LED vs. HPS

A cost / benefit analysis

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Executive Summary

Using a hypothetical 10,000 sq. ft. Cannabis facility this LED vs HID Cost-Benefit Analysis illustrates conservative **savings of $1,289,276** by using LED technology when compared against High Pressure Sodium (HPS) over a period of 5 years with an ROI (return on investment) of only **1.6 years**.

The primary objective of this Cost-Benefit Analysis is to attempt to quantify the economic difference between the High Pressure Sodium (HPS) technology and LED technology in terms of ROI by focusing on four objectively identifiable primary costs are:

1. Upfront capital costs (factoring in utility rebates)
2. Electrical costs (lighting and cooling)
3. Maintenance costs
4. Light loss factor costs

But, it shouldn't be lost in consideration a list of five secondary factors:

1. Water evaporation:
   Especially in the draught strickened western states.
2. Government legislation:
   Governments are already beginning to restrict electrical consumption for horticultural applications.
3. Rack growing:
   Increases the amount of available cultivation space.
4. Hazardous materials:
   HPS has mercury and requires proper disposal.
5. Dirt, dust and degradation of HPS reflectors also has a direct impact on yields.

And finally, as grow environments continues to experience the stresses of the market place the cultivator will require tools that will adapt to his changing needs. LED grow light technology is a sustainable solution in terms of creating an optimum controlled environment. Among those additional factors are:

- LED has the ability to make spectral changes
- LED has the ability to be updated as technology changes
- LED can be controlled in a wireless mesh network
- LED can be engineered to be modular in order to make in the field updates/repairs
- LED is robust enough to stand up to the environment

In spite of our conservative approach we have chosen **not** to factor in the 2017 ground-breaking research conducted by Dr. Allison Justice, Phd. in plant science and Joshua Gerovac, botanist. Their research found:

> ...the pound per fixture yields were 2.53 vs 2.01 when comparing the LED and HPS...
>
> https://www.cannabizjournal.com/2018-cannabiz-journal/lighting-the-way:

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Yields

"The pound per fixture yields were 2.53 vs. 2.01 when comparing the LED and HPS."

Since the expense side of the equation and combined with the effects of light source degradation is fairly straight forward the wild card in this analysis is the yield difference between the two technologies.

LED technology has made great strides in only the last couple of years regarding intensity and efficacy so the amount of quality research is minimal. However, a respected impartial 3rd party industry study in 2017 was conducted by Allison Justice, Phd. in plant science from Clemson attempted to control factors such as nutrients, water, HVAC, pest control and CO2. She concludes:

> [1] "The pound per fixture yields were 2.53 vs 2.01 when comparing the LED and HPS (respectively). While HPS and LED had nearly identical terpene yields, plants grown under the LED tested at 20.8% THC while the HPS plants tested at 19%....the reduced temperature load of the LED lights also allowed cultivators to keep the fixtures closer to plants. With this improvement, they were able to stack two layers of plants vertically in a building—effectively doubling the cultivation space."

In addition, the possible, and highly probable, cause for increased crop yields under LED lighting was identified by Dr. Erik Runkle of Michigan State University. Dr. Runkle's research concludes:

> [2] The utility of green light in plant growth applications has been demonstrated by multiple researchers at different universities and research institutes. For example, in an experiment performed at Michigan State University, partly substituting red light for green light (resulting in 25 to 50 percent green light) reduced extension growth of seedlings, making leaves slightly smaller and stems shorter. However, plant fresh weights were similar. Under higher proportions of green, some experiments indicate that green light can actually promote extension growth, somewhat similar to the effects of far-red radiation. Therefore, the effects of green depend on its intensity, the crop and whatever wavebands and intensities of light that are delivered....However our recent research has shown that in many plants green light is just as effective at regulating flowering of day-long plants as the same intensity of red plus far red radiation.

His ground breaking research on the green spectra has been corroborated by other multiple researchers at different universities and research institutes.

Due to the fact that Dr. Justice's research is relatively new and has not been replicated by independent testing facilities this LED vs. HID analysis' will remain conservative and will **not** factor in her findings.

