RESOURCE INNOVATION INSTITUTE

Optimizing Automation & Controls In Cannabis Cultivation Environments

In partnership with

ASABE

ACEEE American Council for an Energy-Efficient Economy

ASHRAE

Sept 16, 2021

Agenda

Welcome & Purpose	1:00 pm ET
Introductions & Context	1:05 pm ET
Cultivator & Plant Perspectives	1:10 pm ET
Lighting Controls Opportunities	1:20 pm ET
HVAC Controls Opportunities	1:30 pm ET
Greenhouse Controls Opportunities	1:40 pm ET
Water Controls Opportunities	1:50 pm ET
Integrating Controls for Increased Savings	2:00 pm ET
Using Data from Controls Systems	2:10 pm ET
Efficiency Program Experience & Examples	2:20 pm ET
Breakout Sessions, Q&A	2:30 pm ET

SECTION 01

WELCOME & PURPOSE

ABOUT US

About RII

- Objective, data-driven non-profit
- Founded 2016 in Portland, Oregon
- Expertise in climate policy, utility programs, green building certification, sustainable business, construction & indoor cultivation
- In 2020, received 3-year grant from USDA to develop KPIs, standards & building rating system for CEA

ABOUT RII

What We Do / Our Mission

We measure, verify & celebrate the world's most efficient agricultural ideas.

Measure

Efficiency & Productivity

- Key Performance Indicators
- Benchmarks
- Baselines

Verify

Best Practices & Standards

- Training
- Policies
- Utility Programs

Celebrate

Leadership Recognition

- Verification
- Case Studies
- Certification

ABOUT RII

Our Network

ABOUT RII

Technical Advisory Council

Multi-disciplinary body who aggregates knowledge to support producers and other stakeholders with objective and peer-reviewed data and curriculum on benchmarking resource efficiency

- **Guides** development of standards
- **Shapes** tools and resources to support best practices
- **Advocates** for informed policies, incentives and regulations

HVAC - Lighting - Utility - Water
Policy - Data - Controls - Emissions

Kicking off in October: Facility Design & Construction

SECTION 02

INTRODUCTIONS & CONTEXT

Today's Speakers

Gretchen Schimelpfenig
RESOURCE INNOVATION INSTITUTE

Neda Vaseghi
microclimates™
Unified Control. Unified Data.

Taylor Kirk
FLUENCE BY OSRAM

Lindsay Buckwell
Evergreen Consulting Group

Jan Westra
PRIVA

Colin Brice
Signify

Jeannie Sikora
CLEAResult

RII Controls Working Group

Objective: To **share insights on effective integration and automation of resource-consuming building systems in CEA facilities**, improve data and best practices resources for the market, and help utility & efficiency programs support controls infrastructure and smart controls strategies.

Controls Working Group Challenges and Solutions

Challenges:

- CEA operators use manual controls or work with what they have
- Efficient equipment installed in facilities is operated in diverse ways
- The value of integrated systems and controls needs to be proven
- Utility programs require data to validate energy savings of controls strategies
- Connectivity, security and reliability of Wifi
- Networked lighting controls specifications and integration

Initial Solution:

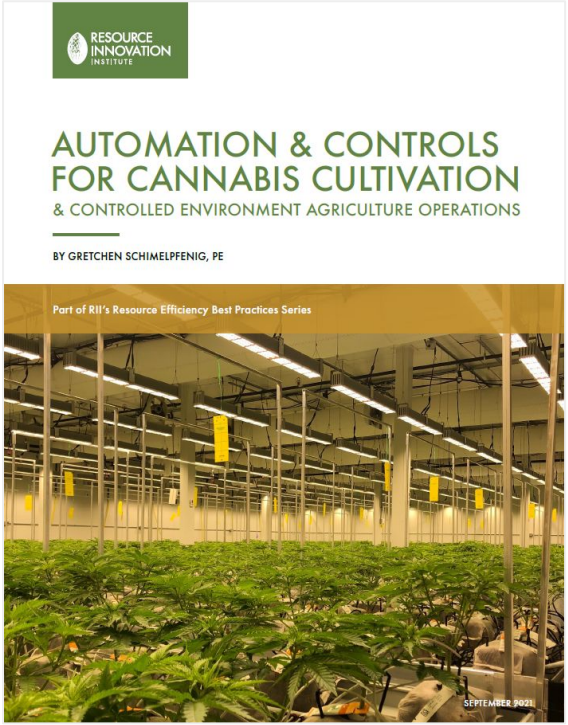
Automation & Controls Best Practices Guide for Cannabis Cultivators

Automation & Controls Best Practices Guide

Thank you to our Controls Working Group

30+ contributors and peer reviewers

- Speak the language relevant to controlling and automating environmental control systems in horticultural applications
- Understand types of control systems optimizing horticultural environments
- Plan for integrated controls approaches in greenhouses and indoor operations
- Install and operating successful controls solutions in alignment with business models
- Use data from control systems to improve productivity and efficiency
- Demonstrate energy savings for utility energy efficiency incentive programs



DOWNLOAD NOW

Efficiency Programs Incentivizing CEA Controls

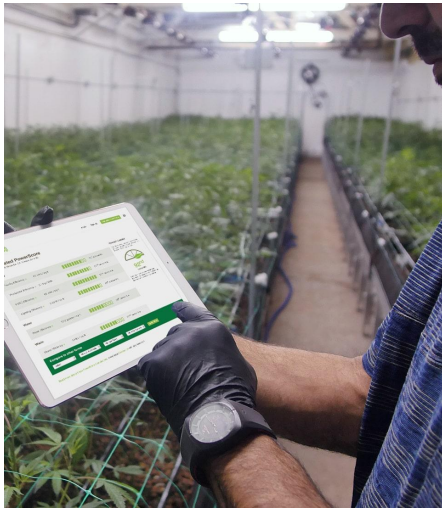
- Savings opportunities, lighting and otherwise
- Flexible load management and demand response opportunities
- Load opportunity (DTE example)
  - Early utilities can manage where in the grid their load profile is being created
- Experience at ETO with fan and pump controls
  - Incentives were less robust than lighting control incentives
- Non-energy benefits
  - Product quality, controls in drying room would optimize temperature and humidity, could impact product margin and bottom line
- Decarbonization opportunity
  - Claiming savings for efficiency and emissions in the market

Efficiency Program Perspective

Need to claim verifiable savings

Data can validate performance

Growers can provide the crucial data



Evergreen Consulting Activity in CEA

Serving programs in:

- Michigan: “Getting ahead of the load”
- Arizona
- Utah
- Oregon
- Washington
- Idaho
- Montana
- *Massachusetts coming soon*

Evergreen Consulting Group

Expanding programs:

- Greenhouses, excited to hear about greenhouse controls
- Residential
- Consumption site ventilation and controls

SECTION 03

CULTIVATOR & PLANT PERSPECTIVE

Start with the Plant

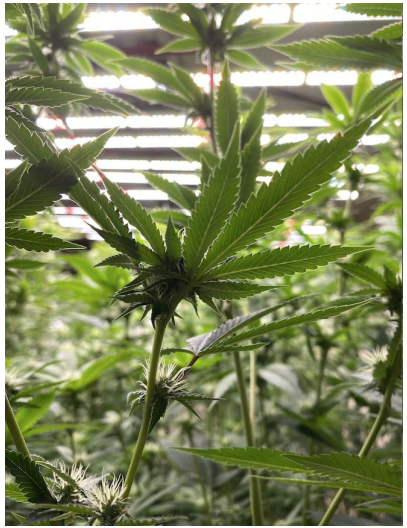
Environmental control for optimal growth

- Automate systems to provide light, climate, airflow, and water to support:
  - High yields
  - Quality biomass

Systems need to be designed and deployed with full system view of how facilities will be operated to keep plants happy

Light:
~40W / canopy square feet (for LED)
12 hours ON

Water:
~500-1000 ml per day



Climate:
78-82 F
55-65% RH
1.2-1.4 kPa VPD

CO2:
~1200-1500 PPM

~ 20 Air Changes Per Hour, MERV 13 Filtration

Figure credit: Zartarian Engineering

Example Cannabis Production Lifecycle

Cuttings are taken from Mothers and moved into propagation. Expected duration 14-21 days.

Rooted cuttings placed in final .7 gal coir bags and placed at density of X plants per 4x4 tray.

Plants are moved from Veg room to flower and placed at a density of Y square feet per plant.

Plants are harvested and hung in drying room until ready for trim.

Plants are trimmed and stored in vault, occasionally opened for curing. They will stay here until testing is complete and the product is released to retail or further processing.

