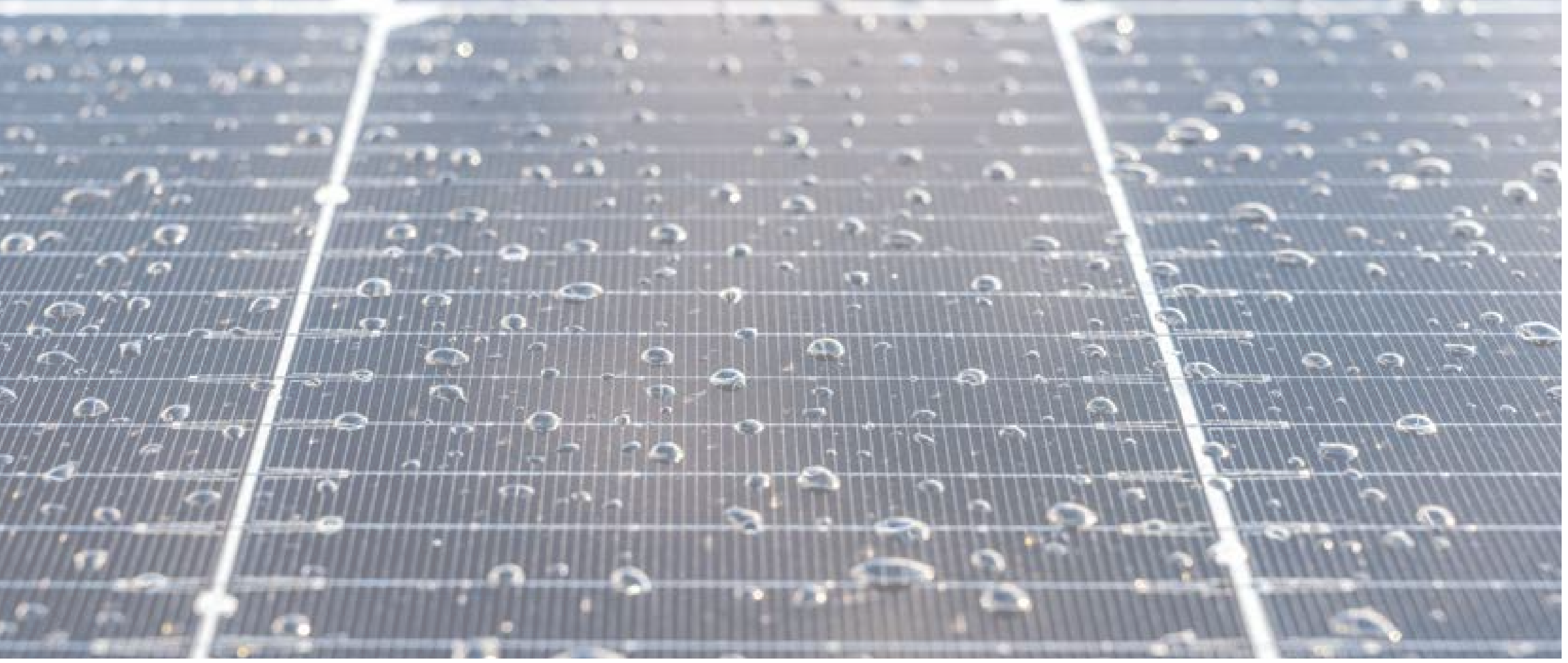
Environmental monitoring solutions for PV Systems

MAXIMIZE THE PERFORMANCE OF YOUR PV SYSTEM WITH INTELLIGENT MONITORING

senseca



Why measuring solar efficency

Did you know that weather conditions have a considerable influence on photovoltaic generation?
Even a simple cloudy day can drastically affect incident solar energy.
Besides solar irradiance, also temperature, humidity, atmospheric pressure, precipitation, and wind speed and direction can affect solar cell efficiency. For this reason, monitoring weather parameters through a weather station is essential to accurately assess the performance ratio of PV systems.

