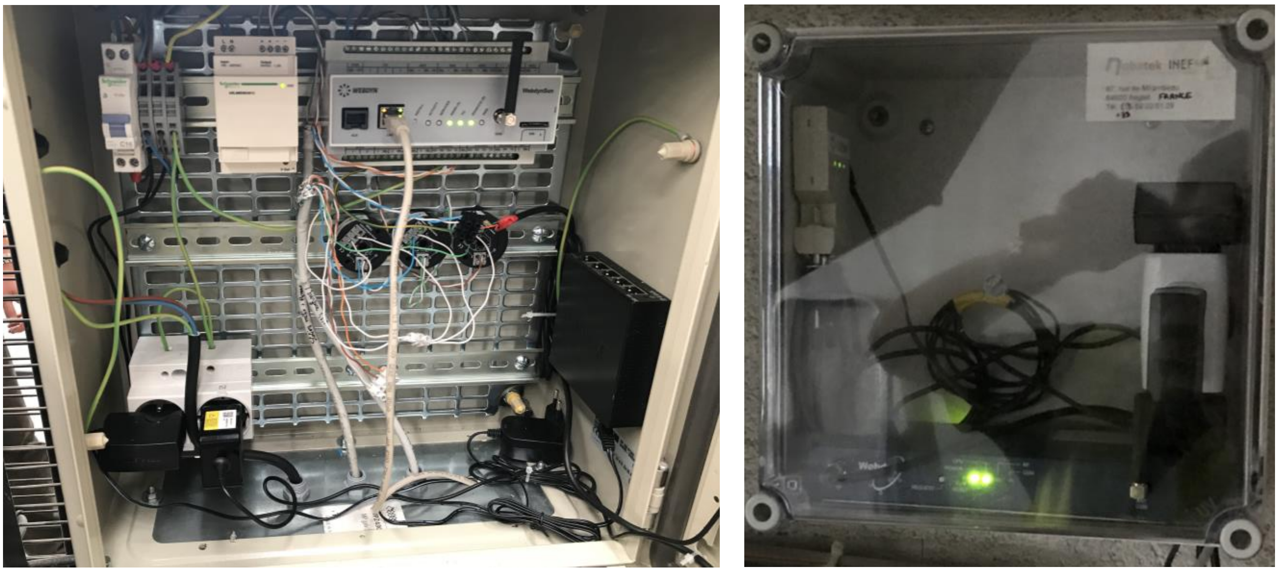


Figure 3.14 Monitoring boxes including the gateways collecting the data from the temperature sensors, from the weather station and from the electrical clamp-on sensors

Figure 3.15 Remote antenna for communication with wireless T/RH sensors

Annex 3 (paragraph 6.3) provides the list of data which are collected for CRICURSA site, the date from which the data are available and the sample frequency of each data.

3.5 Demo 5 – VILOGIA building (Wattignies, FRANCE)

Table 3.7 provides the list of monitoring devices that have been installed in VILOGIA building.

Table 3.7 Monitoring devices installed in VILOGIA building

Equipment installed	Parameters measured or function
1 weather station Vaisala WXT536	Temperature Relative Humidity Atmospheric pressure Wind speed and direction at the location of the BIPV Rain intensity Hail intensity
1 pyranometer Kipp&Zonen SMP6-First Class	Global solar radiation measured in the plane of the PV cells
4 optical readers FLUDIA[7]	Energy consumed by common spaces of the building (entrances 12, 13 and 14)
3 HOBO sensors + dataloggers	Air temperature and relative humidity in the area behind the wall where the BIPV will be installed
2 wireless WM-BUS T/RH sensors WebdynThyg	Air temperature and relative humidity into the dwellings behind the wall planned for BIPV installation
4 Pt 1000	Interior and exterior wall surface temperature
1 pulse counter SOCOMEC[8]	Pulses counting from the 4 optical readers Fludia
1 gateway WebdynSun	Collects data from the pyranometer and exterior wall surface temperature sensor
1 gateway WebdynRF WM-BUS with distant antenna	Communication gateway with 2 temperature/relative humidity sensors WM-BUS
1 mini-PC	Collects data from the weather station and allows remote maintenance of the whole system

The electricity consumption data of the general common spaces is collected manually by the energy supplier of the building twice per year (estimations are also delivered on a two-monthly basis). This regular manual monitoring allows a cross-checking with the automatic measurement conducted with the Fludia sensor than can be impaired by the general state of old electricity meters.

Heating consumption data is not collected because the common spaces and dwellings are heated by a central heating network.

The following photos illustrate the installation of the monitoring devices in the building.

[7] Technical information: https://www.fludia.com/-FM200-interfaces-optiques-.html

[8] Technical information: https://www.socomec.com/files/live/sites/systemsite/files/SCP/6_gestion_energie/countis/countis_e/538470a_F.pdf

Figure 3.16 Fludia sensors connnected on various electricty meters corresponding to lines feeding common spaces of the building

Figure 3.17 Weather station and pyranometer installed on the roof of the building

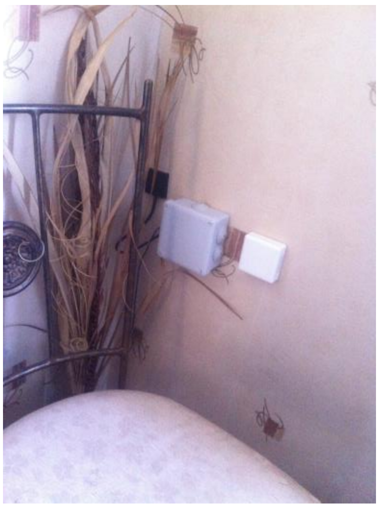


Figure 3.18 Air temperature/relative humidity sensors and wall temperature sensor

Figure 3.19 Gateway associated with the weather station

Figure 3.20 Monitoring control room (gateway, computer for remonte access…)

Figure 3.21 describes the overall implementation of the different devices used within the monitoring infrastructure of VILOGIA building.

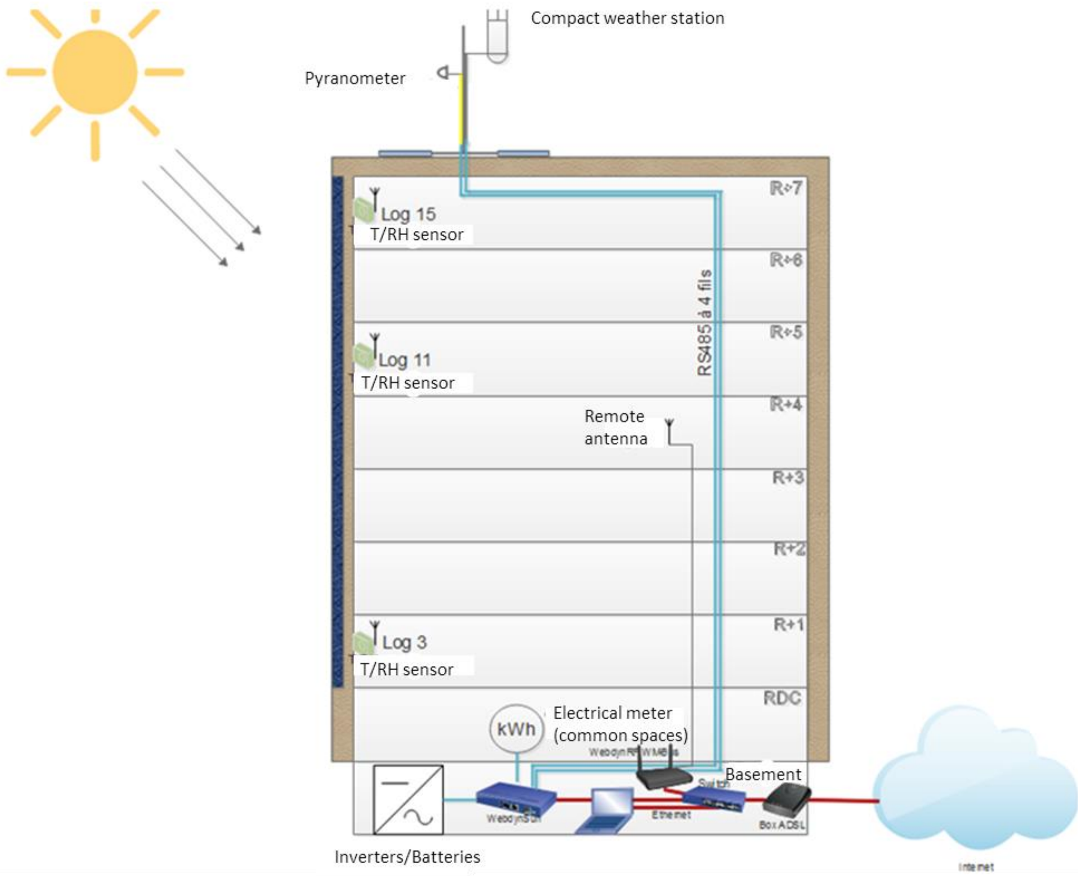


Figure 3.21 Overall implementation of the monitoring infrastructure in VILOGIA building

Annex 4 (paragraph 6.4) provides the list of data which are collected for VILOGIA building, the date from which the data are available and the sample frequency of each data.

3.6 Demo 6 – TECNALIA building (San Sebastian, SPAIN)

Table 3.8 provides the list of monitoring devices that have been installed in TECNALIA building.

