

You Don't Have to Grow It Alone!

Cultivating Plants and Load the Efficient Way

Emily Backus
Dave Bisbee
Bryan Jungers
John Morris
Eric Stern



E Source

E Source Forum 2018

Agenda

Introduction

Why grow plants indoors?

Developments in lighting

Moving beyond lighting

Benefiting utilities and customers

Q&A

Today's speakers



Bryan Jungers
Lead Analyst, Customer Energy
Solutions, E Source



John Morris
Vice President of Market
Development, D+R International



Dave Bisbee
R&D Research Manager,
Sacramento Municipal Utility
District



Eric Stern
Co-Founder & Managing Partner,
Cultivate Energy Optimization



Emily Backus
Sustainability Advisor, City and
County of Denver



Introduction

Is “indoor agriculture” code for cannabis?



Reaching Customers Who Operate Indoor Agriculture Facilities



Harvesting Energy Savings in Indoor Agriculture Facilities



Budding Opportunities for Energy Efficiency in Indoor Agriculture

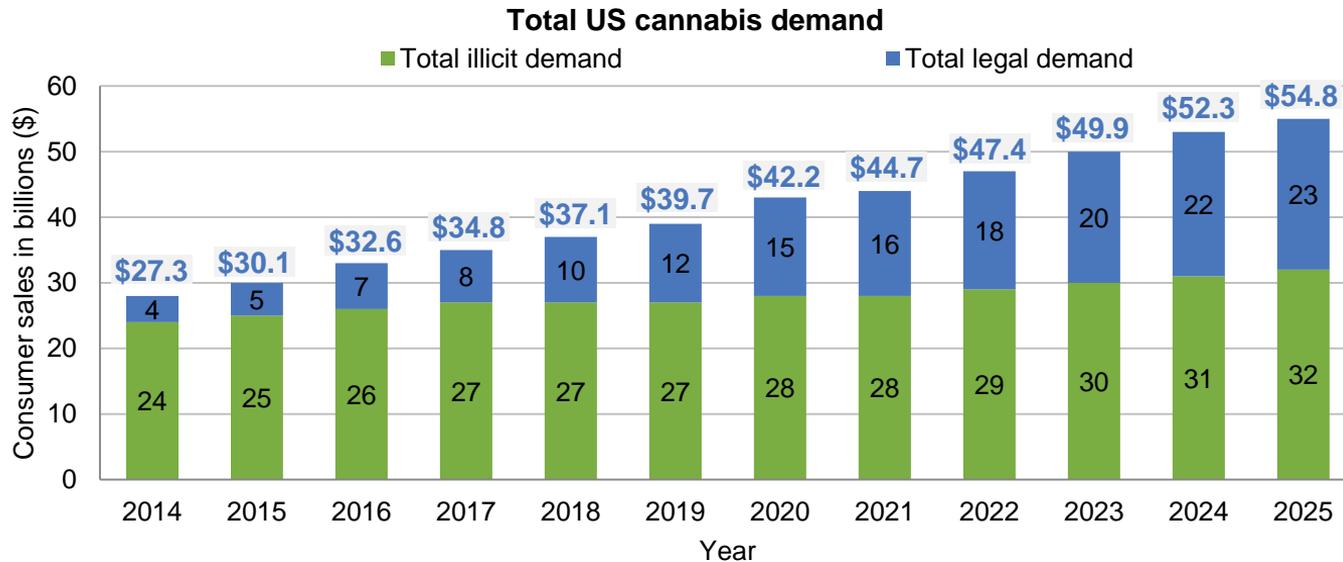
A new class of hard-to-reach customers

REGION	ENVIRONMENT	GROW AREA	EXPERIENCE	MOTIVATION
 <p>Northern California</p>	 <p>Large residential building, rural neighborhood; half indoor, half outdoor</p>	 <p>About 5,000 ft²  = 5,000 square feet (ft²)</p>	 <p>About 10 years in black market operations</p>	 <p>Stay competitive in spite of shifting market dynamics</p>

© E Source ([Indoor Agriculture Customer Type: Small Indoor-Outdoor Grower](#))

Illicit demand is three-fourths of total market

With most states only allowing restricted medical use and other regulatory factors, including high tax rates and regional cannabis business bans limiting consumer participation, there will remain an illicit market for the foreseeable future.



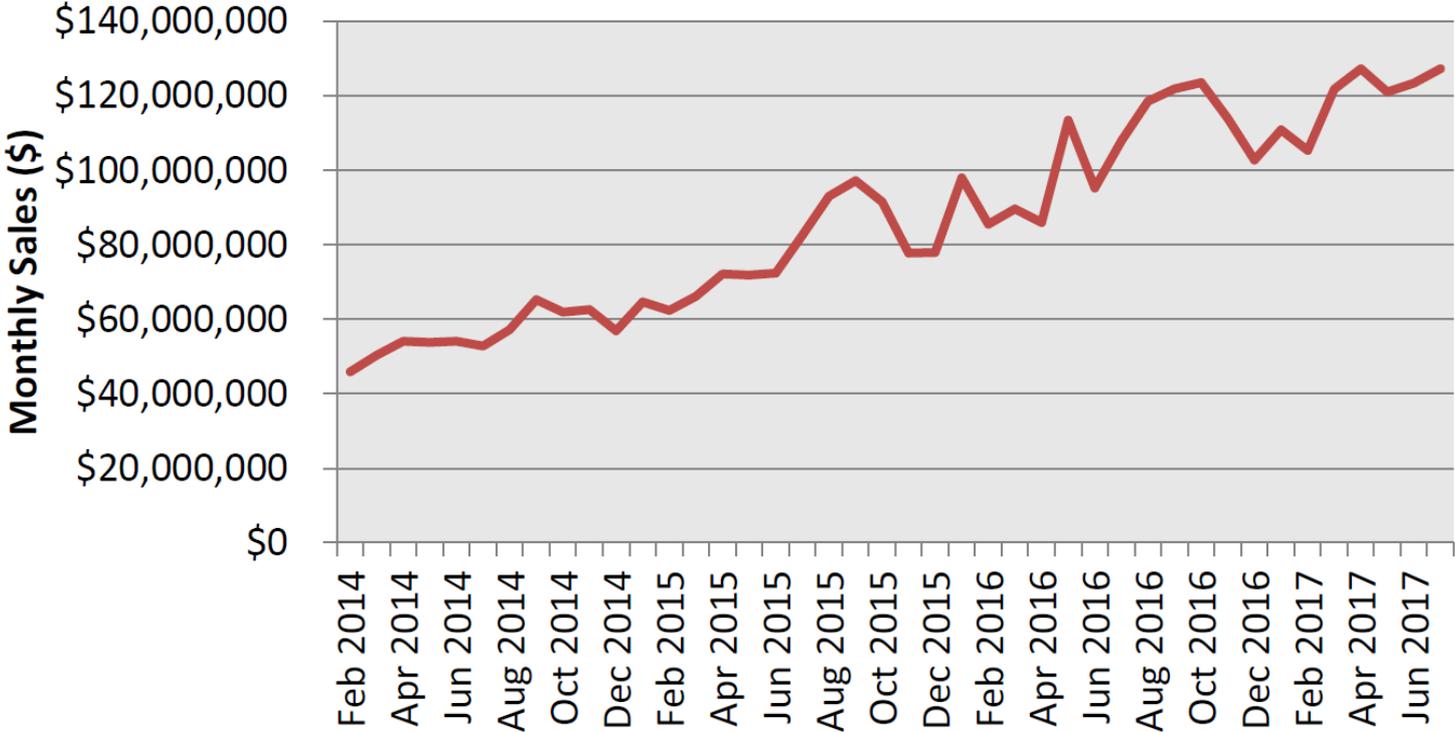
Change in share of market

2018
Legal: 27%
Illicit: 73%

2025
Legal: 42%
Illicit: 58%

© E Source: data from New Frontier

Colorado marijuana sales

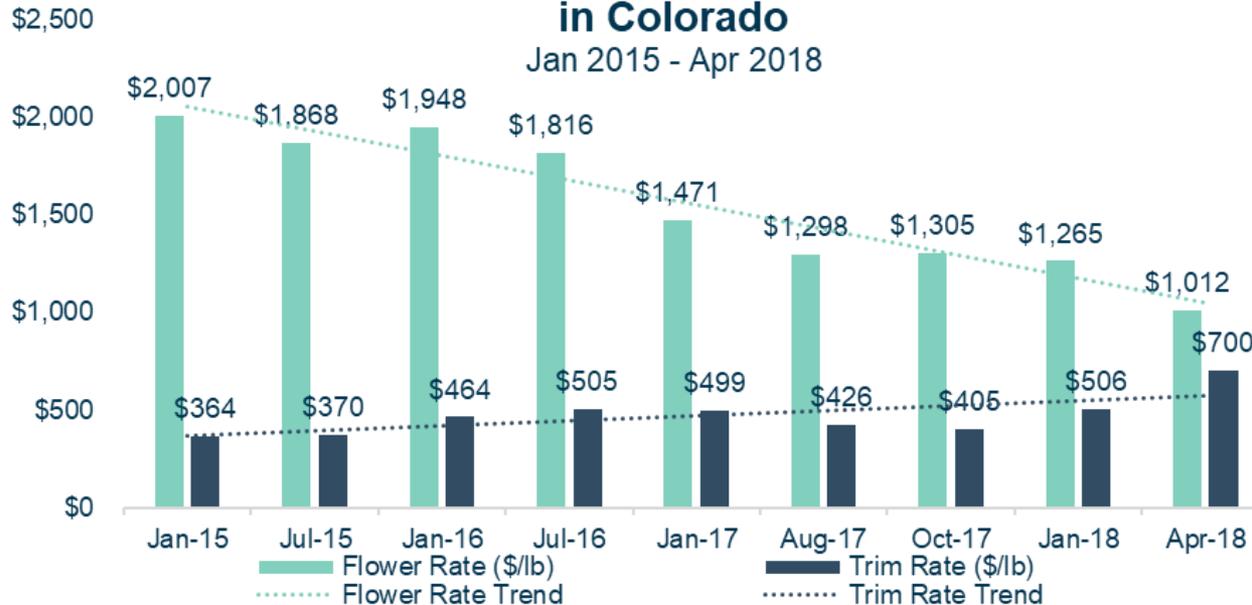


Source: [Taking Efficiency to a Higher Level](#), Neil Kolwey, Southwest Energy Efficiency Project (2017)