1 David Heldreth, Lighting the Way: Justice, Gerovac Investigate LED Use in Growing Cannabis, Hempbiz, April, 18, 2018

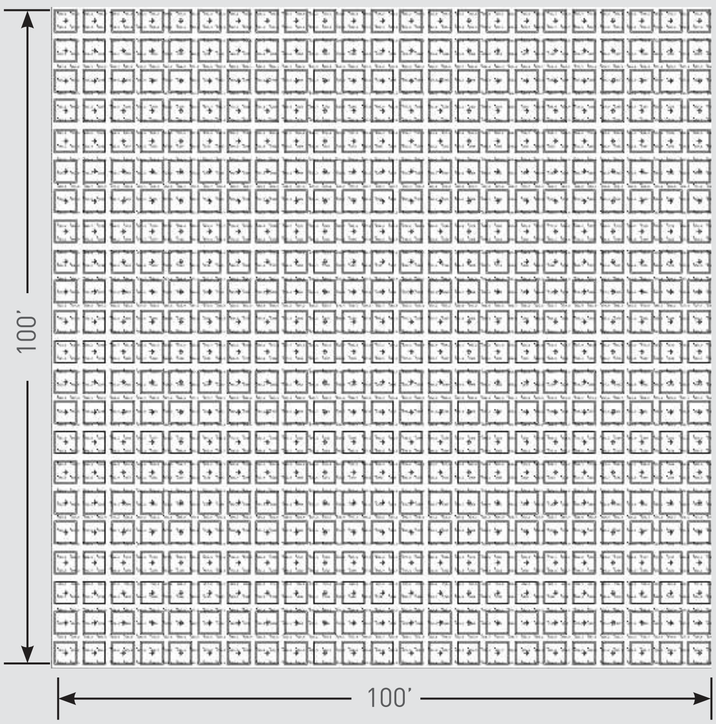
2 Erik Rundle, Growing Plants with Green Light, GPN Magazine, June 2017

LED & HPS Photometric Calculations

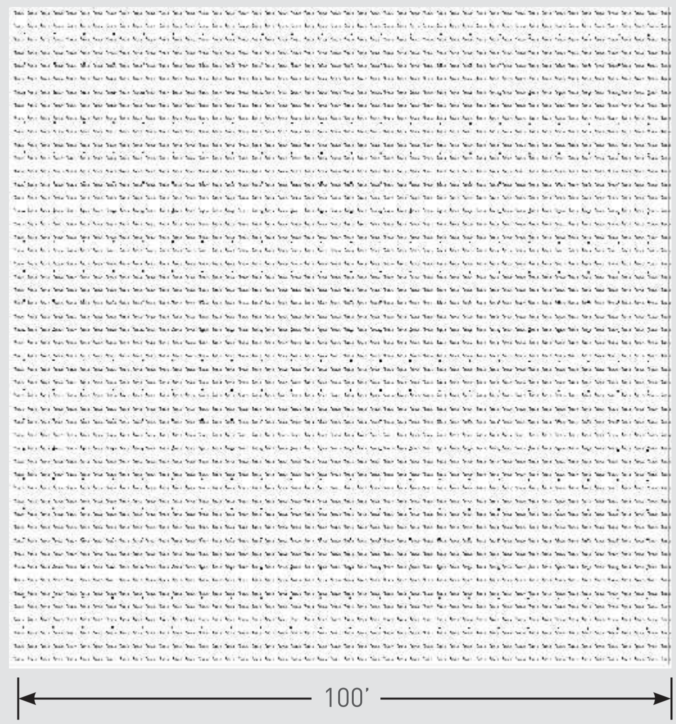
Grow Facility

Crop:	Cannabis	Plant Density:	1 plant per square meter	Target PPFD:	800 µmol/s
Facility Size:	10,000 sq. ft. (100' x 100')	Growing Style:	Sea of green (no aisles)	Software Used:	AGI32

LED layout (10,000 sq. ft. facility)



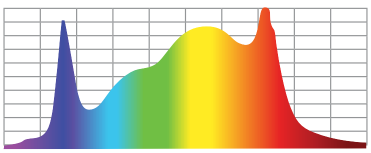
HPS layout (10,000 sq. ft. facility)

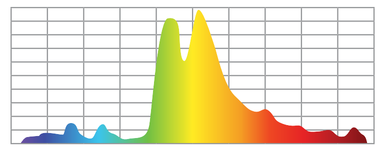


Specifications & Calculations

LED Specifications	
LED Grow Light	SpecGrade, Verta-8, A-1 Spectra
Wattage	645-Watts
Hanging Height	2' over canopy
PPF	1700 µmol/s
Efficacy	2.5 µmol/J

HPS Specifications	
LED Grow Light	Generic DE High Pressure Sodium
Wattage	1000-Watts DE (actually pulls 1060W)
Hanging Height	4' over canopy
PPF	1700 µmol/s
Efficacy	1.6 µmol/J

LED Calculation Results		
Quantity	462	
LLF	0.78	
Average PPFD	799	
Avg./Min.	3.33	SpecGrade A-1 Spectrum

HPS Calculation Results		
Quantity	506	
LLF	0.97	
Average PPFD	822	
Avg./Min.	1.88	Generic DE HPS Spectrum

LED vs. HPS 5-Year Cost / Benefit Analysis

Upfront Capital Cost

	SpecGrade Verta-8 277W, 645W. A-1 Spectrum	Generic DE HPS 240V, 1060W	Savings over 5 years from using LED over HID					
			Year 1	Year 2	Year 3	Year 4	Year 5	Total
Grow light quantity	506	462						
Grow light cost	$1,150	403						
Cost before rebate	**$581,900**	**$186,186**						
(Less 20% utility incentive rebate)	$116,380	—						
TOTAL COST	$465,520	$186,186	**$279,334**					**($278,334)**

Notes/Assumptions:

- The LED that was used was SpecGrade's Verta-8 qualifies for available local utility rebates because of having the DLC certification.
- Although the rebates commonly range from 10%-30% we used a conservative 20%.
- The DE HPS grow light is a generic one. We priced it out as an average fixture taken from the Amazon.com website.
- There is additional electrical installation savings from using SpecGrade's Grow-Connect daisy-chain solution (see Illustration on pg. 12)
- The 1000W DE HPS actually draws 1060-watts once the ballast is factored in.