Table 3.8 Monitoring devices installed in TECNALIA building

Equipment installed	Parameters measured or function
1 weather station Vaisala WXT536	Temperature Relative Humidity Atmospheric pressure Wind speed and direction at the location of the BIPV Rain intensity Hail intensity
Solar Tracker Kipp&Zonen RaZON+[9]	Direct and diffuse solar irradiation
4 direct electricity meters Schneider Electric A9MEM3155[10]	Energy consumed by the offices areas (2 floors, 2 parts of building, lighting+others)
4 WM-BUS sensors WebdynThyg	Air temperature and relative humidity on 2 floors and 2 parts of building just behind the glass façade where the BIPV will be installed
1 Pyranometer Kipp&Zonen SMP6-First Class + rotating support (vertical position)	Indoor solar radiation on the first floor just behind the glass facade
1 Pt 1000 black ball sensor	Operative temperature on the first floor just behind the glass facade
1 PT1000 with signal converter	Indoor window surface temperature on the first floor just behind the glass facade
1 Pyranometer Kipp&Zonen SMP6-A First Class	Outdoor global solar irradiation in the plane of the BIPV
1 gateway WebdynSun	Collects data from outdoor pyranometer, solar tracker and electricity meters
1 gateway WebdynRF WM-BUS	Collects data from wireless temperature/relative humidity sensors WM-BUS and from indoor pyranometer
1 mini-PC	Collects data from the weather station and allows remote maintenance of the whole system

Figure 3.22 describes the overall implementation of the different devices used within the monitoring infrastructure of TECNALIA building.

[9] Technical information: http://www.kippzonen.com/Product/378/RaZON#.WrNPkZeDPgc

[10] Technical information: https://www.schneider-electric.fr/fr/product/A9MEM3155/acti9-iem---compteur-d%27%C3%A9nergie-tri---63a---multitarif---alarme-kw---modbus---mid

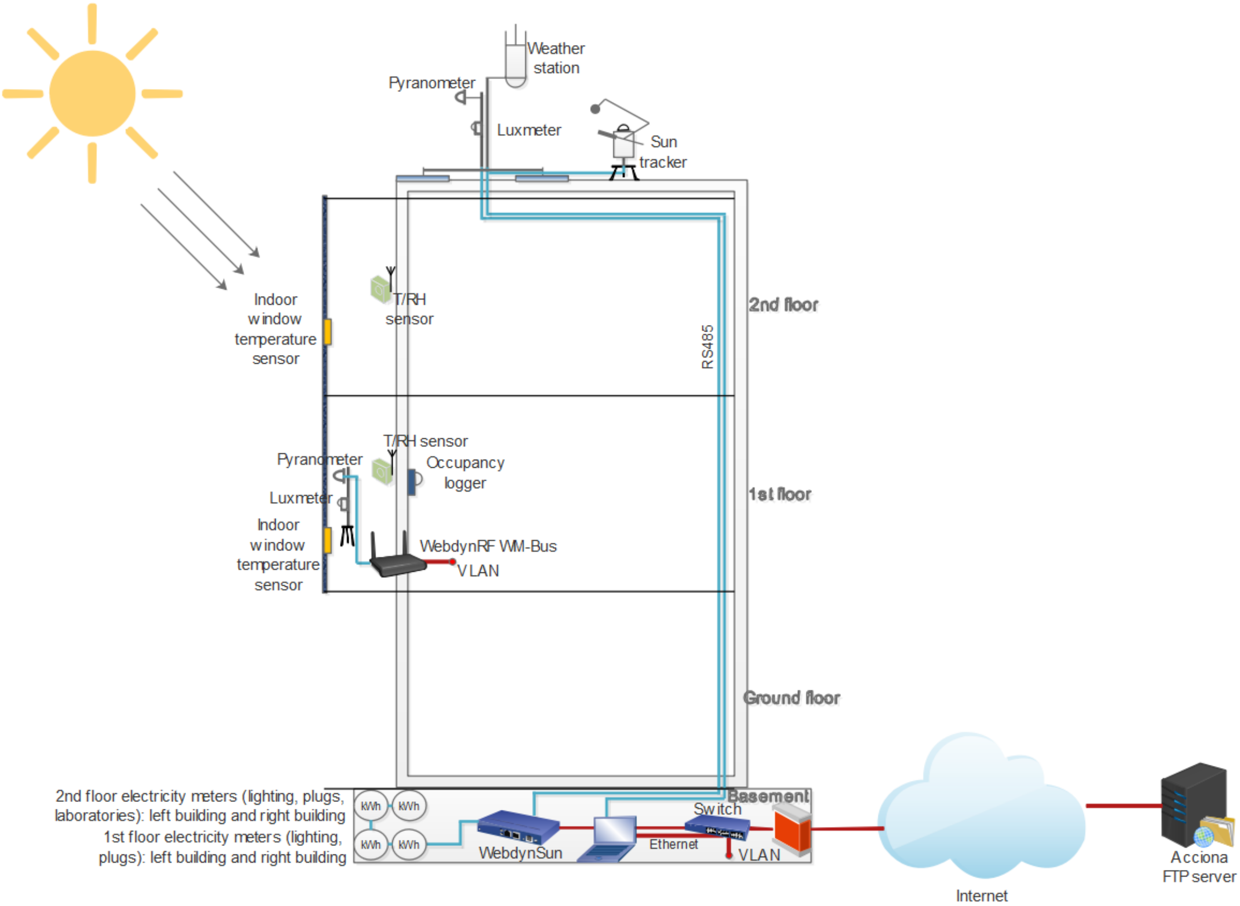


Figure 3.22 Overall implementation of the monitoring infrastructure in TECNALIA building

The following photos illustrate the installation of the monitoring devices in the building.

Figure 3.23 Weather station and solar tracket installed on the roof of TECNALIA building

Figure 3.24 Electricity meters installed in the elctrical board and covering the consumptions of the offices areas of the building

Figure 3.25 Operative temperature sensor, air temperature + relative humidity sensor, and luminance sensor installed in the buffer area located behind the window where the BIPV system will be installed

Figure 3.26 and Figure 3.27 provide an overview of sensors location in both levels where BIPV will be installed.

Figure 3.26 Location of the sensors on the first floor of the building

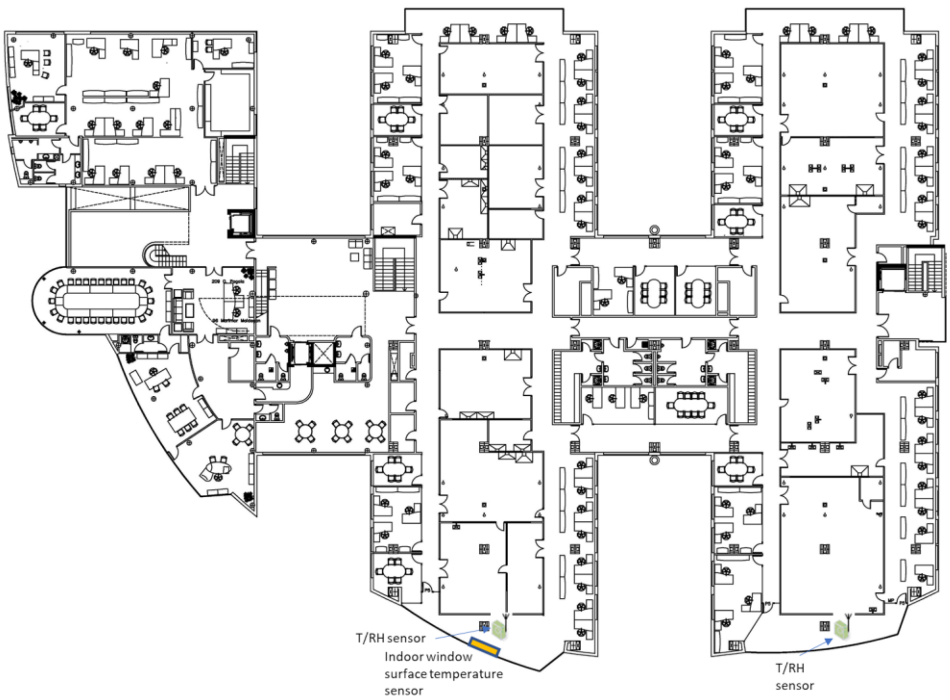


Figure 3.27 Location of the sensors on the second floor of the building

Annex 5 (paragraph 6.5) provides the list of data which are collected for VILOGIA building, the date from which the data are available and the sample frequency of each data.

3.7 Main difficulties encountered during implementation of monitoring and lessons learnt

An overall methodology has been defined and implemented within the project in order to get a common performance evaluation process for all six pilot sites. However, the implementations of this monitoring strategy led to adaptations in the methodology and in its application, giving the opportunity during this preliminary phase to learn various lessons on this topic.

From the observation realized between initial methodology and pragmatic implementation on sites, the main lessons learned about monitoring practices are presented hereafter.

- Involvement of buildings owners and local technical representation: some difficulties have been noticed for gathering information about some of the demonstration sites when the site owner is not involved as partner in the project for instance. On the contrary, a great support has been received from the pilot sites managers who are also partners in the project for speeding up the process or solving issues related with site specificities. This is of crucial importance when deploying a monitoring infrastructure especially when the implementation schedule is short.

- Monitoring plan: the selection of sensors and definition of M&V plans are critical in order to achieve the right balance of usefulness, cost and local stakeholders' inconvenience. During the phase of the M&V plans definition, additional requirements have been expressed by WP6 '"Building energy management system for different building uses"). And WP8 has tried as far as possible to include these requirements in the M&V plans definition in order to share the needs and manage equipment purchase efficiently. This may potentially and punctually slow down the whole process.

