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WHEN MEASUREMENTS MATTER

Solar Energy

Fall 2014

Solar-energy monitoring solutions for research, resource assessment, and performance validation

www.campbellsci.com

Campbell Scientific designs, manufactures, and sells rugged dataloggers, data acquisition systems, and measurement and control products used worldwide in environmental, research, and industrial markets.

Campbell Scientific headquarters in Logan, Utah, U.S.

Campbell Scientific was organized in 1974 by two brothers, Eric and Evan Campbell, in Logan, Utah. Other Campbell family members helped build the business by providing initial capital, direction, new product definition, and conceptual development.

The first product Campbell Scientific marketed was the CA-9 Path-Averaging Laser Anemometer in 1974. The laser anemometer was followed in 1975 with the company's first data-acquisition system, the CR5 Measurement and Control System. Since then, Campbell Scientific has manufactured more than 250,000 dataloggers.

Building on decades of experience, Campbell Scientific has developed increasingly powerful dataloggers that have achieved worldwide use in environmental, research, and industrial markets for diverse applications. Campbell Scientific also manufactures numerous related products for the measurement field, including a wide variety of sensors and devices for the collection, storage, communication, and retrieval of data.

Through innovative product development, the manufacture of high-quality products, and excellent customer support, Campbell Scientific meets the instrumentation needs of customers worldwide. To better serve our customers, Campbell Scientific has group companies in Australia, Brazil, Canada, China, Costa Rica, France, Germany, South Africa, Spain, the United Kingdom, and the United States, as well as official representatives in 28 additional countries.

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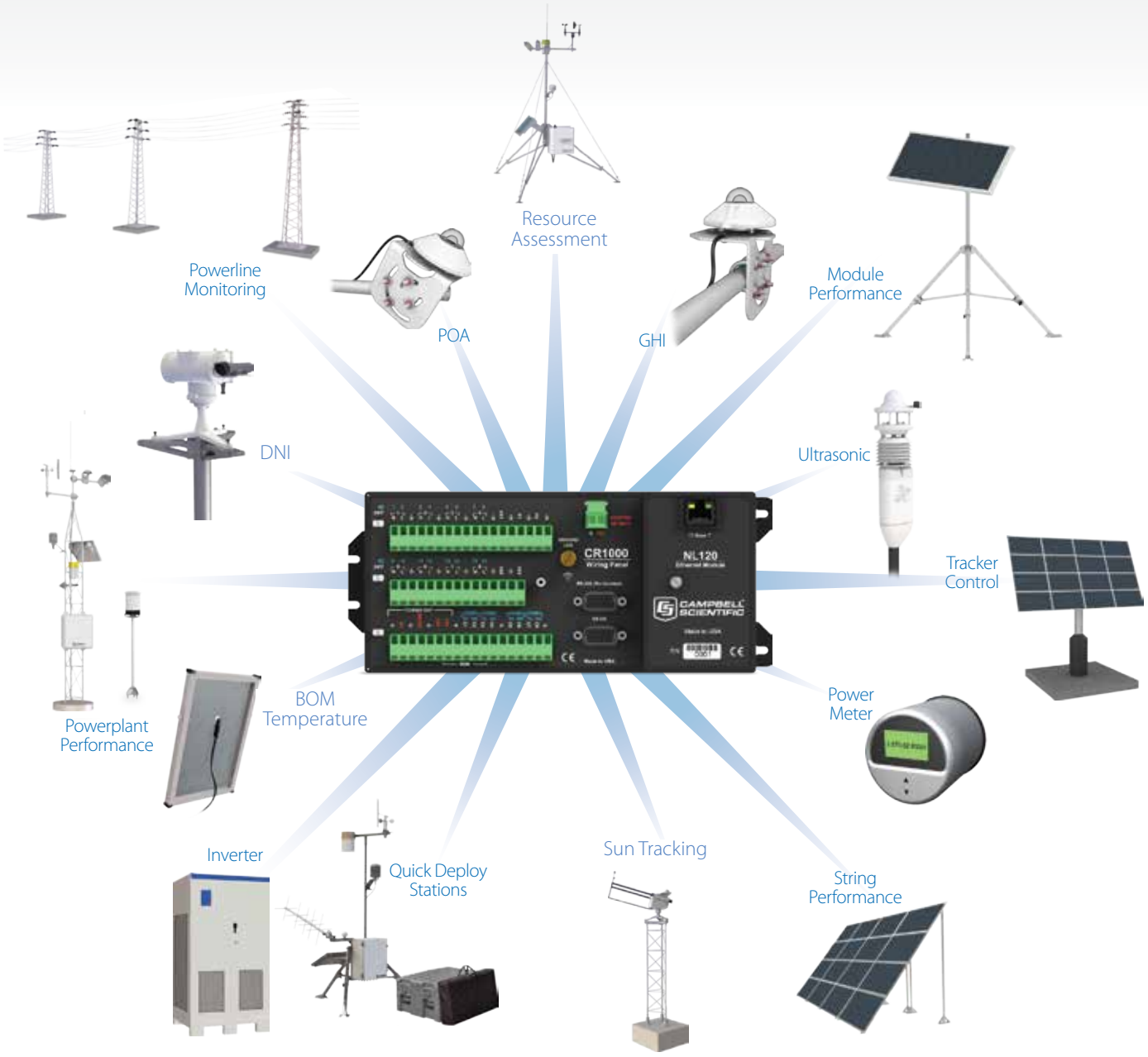
Solar Energy Solutions for Any Application



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Front cover photo courtesy of GroundWork Renewables (www.grndwork.com). GroundWork designs, builds, installs, and maintains meteorological stations, and operates a rigorous data quality program for delivering their clients low uncertainty datasets.

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SOLAR ENERGY

Systems for Solar Resource Assessment, Power Performance, and Advanced Monitoring

Campbell Scientific offers automated data-acquisition systems specifically designed for solar monitoring applications. Preconfigured systems, designed to meet CAISO standards for solar telemetry, are available for photovoltaic and concentrated solar technology projects of all sizes. Our engineers work closely with the customer to design highly customized stations, advanced research and development stations, and custom application programming interfaces (API) for data collection.