Colorado is facing declining prices as well. This will impact the number of suppliers in the market as well as energy consumption patterns

Average Market Rate Per Pound for Flower & Trim in Colorado

Jan 2015 - Apr 2018



Source: Colorado Marijuana Enforcement Division

-50%
Flower
Decrease

+92%
Trim
Increase

Source: New Frontier

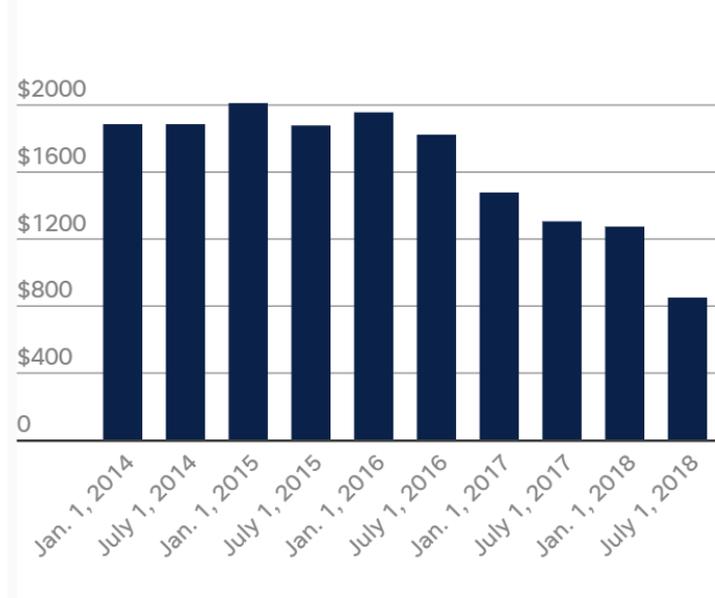


All conversations must start with a cannabis business discussion; energy will follow

Beginning engagement with each cultivation customer by discussing the following will ultimately lead to an energy management discussion:

- Current price of flower
- Licensing and compliance challenges
- Identifying key staff/head growers and what they are working on
- Business objectives and how they fit into the cannabis market
- Key operating procedures and why they are set up a certain way
- Plans for equipment upgrades and future expansion

Price per pound of marijuana bud in Colorado



Average prices are determined by the average transaction in the months leading up to the listed dates. *Source: Colorado Department of Revenue*

Industry's Use Is No Surprise/Secret

Marijuana Grow Ops Could Soon Rival Data Center Energy Use

Forget about electric vehicles; pot is driving new energy peaks in the states where it is legal.

KATHERINE TWEED | SEPTEMBER 27, 2016

The Washington Times

HOME NEWS - OPINION - SPORTS - MARKET - SUBSCRIBE -



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Environmentalists alarmed at marijuana industry's massive use of carbon-based electricity

Nearly 4 Percent Of Denver's Electricity Is Now Devoted To Marijuana

BY GRACE HOOD | GRACE.HOOD@CPR.ORG
FEB 19, 2018

Massachusetts sets new rules that limit energy use by marijuana growers

Published March 9, 2018

123
SHARES



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Massachusetts' marijuana industry is up in arms over new regulations designed to [limit the amount of electricity](#) that growers can use.

According to The Boston Globe, the Cannabis Control Commission's [final rules](#) for the recreational marijuana industry cap electricity use at 36 watts per square foot of cultivation space.

Energy intensity of indoor grows

- Energy is approximately 20% to 50% of operating costs
- These facilities are 10 times more energy intensive than office buildings
- This represents about 1% of total electricity use in Colorado

Source: [Taking Efficiency to a Higher Level](#), Neil Kolwey, Southwest Energy Efficiency Project (2017)

Efficiency will become a key factor for business success in increasingly competitive markets

CANNABIS: THE NEXT EFFICIENCY OPPORTUNITY



WHAT HAS NOT HAPPENED IN THE CANNABIS SECTOR

- Pilot programs customized for cannabis growers
- Baseline studies that are segmented by building type
- Significant uptake on LED lights at a national level
- Increase in awareness for growers of the energy impacts of grows
- Increased education for growers on how to navigate utility hook up processes
- Growers deploying Microgrid applications

Cannabis is a convergent opportunity

CEA (vertical farms, urban farms)



Private Investment



Source: The Resource Innovation Institute

Global agriculture problems



Rapid population growth & urbanization

Expected 10 billion people globally and 75% urban population by 2050
Increasing demand for food by 70% (United Nations FAO, 2017)



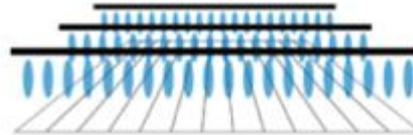
Food transport

Leads to significant food waste
and greenhouse gas emissions



Pesticide use

Leads to 75% of world
polluted water



Freshwater use

80% of all freshwater is used
in agriculture



Global warming

Threatens global food supply
Accelerate Soil Erosion

Source: BlueHouse

Benefits of controlled environment ag



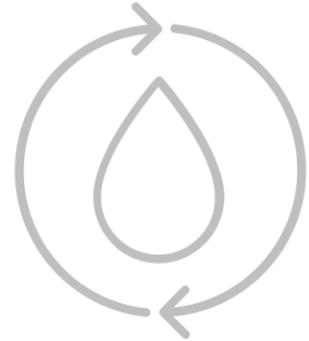
Economic

- Year-round production independent of:
 - Climate,
 - Region
 - Weather events
 - Pest outbreaks
- 2 to 3x faster growth
- Efficient land use



Food quality

- Locally grown, fresher greens for consumer
- No heavy metals or herbicides
- Limited or no pesticide
- High vitamin and mineral content
- Optimized food safety



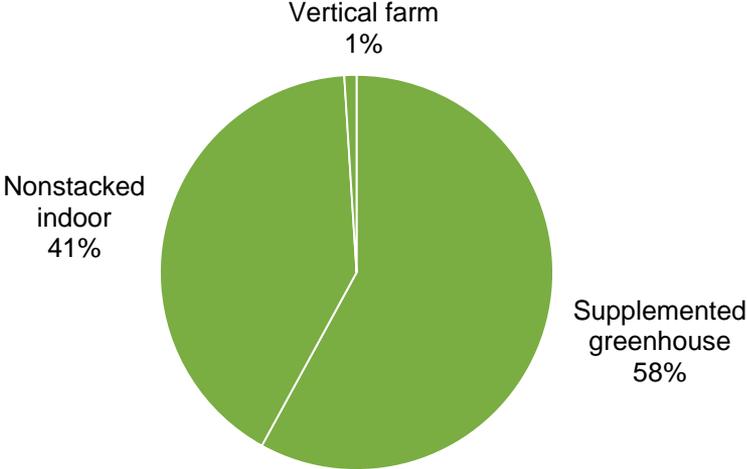
Environmental

- Up to 99% less water used
- Less food waste
- Less food miles

Source: BlueHouse

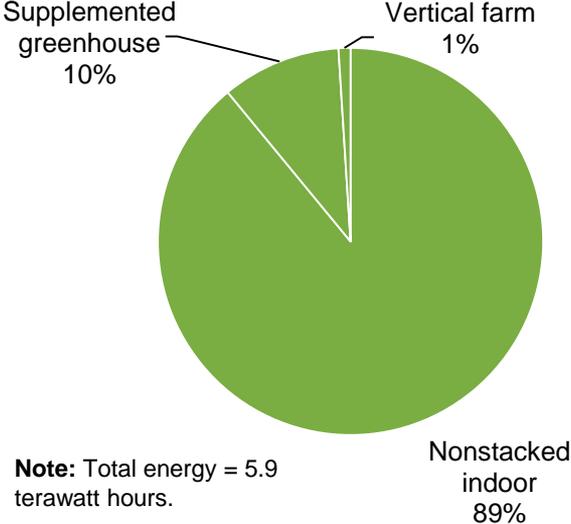
Indoor agriculture is large and growing

Size of indoor agriculture grow area by type



Note: Total area = 46 million square feet.

Energy consumption of indoor agriculture grow area by type



Note: Total energy = 5.9 terawatt hours.