Utility Rebates

An often overlooked factor are readily available utility rebates. These rebates, which commonly range from 10%-30% are put in place to encourage the cultivator to specify a more energy efficient light source solution for their grow facility. A cursory view of the utilities and their requirements can be found at www.dsire.com (since a significant amount of money is involved we encourage the reader to seek the additional advice of a professional). Local utilities look to the DLC certification (Design Lights Consortium), an independent third party certification body, before considering any rebates to owners of horticultural facilities.

Before putting a manufacturer on the DLC Qualified Products List (QPL) they are required to meet a stringent number of performance criteria. This horticulture QPL for can be found at: https://www.designlights.org/horticultural-lighting/search/

It should also be noted that earning the UL 8800 certification is a requirement of the DLC certification. Because horticultural lighting equipment is commonly exposed to water, dust, dirt, humidity and high levels of ambient temperatures on May 4, 2017 Underwriters Laboratory (UL) published UL8800, a set of safety requirements to be used when evaluating lighting equipment including not only the luminaire but also non-permanent cords and plugs for horticultural applications. The specifier should look for this UL safety Mark before purchasing this type of equipment. You can find a list of products that qualify at: www.ul8800.com.

> "Local utilities look to the DLC certification...before considering any rebates to owners of horticultural facilities."

Electrical Costs

Lighting	SpecGrade Verta-8 277W, 645W. A-1 Spectrum	Generic DE HPS 240V, 1060W	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Daily usage (hours)	12 hours	12 hours						
Total kW	326kW	489kW						
Annual operating hours	4,380	4,380						
Annual kW usage	1,427,880 kWh	2,141,820 kWh	$85,672	$85,672	$85,672	$85,672	$85,672	**$428,360**

HVAC (Cooling)			Year 1	Year 2	Year 3	Year 4	Year 5	Total
Daily usage (hours)	12 hours	12 hours						
Annual usage to light facility	326kW	489kW						
Annual 1:3 hour factor	4,380	4,380						
$0.12	$57,115	$85,673	$28,558	$28,558	$28,558	$28,558	$28,558	**$142,790**

Notes/Assumptions:

Lighting:

- Used a national average rate of $0.12/kWh
- Operating all grow lights on a 12/12 cycle

HVAC:

- Rule of thumb in the industry is that 1 kWh of air conditioning energy is saved for every 3 kWh of lighting energy.
- This metric can vary greatly based on the geographic location of the grow facility

Legislation

Due to changing climate on earth agriculture is being forced indoors which is putting stress on local utilities. Massachusetts, for example, is currently passing legislation that restricts the amount of power a grow facility is able to draw http://www.climateresourcesgroup.com/new-energy-rules/

So, for example, if you review the above 10,000 sq. ft. Cannabis scenario the 1000-Watt DE HPS would consume an average of over 50-watts per square foot of HID technology to attain a PPFD level of 800 umol/s verses the 36-watt limitation the state of Massachusetts is considering. On the other hand, SpecGrade's Verta-8 using a 645-watt Verta-8 grow light consumes only 30-watts a square foot in the same 10,000 sq. ft. facility.

> "...agriculture is being forced indoors which is putting stress on local utilities."

LED vs. HPS
5-Year Cost / Benefit Analysis

Maintenance Costs

Replacing high pressure sodium & reflector	SpecGrade Verta-8 277W, 645W. A-1 Spectrum	Generic DE HPS 240V, 1060W	Year 1	Year 2	Year 3	Year 4	Year 5	Total
	50,000*	10,000*						
Cost for new lamp	—	$89.00						
Cost for new reflector	—	$56.00						
Installation cost (per fixture)	—	$20.00						
Cost per rated life/fixture	—	$165.00						
12 hrs. per day	—	$82.50						
		Total per year:		$38,115		$38,115		**$76,230**

Replacing ballast expense

			Year 1	Year 2	Year 3	Year 4	Year 5	Total
Quantity of fixtures	506	462						
Usage over 5 years @12 hrs./day	—	21,900 hrs.						
Price per 1000W ballast	—	$175.00			$80,850			**$80,850**
Replacement labor costs (3 hrs. to replace lamp & driver):					$3,080			**$3,080**

*Useful life (L90 hrs.)

Notes/Assumptions:

Lamp (bulb) & Reflector:

- Labor Rate: $20/hr.
- The HID reflector should be changed out at the same time the lamp (bulb) is changed
- The reflector is critical to the grow light's performance.

Ballasts / Drivers:

- The expected life of a ballast is approx.12,000 hrs.
- SpecGrade Uses Inventronics drivers have a 7-year warranty.

