



Stakeholder MEETING

2017

Harvesting the Benefits of Horticultural Lighting

Horticultural Lighting

- As legislation expands across the country, horticultural grow facilities are becoming the fastest-growing load for DLC-member utilities.
 - New facilities → New load
- More and more facilities are coming online.
 - Addressing product performance and energy consumption is critical.

Near-Term Plans

Participate in industry working groups on standards development and track industry activities and publications

- ASABE
- IES
- LRC
- GLASE
- Others



Create home on DLC website to explain technology and market status, highlight product considerations, and provide DLC updates

- Launching in August



Investigate (interim) approach for qualifying products and reporting performance data

- Draft proposal Q1 2018



Potential Market Paradigm

1. Industry-developed guidance document will lay out parameters that need to be known/considered to determine installation/lighting needs
2. Grower/Specifier will take this information to build a spec for product selection
3. DLC QPL will have verified list of products meeting minimum thresholds
 - a) Published performance data
 - b) Enable utility incentives

Potential Market Paradigm



What Goes In To a DLC Spec?

1. What types of products need to be covered?
 - a) How should they be structured?
2. What are the metrics?
 - a) Which metrics should have minimum thresholds?
3. Where to set the minimum thresholds?
 - a) What performance will meet customer needs and save energy?
4. Is there a standardized test procedure?
 - a) Are there labs accredited to that standard?

Beyond the Spec

- Determining energy savings
 - How will utilities set baselines?
- Informing product selection
 - Will the growers know what their plants' needs are?
 - Various stages of cultivation
 - Different crops
- Driving adoption
 - Will energy savings be the motivating factor?

Panelists



**Philip
Smallwood**

*Strategies
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**Travis
Williams**
*Fluence
Bioengineering*



**Doug
Oppedal**
*Evergreen
Consulting*

NORTH AMERICAN HORTICULTURAL LIGHTING MARKET OVERVIEW

PENNWELL LED & LIGHTING NETWORK



Technology

Application

Inspiration



Strategies in Light®

Strategies Unlimited®



lightspace
dot
london
2016

lightspace
california
2017

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OFFICIAL SUPPORTERS: **LEDs MAGAZINE**

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MARKET INTELLIGENCE | PHOTONICS • LEDS • LIGHTING



Markets Covered

The Worldwide Market for LEDs

Market Review and Forecast
2015



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LED Modules & Light Engines

Market Analysis and Forecast
2015



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The World Market for Chip on Board (COB) LEDs in General Lighting

Market Analysis and Forecast
2014



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UV LEDs

Market Analysis and Forecast
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LEDs in Lighting Applications

Market Analysis and Forecast
2015



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Horticultural Lighting

Market Analysis and Forecast
2016

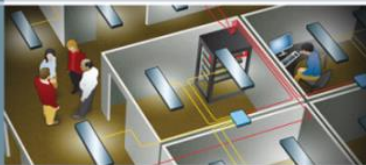


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Connected Indoor Lighting

Market Analysis and Forecast
2015



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Connected Lamps

Market Analysis and Forecast
2015



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Global Luminaires

Lighting Market Analysis and Forecast
2016



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Connected Outdoor Lighting

Market Analysis and Forecast
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The Worldwide Market for Lamps

Market Analysis and Forecast
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LEDs for Horticultural

Small Form Factor and Heat

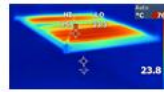
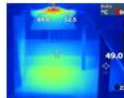


- LED's small form factor provides a fixture manufacturer a degree of design freedom that they didn't have before. This enables:

- Inter-lighting applications
- Vertical farming applications
- Use of secondary optics
- Unique population patterns

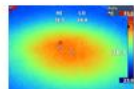


Photo Courtesy of Netted Oy



- Temperature 1000W HPS vs 400W LED grow lamp at equal distance

	Max LED	Max HPS
Fixture	75°C	84°C
Floor	31°C	63°C
Diff	44°C	21°C



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Longer Operating Life



- A major parameter in calculating ROI when deciding what type of light technology to purchase is lifetime or how often you need to replace or service the fixture.

	Average Life (hrs)	Time to failure
High Pressure Sodium	10K-24K (6k hours)	
	L70B50 (hrs) (Tj=120C, I=300mA)	Time to when flux is ≤ 70% of initial value
High Power LEDs	100K (25k hours)	

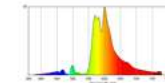
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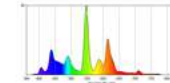


Tunable Spectrum

- Traditional light sources (HPS, MH, Fluorescent) only offer static spectrum solutions

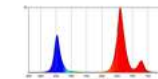


1000W HPS SPD



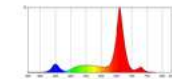
TSHO - Fluorescent SPD

- LEDs allow you to custom tune the spectrum to suit the plant's needs



Condition#1 SPD

	Blue 400-499nm	Green 500-599nm	Red 600-699nm	Far Red 700-799nm
Condition #1	30%	0%	60%	10%
Condition #2	10%	20%	65%	5%



Condition#2 SPD

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Disadvantages of LEDs in Horticultural



- High capital expenditure + other related incremental costs
- Optimal light recipes for specific crops & varieties still largely unproven
- PPF and PPFD of LED vs. Incumbent technologies is not equal (Especially important for plants with higher DLI)
- Lack of Quality Standards



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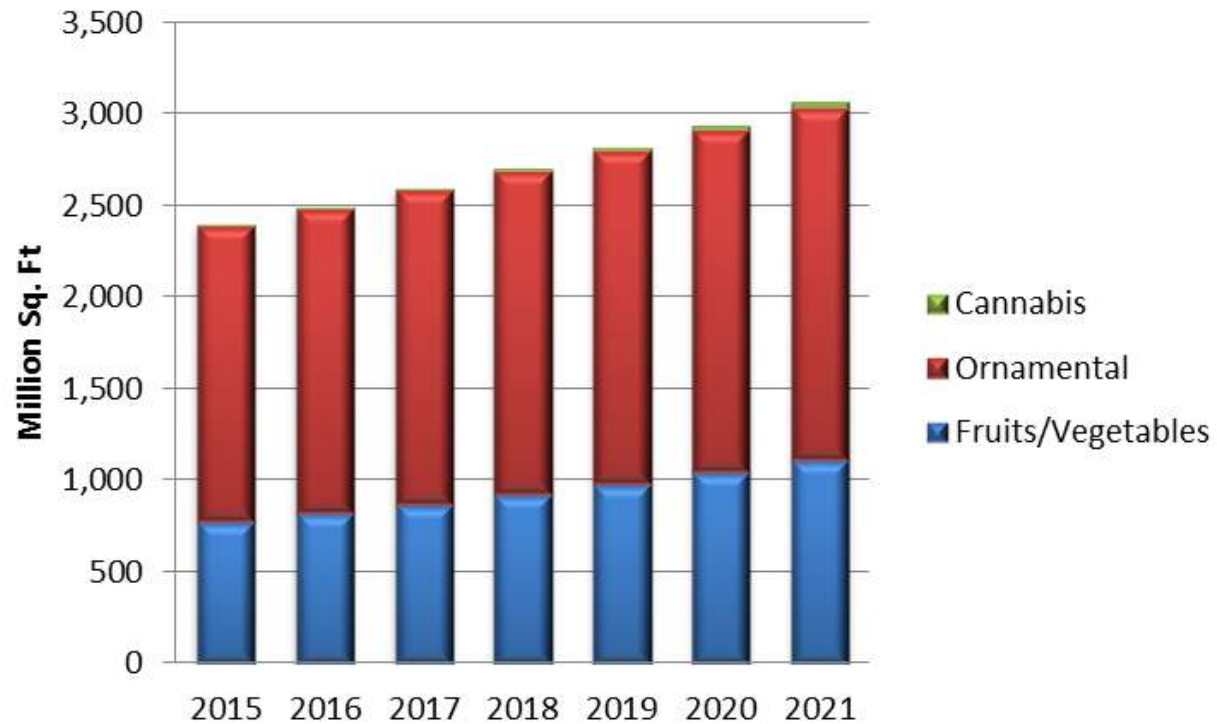
Greenhouse Lighting Market

How do You Measure the Market Cont'd?

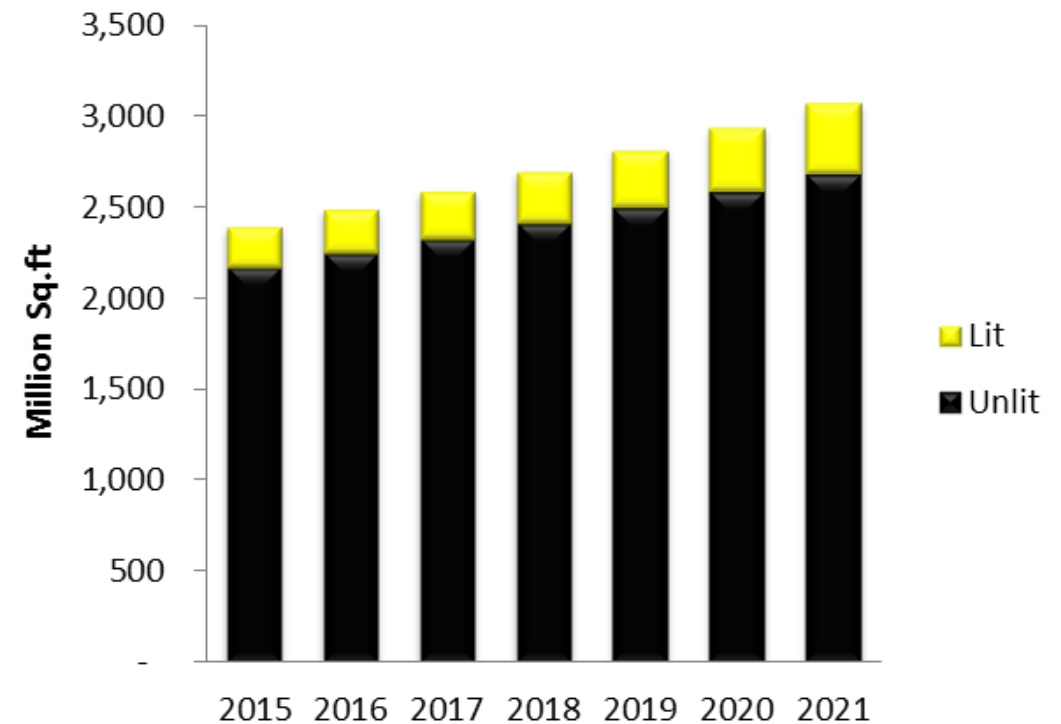
- Installed base
- What You're Measuring
 - \$/Sq. Ft Light Installations by End Application
- Incumbent
 - Cost of market (Replacement Lamps and Luminaires)
- LED
 - Mostly Luminaires replacing canopy lights (For Now)
 - New form factors could have a huge impact on production!