MAJOR SYSTEMS

		Measurements		Datalogger	Power	Communications
		Typical	*Optional*			
SOLAR800 Complete MET Solution for Solar Resource Assessment		Global Horizontal Irradiance (GHI), Plane-of-Array Irradiance (POA), air temperature, wind speed, wind direction, precipitation, solar position	relative humidity, barometric pressure	CR800	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP
SOLAR1000 Operational Met Station for Solar Energy Producing Utilities		Global Horizontal Irradiance (GHI), Plane-of-Array Irradiance (POA), back-of-solar panel temperature, wind speed, wind direction, air temperature, relative humidity, barometric pressure, precipitation, solar position	DC current and voltage (string and/or module), visibility, electric field, cloud height, short circuit current, module soiling, surface moisture	CR1000, CR800 CR3000	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP, TCP/IP, fiber optic, radio, serial, field display, satellite, Wi-Fi
SOLAR1000-SCE Operational Met Station for Solar Energy Producing Utilities; meets CAISO, SCE compatible		Global Horizontal Irradiance (GHI), Plane-of-Array Irradiance (POA), diffuse radiation, back-of-solar panel temperature, wind speed, wind direction, air temperature, relative humidity, barometric pressure, precipitation, solar position	DC current and voltage (string and/or module), visibility, electric field, cloud height, short circuit current, module soiling, surface moisture	CR1000, CR3000	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP, TCP/IP, fiber optic, radio, serial, field display, satellite, Wi-Fi

		Measurements		Datalogger	Power	Communications
		Typical	*Optional*			
CSP100 Highest accuracy solar monitoring solution with 2-axis sun tracker		Direct Normal Irradiance (DNI), Diffuse Horizontal Irradiance (DIFF), Global Horizontal Irradiance (GHI), wind speed, wind direction, air temperature, relative humidity, barometric pressure, precipitation, solar position	visibility, cloud height, spectral irradiance	CR1000, CR3000	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP, TCP/IP, fiber optic, radio, serial, field display, satellite, Wi-Fi
RSR100 Rotating Shadow-band Radiometer		Global Horizontal Irradiance (GHI), Diffuse Horizontal Irradiance (DIFF), Plane-of-Array Irradiance (POA), Direct Normal Irradiance (DNI), back-of-module temperature (BOM), solar position/air mass, wind speed, wind direction, air temperature, relative humidity, barometric pressure, precipitation	string current and voltage	CR1000 CR800	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP, TCP/IP, fiber optic, radio, serial, field display, satellite, Wi-Fi
SMP100 Solar module performance solutions, including Soiling		module current, module voltage, back-of-panel temperature, short-circuit current, wind speed, irradiance, solar position	string current and voltage, spectral irradiance	CR1000 CR800	AC, DC, or solar	Modbus, cellular, email, DNP3, FTP, TCP/IP, fiber optic, radio, serial, field display, satellite, Wi-Fi
SOLAR200 Small to Medium Commercial Solar Monitoring Solution		Global Horizontal Irradiance (GHI), Plane-of-Array Irradiance (POA), back-of-solar panel temperature, wind speed, wind direction	relative humidity, barometric pressure	CR200X	AC, DC, or solar	Modbus, multidrop, cellular, TCP/IP, fiber optic, radio, satellite, Wi-Fi
UTILITY-MET100 Utility-Grade Weather Station for SCADA Operations		air temperature, relative humidity, wind speed, wind direction, precipitation, barometric pressure, solar radiation	back-of-solar panel temperature	CR1000	AC, DC, or solar	Modbus, multidrop, cellular, TCP/IP, fiber optic, radio, satellite, Wi-Fi

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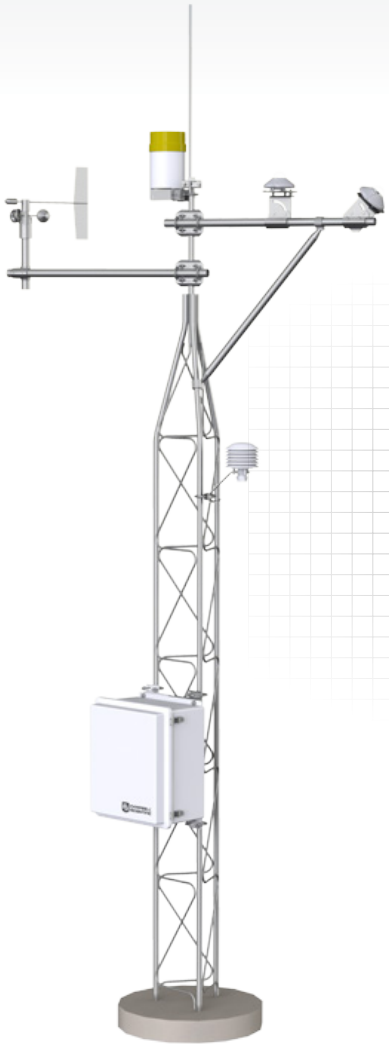
Solar1000

Solar Monitoring Station

Robust, Reliable, High Accuracy

Operational MET Station for Solar Energy Producing Utilities



Solar1000
Standard CAISO

Solar1000-SCE Meets
CAISO, SCE Compatible

Solar1000 Customized for PG&E

Overview

The Solar1000 is a configurable, turn-key solar measurement data acquisition station specifically designed to meet utility and industrial standards for solar monitoring applications, including power performance monitoring and operational assessment.

Built with fast to field features, delivered with complete system documentation including system drawings, wiring diagram, and installation guide, and supported by Campbell Scientific's experienced Application Engineers, the Solar1000 simplifies the high accuracy, high demand requirements of utility MET monitoring.

Configurable Any Spec or PPA

- *CAISO PIRP*
- *Southern California Edison*
- *Pacific Gas & Electric*
- *San Diego Gas & Electric*
- *Arizona Public Service*
- *MidAmerican Energy*
- *Duke Energy*
- *NextEra Energy*
- *Austin Energy*
- *Long Island Power Authority*

specs, questions, & quotes: **435.227.9030**
www.campbellsci.com/solar1000

Common Measurements Options

- Global Horizontal Irradiance (GHI)
- Plane of Array Irradiance (POA)
- Diffuse Horizontal Irradiance (DHI)
- Direct Normal Irradiance (DNI)
- Back of Module Temperature (BOM)
- Soiling
- Air Temperature
- Relative Humidity
- Wind Speed
- Wind Direction
- Precipitation
- Solar Position
- Barometric Pressure
- Visibility
- GPS Time and Position
- Snow Level
- Inclination/Position
- Sensor and Communication Fault Detection

Common Features and Options

- SCADA Protocols (Modbus, DNP3, and others)
- One Second Measurement, Data Delivery and Storage
- Wireless SCADA Connectivity
- Ethernet Connectivity
- Cellular Connectivity
- Fault Detection and Reporting
- AC and/or Autonomous DC Power Supply
- Operator's Manual and Installation Guide
- Technical Sales and Commissioning Support
- Engineering Services Available
- Contract Manufacturing Services Available

Any Configuration, Any Measurement, Any Data Transfer Media and Protocol

The Solar1000, based on the Campbell Scientific CR1000 Measurement and Control Datalogger, is completely customizable, allowing station configuration to meet your project's specifications, while retaining turn-key functionality. Nearly every aspect of the system is customizable, including sensors, communications, mounting, and power supply. Campbell Scientific dataloggers are the most versatile measurement platforms available. Any sensor can be measured and the data can be retrieved and sent over many different media, using any number of different protocols.

