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Trade Show and Conference

Designers Lighting Forum

Lumens Are For Humans

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Learning Objectives

At the end of this course, participants will be able to:

1. Participants will become familiar with various lighting technologies used in horticulture, including their benefits and applications in different growing environments.
2. Attendees will learn about critical horticultural lighting metrics such as PPF, PPFD, and PAR, and their importance in plant growth optimization.
3. Participants will gain insights into innovative horticultural techniques, including vertical cultivation and greenhouse supplemental lighting, and their practical applications across various crops.
4. Attendees will understand how different lighting strategies can enhance crop yield and quality, equipping them with the knowledge to advise clients effectively.

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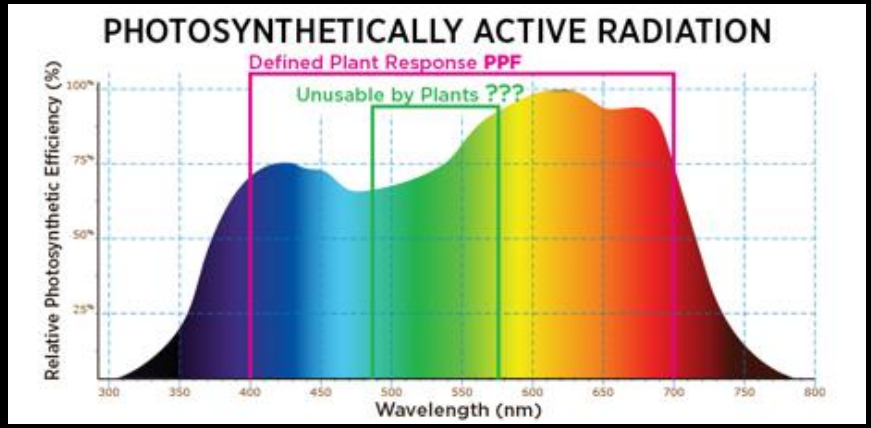
Terminology

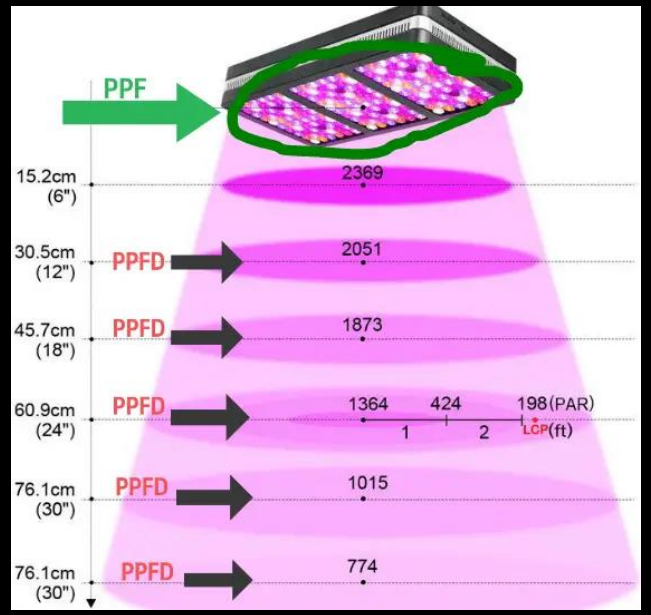
PPF	PPFD	PAR
micromoles	Spectrum	Vertical Cultivation
Rolling Benches	Greenhouse Supplemental	DLI

What is PPF?



- **PPF** is photosynthetic photon flux. **PPF** measures the total amount of PAR that is produced by a lighting system each second. This is probably the second most important way of measuring a **horticulture** lighting system, but, for whatever reason, most lighting companies don't list this metric.

What is PPFD?



- Photosynthetic Photon Flux Density (**PPFD**) is the measurement of PAR delivered to a specific area. It is expressed as micromole-per-meter squared-per second (µmol/m2/s). This is the only measurement that informs us of the amount of light being delivered to a crop which enables photosynthesis.