N. A. Installed Base

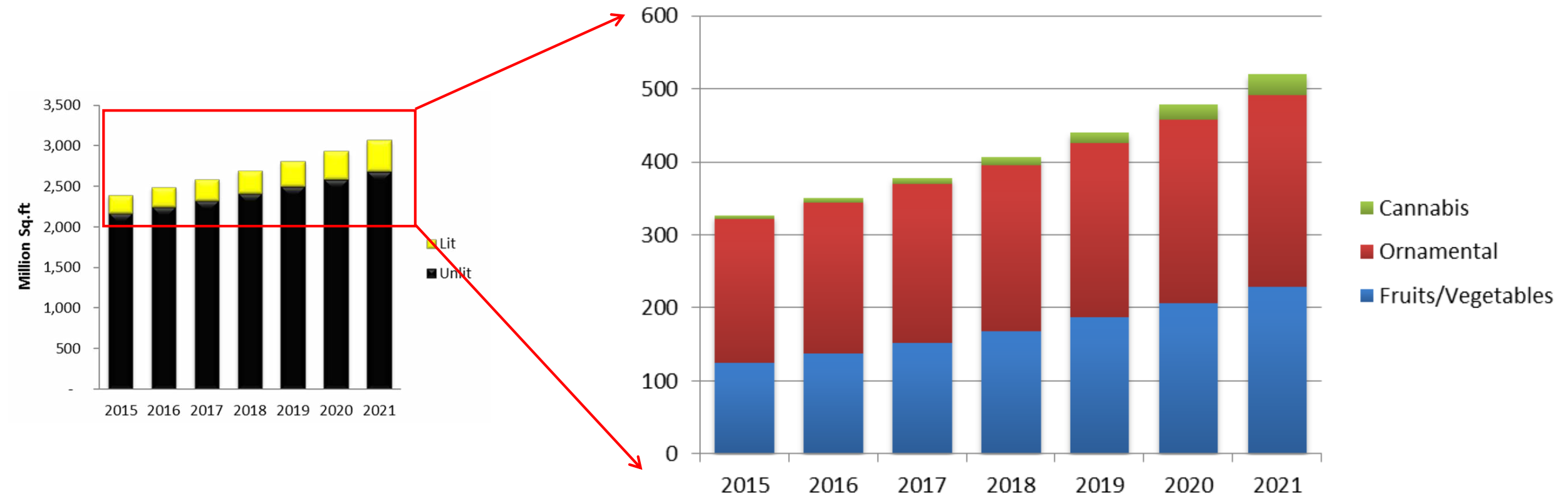
Total Sq. Ft Greenhouses



Total Sq. Ft Greenhouses Lit vs. Unlit

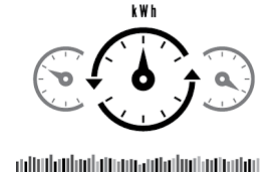


Total N.A. Illuminated Sq. Footage of Greenhouses

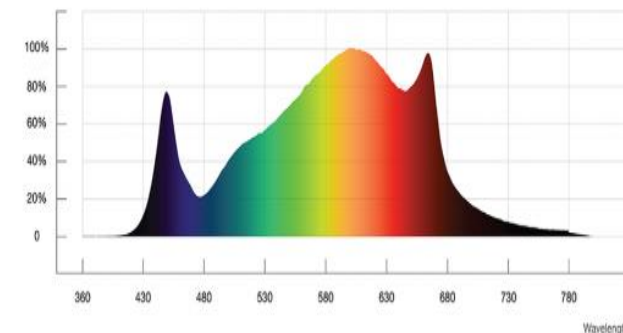


How do You Measure the Market Cont'd?

- Most likely Product
- Needs of Product
 - Costs of Production
- Lighting Qualities
 - Incumbent
 - LED
- Market Dynamics
- Geographic Dynamics
- Payback and ROI