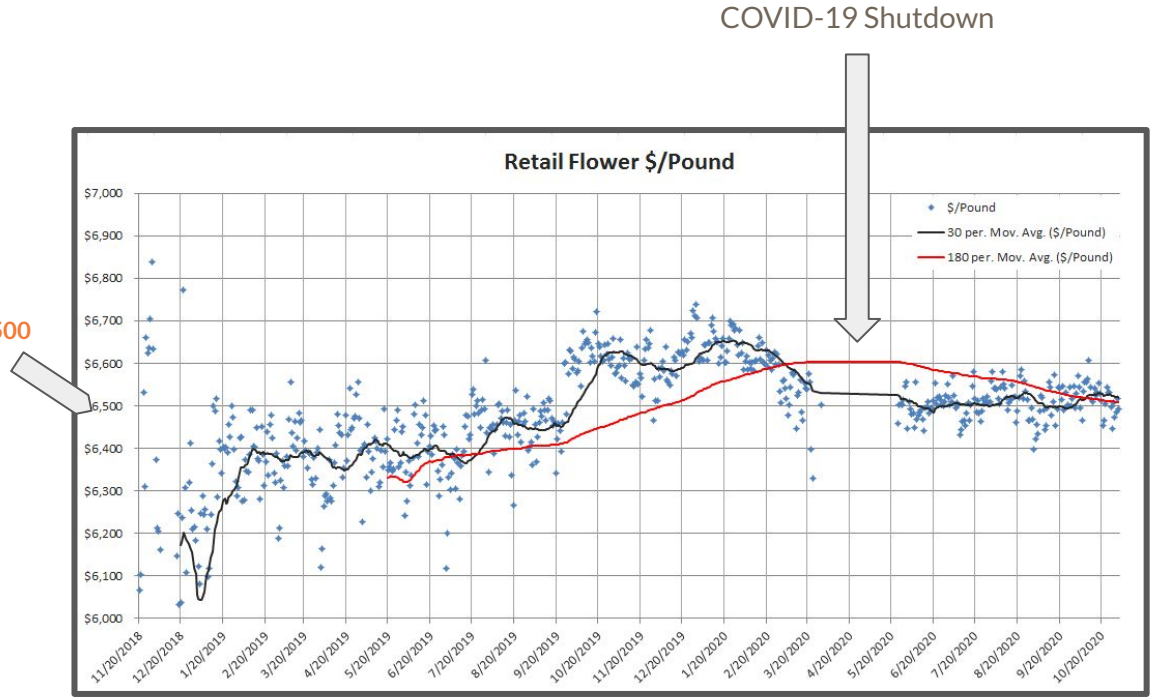
Credit: Zartarian Engineering

Cultivator Perspective

Cannabis market dynamics

- Two basic models in commercial controlled environment agriculture:
  - Maximize output
  - Maximize efficiency

The cannabis industry currently is in 'maximize output' especially in states like MA where wholesale prices are extremely high



Massachusetts Adult-Use Retail Cannabis Flower Prices -
Chart Credit: Ed Watson / Mainley Productions from Public CCC Data

Credit: Zartarian Engineering

Dive Deeper into Controls for Cannabis Cultivators

Lessons All Growers Can Learn From the Cannabis Gold Rush

GREENHOUSE GROWER

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Articles co-authored by RII with members of our Technical Advisory Council Working Groups

SECTION 04

LIGHTING CONTROLS OPPORTUNITIES

Lighting Controls: Value Proposition

Dial in the number one nutrient for plants

Provide with granularity:

- Proper light levels
- Optimal spectra for cultivars
- Preferred photoperiod by stage of development
- Desired DLI to empower plant growth

Provide plants with the exact intensity and quantity of light while minimizing energy consumption and lowering bills

Figure credit: Signify

Lighting Controls: Measures

Scheduling

- Adjust photoperiod

Dimming

- Modulate light intensity by zone of control
  - Daily
  - By stage of plant growth

Spectral Tuning

- Modulate photon output from wavelength ranges

Understand energy savings potential of strategies and data needed to validate performance

Table 3: Lighting Controls Parameters Measured by Cannabis Cultivators

Lighting Data Collected[5]	Percentage of Growers Collecting, 2020
Light intensity (PPFD)	55%
Spectral quality	33%

Figure data source: Cannabis Business Times

Lighting Controls: Baselines - Indoor & Greenhouse

Table 2: Lighting Schedules and DLI Targets for Cannabis Cultivation

Cannabis Growth Stage	Average DLI Target for Cannabis (Moles/Square Meter/Day)	Example Sole-Source Daily Lighting Hours (Indoor)	Example Supplemental Daily Lighting Hours[3] (Greenhouse)
Flower/Bloom	25 - 50	12	North: 6 - 8 hours South: 5 - 6 hours
Vegetative	20 - 40	18 - 24[4]	North: 4 - 6 hours South: 1 - 3 hours
Clone/Seedling	15 - 20	14 - 24	North: 0 - 2 hours South: Not needed
Mother	20 - 40	18	North: 4 - 6 hours South: 1 - 3 hours

Lighting Controls: Dimming Strategies

Cost-effective with non-energy benefits

- Photoacclimation
  - Photoacclimation sequences of control can result in energy savings of 20% in some scenarios
- DLI targets
  - Allow growers to lower the lighting power during peak hours and increase it during off-peak hours

As LEDs dim, light fixture photosynthetic photon efficacy (PPE) can increase

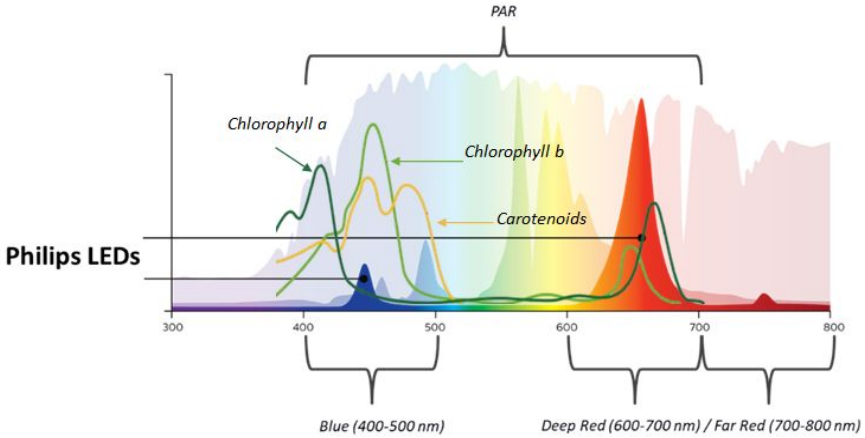
Figure credit: Fluence by OSRAM

Lighting Controls: Spectral Tuning

LED lighting solutions can modulate spectra

- LEDs are the only type of grow light that has customizable spectral quantum distribution; manufacturers can provide unique light recipes targeting specific plant responses
- Spectral compositions tuned for maximum pigment absorption in plants
  - Affects photomorphogenic qualities
  - Higher absorption leads to more efficient photosynthetic activity and growth
- Impacts energy consumption

Spectral tuning sequences can be incentivized by efficiency programs



	Operating		Light Setting				Power Consumption (W)			PUD Ltg hrs	No. of Fixtures
		Hr	White	Blue	Red	Deep Red	Power Consumption (W)	Average Power Consumption (W)	Average Power Consumption in Flower/Veg Stage (W)	Hrs per year	48
Flower Light (25ft² Coverage Area)	Week 1-2	0.5	70	100	0	0	470	650.1	732.4	973	30,372
		11	80	40	60	60	663				
		0.5	50	25	60	60	546				
	14 days										
	Week 3-7	0.5	70	100	0	0	470	714.3		2433	83,424
		11	70	40	80	80	733				
		0.5	50	25	60	60	546				
	35 days										
	Week 8-9	0.5	70	100	0	0	470	860.0		973	40,179
		11	70	40	80	80	892				
		0.5	50	25	60	60	546				
	14 Days										
Veg. Light (25ft² Coverage Area)	Veg.	18	80	90	30	30	610		610	6570	32,062

Figure credit: Signify, GS Thermal Solutions & SnoPUD

Lighting Controls Planning: Indoor & Greenhouse

Designing controls for lighting cultivation spaces

- Placement
- Crop light levels: *PPFD*
- Spectrum choice: *Spectral tuning sequence of operations*
- Timing: *Photoperiod, dimming schedule, DLI*
- Light distribution and uniformity
- Product specifications
- Fixture count
- Power and voltage

