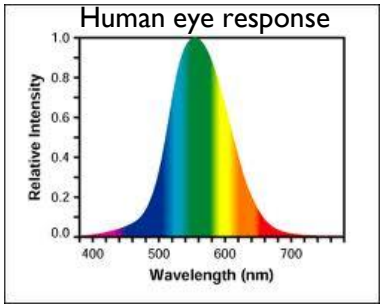
SolarSystem 550

LUMINOUS DATA MEASUREMENTS

CALIFORNIA LIGHTWORKS™

How Do You Measure Grow Light Efficacy?



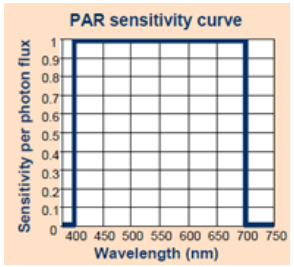
- Lumens, LUX designed for humans
  - Human eye response to the light spectrum peaks around 555nm (green)
  - Plant response is opposite
  - We cannot use Lumens to measure grow light efficacy

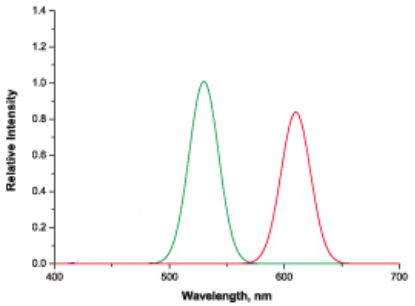
- PAR (photo-synthetically active radiation) is a better metric for grow lights
  - PAR is measured in micro-moles per square meter, per second (uMoles/m^2/s)
  - PAR is calculated using the integral (i.e. area under the curve) of the spectral power distribution curve of a given grow light source

- However….

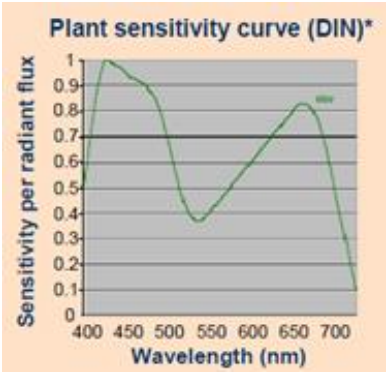
PAR Needs Adjustment

- PAR weights the entire 400nm-700nm spectrum equally
  - But in reality this is not accurate
  - Ex: On the chart to the right, the Green LED has a larger surface area and will get a higher PAR value. But the light form the Red LED will be absorbed at a much higher rate by plants. Green light alone is useless to plants.

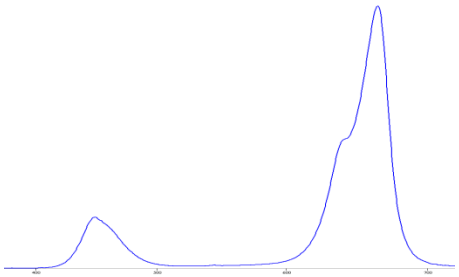




- PAR needs to be adjusted for absorbance. One of the best methods is to use the DIN 5031-10 sensitivity curve
  - The curve shows that green (550nm) is absorbed at a ~40% relative rate (0.4) whereas deep red (660nm) is absorbed at a ~82% relative rate (0.8)



Our Measurement Technique



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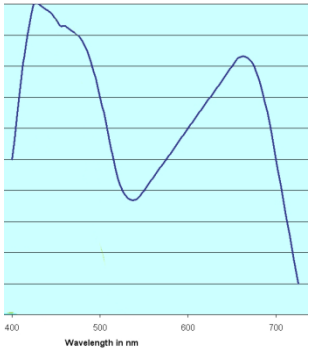

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Adjusted PAR Value

Start with accurate Spectroradiometric measurement curve

Multiply by a DIN 5031-10 derived adjustment curve to adjust for the various absorbance rates

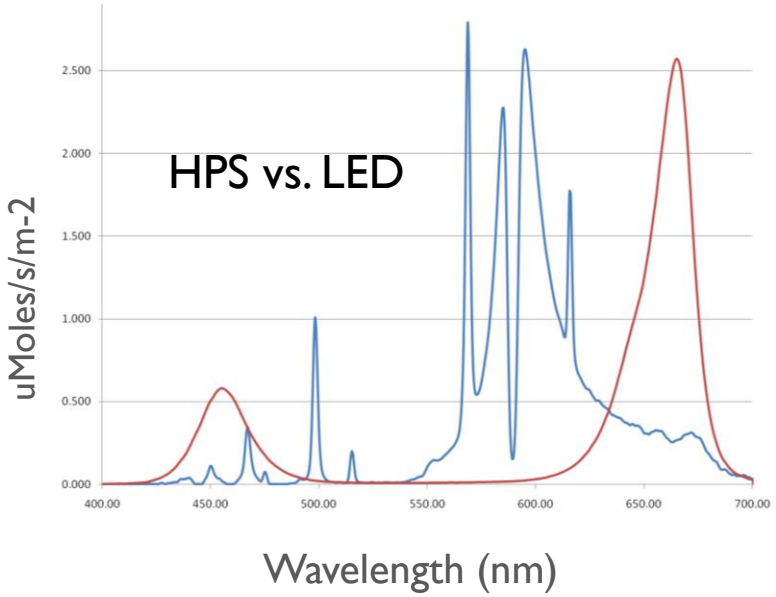
Calculate area under new curve

Ex: SolarStorm 550:

PAR value measured from 12 inch distance = 2,880 uMoles/m^2/s
Adjusted PAR value from 12 inch distance = 3,743 uMoles/m^2/s

Apples to Apples Comparison

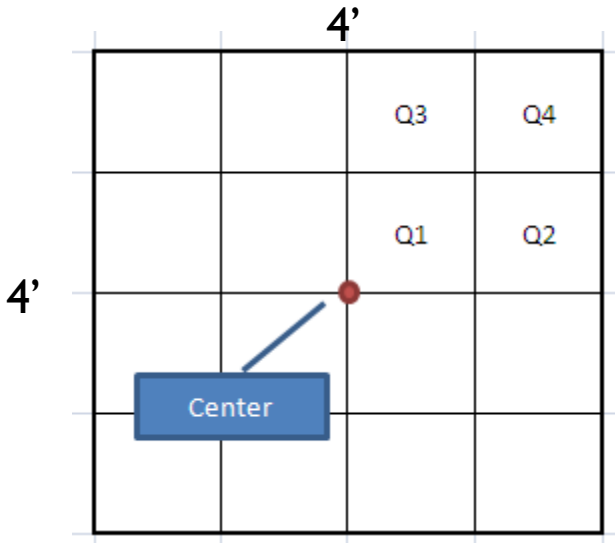
By using our *Adjusted PAR* metric, it's now possible to do a more objective and realistic comparison between HPS grow lights and LED grow lights



The blue and red curves represent HPS and LED spectral distributions respectively. Even though the area under the HPS curve is larger, the *Adjusted PAR* value of the LED will be higher because the power is concentrated in the higher absorbance regions of light spectrum.

Measurement Method

- All light measurements made using high quality Spectroradiometer with NIST traceable calibration
- Fixture consists of a 4’ x 4’ matte black surface
- Light positioned at 4 different heights and measurements are taken:
  - 30”, 24”, 18”, 12”
- Five measurements taken per height level:
  - Center, Q1, Q2, Q3 and Q4
- PAR is calculated using the integral of the spectral distribution curve (400-700nm)
- Adjusted PAR is calculated by multiplying radiant flux by the adjusted DIN5031-10 factor for each wavelength



VS.

SolarSystem 550

600 W HPS

Luminous Output Data Comparison (Values in uMoles/m^2/s)

SolarSystem 550 LED

	32 in Ctr	32 in Q1	32 in Q2	32 in Q3	32 in Q4
PAR	499.48	418.87	251.77	224.22	146.74
Adjusted PAR	651.31	545.96	328.16	292.47	190.89
	24 in Ctr	24 in Q1	24 in Q2	24 in Q3	24 in Q4
PAR	836.92	624.50	271.41	226.09	111.56
Adjusted PAR	1090.29	813.27	353.61	294.74	145.90
	18 in Ctr	18 in Q1	18 in Q2	18 in Q3	18 in Q4
PAR	1431.67	869.29	232.29	164.46	68.48
Adjusted PAR	1864.66	1132.58	302.10	213.78	89.44
	12 in Ctr	12 in Q1	12 in Q2	12 in Q3	12 in Q4
PAR	2879.47	1083.07	124.69	75.03	31.63
Adjusted PAR	3743.45	1412.62	162.49	98.18	41.35

Actual Power Draw at AC Mains: 400 W

600W HPS with a 25"x22"x10" Reflector

	30 in Ctr	30 in Q1	30 in Q2	30 in Q3	30 in Q4
PAR	371.05	306.55	236.40	150.94	125.87
Adjusted PAR	364.04	300.18	231.50	147.61	123.07
	24 in Ctr	24 in Q1	24 in Q2	24 in Q3	24 in Q4
PAR	516.55	405.72	273.57	163.69	121.20
Adjusted PAR	507.68	397.82	268.39	160.30	118.71
	18 in Ctr	18 in Q1	18 in Q2	18 in Q3	18 in Q4
PAR	755.04	522.33	254.71	170.60	103.72
Adjusted PAR	740.44	511.14	248.70	165.99	100.42
	12 in Ctr	12 in Q1	12 in Q2	12 in Q3	12 in Q4
PAR	1182.87	737.01	139.34	134.76	48.35
Adjusted PAR	1154.31	717.44	132.49	127.83	44.92

Actual Power Draw at AC Mains: 658 W

Power Savings: ~40%

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