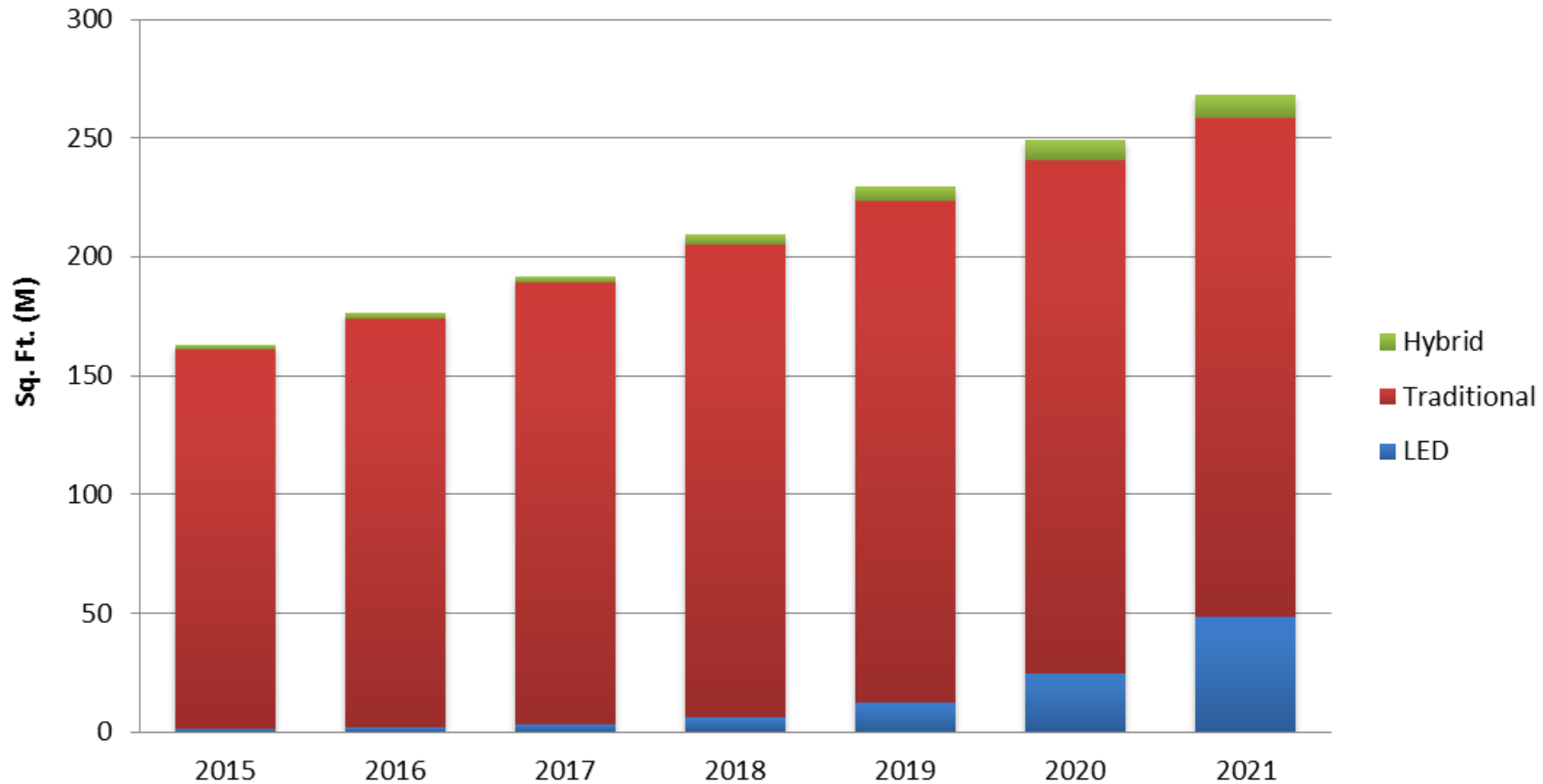


Measurements of Normalized Radiometric Power

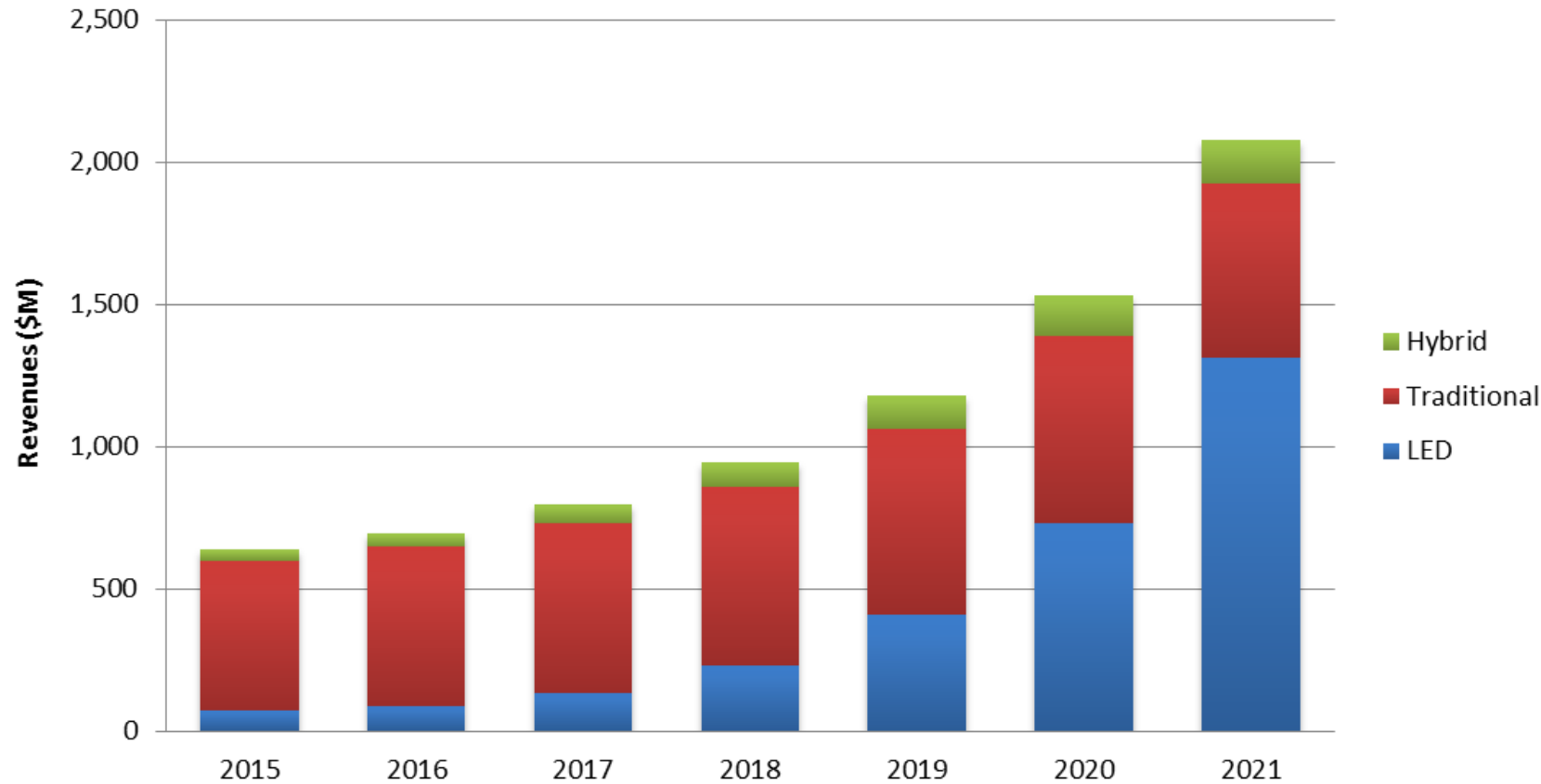


	2014	2015	2016	2017	2018	2019	2020	2021	2022
HID Fixture Watts	1000	1000	1000	1000	1000	1000	1000	1000	1000
LED Wattage									
Troffer	320	320	320	320	320	320	320	320	320
Saved per fixture (Watts)	480	480	480	480	480	480	480	480	480
Fixture Quantity	200	200	200	200	200	200	200	200	200
HPS Lamp Cost	30	30	30	30	30	30	30	30	30
HPS Ballast Cost	\$100	\$100	\$100	\$100	\$100	\$100	\$100	\$100	\$100
LED Fixture									
Multiplier	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Power Saved (Watts)	96000	96000	96000	96000	96000	96000	96000	96000	96000
Only Use (hrs)	12	12	12	12	12	12	12	12	12
Weekly Use (days)	7	7	7	7	7	7	7	7	7
Yearly Use (weeks)	52	52	52	52	52	52	52	52	52
Annual Energy Savings (kWhr)	419328	419328	419328	419328	419328	419328	419328	419328	419328
Power Cost (\$/kWhr)	\$ 0.11	\$ 0.11	\$ 0.11	\$ 0.11	\$ 0.11	\$ 0.11	\$ 0.11	\$ 0.11	\$ 0.11
Annual Energy Cost Savings	\$ 46,797	\$ 46,797	\$ 46,797	\$ 46,797	\$ 46,797	\$ 46,797	\$ 46,797	\$ 46,797	\$ 46,797
Savings on HVAC due to LEDs	10%	10%	10%	10%	10%	10%	10%	10%	10%
HVAC Savings	\$ 87,360	\$ 87,360	\$ 87,360	\$ 87,360	\$ 87,360	\$ 87,360	\$ 87,360	\$ 87,360	\$ 87,360
Capital Cost									
Cost Per LED									
Fixture	\$ 1,300	\$ 1,300	\$ 1,300	\$ 1,300	\$ 1,300	\$ 1,300	\$ 1,300	\$ 1,300	\$ 1,300
Total Project Cost	\$ 420,000	\$ 378,000	\$ 340,200	\$ 319,780	\$ 300,601	\$ 282,563	\$ 265,611	\$ 249,674	\$ 234,694
Labor Cost	\$ 1,200	\$ 1,200	\$ 1,200	\$ 1,200	\$ 1,200	\$ 1,200	\$ 1,200	\$ 1,200	\$ 1,200
Total Installation Cost	\$ 421,200	\$ 379,200	\$ 341,400	\$ 321,177	\$ 302,059	\$ 284,086	\$ 267,119	\$ 251,381	\$ 236,467
LED Life (hrs)	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
LED Operational Lifetime (yrs)	3.72	3.72	3.72	6.01	6.31	6.63	6.96	7.30	7.67
Lifetime Energy Cost Savings	\$ 267,840	\$ 275,875	\$ 284,151	\$ 307,310	\$ 332,356	\$ 359,443	\$ 388,737	\$ 420,419	\$ 454,683
Maintenance Savings									
HID Life (hrs)	4,368	4,368	4,368	4,368	4,368	4,368	4,368	4,368	4,368
Repair Cost of HID Fixture	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000
Lifetime Maintenance Savings (bill placement of original LED fixture)	\$ 143,086.08	\$ 143,086.08	\$ 143,086.08	\$ 143,086.08	\$ 143,086.08	\$ 143,086.08	\$ 143,086.08	\$ 143,086.08	\$ 143,086.08
Yearly Maintenance Savings	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000	\$ 25,000
Payback years on energy alone (yrs)	9.00	7.87	6.88	6.28	5.73	5.24	4.78	4.37	3.99
Payback years on energy and HVAC alone (yrs)	3.14	2.90	2.69	2.52	2.36	2.21	2.07	1.93	1.81
Payback year on energy + Maintenance savings (yrs) no HVAC	3.57	3.18	2.85	2.62	2.43	2.26	2.10	1.94	1.81
Payback year on energy + Maintenance savings (yrs)	2.85	2.36	2.11	1.96	1.83	1.71	1.59	1.48	1.38

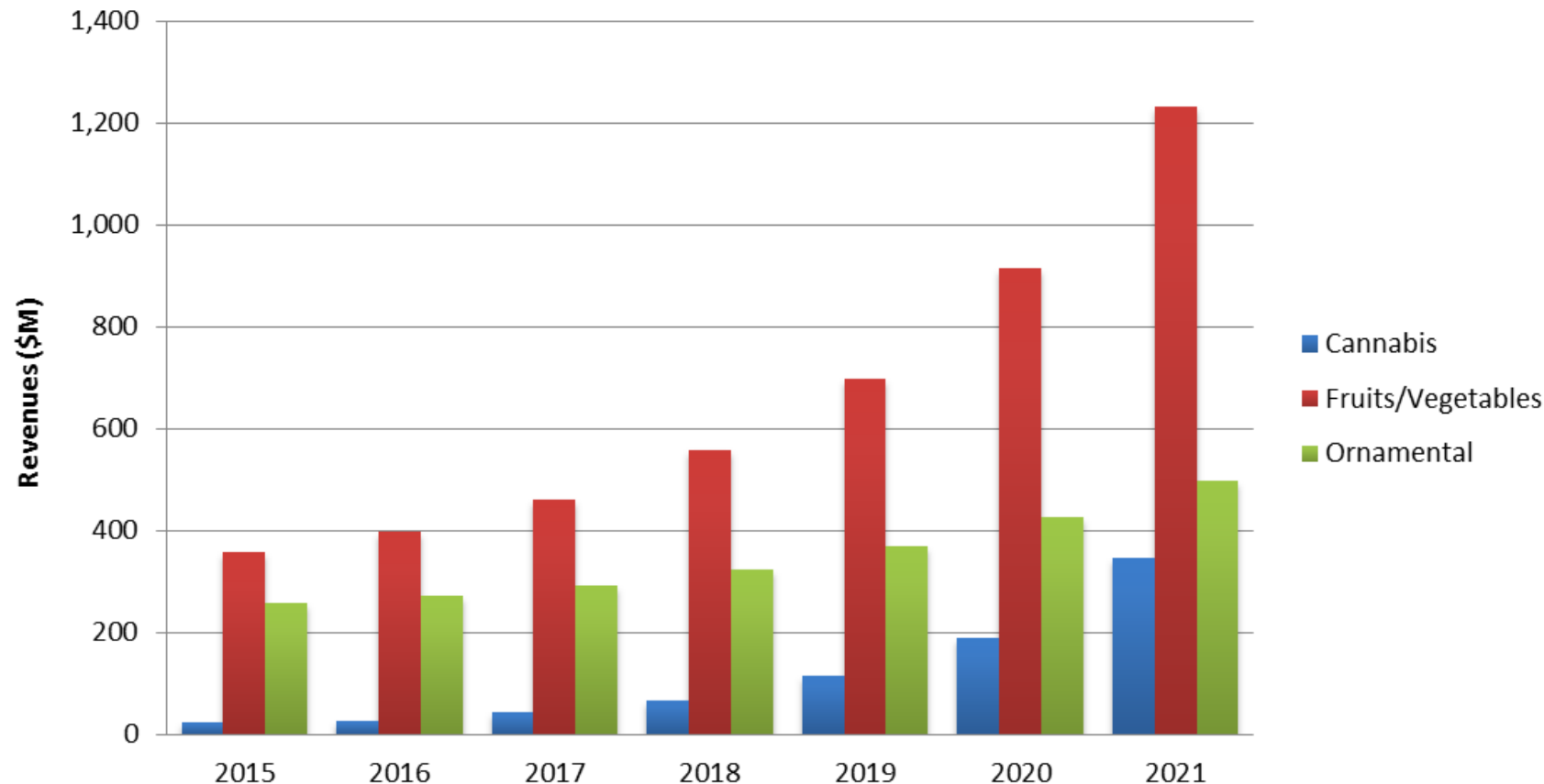
N.A. Sq. Foot area of Lighting Installations



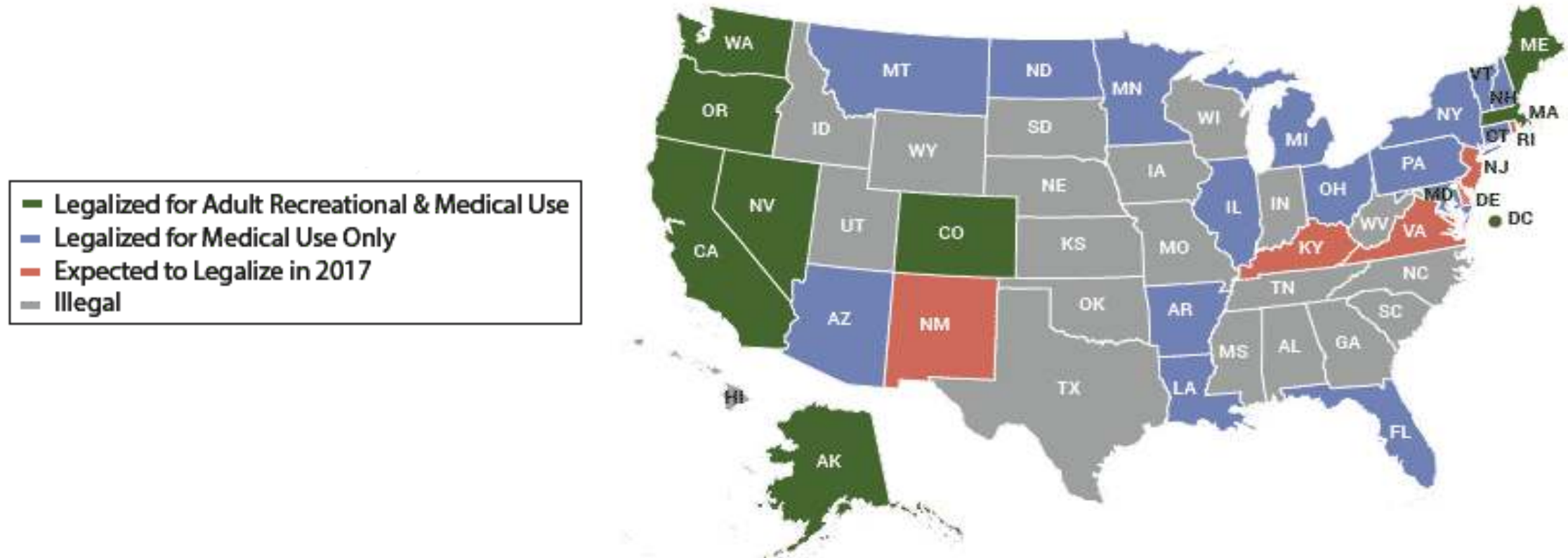
N.A. Greenhouse Lighting Market Forecast