Maximize Financial Return

A monitored photovoltaic system not only produces more energy but can also generate significant savings on operational and maintenance costs. This translates into better overall financial returns for investors and system owners.

Remote Monitoring

The ability to monitor photovoltaic systems remotely allows for constant control and efficient management, even for systems located in remote or hard-to-reach location. This feature is particularly important for optimizing the management of large portfolios of systems distributed over vast territories.

Maintenance Optimization

Thanks to monitoring, it's possible to proactively plan maintenance interventions based on collected data on system efficiency and performance. This reduces downtime and the costs associated with reactive maintenance.

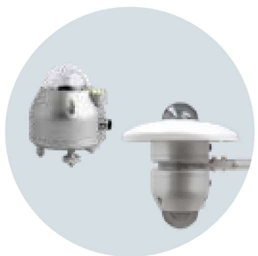
Different components of radiation

DHI

DHI (Diffuse Horizontal Irradiance): Diffuse sunlight measured with a pyranometer and shadow ring, or alternatively with a tracker system that excludes direct irradiance.

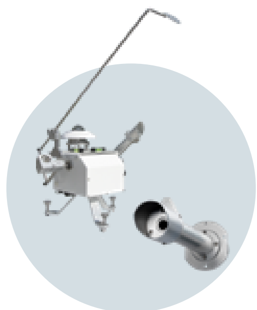
POA and GHI

POA (Plane of Array) irradiance: Measures the solar irradiance hitting the PV panel surface, considering its tilt and orientation. **GHI (Global Horizontal Irradiance):** Measures the total sunlight (direct and diffuse) received on a flat horizontal surface.
For POA and GHI, pyranometers and albedometers are required.



DNI

DNI (Direct Normal Irradiance): Solar radiation received directly from the sun on a surface perpendicular to the sun's rays, excluding diffuse radiation; measured using a pyrheliometer mounted on a solar tracker.



IEC 61724-1

How to apply the standard in your photovoltaic system

IEC 61724-1 is an international standard that specifies the terminology, quantities, symbols, and basic concepts for photovoltaic (PV) system performance monitoring and analysis. It provides guidelines for the monitoring of parameters relevant to the performance of PV systems, including meteorological and system parameters. This standard helps in assessing the performance of PV systems, ensuring their reliability, and facilitating comparisons between different systems.

System size	Multiplier
<40	2
≥ 40 to < 100	3
≥ 100 to < 300	4
≥ 300 to < 500	5
≥ 500 to < 700	6
≥ 700	7, plus 1 for each additional 200 MW

The standard delineates two classifications of monitoring systems, namely Class A and Class B.

- **Class A** is designed for extensive PV systems, such as utility-scale or large commercial installations.
- **Class B** is tailored for smaller-scale systems, such as rooftop or small to medium-sized commercial installations.

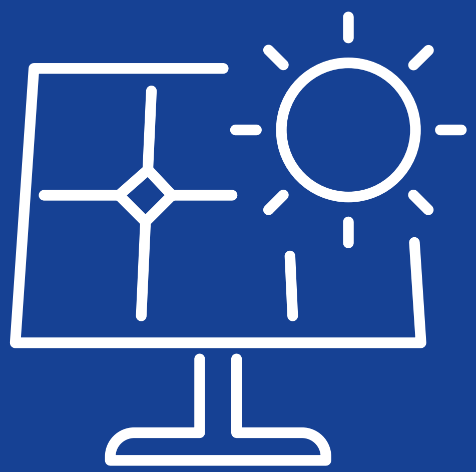
Regardless of the size of the PV system, users of this document can select the classification that best suits their specific application.