LED vs. HPS
5-Year Cost / Benefit Analysis

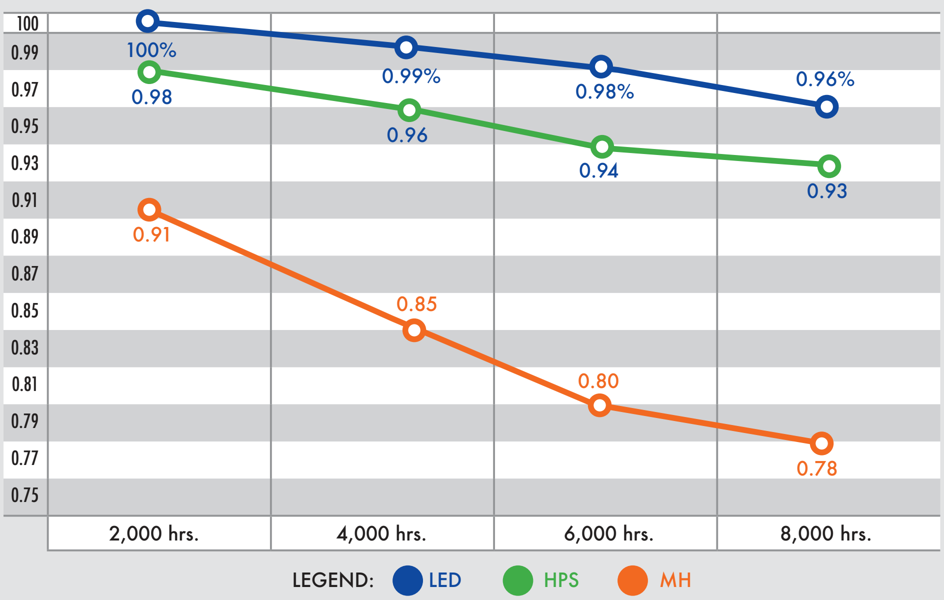
Light Loss Factor Cost (3% HID yield loss)

	SpecGrade Verta-8 277W, 645W. A-1 Spectrum	Generic DE HPS 240V, 1060W	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Plants per meter		1						
Square meters per 10,000 sq. ft.		929						
Total plants		929						
Yield: 2 lbs. per plant		2						
Yield per turn (pounds)		1,858						
Turns per year		3						
Total yield per year (pounds)		5,574						
Total revenue @ conservative $1,000/lbs.		$5,574,000						
	Annual HID 3% degradation expense:		$167,220	$167,220	$167,220	$167,220	$167,220	**$836,100**

Notes/Assumptions:

- Labor Rate: $20/hr.
- The average differential light loss due to degradation between LED and HPS is approximately 3% over the first 8000 hours of life of the HPS lamp. See Illustration on the right.
- The assumption is that there will be a direct correlation of yield to light loss.