N.A Horticultural Lighting Market by Application

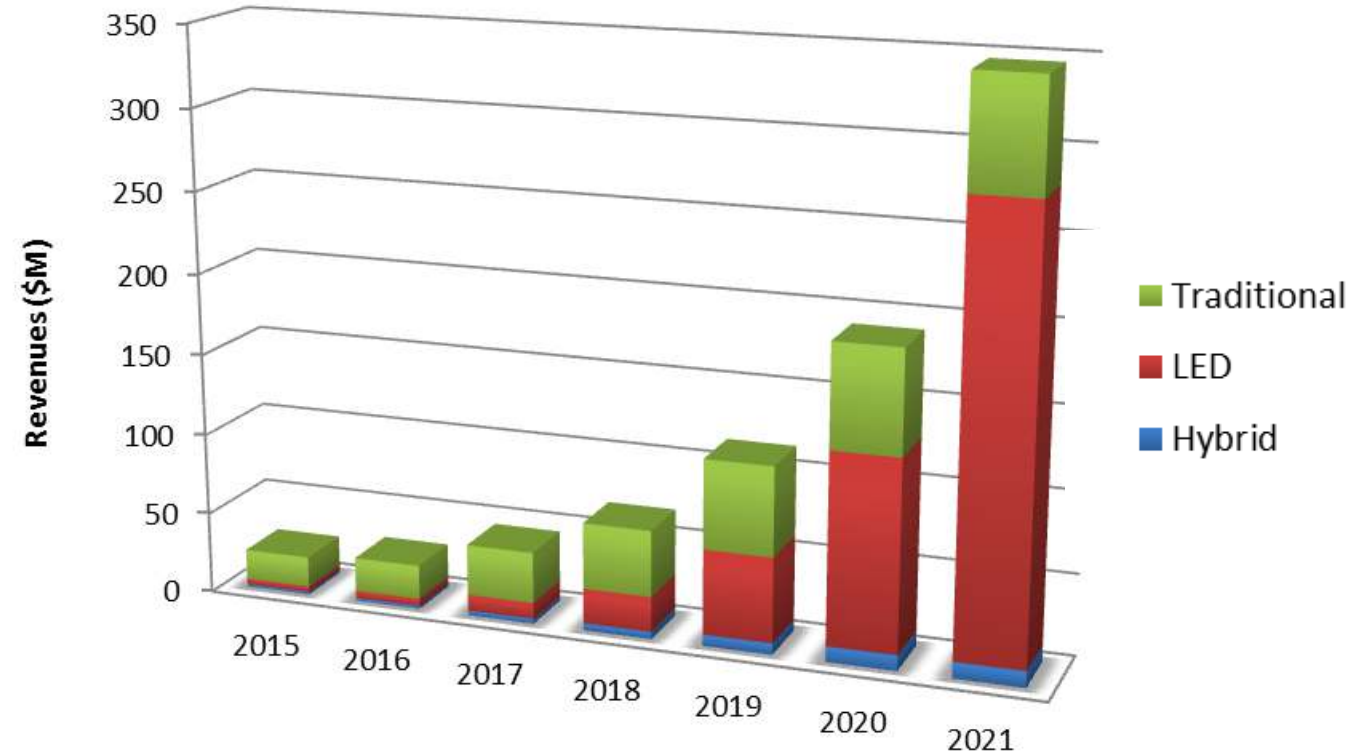
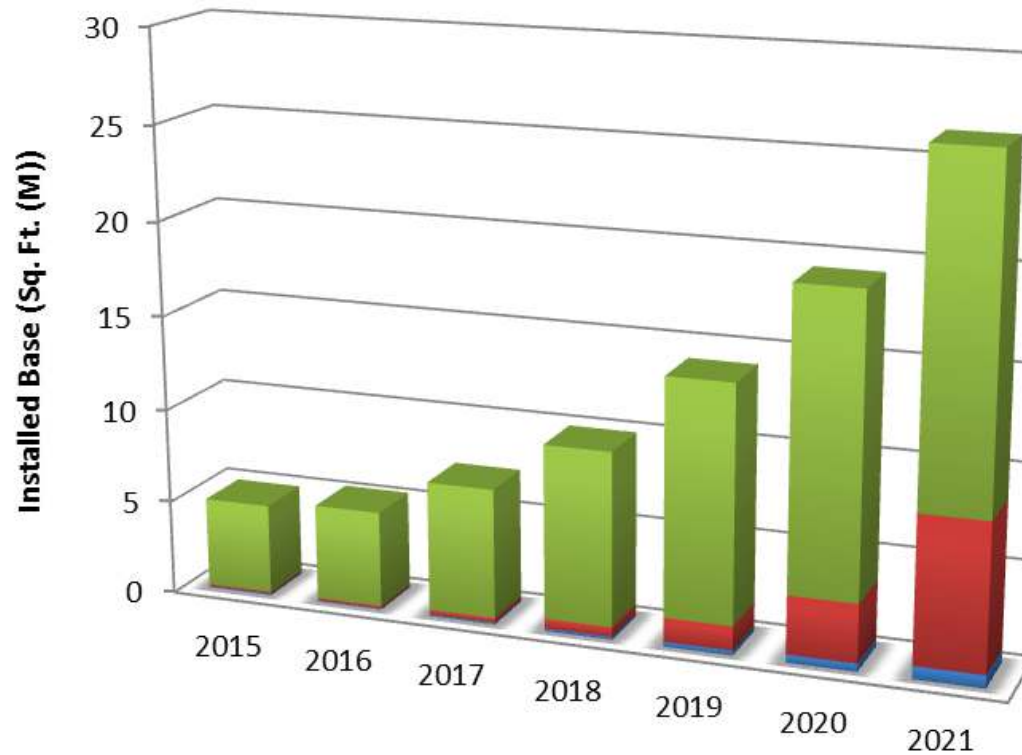


Application Focus Cannabis



Sources: Money Morning Staff Research

N.A. Cannabis Grow houses (Installations and Market)



Market Indicators for Growth

- 2 major indicators
 - Quality of light
 - Decreasing prices (Payback period under 3 years and ROI)
- What will speed up/slow down the market?
 - Increased Education
 - End Users
 - Manufacturers
 - Product/technology development
 - Decreased prices
 - Increased ease of use
 - Market acceptance

Standards play a major role in all of this!

Thank You!

Philip Smallwood

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HORTICULTURE LIGHTING

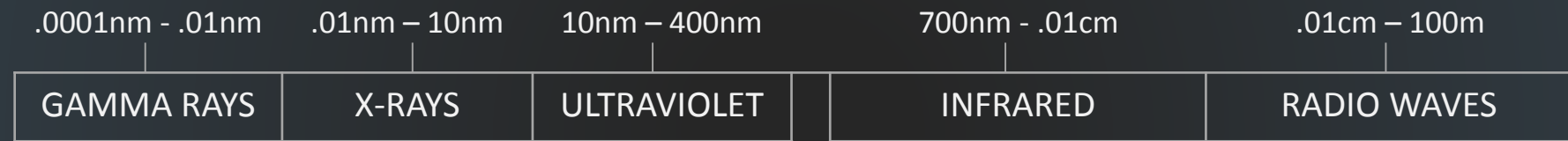
NUANCES & THE NEED FOR STANDARDS

Travis Williams

Vice President of Marketing & Research, Fluence Bioengineering

PHOTOBIOLOGY

WAVE + PARTICLE (PHOTON)



PAR/VISUAL LIGHT

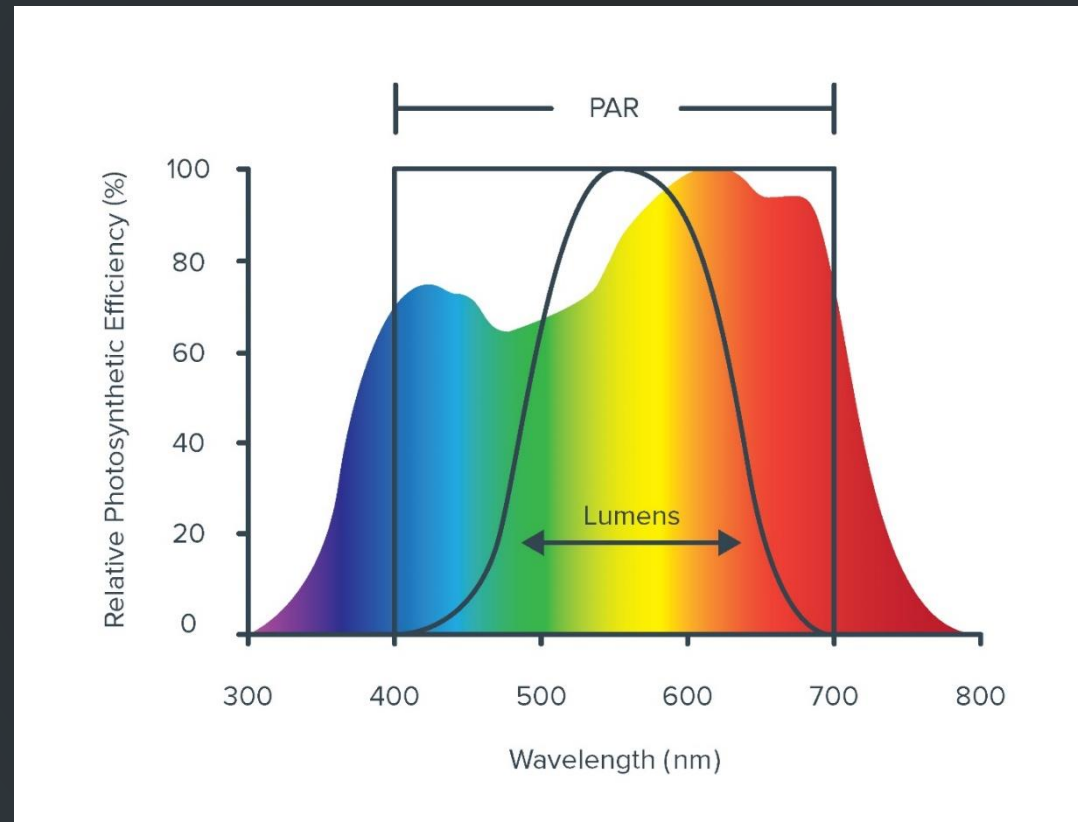


400nm-----700nm

HORTICULTURE vs. VISION

Photopic Vision

- Lumens
- LUX /Foot Candles
- Lumens/Watt



Photobiology

- PAR
- PPF
- PPFD
- $\mu\text{mol/J}$

PHOTOBIOLOGY

PHOTOSYNTHESIS

SERIES OF LIGHT & DARK REACTIONS THAT OCCURS IN THE CHLOROPLASTS USING LIGHT ENERGY (PHOTOSYNTHETIC PHOTON FLUX) TO GENERATE CARBOHYDRATES FROM CO₂ AND H₂O.

YIELD

PHOTOMORPHOGENESIS

LIGHT-CONTROLLED PROCESSES THAT REGULATE PLANT PHYSIOLOGICAL DEVELOPMENT OF FORM AND STRUCTURE

QUALITY

PHOTOPERIODISM

PHYSIOLOGICAL RESPONSE TO RELATIVE LENGTHS OF LIGHT AND DARK PERIODS

FLOWER/FRUIT MANIPULATION

HORTICULTURE vs. VISION

Photobiology requirements in commercial agriculture

PPF | PPFD | UNIFORMITY | SPECTRUM | EFFICACY | SIZE | PROXIMITY

The amount of light emitted by a light source. Measured in:
micromoles per second ($\mu\text{mol/s}$)

HORTICULTURE vs. VISION

Photobiology requirements in commercial agriculture

PPF | **PPFD** | UNIFORMITY | SPECTRUM | EFFICACY | SIZE | PROXIMITY

The amount of light reaching your canopy. Measured in:
micromoles per meter squared per second ($\mu\text{mol}/\text{m}^2/\text{s}$)