Crop (Growth Stage)	Typical PPFD (Greenhouse)	Typical PPFD (Indoors)
Cannabis (Veg)	200-400	350-400
Cannabis (Flower)	300-500+	700-1000+

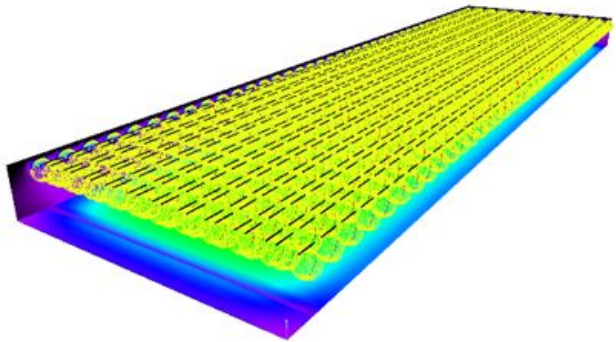


Figure credit: Signify

Lighting Controls: Recipes for Cannabis Steering

Gather data to support lighting controls incentives

Table 4: Lighting Controls for Cannabis Steering by Stage of Plant Growth[6]

Lighting Controls	Vegetative	Flowering	Ranges of Controls Values
PPFD	Lower	Higher	300 - 1500+ µmols/m²/s
DLI	Less	More	20 - 42 moles/m²/day
Spectral Treatments (R:B ratio)	Higher	Lower	7 - 15%; higher blue for shorter plants
Far Red Treatments	More	Less	Used to manage shade avoidance

Figure data source: Signify

Dive Deeper into Lighting Controls

The Right Light

CANNABIS BUSINESS TIMES

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How Manipulating Light Treatments Affects Plant Expression

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How LED Light Recipes and Controls Can Improve Quality and Yield for Cannabis Producers

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SECTION 05

HVAC CONTROLS OPPORTUNITIES

HVAC Controls: Value Proposition

Optimize environmental conditions for plants

- Proper temperature (space, relative & leaf), humidity, airflow, CO2 levels
- Optimal plant growth, control mold, mildew and other pests
- ROI plus visibility of data to create a more stable operation

Reduce operating costs while maximizing efficiency and productivity

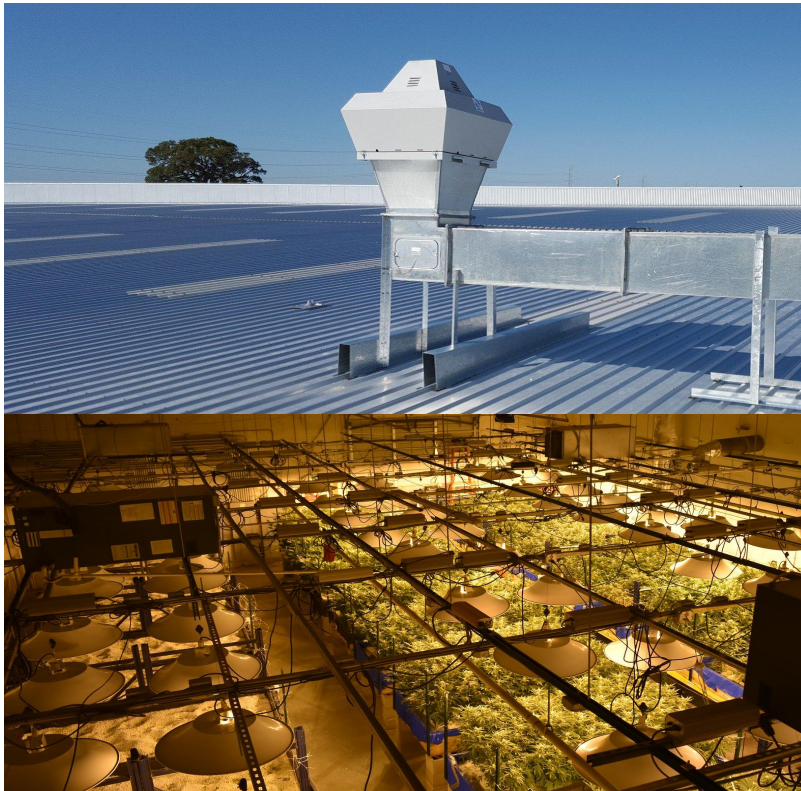

Figure credit: Microclimates

HVAC Controls: Measures

Monitoring, Calibrating, Commissioning

- Monitor (Inputs) → Controls (Outputs)
- Automated System - User Interface
- Sequence of Operations
- Calibrating
- Commissioning

VPD Controls

- Modulate temperature and relative humidity setpoints to operate within target VPD ranges
  - By stage of plant growth

Airflow Controls

- Modulate supply airflow

Understand energy savings potential of strategies and data needed to validate performance

Table 5: Climate and Airflow Controls Parameters Measured by Cannabis Cultivators

Climate and Airflow Data Collected[7]	Percentage of Growers Collecting, 2020
Space Temperature	85%
Relative humidity	72%
CO2 concentration	66%
Leaf temperature	31%
Air speed	19%

Figure data source: Cannabis Business Times

HVAC Controls: VPD Controls

Maintain efficient VPD targets

- There is not a target VPD that is appropriate for all cultivars, environments, or cultivation methods
- Consider acceptable VPD ranges by stage of plant growth

Dial in HVAC system automation to tailor VPD to specific cultivars, systems, and facility configurations

Figure 2: VPD - The Differential Between Grow Room and Leaf Conditions

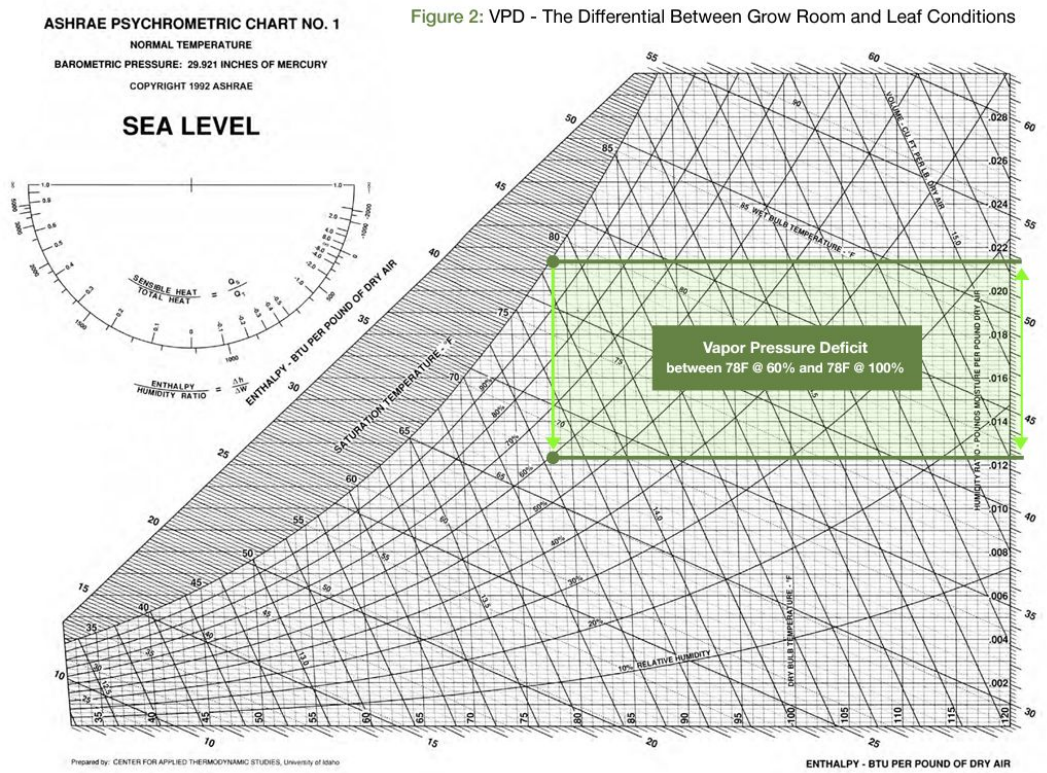

Figure credit: Desert Aire & ASHRAE

HVAC Controls Baselines: Indoor & Greenhouse

VPD Controls

- Target ranges vary by stage of plant growth
- Dial in energy-efficient VPD setpoint ranges

Airflow Controls

- Sizing for cultivation can range from 10 to 20 ACH, with some cases as high as 30 - 40 ACH
- Reduce supply air volume setpoint during dark periods

Understand energy savings potential of strategies and data needed to validate performance