The first 8,000 hours of
LED, HPS vs. MH Lumen Maintenance Factor



LED vs. HPS 5-Year Cost / Benefit Analysis Summary

Upfront Capital Cost	SpecGrade Verta-8 A-1 Spectrum 277W, 645W	Gavita Pro-DE Flex Series 240V, 1060W	Savings over 5 years from using LED over HID					
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Grow light cost	$1,150	403						
Cost before rebate	**$581,900**	**$186,186**						
(Less 20% utility incentive rebate)	$116,380	—						
Total cost:	$465,520	$186,186	$279,334					($278,334)
Electrical Costs								
Lighting								
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Total kW	326kW	489kW						
Annual operating hours	4,380	4,380						
Annual kW usage	1,427,880 kWh	2,141,820 kWh						
Annual saved kWh	713,940							
Annual savings @ $0,12 kWh			$85,672	$85,672	$85,672	$85,672	$85,672	**$428,360**
HVAC (Cooling)								
Daily usage (hours)	12 hours	12 hours						
Annual usage to light facility	326kW	489kW						
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$0.12	$57,115	$85,673	$28,558	$28,558	$28,558	$28,558	$28,558	**$142,790**
Maintenance Costs								
Replacing high pressure sodium & reflector	Useful life (L90 hrs.)							
	50,000	10,000						
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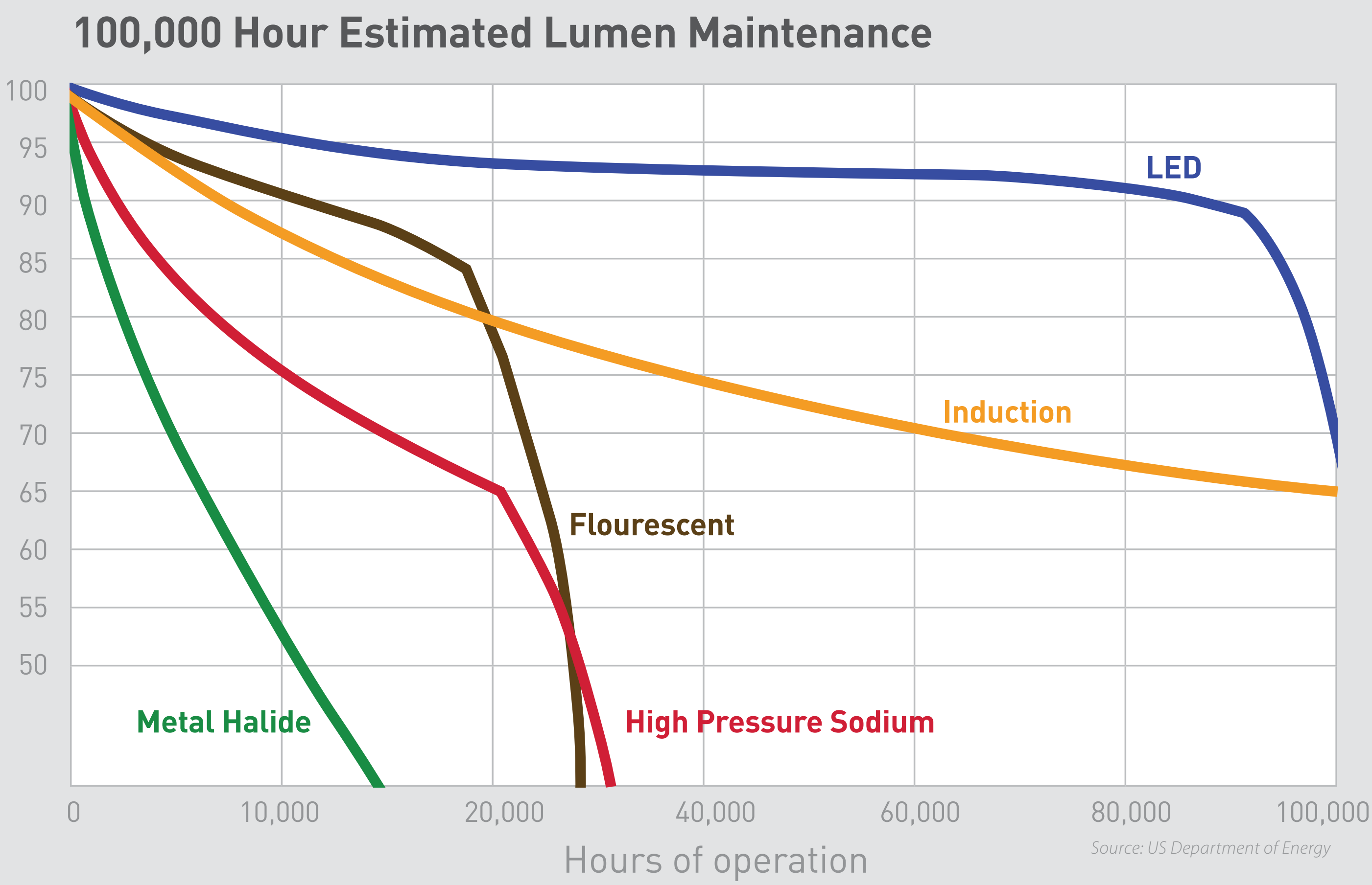
								$1,289,076

Estimated 100,000 Hour Lumen Maintenance



> "...LED technology should absolutely be at least considered for any grow facility."