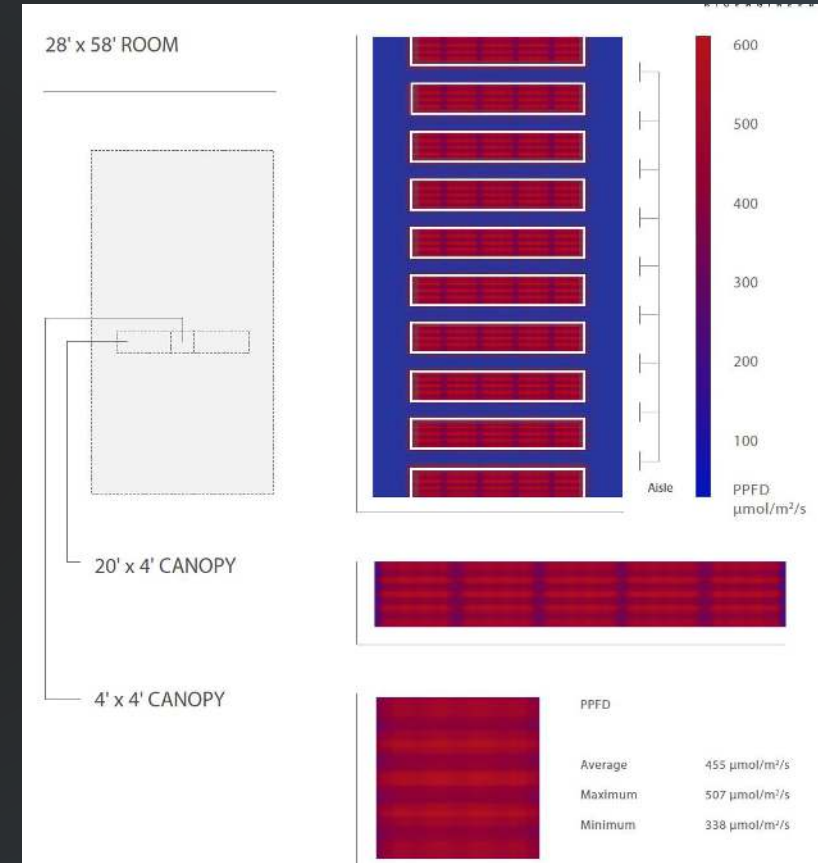
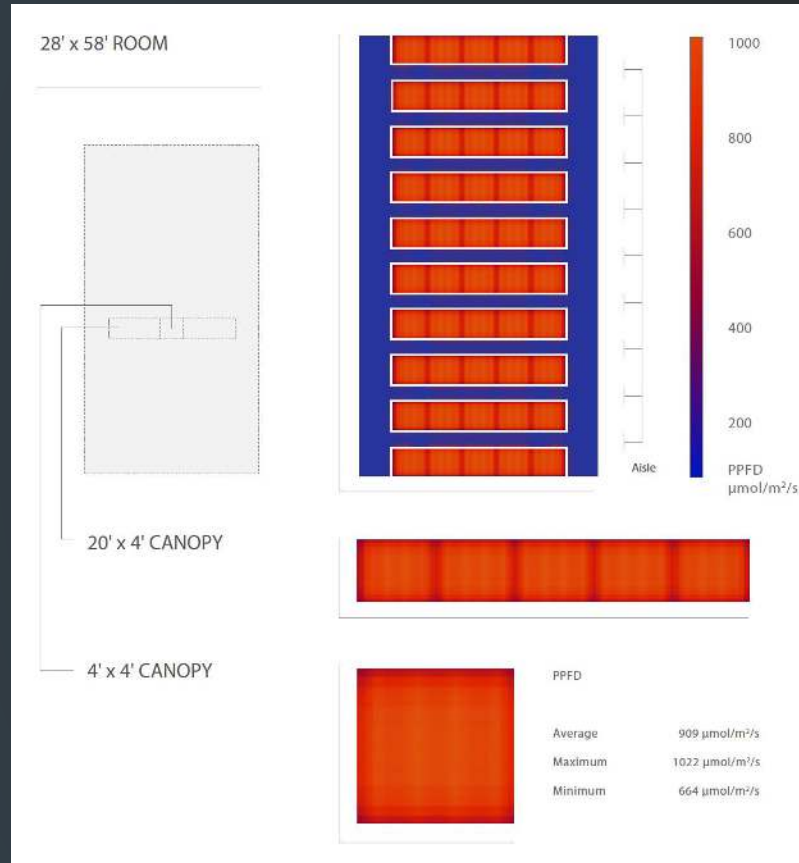
HORTICULTURE vs. VISION

Photobiology requirements in commercial agriculture

PPF | PPFD | **UNIFORMITY** | SPECTRUM | EFFICACY | SIZE | PROXIMITY

The average, maximum and minimum amount of ppfd. Measured with:
a PAR map

HORTICULTURE vs. VISION



HORTICULTURE vs. VISION

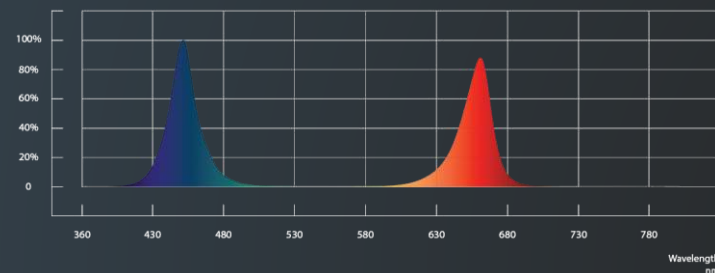
Photobiology requirements in commercial agriculture

PPF | PPFD | UNIFORMITY | SPECTRUM | EFFICACY | SIZE | PROXIMITY

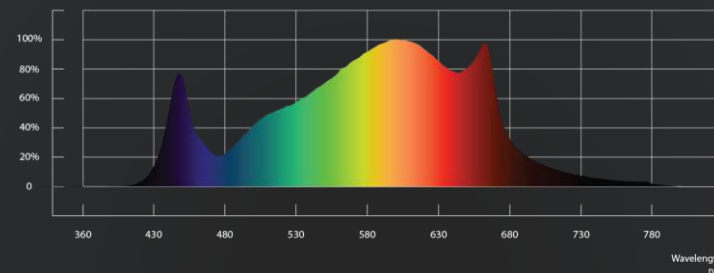
The proportions of different wavelengths. Measured with:
a spectral power distribution chart

HORTICULTURE vs. VISION

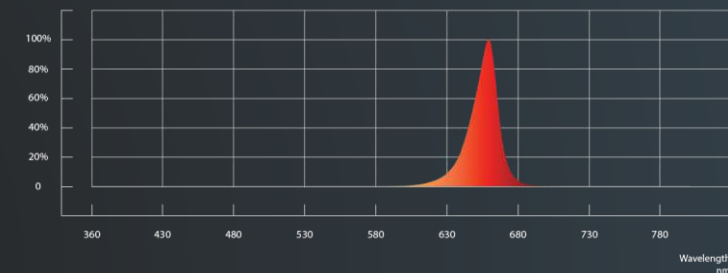
Measurements of Normalized
Photosynthetic Photon Flux



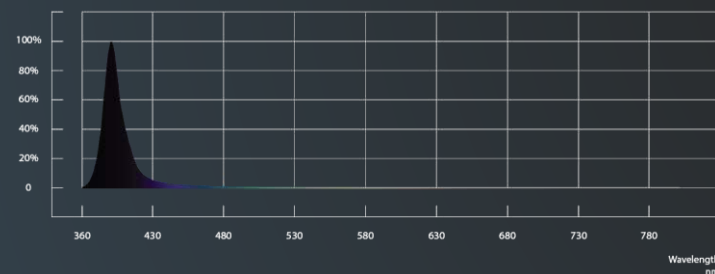
Measurements of Normalized
Photosynthetic Photon Flux



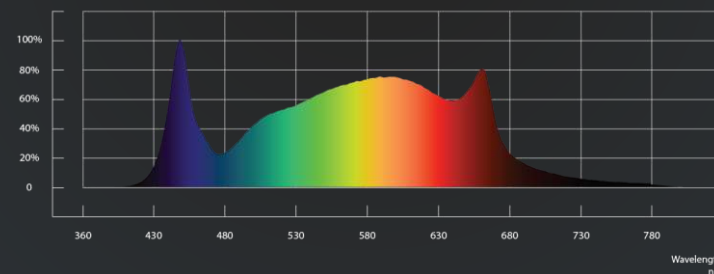
Measurements of Normalized
Photosynthetic Photon Flux



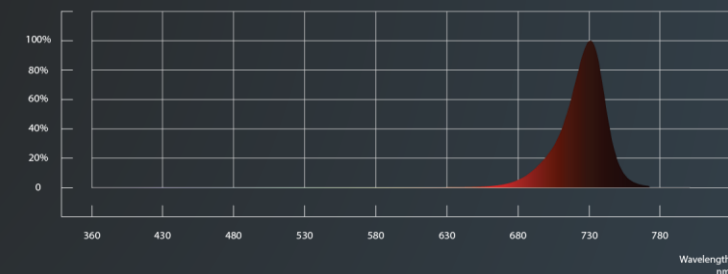
Measurements of Normalized
Photosynthetic Photon Flux



Measurements of Normalized
Photosynthetic Photon Flux



Measurements of Normalized
Photosynthetic Photon Flux



Petunia 'Classic Purple Wave'

57 Days After Transplant at 61 °F

Light Source and PPE of 4-h night interruption:

9-h Short day	Incandescent	LED 1	LED 2	LED 3
	0.627	0.631	0.711	0.700



-	92	58	92	-
Flowering Percentage				

-	56	61	58	-
Days to Flower				

Celosia 'Dragon Breath'

57 Days After Transplant at 61 °F

Light Source and PPE of 4-h night interruption:

9-h Short day

Incandescent

LED 1

LED 2

LED 3

0.627

0.631

0.711

0.700



100

100

100

100

100

Flowering Percentage

34

61

61

62

61

Days to Flower

African Marigold 'Antigua Yellow'

46 Days After Transplant at 61 °F

Light Source and PPE of 4-h night interruption:

9-h Short day	Incandescent	LED 1	LED 2	LED 3
	0.627	0.631	0.711	0.700



100

100

100

100

100

Flowering Percentage

42

44

51

52

47

Days to Flower

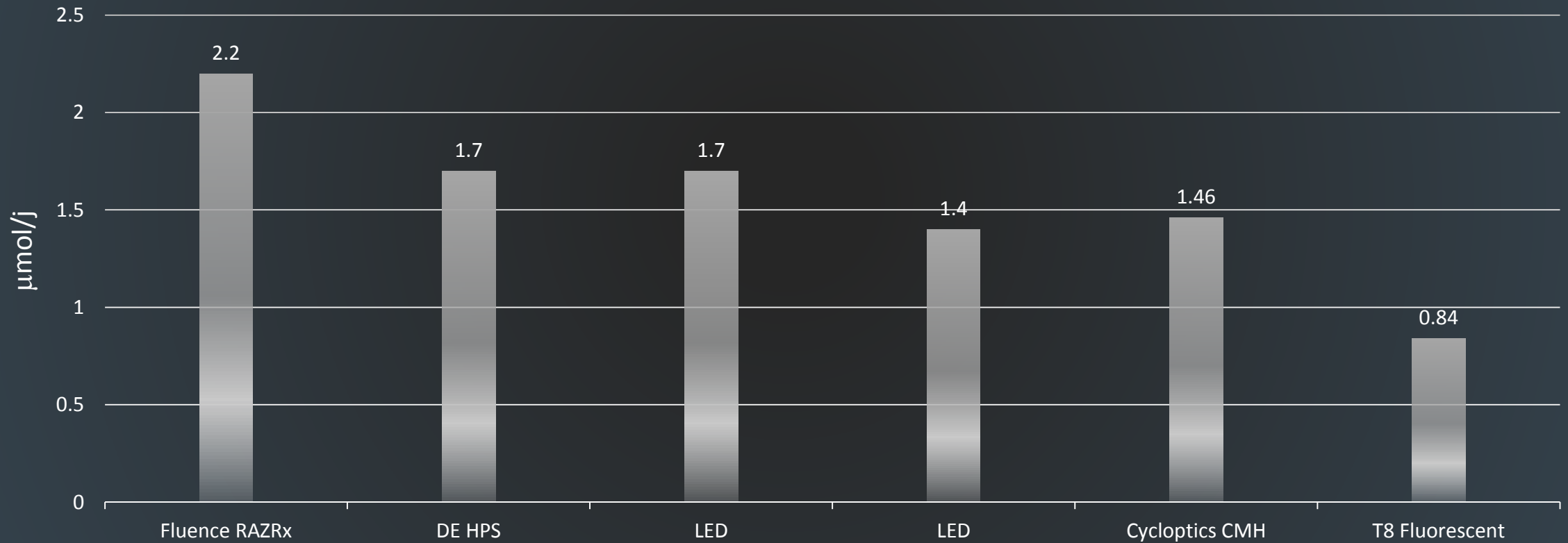
HORTICULTURE vs. VISION

Photobiology requirements in commercial agriculture

PPF | PPFD | UNIFORMITY | SPECTRUM | EFFICACY | SIZE | PROXIMITY

How energy efficient a light fixture is at converting electrons into photons. Measured
in: Micromoles per joule ($\mu\text{mol/J}$)

EFFICACY



HORTICULTURE vs. VISION

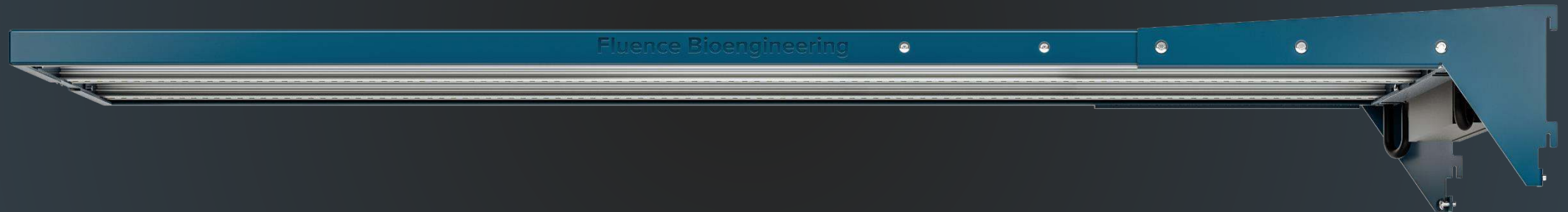
Photobiology requirements in commercial agriculture

PPF | PPFD | UNIFORMITY | SPECTRUM | EFFICACY | SIZE | PROXIMITY

How much space does your lighting system require? Measured in:
inches, centimeters, millimeters, etc.

