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# Cultivating Cannabis with LED Lighting

A PRIMER: What You Need To Know

## About this document

The cannabis industry suffers from a lack of credible, third-party information about cultivation technologies and how they achieve energy efficiency while supporting product quality and yield. *Cultivating Cannabis with LED Lighting* is an objective document outlining key considerations related to incorporating horticultural LED lighting into cannabis cultivation operations. The purpose of the document is to support cultivators and operators in making informed decisions related to purchasing efficient cultivation lighting. Funding for this document was provided by E4TheFuture.

## About Resource Innovation Institute

The Resource Innovation Institute (RII) is a non-profit organization whose mission is to advance resource efficiency to create a better cannabis future. RII provides best practices guidance on resource efficient cultivation technologies and techniques via peer-reviewed reports and curated events. RII's performance benchmarking service, the Cannabis PowerScore, enables operators to gain insights about how to reduce energy expenses and improve their competitive position. Resource Innovation Institute is funded by foundations, governments, utilities and industry leaders. **For more information, go to [ResourceInnovation.org](https://ResourceInnovation.org).**



Technologies are changing rapidly to address the needs of the fast-growing cannabis cultivation operations. One technology gaining widespread adoption due to its ability to significantly reduce energy use is horticultural LED lighting. Despite recent advancements, many cultivators remain unfamiliar with, and deeply skeptical about, incorporating LED lighting solutions into cultivation operations to enhance plant quality and consistency, as well as accelerate revenue cycles.

**What are LED lights?**

Light-Emitting Diodes (LEDs) are semi-conductor devices that produce light when an electrical current flows through them<sup>[1]</sup>. High-quality LEDs have been incorporated into commercial horticultural lighting products over the past five years, spurred on by the recent legalization of cannabis in a growing number of states, provinces and countries. As shown throughout this document, LED lighting comes in all shapes, sizes, and functionalities - from fixed to adjustable spectrum, and with the ability to control a range of photoperiods.

High-quality horticultural LED lighting solutions can range from two to five times the upfront cost of high-intensity discharge (HID) lighting solutions, the dominant technologies used in cannabis cultivation for decades. However, several outcomes associated with use of LED lighting solutions can accelerate return on investment and dramatically reshape an operation's competitiveness.

Operators should take care to understand

horticultural lighting terms, and exercise caution when evaluating solutions in order to ensure their full range of business needs from costs to quality, along with plant requirements, are met.

**Horticultural lighting terms and why they are important**

Horticultural lighting performance is measured using the following terms:

TERM	DEFINITION	METRIC	WHY IT'S IMPORTANT
<b>Photosynthetically Active Radiation (PAR)</b>	Light that falls between the range needed for photosynthesis (400-700 nanometers)	Nanometers (nm)	PAR is the light plants "see" and use for photosynthesis. It is defined within the range of 400-700nm.
<b>Photosynthetic Photon Flux (PPF)</b>	The total amount of PAR produced by the product	Micromoles per second ( $\mu\text{mol/s}$ )	PPF measures the quantity of light produced by the lighting system or fixture. PPF is different from lumen output, which is used to measure
<b>Photosynthetic Photon Flux Density (PPFD)</b>	The concentration of PPF delivered to the plant canopy	Micromoles per square meter per second (commonly expressed as $\mu\text{mol/m}^2/\text{s}$ or $\mu\text{mol/m}^2 \cdot \text{s}$ or $\mu\text{mol m}^{-2} \text{s}^{-1}$ )	PPFD represents the intensity of useful radiation for photosynthesis that is delivered to the plant canopy.
<b>Photon Efficacy</b>	How efficiently a horticulture lighting system converts energy into photons of PPF	Micromoles per Joule ( $\mu\text{mol/J}$ )	Photon Efficacy describes the efficiency of a fixture

**Photon efficacy ranges by lighting type<sup>[2][3]</sup>**

FLUORESCENT	HID/OTHER (HPS, CMH, MH, PLASMA)	LED
.7-1.2 $\mu\text{mol/J}$	.9-1.8 $\mu\text{mol/J}$	1.5-3.0 $\mu\text{mol/J}$

### Where are LED lighting solutions used?

To date, LED lighting has most commonly been used in the vegetative stage of cultivation. However, with advances in technology, fixture performance and validation by leading commercial operators, cannabis cultivators are increasingly comfortable with use of LED lighting in all phases of growth and cultivation.