Parameter	Monitoring purpose	Class A system*	Minimum N° of sensors
In-plane irradiance (POA)	Solar resource	√	1 * multiplier
Global horizontal irradiance	Solar resource, connection to historical and satellite data	√	1 * multiplier
Horizontal albedo	Solar resource rear side	√ *(bifacial)*	1 * multiplier
In-plane rear-side irradiance (POA)		√ *(bifacial)*	3 * multiplier
Diffuse irradiance	Solar resource	√ *(bifacial / CPV)*	1 * multiplier
Direct normal irradiance		√ *(CPV)*	1 * multiplier
PV module temperature	Determining temperature-related losses	√	3 * multiplier
Ambient air temperature	Estimation of PV temperature, connection to prediction models	√	1 * multiplier
Wind speed		√	1 * multiplier
Wind direction		√	1 * multiplier
Soiling ratio	Estimation of soiling-related losses	√ *if typical annual soiling losses without cleaning expected to be > 2 %*	1 * multiplier
Rainfall	Estimation of soiling losses	√	1 * multiplier
Snow	Estimation of snow-related losses	√ *if typical annual snow losses without cleaning expected to be > 2 % and soiling measurement does not measure snow loss*	1 * multiplier

Further requirements for solar radiation measurement in the IEC 61724-1 monitoring

Cleaning	Alignement	Recalibration
1 x / week (unless it can be proven that this is not needed)	tilt ± 1° azimuth ± 2°	1 x / 2 yr

*This excerpt from IEC 61724-1 outlines the measurements required for a Class A PV system. Additional optional monitoring parameters may be necessary for other types of systems. We recommend consulting the full standard to determine the specific requirements for your system.



Monofacial Solar Panels

Monofacial solar panels are the traditional and most commonly used photovoltaic modules.

They absorb sunlight only from the front side (the side facing the sun), while the back is typically covered by an opaque sheet (often white or black).

1 POA & GHI - PLANE OF ARRAY & GLOBAL HORIZONTAL IRRADIANCE

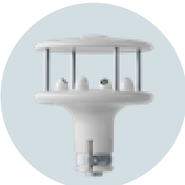
PYRANOMETERS AND ALBEDOMETERS - LPS... SERIES

In monofacial PV systems, Global Horizontal Irradiance (GHI) is measured with a horizontal pyranometer, while Plane of Array (POA) irradiance is determined using a front-side sensor mounted at the same tilt and orientation as the PV modules. Since monofacial systems do not utilize rear-side irradiance, back-side measurements and albedometers are not required.

2 PV MODULE TEMPERATURE

TEMPERATURE TRANSMITTER- HD48...TFP

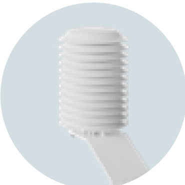
Panel temperature is monitored using transmitters equipped with Pt100 contact probes. These are available with active analog outputs (4–20 mA or 0–10 V), RS485 MODBUS-RTU digital output, or as passive (2-wire) 4–20 mA transmitters.



3 WIND SPEED & DIRECTION

2-AXIS ANEMOMETER - HD52.3D

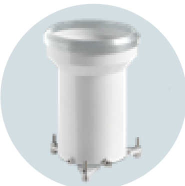
Wind speed and direction are measured using anemometers installed at representative heights to capture conditions affecting the array. These measurements support performance modeling by helping assess the cooling effect of wind on module temperature and are valuable for correlating with historical weather data or evaluating site-specific risks.



4 AMBIENT AIR TEMPERATURE

THERMOHYGROMETER WITH PROTECTIVE SHIELD - ETS80... + HD9007-A.1

Environmental parameters such as temperature, relative humidity, and optionally barometric pressure are measured using sensor series equipped with standard RS485 Modbus-RTU output. All sensors are housed within UV-resistant shields to ensure protection from solar radiation, rain, and wind.



5 RAINFALL

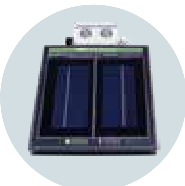
RAIN GAUGES - HD2015... / HD2013...

Tipping bucket rain gauges with collecting areas of 400 cm² and 200 cm² are constructed from corrosion-resistant materials to ensure long-term durability. An optional integrated heating system is available to maintain accurate performance in freezing weather conditions.

