CANNABIS SUSTAINABILITY SYMPOSIUM

LIGHTING & ENERGY MANAGEMENT

Moderator: Ean Seeb, Denver Relief Consulting
Panelists:
Brian Bennett, Thrive Agritech
Shelly Peterson, urban-gro
Bob Gunn, Seinergy LLC
Efficient Lighting Design

Brian Bennett
CEO, Thrive Agritech
Agenda

- Grow lighting 101
- Efficient lighting design and grow tips
- Thoughts on the future...
A photon is a small “packet” of energy.

Most importantly - it can transfer kinetic energy to matter.

A photon has properties of both a wave and a particle.
What is light?

Light is electromagnetic radiation in the visible (and photosynthetically active) portion of the EM spectrum.
Photon Fact!

* Radio waves can be as long as 62 miles!
<table>
<thead>
<tr>
<th><strong>Term</strong></th>
<th><strong>Abbreviation</strong></th>
<th><strong>Units</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>micro-mole</td>
<td>umole</td>
<td>$10^{17}$th photons</td>
</tr>
<tr>
<td>Photosynthetic Photon Flux (light output)</td>
<td>PPF</td>
<td>umoles / second</td>
</tr>
<tr>
<td>Photosynthetic Photon Flux Density (brightness)</td>
<td>PPFD</td>
<td>umoles / second * meter</td>
</tr>
<tr>
<td>Efficacy (Efficiency)</td>
<td>--</td>
<td>umoles / joule</td>
</tr>
</tbody>
</table>
Lighting Design
Only Photons hitting plants matter
Paint your walls, floors and ceilings white
Uniformity is as important as light levels
What is the future?
What is the future?

- Grow light efficiency will double over the next 10 years!
- Theoretical maximum is 5 umoles/joule (full spectrum)
  - Practical maximum of 4 umoles/joule
Big Data will be a big deal

- Farms, indoor and outdoor are, for the first time, collecting massive amounts of data
- Understanding this data will change how we light our plants
Demand response will be a big deal

- There are 5-days per year where utilities see extra high peak demand.
- 25% of everyone’s entire energy bill is based on building capacity for 40 hours of demand each year.
- Sustainable Cannabis producers have a great opportunity to work with utilities to solve this problem.
Thanks!
Brian Bennett
CEO, Thrive Agritech
Cannabis Cultivation
Creating a Sustainable Industry

Shelly Peterson, Vice President of Sales,
urban-gro
The Bigger Picture

Cannabis cultivation is not sustainable in its current state.

• As margin decreases, production costs will need to decrease as well
• Indoors, electricity can make up over 50% of cost of good sold
• Growers must make a shift to producing a more sustainable/energy efficient product
Energy Use Breakdown of a Commercial Marijuana Grow Facility

- Lighting: 33%
- Ventilation and Dehumidification: 27%
- Air Conditioning: 19%
- Space Heat: 4%
- CO2 Injection: 2%
- Water Handling: 2%
- Drying: 1%
- Vehicles: 12%

*Chart reflects a “central estimate” using a wide range of types and sizes of grow facilities.

Source: Energy and environmental systems analyst, Evan Mills.
Creating a Sustainable Industry

- **Greenhouses**: Treat the crop as an agricultural crop, not industrial.

- **Adjust lighting schedules** to account for peak usage on the grid.

- **Target the correct DLI**.

- Plan and design facilities to **maximize the square footage. Use professional light plans**.
What is DLI?

DLI Measures the total amount of PAR received in a day.