- Data missing: communication between the different equipment when wireless technology is used is a recurrent issue that highly depends on the monitoring infrastructure. Communication problems can lead to data missing over long periods of time penalising the data analysis. The capacity of the monitoring system to automatically detect errors and to evaluate the accuracy of the treated data (i.e. missing data or data indicating a wrong value) should be strong enough in order to improve the reliability of the data collected through the monitoring infrastructure.

- The local networks of pilot sites are used for data sending to the ftp server. Due to security constraints in place in some demonstration sites, the implementation process has been slowed down by the delays required to get authorisations and specific set-up from the local IT managers.

4 MEASUREMENT PLAN FOR THE BIPV PERFORMANCE ASSESSMENT

Regarding the BIPV performance assessment, a first plan has been established and proposed in the deliverable D8.8 “Specific monitoring plan for every demonstration site”.

The main objectives regarding the measurement associated with BIPV assessment are the following:

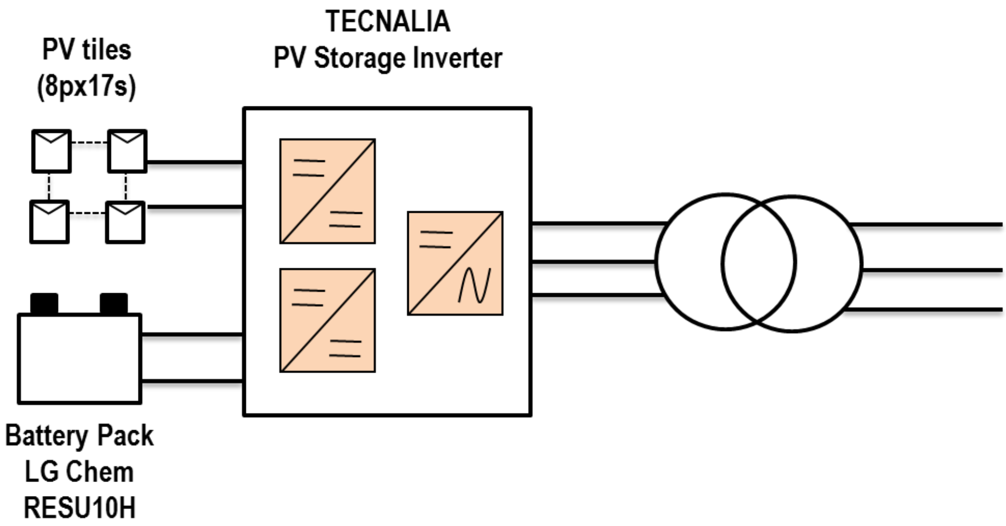
- Evaluate the real energy which is produced by the whole system according to the environmental conditions (solar radiation, temperature, wind) and the functioning parameters (module temperature) in addition to the evaluation of the influence of the BIPV systems on the buildings energy performance and comfort conditions,
- Compare these results to the expectations and simulations conducted in other WPs of the project. This will be done continuously and will lead to intervention on the BIPV system itself when required or when a performance gap is observed.

Since the delivery of D8.8 (July 2017), several adjustments have been made in the design of BIPV installation and selection of inverters and batteries technologies.

The following paragraphs present the electrical configurations that are currently retained for all the pilot sites and the complementary instrumentation that should be deployed to cover the M&V plan defined in D8.8.

4.1 Electrical configurations retained for all the pilot sites

The following schemes (Figure 4.1 up to Figure 4.6) present the electrical configurations retained for each pilot site.



