Measurements for Solar Power, Greenhouse Lighting, and Architectural Lighting Applications

Solar energy, horticulture, and indoor lighting all depend upon high quality light measurements. These measurements are made with pyranometers, quantum sensors, and photometric sensors.

> *"Whether you are evaluating solar energy resources, measuring light in a greenhouse, or evaluating architectural lighting, light and radiation are important variables to measure."*

What do potential solar energy yield, greenhouse brightness, and architectural lighting have in common? They all depend upon measurements of radiant energy. In the simplest applications, radiant energy is measured with a small sensor and readout device or data logger. More complex applications may use the reading from a light sensor to automate a process, such as adjusting lighting in a room or checking the efficiency of a solar panel.

Whether you are trying to improve solar power generation efficiency, optimise greenhouse productivity, or position lights in an exhibit, radiant energy measurements can help ensure your success. Although these applications depend upon measurements of radiant energy, these three types of measurements are made with specific sensors.

Solar Power

Global solar radiation is measured with a pyranometer and expressed as watts per meter squared (W m^{-2}). Thermopile pyranometers are the highest-quality pyranometers—they are sensitive to solar radiation with wavelengths from 280 to 2800 nm. Many lower-cost pyranometers use silicon photodiodes and are sensitive to radiation with wavelengths from 300 to 1100 nm. Silicon photodiodes respond more quickly to changes in sunlight and are suitable for most solar energy applications.

In solar power applications, pyranometers can determine potential yield, identify ideal locations for solar power stations, and monitor system performance over time. Variations in solar radiation at a site can dramatically affect energy yields from solar generation facilities. Accurate assessments of solar power resources can support planning and provide information that ensures optimum solar power yield.

Many service providers use pyranometers to evaluate potential solar energy yield and long-term performance of photovoltaic cells. For example, Solmetric (Sebastopol, CA) makes a wireless photovoltaic reference sensor known as the SolSensor that is used to evaluate performance of solar panel arrays. Another company, Irradiance (Lincoln, MA), uses a Rotating Shadowband Radiometer (RSR2) to measure site-specific solar energy resources. Both of these systems include a LI-COR pyranometer that uses a silicon photodiode detector.

Plant Growth

In greenhouses and plant growth studies, people are often interested in measuring light that drives photosynthetic reactions. This is referred to as Photosynthetically Active Radiation (PAR), and includes all energy with wavelengths between 400 nm and 700 nm. PAR is measured with a quantum sensor. Units are expressed as the number of photons over time over an area, or µmol s^{-1} m^{-2}.

Quantum sensors typically use either a silicon or gallium arsenide photodiode and one or more light filters to achieve this sensitivity. Generally, silicon photodiodes are superior to gallium arsenide photodiodes because the latter are less sensitive to blue light below 450 nm or red light above 650 nm, and therefore they tend to underestimate (or fail to detect) light in these wavebands. This can induce large errors in measurements of light sources that are not spectrally uniform.

Greenhouses and plant growth facilities require optimum lighting to maximise plant growth and productivity, while minimising energy consumption. Light measurements help optimise growth, and can be used to automate supplemental light levels in greenhouses and guide positioning of lights in indoor growth facilities. Measurements of PAR from a quantum sensor provide this information.

Figure 1: Pyranometers are used to assess solar energy potential and efficiency.

Figure 2: Quantum sensors can help optimise lighting conditions in greenhouse applications.

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Indoor Lighting

When designing for visual comfort—in workspaces, exhibits, and meeting rooms—light measurements can guide planning and placement of lights. The ideal sensor for this application will measure light as perceived by a typical human eye. In human-interest applications, light is measured as lux or lumens.

Light measurements can guide planning—such as the placement and brightness of lights; or tinting and glazing windows. In addition, they can be used to automate processes that control light levels, such as automatically opening and closing blinds, and automatically dimming lights.

Buildings, large and small, are improved with careful attention to lighting. Architects can incorporate systems to automate shading and lighting in buildings from homes to skyscrapers. The technologies they use can automatically adjust shading over windows to optimise lighting, provide a more pleasant environment, and save money on energy costs.

Sensor Design Improvements

LI-COR Biosciences has over 40 years of experience designing and manufacturing light sensors. Recently redesigned sensors present a big step forward in low-cost light measurement instruments—bringing a new level of durability, sensitivity, and utility to light and solar radiation measurements. They feature a core of design characteristics that simplify installation and ensure high-quality, dependable measurements.

Each sensor is easily removable from its cable. This simplifies installations that have complex cable runs and reduces costs because sensors can be removed while the cables are left in place. This feature also makes it easy to remove a sensor for recalibration or to replace a damaged component.

The LI-190R Quantum Sensor is well suited for measuring light in greenhouse operations because it is sensitive to light between wavelengths of 400 nm and 700 nm—the light that drives photosynthesis in plants. The LI-190R uses a high-quality silicon photodiode and a carefully selected optical filter for uniform sensitivity to photosynthetically active radiation. As a result, the LI-190R maintains accuracy when measuring light that is not spectrally uniform, such as light from artificial light sources, light under a plant canopy, or light in a greenhouse.

The LI-200R Pyranometer combines accuracy, durability, and economy as a low cost alternative to class one thermopile pyranometers. It provides accurate measurements under clear sky conditions, and is well suited for solar power planning and evaluation.

The LI-210R features bell-shaped sensitivity to light between 450 and 675 nm, with a peak at about 550 nm. Although each human perceives light differently, the sensitivity of the LI-210R closely matches the Standard Observer Curve described by the International Commission on Illumination (CIE), which represents the sensitivity of a typical human eye.

Whether you are evaluating solar energy resources, measuring light in a greenhouse, or evaluating architectural lighting, light and radiation are important variables to measure. With over 40 years of experience designing and manufacturing the most widely used light and radiation sensors worldwide, the new LI-COR sensors represent a big step forward for industries and scientific disciplines that depend upon light measurements.

Figure 3: Photometric sensors are sensitive to light as perceived by the human eye and are used to optimise lighting.

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