Turn-key measurement solutions such as the Solar 1000 are built using industrial best practice system fabrication methods to our client's specification. System documentation, including schematics, wiring diagrams, and installation guides are offered.

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Solar1000-SCE

SCE Compatible Solar Monitoring Station

CAISO, SCE Compatible

Operational MET Station for Solar Energy Producing Utilities

Sensors / Equipment

- *Heated Wind*
- *Air Temperature*
- *Relative Humidity*
- *Total Global Plane of Array Irradiation (one per collector plane)*
- *Total Global Horizontal Irradiation*
- *Diffuse Radiation*
- *Solar Altitude Angle*
- *Solar Azimuth Angle*
- *Precipitation*
- *Back of Module Temperature*
- *Soiling (Optional)*

Overview

The Solar1000-SCE is a meteorological station that meets or exceeds CAISO PIRP standards and is compatible with SCE Exhibit T Meteorological Station Specifications. Although offered as a turn-key package, the Solar1000-SCE retains the powerful, module nature of the Campbell Scientific product line. Nearly every aspect of the station is customizable, including sensors, communications, mounting, and power supply.

Features

- Station designed to minimize field wiring errors and reduce deployment time
- Wiring diagram, system drawings, and support documentation included
- Technical sales and commissioning support from Campbell Scientific application engineers included
- Station factory fabricated and tested prior to shipment

Attributes

- Campbell Scientific CR1000 or CR3000 Measurement and Control Datalogger
- Battery-backed system sized to allow data collection during power outages and network failure
- Any communication technologies such as TCP/IP, RS-485, fiber, cellular, satellite, and radio supported
- Compliant with Modbus, PakBus, and DNP3 protocols
- One second data delivery, storage, and management operation

Typical Configuration

1. CR1000 Measurement and Control Datalogger
2. SCADA Connectivity via Modbus and DNP (wireless and remote options available)
3. Uninterruptible Power Supply (solar panels available)
4. Robust Instrumentation Tower and Mounting Hardware
5. Heated Wind Sensor
6. Air Temperature Sensor
7. Relative Humidity Sensor
8. Barometric Pressure Sensor
9. Total Global Plane of Array Irradiation Sensor (one per collector plane)
10. Total Global Horizontal Irradiation Sensor
11. Diffuse Radiation Sensor
12. Precipitation Sensor
13. Back of Module Temperature Sensor
14. Soiling (Optional)

See Also

Solar800

Solar Resource Assessment Station with turn-key functionality and data collection

CSP100

Power Plant Assessment Station with the best possible solar resource measurements.

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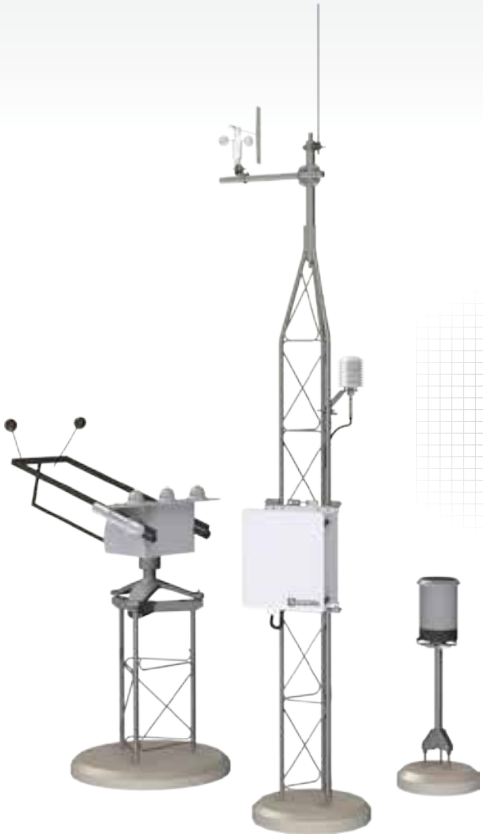
CSP100

Concentrated Solar Power Monitoring System with 2-Axis Sun Tracker



High Accuracy

Resource Assessment and Power Performance Monitoring for Concentrated Solar Power

Common Measurements

- *Direct Normal Irradiance (DNI)*
- *Diffuse Horizontal Irradiance (DIFF)*
- *Global Horizontal Irradiance (GHI)*
- *Wind Speed*
- *Wind Direction*
- *Air Temperature*
- *Relative Humidity*
- *Barometric Pressure*
- *Precipitation*
- *Solar Position*

Overview

The CSP100 is a turn-key automated data acquisition system specifically designed to meet CAISO meteorological station requirements of concentrated solar power generating facilities. It is recommended for assessing power plant performance, which requires the best possible solar resource measurements.

The CSP100 is field ready with features to minimize installation time and field wiring errors. Though offered as a turn-key package, nearly every aspect of the system is customizable, including sensors, communications, mounting, and power supply.