Table 6: VPD Targets for Cannabis Cultivation

Cannabis Growth Stage	Target VPD Range (kPa)
Flower/Bloom/Mother	1.0 - 1.5
Vegetative	0.8 - 1.1
Clone/Seedling	0 - 0.2

HVAC Controls: Monitoring, Calibration, Commissioning

Monitoring

- You can't manage what you don't measure...but you can't measure what you don't monitor
- Make data to support savings claims

Calibration

- Ensure sensor accuracy so HVAC systems respond to actual environmental conditions
- Configure response times to reduce short-cycling

Commissioning

- Functionally test HVAC sequences of operation to ensure persistent energy savings

Figure credit: Gro iQ / InfiSense

HVAC Controls: Interactive Effects

Respond to light and water

- Orchestrate your HVAC controls to call and respond to your lighting controls
- When lights go off, humidity spikes, and controls can give your HVAC equipment more time to ramp up and respond
- Likewise, plant stage of growth and timing of watering events can demand more of your HVAC system

HVAC equipment should monitor both lighting and irrigation controls activities for faster response times and happier plants

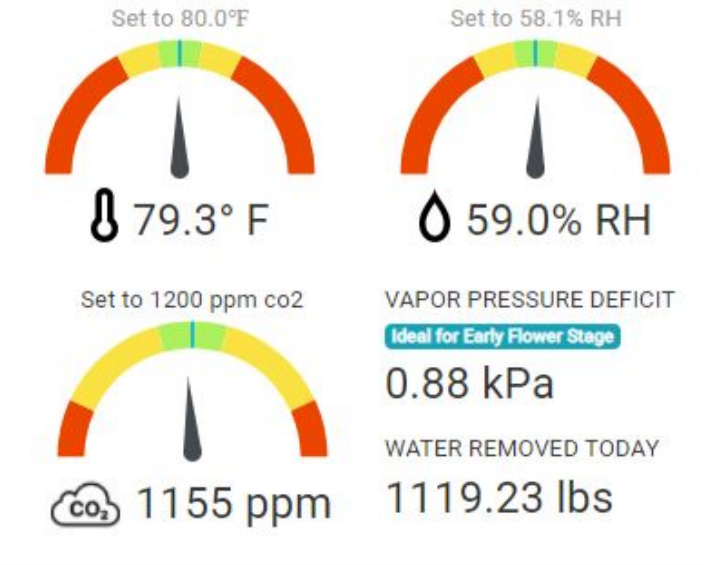

Figure credit: Inspire Transpiration Solutions

Dive Deeper into Environmental Controls

Empowering Plants with Environmental Controls Systems

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Avoiding Cannabis Crop Loss in Cultivation

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Integrated Pest Management for Cannabis Cultivation Monitoring, Identifying, Preventing, and Controlling Pests with HVAC Solutions

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SECTION 03

GREENHOUSE CONTROLS OPPORTUNITIES

Lighting Controls: Greenhouse

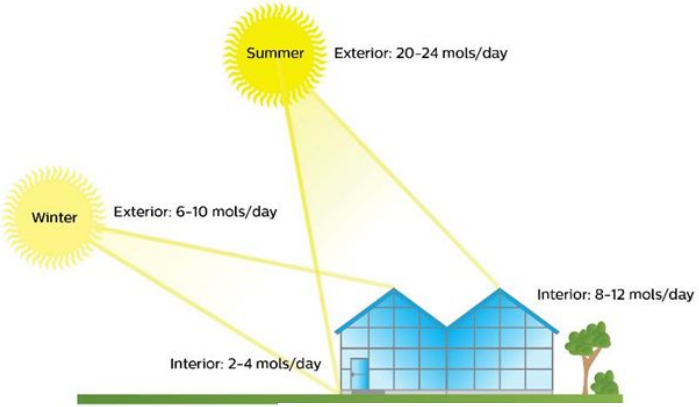
Seasonal Light Variation

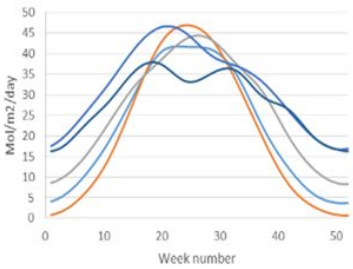
- Changes in solar radiation
- Losses through various types of greenhouse coverings

Regional Light Variation

- Seasonal patterns vary between different regions
- Location and facility specifications determine expected solar radiation

Anticipate your light sums, use interior light sensors, and program appropriate control responses





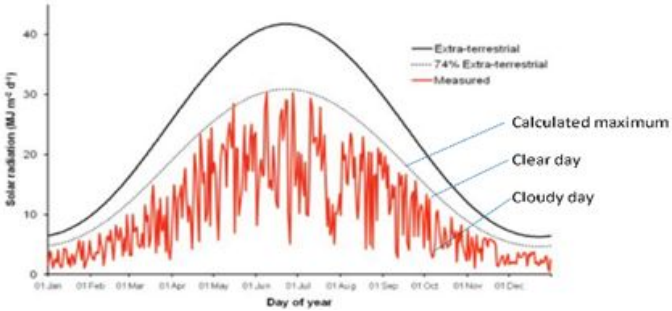


Figure credit: Signify

HVAC Controls: Greenhouse

Solar Radiation

- Seasonal patterns vary between different regions
- Location and facility specifications determine expected solar radiation

Building Envelope

- Energy screens and shade curtains

Growth by plant empowerment keeps a uniform ratio of average temperature to DLI and and can reduce energy consumption

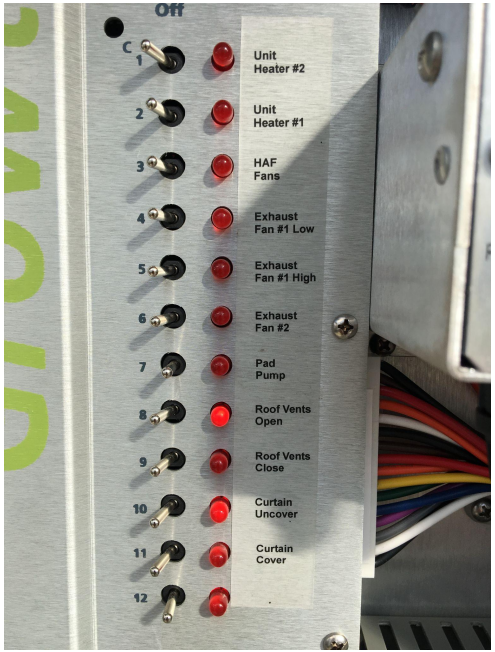


Figure credit: Rob Eddy

HVAC Controls: Recipes for Cannabis Steering

Table 7: Climate & Airflow Controls for Cannabis Steering by Stage of Plant Growth[8]

Climate Controls	Vegetative	Flowering	Ranges of Controls Values
Day-Night Temperature Difference	Smaller	Larger	0 - 9 degrees F
Afternoon Temperature Increase	None or small	Larger	0 - 5.5 degrees F
Start Time for Heating System	Earlier	Later	4 hours before sunrise to sunrise
Night-Day Temperature Increase	Higher	Lower	1 - 4.5 degrees F
Start Time for Day-Night Temperature Decrease	Earlier	Later	2 hours before to 2 hours after sunset
Speed of Day - Night Temperature Decrease	Slower	Faster	0 - 7 degrees F per hour
Average Daily Setpoint Temperature	Lower	Higher	68 - 82 degrees F
Vapor Pressure Deficit Target	Lower	Higher	0.8 - 1.5 kPa
Ventilation for Temperature Control	More	Less	Used for temperature control
CO_2 Enrichment	More	Less	350 - 1500 ppm
Energy Screen	Close	Open	Used to manage plant stress