6 DATA ACQUISITION SYSTEMS

DATA LOGGER - HD33LMT.4 / 4000CP / 4000CM

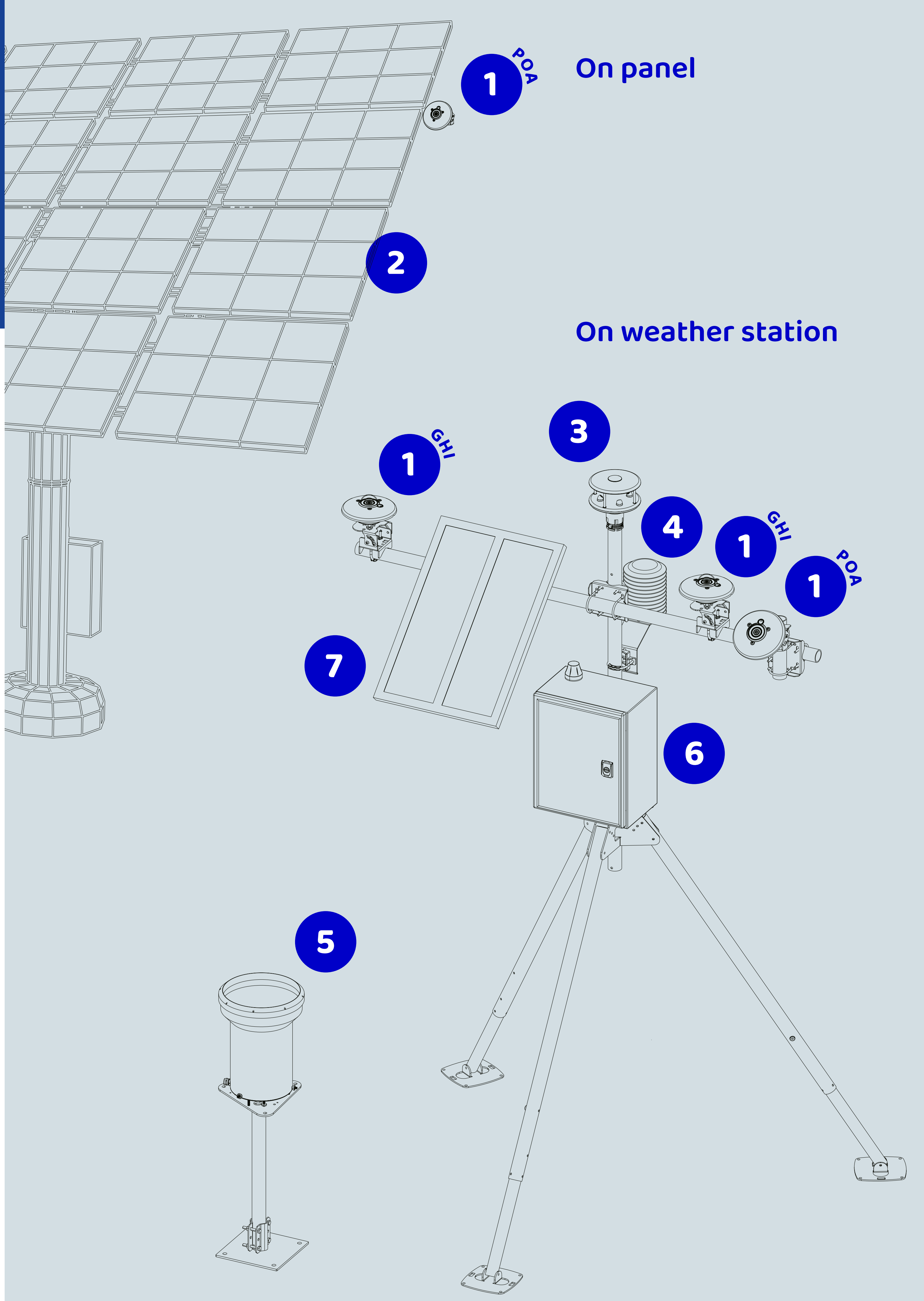
Data acquisition systems (DAS) are essential for monitoring performance, enabling real-time collection of key parameters. This data supports performance analysis, fault detection, and preventive maintenance, ensuring reliable operation and optimal energy yield over the system's lifetime.

