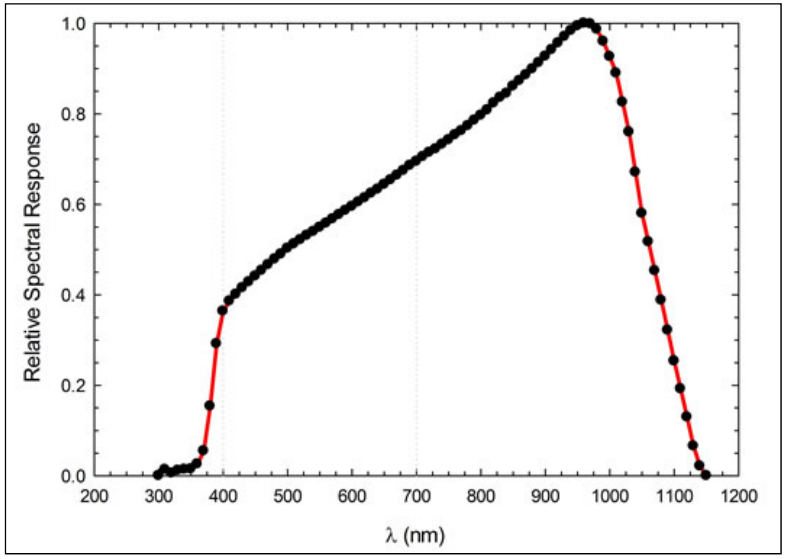
Pyranometer
(PYR-BTA)

The Vernier Pyranometer measures the power of electromagnetic radiation in watts per square meter. It is sensitive to the near infrared, visible, and UV ranges, where nearly all of the solar energy is concentrated. It is great for experiments with solar cells and calculating their efficiency. The sensor is weatherproof and has a dome-shape top to allow it to work with a wide range of sun angles. The Pyranometer has a 6 m cable.

An ideal pyranometer measures the entire solar spectrum, 280 to 2800 nm. However, about ninety percent of sunlight energy is in the wavelengths between 300 and 1100 nm. The Vernier Pyranometer detects all of this energy.

The Vernier Pyranometer is cosine corrected and is designed to maintain its accuracy when radiation comes from different angles. The cosine response when the sun is at 75° to the zenith is ± 5 percent. Zenith angles greater than 75° contribute less than 3 percent of daily radiation.



Spectral response of the Vernier Pyranometer

What is Included with the Pyranometer

- Pyranometer
- Cover for the lens of the Pyranometer

Mounting the Pyranometer

The Pyranometer is designed to be permanently mounted outside. It is weatherproof and has a lens to work with a wide range of sun angles. The sensor, itself, is designed for continuous outdoor use. The black electronics box should be kept dry.

The Pyranometer should be mounted with the white lens pointing straight up and with the cord pointing toward the north (if you are in the Northern Hemisphere) or toward the south (if in the Southern Hemisphere).

The nylon 10–32″ x 3/8″ mounting screw can be used for attaching the Pyranometer to a solid object.

Cleaning the Pyranometer

Debris on the Pyranometer lens is a common cause of low readings. Salt deposits can accumulate on the sensor from evaporation of sprinkler irrigation water, and dust can accumulate during periods of low rainfall. Salt deposits should be dissolved and removed with vinegar and a soft cloth or cotton swab. Dust and other organic deposits are best removed with water, rubbing alcohol, or window cleaner. Never use an abrasive cleaner on the lens.

Collecting Data with the Pyranometer

This sensor can be used with the following interfaces to collect data.

- Vernier LabQuest® 2 or original LabQuest as a standalone device or with a computer
- Vernier LabQuest Mini with a computer
- Vernier LabPro® with a computer or TI graphing calculator
- Vernier Go!®Link
- Vernier SensorDAQ®
- Vernier EasyLink®
- CBL 2™
- TI-Nspire™ Lab Cradle

Data-Collection Software

This sensor can be used with an interface and the following data-collection software.

- **Logger *Pro* 3** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, or Go! Link.
- **Logger Lite** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, or Go! Link.
- **LabQuest App** This program is used when LabQuest 2 or LabQuest is used as a standalone device.
- **LabVIEW™** National Instruments LabVIEW™ software is a graphical programming language sold by National Instruments. It is used with SensorDAQ and can be used with a number of other Vernier interfaces. See www.vernier.com/labview for more information.
- **DataQuest™ Software for TI-Nspire™** This calculator application for the TI-Nspire™ can be used with the EasyLink or TI-Nspire™ Lab Cradle.