Figure data source: Signify

Dive Deeper into Greenhouse Controls

Optimizing Systems for Cannabis Greenhouses

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SECTION 07

WATER CONTROLS OPPORTUNITIES

Water Controls: Water Recycling

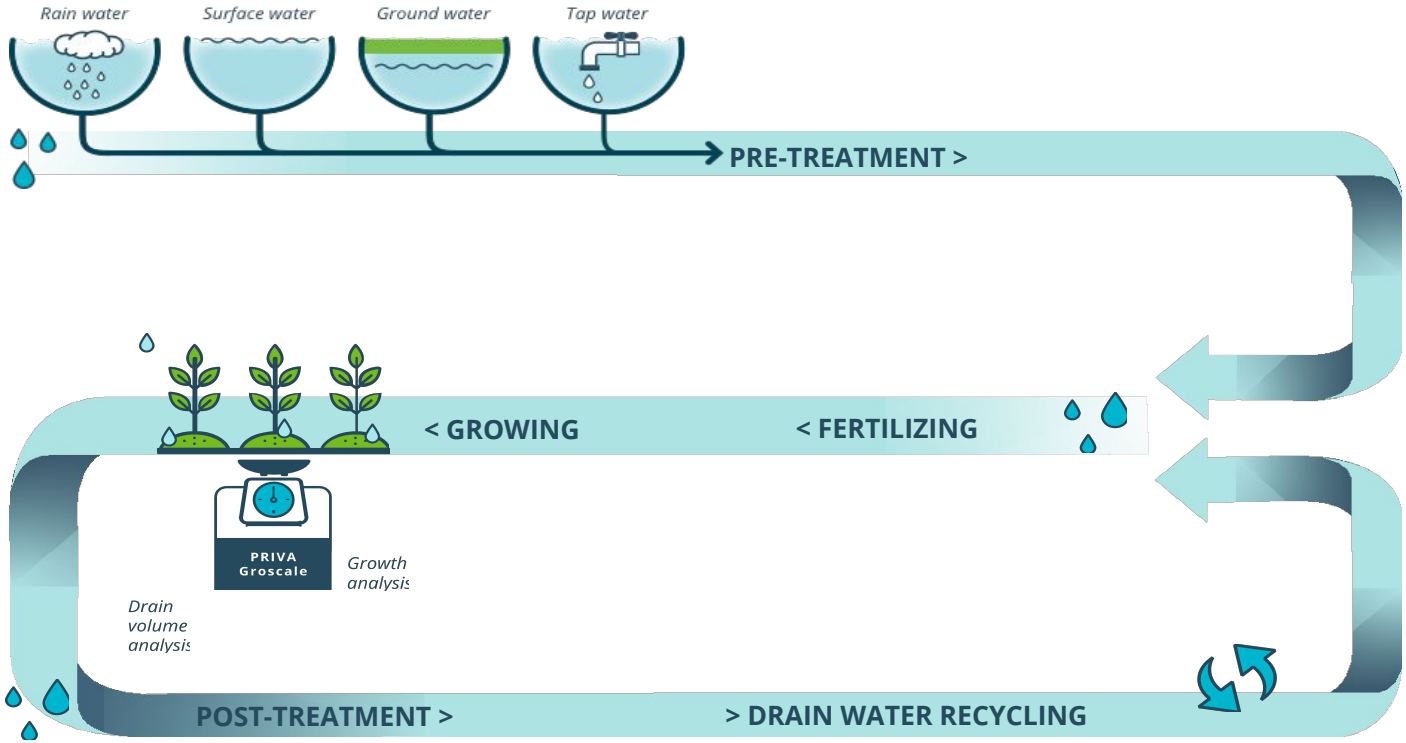

Figure credit: Priva

Water Controls: Value Proposition

Design and operate for recapture and reuse

- Treat irrigation runoff and HVAC condensate

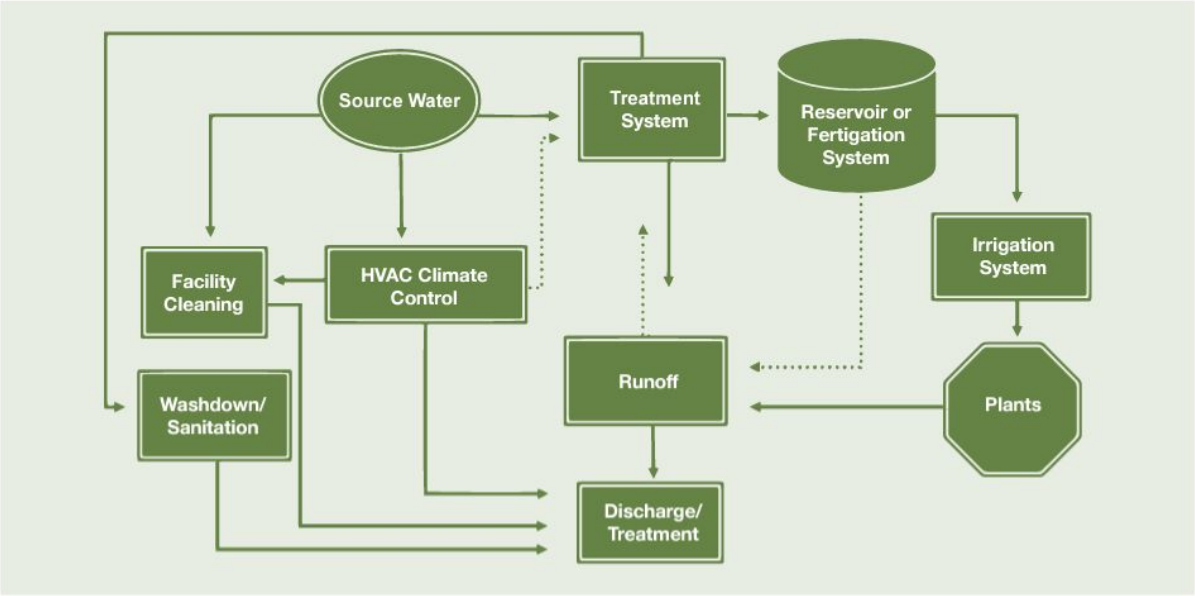

Figure credit: Silver Bullet Water Treatment and Priva

Water Controls: Irrigation Measures

Reduce pumping energy while managing water quality

- Choose substrates with lower leach percentage to manage less runoff
    - Lower leach may be achieved with water culture approaches that recirculate irrigated water
- Understand watering and drainage rates
    - Watering events can range from 1 - 20 per day depending on your choice of substrate
- Employ drip irrigation controls

Precise targeting of drip irrigation can reduce water consumption by 30% to 70%, and improve water productivity by 20% to 90%

Table 8: Water Controls Parameters Measured by Cannabis Cultivators

Water Data Collected	Percentage of Growers Collecting, 2020
Nutrient solution pH	76%
Substrate pH	54%
Nutrient solution electrical conductivity (EC)	51%
Media EC	38%
Root zone temperature	21%

Figure data source: Cannabis Business Times

Water Controls: Recipes for Cannabis Steering

Table 9: Water Controls for Cannabis Steering by Stage of Plant Growth

Watering Controls	Vegetative	Flowering	Ranges of Controls Values
EC Growing Medium	Decrease	Increase	1.8 - 4.5 EC
EC Irrigation Water	Decrease	Increase	2 - 2.8 EC
Substrate Water Content	Increase	Decrease	45 - 65%
Day-Night Water Content Decrease	Decrease	Increase	2 - 10% (5 - 15% with rock wool)
Irrigation Cycle Length and Frequency	Short & Higher	Long & Lower	50 - 150 ml per dripper
Start Time First Irrigation	Earlier	Later	1-3 hours after sunrise/lights on
Stop Time Last Irrigation	Later	Earlier	3-5 hours before sunset/lights off

Figure data source: Signify

Dive Deeper into Irrigation Controls

Rooting for Recapture and Reuse

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SECTION 08

INTEGRATING CONTROLS FOR INCREASED SAVINGS

Integrated Controls: Value Proposition

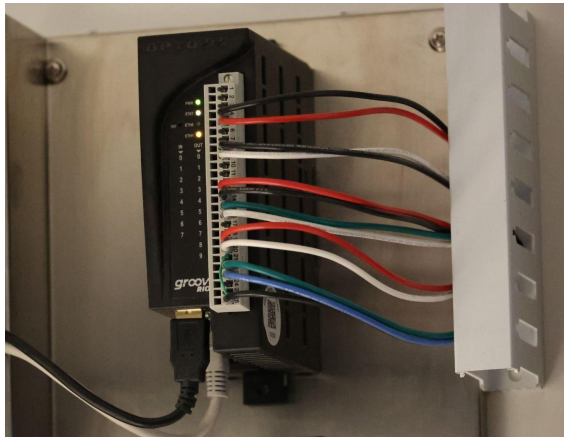
Integration creates consistency across facility systems

Consistent Data

- Cross-system health at a glance - faster resolution
- Consistent dashboards, overlays - spot interactions
- Common data repository - record all data
- Controlled API access - external integrations

Consistent User Experience

- Ease of use - personnel
- Consistent access controls - security
- Common alerting, configuration, annotations - risk