### How to adjust operations upon installation

Because of changes in heat and spectra, a switch from HID lamps to LED lighting will necessitate adjustments to water, nutrients and environmental conditions. Cultivators will need to be flexible to understand and adapt to new methods of gardening. However, growers should avoid making any changes to their horticultural recipe until they evaluate how their plants are responding to any new adjustment, such as adopting LED lighting.

As cultivators learn about new methods of growing, they will also better understand

how to evaluate technologies from the plant's perspective. For example, a high-quality PAR meter is essential to monitor the plant's required light levels, as opposed to old rules of thumb based on lumens and input power. Leading manufacturers and consultants can help cultivators make a successful transition.

### Common pitfalls to avoid

Among the hundreds of cultivators who have made the switch from HID to LED lighting, common experiences have identified what to monitor to minimize problems with the conversion to LED. Typical challenges include:

- Adjusting HVAC to address overall changes in heat reduction
- Feeding schedules and quantities
- Nutrient recipes and regimen
- Fixture spacing and distance to canopy
- PPFD intensity
- Adjusting CO2 levels
- Cold water shock



### Benefits of using LED lighting

A common misperception of LED technology is that it is ineffective at generating superior cannabis growth relative to HID. This view is often based on third-hand experiences where non-horticultural LEDs were used "back in the day."

The reality is today's leading LED lighting solutions are designed specifically for cannabis cultivation. They work well to balance light quality (spectra) with light quantity (intensity and duration). While there is a learning curve, case studies are showing that achieving high-quality plant performance with LED lighting is a growing trend.

Cultivators using today's leading LED lighting solutions often report the following benefits:

**ENERGY SAVINGS** - While results vary by manufacturer and cultivator, horticultural LED solutions demonstrate the potential to save 40% on electricity relative to HID and traditional lighting choices<sup>[4]</sup>. In a study of RII's Cannabis PowerScore dataset, electricity use by indoor farms using LEDs vs. indoor farms using HIDs indicates that LED-lit canopies generate more than double the grams per kWh than HID-lit canopies<sup>[5]</sup>.

LIGHTING TYPE (INDOOR)	HPS	LED
Average Electricity Productivity (grams/kWh)	0.6	1.4

**PLANT AND CROP PERFORMANCE** - Initial studies indicate growers using LED lighting may experience yield increases and changes in cannabinoid and terpene profiles, leading to more consistent medicinal product profiles from harvest to harvest<sup>[6][7]</sup>.

**LESS MAINTENANCE** - HID bulbs are generally replaced every 6-24 months, depending on the grower and their financial abilities. In a large HID facility, bulb replacement and associated labor costs can add tens of thousands of dollars over the life of LED alternatives, which are often rated and guaranteed for 50,000 hours of use.

**REDUCED HVAC CAPEX AND OPEX** - Because most LEDs are more efficient than HPS, less wattage equals less heat into the space, allowing for potentially lower HVAC loads and operating expense.

**SAFETY** - LEDs do not contain mercury as an active ingredient like HID and fluorescent lamps, thus there is lower risk of crop contamination upon breakage.