- **EasyData App** This calculator application for the TI-83 Plus and TI-84 Plus can be used with CBL 2™, LabPro, and Vernier EasyLink. We recommend version 2.0 or newer, which can be downloaded from the Vernier web site, www.vernier.com/easy/easydata.html, and then transferred to the calculator. See the Vernier web site, www.vernier.com/calc/software/index.html for more information on the App and Program Transfer Guidebook.
- **DataMate program** Use DataMate with LabPro or CBL 2 and TI-73, TI-83, TI-84, TI-86, TI-89, and Voyage 200 calculators. See the LabPro and CBL 2™ Guidebooks for instructions on transferring DataMate to the calculator.

Here is the general procedure to follow when using the Sensor.
1. Connect the Sensor to the interface.
2. Start the data-collection software.
3. The software will identify the Sensor and load a default data-collection setup. You are now ready to collect data.
4. If you have an old version of the software, or you are using a different interface, the sensor may not auto-ID. You can read the Raw Voltage (0–5 volts) from the sensor and set up a New Calculated Column to multiply the voltage reading by 250 to convert voltage to Irradiance in watts per square meter.

NOTE: Vernier products are designed for educational use. Our products are not designed nor recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

Calibration:

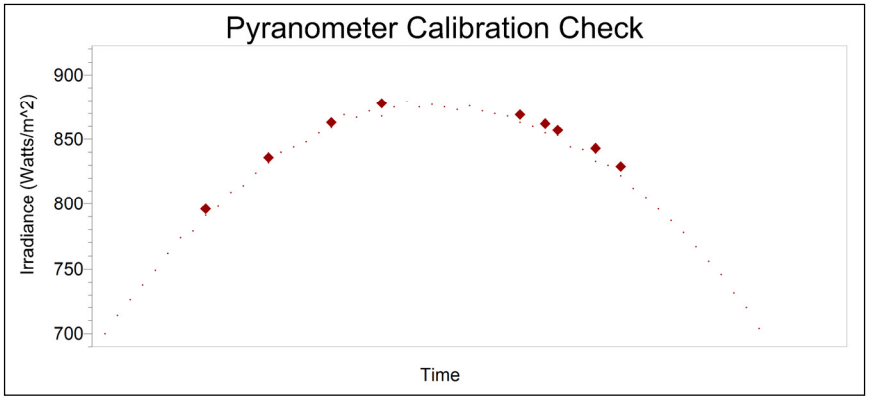
This Pyranometer was calibrated before shipping and should not need user calibration. It was calibrated over a multiple day period by comparison to a heated and ventilated Kipp & Zonen model CM21 precision reference radiometer.

Optional Calibration Check:

Our Pyranometer should never need calibration, but if you want to verify that the calibration is correct, you can check it using a Clear Sky Calibration. The concept involved here is that if you know your latitude, longitude, altitude, time of day, air temperature, and humidity, you should know the irradiance on a day with a totally clear sky (no clouds or pollution). If you have a clear sky day and you can get all the information, visit www.clearskycalculator.com

This site will offer you a web application that will calculate the irradiance in Watts per square meter, assuming a completely clear sky. Complete the required fields and you will get a reading, which you can compare with the Pyranometer reading. Repeat at several times near solar noon and over several days, if possible. If the reading from the Pyranometer is consistently lower than the Clear Sky Calculator value, the Pyranometer may need to be cleaned or re-leveled. If that does not correct the problem, contact Vernier Software & Technology.

Below is a graph showing a series of Clear Sky Calibration checks done on a clear day in Oregon. On this graph Irradiance readings from the Pyranometer are shown as dots and Clear Sky Calculator values shown as diamonds.