Summary

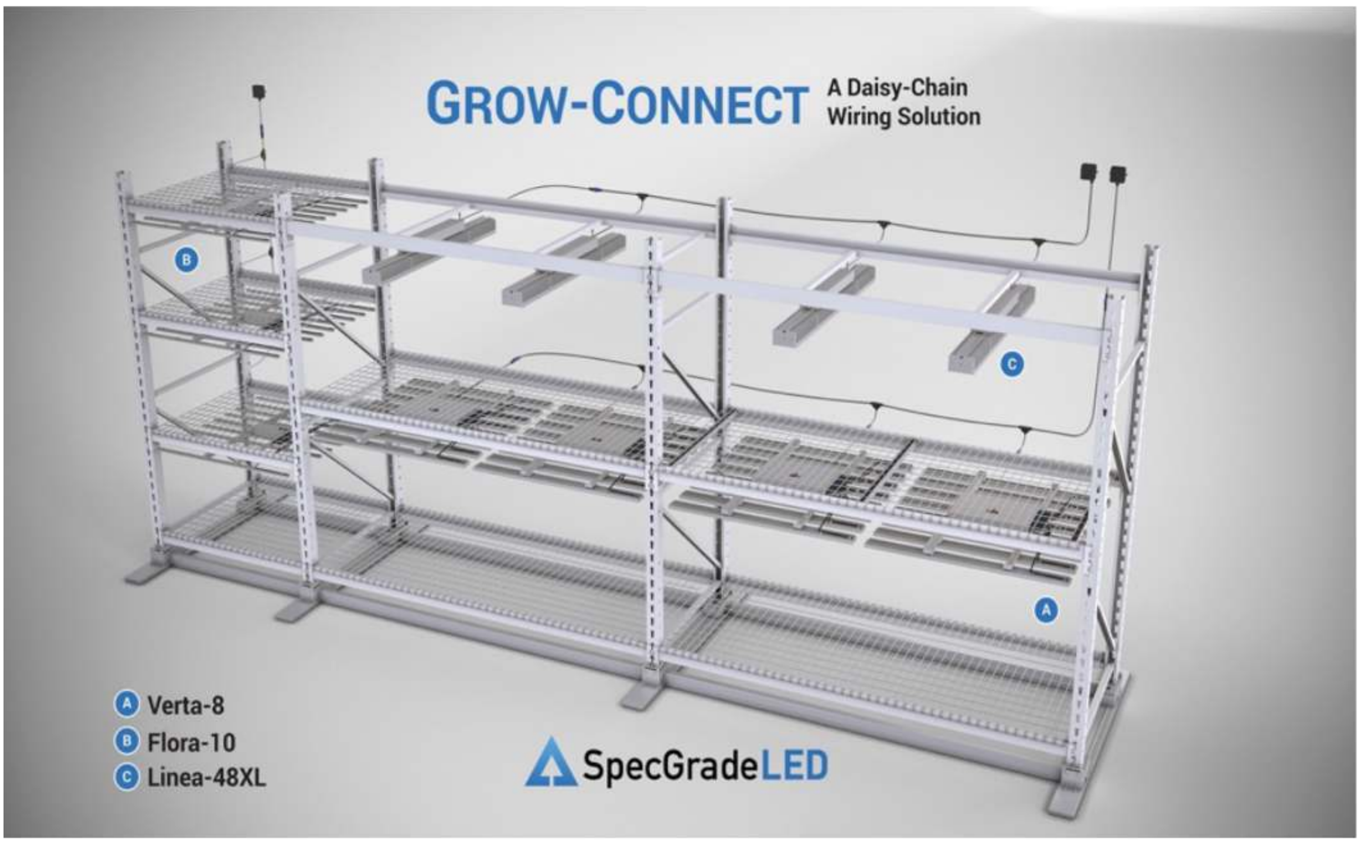
Our conservative approach to quantifying over $1.2M economic advantage would not have been possible even 2-3 years ago due to technological performance advantages of the LED's light intensity to generate a PPF of 1700μmol/s at an efficacy ratio of 2.5μmol/J.

In conclusion, when the critical secondary issues of LED, not quantified in our spread sheet are factored into the equation LED technology should absolutely at least be considered as an artifical light source for any grow facility.

Greenhouse Growing Facility Secondary Factors

Increase Available Cultivation Space While Lowering Installation Costs

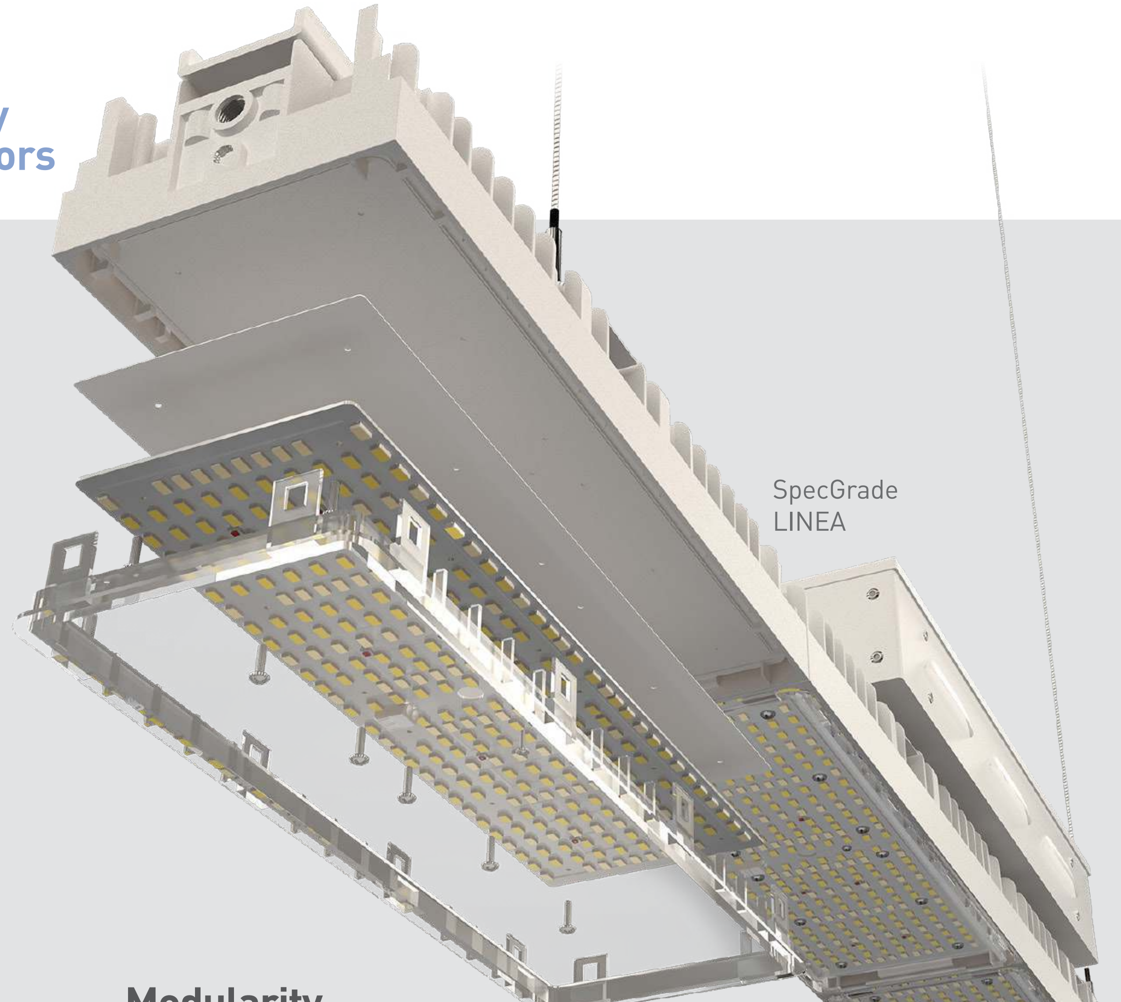
LED's lower radiant heat levels also affords the cultivator the ability to simply increase the cultivation space by using racking to stack multiple layers. He can further lower his electrical installation cost, while giving him the future flexibility to reconfigure the grow facility, by using a do-it-yourself wiring retrofit solution.