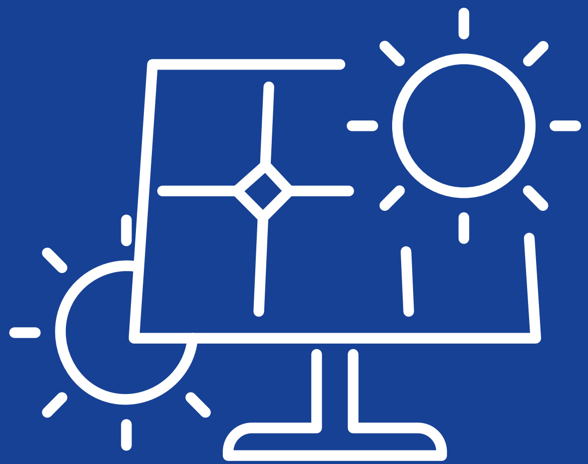


7 SOILING RATIO

GEO-MDFS2

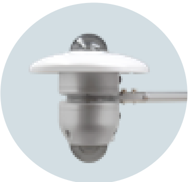
Soiling sensors are used to monitor the accumulation of dust and debris on the surface of PV modules, enabling the assessment of performance losses due to soiling and supporting timely maintenance or cleaning interventions to maintain optimal system efficiency.





Bifacial Solar Panels

Bifacial solar panels are photovoltaic modules designed to absorb sunlight from both the front and the rear sides.
The front captures direct sunlight, while the rear captures reflected and diffused light from the environment.



1 POA & GHI - PLANE OF ARRAY & GLOBAL HORIZONTAL IRRADIANCE

PYRANOMETERS AND ALBEDOMETERS - LPS... SERIES

In bifacial PV systems, GHI is measured with a horizontal pyranometer, while POA irradiance is captured using two pyranometers mounted at the module tilt — one front-facing and one rear-facing. Albedo is measured at the weather station with an albedometer using upward- and downward-facing sensors to assess ground-reflected irradiance.

2 PV MODULE TEMPERATURE

TEMPERATURE TRANSMITTER- HD48...TFP

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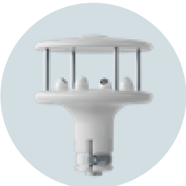

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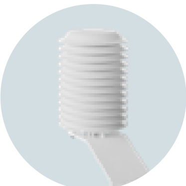

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THERMOHYGROMETER WITH PROTECTIVE SHIELD - ETS80... + HD9007-A.1

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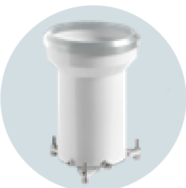

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RAIN GAUGES - HD2015... / HD2013...

Tipping bucket rain gauges with collecting areas of 400 cm² and 200 cm² are constructed from corrosion-resistant materials to ensure long-term durability. An optional integrated heating system is available to maintain accurate performance in freezing weather conditions.

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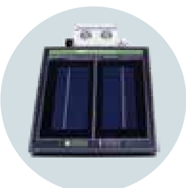