s

Figure 4.1 Electrical configuration for FD2 house

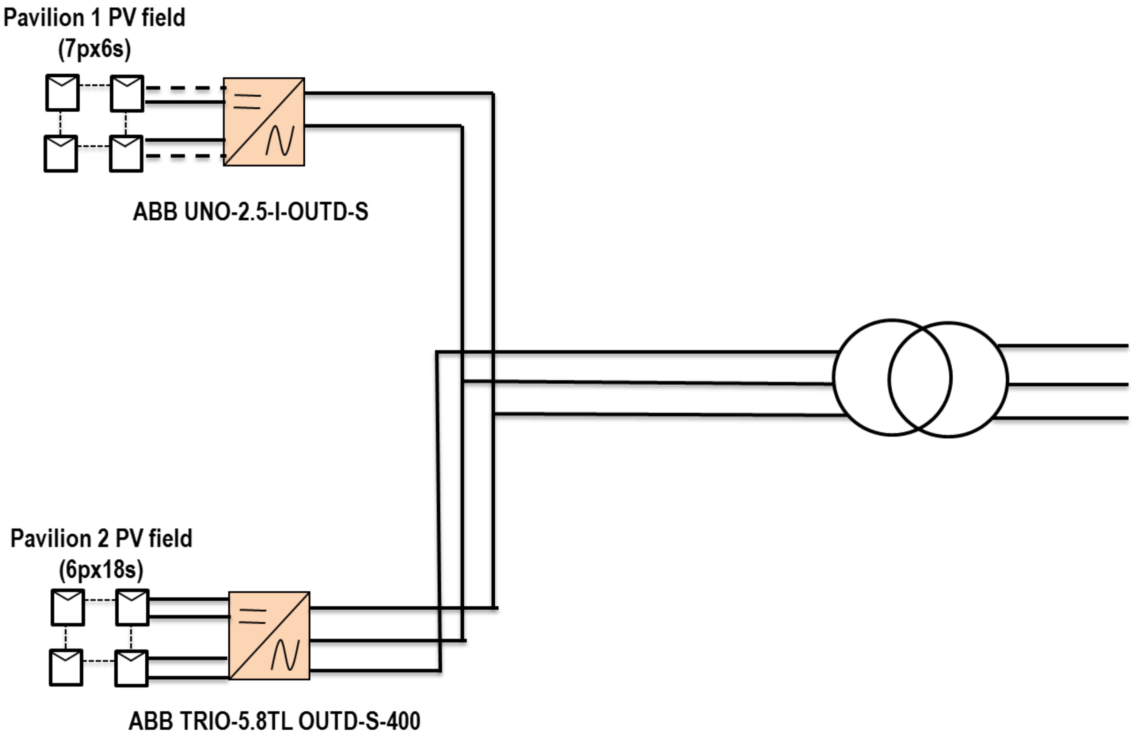


Figure 4.2 Electrical configuration for EHG site

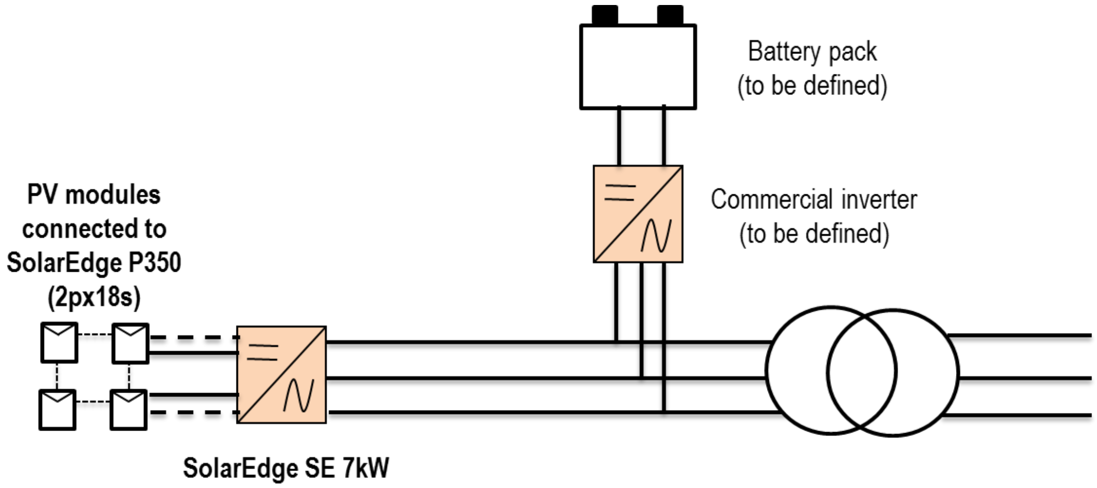


Figure 4.3 Electrical configuration for the EMPA carport

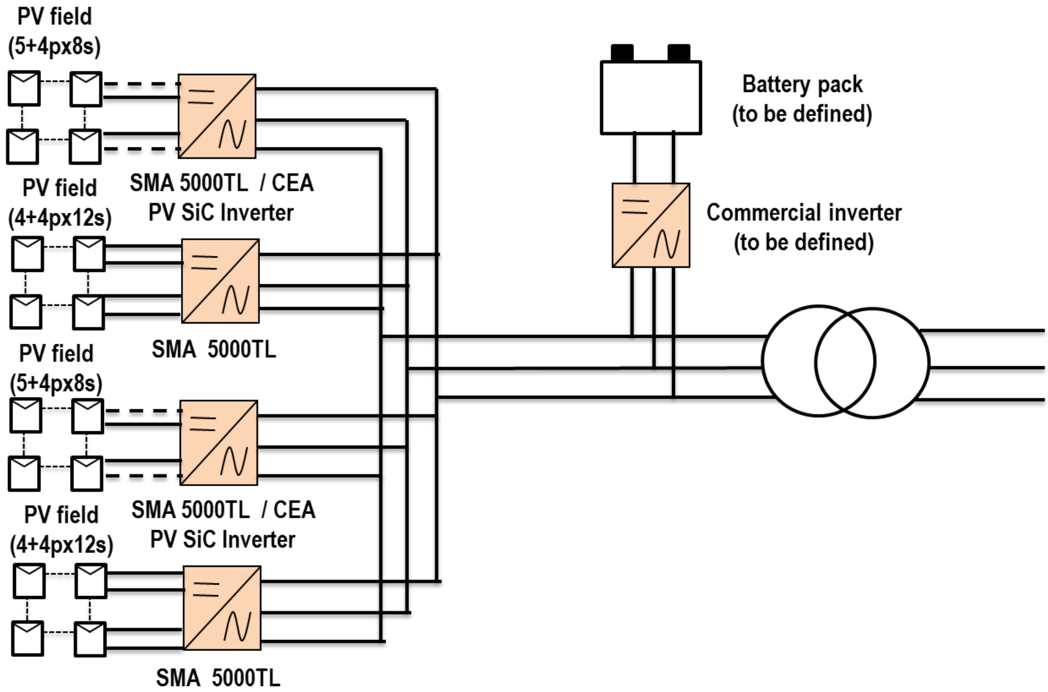


Figure 4.4 Electrical configuration for CRICURSA building

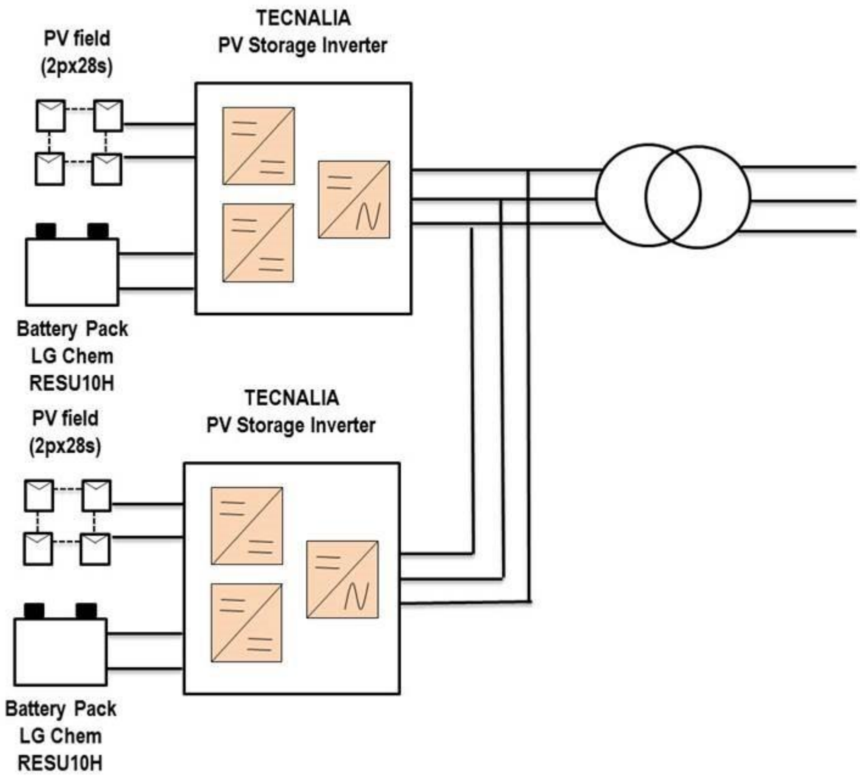


Figure 4.5 Electrical configuration for VILOGIA building

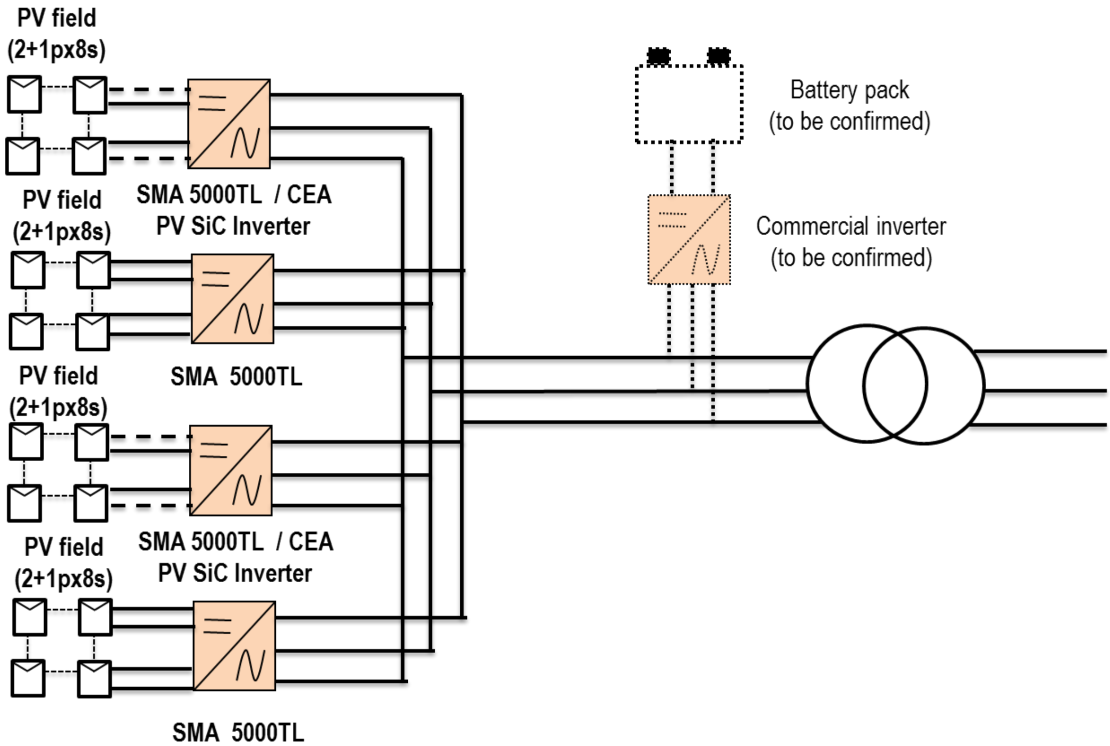


Figure 4.6 Electrical configuration for TECNALIA building

Some of the commercial inverters selected for the demonstrators include integrated measurements. So, in this case, there is no need to install complementary instrumentation. Concerning the inverters that are developed by TECNALIA and CEA, additional or redundant instrumentation is required to cover the whole M&V plan. The technical features of these selected commercial inverters are provided in Appendix 6 (paragraph 6.6)

4.2 Complementary instrumentation to be deployed for BIPV performance assessment

According to the electrical configurations, several additional meters need to be deployed to cover the whole M&V plans and objectives of the project (see Table 4.1). This equipment will be deployed at the same time or just after the BIPV systems are installed in the pilot sites.

Table 4.1 Additional instrumentation to be planned for the assessment of BIPV systems performances during the reporting period

PILOTS	Additional instrumentation to be planned	Boundary of the measurement
Pilot #1	1 electrical meter/power meter	Energy and Electrical power produced by the BIPV at the output of the inverter
	2 self-adhesive sensors PT1000 with signal converters	Surface temperature of the BIPV modules (back side)
	2 Wattmeter ACCUENERGY	Electrical power and energy (DC current) before the inverter
Pilot #2	2 Self-adhesive sensors PT1000	Surface temperature on the back side of the module
Pilot #3	1 Self-adhesive sensor PT1000 with signal converters	Surface temperature on the back side of the module
Pilot #4	1 bidirectional Electrical meter	Electricity coming from and going to the grid
	2 electrical meters	Energy and Electrical power produced by the BIPV at the output of the inverter
	2 Wattmeter ACCUENERGY	Electrical power and energy (DC current) before the inverter
	2 self-adhesive sensors PT1000 with signal converter	Surface temperature on the back side of the module
	1 PT1000 sensor with signal converter	Air temperature of the air gap between the BIPV and the roof
Pilot #5	PT1000 sensor with signal converter	Air temperature of the gap between the BIPV and the wall
	2 bidirectional electrical meters	Energy and Electrical power produced by the BIPV at the output of the inverter
	4 Wattmeter ACCUENERGY	Electrical power and energy (DC current) before the inverter
	2 self-adhesive sensors PT1000 with signal converter	Surface temperature of the BIPV modules (back end)
Pilot #6	2 electrical meters	Energy and power produced by the BIPV at the output of the inverter
	2 Wattmeter ACCUENERGY	Electrical power and energy (DC current) before the inverter
	2 self-adhesive sensors PT1000 with signal converter	Surface temperature on the back side of the module

In parallel to the concrete measurements of physical parameters, punctual and periodical visual observation (monthly observation for instance) will be conducted in order to check visual aspect of the BIPV modules (dust deposit for instance).

5 CONCLUSIONS

Deliverable D8.10 reports the installation of monitoring equipment that was conducted in the pilot sites to establish the baseline situation of the sites in terms on energy performance and indoor environmental conditions. The document also presents the monitoring equipment that is planned to be deployed in addition to assess the BIPV systems performance. This equipment will be deployed at the same time or just after the BIPV systems are installed in the pilot sites.