Benefits and Features

- Contains a Campbell Scientific CR1000 Measurement and Control Datalogger
- Provides the lowest uncertainty of the GH, DNI, and DIFF solar radiation measurements
- Fast to field with industry-proven, high-accuracy sensors
- Factory fabrication, programming, and testing minimizes field wiring errors and reduces deployment time
- Meets CAISO required meteorological data points
- Approved California ISO Remote Intelligent Gateway (RIG) for secure encrypted information transmission to CAISO
- Complies with Modbus, PakBus, and DNP3 protocols
- Supports nearly all communication technologies such as RS-485, fiber, TCP/IP, cellular, or satellite
- Reference design: "Solar Resource and Meteorological Project (SOLRMAP)", NREL
- Provides a modular, programmable, and customizable system
- Provides a battery back system that allows data collection during power outages and network failure
- Acts as single point data gateway for environmental, inverter, and meter data
- Supports TCP/IP functionality, including: HTTP Get, HTTP Post, FTP server and client, TelNet server, PING, Micro serial server, DHCP client, DNS client, email send and receive
- Supports Web Service API
- Supports individual module and string level power measurements
- Shipped with a quick-deploy installation guide and system schematics

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Solar800

Quick-Deploy Solar Resource Assessment Station

End-to-End

Complete Meteorological Solution for Solar Resource Assessment

Key Benefits

- *The right measurements*
- *Easy and quick to deploy*
- *No specialized training*
- *Data automatically delivered*

Overview

The Solar800 is a complete solar measurement data acquisition solution specifically designed for solar resource assessment. The Solar800 delivers the on-site observations essential for a thorough understanding of a project site's solar resource and variability.

The Solar800 is easy and quick to deploy, requiring no specialized training for proper installation and operation. Data is automatically sent to the client's server, cloud, SCADA, and/or FTP site.

Major System Components

Configuration Software
- Communication IP Addressing

MET Station
- Tripod
- Power Supply
- Cell modem/Ethernet interface

MET Sensors
- Global Horizontal Irradiance
- Plane of Array Irradiance
- Air Temperature
- Wind Speed
- Precipitation
- Relative Humidity
- Wind Direction
- Barometric Pressure

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RSR100

Rotating Shadowband Radiometer

Lower Cost / Lower Maintenance
Solar Resource Measurement System

Measurements

- *Global Horizontal Irradiance (GHI)*
- *Diffuse Horizontal Irradiance (DIFF)*
- *Plane-of-Array Irradiance (POA)*
- *Direct Normal Irradiance (DNI)**
- *Back of Module Temperature (BOM)*
- *Solar Position/Air Mass*
- *Wind Speed*
- *Wind Direction*
- *Air Temperature*
- *Relative Humidity*
- *Barometric Pressure*
- *Precipitation*

**Computed*

Overview

The RSR100, Rotating Shadowband Radiometer, offers a lower-cost option for providing solar measurements, GH, DIFF, and DNI. The RSR100 system utilizes the fast response time of a Li-Cor photocell diode (10 µsec) coupled with the burst measurement (up to 2 kHz), control, and processing capability of a Campbell Scientific datalogger to measure GHI and DIFF solar irradiance and compute DNI. An extensive range of additional sensors are available with the RSR100 for measuring meteorological and power parameters, such as wind speed and PV string performance. Reliable, low maintenance, low power requirements, and simple operation allow for long-term unattended remote solar resource assessment.

The RSR100 is built around Irradiance, Inc.'s RSR2™ Rotating Shadowband Radiometer. The RSR2™ is a second-generation instrument incorporating improvements in accuracy and mechanical reliability from collaborative research conducted at NREL, Sandia, and the University of Oregon Solar Monitoring Lab. Irradiance has manufactured over 500 RSR2™ units operating across six continents.

Benefits and Features

- Contains a Campbell Scientific CR1000 Measurement and Control Datalogger
- Provides a lower-cost and low power option for GHI, DNI, and DIFF solar radiation measurements
- Fast to field with industry-proven design
- Factory fabrication, programming, and testing minimizes field wiring errors and reduces deployment time
- Complies with Modbus, PakBus, and DNP3 protocols
- Supports nearly all communication technologies such as RS-485, fiber, TCP/IP, cellular, and/or satellite
- Provides a battery back system that allows data collection during power outages and network failure
- Supports Web Service API
- Supports individual module and string level power measurements

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Solar200
Solar Monitoring Station

Solar Monitoring Station

For commercial installations and distributed solar monitoring applications

Common Measurements

- *Solar radiation (plane-of-array)*
- *Solar radiation (global)*
- *Air temperature*
- *Back-of-panel temperature*
- *Wind speed*
- *Wind direction*

Overview

The Solar200 is an economic solar monitoring platform designed for commercial rooftop or other small to medium solar installations, as well as distributed solar resource monitoring. This turnkey system includes the hardware and software necessary to monitor the critical environmental parameters of any solar installation: solar irradiance, wind speed, wind direction, air temperature, and back-of-panel temperature.

Interfacing to the Solar200 is simple and can be accomplished with Campbell Scientific's Loggernet software that includes a Real-Time Monitoring dashboard. The Solar200's data also can be obtained via the Modbus protocol over an RS-485 interface, making connection to existing systems simple and easy. As with all Campbell Scientific products, the Solar200 is built for long-term unattended monitoring, with a focus on ruggedness, reliability, and measurement excellence.

Benefits and Features

- High reliability and longevity with a Campbell Scientific CR200X Measurement and Control Datalogger
- Easy, turn-key installation
- Factory fabrication, programming, and testing minimizes field wiring errors, reduces deployment time, and eliminates system programming
- Battery-back system enables continuous data collection, even during power outages and network failure
- Easy and flexible data retrieval
- Retains the powerful, modular nature of the Campbell Scientific product line allowing for user-defined modifications and customization

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SMP100

Solar-Module Performance Monitoring System

Simple Solutions for in-Field Soiling Measurements

Common Measurements

- *Short Circuit Current*
- *Open Circuit Voltage*
- *Cell Temperature**
- *Back of Module Temperature*
- *Plane of Array Irradiance*
- *Wind Speed*
- *Air Temperature*
- *Precipitation*
- *Solar Position**
- *Air Mass**
- *Angle of Incidence**

**Calculated value*

Overview

The SMP100 represents a novel approach to understanding PV performance. PV module soiling and power performance monitoring are two common applications for the SMP100.

The SMP100 can be combined with any Campbell Scientific datalogger-based system, including industry standard systems such as the Solar1000, Solar800, RSR100, and CSP100.

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RIG100

Remote Intelligent Gateway for CAISO Renewable Energy Applications

CAISO Validated RIG

Real-time local to EMS data interface

Overview

The RIG100 is a CAISO validated Remote Intelligent Gateway (RIG) used to telemeter secure real-time operational data from renewable energy generating units to the CAISO Energy Management System (EMS). It consists of a Campbell Scientific CR1000 datalogger and NL201 Network Link Interface, which uses a secure DNP3 over TCP/IP.