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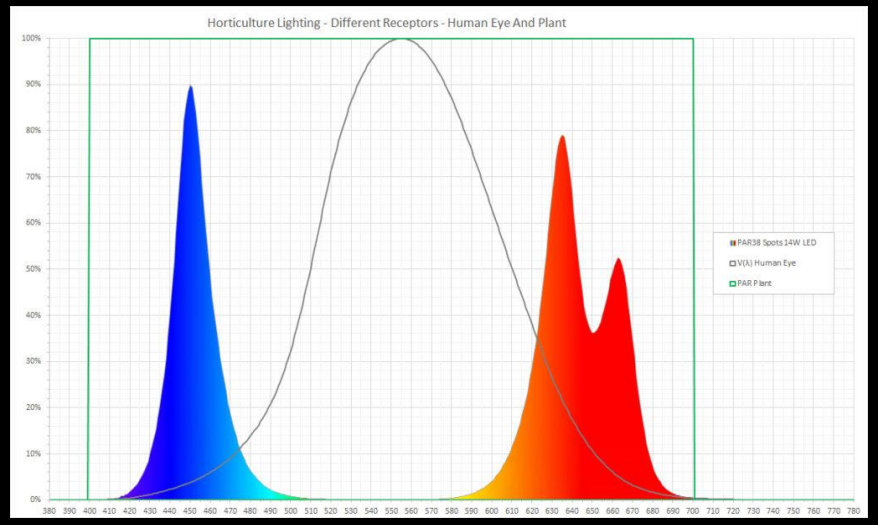
What is PAR?



- **PAR** is photosynthetic active radiation. **PAR** light is the wavelengths of light within the visible range of 400 to 700 nanometers (nm) which drive photosynthesis (Figure 1). **PAR** is a much used (and often misused) term related to **horticulture** lighting. ... Rather, it defines the type of light needed to support photosynthesis.

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What is a mole? µmol/m2/s

- A measure of radiant **light** from a standard candle that falls on one square meter of surface area one meter from the source. **Micromol**: One **micromol** per square meter per second (**umol**. ... A unit of measure of the amount of **light** hitting a surface that is in the range of 400-700 nanometers.
- A **micromole** is a unit of measure defined as 10^{-6} (one-millionth) of a mole. The symbol for **micromole** is commonly **umol** or **µmol**. A mole is defined as approximately 6.022140857 x 10^{23}, so therefore a **micromole** can also be defined as: 1 **µmol** = 6.022140857 x 10^{17}.
- 1 micro mole is 1/1000000th of a mole.

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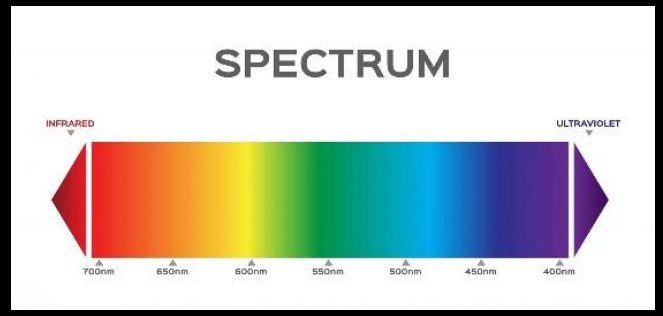
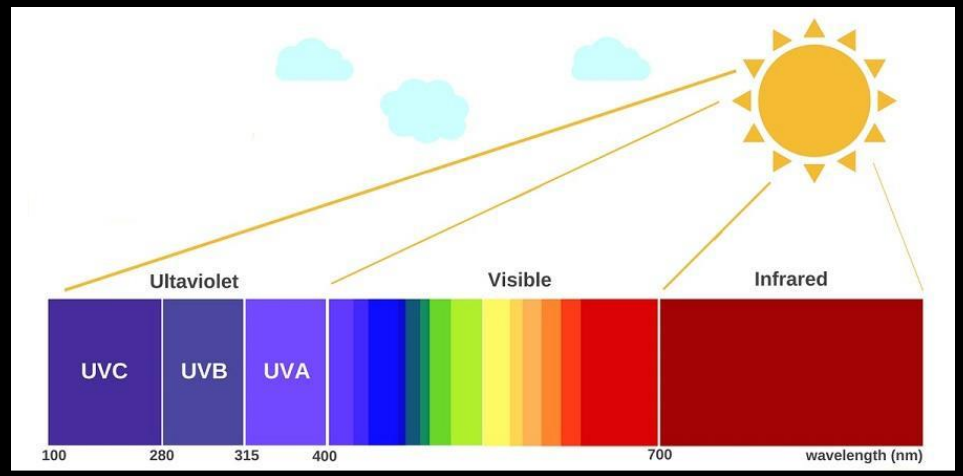
Spectrum and how it relates to plants?