6 APPENDICES

6.1 Appendix 1: Summary of the data collected for Pilot#1 for the baseline period

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
Outdoor Temperature	Outdoor Temperature	°C	10	01/04/2017
Relative humidity outdoor	Outdoor relative humidity	%RH	10	01/04/2017
Atmospheric pressure	Atmospheric pressure	hPa	10	01/04/2017
Wind speed	Wind speed	m/s	10	01/04/2017
Wind direction	Wind direction	degrees	10	01/04/2017
Inclined global irradiation	Global non-corrected solar radiation in the plane of PV panels	W/m^2	10	01/04/2017
Corrected inclined global irradiation	Global corrected solar radiation in the plane of PV panels	W/m^2	10	01/04/2017
Pyranometer temperature	Outdoor temperature measured by pyranometer in the plane of PV panels	°C	10	01/04/2017
Domestic hot water power and energy consumption	Domestic hot water system electricity consumption	W, Wh	10	01/01/2016
Heater power and energy consumption	Heater electricity consumption	W, Wh	10	01/01/2016
Lighting system power and energy consumption	Total lighting electricity consumption of the house	W, Wh	10	01/01/2016
Ventilation system power and energy consumption	Ventilation system electricity consumption	W, Wh	10	01/01/2016
Appliances power and energy consumption	Appliances electricity consumption	W, Wh	10	01/01/2016

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
Thermal power and energy for domestic hot water	Thermal energy	W, Wh	10	01/01/2016
Wood consumption for heating	Wood consumed for the heating of the house	Kg, kWh	1 month	01/04/2017
Temperature and relative humidity	Temperature and relative humidity in 8 rooms of the building	°C, %RH	10	11/01/2016
General electricity consumption	General electricity consumption of the whole building	kWh	10	02/02/2018

6.2 Appendix 2: Summary of the data collected for Pilot#2 for the baseline period

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
Outdoor Temperature	Outdoor Temperature	°C	10	No data
Relative humidity outdoor	Outdoor relative humidity	%RH	10	No data
Atmospheric pressure	Atmospheric pressure	hPa	10	No data
Wind speed	Wind speed	m/s	10	08/07/2017
Wind direction	Wind direction	degrees	10	08/07/2017
Inclined global irradiation	Global non-corrected solar radiation in the plane of PV panels on Pavilion 2	W/m^2	10	30/06/2017
Corrected inclined global irradiation	Global corrected solar radiation in the plane of PV panels on Pavilion 2	W/m^2	10	30/06/2017
Pyranometer temperature	Outdoor temperature measured by pyranometer in the plane of PV panels on Pavilion 2	°C	10	30/06/2017
Inclined global irradiation	Global non-corrected solar radiation in the plane of PV panels on Pavilion 1	W/m^2	10	18/01/2018
Corrected inclined global irradiation	Global corrected solar radiation in the plane of PV panels on Pavilion 1	W/m^2	10	18/01/2018
Pyranometer temperature	Outdoor temperature measured by pyranometer in the plane of PV panels on Pavilion 1	°C	10	18/01/2018
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions in classroom Salève, Pavilion 1	°C	15	30/06/2017
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions in classroom Bellevue, Pavilion 2	°C	10	18/01/2018

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions in classroom Carlton, Pavilion 2	°C	10	18/01/2018
Wall surface temperature Pavilion 1	Wall surface temperature in classroom Salève, Pavilion 1	°C	10	18/01/2018
Wall surface temperature Pavilion 2	Wall surface temperature in one classroom in Pavilion 2	°C	10	18/01/2018
General electricity consumption	Electricity consumption of the whole EHG demo site	kWh	15	01/01/2016
General gas consumption	Gas consumption for heating and cooking for the whole EHG demo site	kWh	Monthly	01/01/2016

6.3 Appendix 3: Summary of the data collected for Pilot#4 for the baseline period

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
Temperature outdoor	Outdoor temperature	°C	10	20/07/2017
Relative humidity outdoor	Outdoor relative humidity	%RH	10	20/07/2017
Atmospheric pressure	Atmospheric pressure	hPa	10	20/07/2017
Wind speed	Wind speed	m/s	10	20/07/2017
Wind direction	Wind direction	degrees	10	20/07/2017
Inclined global irradiation	Global non-corrected solar radiation in the plane of PV panels	W/m^2	10	20/07/2017
Corrected inclined global irradiation	Global corrected solar radiation in the plane of PV panels	W/m^2	10	20/07/2017
Pyranometer temperature	Outdoor temperature measured by pyranometer in the plane of PV panels	°C	10	20/07/2017
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions below the roof at the middle point	°C, %RH	15	20/07/2017
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions below the roof at the edge point	°C, %RH	15	20/07/2017
Indoor roof surface temperature	Surface temperature on the roof at the high point at the location planned for BIPV installation	°C	10	20/07/2017
Indoor roof surface temperature	Surface temperature on the roof at the middle point at the location planned for BIPV installation	°C	10	20/07/2017
Indoor roof surface temperature	Surface temperature on the roof at the edge point at the location planned for BIPV installation	°C	10	20/07/2017

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
Electricity consumption of heating/cooling systems of offices	Electricity consumption of the 2 'small' heating/cooling systems used for offices area of the building	W, Wh	60	20/07/2017
Electricity consumption of heating/cooling systems of offices	Electricity consumption of the 2 'large' heating/cooling systems used for offices area of the building	W, Wh	60	20/07/2017
Electricity consumption of offices	Electricity consumption of offices area of the building	W, Wh	60	05/02/2018
General electricity consumption	Electricity consumption of the whole CRICURSA demo site	kWh	15	31/07/2017

6.4 Appendix 4: Summary of the data collected for Pilot#5 for the baseline period

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
Outdoor Temperature	Outdoor Temperature	°C	10	11/04/2017
Relative humidity outdoor	Outdoor relative humidity	%RH	10	11/04/2017
Atmospheric pressure	Atmospheric pressure	hPa	10	11/04/2017
Wind speed	Wind speed	m/s	10	11/04/2017
Wind direction	Wind direction	degrees	10	11/04/2017
Inclined global irradiation	Global non-corrected solar radiation in the plane of PV panels	W/m^2	10	21/06/2017
Corrected inclined global irradiation	Global corrected solar radiation in the plane of PV panels	W/m^2	10	21/06/2017
Pyranometer temperature	Outdoor temperature measured by pyranometer in the plane of PV panels	°C	10	21/06/2017
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions in dwelling 3	°C, %RH	15	01/08/2017
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions in dwelling 11	°C, %RH	15	19/09/2016
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions in dwelling 15	°C, %RH	15	19/09/2016
Inside wall surface temperature	Inside wall surface temperature on the wall planned for BIPV installation in dwelling 3	°C	10	23/10/2017
Inside wall surface temperature	Inside wall surface temperature on the wall planned for BIPV installation in dwelling 11	°C	15	10/04/2017

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
Inside wall surface temperature	Inside wall surface temperature on the wall planned for BIPV installation in dwelling 15	°C	15	11/04/2017
Outside wall surface temperature	Outside wall surface temperature on the wall planned for BIPV installation	°C	10	15/06/2017
Elevator electricity consumption, entrance 12	Electricity consumption of the lift located in entrance 12	W, Wh	10	01/12/2017
Elevator & Ventilation electricity consumption, entrance 13	Electricity consumption of the lift and ventilation system located in entrance 13	W, Wh	10	01/12/2017
General services electricity consumption, entrance 13	Electricity consumption of general services of the 3 entrances of the whole building	W, Wh	10	01/12/2017
Elevator electricity consumption, entrance 14	Electricity consumption of the lift located in entrance 14	W, Wh	10	01/12/2017
General electricity consumption	Electricity consumption of common spaces for the whole demo site	kWh	Monthly	10/12/2015

6.5 Appendix 5: Summary of the data collected for Pilot#6 for the baseline period

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
Outdoor Temperature	Outdoor Temperature	°C	1	04/03/2017
Relative humidity outdoor	Outdoor relative humidity	%RH	1	04/03/2017
Atmospheric pressure	Atmospheric pressure	hPa	1	04/03/2017
Wind speed	Wind speed	m/s	1	04/03/2017
Wind direction	Wind direction	degrees	1	04/03/2017
Inclined global irradiation	Global non-corrected solar radiation in the plane of PV panels	W/m^2	10	22/08/2017
Corrected inclined global irradiation	Global corrected solar radiation in the plane of PV panels	W/m^2	10	22/08/2017
Pyranometer temperature	Outdoor temperature measured by pyranometer in the plane of PV panels	°C	10	22/08/2017
Outdoor illuminance	Outdoor global illuminance on the roof	lux	10	14/03/2018
DHI irradiation (diffuse horizontal irradiation)		W/m2	10	22/08/2017
DNI (direct normal irradiation)		W/m2	10	22/08/2017
GHI (global horizontal irradiation)		W/m2	10	22/08/2017
Angle zenith			10	22/08/2017
Daily sunshine duration			10	22/08/2017
Indoor inclined global irradiation	Indoor non-corrected solar radiation in the vertical plane in the room behind the location planned for BIPV installation	W/m^2	10	12/07/2017

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
Indoor temperature-corrected inclined global irradiation	Indoor temperature-corrected irradiation in the vertical plane in the room behind the location planned for BIPV installation	W/m^2	10	12/07/2017
Indoor pyranometer temperature	Indoor temperature measured by pyranometer in the vertical plane	°C	10	12/07/2017
Inside window surface temperature	Inside surface temperature of the window on the first floor planned for BIPV installation	°C	10	12/07/2017
Operative temperature	Operative temperature in the room located behind the glass façade planned for BIPV installation	°C	15	12/07/2017
Occupancy at the offices part of the first floor right	Occupancy data (occupied/no occupied) in the offices located in the right area of the first floor	Occupied/ no occupied	Change Of State (COV)	12/07/2017
Occupancy at the offices part of the first floor left	Occupancy data (occupied/no occupied) in the offices located in the left area of the first floor	Occupied/ no occupied	Change Of State (COV)	12/07/2017
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions in the first-floor left area of the building	°C, %RH	10	12/07/2017
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions in the first-floor right area of the building	°C, %RH	10	12/07/2017
Temperature and relative humidity ambient conditions	Temperature and relative humidity ambient conditions into the second-floor left area of the building	°C, %RH	10	12/07/2017
Temperature and relative humidity	Temperature and relative humidity ambient conditions into the second-	°C, %RH	10	12/07/2017

Data point	Physical correspondence	Units	Sample rate [min]	Data available from
ambient conditions	floor right area of the building			
Electricity consumption of the first-floor right part	Electricity consumption of lighting and plugs of the right area on the first floor of the building	W, Wh	10	22/08/2017
Electricity consumption of the first-floor left part	Electricity consumption of lighting and plugs of the left area on the first floor of the building	W, Wh	10	22/08/2017
Electricity consumption of the second-floor right part	Electricity consumption of laboratories located in the right area of the second floor of the building	W, Wh	10	22/08/2017
Electricity consumption of the second-floor left area	Electricity consumption of laboratories located in the left area of the second floor of the building	W, Wh	10	22/08/2017

6.6 Appendix 6: Technical features of the commercial inverters selected for the demonstrators

SUNNY TRIPOWER
5000TL – 12000TL

Economical
- Maximum efficiency of 98.3 %
- Shade management with OptiTrac Global Peak
- Active temperature management with OptiCool

Flexible
- DC input voltage of up to 1,000 V
- Integrated grid management functions
- Reactive power supply
- Module-tailored system design with Optiflex

Communicative
- SMA Webconnect
- Sunny Portal communication
- SMA and SunSpec Modbus communication
- Simple country configuration
- Multifunction relay comes standard

Easy-to-Use
- Three-phase feed-in
- Cable connection without tools
- SUNCLIX DC plug-in system
- Integrated ESS (Electronic Solar Switch)
- Easy wall mounting

SUNNY TRIPOWER 5000TL – 12000TL

The Three-Phase Inverter – Not Only for Your Home...

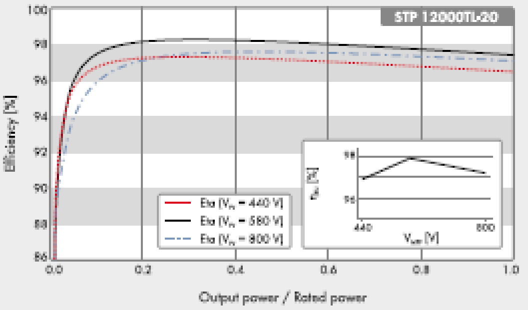
...but also perfectly suited to the design of the traditional residential PV system up to the higher power outage range. After all, with the addition of the new 10 kVA and 12 kVA versions to the portfolio, the Sunny Tripower product range covers a broad spectrum of applications. Users benefit from numerous tried-and-tested product features. Highly flexible with its proven Optiflex technology and asymmetrical multistring, it delivers maximum yields with a top efficiency rating and OptiTrac Global Peak. In addition to SMA and Sunspec Modbus communication, it also comes standard with a direct Sunny Portal connection via SMA Webconnect. Other standard features include integrated grid management functions, reactive power supply and suitability for operation with a 30 mA RCD. In summary, when it comes to system design in the 5 kW to 12 kW power classes, the Sunny Tripower is the optimum product solution – for applications ranging from use in your own home and larger PV rooftop systems to implementation of smaller-scale PV farms.

SUNNY TRIPOWER
5000TL / 6000TL / 7000TL / 8000TL / 9000TL / 10000TL / 12000TL

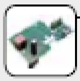
Technical Data	Sunny Tripower 5000TL	Sunny Tripower 6000TL
Input (DC)		
Max. generator power	9000 Wp	9000 Wp
Max. input voltage	1000 V	1000 V
MPP voltage range / rated input voltage	245 V to 800 V/580 V	295 V to 800 V/580 V
Min. input voltage / start input voltage	150 V / 188 V	150 V / 188 V
Max. input current input A / input B	11 A / 10 A	11 A / 10 A
Max. short-circuit current input A / input B	17 A / 15 A	17 A / 15 A
Number of independent MPP inputs / strings per MPP input	2 / A:2; B:2	2 / A:2; B:2
Output (AC)		
Rated power (at 230 V, 50 Hz)	5000 W	6000 W
Max. AC apparent power	5000 VA	6000 VA
Nominal AC voltage	3 / N / PE; 230 / 400 V	3 / N / PE; 230 / 400 V
AC grid frequency / range	50 Hz / -5 Hz to +5 Hz	50 Hz / -5 Hz to +5 Hz
Rated power frequency / rated grid voltage	50 Hz / 230 V	50 Hz / 230 V
Max. output current	7.3 A	8.7 A
Power factor at rated power	1	1
Adjustable displacement power factor	0.8 overexcited to 0.8 underexcited	0.8 overexcited to 0.8 underexcited
Feed-in phases / connection phases	3 / 3	3 / 3
Efficiency		
Max. efficiency / European efficiency	98 % / 97.1 %	98 % / 97.4 %
Protective devices		
DC disconnect device	●	●
Ground fault monitoring / grid monitoring	● / ●	● / ●
DC reverse polarity protection / AC short-circuit current capability / galvanically isolated	● / ● / –	● / ● / –
All-pole sensitive residual-current monitoring unit	●	●
Protection class (according to IEC 62103)/overvoltage category (according to IEC 60664-1)	I / III	I / III
General data		
Dimensions (W / H / D)	470 / 730 / 240 mm (18.5 / 28.7 / 9.5 inch)	470 / 730 / 240 mm (18.5 / 28.7 / 9.5 inch)
Weight	37 kg (81.6 lb)	37 kg (81.6 lb)
Operating temperature range	-25 °C to +60 °C (-13 °F to +140 °F)	-25 °C to +60 °C (-13 °F to +140 °F)
Noise emission (typical)	40 dB(A)	40 dB(A)
Self-consumption (at night)	1 W	1 W
Topology / cooling concept	Transformerless / Opticool	Transformerless / Opticool
Degree of protection (according to IEC 60529)	IP65	IP65
Climatic category (according to IEC 60721-3-4)	4K4H	4K4H
Maximum permissible value for relative humidity (non-condensing)	100 %	100 %
Features		
DC connection / AC connection	SUNCLIX / spring-cage terminal	SUNCLIX / spring-cage terminal
Display	Graphic	Graphic
Interface: RS485, Modbus, Speedwire / Webconnect	○ / ● / ●	○ / ● / ●
Multifunction relay / Power Control Module	● / ○	● / ○
Guarantee: 5 / 10 / 15 / 20 years	● / ○ / ○ / ○	● / ○ / ○ / ○
Certificates and permits (more available on request)	AS 4777.2:2015, CE, CEI 0-21:2016, C10/11:2012, DIN EN 62109-1, EN 50438[1], G59/3, G83/2, IEC 61727/MEA[2], IEC 62109-2, NEN EN 50438, NRS 097-2-1, PPC, PPDS, RD 661/2007, RD 1699:2011, SI 4777, UTE C15-712-1, VDE0126-1-1, VDE ARN 4105, VFR 2013, VFR 2014	
Type designation	STP 5000TL-20	STP 6000TL-20

Sunny Tripower 7000TL	Sunny Tripower 8000TL	Sunny Tripower 9000TL
13500 Wp	13500 Wp	13500 Wp
1000 V	1000 V	1000 V
290 V to 800 V / 580 V	330 V to 800 V / 580 V	370 V to 800 V / 580 V
150 V / 188 V	150 V / 188 V	150 V / 188 V
15 A / 10 A	15 A / 10 A	15 A / 10 A
25 A / 15 A	25 A / 15 A	25 A / 15 A
2 / A:2; B:2	2 / A:2; B:2	2 / A:2; B:2
7000 W	8000 W	9000 W
7000 VA	8000 VA	9000 VA
3 / N / PE; 230 / 400 V	3 / N / PE; 230 / 400 V	3 / N / PE; 230 / 400 V
50 Hz / -5 Hz to +5 Hz	50 Hz / -5 Hz to +5 Hz	50 Hz / -5 Hz to +5 Hz
50 Hz / 230 V	50 Hz / 230 V	50 Hz / 230 V
10.2 A	11.6 A	13.1 A
1	1	1
0.8 overexcited to 0.8 underexcited	0.8 overexcited to 0.8 underexcited	0.8 overexcited to 0.8 underexcited
3 / 3	3 / 3	3 / 3
98 % / 97.5 %	98 % / 97.6 %	98 % / 97.6 %
●	●	●
● / ●	● / ●	● / ●
● / ● / –	● / ● / –	● / ● / –
●	●	●
I / III	I / III	I / III
470 / 730 / 240 mm (18.5 / 28.7 / 9.5 inch)	470 / 730 / 240 mm (18.5 / 28.7 / 9.5 inch)	470 / 730 / 240 mm (18.5 / 28.7 / 9.5 inch)
37 kg (81.6 lb)	37 kg (81.6 lb)	37 kg (81.6 lb)
-25 °C to +60 °C (-13 °F to +140 °F)	-25 °C to +60 °C (-13 °F to +140 °F)	-25 °C to +60 °C (-13 °F to +140 °F)
40 dB(A)	40 dB(A)	40 dB(A)
1 W	1 W	1 W
Transformerless / Opticool	Transformerless / Opticool	Transformerless / Opticool
IP65	IP65	IP65
4K4H	4K4H	4K4H
100 %	100 %	100%
SUNCLIX / spring-cage terminal	SUNCLIX / spring-cage terminal	SUNCLIX / spring-cage terminal
Graphic	Graphic	Graphic
○ / ● / ●	○ / ● / ●	○ / ● / ●
● / ○	● / ○	● / ○
● / ○ / ○ / ○	● / ○ / ○ / ○	● / ○ / ○ / ○
AS 4777.2:2015, CE, CEI 0-21:2016, C10/11:2012, DIN EN 62109-1, EN 50438[1], G59/3, G83/2, IEC 61727/MEA[2], IEC 62109-2, NEN EN 50438, NRS 097-2-1, PPC, PPDS, RD 661/2007, RD 1699:2011, SI 4777, UTE C15-712-1, VDE0126-1-1, VDE AR-N 4105, VFR 2013, VFR 2014		
STP 7000TL-20	STP 8000TL-20	STP 9000TL-20