Greenhouse growers can use light meters to measure the number of light photons that accumulate in a square meter over a 24-hour period. In a greenhouse, values seldom exceed 25 mol\(\cdot m^{-2} \cdot d^{-1}\) due to glazing, structure, shadowing.
## Moles vs. µmoles

<table>
<thead>
<tr>
<th>µmoles</th>
<th>12 Hr. Period Moles</th>
<th>18 Hr. Period Moles</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>4.32</td>
<td>6.48</td>
</tr>
<tr>
<td>150</td>
<td>6.48</td>
<td>9.72</td>
</tr>
<tr>
<td>200</td>
<td>8.64</td>
<td>12.96</td>
</tr>
<tr>
<td>250</td>
<td>10.8</td>
<td>16.2</td>
</tr>
<tr>
<td>300</td>
<td>12.96</td>
<td>19.44</td>
</tr>
<tr>
<td>350</td>
<td>15.12</td>
<td>22.68</td>
</tr>
<tr>
<td>400</td>
<td>17.28</td>
<td>25.92</td>
</tr>
<tr>
<td>450</td>
<td>19.44</td>
<td>29.16</td>
</tr>
<tr>
<td>500</td>
<td>21.6</td>
<td>32.4</td>
</tr>
<tr>
<td>550</td>
<td>23.76</td>
<td>35.64</td>
</tr>
<tr>
<td>600</td>
<td>25.92</td>
<td>38.88</td>
</tr>
<tr>
<td>650</td>
<td>28.08</td>
<td>42.12</td>
</tr>
<tr>
<td>700</td>
<td>30.24</td>
<td>45.36</td>
</tr>
<tr>
<td>750</td>
<td>32.4</td>
<td>48.6</td>
</tr>
<tr>
<td>800</td>
<td>34.56</td>
<td>51.84</td>
</tr>
<tr>
<td>850</td>
<td>36.72</td>
<td>55.08</td>
</tr>
<tr>
<td>900</td>
<td>38.88</td>
<td>58.32</td>
</tr>
<tr>
<td>950</td>
<td>41.04</td>
<td>61.56</td>
</tr>
<tr>
<td>1000</td>
<td>43.2</td>
<td>64.8</td>
</tr>
</tbody>
</table>

### Optimal Cannabis Production

**Veg**: 200 – 500 µmoles

**Flower**: 750 – 1,000 µmoles
Average DLI Per State
Efficiency Tactics

Use a professional light meter to measure intensity

Clip fixtures to trusses when possible to minimize shadowing
Sample Light Plan – Hybrid – LED HPS 86x24

Sixty (60) 1,000w HPS fixtures and sixty (60) 320w LED fixtures needed to reach 800 µmoles.

Total wattage: 81,900w
Sample Light Plan – Indoor 86x24 Room DE 1,000w HPS

Eighty-five (85) fixtures needed to reach approximately 800 µmoles

Total wattage: 88,825w – 8% - 12% savings in energy
Sample Light Plan – Indoor 86x24 Room All LED

One hundred seventy-two (172) fixtures needed to reach approximately 800 µmoles

Total wattage: 55,040w – 35% - 40% savings in energy
Greenhouse vs. Warehouse

• Result is a **55% reduction in energy costs** associated with lighting

• **70% reduction in total energy**

• **Creating sustainability** for our industry
Choosing an Energy Efficient Light Fixture

• Evaluate the light conversion efficiency of the fixture

• Just because it says ”LED” doesn’t mean it is efficient for plant growth

• Photon efficiency: HPS: 1.90 µmoles per joule | New LEDs: 2.0 – 2.7 depending on spectrum

• Evaluate the initial capital cost of the fixtures per photon delivered

• The lowest lighting system costs are realized when an efficient fixture is paired with canopy photon capture.
Efficiency of Different Technologies

- **1,000w Metal Halide**: 1.0 μmoles per watt
- **315w CMH**: 1.65 μmoles per watt
- **1,000w Single End HPS**: 1,6 μmoles per watt
- **1,000w DE HPS**: 1.9 μmoles per watt
- **LED**: varies from 2.0 μmoles per watt to 2.7 μmoles per watt
# LED Efficiency vs. DE HPS Efficiency