Minimize risk while maximizing security and speed

Figure credit: Microclimates

Integrated Controls: Hardware & Software

Integration ties together silos

Macro

Between functionality silos

Example: lighting + hvac + curtains

Micro

Between hardware silos

Example: RTU A/C + portable dehumidifiers

Increase savings with multiple integrations

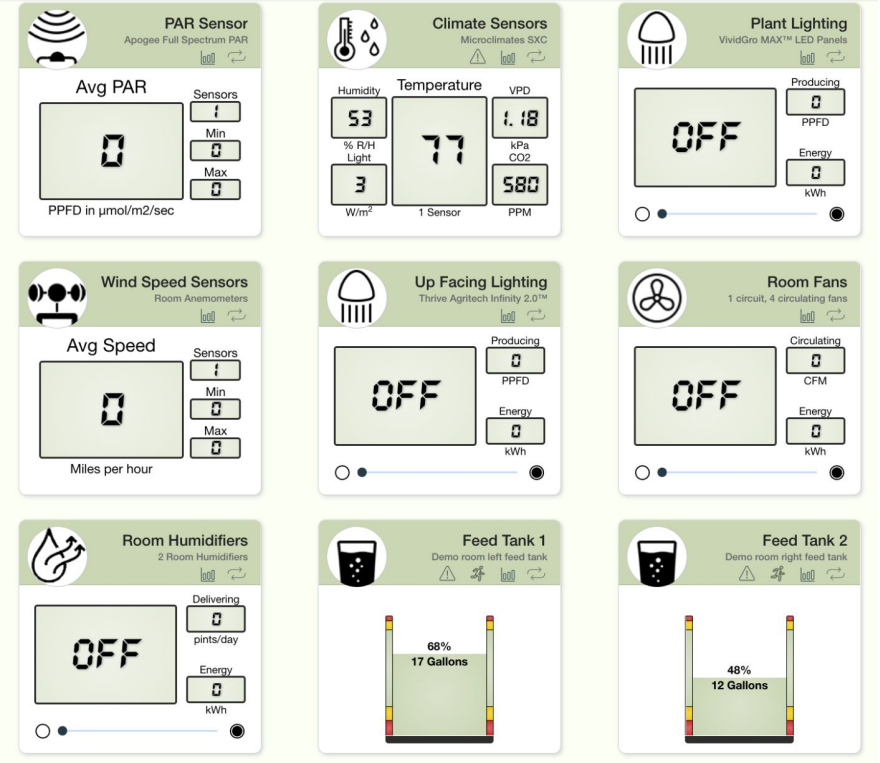


Figure credit: Microclimates

Integrated Controls: Post-Harvest Example

Curing Room Example

A/C + portable dehumidifier integration

Large WA cannabis producer

- Capacity based control 0-100%
- Progressive multi-unit
- Multiple curing strategies
- Data retention for validation

Controls can ensure cost-efficient cannabis curing processes and consistent and predictable product quality

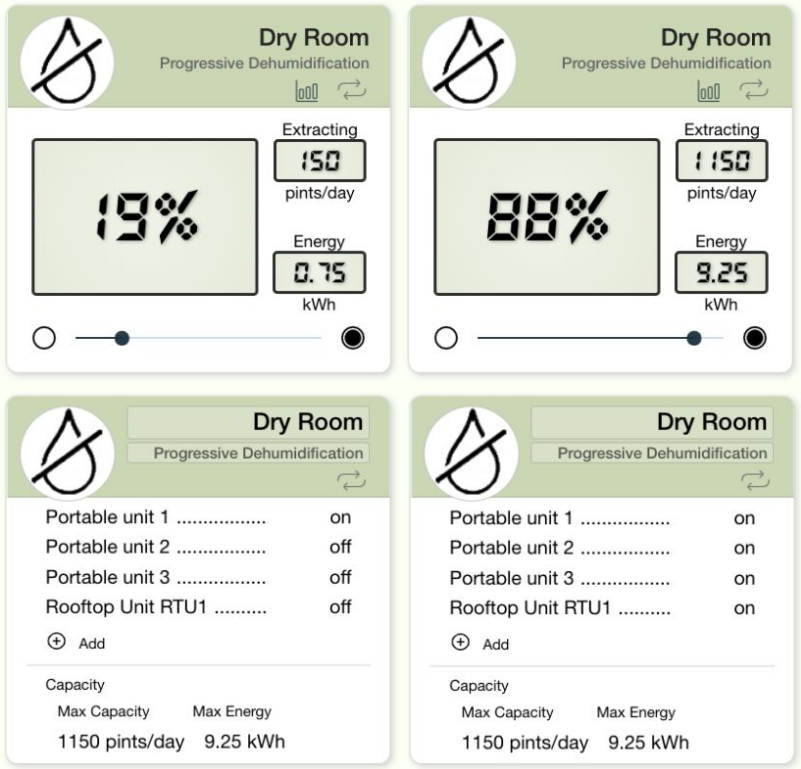


Figure credit: Microclimates

Dive Deeper into Integrated Controls

Fine-Tune Environmental Controls to Drive Your Competitive Edge

CANNABIS BUSINESS TIMES

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Integrate Environmental Controls For Better Cannabis Production

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Articles co-authored by RII with members of our Technical Advisory Council Working Groups

SECTION 09

USING DATA FROM CONTROLS SYSTEMS

Using Data: Trending History

Back up stored data regularly

- Hundreds of sensors measuring various conditions and collecting data at regular intervals to track historical trends
- A typical control system can generate tens of thousands of data points from a cultivation facility every single day
- Determine how long you want to store your historical logs of trends