Efficiency curve



Accessories


Power Controle Module PWCBRD-10


RS485 Interface 485BRD-10

[1] Does not apply to all national appendices of EN 50438
[2] Only STP 9000TL-20

● Standard feature ○ Optional feature – Not available
Last updated: May 2017
Data at nominal conditions

Sunny Tripower 10000TL	Sunny Tripower 12000TL	
13500 Wp	18000 Wp	
1000 V	1000 V	
370 V to 800 V / 580 V	440 V to 800 V / 580 V	
150 V / 188 V	150 V / 188 V	
18 A / 10 A	18 A / 10 A	
25 A / 15 A	25 A / 15 A	
2 / A:2; B:2	2 / A:2; B:2	
10000 W	12000 W	
10000 VA	12000 VA	
3 / N / PE; 230 / 400 V	3 / N / PE; 230 / 400 V	
50 Hz / -5 Hz to +5 Hz	50 Hz / -5 Hz to +5 Hz	
50 Hz / 230 V	50 Hz / 230 V	
14.5 A	17.4 A	
1	1	
0.8 overexcited to 0.8 underexcited	0.8 overexcited to 0.8 underexcited	
3 / 3	3 / 3	
98 % / 97.6 %	98.3 % / 97.9 %	
●	●	
● / ●	● / ●	
● / ● / –	● / ● / –	
●	●	
I / III	I / III	
470 / 730 / 240 mm (18.5 / 28.7 / 9.5 inches)	470 / 730 / 240 mm (18.5 / 28.7 / 9.5 inch)	
37 kg (81.6 lb)	38 kg / 84 lbs	
-25 °C to +60 °C (-13 °F to +140 °F)	-25 °C to +60 °C (-13 °F to +140 °F)	
40 dB(A)	40 dB(A)	
1 W	1 W	
Transformerless / Opticool	Transformerless / Opticool	
IP65	IP65	
4K4H	4K4H	
100 %	100 %	
SUNCLIX / spring-cage terminal	SUNCLIX / spring-cage terminal	
Graphic	Graphic	
○ / ● / ●	○ / ● / ●	
● / ○	● / ○	
● / ○ / ○ / ○	● / ○ / ○ / ○	
AS 4777.2:2015, CE, CEI 0-21:2016, C10/11:2012, DIN EN 62109-1, EN 50438[1], G59/3, G83/2, IEC 61727/MEA[2], IEC 62109-2, NEN EN 50438, NRS 097-2-1, PPC, PPDS, RD 661/2007, RD 1699:2011, SI 4777, UTE C15-712-1, VDE0126-1-1, VDE AR-N 4105, VFR 2013, VFR 2014		
STP 10000TL-20	STP 12000TL-20	

WECHSELRICHTER

SolarEdge Dreiphasen-Wechselrichter

SE4K - SE12.5K

Die optimale Wahl für SolarEdge-Systeme

- Einzigartiger Wirkungsgrad (98%)
- Klein, leichtester seiner Klasse, einfache Installation
- Integrierte Überwachung auf Modulebene
- Internetverbindung via Ethernet oder Wireless
- IP65 – Installation im Freien und in Gebäuden
- Festspannung für optimale DC/AC Umwandlung

USA - KANADA - DEUTSCHLAND - ITALIEN - FRANKREICH - JAPAN - CHINA - AUSTRALIEN - NIEDERLANDE - GB - ISRAEL www.solaredge.de

SolarEdge Dreiphasen-Wechselrichter

SE4K - SE12.5K[1]

	SE4K[1]	SE5K	SE7K	SE8K	SE9K	SE10K	SE12.5K	
AUSGANG								
AC-Nennleistung	4000	5000	7000	8000	9000	10000	12500	VA
Maximale AC-Leistung	4000	5000	7000	8000	9000	10000	12500	VA
Ausgangsspannung AC - Phase zu Phase / Phase zu Neutralleiter (Nennspannung)	380 / 220 ; 400 / 230							Vac
AC - Ausgangsspannungsbereich - Phase zu Neutralleiter	184 - 264,5							Vac
AC-Frequenz	50/60 ± 5							Hz
Maximaler Dauerausgangsstrom (pro Phase)	6,5	8	11,5	13	14,5	16	20	A
Fehlerstromüberwachung / Fehlerstrom-Schutzschalter	300 / 30							mA
Unterstützte Netze – Dreiphasig	3 / N / PE (Mittelpunktgeerdetes Sternnetz mit Neutralleiter)							V
Netzüberwachung, Schutz vor Inselbildung, konfigurierbarer Leistungsfaktor, konfigurierbare landesspezifische Schwellenwerte	Ja							
EINGANG								
Maximale DC-Leistung (Modul STC)	5400	6750	9450	10800	12150	13500	16850	W
Ohne Transformator, ungeerdet	Ja							
Maximale Eingangsspannung	900							Vdc
DC-Nenneingangsspannung	750							Vdc
Maximaler Eingangsstrom	7	8,5	12	13,5	15	16,5	21	Adc
Verpolungsschutz	Ja							
Erdschlusserkennung	Empfindlichkeit 700kΩ							
Maximaler Wirkungsgrad des Wechselrichters	98							%
Europäischer (gewichteter) Wirkungsgrad	97,3	97,3	97,3	97,5	97,5	97,6	97,7	%
Energieverbrauch nachts	< 2,5							W
WEITERE FUNKTIONEN								
Mögliche Kommunikationsinterfaces[2]	RS485, Ethernet, Zigbee (optional), Wi-Fi (optional), integriertes GSM (optional)							
ERFÜLLTE NORMEN								
Sicherheit	IEC-62103 (EN50178), IEC-62109							
Netzanschluss[4]	VDE 0126-1-1, VDE-AR-N-4105, AS-4777, G83 / G59							
EMV	IEC61000-6-2, IEC61000-6-3, IEC61000-3-11, IEC61000-3-12, FCC Teil 15, Klasse B							
RoHS	Ja							
MECHANISCHE SPEZIFIKATIONEN								
AC-Ausgang	Kabelverschraubung – Durchmesser 15-21							mm
DC-Eingang	2 MC4 Paare							
Abmessungen (HxBxT)	540 x 315 x 260							mm
Gewicht	33,2							kg
Betriebstemperaturbereich	-20 - +60 (M40 version -40 - +60)							°C
Kühlung	Lüfter (auswechselbar)							
Geräuschemission	< 50[5]							dBA
Schutzklasse	IP65 - im Freien und in Gebäuden							
Montage an Halterung (Halterung wird mitgeliefert)								

[1] Informationen zu höheren Leistungsklassen finden Sie unter: http://www.solaredge.com/files/pdfs/products/inverters/se-three-phase-inverter-extended-power-datasheet-de.pdf
[2] Verfügbar in einigen Ländern; alle Zertifikate sind im Downloadbereich verfügbar: http://www.solaredge.com/groups/support/downloads
[3] Weitere Informationen finden Sie in unseren Datenblättern, Kategorie Kommunikation unter: http://www.solaredge.com/groups/support/downloads
[4] Alle Zertifikate sind im Downloadbereich verfügbar: http://www.solaredge.com/groups/support/downloads
[5] Wechselrichter geeignet für Hausinnenbereiche durch reduzierte Geräuschemission finden Sie hier: http://www.solaredge.com/files/pdfs/products/inverters/se-three-phase-indoor-inverter-datasheet-de.pdf

TRIO-5.8-TL-OUTD-S-400

Products → Power Converters and Inverters → Solar Inverters → String Inverters → Three Phase

General Information

Extended Product Type:	TRIO-5.8-TL-OUTD-S-400
Product ID:	6AGC003146
ABB Type Designation:	TRIO-5.8-TL-OUTD-S-400
EAN:	8054529630967
Catalog Description:	TRIO-5.8-TL-OUTD-S-400;IT
Long Description:	Three-phase string inverter, 5800Wac, 1 MPPT, RS485 communication int erface, IP65_NO UNIT$ environmental protection degree, integrated DC di sconnect switch

Additional Information

ABB Type Designation:	TRIO-5.8-TL-OUTD-S-400
Country of Origin:	Italy (IT)
Customs Tariff Number:	8504408490
Data Sheet, Technical Information:	BCD.00376
Declaration of Conformity - CE:	9AKK106103A5462
Degree of Protection:	IP65
EAN:	8054529630967
ETIM 6:	EC001747 - Photovoltaics DC/AC grid inverter
Gross Weight:	30.2 kg
Input Current:	18.9 A
Input Voltage (U_{In}):	1000 V
Instructions and Manuals:	M000018DG
Invoice Description:	TRIO-5.8-TL-OUTD-S-400;IT
Made To Order:	No
Minimum Order Quantity:	1 piece
Order Multiple:	1 piece
Package Level 1 EAN:	8054529630967
Package Level 1 Gross Weight:	31 kg
Package Level 1 Height:	295 mm
Package Level 1 Length:	785 mm
Package Level 1 Width:	580 mm
Product Main Type:	TRIO
Product Name:	Inverter
Product Net Depth:	220 mm

Product Net Height:	641 mm
Product Net Length:	429 mm
Product Net Weight:	25 kg
Product Net Width:	429 mm
Quote Only:	No
Selling Unit of Measure:	piece

Solar inverters

ABB string inverters UNO-2.0/2.5-I-OUTD 2.0kW to 2.5kW

ABB's UNO 2.0 and 2.5 inverters have a lightweight design that enables inverter mounting flexibility for residential applications.

