



Evaluating greenhouse LED output and efficacy

LED lighting continues to gain traction in the commercial production of ornamentals, vegetable crops, leafy greens, cannabis and culinary herbs. The benefit of greenhouse lighting is greatest during mid-winter through early spring, typically during peak propagation, when solar light levels are low. That's when growers see the most economic benefits of lighting: to cuttings once they have formed root initials and to seedlings.

The development and performance of horticultural LED lighting fixtures continue to improve. This has resulted in fixtures that better tolerate dust and humidity that are common inside greenhouses, have a higher light output and have greater energy efficacy.

Energy efficacy refers to how well a lamp converts electricity into photons in the photosynthetically active radiation (PAR) waveband, which is 400 to 700 nm. However, continued research has shown that far-red light (700 to 750 nm) is often also effective when delivered with PAR. Thus, using the extended PAR (ePAR) waveband of 400 to 750 nm could be more appropriate. Sometimes the ePAR efficacy or the efficacy for the biologically active radiation waveband of 280 to 800 nm are also reported.

The DesignLights Consortium (DLC) established specific technical performance requirements for horticultural LED fixtures to be considered durable and energy efficient. The initial efficacy threshold (based on PAR) was $1.9 \mu\text{mol}\cdot\text{J}^{-1}$ (in 2018) and has increased to $2.5 \mu\text{mol}\cdot\text{J}^{-1}$ as the performance of LEDs has improved. This represents a 4% average increase each year.

As of July 2026, the DLC Qualified Product List for horticultural lighting included nearly 1,200 fixtures. Of these, 336 LED products (28%) had a tested efficacy of at least $3.0 \mu\text{mol}\cdot\text{J}^{-1}$ and 68 products (6%) at $3.5 \mu\text{mol}\cdot\text{J}^{-1}$ or higher. By comparison, in 2022, only 6% of fixtures had an efficacy of at least $3.0 \mu\text{mol}\cdot\text{J}^{-1}$.

Another important parameter is the light output of an LED fixture. This is referred to as the photosynthetic photon flux (PPF) with a unit of $\mu\text{mol}\cdot\text{s}^{-1}$ and only considers photons in the PAR waveband. If we assume a minimum efficacy of $3.0 \mu\text{mol}\cdot\text{J}^{-1}$, and that a supplemental

“Higher fixture efficacy reduces operating costs over the life of the lighting system.”

lighting fixture should emit at least as much light as a traditional 400-watt high-pressure sodium (HPS) lamp with a magnetic ballast ($420 \mu\text{mol}\cdot\text{s}^{-1}$), there are currently around 275 products on the DLC list. Of these, 227 emit at least $1,000 \mu\text{mol}\cdot\text{s}^{-1}$, 183 emit at least $2,000 \mu\text{mol}\cdot\text{s}^{-1}$, and 77 emit at least $3,000 \mu\text{mol}\cdot\text{s}^{-1}$. These highest-intensity LED fixtures usually need to be mounted high above a crop to ensure uniformity.

The investment in LED supplemental lighting is highly situational and usually based on economics. As with any large investment, growers are encouraged to obtain multiple price quotes for the purchase and installation of a desired light intensity. Many commercial electric companies offer substantial cash incentives for upgrading to energy-efficient LED lighting, and fixtures on the DLC Qualified Product List are usually eligible. While comparison of price quotations and potential rebates are straightforward, differences in fixture efficacy can easily be underappreciated.

Let's create a case study to compare how lighting fixture efficacy influences operating costs. Assume half an acre ($21,780 \text{ ft}^2$ or $2,023 \text{ m}^2$) of lighted greenhouse space, an average intensity of $80 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, and 15% loss of light to non-growing areas. To deliver this light intensity to this growing area, fixtures need to emit a total of $190,400 \mu\text{mol}\cdot\text{s}^{-1}$ ($2,023 \times 80 / 0.85$). If we also assume the grower operates their lighting system 1,200

EFFECTIVE ELECTRICITY RATE PER KWh	LIGHTING FIXTURE TYPE AND EFFICACY ($\mu\text{mol}\cdot\text{J}^{-1}$)							
	HPS		LEDs					
	0.90	1.70	2.50	2.75	3.00	3.25	3.50	3.75
\$0.15	\$38,080	\$20,160	\$13,709	\$12,463	\$11,424	\$10,545	\$9,792	\$9,139
\$0.20	\$50,773	\$26,880	\$18,278	\$16,617	\$15,232	\$14,060	\$13,056	\$12,186
\$0.25	\$63,467	\$33,600	\$22,848	\$20,771	\$19,040	\$17,575	\$16,320	\$15,232

Table 1. Estimated annual electricity costs in a case study to light half an acre of greenhouse at $80 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for 1,200 hours per year, with 15% light loss, at different electricity rates and fixture efficacies.

hours per year, we can estimate the effective electricity costs considering different utility rates and efficacy values for HPS and LED fixtures (**Table 1**).

Obviously installing new 400-watt HPS lamps is usually not economical considering the large electricity cost. Growers that still use HPS lamps can calculate potential energy savings by switching to a more effective LED fixture. The efficacy values for HPS lamps are for new fixtures. However, their light output decreases by 1% to 3% for every 1,000 hours of operation, and magnetic ballasts degrade in efficiency over time. In contrast, DLC-qualified

horticultural LED fixtures lose, at most, 10% of light output after 50,000 hours of operation.

Finally, HPS lamps have relatively low efficacy because they emit a lot of radiant heat, which increases crop temperature. Switching to more effective LEDs means you probably need to increase the heating setpoint (by 2 to 4 °F) in the winter to maintain a similar canopy temperature. [gpn](#)

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