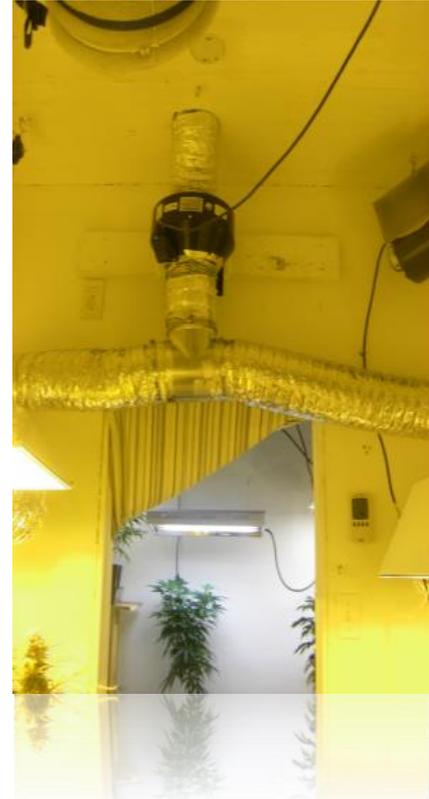
© E Source; data from [Energy Savings Potential of SSL in Horticultural Applications](#) (PDF), US Department of Energy (2017)

Vertical farming yields are greater than field yields

Crops	Vertical farming yield due to tech (tons/hectare)	Field yield (tons/hectare)	Factor increase	Vertical farming yield with tech and stacking (tons/hectare)
Carrots	58	30	1.9	347
Radishes	23	15	1.5	829
Potatoes	150	28	5.4	552
Tomatoes	155	45	3.4	548
Peppers	133	30	4.4	704
Strawberries	69	30	2.3	368
Peas	9	6	1.5	283
Cabbage	67	50	1.3	215
Lettuce	37	25	1.5	708
Spinach	22	12	1.8	820
Total (average)	71	28	2.5	516

© E Source; data from [Up, Up, and Away! The Economics of Vertical Farming](#) (PDF), Chirantan Banerjee, GIZ (2013)

RESIDENTIAL GROW OPERATIONS



INDUSTRY BLIND SPOT



FULLY AUTOMATED GROW TRAILERS

*All trailer photos taken at the
offices of Grotec Builders*



HOOP HOUSE



“MIDSIZE”
COMMERCIAL
GROW
FACILITIES-
DENVER



LARGE
INDUSTRIAL
SCALE GROWS-
WA



SUPER SIZE
INDUSTRIAL
GROW FACILITIES-
OR

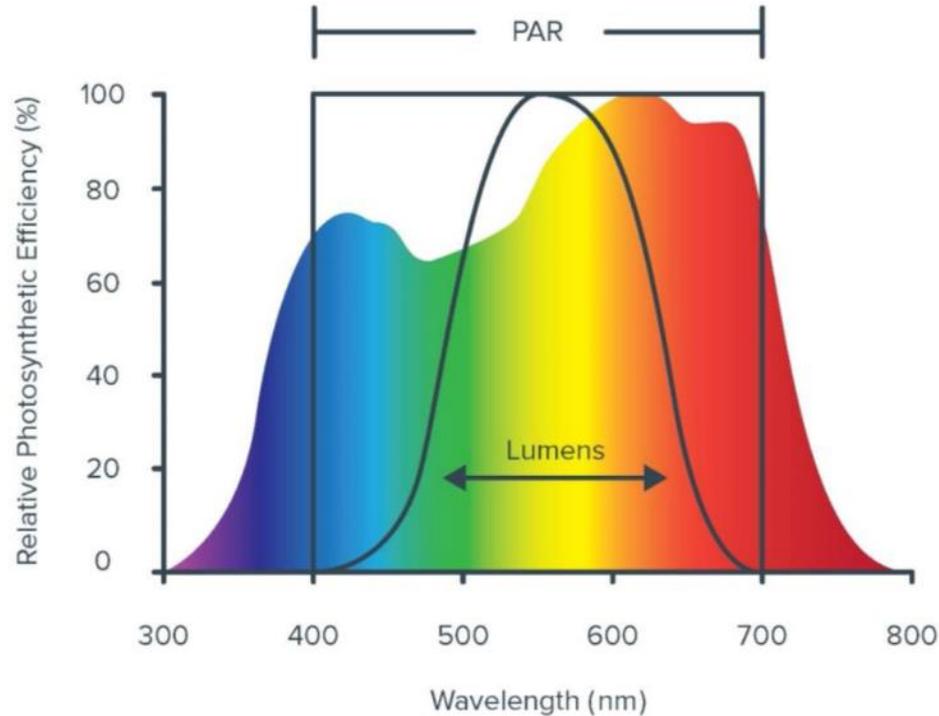


State of the Art Marijuana Production Facility

Lighting 101

Photopic Vision

- Lumens
- Lux / Foot-Candles
- Lumens / Watt



Horticulture

- PPF
- PPFD
- $\mu\text{mol} / \text{J}$
- DLI (mainly greenhouses)

Lighting 101

TYPICAL PPFD REQUIREMENTS

Lighting Application	PPFD ($\mu\text{mol}/\text{m}^2/\text{s}$)	Foot-candle (lumen/ ft^2)	LUX (lumen/ m^2)
Office Space	6 - 10	30 - 50	324 - 540
Lettuce	200 - 300	1002 - 1503	10,800 - 16,200
Herbs	300 - 500	1503 - 2505	16,200 - 27,000
Tomatoes	500 - 700	2505 - 3507	27,000 - 37,800
Cannabis	700 - 900	3507 - 4509	37,800 - 48,600

* Conversion factors based on the spectrum of sunlight

Significant lighting savings potential

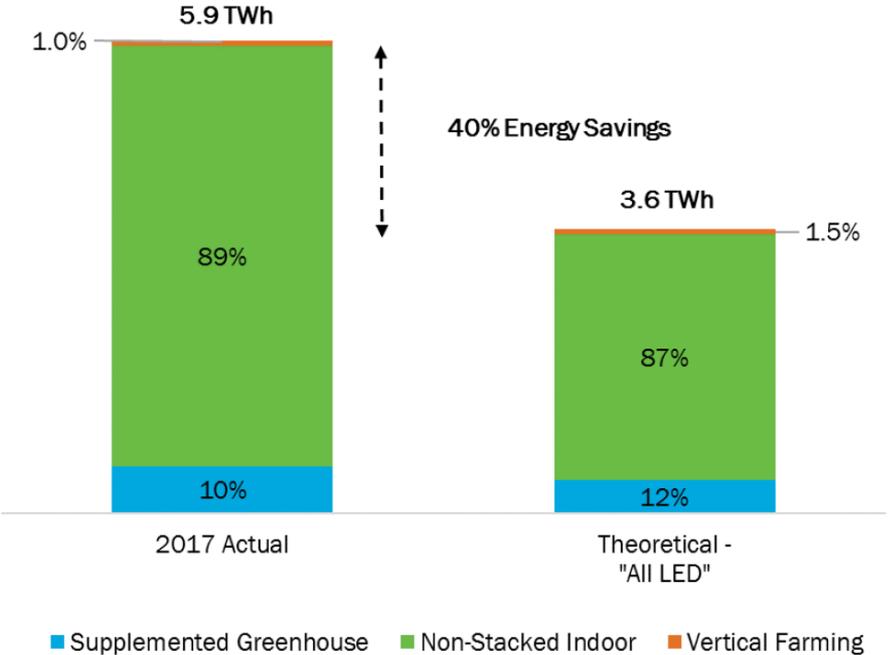


Figure E.2 2017 Annual Energy Consumption (TWh) of U.S. Horticultural Lighting

Source: [Energy Savings Potential of SSL in Horticultural Applications](#) (PDF), US Department of Energy (2017)