<table>
<thead>
<tr>
<th></th>
<th>Efficiency (umoles/watt)</th>
<th>Watts per Fixture</th>
<th>Light Output of Fixture</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED</td>
<td>1.5</td>
<td>640</td>
<td>960</td>
<td></td>
</tr>
<tr>
<td>HPS</td>
<td>1.8</td>
<td>1045</td>
<td>1881</td>
<td>*Light Intensity decreases by 50%</td>
</tr>
<tr>
<td>LED</td>
<td>1.8</td>
<td>640</td>
<td>1152</td>
<td>*Light Intensity decreases by 39%</td>
</tr>
<tr>
<td>HPS</td>
<td>1.8</td>
<td>1045</td>
<td>1881</td>
<td></td>
</tr>
<tr>
<td>LED</td>
<td>2.7</td>
<td>640</td>
<td>1728</td>
<td>**Light levels are almost the same and energy savings is 39%</td>
</tr>
<tr>
<td>HPS</td>
<td>1.8</td>
<td>1045</td>
<td>1881</td>
<td></td>
</tr>
</tbody>
</table>
Utility Rebates

- Xcel Energy and other Utility providers have **specific rebate programs** for cultivation sites.

- **Work with a professional** to ensure you are successful in presenting your application.

- Ensure you receive light plans from a vendor **to map the light intensity and uniformity**.
Four Questions to Ask When Evaluating a Light Fixture

• What is the **efficiency of the fixture** measured in µmoles/wattage?

• Am I targeting the **correct intensity for each stage of growth**?

• Is the **spectrum correct for each stage of growth**?

• What is the **cost of the fixture** measured in cost/µmole?
FOR MORE INFORMATION OR FOR A CUSTOMIZED LIGHTING PLAN

Contact Shelly Peterson

720-468-3037 or shelly@urban-gro.com
Where are the Cannabis Utility Programs?

Bob Gunn
Founder + CEO, Seinergy LLC
A $6b market on top of a $20b market on Utility spend on Energy Efficiency.

Source: ACEEE
Where are the Cannabis Energy Incentives?

- 3,000 utilities (per eia.gov)
- All custom jobs
- No baseline published
- No code regulations
- Lack:
  - precedent
  - standards
  - qualified product list

https://seinergy.org/where-are-cannabis-energy-rebates-available/
## Estimating Savings – Different for every utility

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Efficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>kW Installed</td>
<td>Negotiable</td>
<td>Known</td>
</tr>
<tr>
<td>Annual runtime</td>
<td>Same</td>
<td>Same – except for controls</td>
</tr>
<tr>
<td>HVAC Interaction</td>
<td>TBD</td>
<td>TBD</td>
</tr>
<tr>
<td>Coincidence with Peak</td>
<td>Known</td>
<td>Known</td>
</tr>
<tr>
<td>Cost</td>
<td>Negotiable</td>
<td>Known</td>
</tr>
</tbody>
</table>
## Example Project - Inputs

**Retrofit**
100 HPS with 100 LEDs

**Total Cost**
$130,000/$1,300 ea

**Rebate**
TBD

<table>
<thead>
<tr>
<th>Effcient Case</th>
<th>Veg</th>
<th>Flower</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Lights</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Hours/day</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Baseline Wattage</td>
<td>1,090</td>
<td>1,090</td>
</tr>
<tr>
<td>Efficient Wattage</td>
<td>400</td>
<td>600</td>
</tr>
<tr>
<td>Savings, kW</td>
<td>20.7</td>
<td>34.3</td>
</tr>
<tr>
<td>Savings/yr, kWh</td>
<td>135,999</td>
<td>150,234</td>
</tr>
</tbody>
</table>
Example Project - Results

Same Project, Different Results

- Cleveland
- Denver
- Seattle
- Oakland

$0  $20,000  $40,000  $60,000  $80,000
1) Lumens are for humans, 2) Existing tools don’t work
3) Need for standards, 4) Application matters

Source: blackdogled.com
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