Controlling Water Evaporation

Especially in the draught stricken western states where water has become a precision commodity water evaporation, HID's high radiant heat levels puts additional stress on an already burdened water supply. And, it has already resulted in an additional expense to the cultivator.

Greenhouse Growing Facility Secondary Factors

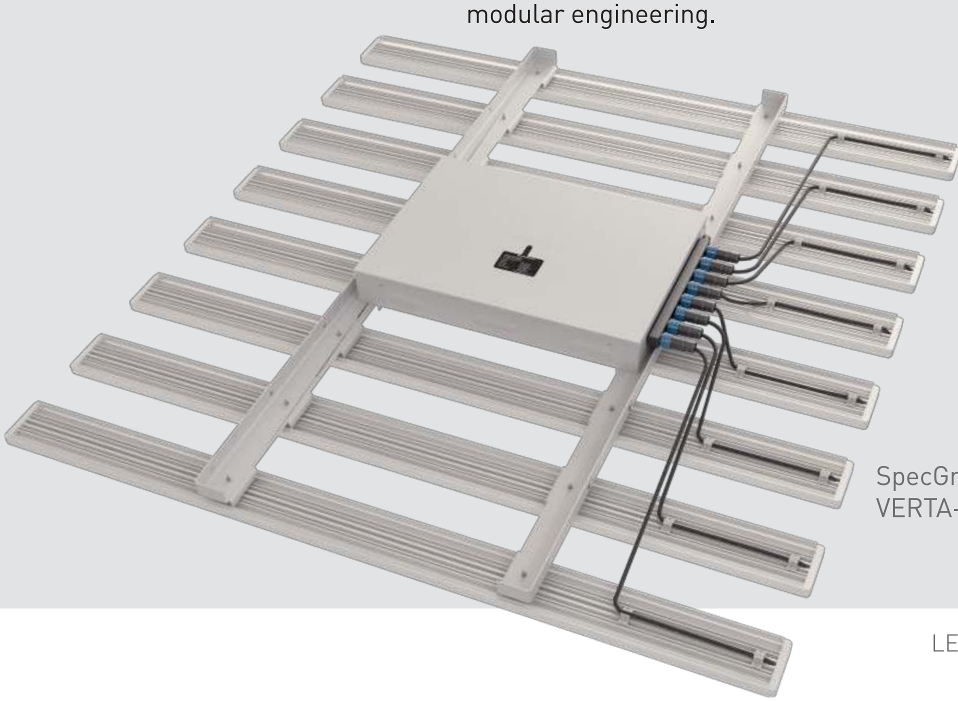


SpecGrade
LINEA

Modularity

LED will not only give you the flexibility to update your investment as technology evolves but it will also permit you to replace a module should one fail.

These are examples of SpecGrade's innovative modular engineering.



SpecGrade
VERTA-8

Greenhouse Inter-Canopy Grow Light

"Increase yields from 10%~15%"

Supplimental Grow Lighting Bar

LED Inter-Canopy lighting can commonly increase yields from 10%~15% by increasing the secondary buds below the canopy. The leaves of most plants prohibit the PAR from top lighting to reach lower levels on the stalk.

SpecGrade's 'Extra-60' can surgically add an additional 180 µmols (±10%).