Save multiple years of data for year-over-year comparisons

Figure 5: Dashboard of Trended Facility Data

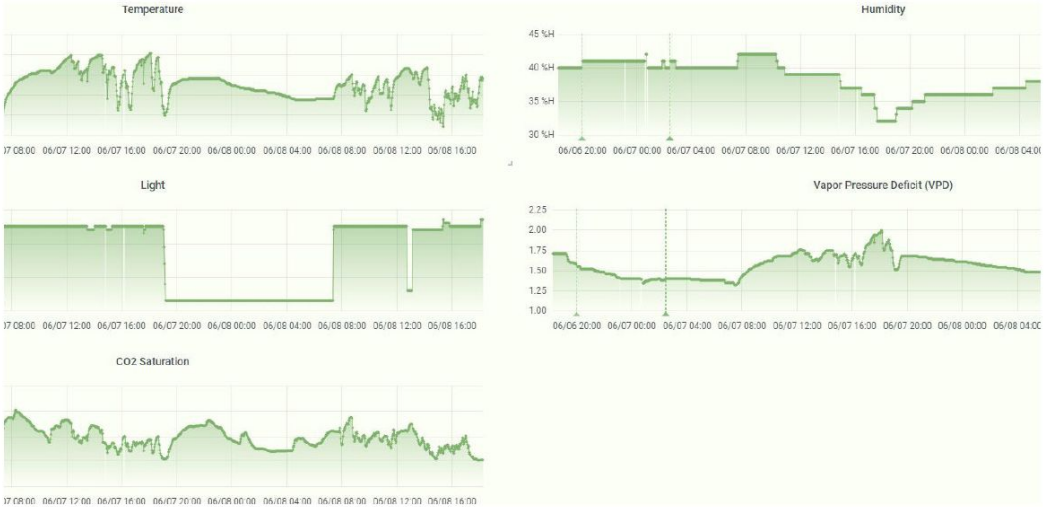


Figure credit: Microclimates

HVAC Controls Trends: VPD Controls

Validate actual conditions are within target ranges

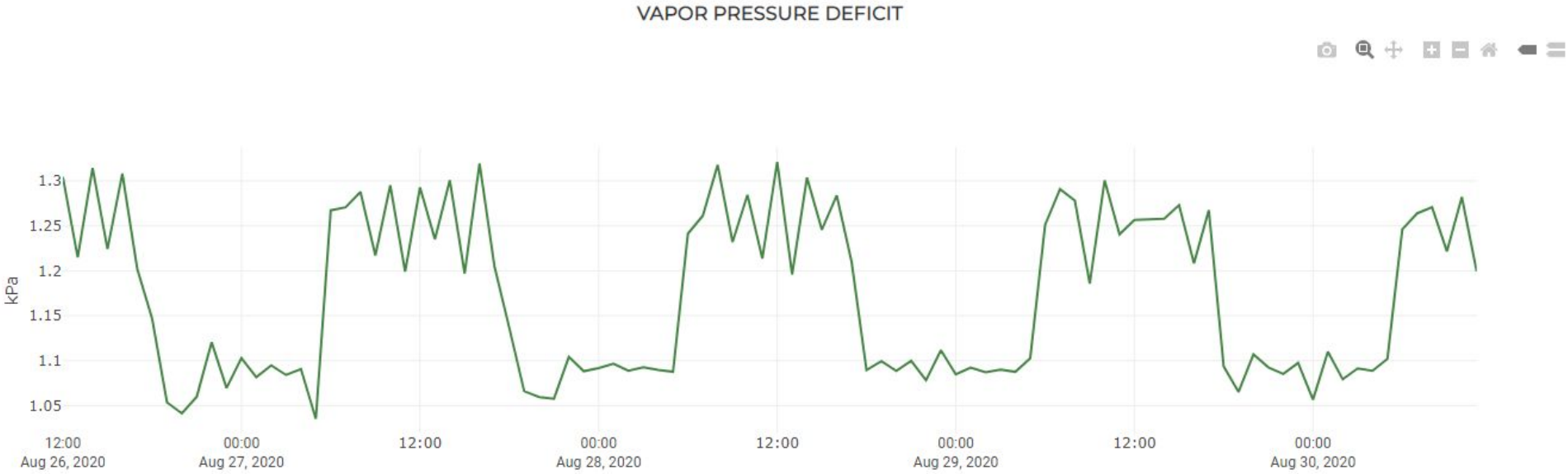


Figure credit: Inspire Transpiration Solutions

HVAC Controls Trends: Temperature, RH, CO2

Understand how parameters affect environment

- Observe the interaction between control points

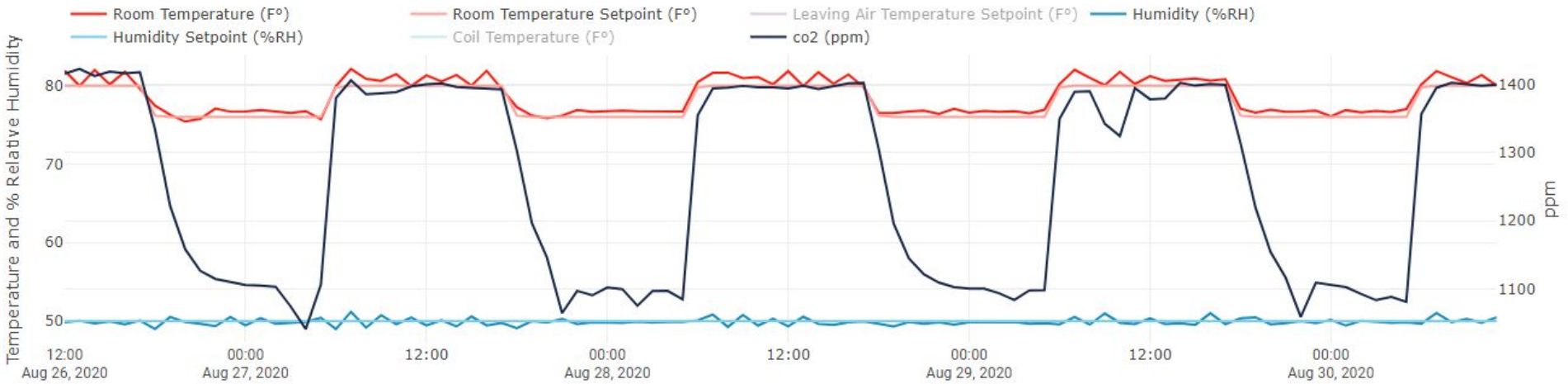


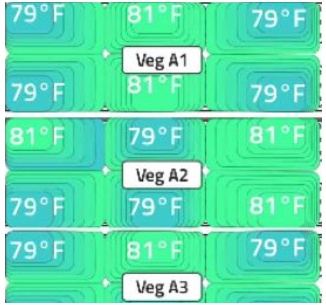
Figure credit: Inspire Transpiration Solutions

Using Data: Data Analytics

Fault detection & diagnostics

- Most control systems generate alarms when certain conditions are out of range
- Cultivation facilities rely on precise control, and too often, alarms occur when it is too late, and issues have become an emergency
- Augment human vision with data from sensors and proactive trend analysis
- Analytics software detects problems in the system well before reaching an emergency alarm state by searching for patterns in control system data and alerting the user when conditions begin slipping away from the norm

Take action using FDD recommended resolutions to fix issues



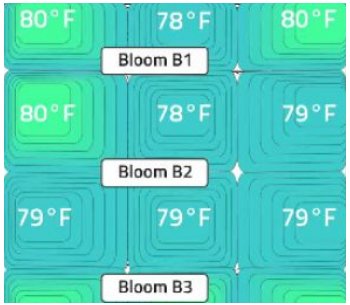


Figure credit: Grownetics

SECTION 10

EFFICIENCY PROGRAM EXPERIENCE & EXAMPLES

The M&V Balance

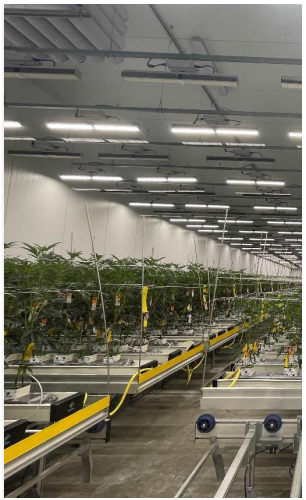
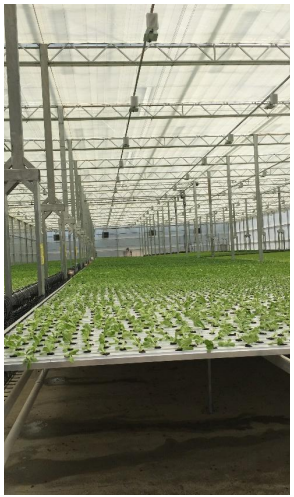
Customer Incentive

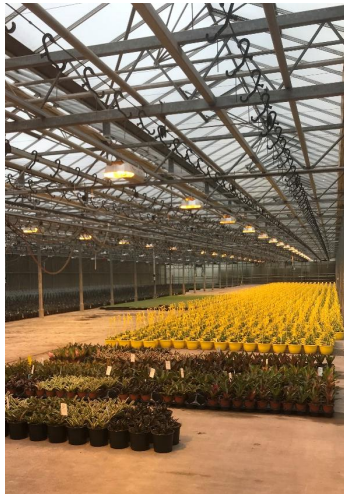
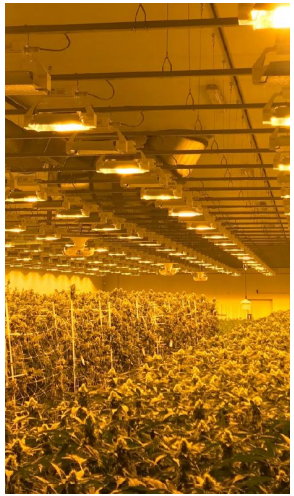
Utility Client Savings

Savings Integrity

Realization Rate

“Typical” CEA Projects

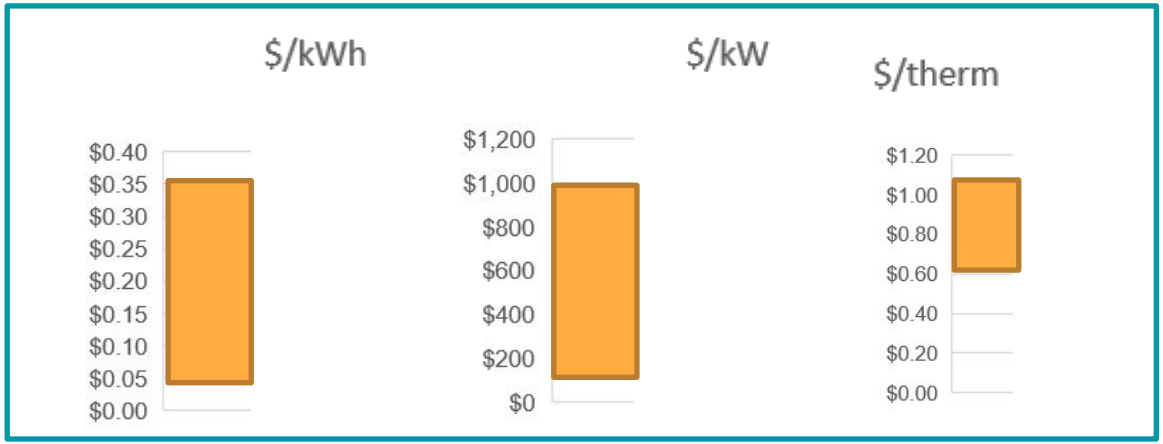



Incentives and Savings

Custom incentives for horticultural projects

- Electric incentives vary – most based on M&V savings and quantified at $/savings
- Some combine kW and kWh
- Incentive caps range widely also - $6k to 75% of total project cost



