



# PHOTOVOLTAIC COLLABORATIVE TO ADVANCE MULTI-CLIMATE PERFORMANCE ENERGY RESEARCH (PV CAMPER)

## OVERVIEW

Formed in 2018, PV CAMPER is an international community of research institutions committed to sharing high-fidelity meteorological and performance data in order to advance photovoltaic (PV) research and expand solar markets. To date, PV CAMPER has 10 members and a network of 13 field sites that span both hemispheres and most major climate zones.

## TECHNICAL OBJECTIVES

Accelerating solar capacity worldwide requires confidence in 1) the cross-climate performance of emergent, high-efficiency PV technologies, 2) the accuracy of irradiance and other sensor measurements needed for yield comparison and simulations and 3) identification of local environmental contributors to long-term reliability. To help meet these challenges, PV CAMPER aims to:

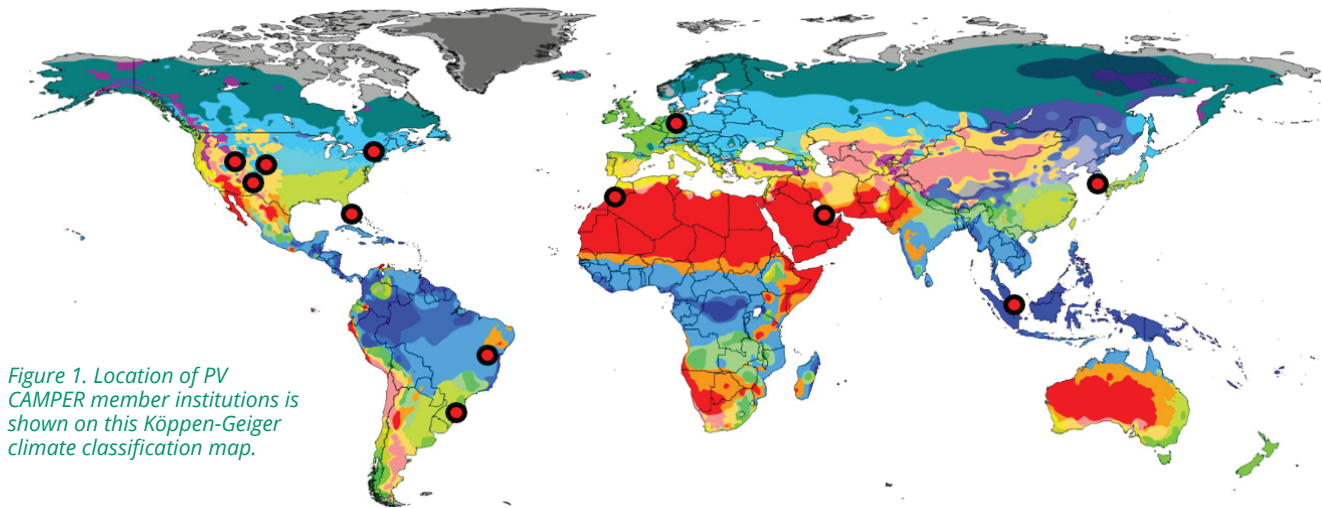


Figure 1. Location of PV CAMPER member institutions is shown on this Köppen-Geiger climate classification map.

Each member institution operates one or more field laboratories and is actively engaged in PV performance and reliability research. To facilitate collaboration and ensure data quality across all sites, PV CAMPER representatives have agreed to deploy similar instrumentation, methods of data collection, and O&M protocols. The result is a global network of outdoor laboratories that can be leveraged for research investigations ranging from experimentation to simulation and validation studies.

- Foster collaborative R&D in the areas of PV performance-validation and reliability
- Provide a global platform for evaluating emerging, high-efficiency PV technologies, and for identifying and quantifying the factors that contribute most to climate specific efficiencies
- Generate a set of best practices with respect to data collection; quantify and reduce measurement uncertainties, and increase the accuracy and global applicability of performance models
- Develop a technical basis for matching new technologies, including novel cell and module types, to their operating environments (spectral sensitivities, irradiance characteristics, temperature range, etc.)



Figure 2. Images of irradiance sensors at three field sites: (clockwise from top left) POA pyranometer and reference cells on baseline system in Vermont, USA; POA pyranometer and PV-modules in Halle, Germany; GHI and DNI sensors in Köthen, Germany; irradiance sensors in Florianopolis, Brazil; (above) albedometer in Vermont.



## MEMBERSHIP REQUIREMENTS

PV CAMPER is an expandable organization and welcomes new members willing to meet the organization's high standards for data quality and availability. To that end, each member institution must maintain an outdoor field laboratory with the following technical capabilities:

- Grid-tied crystalline-silicon reference system for crosssite data analysis and to establish a baseline against which other technologies can be compared;
- High-accuracy meteorological instrumentation to measure multiple irradiance levels (DNI, GHI, DHI, POA and albedo), precipitation, relative humidity, ambient air temperature and wind-speed and direction);
- Soiling measurement station;
- High-resolution DC data-monitoring instrumentation to measure PV system performance;
- High-frequency data acquisition systems for both meteorological and PV performance data;
- Module characterization capabilities that meet IEC standards (solar simulator and EL imaging capabilities).

PV CAMPER members must sign a Memorandum-of-Understanding and agree to:

1. Transmit data daily to a cloud database, where it can be accessed by members of the collaborative;
2. Adopt PV CAMPER baseline characterization and O&M protocols;
3. Participate in PV CAMPER collaborative R&D;
4. Attend regular conference calls and at least one annual face-to-face meeting.

## PARTNER ORGANIZATIONS



## VALUE TO THE GLOBAL PHOTOVOLTAICS COMMUNITY

PV CAMPER's network of research institutions reflects a common goal: the desire to foster and grow a community that can help transition the world to a more solar-intensive future. Collectively, this organization offers:

- Repository of high-fidelity meteorological and PV performance data from geographically and climatically diverse sites
- Broad expertise in such areas of PV research as soiling losses, uncertainty drivers (cloud persistence, moisture, airborne particulates) and spectral responsiveness
- Data to support the design and optimization of PV systems for specific operating environments, helping increase markets and expand the solar industry

### Founding Members

**Brazil:** Universidade Federal de Santa Catarina (UFSC)  
*Ricardo Rüther*

**Germany:** Anhalt University of Applied Sciences  
*Sebastian Dittmann*

**Germany:** Fraunhofer Center for Silicon Photovoltaics (CSP)  
*Ralph Gottschalg*

**Morocco:** Institut de Recherche Energie Solaire et Energie Nouvelle (IRESEN)  
*Ahmed Benlarabi*

**Qatar:** Qatar Environment & Energy Research Institute  
*Ben Figgis*

**Singapore:** Solar Energy Research Institute of Singapore (SERIS)  
*Thomas Reindl*

**South Korea:** Yeungnam University  
*Soo-Young Oh*

**South Korea:** Korean Institute for Energy Research (KIER)  
*Kyungsoo Kim*

**South Korea:** Korea Testing Laboratory (KTL)  
*Jun-Hong Choi*

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