> "…real-time aggregated data boosts efficiency, saves energy, controls and maintains equipment, tracks assets and inventory… "

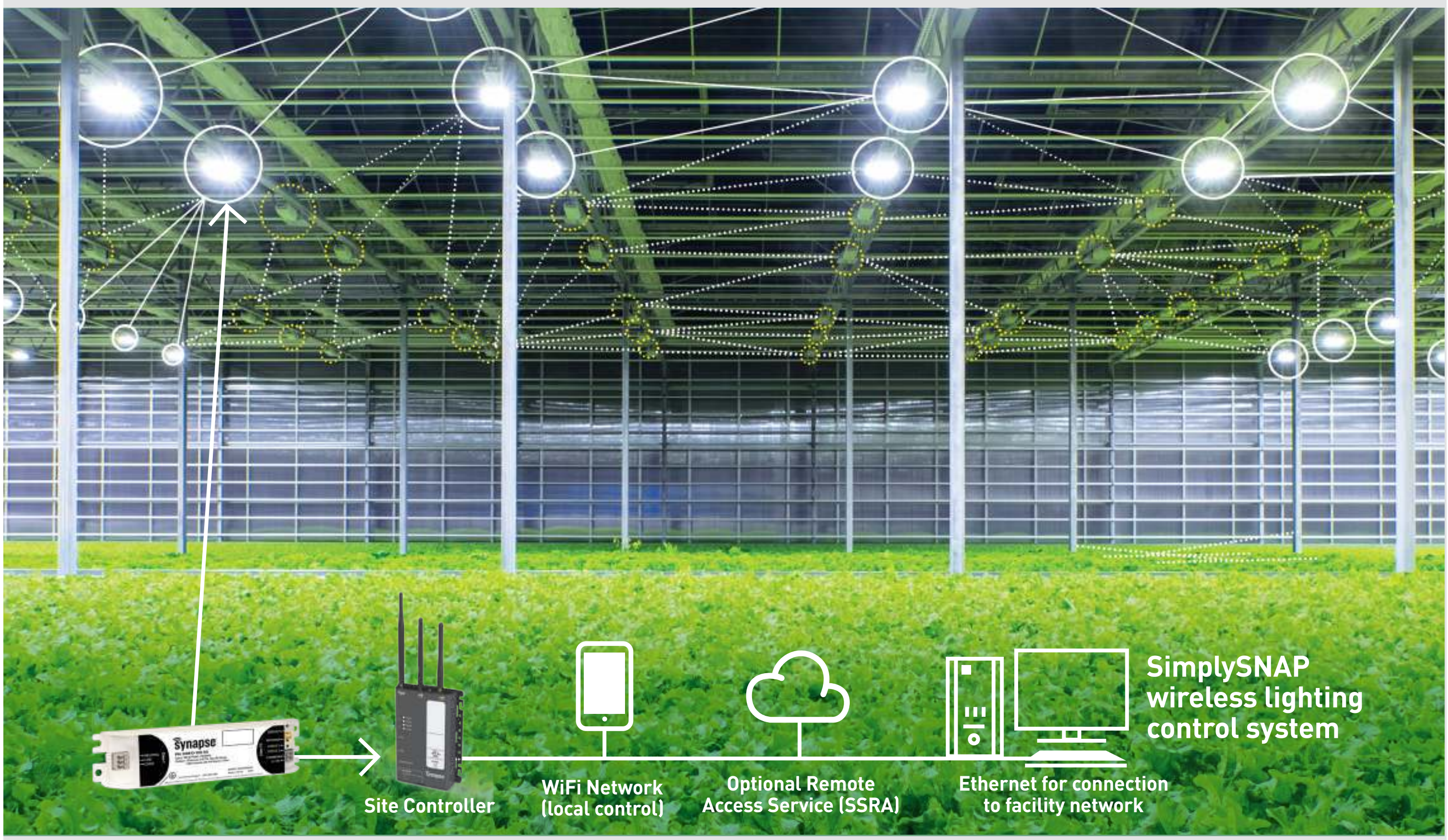
Synapse Our Controls Partner

With a managed services approach, **Synapse** provides its customers with end-to-end intelligent systems that begin with a deep understanding of how to apply technology to business problems in ways that create value. Synapse's team goes far beyond making devices talk to and control one another. They develop well-managed, easily replicated smart solutions with no single point of failure that deliver real-time aggregated data which boosts efficiency, saves energy, controls and maintains equipment, tracks assets and inventory, and ultimately refines and transforms business models.

SimplySNAP wireless lighting control system

SNAP enables millions of diverse devices, fitted with synapse sensor technology for wireless communication, to effectively communicate in a way that makes each sensor and device part of an intelligent system that can both sense and respond to data.

Synapse's SNAP technology elevates yesterday's device monitoring to a new place where organizations can reinvent their business models based on new analytics gathered by the intelligent devices managed by the SNAP network.



Synapse®

Quickly and easily deployed, Synapse created SNAP with the flexibility to seamlessly interface with the Internet, run concurrently with existing network infrastructures, and allow for upgrades to processors and other technologies—extending its scalability to existing and future technology. IoT solutions featuring Synapse's SNAP technology can be found in many industries including smart lighting controls, manufacturing, smart agriculture, asset tracking food processing, pest control facilities management and more.