RESOURCE INNOVATION INSTITUTE

Efficient Yields
Best practices on energy, water efficiency, and productivity

Indoor Optimization - HVAC & Lighting Best Practices

In partnership with

3C-REN
TRI-COUNTY REGIONAL ENERGY NETWORK
SAN LUIS OBISPO • SANTA BARBARA • VENTURA

February 3, 2022

Agenda

About RII	1:30 pm
Introductions & Purpose	1:35 pm
Best Practices for Advanced Controls & Automation in Cultivation: Indoor	1:45 pm
Understanding California Title 24, Part 6: Energy Codes for CEH	2:00 pm
Indoor Lighting Controls & Automation Best Practices	2:20 pm
Indoor Environmental Controls Best Practices: Avoiding Microclimates for Plant Health	2:40 pm
Efficiency Program Examples	3:00 pm
Q&A	3:15 pm

SECTION 01

WELCOME & ABOUT RII

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

INPUT from industry leaders and partners

RESOURCE INNOVATION INSTITUTE

EDUCATION and advocacy about best practices for growers

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
Facility Design & Construction

ABOUT RII

PowerScore Benchmarking

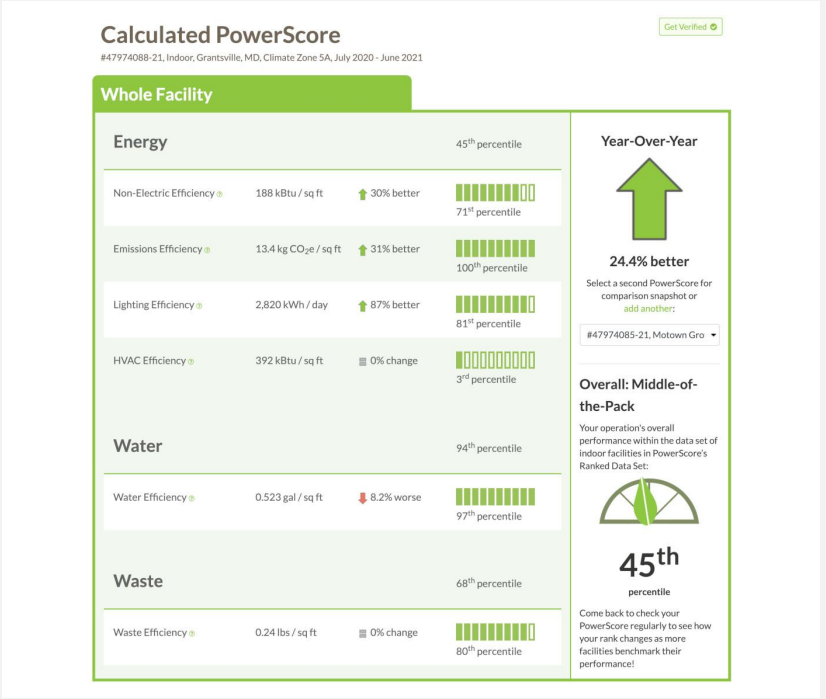
PowerScore

Specialized Key Performance Indicators

- Performance Snapshots
  - Year-over-year energy, water, and emissions rankings
  - Third-party data verification
- PowerScore Comply in select jurisdictions
- Access PowerScore Pro as an RII member
  - Enhanced portfolio management
  - Dashboard reports
  - Filters
  - Access Ranked Data Set

Competitive business insights

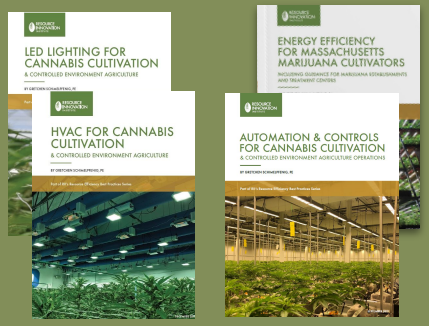
- Get ahead of compliance
- Assess portfolios of facilities to continuously improve
- Prioritize capital projects
- Forecast KPIs for new facilities and retrofits



ABOUT RII

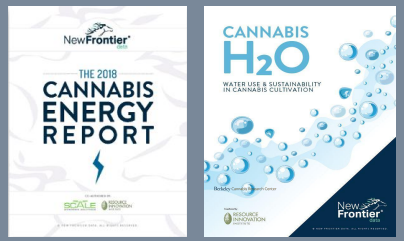
Informing Audiences with Peer-Reviewed Publications

Best Practices Guides
for Producers



Primers
for Governments & Utilities

Collaborative Reports
on Resource Usage

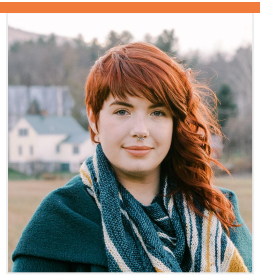


Intelligence Insights
for Members

SECTION 02

INTRODUCTIONS & PURPOSE

Today's Speakers



Gretchen Schimelpfenig

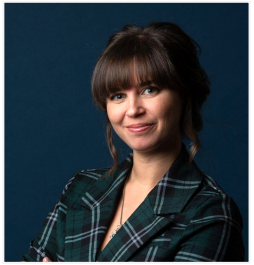
RESOURCE INNOVATION INSTITUTE

Neda Vaseghi

microclimates™ Integrate Automate Accelerate

Dario Boyce

ANDERSON PORTER DESIGN



Corinne Wilder

FLUENCE BY OSRAM

Anders Peterson

INSPIRE

Eric Noller

ERI

3C-REN: Tri-County Regional Energy Network

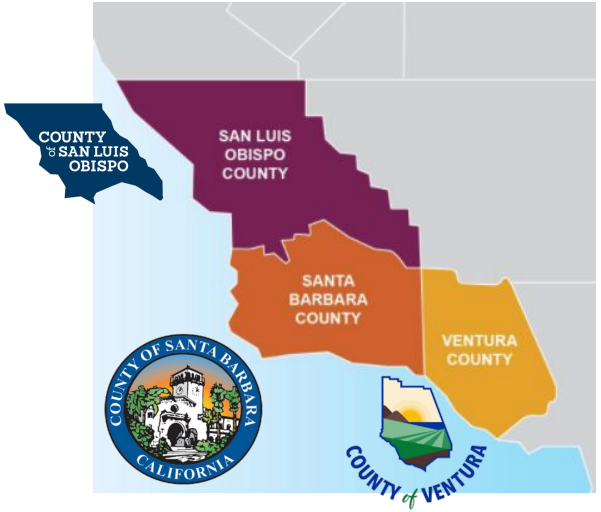
Three counties working together to improve energy efficiency in the region with free programs:

- Energy Code Connect
  - Industry Trainings and Forums
  - Energy Code Coach: Title 24 Compliance Support Hotline (805) 220-9991
- Building Performance Training
  - Training & certification for current and prospective building professionals
  - Helps workers thrive in an evolving industry
- Home Energy Savings
  - Improves home comfort and safety
  - Owners & Renters; Multifamily & Single Family
- Upcoming Courses

3C REN

TRI-COUNTY REGIONAL ENERGY NETWORK

SAN LUIS OBISPO • SANTA BARBARA • VENTURA



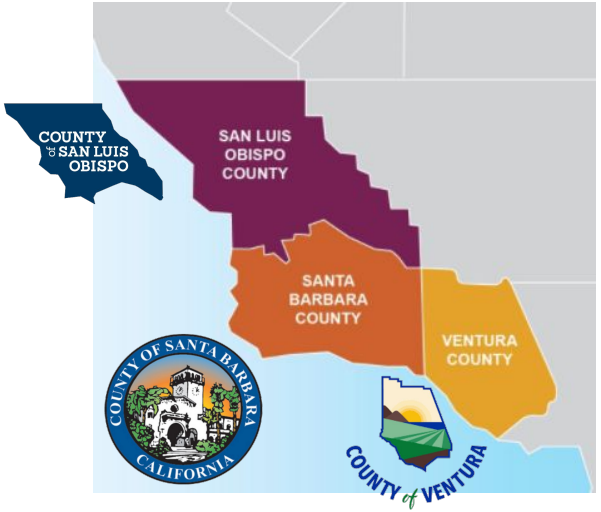
Purpose of Today's Workshop

- Help cannabis producers improve the efficiency of their operations with environmental control systems
- Convey scientific insights directly to producers and finding the best ways to translate them in the context of a local ecosystem
- Help government agencies and energy efficiency programs achieve their climate goals through knowledge sharing
- Encourage cultivators to take advantage of 3C-REN resources to support compliance with County energy conservation plans

3C-REN

TRI-COUNTY REGIONAL ENERGY NETWORK

SAN LUIS OBISPO • SANTA BARBARA • VENTURA



Access Your Tri-County Virtual Classroom

Access the virtual classroom to continue learning

Free guidance on efficient cannabis cultivation

All live workshops are available for on-demand viewing!

- Recordings of live workshops
- Tip Clips
- Downloadable resources
- 3C-REN tools

Create an account at
ResourceInnovation.org/Tri-County

Register for the Last Workshop

Access the virtual classroom to continue learning

Free guidance on efficient cannabis cultivation

All live workshops are available for on-demand viewing!

- Apr 7, 2022
  - Sungrown Efficiency - Optimizing the Energy-Water Nexus

Efficient Yields

Best practices on energy, water efficiency, and productivity

SUNGROWN EFFICIENCY

OPTIMIZING ENERGY-WATER NEXUS

RESOURCE INNOVATION INSTITUTE

3C-REN

Apr. 7, 2022

SECTION 03

ADVANCED CONTROLS & AUTOMATION: INDOOR

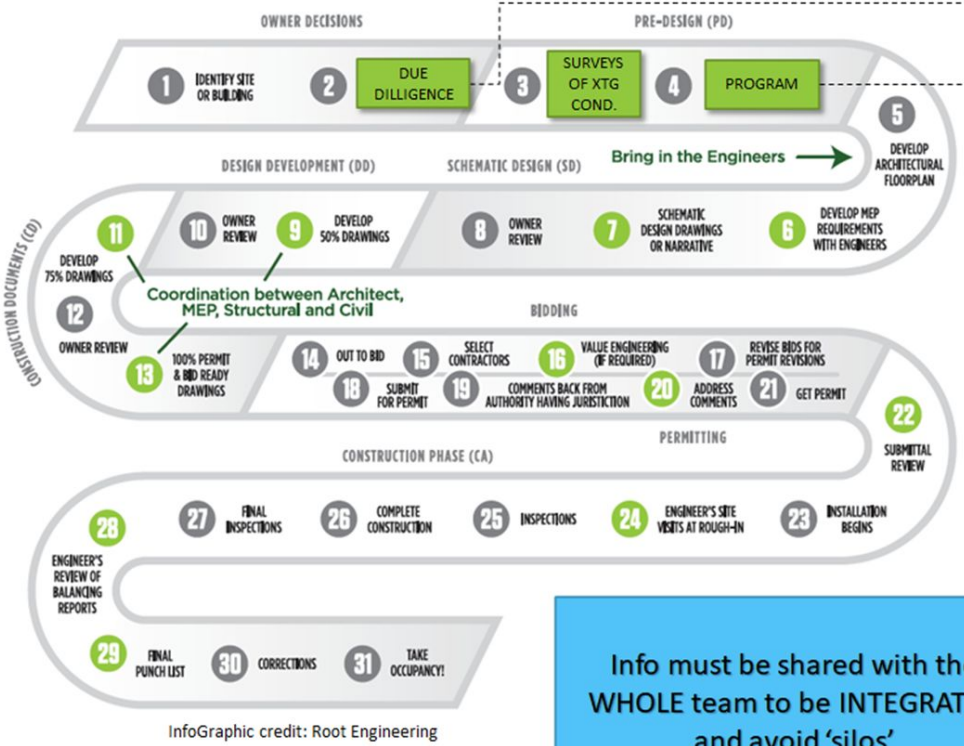
First Understand Your Building

- What utilities are available?
  - Do you need to upgrade any of them?

- What is the structural capacity of the building?
  - Get a Chapter 34 done is possible to understand:
    - Roof capacity
    - Seismic and shear loads

- How tight is your envelope?
  - Get an envelopment analysis done to understand:
    - Base building improvements needed

Image credit: Solar Therapeutics



InfoGraphic credit: Root Engineering

STRUCTURAL CAPACITY?
UTILITIES – ELECT, WATER, GAS?
ENVIRONMENTAL – HazMat?

- **TO ESTABLISH A PROPER FACILITY PROGRAM, OWNERSHIP MUST RECORD, AND SHARE THE FOLLOWING INFO:**

KPIs / KPTs KEY PERFORMANCE INDICATORS / TARGETS

- grams/sf or /kWh or /gal of water
- biomass of production / total cost
- Manuf. Units of production / total cost

HORTICULTURE/GROW NARRATIVE

- LIGHTING CHOICE by growth phase
- BENCH / RACK
- PLANT PER SQ FT
- WATER CONSUMPTION RATE
- CO_2 ENRICHMENT
- SOIL/MEDIA CHOICE
- CROP CYCLE – in days. CYCLES /YR

MANUFACTURING NARRATIVE

- MENU – OF PRODUCTS
- VOLUME – UNITS/SHIFT/DAY/YR
- INGREDIENTS – STORAGE CAPACITY

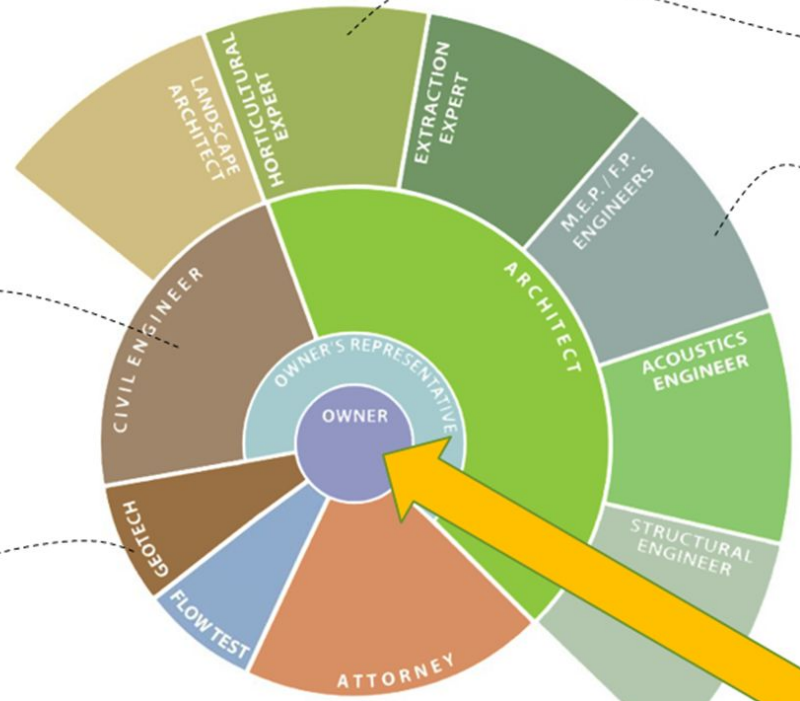
FACILITY GOALS

- MIXED LIGHT GREEHOUSE or CEH
- OPERATIONS – PERSONNEL TARGETS
- BUILDING TYPE – RENO OR NEW BUILD

Info must be shared with the WHOLE team to be INTEGRATED and avoid 'silos'

Image credit: Root Engineering

INTEGRATED PROJECT DELIVERY = **TEAM COORDINATION**



Horticulture Specifications and Vendor Coordination

Primary Building Systems and Controls

Parking
Truck access
Site Design

Soils Quality and Bearing Capacity

Owner sets the **Conditions of Satisfaction**

The Construction Manager / General Contractor should be part of the team early

Image credit: Anderson Porter Design

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.

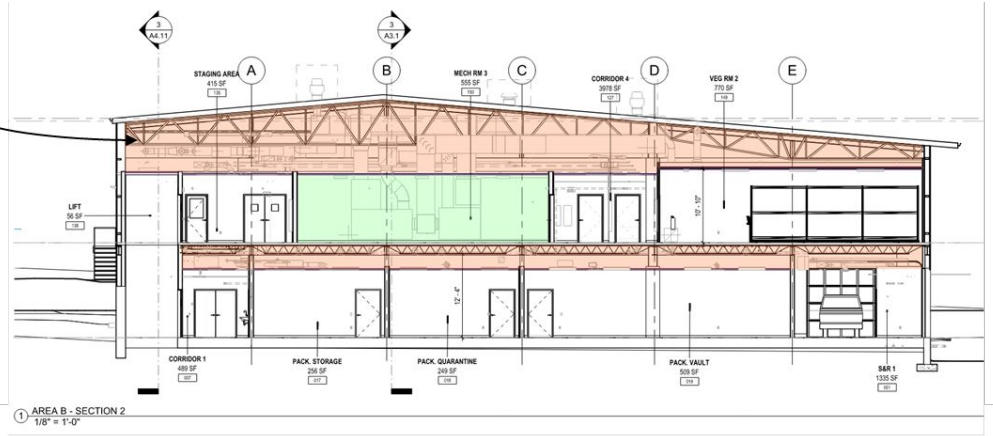
Plants are trimmed and stored in vault, occasionally opened for curing. They will stay here until testing is complete and the product is released to retail or further processing.

Credit: Zartarian Engineering

Structural capacity is importance

The space above the ceiling is critical

What can't fit above must live on the floor



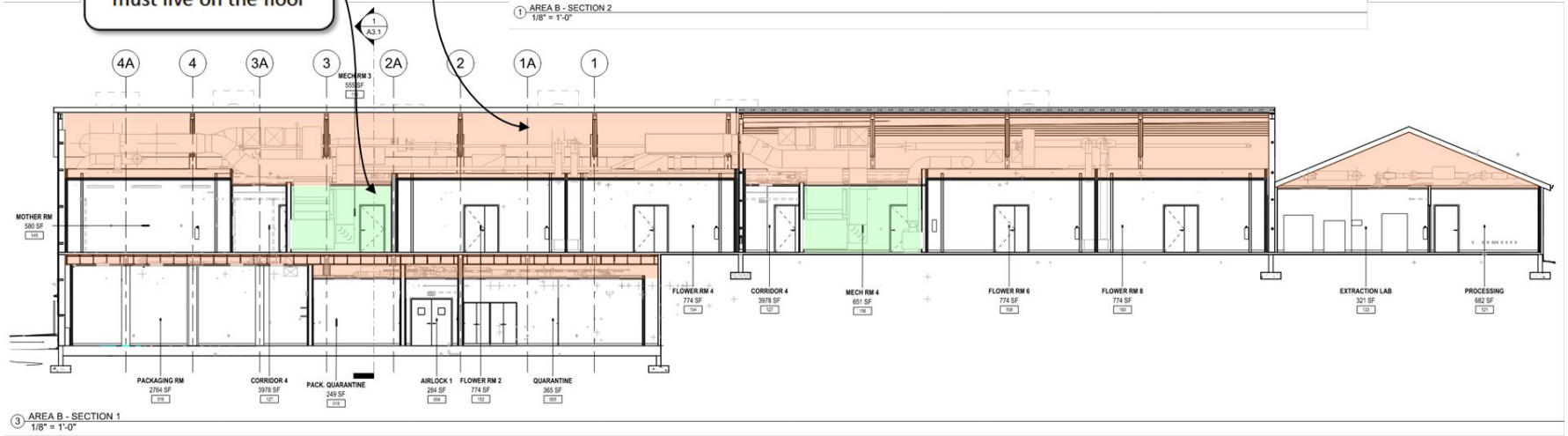


Image credit: Anderson Porter Design

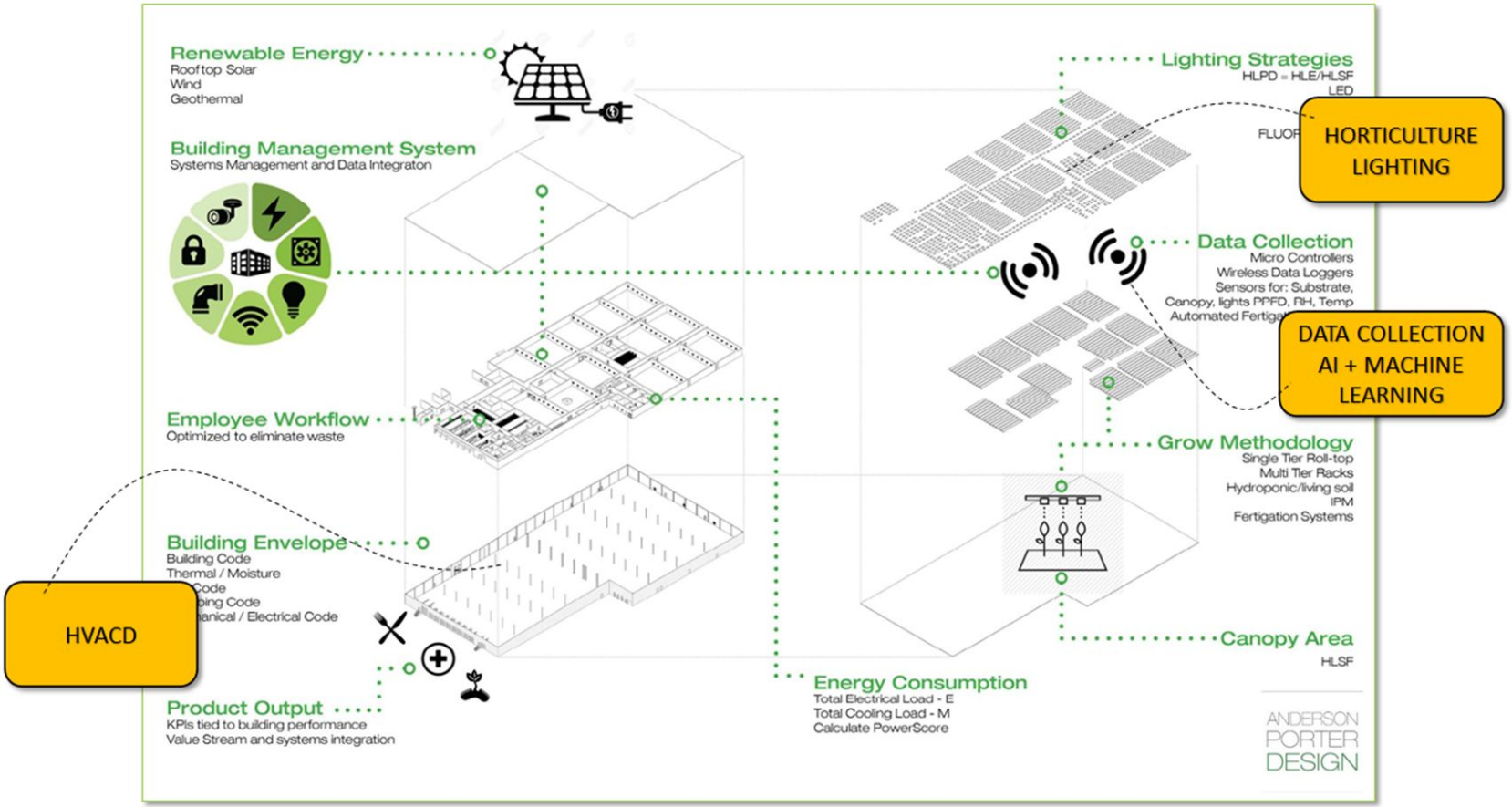
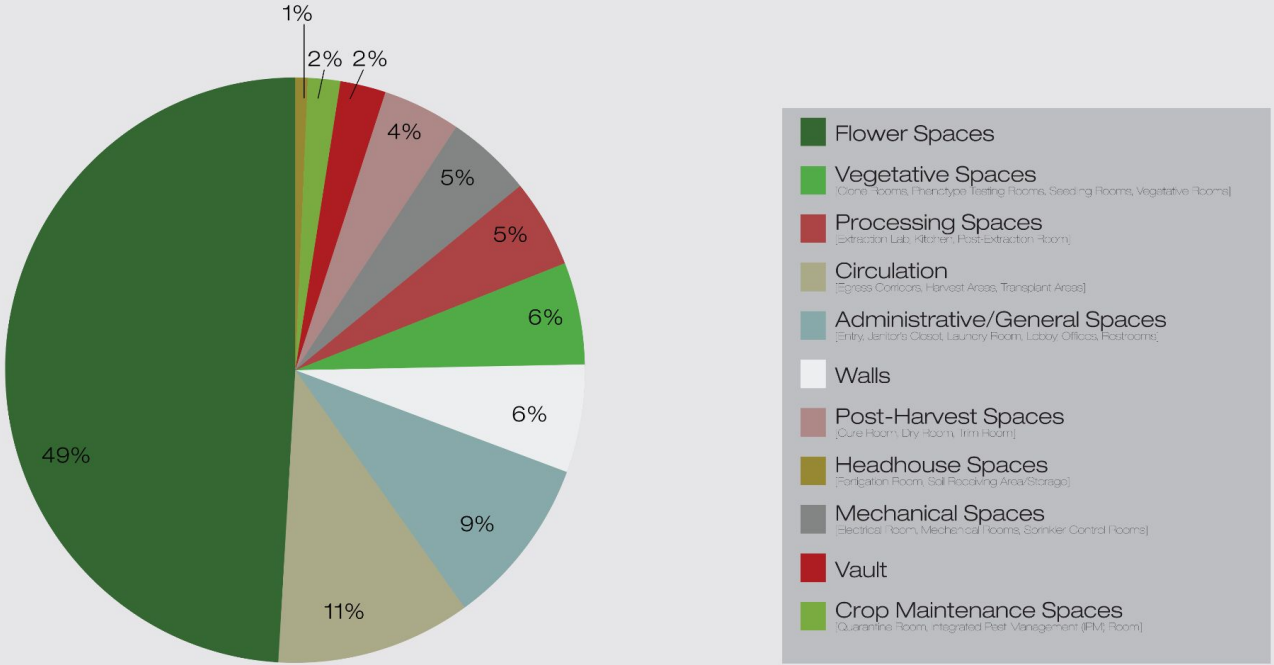


Image credit: Anderson Porter Design

Cultivation Program Analysis



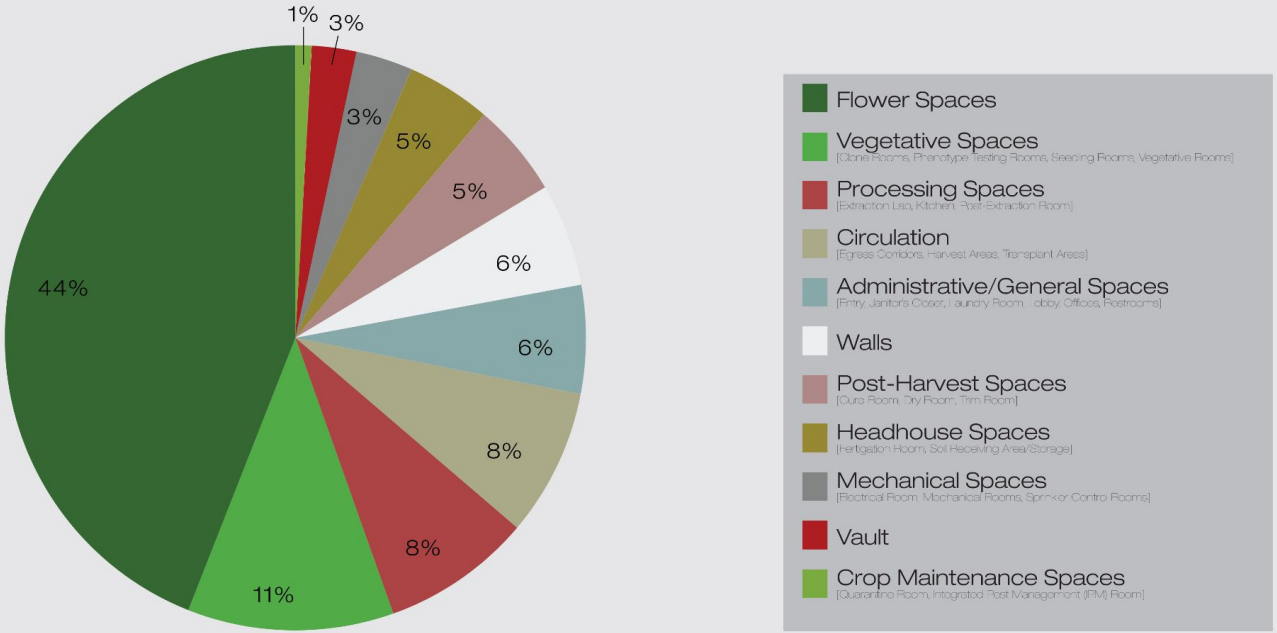
Hybrid Light Fixtures | Indoor Grow Facility | Air Rotation System

110,000 GSF

ANDERSON PORTER DESIGN

Image credit: Anderson Porter Design

Cultivation Program Analysis



Hybrid Light Fixtures | Indoor Grow Facility | Chilled Water System
36,000 GSF

ANDERSON PORTER DESIGN

Image credit: Anderson Porter Design

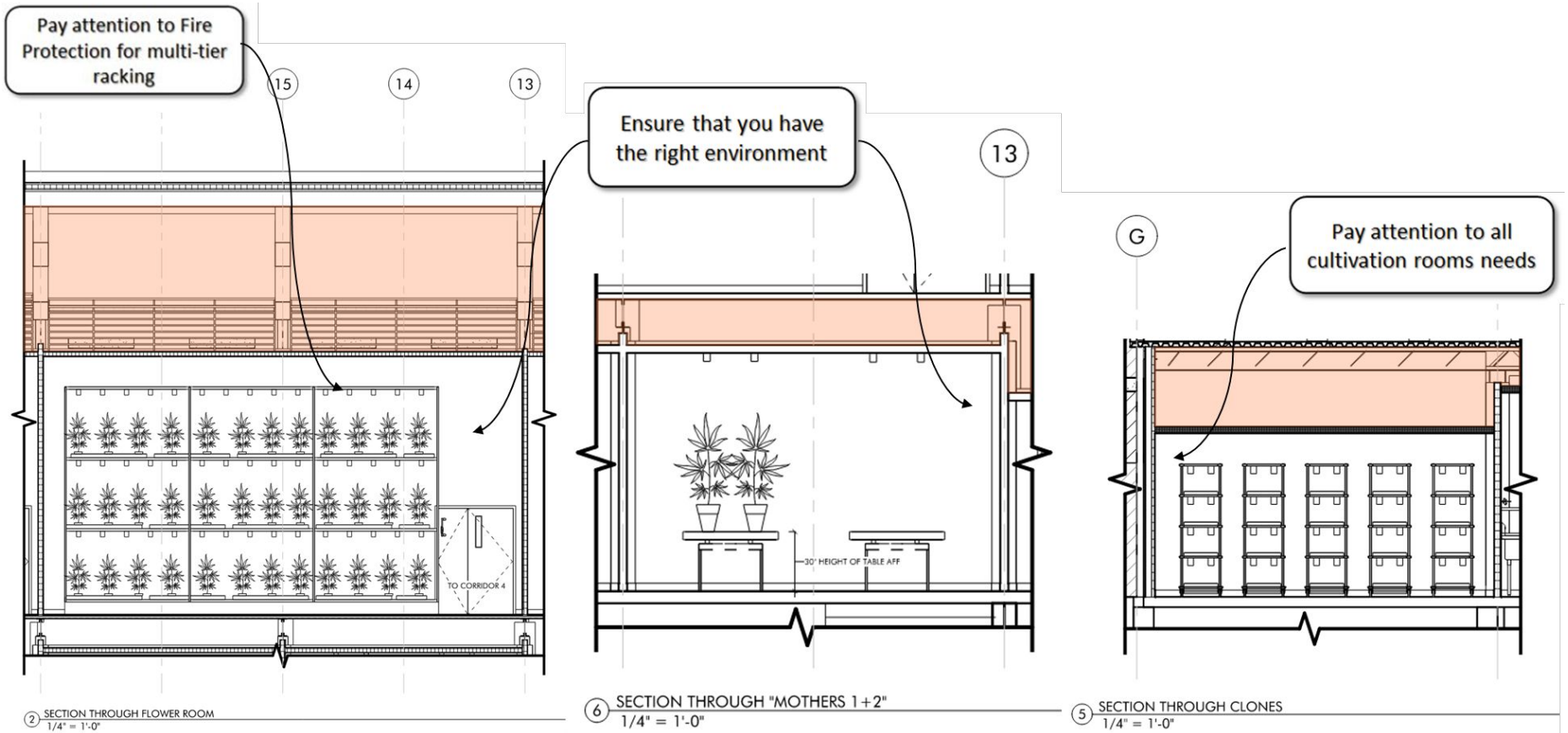


Image credit: Anderson Porter Design

Managing Energy with Controls

Sources of Energy Use

Cultivation operations may use:

Electricity

- Electricity for horticultural lighting
- Electricity for HVAC processes
- Electricity for motors:
  - Pumping water
  - Actuating greenhouse vents
  - Running fans

Fuel (natural gas, propane)

- Fuel for heating processes
- Fuel for combined heat and power (CHP)

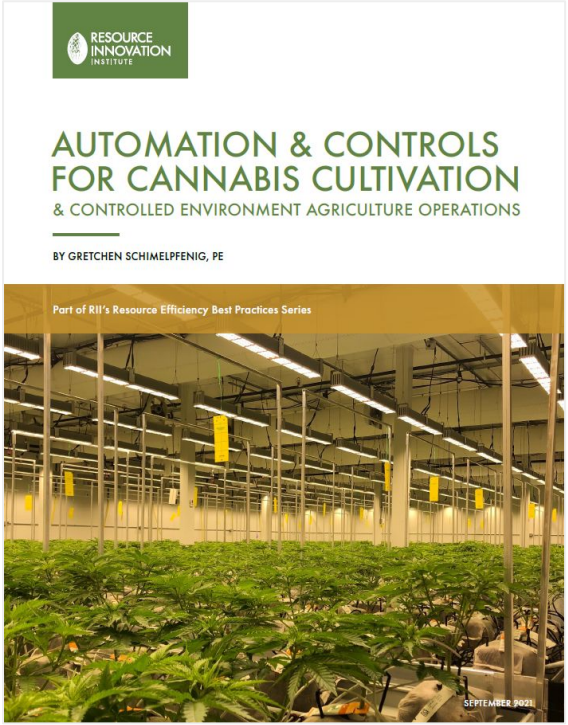
Image credit: Solar Therapeutics

Download the Controls Best Practices Guide

Brand-agnostic information for producers

Free guidance on lighting, HVAC, and water controls

- 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

Start Your Journey to Automation

Increase Productivity & Efficiency

- Continual Improvement to stay competitive
  - Consistent yields
  - Verifiable results

Controls Considerations

- Wired vs wireless control systems
- Sensor placement
- Point of control
- Resolution & accuracy
- Integration
- Maintenance

Fully Integrated Controls

- **Remove Human Error & Inefficiencies**
  - Understand your process before you integrate it
- **Integration benefits**
  - Reduce wear and tear
  - Improve control
  - Save energy
  - Save water
  - Real time data for troubleshooting

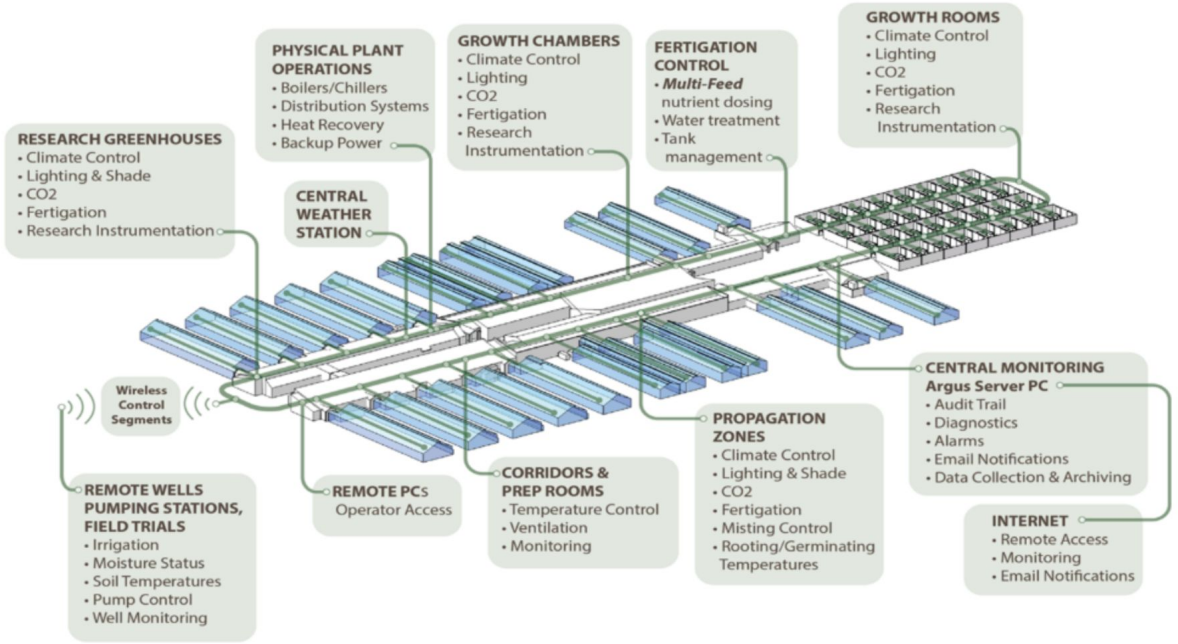


Image credit: Argus Controls

Benefits of Commissioning

Ensure Mission-Critical Systems Perform Optimally

- Improve maintenance procedures
- Save staff time
- Reduce operations & maintenance expenses
- Save energy: 3% and 12% for industrial facilities
- Verify systems respond as expected
- Validate resource efficiency
- Resolve problems before product at risk
- Avoid expensive fixes requiring shutdowns in operation

CANNABIS BUSINESS TIMES

Reduce Expenses by Commissioning Your Cannabis Facility

READ MORE

Design-Phase Commissioning

Third-Party Review of Project Design Docs

- Review Owner's Project Requirements (OPR) including target setpoints, standard operating procedures, failure conditions
- Assist design team with creating Basis of Design (BOD)
- Develop a commissioning plan
- Perform design review of drawings
- Review equipment submittals
- Identify issues & suggest adjustments

STEP 1:
Design Phase Commissioning
Timeframe: months - can seamlessly connect to construction phase commissioning

Design-Phase Commissioning

Early Engagement to Plan Controls

- Design for annual production
  - All seasons and consistent production
- Understand interactive effects on systems:
  - Power
  - HVAC and humidity management
  - Water
- Plan your controls system responses to conditions outside of target ranges

Image credit: Fluence

Construction-Phase Commissioning

Performance Testing to Validate Controls

- Multistage process involving several project team members:
  - Construction manager
  - Controls contractor
  - Commissioning agent
- Create prefunctional checklists and functional performance tests and work with controls contractors to witness and record all functional tests
- Identify issues in the field and issue reports recommending resolutions
- Create staff training agendas
- Produce a final commissioning report
- Ensure that Contractors have provided operations and maintenance (O&M) manuals

SECTION 04

CALIFORNIA TITLE 24 PART 6

Upcoming Code Changes: HVAC

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Read the Final CASE Report

Dehumidification Equipment Standards

Dehumidification equipment shall be one of the following:

1. Stand-alone dehumidifiers that meet minimum integrated energy factors:
    - Minimum integrated energy factor of 1.77 L/kWh for product case volumes of 8.0 ft^3 or less
    - Minimum integrated energy factor of 2.41 L/kWh for product case volumes greater than 8.0 ft^3
2. Integrated HVAC system with on-site heat recovery designed to fulfill at least 75% of the annual energy for dehumidification reheat
3. Chilled water system with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat
4. Solid or liquid desiccant dehumidification system for system designs that require dewpoint of 50°F or less

Upcoming Code Changes: Lighting

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Read the Final CASE Report

Indoor Growing, Horticultural Lighting

In a building with CEH spaces and with more than 40 kW of aggregate horticultural lighting load, the electric lighting systems used for plant growth and plant maintenance shall meet the following requirements:

1. Luminaires shall have a photosynthetic photon efficacy of at least ***1.9 micromoles per joule*** rated in accordance with ANSI / ASABE S640 for wavelengths from 400 to 700 nanometers.

2. Time-switch lighting controls shall be installed and comply with Section 110.9(b)1, Section 130.4(a)4, and applicable sections of NA7.6.2.

3. Multilevel lighting controls shall be installed and comply with Section 130.1(b).

Horticultural Lighting Options – Fixture Choices

	FLUORESCENTS		HIGH-INTENSITY DISCHARGE (HID)			LEDs
	T8 *Linear, Tube*	T5 *Linear, Tub*	DE HPS *High Pressure Sodium*	MH *Metal Halide*	CMH *Ceramic Metal Halide*	LED *Light-Emitting Diode*
Spectrum	Balanced	Well Balanced	Warm (Yellow-Red)	Cool (Blue-Green)	Well Balanced	Custom (Balanced)
Initial Cost	Low	Medium	Medium	Medium	Medium-High	Low - High
Power Draw	Low / 32W	Medium / 54W	Med / 400-1000W	Med / 400-1000W	Med / 400-1000W	Low-High / 100-800W
Efficiency	Low	Low-Good	Better	Better	Best	Good - Best
µmol/j	0.8 - 1.0	0.9 - 1.2	1.9 - 2.1	1.7 - 1.8	1.6-1.9	1.8 - 3.7
Lifetime (hrs)	12,000	12,000	5,000 - 10,000	6,000-12,000	5,000	≥36,000

Image credit: Fluence by OSRAM

Upcoming Indoor Code Changes

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Read the Final CASE Report

Indoor Growing, Electrical Power Distribution Systems

Electrical power distribution system serving CEH spaces shall be designed so that a measurement device is capable of monitoring the electrical energy usage of aggregate horticultural lighting load.

SECTION 05

LIGHTING CONTROLS & AUTOMATION

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: Grownetics

Key Lighting Terms

PAR

Photosynthetic Active Radiation

PAR light is the wavelengths of light within the visible range of 400 to 700 nanometers, which drive photosynthesis.

PPF

Photosynthetic Photon Flux

PPF measures the total amount of PAR that is produced by a lighting system each second.

PPFD

Photosynthetic Photon Flux Density

PPFD measures the number of photosynthetically active photons that fall on a given surface each second.

DLI

Daily Light Integral

DLI is the total number of photons of PAR accumulated over one given area, over one 24-hour period.

Image credit: Fluence by OSRAM

Spectra Choices

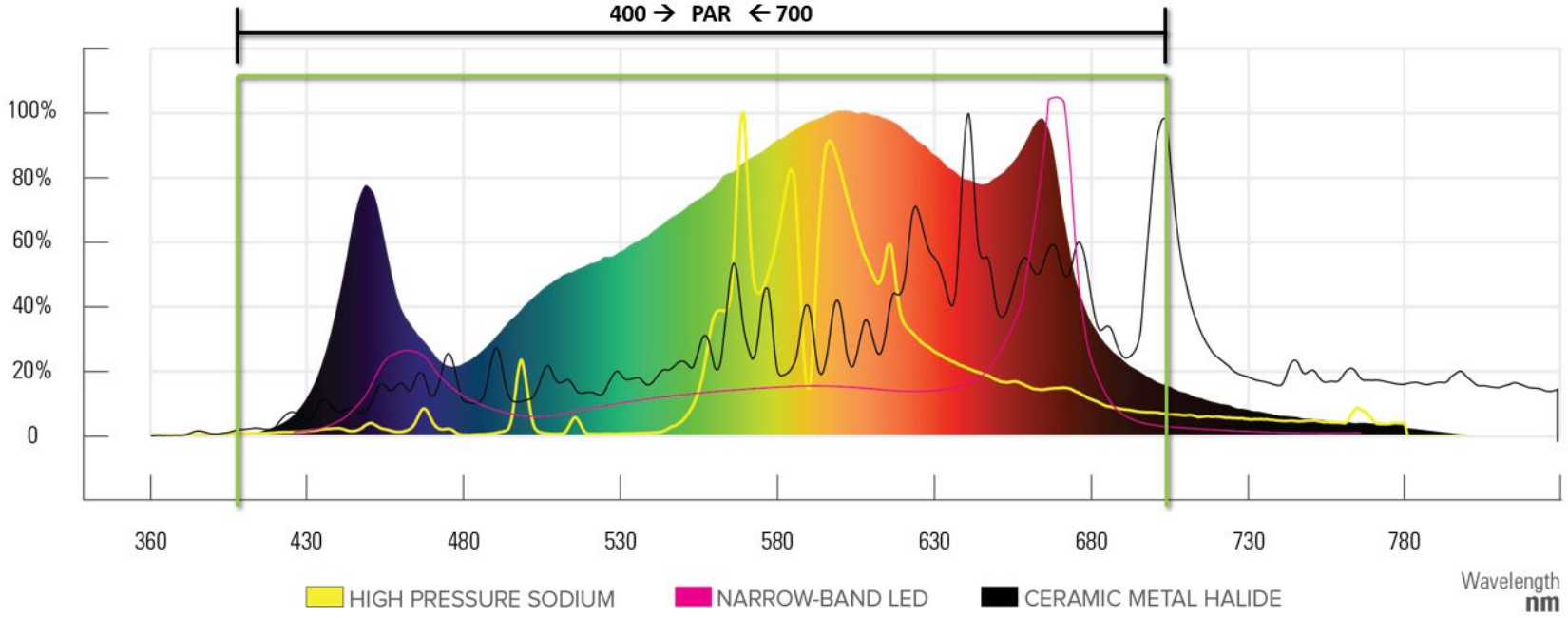


Image credit: Fluence by OSRAM

Designing Lighting Controls Systems

Planning Lighting Controls

- Facility location
- Crop being grown
- Growing seasons
- Cost vs. performance
- