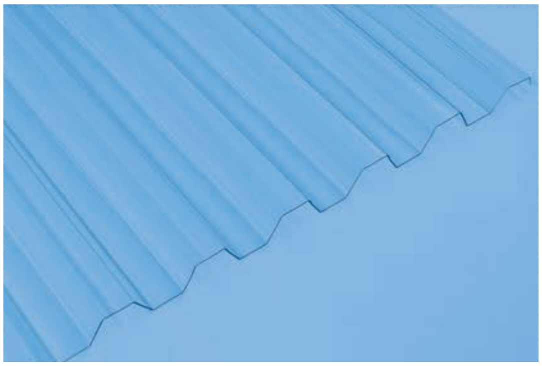



Corrugated Polycarbonate Panels

Greenhouse Covering for Optimal DLI

Build On.

Corrugated Polycarbonate Panels: Greenhouse Covering for Optimal DLI

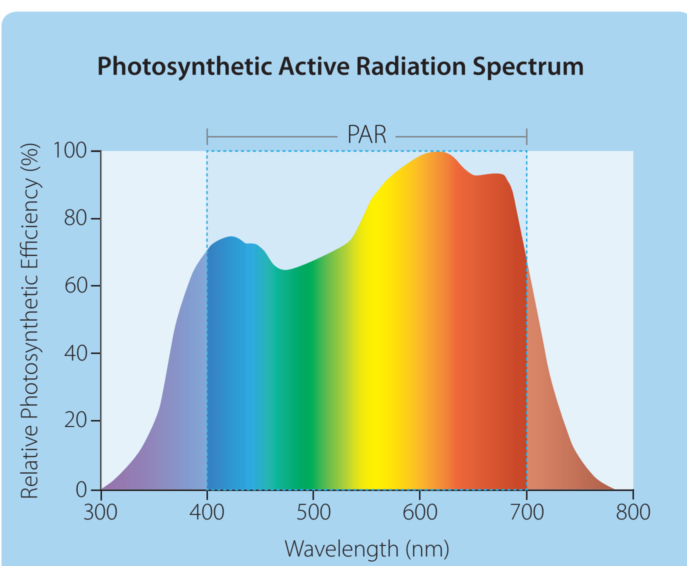
There are a variety of materials and configurations when it comes to choosing the cover for a commercial greenhouse. Different materials provide different properties, and understanding the impact of those properties on the energy balance of the greenhouse is vital for making the right choice.

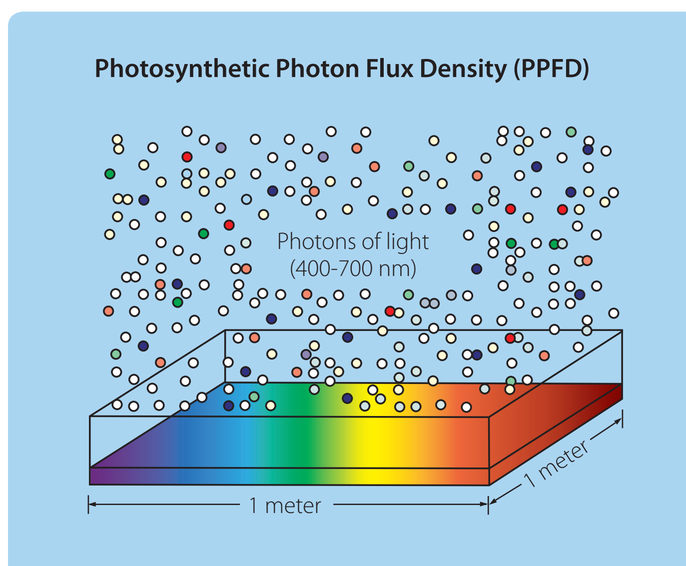
Most growers strive to get as much light into their greenhouses as possible, however this is a vague statement as there are many factors involved in determining light measurements. In this example, we will assume maximum light into the greenhouse is the goal, as using natural daylight cuts down on the cost of artificial light sources.

The light measurement most growers rely on is Daily Light Integral (DLI) which indicates the daily amount of PAR accumulated. This is basically a rain gauge for light.

PAR (Photosynthetic Active Radiation) is intensity of the portion of the light spectrum between 400 nm and 700 nm. This is the light a plant needs for photosynthesis to occur, allowing plants to grow.

Photosynthetic Photon Flux Density **(PPFD)** is a measurement unit for the amount of photons that reach the plant leaf over a 1 square meter area every second, and is indicated in micromoles or (µmol) per square meter (m^{-2}) per second (s^{-1}), or: **µmol·m^{-2}·s^{-1} of PAR**.





DLI is the measurement of **PAR** in **$\mu mol \cdot m^{-2} \cdot s^{-1}$** accumulated over the course of a 24 hour period.

There are many factors that affect the amount of light being seen by the plants down at the leaf level. Some of these factors include the greenhouse structural members, internal obstructions, angle of the sun, directional orientation of the greenhouse, geographic location and time of year. To simplify things we will focus primarily on the factors involved in creating optimal sunlight penetration of the greenhouse covering.

The angle of the sun to the earth's surface plays a very large part in greenhouse DLI measurements. This angle varies throughout the day and throughout the year as the earth rotates around itself and around the sun.

For example, a greenhouse in Pennsylvania, in July, can receive an average of 40-45 $mol \cdot m^{-2} \cdot d^{-1}$. The exact same greenhouse in January will receive 10-15 $mol \cdot m^{-2} \cdot d^{-1}$. With this kind of variance it is imperative that in the winter months, every effort is made to get as much of the available PAR light into the greenhouse.

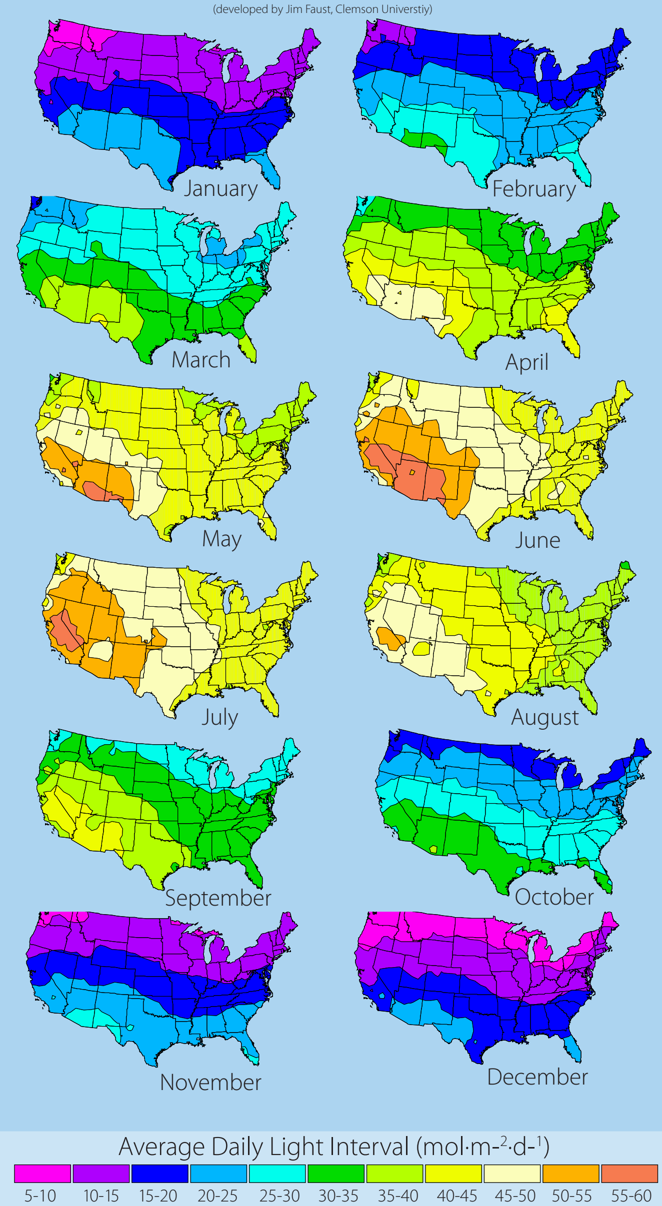
There are many plants that need as much as 22 $mol \cdot m^{-2} \cdot d^{-1}$ to thrive and flourish. A simple solution might be to put clear glass on the greenhouse. While this sounds logical, it isn't this simple. If we were only measuring light at 12:00 noon every day, it could be assumed that glass would be the optimal covering. However, for an accurate DLI measurement, we need to measure light over the course of the *entire* day from sunrise to sunset. This poses challenges for all flat covering materials.

The angle of incidence of the sun to the greenhouse canopy surface plays a very large part of the overall PAR light transmission into the greenhouse. When the sun is at its lowest point in the sky at sunrise and sunsevvt, flat greenhouse canopies reflect more light than they transmit. So while glass may transmit an extra 1% of light while the sun is at its highest, ***it will reflect most of the light as the sun sets lower.***

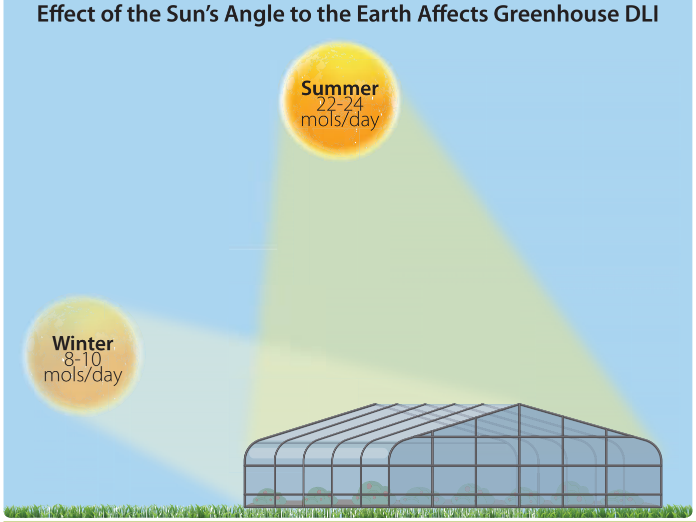
Corrugated polycarbonate, on the other hand, refracts light at low angles, thereby increasing its average light transmittance into the greenhouse.