Benefits and Features

- Easily customized for specific plant needs
- Low cost
- Low power
- Multiple local wireless transmission options
- Uses PKI encryption to provide secure DNP3 data
- Customizable local dashboard for onsite, real-time data monitoring
- Supports TCP/IP functionality and Web Service API
- See www.campbellsci.com/california-wind-energy

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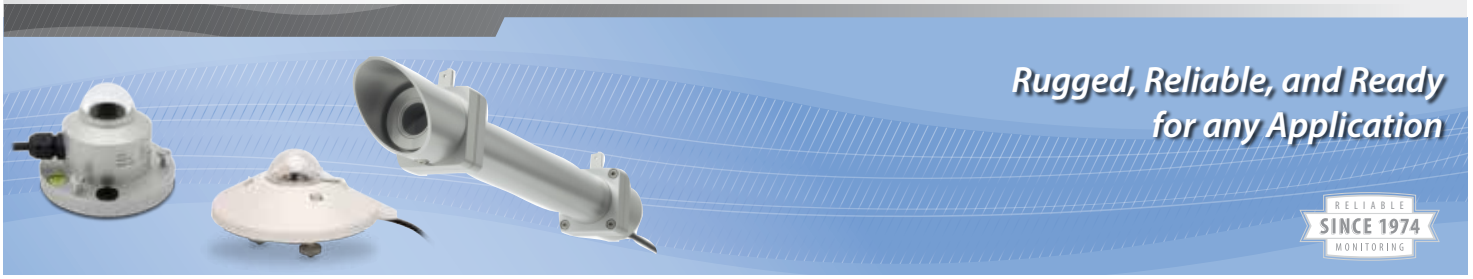
Solar Energy Sensors & Components

Pyranometers, pyrheliometers, radiometers, reference cells, spectroradiometers & sun trackers



Campbell Scientific offers pyranometers, pyrheliometers, radiometers, reference cells, spectroradiometers, and sun trackers, all designed to measure various aspects of the energy imparted by the sun on the Earth's surface.

SILICON PYRANOMETERS

	Features	Spectral Range	Sensitivity	Operating Temperature
LI200X | Silicon Pyranometer	• Long record of performance at NREL • Cosine corrected miniature head • Calibrated against Eppley PSP	400 to 1100 nm	0.2 kW m^{-2} mV^{-1}	-40° to +65°C
CS300 | Silicon Pyranometer	• Patented dome-shape does not trap water or debris • Excellent cosine response (silicon-cell pyranometer) • Four year warranty	360 to 1120 nm	5 mV/Wm^{-2}	-40° to +70°C
SP-212[a] | Silicon Pyranometer	• Amplified sensor • Excellent cosine response (silicon-cell pyranometer) • Dome-shaped for fully weatherproofing and self-cleaning	360 to 1120 nm	2.0 mV/W/m^2	-40° to +70°C

ISO SECOND-CLASS STANDARD

	Features	Spectral Range	Sensitivity	Operating Temperature
LP02 | ISO-Second Class Pyranometer	• ISO 9060 Second Class • Designed for continuous indoor and outdoor use	305 to 2800 nm	15 µV/W/m^2	-40° to +80°C
CMP3 | ISO-Second-Class Pyranometer	• ISO 9060 Second Class • Designed for continuous indoor and outdoor use	310 to 2800 nm	5 to 20 µV/W/m^2	-40° to +80°C

ISO FIRST-CLASS STANDARD

	Features	Spectral Range	Sensitivity	Operating Temperature
SR12[a] | ISO-First-Class Pyranometer	• Meets ISO 9060 "solar energy test applications" • Built in dome heater • Low calibration uncertainty (first class)	285 to 3000 nm	15 µV/W/m^2	-40° to +80°C
CMP6 | ISO-First-Class Pyranometer	• Fully compliant with ISO 9060:1990 • Fast response time • Long term stability characteristics	285 to 2800 nm	5 to 20 µV/W/m^2	-40° to +80°C

ISO SECONDARY STANDARD

		Features	Spectral Range	Sensitivity	Operating Temperature
SR20[a] | ISO-Secondary Standard Pyranometer		• Low calibration uncertainty • Reduced "zero offset A" • Low temperature dependence • Characterized temperature dependence • Characterized directional response • Built in dome heater • Built in temperature sensor	285 to 3000 nm	15 x 10^{-6} V/W/m^2	-40° to +80°C
CMP10 | ISO-Secondary Standard Pyranometer		• Based on CMP11 technology • Internal drying cartridge • 5-year warranty	285 to 3000 nm	15 x 10^{-6} V/W/m^2	-40° to +80°C
CMP11 | ISO-Secondary Standard Pyranometer		• Temperature compensated detector • Fast response time • Low tilt error • Excellent linearity	285 to 2800 nm	7 to 14 µV/W/m^2	-40° to +80°C
CMP21 | ISO-Secondary Standard Pyranometer		• Verified cosine response • Verified temperature dependence • Low dome IR offset error • Excellent linearity • Fast response time	285 to 2800 nm	7 to 14 µV/W/m^2	-40° to +80°C
CMP22 | ISO-Secondary Standard Pyranometer		• Most accurate pyranometer currently available • Negligible thermal gradient zero-offset • Lowest zero-offset due to FIR radiation • Low directional error • Wide spectral range	285 to 2800 nm	7 to 14 µV/W/m^2	-40° to +80°C

ISO FIRST CLASS PYRHELIOMETER

		Features	Spectral Range	Sensitivity	Operating Temperature
DR01[a] | ISO First Class Pyrheliometer		• ISO First Class • Heated window • Option temperature sensor • Optional temperature dependence characterization	(0 to 2000) W/m^2	10 x 10^{-6} V/(W/m^2)	-40° to 80°C
CHP1 | First Class Pyrheliometer		• ISO First Class • Built on legacy CH 1 • Built-in temperature sensors • Excellent temperature dependence of sensitivity	(200 to 4000) nm	7 to 14 µV/W/m^2	-40° to +80°C
MS-56[a] | ISO First Class Pyrheliometer		• ISO First Class • Ultra-fast response detector • Excellent temperature stability • Outdoors calibration • Window heater	200 to 4000 nm	6 to 10 µV/W/m^2	-40° to 80°C
NIP[a] | WMO First Class Pyrheliometer		• Same geometric dimensions as AHF Cavity Radiometer • Optional calibration can be performed against AHF • Meets ISO Secondary Standard	(0 to 1400) W/m^2	8 µV/W/m^2	-40° to 40°C