Irradiance on a clear day with Clear Sky Calculator values shown as diamonds

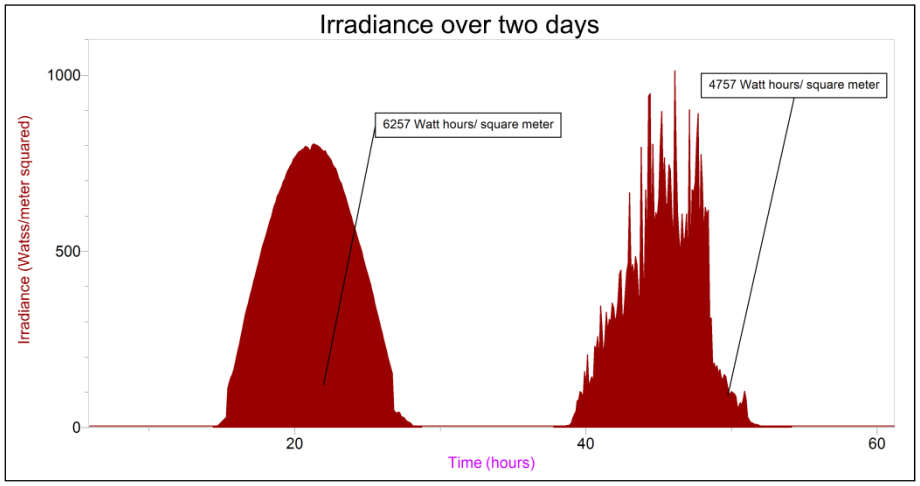
Specifications

Irradiance range		0 to 1100 W/m^2 (in full sun)
Absolute accuracy		±5%
Repeatability		±1%
Long-term drift		Less than 3% per year
Cosine response		1%
45º zenith angle		
75º zenith angle		±5%
Wavelength covered		370 –1140 nm
Current draw		300 µA
Resolution		
12-bit (LabPro, LabQuest, LabQuest 2, LabQuest Mini, Go!Link, SBI, ULI II)		0.3 W/m^2
10-bit (CBL 2)		1.2 W/m^2
Sensor dimensions		2.4 cm diameter by 2.75 cm height
Materials		Anodized aluminum with cast acrylic lens
Operating environment		–25 to 55˚ C 0–100% relative humidity Designed for continuous outdoor use Sensor can be submerged in water. The black electronics box should be kept dry.
Stored calibration values		
	slope	(250 W/m^2) / volt
	intercept	0 W/m^2

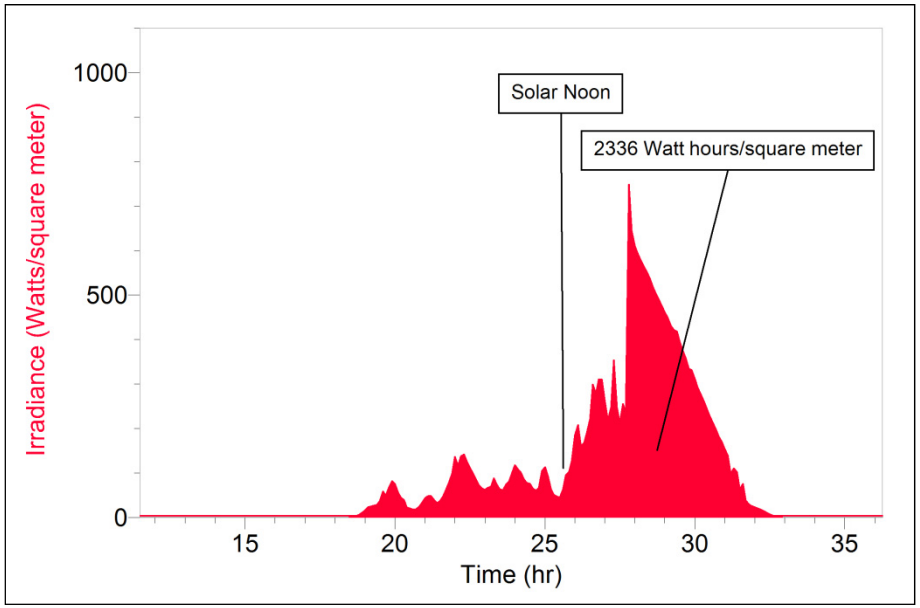
Suggested Experiments

Monitor the Energy from the Sun over Several Days

Here is a sample graph of Pyranometer data taken over two consecutive days. The first day had nearly clear skies and the second day was partly cloudy. **Note:** the integral of the irradiance over time is a measure of the energy available per square meter.