These isolated inverters are simple to wall mount and are extremely lightweight.
They feature the flexibility and innovation for which ABB is known for.
These inverters are fully integrated with a DC disconnect and wiring box that saves installation time and cost.

These inverters provide a flexible system with high levels of performance and reliability that designers need.
The high-speed MPPT algorithm and MPPT scan function offers real-time power tracking and improved energy harvesting.
The wide input voltage range makes the inverter suitable for low-power installations with a reduced string size.

Highlights:
- This inverter operates at 96 percent CEC weighted efficiency
- It has a single-phase and split-phase output
- It operates with extra quiet high-frequency transformer inverter architecture
- The NEMA 4X rated enclosure enables unrestricted use under any environmental condition

Power and productivity for a better world™ ABB

Additional highlights:

- The flexible data monitoring options enables users to view inverter performance from any location from virtually any device
- This inverter comes with a standard 10-year warranty, and available extensions to 15 and 20 years

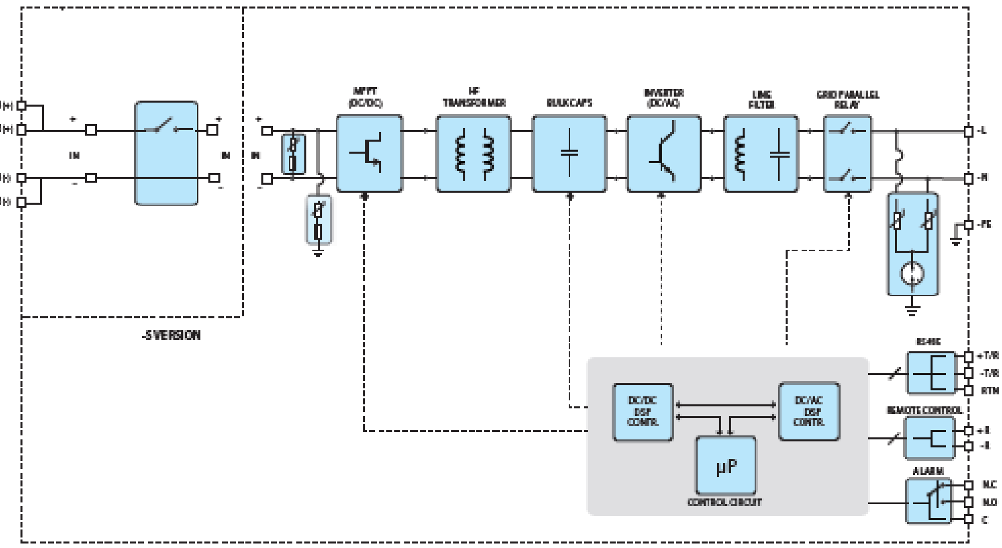
Technical data and types

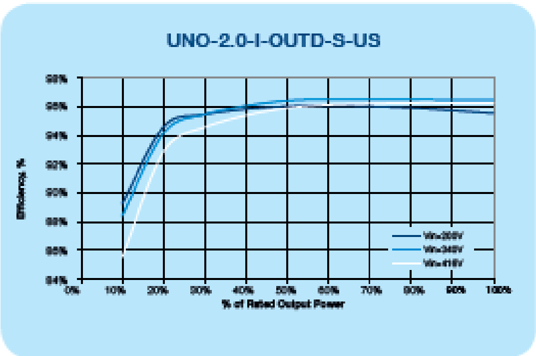
Type code	UNO-2.0-I-OUTD-S-US			UNO-2.5-I-OUTD-S-US		
Nominal output power	2000W			2500W		
Maximum output power	2200W[1]			2750W[1]		
Rated grid AC voltage	208V	240V	277V	208V	240V	277V
Input side (DC)						
Number of independent MPPT channels	1					
Maximum usable power for each channel	2300W			2900W		
Absolute maximum voltage (Vmax)	520V					
Start-up voltage (Vstart)	200V (adj. 120-350V)					
Full power MPPT voltage range	170-470V			200-470V		
Operating MPPT voltage range	0.7xVstart-520 (≥90V)					
Maximum usable current per channel	12.5A			12.8A		
Maximum short circuit current limit per channel	15A					
Number of wire landing terminals per channel	2 pairs					
Array wiring termination	Terminal block, pressure clamp, 20 AWG - 6 AWG					
Output side (AC)						
Grid connection type	1Ø/2W	Split-Ø/3W	1Ø/2W	1Ø/2W	Split-Ø/3W	1Ø/2W
Adjustable voltage range	183-228V	211-264V	244-304V	183-228V	211-264V	244-304V
Nominal grid frequency	60Hz					
Adjustable grid frequency range	57-63Hz					
Maximum current	10A			12A		
Power factor	>0.995					
Total harmonic distortion (@ rated output power)	<2%					
Grid wiring termination type	Terminal block, pressure clamp 20 AWG - 6 AWG					
Input protection devices						
Reverse polarity protection	Yes					
Over-voltage protection type	Varistor, 2					
PV array ground fault detection	Meets UL1741 / NEC 690.5 requirements					
PV array isolation control	GFDI (for use with either positive or negative grounded arrays)					
Output protection devices						
Anti-islanding protection	Meets UL 1741 / IEEE1547 requirements					
Over-voltage protection type	Varistor, 2 (L_1 - L_2 / L_1 - G)					
Maximum AC OCPD rating	15A					
Efficiency						
Maximum efficiency	96.6%					
CEC efficiency	95.5%	95.5%	95.5%	95.5%	96%	96%
Operating performance						
Nighttime consumption	<0.6W					
Stand-by consumption	<8W					
Communication						
User-interface	5.5" x 1.25" graphic display					
Remote monitoring (1xRS485 incl.)	VSN700 Data Logger (opt.)					
Environmental						
Ambient air operating temperature range	-13°F to 140°F (-25°C to +60°C) with derating above 122°F (50°C)					
Ambient air storage temperature range	-40°F to 176°F (-40°C to +80°C)					
Relative humidity	0-100% condensing					
Acoustic noise emission level	<50 db (A) @ 1m					
Maximum operating altitude without derating	6560ft (2000m)					

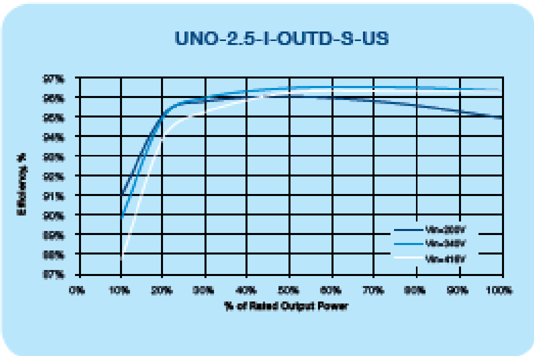
1. At nominal AC voltage and with sufficient DC power available

2 ABB solar inverters | Product flyer for UNO 2.0/2.5-I-OUTD

Block diagram of UNO 2.0/2.5-I-OUTD







Technical data and types

Type code	UNO-2.0-I-OUTD-S-US	UNO-2.5-I-OUTD-S-US
Mechanical specifications		
Enclosure rating	NEMA 4X	
Cooling	Natural convection	
Dimensions (H x W x D)	30.3 x 14.4 x 6.3in (769 x 367 x 161mm)	
Weight	<42.5lb (19.3kg)	
Mounting system	Wall bracket	
Conduit connections	Bottom: (2) 3/4" KO, (3) 1/2" KO / Left and right side: (1) 3/4" KO / Back: (4) 3/4" KO	
DC switch rating (per contact) (A/V)	16A / 600Vdc	
Safety		
Isolation	High-frequency transformer	
Safety and EMC standard	UL 1741, IEEE1547, IEEE1547.1, CSA-C22.2 N. 107.1-01, FCC Part 15 Class B	
Safety approval	CSAus	
Warranty		
Standard warranty	10 years	
Extended warranty	15 & 20 years	
Available models		
With DC switch and wiring box	UNO-2.0-I-OUTD-S-US	UNO-2.5-I-OUTD-S-US

All data is subject to change without notice

Product flyer for UNO 2.0/2.5-I-OUTD | ABB solar inverters 3