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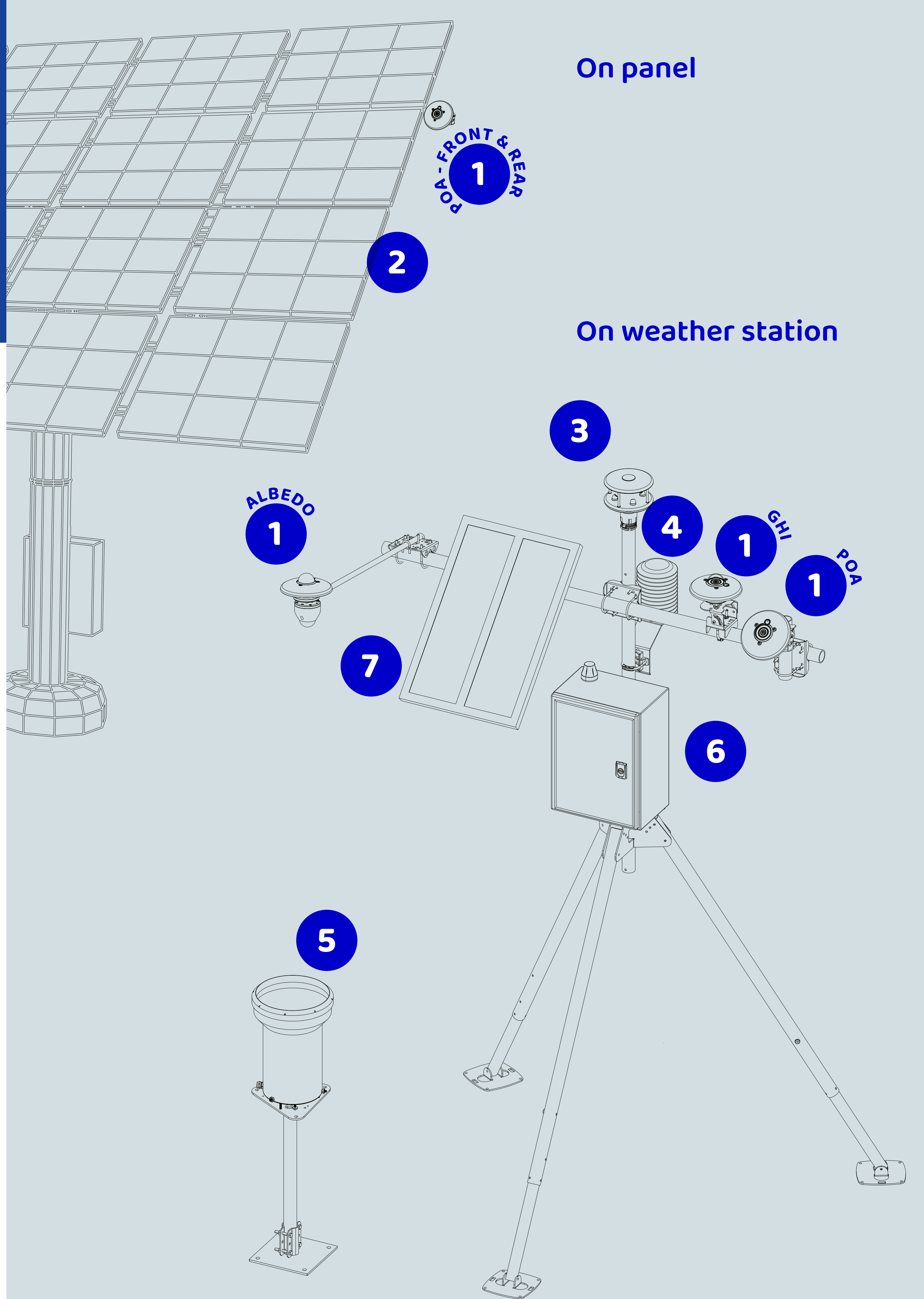

Solar Panels with Tracking Systems

Solar tracking systems are mechanical structures that adjust the position of solar panels throughout the day to follow the sun's path, maximizing the angle of sunlight hitting the panels.

These systems can be combined with monofacial or bifacial panels.

1 POA & GHI - PLANE OF ARRAY & GLOBAL HORIZONTAL IRRADIANCE

PYRANOMETERS AND ALBEDOMETERS - LPS... SERIES

In tracking PV systems, GHI is measured with a horizontal pyranometer, while POA irradiance is measured with one or two pyranometers mounted on the tracker tilt — only front-facing for monofacial panels, and both front- and rear-facing for bifacial panels.

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3 WIND SPEED & DIRECTION

2-AXIS ANEMOMETER - HD52.3D

Wind speed and direction are measured using anemometers placed at representative heights to reflect array conditions. These measurements are essential for safety—triggering stow positions during high winds—and for evaluating the cooling effect of wind on module temperature, which influences system performance.