- Grow light spectrum refers to the electromagnetic wavelengths of light produced by a light source to promote plant growth. For photosynthesis, plants use light in the PAR (photosynthetic active radiation) region of wavelengths (400nm-700nm) measured in nanometers (nm).
- Nanometers are a universal unit of measurement but also used to measure spectrum of light – humans can only detect *visible* light spectrum wavelengths (380-740nm). Plants, on the other hand, detect wavelengths *including* our visible light and beyond, to include UV and Far Red spectrums.
- It's important to note light spectrums affect plant growth differently depending on things like environmental conditions, crop species, etc. Typically, chlorophyll, the molecule in plants responsible for converting light energy into chemical energy, absorbs most light in blue and red light spectrums for photosynthesis. Both red and blue light are found in the peaks of the PAR range.

Vertical Cultivation

- **Vertical** farming is the practice of **growing** crops in **vertically** stacked layers. ... The increased ability to cultivate a larger variety of crops at once because crops do not share the same plots of land while **growing** is another sought-after advantage.

- The term 'vertical cultivation' in this context does NOT mean stacking horizontal grow trays on top of each other, with the plant canopy growing towards (perpendicular) the lights. Instead, imagine taking a horizontal grow and flipping it, along with its light source, 90 degrees so that the plants grow upward *and parallel* to the light.

Racking

- The most efficient indoor **growing** solution and can double storage capacity while also keeping plants safe.

- **Vertical** farming is the practice of **growing** crops in **vertically** stacked layers. It often incorporates controlled-environment agriculture, which aims to optimize plant growth, and soilless farming techniques such as hydroponics, aquaponics, and aeroponics.

Rolling Benches

- **Rolling benches** / growing **tables** are highly recommended for any commercial grow operation. They provide up to 50% more plant space by eliminating the need for a dedicated aisle.

- With a crops as valuable as **marijuana**, this directly equates to much higher profits and maximum space efficiency.

Greenhouse Supplemental

- **Supplemental lighting** is used in greenhouses to increase crop production during time periods with low levels of solar radiation. These time periods usually occur during the winter months, but cloudy summer days can be as dark as some of the darker winter days.

LUMENS ARE FOR HUMANS

- Key things to remember:
  - Lumens
    - PPF
  - Footcandles/Lux
    - PAR
    - PPFD
    - µmol/m2/s
  - Color Temperature
    - Spectrum
    - nm or wavelength
  - Lumens/watt efficacy
    - µmol/J
  - Mounting Height
    - Canopy Clearance

Plant Stages

Seedling
Most plants are considered *seedlings* until they begin to develop mature leaves. A healthy *seedling* should be a vibrant green color, indicating proper nutrient absorption and growth potential.

Clone
A *clone* is a genetic copy of a parent plant, typically used in agriculture to maintain desired characteristics such as high yield, disease resistance, or specific growth traits. When obtained from a reputable source, clones are young plants with stable genetics, providing farmers with a reliable way to replicate successful crops.

Vegetative Stage
The *vegetative stage* is when a plant's growth truly accelerates. At this point, the plant is transplanted into a larger space, allowing its roots and foliage to develop rapidly. This stage is crucial for promoting healthy structural growth, and it's also when farmers may prune or train plants for optimal shape and yield.

Flowering Stage
The *flowering stage* is when the plant begins to produce its reproductive parts. For many crops, this stage is key as it signals the development of fruit, grains, or other harvestable parts of the plant. Ensuring proper lighting, nutrients, and care during this stage is vital for maximizing yield.

Mother Plant
In agriculture, *mother plants* are used in cloning processes to ensure consistent, high-quality crops. These plants are highly valued for their genetic traits, and cuttings from them are used to create *clones* that carry the same characteristics, allowing farmers to cultivate uniform plants with predictable outcomes.

Understanding Light Intensity for Different Plants

Different plants require varying levels of light intensity to thrive, measured in micromoles (µmol/m²/s). Providing the right amount of light is crucial for ensuring healthy growth and optimal yield. Here are some examples of light intensity requirements for various plants:

•**Microgreens:** Typically require around 140 µmol. These small, tender plants need lower light intensity to grow efficiently without becoming stressed by excessive light.

•**Basil:** Grows best at about 210 µmol, ensuring robust leaf development and flavor without overwhelming the plant.