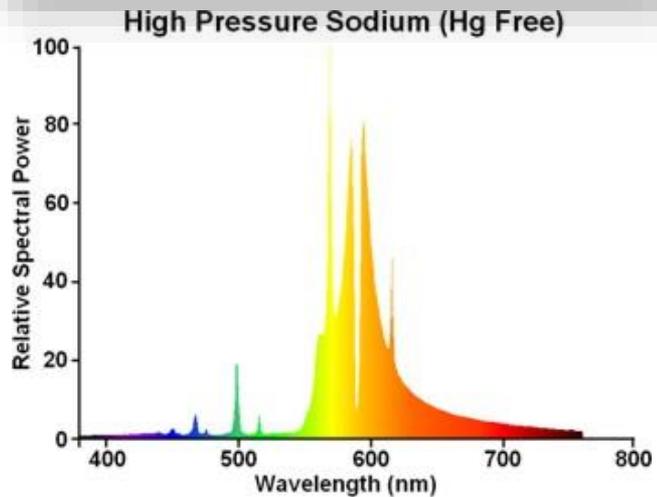
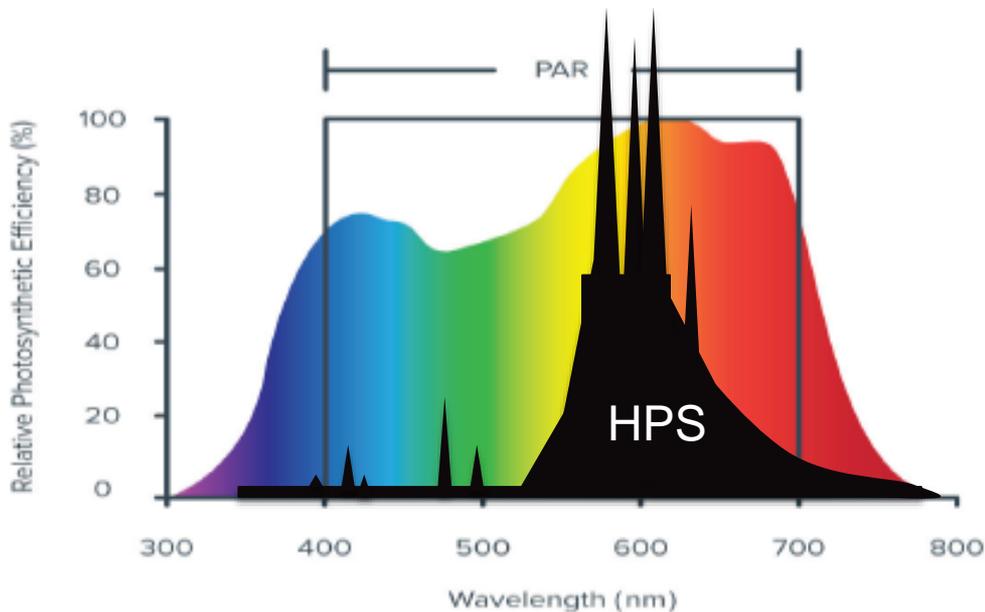


Baseline lighting tech for horticulture

Luminaire type	Brand	Lamp	Rated lamp life (hours)	Lamp cost (\$)	Rated reflector life (hours)	Reflector cost (\$)
1,000 watts high pressure sodium (HPS)	Gavita	Gavita ProPlus 1000 W double-ended HPS	5,000	135	10,000	53
1,000 watts HPS	P.L. Light Systems	Ushio HiLux Gro Super HPS with optimized blue and red spectrum	10,000	120	10,000	40
1,000 watts metal halide (MH)	P.L. Light Systems	Ushio HiLux Gro Super MH with optimized blue and red spectrum	10,000	120	10,000	110
600 watts HPS	P.L. Light Systems	SON-T PIA	12,000	32	10,000	40

© E Source; data from [LED and HID Horticultural Luminaire Testing Report](#) (PDF), Leora C. Tadetsky, Lighting Research Center (2018)

HPS lighting (basecase)



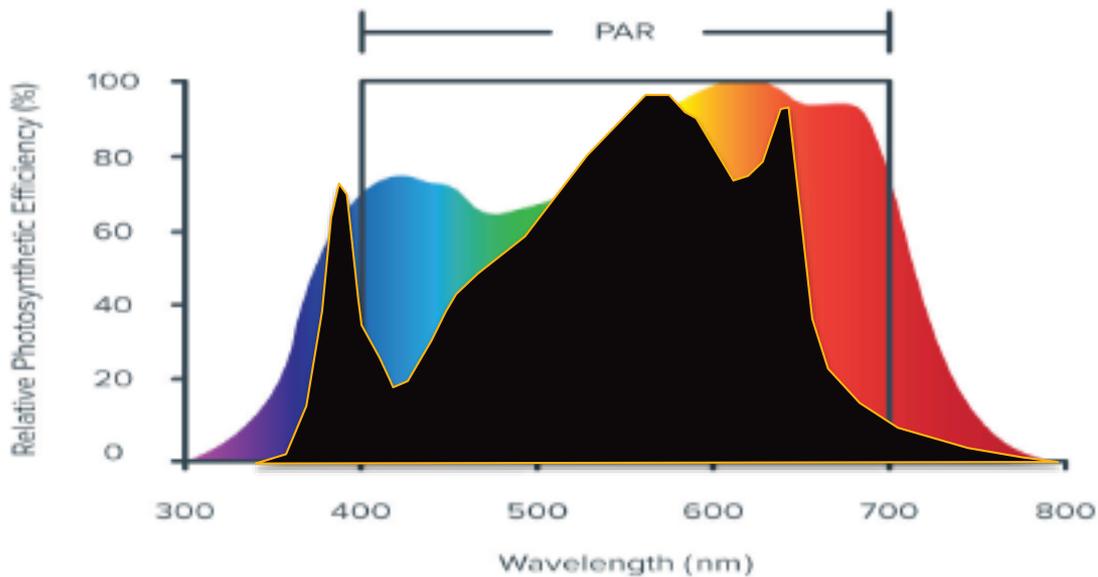
Cheapest LEDs are 3 times HPS, MH per watt

Brand	Type	Rated (W)	Unit price (\$)	Price per watt (\$/W)
Gavita	HPS	1000	540	0.54
PL Light Systems	HPS	1000	525	0.53
PL Light Systems	MH	1000	569	0.57
GE	LED	31	245	7.90
Heliospectra	LED	630	2,400	3.81
Hubbell Inc.	LED	425	911	2.14
Illumitex	LED	63	383	6.08
Illumitex	LED	300	834	2.78
LumiGrow	LED	300	1,100	3.67
Osram	LED	600	1,800	3.00
Philips	LED	200	955	4.78
PL Light Systems	LED	320	1,186	3.71
Sunlight Supply	LED	450	765	1.70

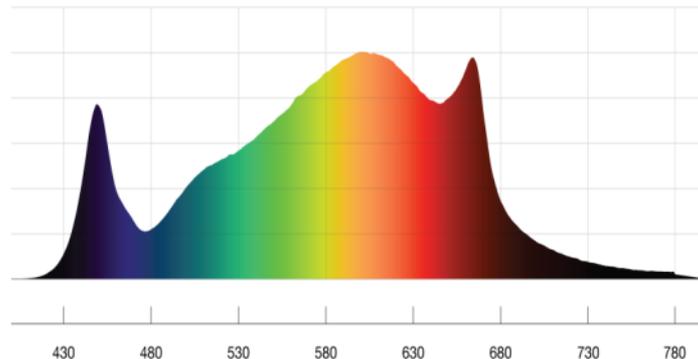
Notes: HPS = high pressure sodium; MH = metal halide; W = watt.

© E Source; data from [LED and HID Horticultural Luminaire Testing Report](#) (PDF),
Leora C. Tadetsky, Lighting Research Center (2018)

Amplified Farms LED

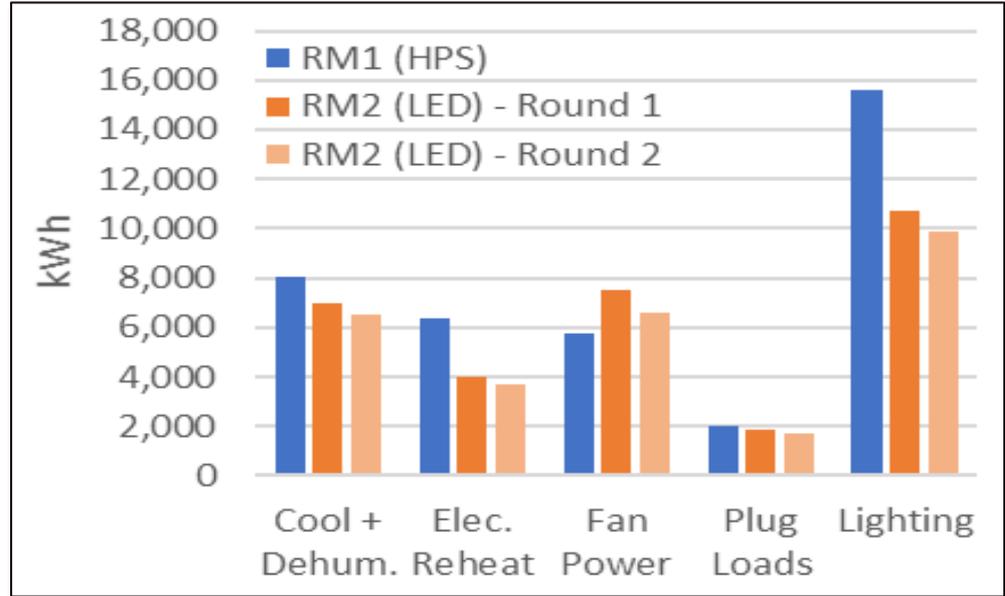


21 Fluence SPYDRx Plus Fixtures



Amplified Farms: energy consumption

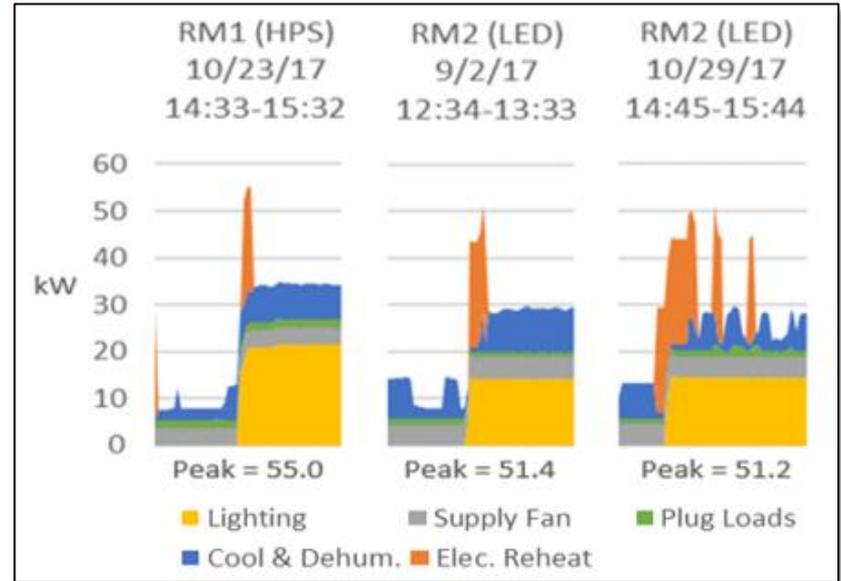
Total energy savings:
7,628 kWh / flowering
cycle (20% reduction)