HORTICULTURE vs. VISION

1.2"



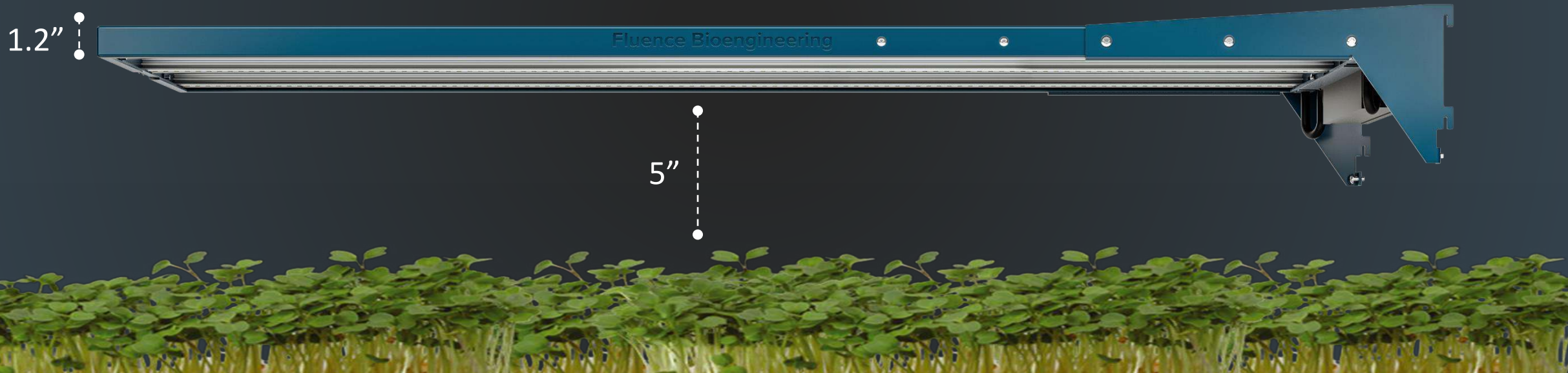
HORTICULTURE vs. VISION

Photobiology requirements in commercial agriculture

PPF | PPFD | UNIFORMITY | SPECTRUM | EFFICACY | SIZE | PROXIMITY

Space requirements from light to canopy? Measured in:
inches, feet, centimeters, millimeters, etc.

HORTICULTURE vs. VISION



HORTICULTURE vs. VISION

Factors to consider when designing or deploying a horticulture
lighting solution

RH | TEMPERATURE | RADIANT HEAT | CO2 | IRRIGATION | & SO MUCH MORE

LIGHTING TECHNOLOGIES

A quick look at what's in use

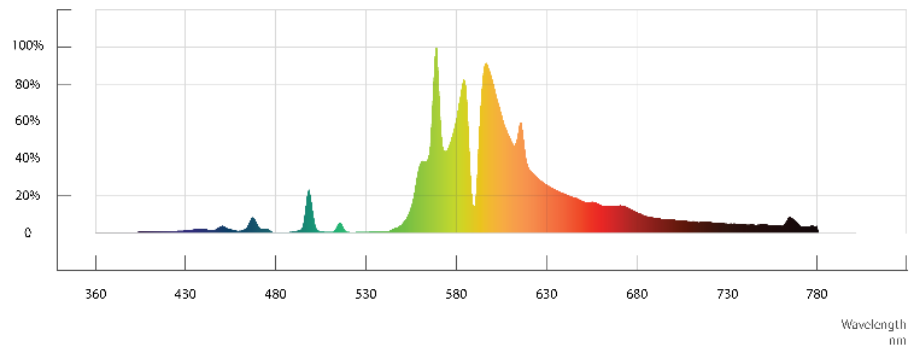
LED | CMH | HPS | FLUORESCENT | PLASMA | & SO MUCH MORE



SPECTRAL POWER DISTRIBUTION CHART
High Pressure Sodium

FLUENCE
BIOENGINEERING

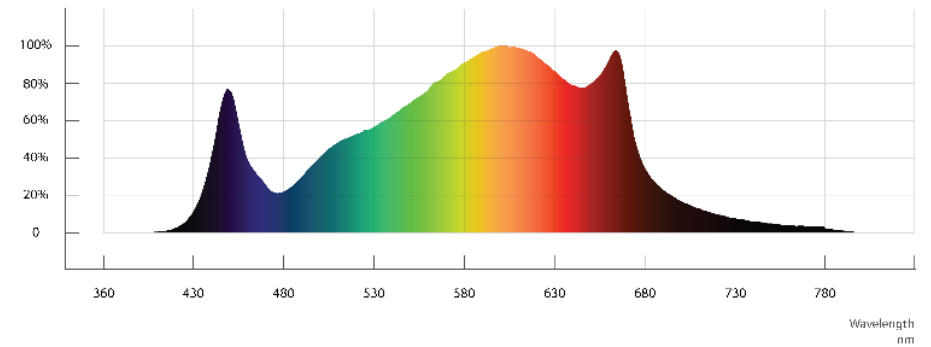
Measurements of Normalized
Photosynthetic Photon Flux

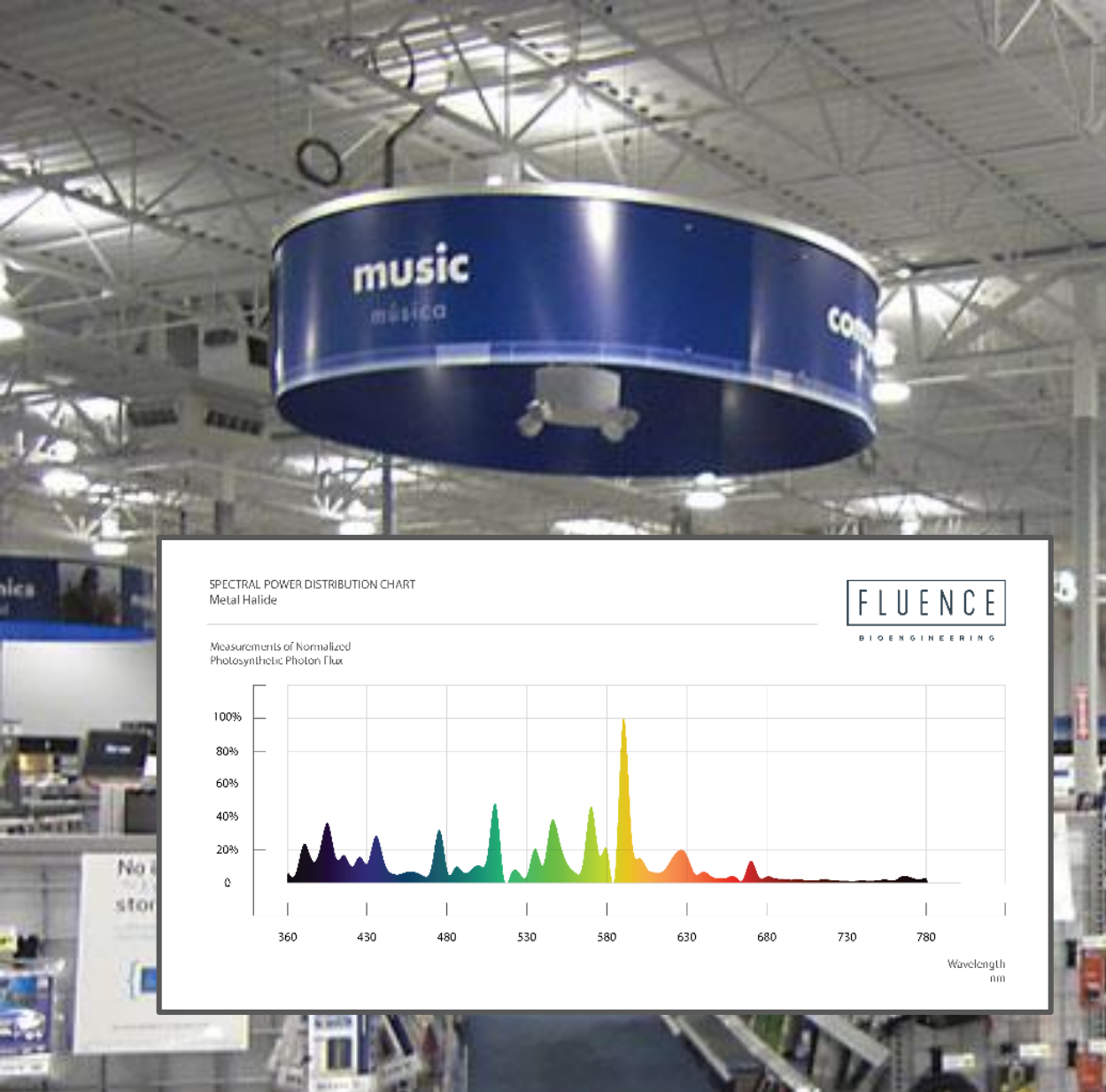


SPECTRAL POWER DISTRIBUTION CHART
PhysioSpec Indoor™

FLUENCE
BIOENGINEERING

Measurements of Normalized
Photosynthetic Photon Flux

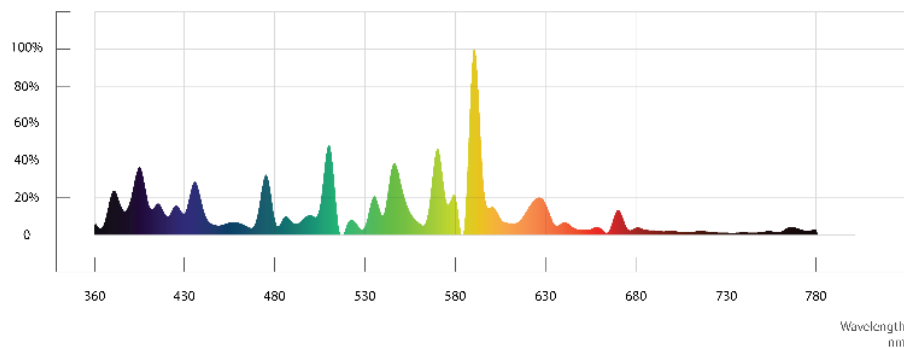




SPECTRAL POWER DISTRIBUTION CHART
Metal Halide

FLUENCE
BIOENGINEERING

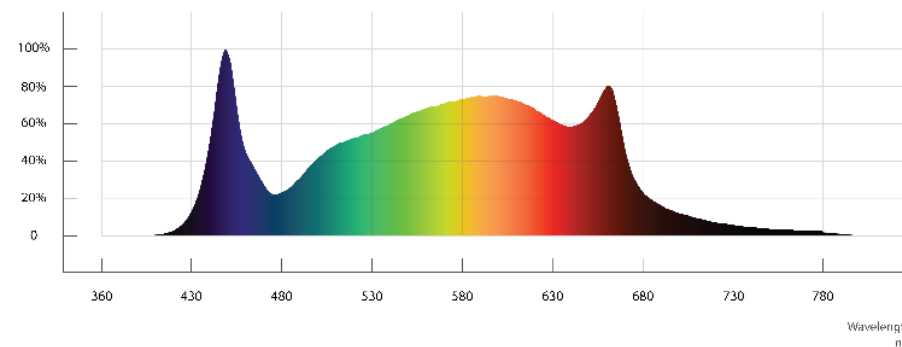
Measurements of Normalized
Photosynthetic Photon Flux