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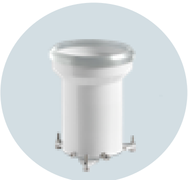

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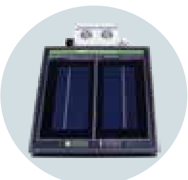

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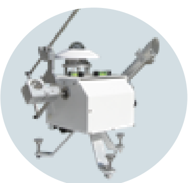
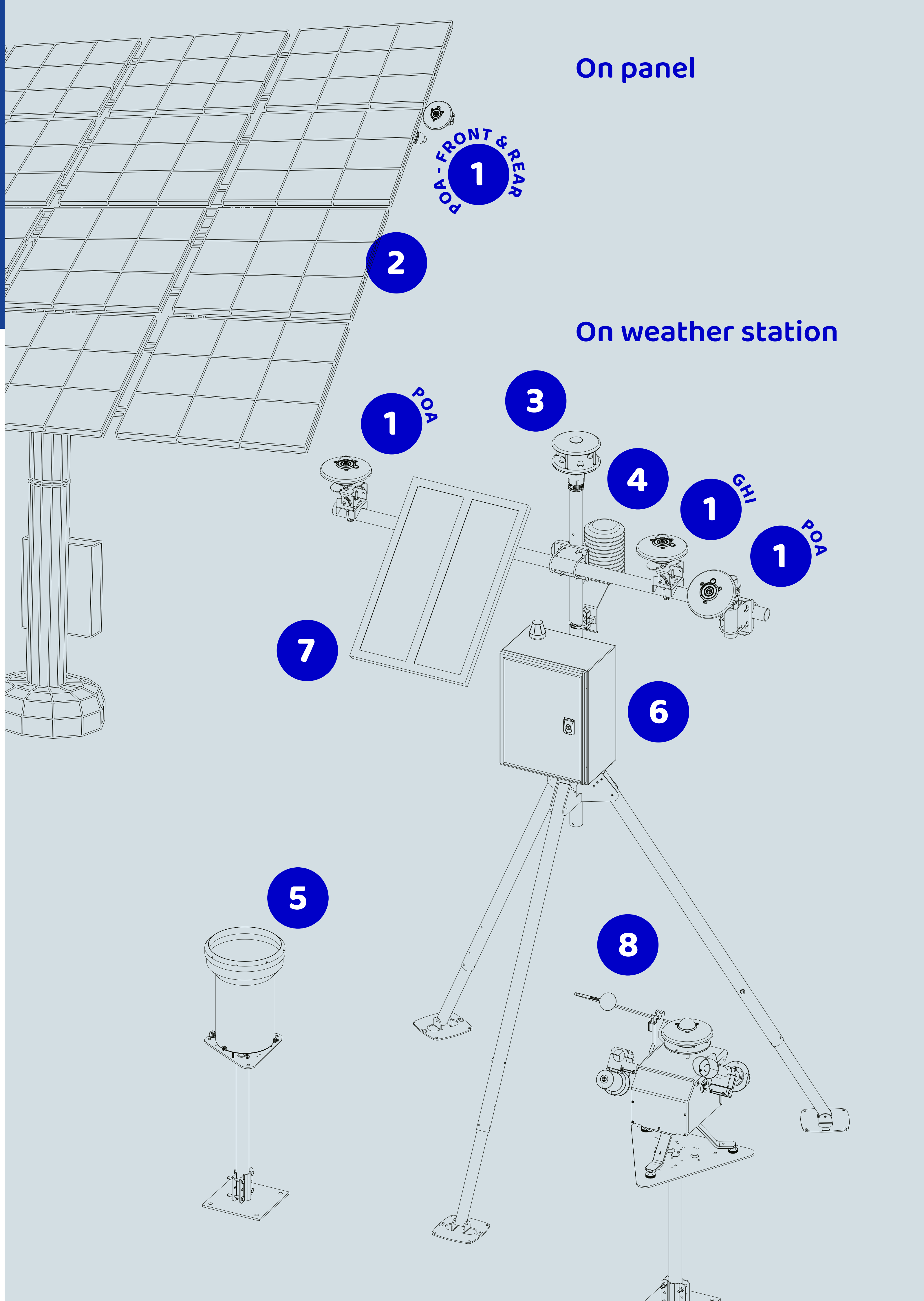


8 TRACKER SYSTEM

SUNTRACKER200 & LPPYRHE16

The tracker system aligns PV modules with the sun to maximize POA irradiance, and a pyrheliometer is mounted on the tracker to continuously point at the sun and accurately measure Direct Normal Irradiance (DNI) for performance and resource assessment.