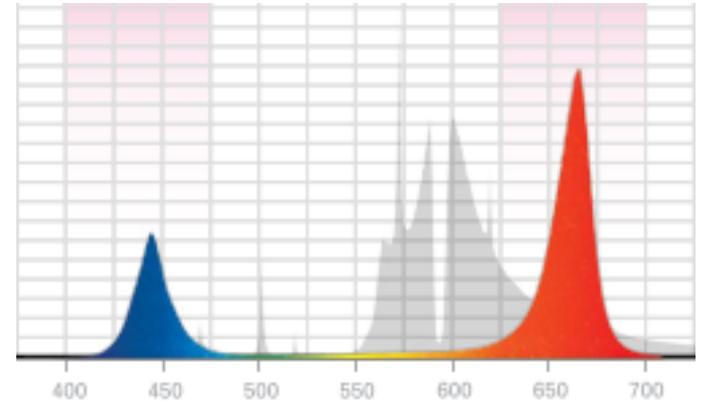
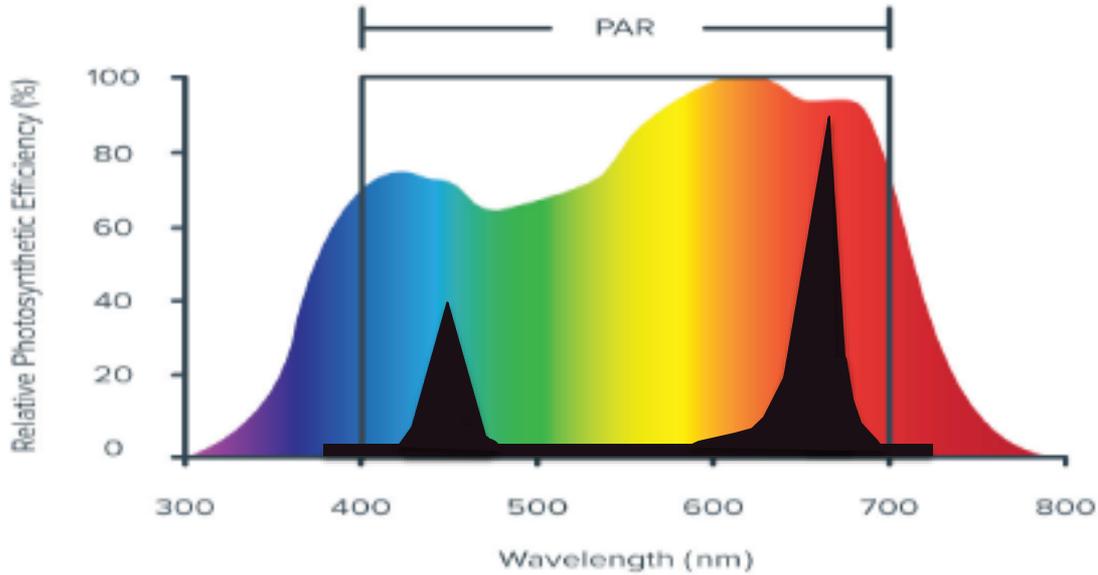
Amplified Farms: electrical demand

Lighting demand was 33% lower yet the overall demand reduction was **only around 3%**.

Why?



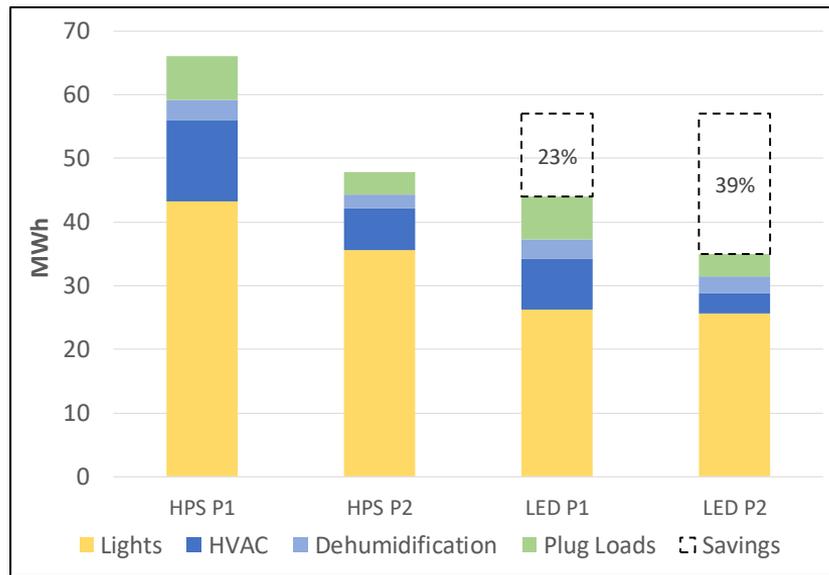
Seven Leaves LED



49 LumiGrow Pro 650e Fixtures

Seven Leaves: energy consumption

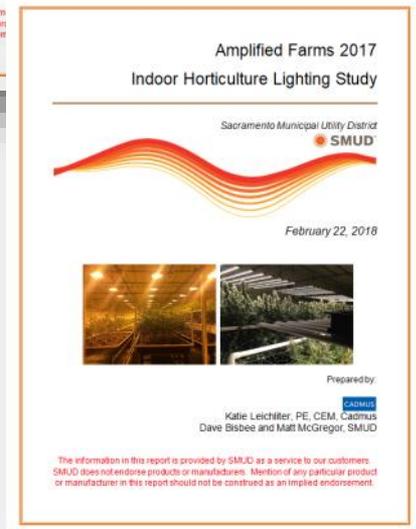
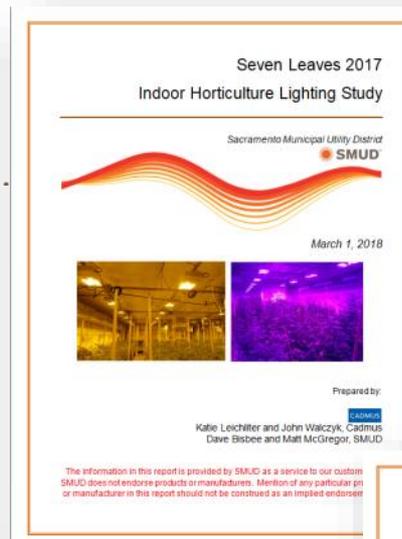
- Lighting energy savings was 36%
- Overall HVAC system usage was 37.5% lower
- Plug loads were 10.5% higher
- Overall energy savings was 30.3% (17,720 kWh / cycle)



SMUD reports

Full reports for these projects are available for download via the Customer Advanced Technologies Program webpage:

<https://www.smud.org/en/Business-Solutions-and-Rebates/Business-Rebates/Advanced-Tech-Solutions>

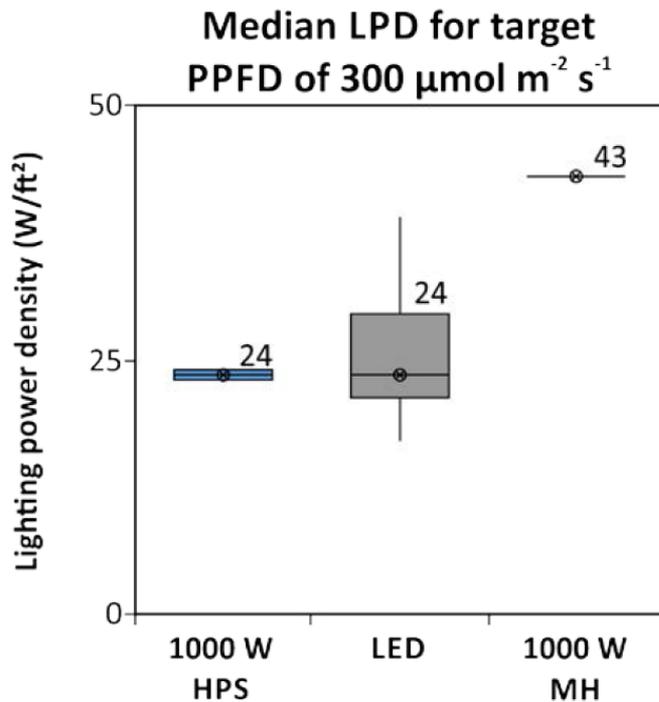
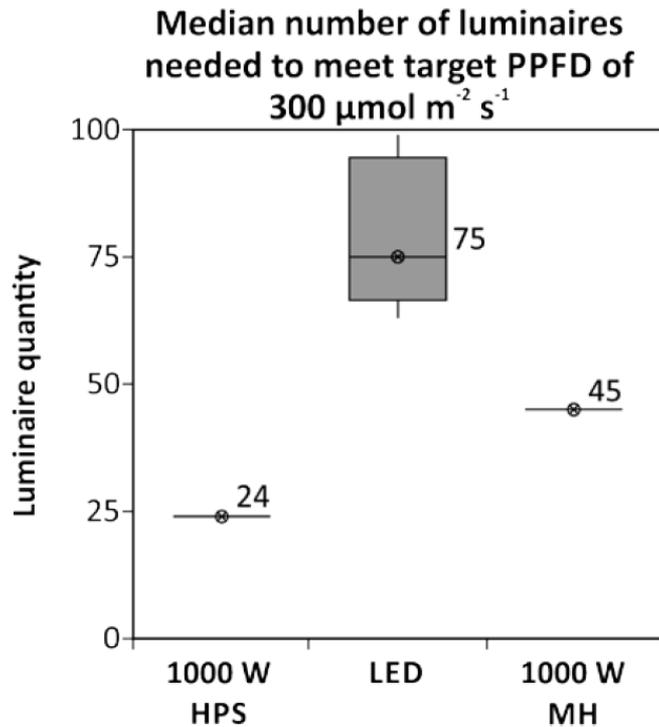