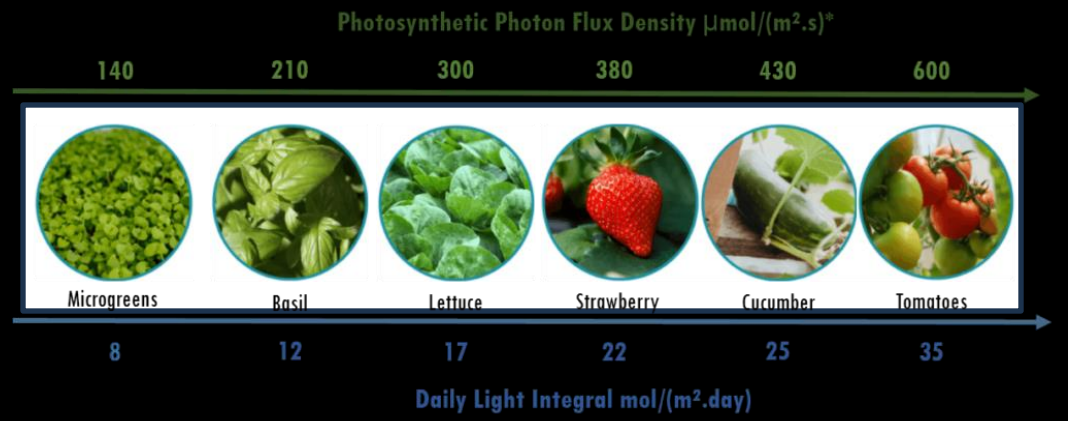
•**Lettuce:** Requires around 300 µmol, supporting steady growth for leafy greens without risking leaf burn or bolting.

•**Strawberries:** Thrive at 380 µmol, allowing for strong fruit development and optimal sugar production.

•**Cucumbers:** Need approximately 430 µmol for healthy vine growth and high fruit yield.

•**Tomatoes:** Require around 600 µmol, as the higher intensity encourages flowering and fruiting.

•**Cannabis:** Typically demands 850+ µmol for maximum growth, resin production, and high yields during the flowering stage.
Each plant has a specific light requirement to support its growth, so adjusting light intensity accordingly is key to promoting healthy development through each growth stage.



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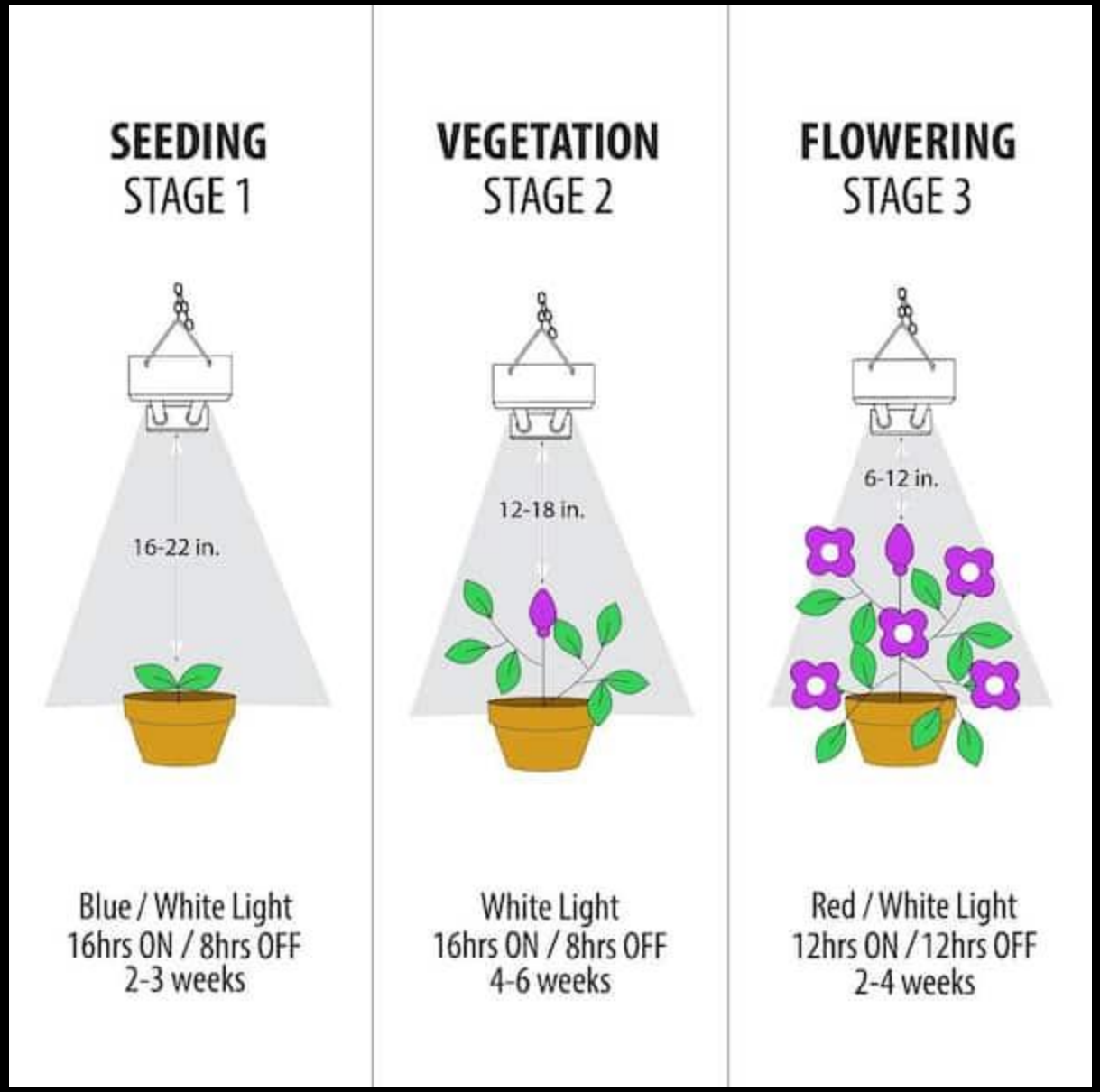