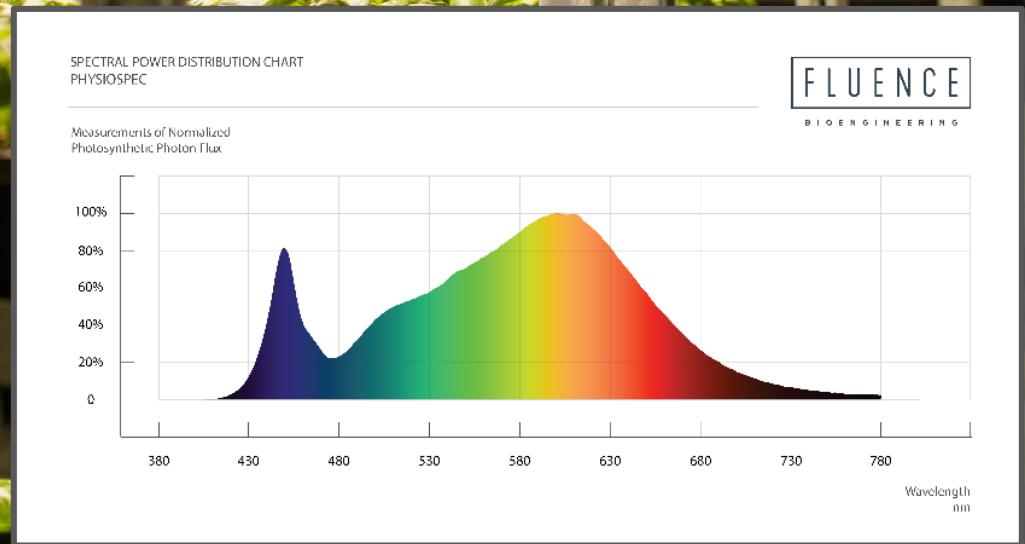
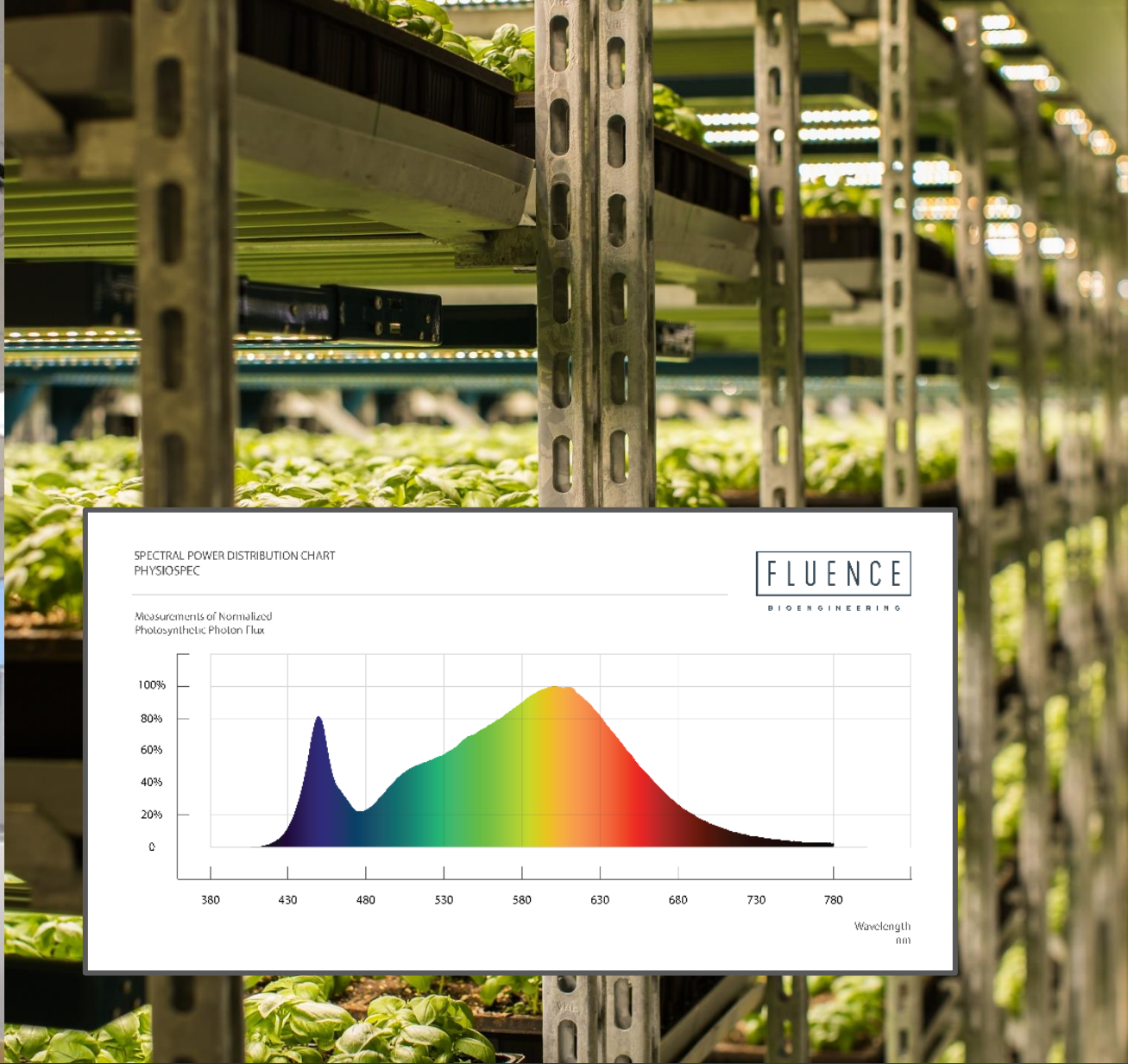
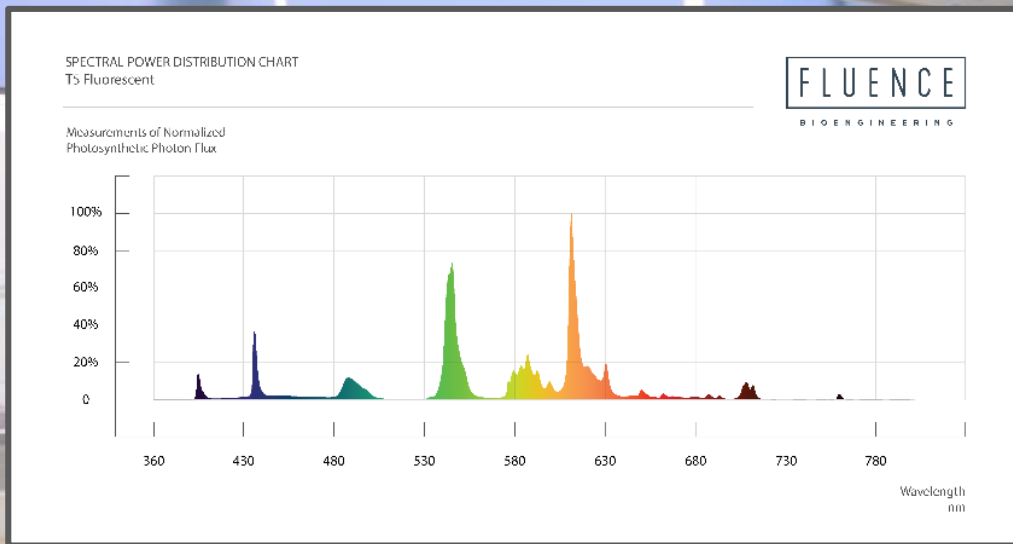


SPECTRAL POWER DISTRIBUTION CHART
PhysioSpec Greenhouse™

FLUENCE
BIOENGINEERING

Measurements of Normalized
Photosynthetic Photon Flux





LIGHTING TECHNOLOGIES

Today and tomorrow

GREENHOUSE TOP LIGHT | GREENHOUSE INTRACANOPY |
GREENHOUSE VERTICAL | VERTICAL FARMING | GROWTH CHAMBERS | & SO
MUCH MORE









DLCSTAKEHOLDERMEETING

FLUENCE

JULY 2017



DLCSTAKEHOLDERMEETING

FLUENCE

JULY 2017



FUTURE

EMPOWERED BY TECHNOLOGY

LED efficiency gains

Thermal management

Automation & big data

FUTURE

EMPOWERED BY SCIENCE

Custom spectra

Environmental optimizations

Genetic optimizations

OPPORTUNITIES

SAVING ENERGY

AND/OR

MAKING MONEY

Maximize yield per cubic foot

Minimize operating cost/pound

Augment pricing power
(quality/consistency/forecast)

FOR NEXT TIME

NOW THAT
THE BASICS
ARE COVERED

Degradation

Maintenance, loss, inconsistency

Rohs

Avoiding mercury and other harmful
contaminants

CU

Don't waste photons

SUMMARY

Plants use light much differently than humans

Growers/KDMs are largely uneducated when it comes to photobiology

There are myriad factors for CEA. No one-size fits all.

Horticulture lighting *should be* revenue-generating, not cost-saving.

WE (ALL OF US) WILL BENEFIT FROM INDUSTRY STANDARDS.