Lighting performance circa 2014

Lighting performance metric	LED	Double-ended high pressure sodium	Standard high pressure sodium	Ceramic metal halide
Photon efficiency (micromoles per Joule)	1.7	1.7	1	1.46
Fixture cost per unit of useful light	\$1.84	\$0.32	\$0.25	\$1.12

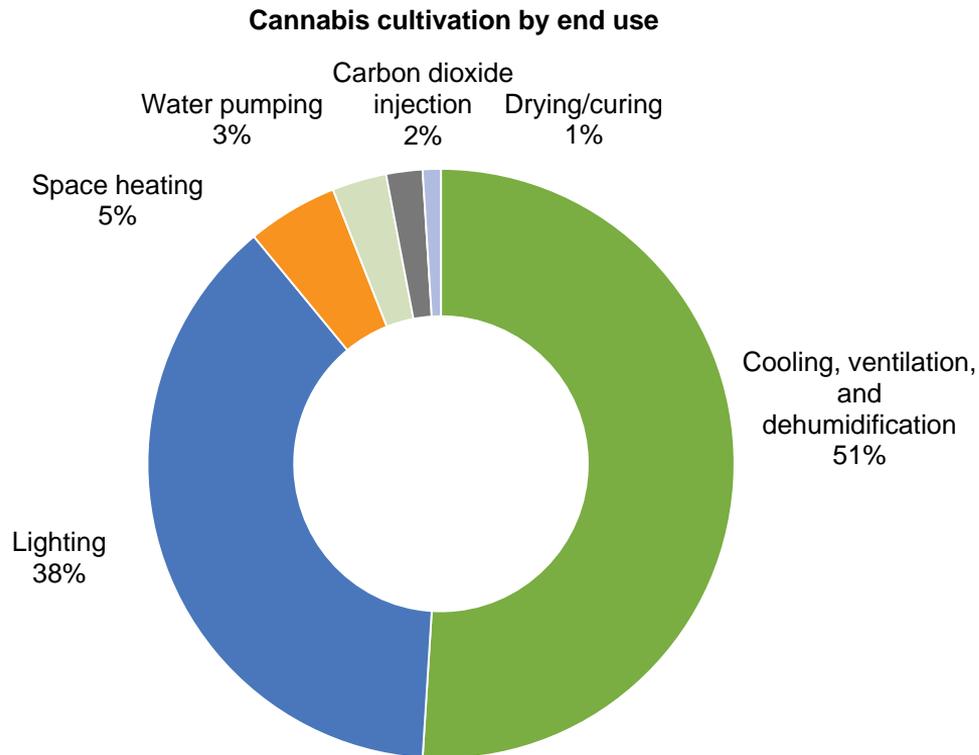
© E Source; data from [Economic Analysis of Greenhouse Lighting: Light Emitting Diodes vs. High Intensity Discharge Fixtures](#), Jacob Nelson, Bruce Bugbee, Utah State University (2014)

Lighting performance circa 2018

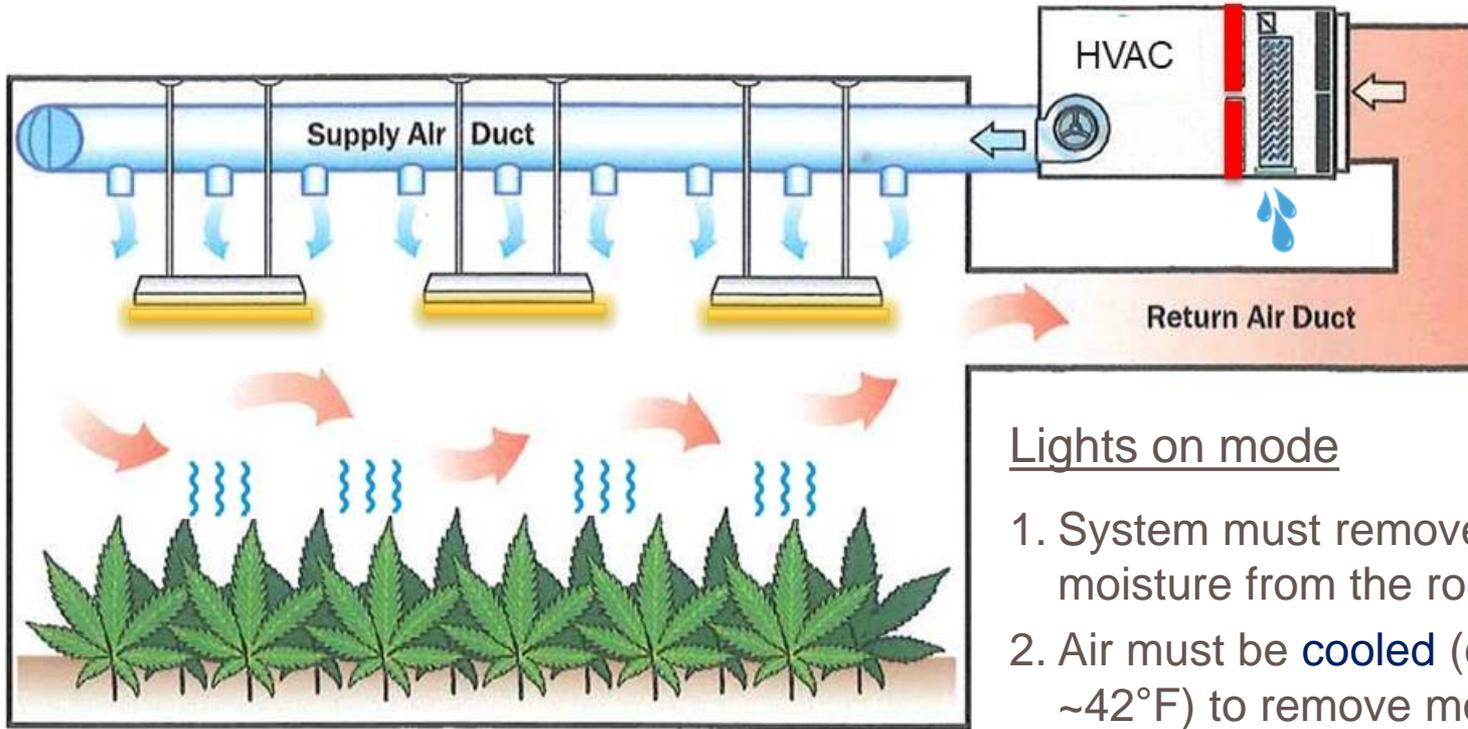


Source: [LED and HID Horticultural Luminaire Testing Report](#) (PDF), Leora C. Tadetsky, Lighting Research Center (2018)