Incentive ranges for a sample of C&I custom programs

Lighting Controls Savings: Lettuce

Project 1:
4-acre lettuce greenhouse with HPS lighting and threshold/DLI controls

- Real-time evaluation
- Baseline technology Ceramic Metal Halide for leafy greens with on/off controls

Energy Saving Results

3,370,000 kWh/yr
390 kW
$202,000 incentive @ $0.06/kWh
Incentive covered 1/2 control system cost

Project 2:
2.5-acre multi-tier lettuce growing facility with LEDs and advanced controls

- Real-time evaluation
- Baselines for lighting technology is T5HO for leafy greens in vertical system with on/off controls (18 hrs/day)

Expected Energy Saving Results

20M kWh/yr
3000 kW
$500,000 incentive @ $250/kW + $0.02/kWh
Incentive capped at program max

HVAC Controls Savings: Indoor Cannabis

Project 1:
Indoor cannabis "grow pods" with advanced dehumidification system

- Baseline dehumidification system established using California Title 24
- Measured performance and modeled baseline
- Ample data from HVAC controls system but misalignment with growing automation software data

Energy Saving Results
1,465,000 kWh/yr
210.6 kW
$322,000 incentive @ $0.22/kWh

Project 2:
40,000 s.f. indoor cannabis growing operation

- Chiller with hot gas waste heat recovery
- Baseline boiler reheat
- Gas program / lighting also captured

Energy Savings Results
400,000 therms
$140,000 incentive @ $0.80/therm
Incentive capped at ½ incremental cost

Lighting Controls Savings: Greenhouse Cannabis

Project 1:
200,000 s.f. Greenhouse Conversion – produce (unlit) to cannabis

- Baseline cannabis growing is indoor sole-source operation
- Incentives for reduced hours of lighting with DLI/threshold controls
- M&V requires 3 months data to correlate

Energy Saving Results

14,100,000 kWh/yr
1580 kW
Incentives $850,000 (2 projects)

Project 2:
6700-s.f. Cannabis Greenhouse

- Baseline is indoor sole-source operation
- Incentives for reduced hours of lighting with PAR meter for manual threshold control
- Collected 2 months data in late summer using manual logs M&V requires 3 months data to correlate

Energy Saving Results

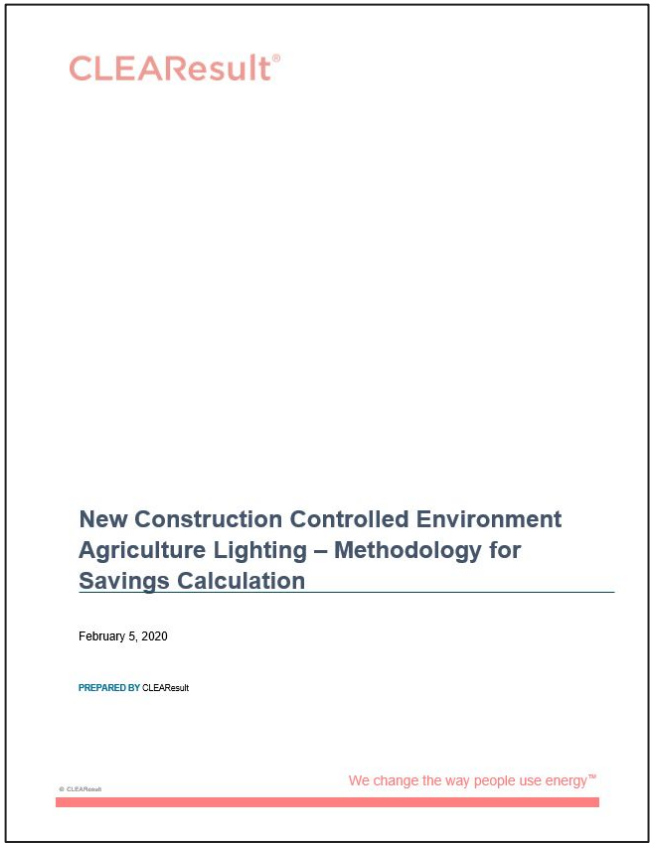
560,700 kWh/yr

32kW

Incentive $123,350

Evaluator Communication for M&V

- Establish baselines
  - Code-minimum
  - Existing equipment
  - Industry standard practices
- Define assumptions
- Collect data
  - The perfect data set is often elusive
  - Balance precision with cost of M&V
- Agree on savings calculation formulas


CLEAResult®

New Construction Controlled Environment Agriculture Lighting – Methodology for Savings Calculation

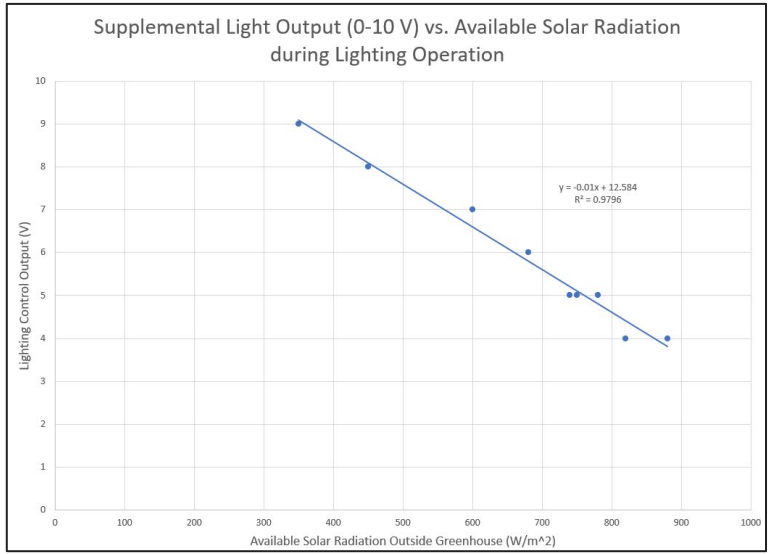
February 5, 2020

PREPARED BY CLEAResult

We change the way people use energy™

Understanding M&V Data

Timestamp	T_{zone1} (°F)	RH_{zone1} (%)	PPFD (Zone 1)	Light Output (0-10V)	T_{amb} (°F)	Solar Radiation (W/m^2)
9/2/21 10:00 AM	75	55	980	5	72	750
9/2/21 11:00 AM	76	54	1020	5	76	780
9/2/21 12:00 PM	77	55	1000	4	77	820
9/2/21 1:00 PM	78	57	1005	4	78	880
9/2/21 2:00 PM	80	55	990	5	79	740
9/2/21 3:00 PM	78	56	995	6	78	680
9/2/21 4:00 PM	77	54	1005	7	78	600
9/2/21 5:00 PM	76	57	1000	8	75	450
9/2/21 6:00 PM	75	58	1000	9	73	350
9/2/21 7:00 PM	75	60	0	0	70	150
9/2/21 8:00 PM	75	61	0	0	68	0

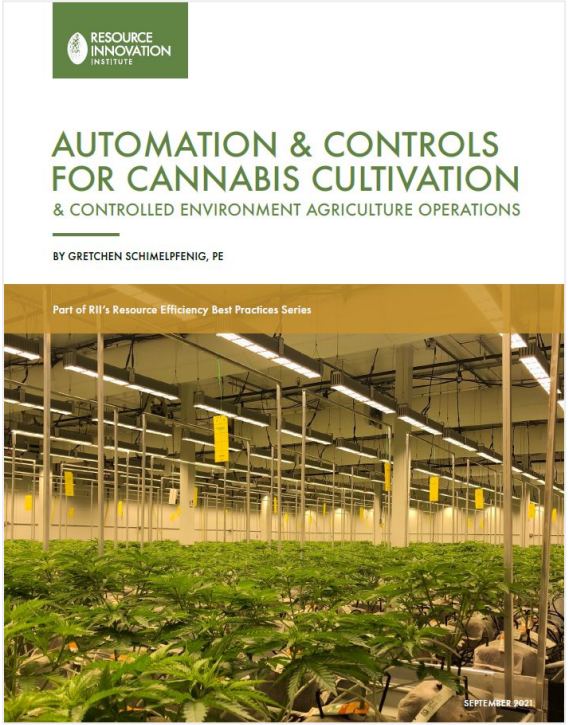


Download the Controls Best Practices Guide

Design baselines for controls informed by best practices

Free guidance for producers, utilities, and efficiency programs

- "Know their grow" and speak the language of horticultural controls
- Understand savings opportunities from controls systems
- Serve greenhouse and indoor cultivator customers
- Use lighting, HVAC, and water baselines for savings calculations
- Ask for the data you need for CEA projects
- Ensure persistent energy savings for your programs



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