Outdoor Daily Light Integral (DLI) Maps

(developed by Jim Faust, Clemson Universtiy)



Effect of the Sun's Angle to the Earth Affects Greenhouse DLI



Light in the Greenhouse

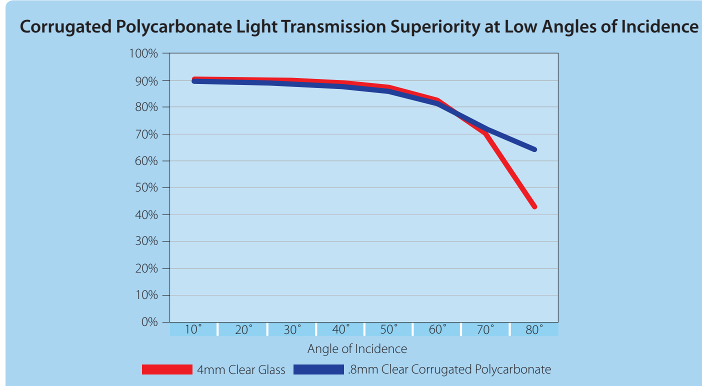
The graph on the right, based on data from Wageningen UR light lab (The Netherlands), compares 0.8mm corrugated polycarbonate to standard 4mm greenhouse glass, the two most common long-term greenhouse covering materials.

Readings clearly indicate that while at direct impact angle the glass and the polycarbonate panels show similar light transmittance; at low angles of incidence the 0.8mm corrugated polycarbonate transmits up to 20% more light.

The corrugation profile is able to capture the sunlight at lower angles and redirect it inwards as opposed to reflecting it outwards. At latitudes of 45º-55º this advantage is even more significant during the five critical months between November and March, as the sun shines most of the day at a 15º-25º angle with the horizon.

Corrugated polycarbonate refracts light at low angles of incidence, reduces reflection, and facilitates more light penetration into the greenhouse than any other material. Of course light transmission is not the only attribute to be taken into account.

Structural elements create shadows and clear glazing creates direct light impact that may damage plants. Polycarbonate

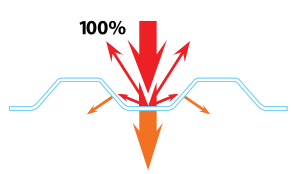
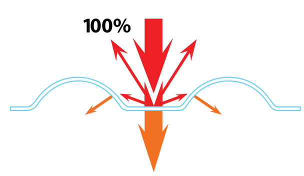
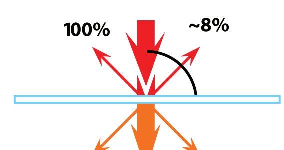
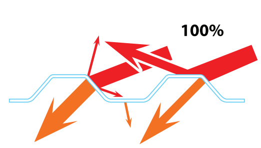
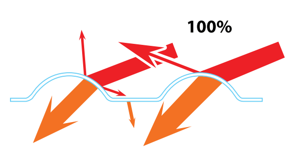
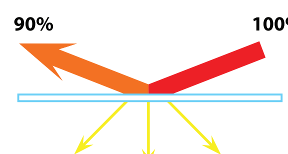


manufacturers are now able to maintain the same high light transmission with corrugated polycarbonate but add diffusing agents or create embossed light diffusing surfaces which results in light that is evenly dispersed throughout the plant canopy making for an ideal growing environment without the increased risk of plant burn due to an intense light beam.

Diffused light also reduces heat buildup in the greenhouse, resulting in a pleasant work environment and reduced possibility of bug infestation.

If you combine the above information along with corrugated polycarbonate's light weight, extreme impact resistance and durability, Corrugated Polycarbonate clearly stands out as the overall champion of greenhouse coverings.

Benefit of Corrugated Profile for Light Transmission to the Greenhouse Interior

	Greca Glazing	Omega Glazing	Flat Glazing
Noon Most glazing material transmits a high percentage of light when the sun is directly above the greenhouse (i.e., high noon).	 **~90% Transmitted**	 **~90% Transmitted**	 **~90% Transmitted**
Sunrise/Sunset Corrugated glazing transmits more light when the sun is low on the horizon while flat products reflect away light from the sun.	 **High Percentage Transmitted** *(Much more than an equivalent flat glazing material)* **52% Transmitted**	 **Higher Percentage Transmitted** *(Much more than an equivalent flat glazing material)* **64% Transmitted**	 **43% Transmitted**

About Palram

With over 50 years of expertise, PALRAM has established manufacturing, distribution and sales operations across seven continents and 120 countries around the world. With global access to our time-tested resources, proprietary technologies and rich history of innovation, Palram has become a trusted partner to markets spanning agriculture, construction and architecture, sign and display, safety and security, transportation, and DIY, among others.

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