Largest piece of the pie is untouched



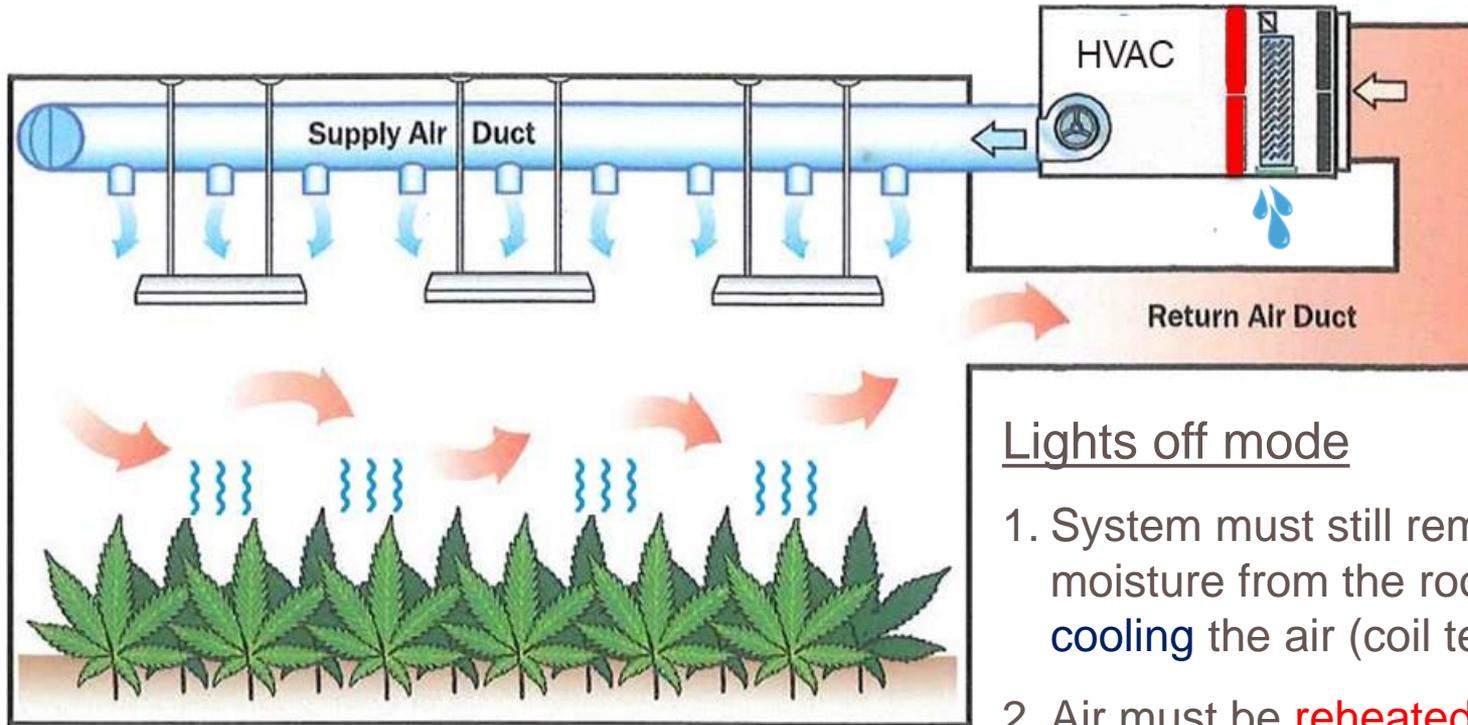
© E Source; data from [A Budding Opportunity: Energy Efficiency Best Practices for Cannabis Grow Operations](#) (PDF), Neil Kolwey, SWEEP (2017)



Graphic used with permission from the DesertAire Corporation

Lights on mode

1. System must remove heat & moisture from the room.
2. Air must be **cooled** (coil temp ~42°F) to remove moisture.
3. Air must be **reheated** to prevent overcooling room. This can be done with hot gas reclaim and/or electric resistance heat strips.



Lights off mode

1. System must still remove moisture from the room by **cooling** the air (coil temp $\sim 42^{\circ}\text{F}$).
2. Air must be **reheated** to prevent overcooling room. **More reheat** is necessary since the lights are off.

Graphic used with permission from the DesertAire Corporation

Few HVAC projects so far

Utility	Lighting projects	HVAC projects	Energy savings (gigawatt hours)
Energy Trust of Oregon	55	0	7.8
Puget Sound Energy	70	1	35 to 40
Tacoma Power	1	4	1.3
Xcel Energy (CO)	1/30/1900	1/0/1900	No data

© E Source; data from [A Budding Opportunity: Energy Efficiency Best Practices for Cannabis Grow Operations](#) (PDF), Neil Kolwey, SWEEP (2017)

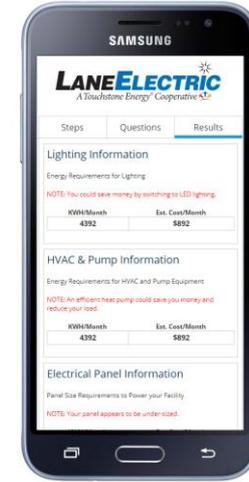
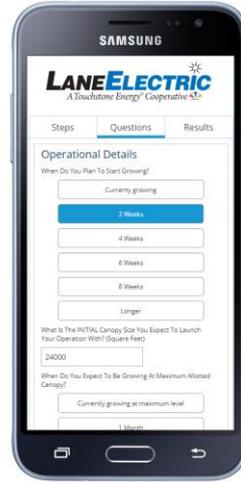
ENERGY
ASSESSMENTS
FOR RURAL
PROPERTY



UTILITY FIELD TOOL ASSESSMENT

UTILITY FIELD TOOL RESULTS

UTILITY LINE EXTENSION TOOL



Understanding, Confidentiality & Trust is Critical

- You can't walk on-site "cold". You must be a known entity in the cannabis industry and be able to access ownership directly prior to engaging or arriving
- You must offer to and sign confidentiality agreements, NDAs, etc. if you're going to work directly in or with cultivation facilities
- Before visiting a facility, the visitor should understand and follow site protocols, regulations and rules related to compliance



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Trade Partners Matter

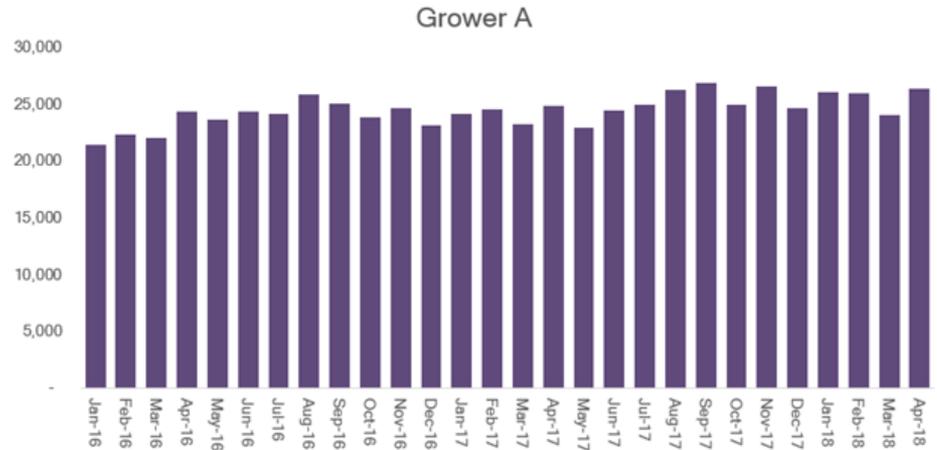
- Traditional lighting, HVAC and other existing trade partner networks often do not have the specialized horticulture products and services needed by cultivation customers
- We have found that creating a new list of vetted and qualified trades partners with specific cannabis qualifications is needed

IDENTIFY THE
RIGHT EE
CHAMPION



Cultivation Facilities Offer “Good Load” & Can Indeed Be Managed

- Usually very consistent month to month during the year
- Load factors typically sit between 80% and 90%
- Annual electric peaks in winter are not uncommon for cultivation sites
- A frequent misconception is that cultivation facility energy use cannot be strategically managed



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The Cultivation Industry Will Engage on Energy Management Discussions

- Key is to create very specific and custom value propositions/offers
- The cannabis industry wants help from their utility; they need help from their utility
- In general, the industry does not understand or is aware of DSM and they do not seek it out
- We must go to them, they have not and will not come to us
- Every 2018 program has sold-out or over-subscribed in the first few weeks



Program Enrollment Form

2018 Energy Insights Program For Eligible Licensed Cannabis Cultivation Businesses

[REDACTED] understands that providing affordable and reliable electricity is critical to its business account-holders, especially licensed cannabis cultivation companies. [REDACTED] be offering a voluntary and FREE energy insights program to interested and eligible licensed cannabis cultivation businesses in 2018. The program will provide participants with a personalized and confidential on-site technical assessment and report, energy use analysis and benchmark insights; displaying when, where and how they use electricity in their current cultivation operations. Participants will also be presented with rebate opportunities for future equipment upgrade opportunities. Participants are under no obligation to make improvements or changes at any time. The program is strictly an informational service offering intended to help businesses understand their current energy use. Program services are provided at no cost to licensed cannabis cultivation businesses by Cultivate Energy Optimization, LLC.

Program Services To Be Provided To Participating Licensed Cannabis Cultivators At No Cost

- A confidential on-site equipment energy use assessment for your facility.
- A presentation of energy use against production trends and other metrics.
- The option to utilize an energy data logger if desired to track circuit level energy use.
- A customized list of equipment upgrades and available rebates for consideration.

Program Timelines

- Completed Program Enrollment Forms submitted by **July 20, 2018**.
- Onsite equipment assessments performed **July 23, 2018 - August 31, 2018**.
- Reports/presentations provided to participants by **October 1, 2018 - November 30, 2018**.

Program Eligibility Criteria

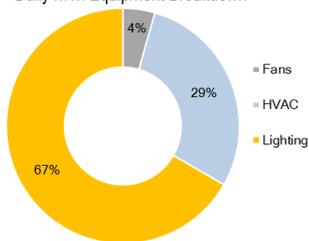
- Be an active cannabis cultivation facility holding all required state and local licenses.
- Be a current [REDACTED] business customer receiving electric services.