Type of Plant	Average PPFD	Hours of Light
Low-Medium Light Plants (Orchids, Microgreens, Herbs, Ferns, Ivy)	100-250	12 ON / 12 OFF
High Light Plants (Succulents, Monstera, Ficus)	250 – 450	12 ON / 12 OFF
Leafy Greens (Lettuce, Spinach, Arugula, Kale, Cabbage)	200	8 ON / 16 OFF
Fruiting Vegetables (Tomatoes, Peppers, Eggplant)	400 – 500	8 ON / 16 OFF
Vegetative Stage	300 – 600	18 ON / 6 OFF
Flowering Stage	900 – 1000+	12 ON / 12 OFF

What to Ask/Listen for?

- Now that you know some of the key terms in the industry and the different stages of plant you can gather information.
- Space Size
- Plant Stage
- Grow Style
  - Vertical
  - Benches
  - Racking
  - Greenhouse
- Fixture Mounting
  - Direct to Rack
  - Ceiling
  - Suspended
- Desired umol/ppfd at Canopy

Traditional Lighting

- HPS (High Pressure Sodium)
  - Also called DE (Double ended)
    - 1000W
    - 750W
    - 600W
- MH (Metal Halide)
  - Also called DE (Double Ended)
    - 1000W
    - 750W
  - CMH (Ceramic Metal Halide)
  - Double Ended
    - 1000W
    - 630W
  - Single End
    - 315 W
- Flourescent
    - T5

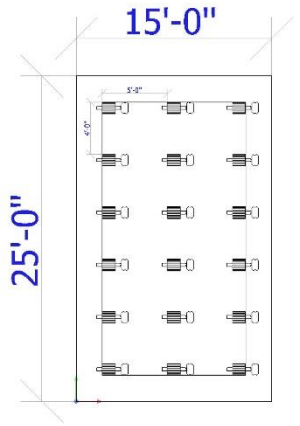
LED
LIGHTING

- LED Lighting
  - Seedling/Clone Solutions
  - Veg State
  - Mother Plants
  - Flower
  - Greenhouse Supplemental
  - Leafy Greens
  - Under Canopy

Grow Lighting Layouts

- Overview of a Comparison Study
  - Summary of Study
  - Results
  - Fixture Plotting
    - Orientation of Fixture
    - Install Location
    - Install Heights (AFF)
  - Renderings
    - 3D Rendering
    - PAR MAP/False Color Rendering
  - Calculations
    - Based on Growth of Plant
    - Taken at Canopy Height
    - Overview

1000W HPS



Clearance height: 12.000 ft, Reflection factors: Ceiling 10.0%, Walls 50.0%, Floor 10.0%, Light loss factor: 1.00

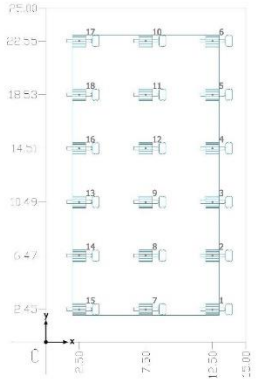
#	Luminaire	Φ(Luminaire) [PPF]	Power [W]	Luminous efficacy [umol/J]
18	Iluminar - 1000W HPS DE	1949	1071.8	1.8
	Total via all luminaires	35082	19292.4	1.8

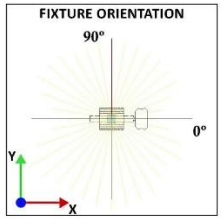
Lighting power density: 51.45 W/sq ft (Floor area of room 375.01 sq ft)

Consumption: 53050 kWh/a of maximum 1250 kWh/a

The energy consumption quantities do not take into account light scenes and their dimming levels.