Environmental parameters to monitor

Measuring the amount of **solar radiation** reaching the PV panels is crucial to assess the available sunlight and determine the energy potential of the PV plant.
This is usually expressed in terms of a performance ratio (PR): the actual yield of the plant (how much energy it produces in a given time period) expressed as a percentage of its theoretical yield (how much energy it could produce in that time period assuming the panels convert the incident light into energy at their nominal efficiency).
The performance ratio is a key indicator for PV system owners, but it is not the only parameter of interest.

Photovoltaic efficiency is highly dependent on **temperature**. As a general rule, for every degree centigrade increase in temperature above 25 °C, the efficiency of a typical PV module decreases by about 0.5 percent. By measuring the **temperature of the ambient air and of the modules** themselves, a temperature-adjusted efficiency ratio can be calculated, giving PV system operators a more accurate overview of system performance.

Wind can also affect the temperature of PV modules dramatically. Because the surface temperatures of PV modules are warmer than those of the ambient air, wind cools them, increasing their efficiency and yield in warmer environments. Wind also has a significant effect on dirt, so knowing wind conditions can play an important role in soil monitoring.
Because high wind speeds can damage PV systems, monitoring wind speed and direction is often important in determining the safe location of the equipment.

Different types of **rainfall** can have a variety of effects, both positive and negative, on PV systems. For example, while heavy rains can drastically reduce soiling by washing away dirt, light rains can actually increase panel soiling. Hailstorms, on the other hand, can cause severe damage to panels and equipment.

Monitoring **thunderstorms** in PV plants is crucial to protect equipment from lightning-induced surges, ensure the safety of on-site personnel, and prevent costly downtime. Real-time detection systems help operators take preventive actions, improving operational reliability. It also supports regulatory compliance, insurance claims, and post-event analysis. Integrating weather sensors and surge protection into the plant's infrastructure ensures better resilience against storm-related risks.

Air pressure and humidity influence the formation of snow, frost, and condensation on the panels, which, in addition to decreasing energy yield, can have an effect on dirt.
Air humidity, in particular, can also produce spectral changes that affect PV module productivity.

Dew and frost mitigation - For Class A systems, the effects of dew and frost accumulation on irradiance sensors shall be mitigated for locations where dew or frost is expected during more than 2 % of annual GHI hours. Determination of whether an installation site requires mitigation may be performed by examining typical meteorological year data for the site, paying attention to ambient temperature and dew point. For the purposes of this assessment, dew or frost is considered expected when ambient temperature is within 1.5 °C of dew point.

Our Service

SENSORS CALIBRATION

To ensure continuous monitoring without interruptions, sensor recalibration must be performed with minimal downtime and sensor interruptions. This can be achieved by various methods, one of which is the replacement of installed sensors with new or recalibrated units.
For Class A systems, recalibration of sensors should take place at least once every two years, or more frequently as recommended by the manufacturer.
For Class B systems, follow the manufacturer's recommended recalibration schedule.
Our **ISO 17025 accreditated Photo-radiometry laboratory** is part of our facilities and guarantees an uncertainty of 1.7 % on the calibration of pyranometers. Fully compliant with the requirements of the IEC standard!

Senseca ISO 17025 Calibration Center is accredited for:

- Photo-radiometry
- Temperature
- Humidity
- Pressure
- Air speed
- Acoustic

- The first in Italy to be accredited for photo-radiometric quantities and still the only one for some of them
- First laboratory in the world to be accredited according to ISO 17025 standard for the calibration of pyranometers
- Solar irradiance sensitivity uncertainty 1.7%

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