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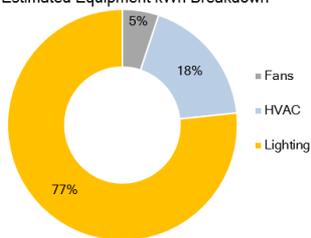
Every cultivation facility is different, every business is unique, every upgrade is custom

- No two cannabis cultivators are alike in our experience
- Use can vary by building type, climate, operating procedures, plant quantity and type, etc.
- Within the same facility, energy use varies dramatically by room

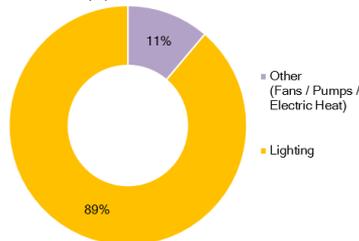
Grower A
Daily kWh Equipment Breakdown



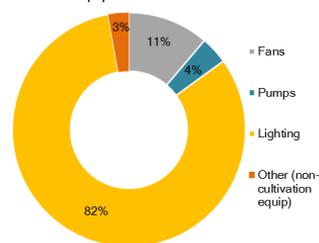
Grower B
Estimated Equipment kWh Breakdown



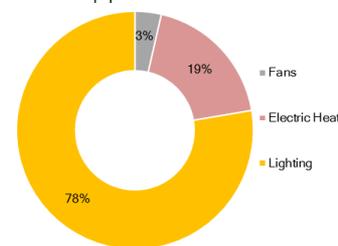
Grower C
Estimated Equipment kWh Breakdown



Grower D
Estimated Equipment kWh Breakdown



Grower E
Estimated Equipment kWh Breakdown



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PowerScore Report #920

Multiple Environments – Grants Pass, Oregon – Climate Zone 4C



Better year than
52%
of the 26 past growing years of all farm
types, across the United States

Facility Efficiency: 3.86 kWh / sq ft



Better than
37%

Production Efficiency: 7.94 grams / kWh



Better than
70%

HVAC Efficiency: 115 kWh / sq ft



Better than
48%

Lighting Efficiency: 0.107 kWh / sq ft



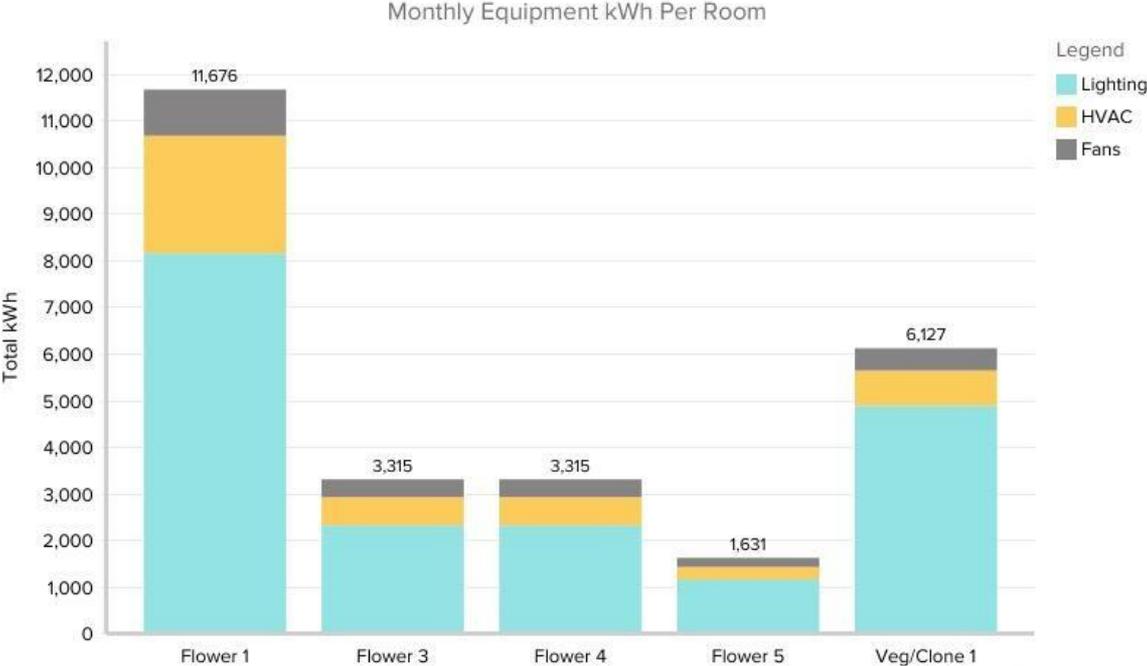
Better than
52%



ENERGY BENCHMARKS ARE NEEDED

To determine
The most efficient
production methods

Same Grower – Very Different Rooms

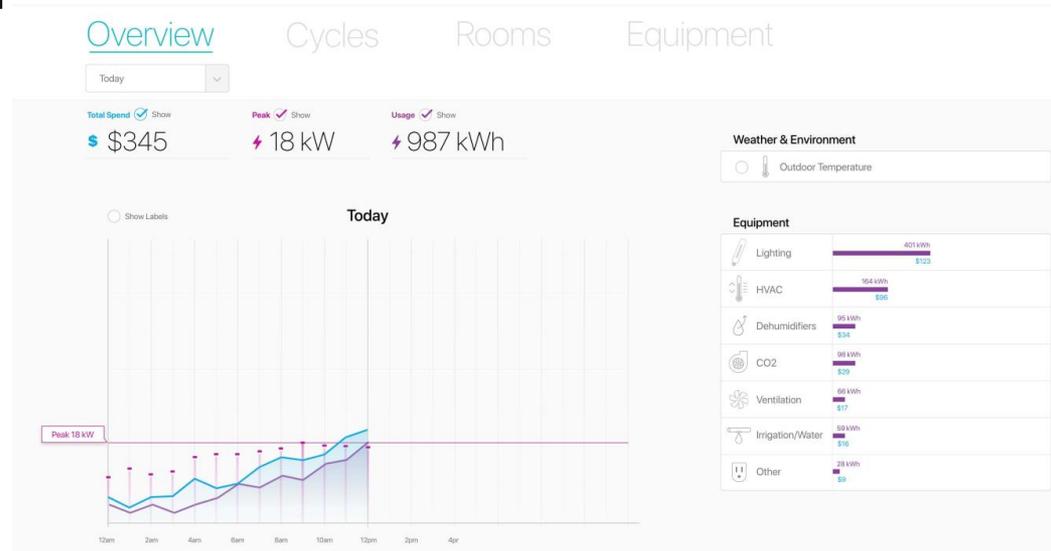


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To Get To An Effective Energy Discussion, You Have To Have Whole Building Context.

Understanding where, why, how, and when a cultivator uses energy:

- On-site assessments
 - Equipment age, efficiency, operating hours, cultivation area SQFT, etc.
- Business processes
 - Plant types, counts, growing processes, room set-ups, etc.
- Historic energy use analysis + previous peak months, including previous billing cost drivers
- Circuit level understanding
 - Examined through a full growing cycle.
- Overall/long-term business motivations, budgets, competition, goals and plans



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Traditional Building Energy Metrics May Not Always Apply To Cannabis Sites

Traditional Metrics

- **Energy Utilization Index (EUI)** - Total energy use of the facility divided by the total floor area, presented as a comparison of “Annual kWh/SQFT”.
- **Energy Cost Index (ECI)** - Total utility expenses divided by total floor area, presented as a comparison of “Annual Electric \$/SQFT”.

Cultivation Metrics To Consider

- **Energy Per Gram, (EPG)** - Total annual energy use divided by the number of grams produced, presented as a comparison of “Monthly Electric \$ and kWh/gram”.
- **Peak Per Gram, (PPG)** - The peak kW reached by the facility during the previous calendar year divided by the number of grams produced, presented as “Facility Peak kW/grams” with both the total kW and date recorded listed.
- **Lighting Power Density, (Watts per SQFT)** - The peak kW reached by the facility during the previous calendar year divided by the number of grams produced, presented as “Facility Peak kW/gram” with both the total kW and date recorded.

Case study from Oregon



Hifi Farms, Hillsboro

ESTIMATED ANNUAL SAVINGS: \$12,000



When selecting lighting for its new grow room, Hifi Farms in Hillsboro opted for efficient, LED technology, cutting annual energy costs by an estimated \$12,000.

“The quality of LEDs has gone up markedly and we’re no longer concerned about yield,” said Richard Vinal, chief operating officer. “We’ve flowered under LEDs before, and the quality is higher than with high pressure sodium or metal halide lighting.”

The 150 LED grow lights installed in the 1,000-square-foot grow room use half the wattage of high pressure sodium lights. With over \$19,800 cash incentives from Energy Trust, Hifi’s investment should pay for itself in less than three years.

Because LEDs have a long-life span, Hifi also expects to save on labor costs. “Grow room lights are on 18 to 24 hours a day during the vegetative cycle and 12 hours a day during flowering,” said Vinal. “The LEDs should last a minimum of five years. That’s a huge savings for us.”

View the slideshow and [read the full story](#).

[Learn more about our cash incentives for lighting and lighting controls >](#)

- 75% of energy savings for industrial programs come from indoor ag projects
- Most projects are LED retrofits for cannabis growers
- Greatly reduces up-front costs for growers, by approximately 50% to 75%
- Energy Trust of Oregon can meet its industrial energy-savings goals
- Oregon utilities benefit from new customers, revenue growth

Source: Energy Trust of Oregon

Q&A



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