1000W HPS

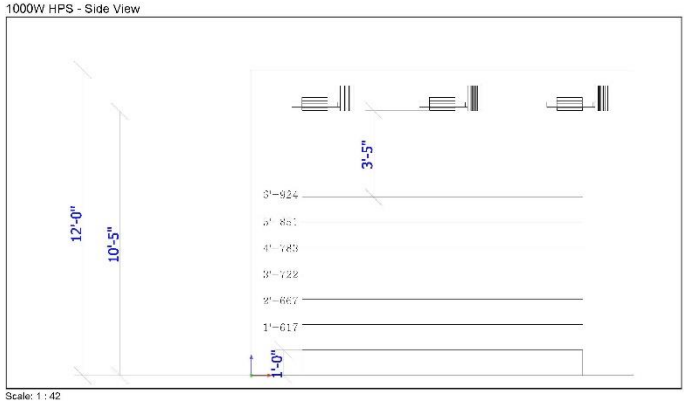




Illuminar 1000W HPS DE

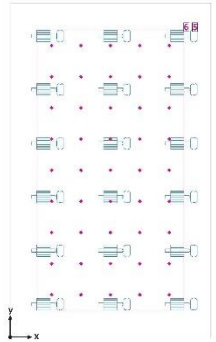
No.	X [ft]	Y [ft]	Mounting height [ft]	Housing rotation [°]
1	12.500	2.449	10.500	0.0
2	12.500	6.469	10.500	0.0
3	12.500	10.490	10.500	0.0
4	12.500	14.510	10.500	0.0
5	12.500	18.531	10.500	0.0
6	12.500	22.551	10.500	0.0
7	7.500	2.449	10.500	0.0
8	7.500	6.469	10.500	0.0
9	7.500	10.490	10.500	0.0
10	7.500	22.551	10.500	0.0
11	7.500	18.531	10.500	0.0
12	7.500	14.510	10.500	0.0
13	2.500	10.490	10.500	0.0
14	2.500	6.469	10.500	0.0
15	2.500	2.449	10.500	0.0
16	2.500	14.510	10.500	0.0
17	2.500	22.551	10.500	0.0
18	2.500	18.531	10.500	0.0

1000W HPS - Side View



Scale: 1 : 42

1000W HPS



Clearance height: 12.000 ft, Reflection factors: Ceiling 10.0%, Walls 50.0%, Floor 10.0%, Light loss factor: 1.00

General

	Surface	Result	Average (Target)	Min	Max	Min/average	Min/max
1	1'	Perpendicular illuminance [umol] Height: 2.000 ft	617	518	702	0.84	0.74
2	2'	Perpendicular illuminance [umol] Height: 3.000 ft	667	558	755	0.84	0.74
3	3'	Perpendicular illuminance [umol] Height: 4.000 ft	722	594	809	0.82	0.73
4	4'	Perpendicular illuminance [umol] Height: 5.000 ft	783	643	894	0.82	0.72
5	5'	Perpendicular illuminance [umol] Height: 6.000 ft	851	723	1009	0.85	0.72
6	6'	Perpendicular illuminance [umol] Height: 7.000 ft	924	749	1102	0.81	0.68

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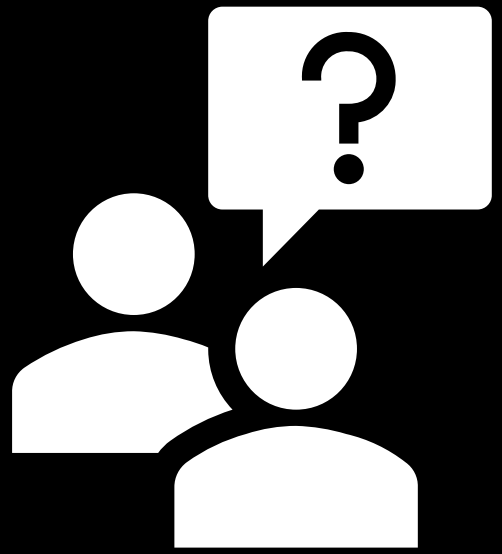

QUESTIONS

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