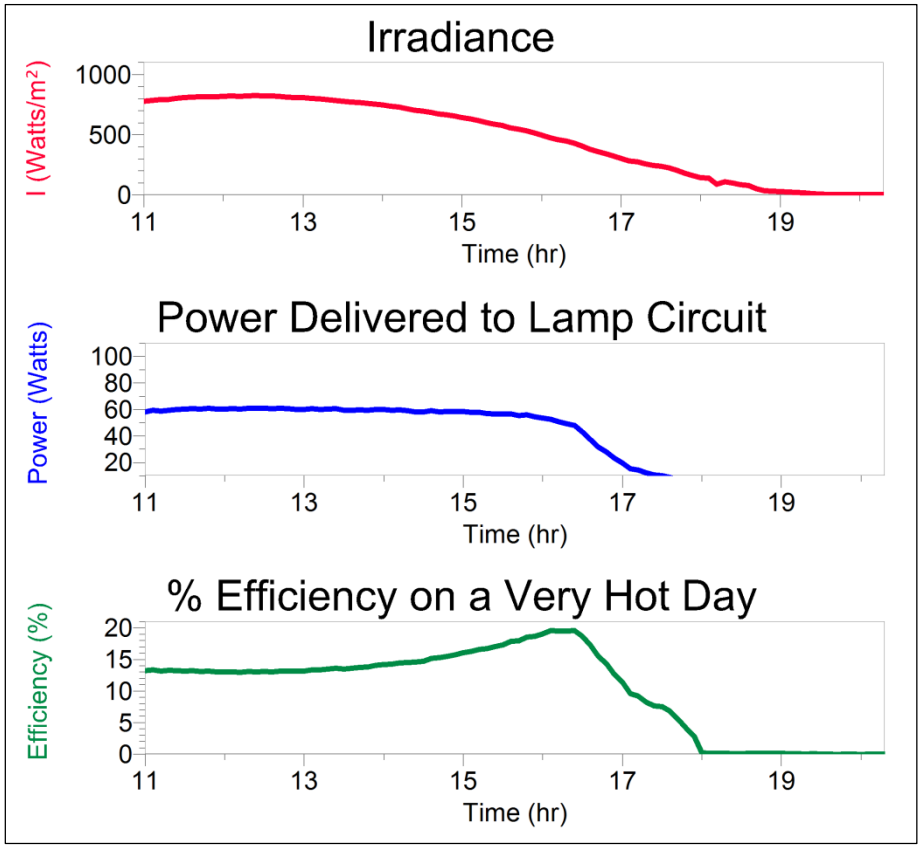


Here is a pyranometer graph for a day with the fairly common weather pattern near the coast of thick clouds in the morning *burning off* in the afternoon. **Note:** the total solar energy available on this day is considerable less.



Determining the Efficiency of a Solar Panel

Since the Pyranometer reads out in watts per square meter, it allows you to easily determine the efficiency of a photovoltaic system. You need to measure the surface area of the solar panels and then monitor the current and voltage delivered to the circuit. The graphs below were made using a automotive lighting system powered by a fairly large (about a half square meter) solar panel. The solar panel was fixed at the recommended angle for solar panels at that location. The experiment took place on a very hot day (high temperature 39ºC or 102ºF). We monitored the current through the circuit with a Vernier High Current Sensor (HCS-BTA) and the voltage with a Vernier 30-Volt Voltage Probe (30V-BTA). We calculated the power as the product of current and voltage. Note that the efficiency of the system varied between 13 and 20 percent.



Use the Pyranometer as a Control in Solar Panel Studies

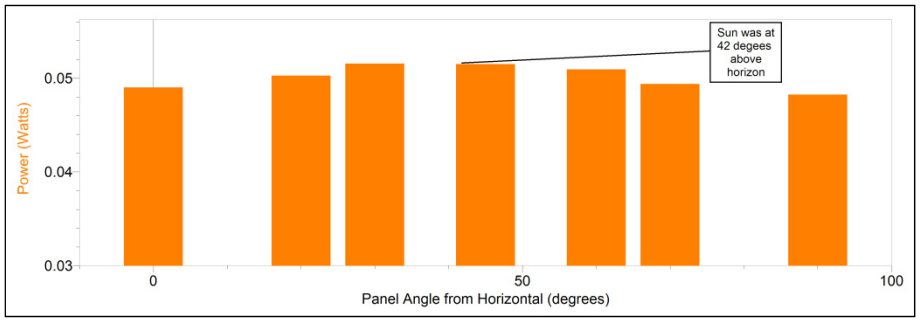
There are a lot of experiments that can be done using photovoltaic cells. Students may be interested in investigating any of the following or other topics:

- What is the optimum tilt of the panel?
- How much does tracking the sun vertically (changing tilt angle during the day) improve the efficiency of the panels?

- How much does tracking the sun horizontally (rotating the panels east to west) have on the efficiency of the panels?
- How does efficiency vary with the temperature of the panel?
- How much impact does minor dust and dirt have on the efficiency of the panel?

If you use the Pyranometer at the same time as you do these experiments, you can make sure that the amount of solar energy available was constant during the experiment and you can calculate efficiency for the panels under different conditions.

Here are some sample results from an experiment with a small photovoltaic cell testing the tilt angle with the Pyranometer used to verify that the irradiance remained constant during data collection.



Related Products

This sensor is great for use with current and voltage probes in solar energy studies with small solar cells (with dimensions of a few centimeters on a side).

Name		Order code
For experiments with small solar cells		
Current Sensor	(max current 0.6 A)	DCP-BTA
Differential Voltage Probe	(max V=6V)	DVP-BTA
or		
Voltage Probe	(max V=10V)	VP-BTA
For experiments with large solar panels (with dimensions greater than 30 cm or so):		
High-Current Sensor	(max current 10 A)	HCS-BTA
30-Volt Voltage Probe	(max V=30V)	30V-BTA

Warranty

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use.

Vernier
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