VENTILATION UNIT

		Features	Sensitivity	Operating Temperature
VU01[a] | Ventilation Unit		• 5 W and 10 W heaters on board, individually controllable • Small footprint, compact design • Fully specified, complies with ISO/TR 9901	Heater: 5 and 10 W at 12 Vdc Vent: 7.8 W at 12 Vdc	-40° to 70°C
CVF4-L[a] | Ventilation Unit		• Improved flow over the top of the dome • Integrated 5.5 W heater • New heater position and cover material reduce power requirement • Replaces CVF3 ventilation unit	Heater: 5.5 W at 12 Vdc Vent: 7.8 W at 12 Vdc	-40° to +70°C

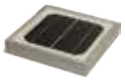
SUN TRACKER

		Sensor	Measurement Description	Sensitivity	Operating Temperature
SOLYS 2[a] | Sun Tracker		Fully automatic sun tracker	BSRN level performance. Can be interfaced for status information over IP	< 0.1° passive tracking <0.02° active tracking (with optional sun sensor)	-20° to +50°C
STR-22G[a] | Sun Tracker		Compact fully automatic sun tracker	BSRN level perfor-mance. Can be inter-faced for status information over serial	± 0.01° (with sun sensor)	-40° to +50°C

SOLAR TRACKER MOUNTING STANDS

		Used With	Material	Heights	Allowable Wind Gusts
Sun Tracker Mounting Stands		SOLYS 2 and EKO STR-22G	Hardened aluminum, corrosion-resistant	178 cm, 132 cm, or 86 cm	178 cm: 51 m/s 132 cm: 59 m/s 86 cm: 66 m/s

REFERENCE CELL

		Sensor	Measurement Description	Spectral Range	Sensitivity	Operating Temperature
Si-01TC-T-K[a] | Reference Cell		General purpose mono-crystalline solar cell	Reference Cell	varies	1 mV/W/m^2	-20° to +70°C
ESTI[a] | Reference Cell		User-supplies cell or chooses between mono or poly reference cell	Reference Cell	varies	varies	varies
PVMeasurements[a] | Module Type Outdoor Reference Cell		Multiple configurations, including module packages available	Reference Cell	varies	varies	varies

BACK OF MODULE TEMPERATURE

		Sensor	Measurement Description	Sensitivity	Operating Temperature
110PV-L | Surface-Mount Thermistor Rugged, Accurate		Thermistor with specially designed protective aluminum disk	Back of Module Temperature	+1°C	-40° to +135°C
CS220-L | Surface-Mount Type E Thermocouple		Type E Thermocouple meets ASTM E230-ANSI MC 96.1	Back of Module Temperature	+1°C	up to 260 °C
CS223-L | Surface-Mount Class A RTD		100 Ω DIN Class A RTD	Back of Module Temperature	±0.06 Ω or ±0.15 °C	-73° to +260 °C

SPECTRORADIOMETERS & ROTATING SHADOWBAND RADIOMETERS

	Sensor	Measurement Description	Spectral Range	Sensitivity	Operating Temperature
MS-700[a] | Spectroradiometer Permanent Outdoor Usage	Spectroradiometer for permanent outdoor usage	Spectral flux density over visible wavelengths	350 to 1050 nm	10 nm (spectral resolution FWHM)	-20° to 50°C
WISER System (MS-710/ MS-712)[a] | Spectroradiometer	Full spectrum spectroradiometer	Higher resolution spectral flux density over visible and NIR wavelengths	350 to 1700 nm	5 nm (MS-710), 7 nm (MS-712) spectral resolution	-10° to 40°C
RSR2[a] | Rotating Shadow-band Radiometer	Silicon-cell photo-diode with rotating shadowband	Global, diffuse, and direct irradiance	400 to 1100 nm	0.2 kW m^{-2} mV^{-1}	-40° to 65°C

WIND SPEED & WIND DIRECTION

	Sensor	Measurement Description	Output Range	Operating Temperature
034B-L | Wind Set Good all purpose wind set	3-cup anemometer and wind vane	wind speed and direction	Wind Speed 0 to 50 m s^{-1} Direction 0° to 360°	-30° to +70°C
03002-L | Wind Sentry Set Good all purpose wind set	3-cup anemometer and wind vane	wind speed and direction	Wind Speed 0 to 50 m s^{-1} Direction 0° to 360°	-50° to 50°C
05103-L | Helicoid Wind Monitor Designed to prevent ice buildup Rugged, Reliable Wind Measurements	heliocoid anemometer and wind vane	wind speed and direction	Wind Speed 0 to 75 m s^{-1} Direction 0° to 360°	-50° to 50°C
WINDSONICX-L | High Quality and Lightweight	2-D sonic anemometer	wind speed and direction	Wind Speed 0 to 60 m s^{-1} Direction 0° to 359°	-35° to 70°C
RM Young 85004[a] | Heated Ultrasonic for Extended Cold Weather Use	heated, 2-D sonic anemometer	wind speed and direction	Wind Speed 0 to 70 m s^{-1} Direction 0° to 360°	-50° to 50°C
CSAT3 | 3D Sonic Anemometer Best instrument for flux and other high-level turbulence research projects	3-D sonic anemometer	u_x, u_y, u_z, c	Full Scale Wind ±65.535 m s^{-1}	-50° to 70°C

BAROMETRIC PRESSURE SENSORS

	Signal Type/Output	Measurement Description	Output Range	Operating Temperature
CS100 (Setra 278) | Standard Barometer Reliable and accurate	analog voltage	barometric pressure	600 to 1100 mb[b]	-40° to 60°C
092-L | Includes Weather-proof Enclosure Reliable and accurate	analog voltage	barometric pressure	600 to 1100 mb	-40° to 55°C