[1] US Dept. of Energy, Energy Savings Potential of SSL in Horticultural Applications (2018).  
 [2] Nelson JA, Bugbee B (2014) Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures.  
 [3] Ladetsky L, The Lighting Research Center, Rensselaer Polytechnic Institute (2018) LED and HID Horticultural Luminaire Testing Report.  
 [4] US Dept. of Energy, Energy Savings Potential of SSL in Horticultural Applications.  
 [5] New Frontier Data, Resource Innovation Institute, Scale Microgrid Solutions, The 2018 Cannabis Energy Report.  
 [6] Eaves J, Eaves S, Morphy C, Murray C, The Impact of Light Intensity and Spectrum-Tuning on Cannabis Yields (2019).  
 [7] Sacramento Municipal Utility District, Amplified Farms 2017 Indoor Horticulture Lighting Study.



### How do you know you're buying a high-quality solution?

When making a purchase as significant as lighting, operators should ensure that manufacturers are providing detailed product specifications and third-party verified information about product performance. Buyers should understand equipment warranties and ensure products are tested to horticultural-specific safety standards from certified test labs such as UL, ETL and CSA.

The DesignLights Consortium (DLC) recently released an LED horticulture lighting specification and Qualified Products List (QPL) to demystify the selection process and help guide growers in locating the certified, efficient technologies most optimal for their needs. The DLC is a non-profit organization that helps electric utilities maximize the results of their efficiency incentives.

The QPL is an online database of products that have been inspected by a professional reviewer and have met the DLC's requirements. It displays standardized performance statistics for all products in a single way, allowing users to quickly sort and identify the measurements that are important to them.



For more information about DesignLights Consortium and the Qualified Products List, visit [www.designlights.org/horticultural-lighting/](http://www.designlights.org/horticultural-lighting/).

### How you can get financial support

Electric utilities increasingly offer incentives on horticulture LED lighting, often representing 25-50% of the purchase price - meaning up to half of the upfront cost can be offset. Surprisingly, many cannabis operations misunderstand or overlook this opportunity to defer some capital costs. As the DLC's QPL becomes available to the market, "automatic" or prescriptive incentives are expected to become more widely available and easier to claim. To understand the incentive process and enable maximum capture of available dollars, it is critical that cannabis operators contact their utility at the very beginning of a project, before purchasing anything, rather than after an LED light purchase.

In addition to utility incentives, private financing options are increasingly available to assist buyers in overcoming the hurdle of upfront costs. Leading LED manufacturers generally provide support for customers interested in accessing incentives and financing.

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#### CASE STUDY:

Eco Firma Farms, Willamette Valley, Oregon

#### REDUCING OPERATING EXPENDITURES VIA EFFICIENCY

"As we were preparing for the sale of Eco Firma Farms to C21 Investments, Davidson & Company, a third party firm, performed an audit and calculated our costs to cultivate at \$189/lb. This represented all variable inputs and COGS directly related to the cultivation of the plant; considering all stages of cultivation and associated electricity, labor, nutrients, water, soil, pest management, CO2, some equipment leases and other non-overhead expenses. We owned the building, so there were no building lease costs attributed.

LED lighting was a significant factor in achieving this performance, as well as many other efficiency practices we implemented to complement our ethos of sustainability. This was hopefully the spark to ignite the flame of far more efficient facilities to come."

- Jesse Peters

#### REDUCING CAPITAL EXPENDITURES WITH UTILITY INCENTIVES

In two phases, Eco Firma Farms installed a total of 233 LED fixtures in two flower rooms, along with 130 LED fixtures in two vegetative rooms. Energy Trust of Oregon awarded incentives, which covered roughly 50% of the costs. Results from Phase 1 are shown below. For full case study details, check out [ResourceInnovation.org/Resources](http://ResourceInnovation.org/Resources).

#### LED LIGHTING IN FLOWER AND VEGETATIVE ROOMS

##### Financial analysis

- \$161,545 project cost
- \$79,864 cash incentive from Energy Trust
- \$33, 827 estimated annual energy cost savings
- 41 percent rate of return
- 2.4-year payback

##### Estimated annual savings

- 388,816 kWh saved
- 185 tons of carbon dioxide