What's Growing on in Oregon





Grow Light Options

***Utility perspective from the
front lines***



Legacy Technologies

Baseline or industry standard



1,000 watt High Pressure Sodium, single ended lamp (one socket)



INDUSTRY RULE OF THUMB – 16 S.F. per grow

Provides approximately 700 to 800 PPFD $\mu\text{mol}/\text{m}^2 \text{ S}$

Step up from a Singled Ended HPS



*1,000 watt High Pressure Sodium
Double ended lamp*



Provides approximately 800 to 1,000 PPFD $\mu\text{mol}/\text{m}^2 \text{ S}$



- *Single Ended (SE). Mogul base The arc tube connects to the base of the bulb with a metal frame wire holding it by each end*
- *Double Ended (DE). Connects on each end at the lamp much like a fluorescent tube*
- *Because of the support and shapes, the DE is much thinner than SE which improves optical properties. Exposing the arc tube to the bulb without any metal framing in the way, increases light delivery. The symmetry of the DE bulbs allows you to create an even spread of light.*
- *Hours: It would appear that SE bulbs last longer than DE bulbs but in reality, you need to change the SE bulb every 6,000 hours and every DE bulb every 10,000 hours to maintain optical properties*
- *Efficiency: SE bulbs are vacuum, DE bulbs are full of nitrogen gas. The gas allows the bulb to operate at higher temperatures, which increases it's efficiency. But, any air movement (fans) can cool the lamp decreasing efficiency.*

Induction



***Race track style
Load 440 watts
Life of lamp 100,000 hours***



Provides approximately 300 to 400 PPFD $\mu\text{mol}/\text{m}^2 \text{ S}$

Light Emitting Ceramic (LEC)

Ceramic Metal Halide (CMH)



2/315 watt CMH lamps

Load 630 watts/240 volts @ 100%



Provides approximately 700 to 800 PPFD $\mu\text{mol}/\text{m}^2 \text{ S}$

One 315 watt lamp is $\frac{1}{2}$

Light Emitting Plasma



1/270 watt Plasma

Load 270 watts/240 volts @ 100%

Life of lamp – 50,000



Provides approximately to 200 to 300 PPFD $\mu\text{mol}/\text{m}^2 \text{ S}$

Tube LED (TLED)



54 watt T5 HO fluorescent baseline



28 watt T5TLED

Works off existing fluorescent ballast

Life of lamp – 50,000 hours



*Provides approximately to 500 to 600 PPFD $\mu\text{mol}/\text{m}^2 \text{ S}$
(8-lamp luminaire)*

Hybrid

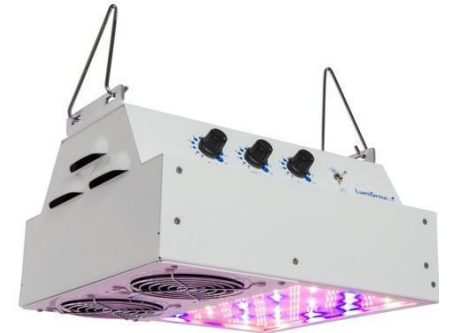
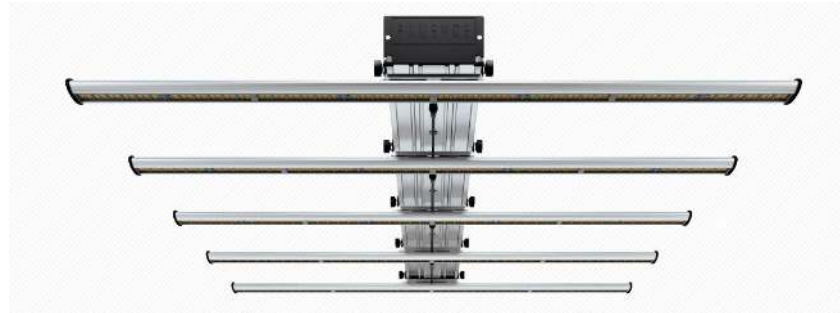


LED (dimmmable, tunable)



Average around 600 watts

Life of LED: 50,000 hours @ 70% output



Some provide approximately 1,000 to 1,200 PPFD $\mu\text{mol}/\text{m}^2 \text{ S}$

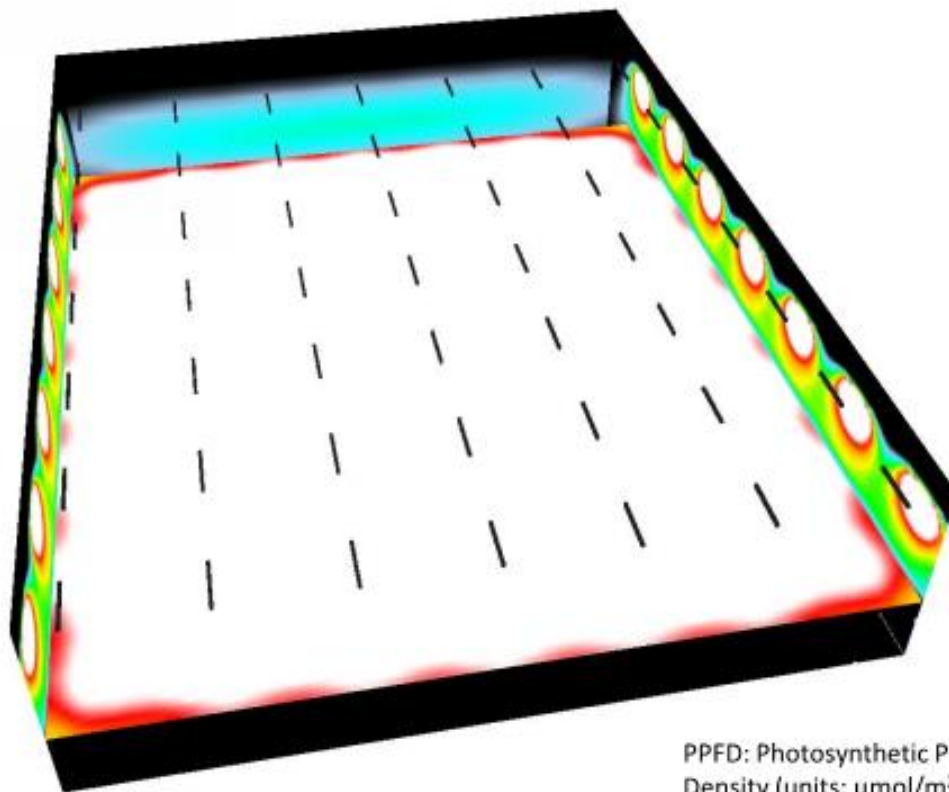


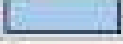
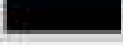
What manufacturers should provide



PPFD distribution at 7' 4" from the fixtures

- Height above the canopy: 7' 4"
- PPFD: 138 (average), 166 (max), 75 (min)
- Light loss Factor: 0.99



	-	110.00
	-	96.38
	-	82.75
	-	69.13
	-	55.50
	-	41.88
	-	28.25
	-	14.63
	-	1.00

PPFD: Photosynthetic Photon Flux
Density (units: $\mu\text{mol}/\text{m}^2/\text{s}$)

Reducing your operational costs



Time is money – cent's per kWh



Indoor

Clone - 18 to 24 hours 7 days per week (8,760)

Vegetative stage - 18 hours 7 days per week (6,570)

Flowering stage - 12 hours 7 days per week (4,380)

Green house

2,118 annual hours for supplemental electric lighting



SunriseSunset

Zip or city, state

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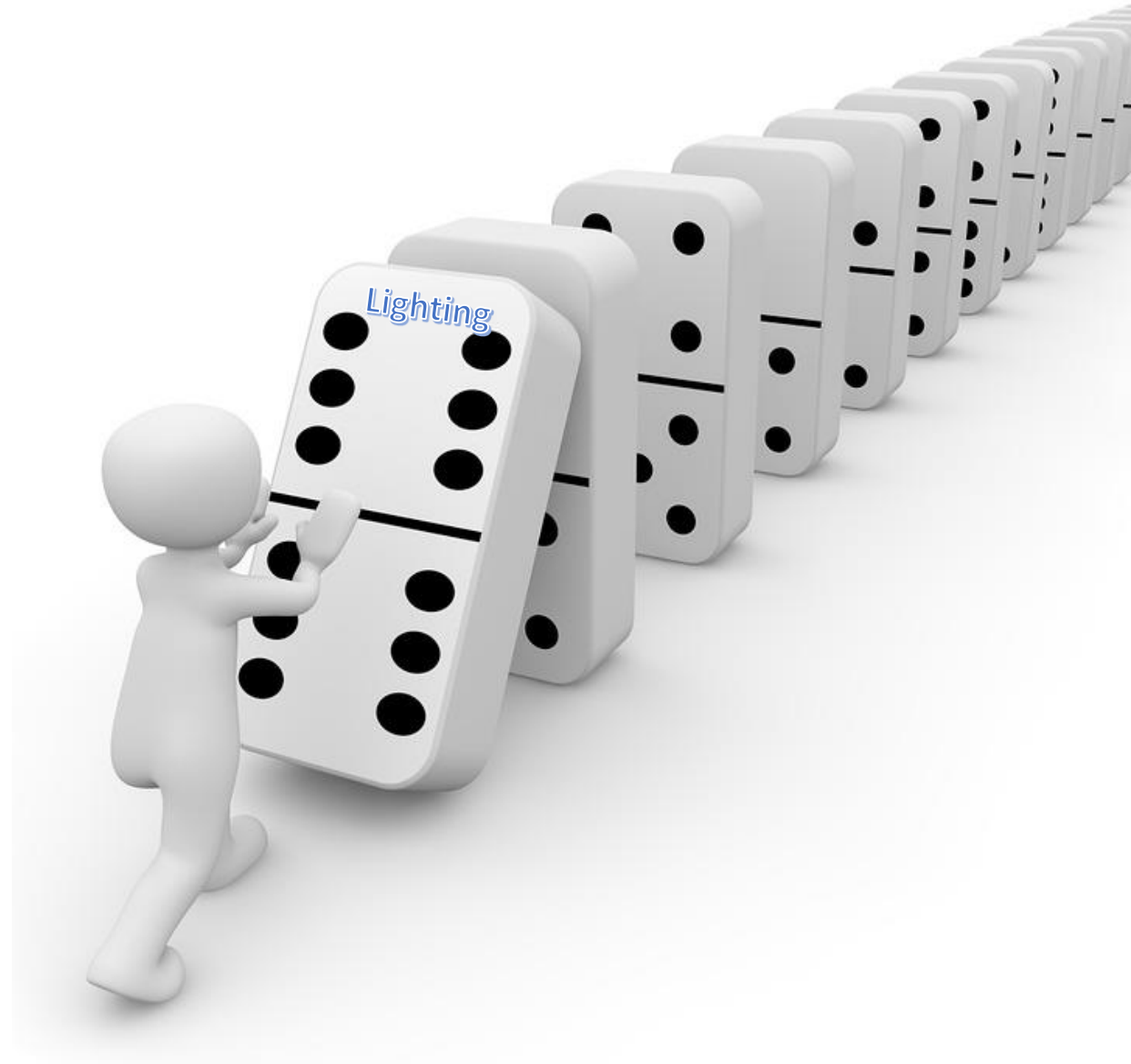
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Lighting is the largest load in an indoor grow operation

Less lighting load means...

- *Less HVAC load*
- *Less fan load*
- *Less electrical service costs*
- *Less insulation*
- *And more*
- *The gift that keeps on giving*



Virtual case study



***3,500 S.F. canopy grow operation
Flower room***

***218, 1,000 watt HPS virtual grow lights (3,500/16 SF)
\$200 ea.***

4,380 annual hours

218, 640 watt LED grow lights \$1,200 ea.

Estimated Annual Energy Savings	429,654 kWh
Estimated Annual Cost Savings	\$ 44,224 per year
Estimated Energy Trust of Oregon Incentive	\$ 107,414
Additional Estimated Incentive, if applicable	\$ -
Estimated Installation Cost	\$ 218,000

Based on your proposed retrofit and estimated installation cost, we show the following financial analysis:

Estimated Installation Cost	\$ 218,000	
<i>minus Energy Trust of Oregon incentive</i>	<u>\$ (107,414)</u>	
Net Installation Cost	<u>\$ 110,586</u>	
Energy Savings Payback (in years)	2.5	
% of installed cost paid for by incentives	49%	
Rate of Return	40%	

Estimated cost for every year the project is delayed	\$ 44,224	PROFIT after 2.5 years!!
--	-----------	---------------------------------

This project requires a pre-installation inspection.

This is an estimate only, as actual savings and incentives will vary based on final installed measures and costs, actual area operating hours, energy rates and building usage.

Green Project Box: (Estimate for informational purposes only. The carbon footprint from electricity generation is calculated from a regional average, which may be different than the national average.)

This proposed project could offset approximately **204** tons of CO2 generated by fossil fuels, equal to taking more than **29** cars off the road.

QPL lists for Horticulture

- Needs to be cognizant of growers methodology, designs and procedures that produce high yields
- Utilities: Should there be a list or should there be specifications to meet?

Thank you



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503.382.9359

Thank You!



**Irina
Rasputnis**
DLC



**Philip
Smallwood**
*Strategies
Unlimited*



**Travis
Williams**
*Fluence
Bioengineering*



**Doug
Oppedal**
*Evergreen
Consulting*