TEMPERATURE & RELATIVE HUMIDITY

	Signal Type/Output	Measurement Description	Output Range	Operating Temperature
CS215-L | Reliable and easy to maintain	SDI-12	temperature relative humidity	Temperature -40° to 70°C Relative Humidity 0 to 100%	-40° to 70°C
083E-L | Accurate and reliable sensor	analog voltage	temperature relative humidity	Temperature -50° to 50°C Relative Humidity 0 to 100%	-50° to 50°C
HC2S3-L | Accurate and rugged	analog voltage	temperature relative humidity	Temperature -40° to 60°C Relative Humidity 0 to 100%	-40° to 100°C
43347-L | Highly accurate RTD for atmospheric stability monitoring ±0.1°C accuracy with NIST calibration	analog voltage	temperature	±50°C	±50°C
43502-L | Aspirated Shield, provides more accurate measurement	NA	Delta T: <0.05°C RMS with like shields	5 to 11 m s^{-1}	-50° to 60°C

OTHER

	Signal Type/Output	Measurement Description	Measurement Range	Operating Temperature
CS120A | Visibility Sensor High Performance Visibility Measurements	RS-232, RS-485	Meteorological Observable Range (MOR)	12 m to 32 km	-25° to 60°C
SR50A-L | Sonic Ranging Sensor used to measure snow depth	SDI-12, RS-232, RS-485	Snow depth	0.5 to 10 m (1.6 to 32.8 ft)	-45° to +50°C
LWS-L | Surface Wetness Sensor Dielectric sensor to determine presence of water and ice	analog voltage	dry, frosted, wet	250 mV to 1500 mV, millivolt reading relates to moisture state	-20° to 60°C
CS135 | LIDAR Ceilometer Sensitive, Long Range Cloud Measurement	RS-232, RS-485	cloud height and vertical visibility	5 m to 10 km: up to four cloud layers reported	-40° to 60°C
CS616-L | Soil Water Content Reflectometer	±0.7 V square wave with frequency dependent on water content	Soil Volumetric Water Content	0% to saturation	0° to 70°C

NOTES:

[a] *Item is special ordered and cabled by Campbell Scientific.*

[b] *The CS100 is available in special ranges of 500 to 1100 and 800 to 1110 mb; contact Campbell Scientific for more information.*

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WHEN MEASUREMENTS MATTER

DATALOGGERS

Also known as Data Loggers, Data Recorders, & RTUs

Rugged, reliable, and ready for any application

RELIABLE SINCE 1974 MONITORING

Dataloggers are the heart of a data acquisition system. They measure sensors at a specific scan rate, process data, store the data, and initiate telecommunications. Our dataloggers also have control capabilities allowing them to respond to specific site conditions by opening flood gates, turning fans off/on, etc. All our dataloggers share similar measurement and programming capabilities. Selection of the appropriate datalogger depends mainly on the type, number, precision, and speed of measurements required.

MAJOR SPECIFICATIONS

	Channels	*Input Voltage Range*	*Analog Voltage Resolution*	*A/D Bits*	*Max imum Scan Rate*
CR6* | Innovative Vibrating Wire Powerfully versatile multi-tool for data acquisition; onboard vibrating-wire measurement **The number of measurements listed in the Channels column assumes all of the U and/or C channels are configured for that type of measurement.*	12 universal (U) and 4 control (C) terminals are programmable to measure up to: • 12 SE analog inputs • 6 DF analog inputs • 16 pulses • 12 voltage switched excitation • 12 current switched excitation • 2 RS-232 • 2 RS-485 • 16 I/Os • 8 SDI-12	±5000 mV	to 50 nV	24	1 kHz
CR1000 | Rugged Versatility Multipurpose Monitoring and Control 	Analog: 16 SE or 8 DF Pulse: 2 Switched Excitation: 3 voltage Digital: 8 I/O or 4 RS-232	±5000 mV	to 0.33 µV	13	100 Hz
CR800 | Smaller, Simpler Research-grade power for smaller installations 	Analog: 6 SE or 3 DF Pulse: 2 Switched Excitation: 2 voltage Digital: 4 I/O or 2 RS-232	±5000 mV	to 0.33 µV	13	100 Hz
CR200X | Smallest Low-cost alternative for simpler applications 	Analog: 5 SE Pulse: 2 Switched Excitation: 2 voltage Digital: 2 I/O	0 to 2500 mV	to 0.6 mV	12	1 Hz
CR3000 | Fast, Compact Supports complex installations, built-in keyboard and display 	Analog: 28 SE or 14 DF Pulse: 4 Switched Excitation: 4 voltage 3 current Digital: 3 SDM, I/O, or 4 RS-232 Continuous Analog Output: 2	±5000 mV	to 0.33 µV	16	100 Hz

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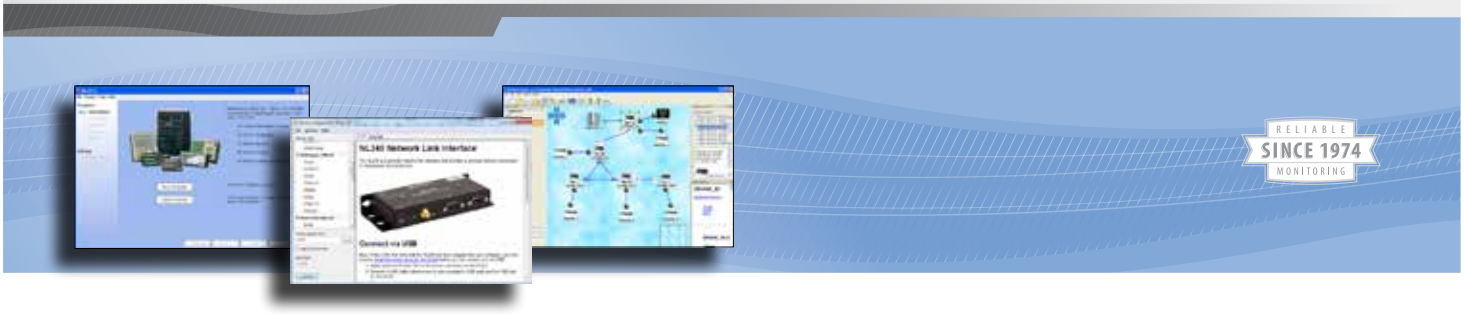
MONITORING AND SUPPORT SOFTWARE



Our software solutions support device configuration, datalogger and station programming, communications between the station and a PC and database, and real-time and historical data monitoring and retrieval. Software supports extend from a single station to large networks.

SOFTWARE

		Description
LOGGERNET/LOGGERNET ADM | Datalogger Support Software		LoggerNet is Campbell Scientific's main datalogger support software packages; supporting programming, communication, and data retrieval between dataloggers and a PC. LoggerNet Admin provides additional clients, capabilities, and tools that are useful when managing a large datalogger network.
LNDB | LoggerNet Database Software		LNDB is an application that enables you to easily move data from a LoggerNet data cache into a database such as Microsoft SQL Server or MySQL. Then you can use industry-standard software to access and query your data for reports. LNDB also comes with QuickReports, an application that allows you to generate simple reports from an LNDB database with just a few mouse clicks.
SCWIN | Short Cut Program Generator for Windows (SCWin)		SCWin is a free, menu-driven, PC-compatible software package that simplifies the creation of datalogger programs; it creates a datalogger program in five easy steps.
LOGGERLINK | Mobile Apps for iOS and Android		LoggerLink Mobile Apps are simple yet powerful tools that allow an iOS or Android device to communicate with CSI dataloggers via an IP device. The apps support field maintenance tasks such as viewing and collecting data, setting the clock, and downloading programs.
RTMCPRO | Real-Time Monitor and Control Software, Professional Version		RTMC Pro is used to create and run graphical screens that provide real-time monitor and control capabilities. You can easily design displays using its large library of components including alarms, switches, status bars, charts, and gauges. Simply select a component, place it on the workspace, and specify the data value to be displayed. Each component has properties that can be set by the user giving maximum design control.
Device Configuration Utility		Device Configuration Utility (DevConfig) is used to download operating systems and set up Campbell Scientific hardware. It will also update PakBus Graph and the Network Planner if they have been installed prior by another Campbell Scientific software package.

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Solar Resource Assessments

Ground data from Campbell Scientific dataloggers reduces solar project finance costs

The utility-scale solar industry specifies Campbell Scientific equipment to measure irradiance and other environmental conditions both before and during solar power generation.

These solar-monitoring stations, when accompanied by a data-quality program, generate low uncertainty datasets used to model energy production. In this way, Campbell Scientific and system integrators like GroundWork Renewables make renewable energy projects possible by reducing capital financing costs and increasing the bankability of the projects.

GroundWork designs, builds, installs, and maintains stations to meet project requirements, including plant type, size, ISO (CAISO), or PPA (e.g., SCE, PGE), and offers a rigorous data-quality program (GroundWatch) that uses Campbell Scientific's Loggernet. The integrators turn to Campbell Scientific for dataloggers, enclosures, sensors, communication, remote power, and mounting equipment.

For irradiance and ancillary weather data measurements, the stations are based on a Campbell datalogger installed on a temporary meteorological tower with remote power and cellular or satellite communication. The stations can measure any and all irradiance components, wind speed and direction, relative humidity, temperature, barometric pressure, and precipitation.

With stations deployed across the country, there are all-weather options with pyranometer ventilators and heaters and heated ancillary sensors. To further assist power modelers, soiling study stations can be integrated into the Campbell logger to analyze soiling trends, effects of weather events and module cleaning requirements.

Independent engineers and developers take the ground data to tune the satellite estimates, generating an adjusted historical time series for the site. The resource assessment that most closely represents solar irradiance at the project site is used to model the plant's energy output.

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WHEN MEASUREMENTS MATTER

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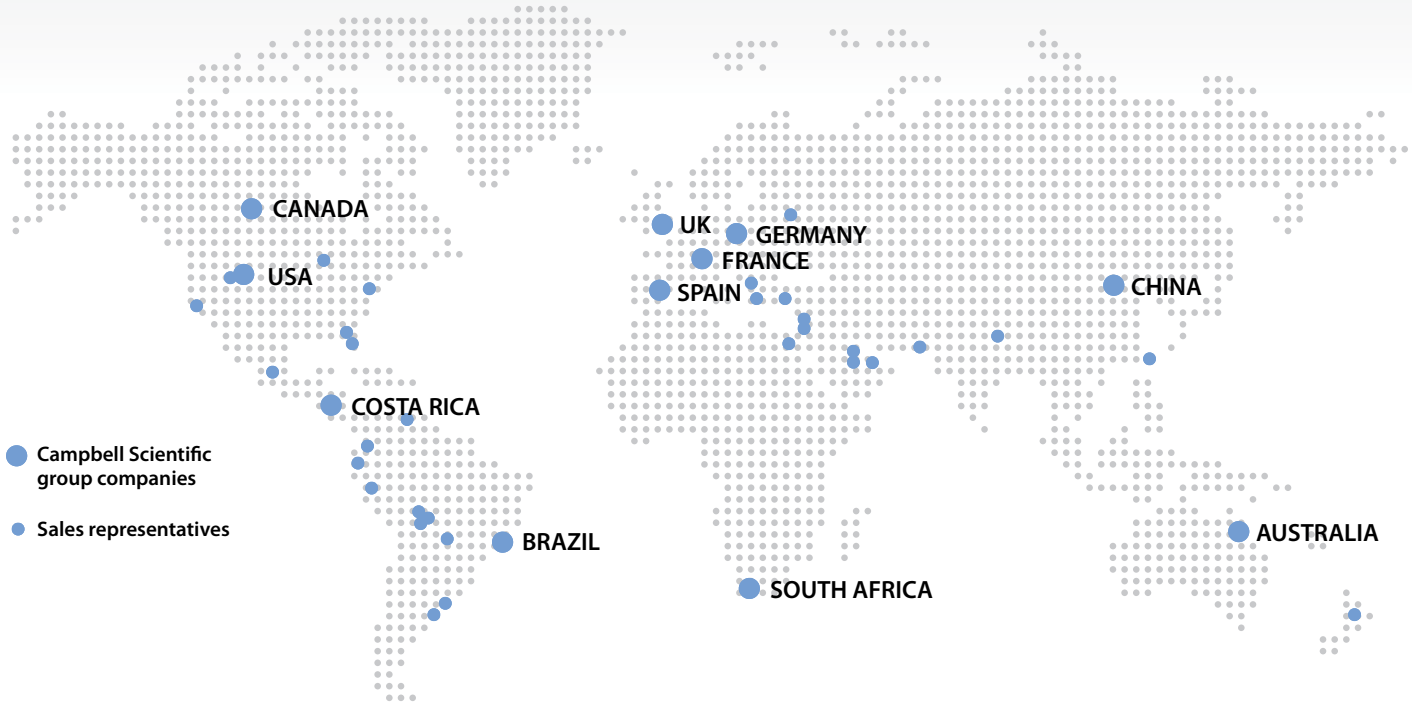

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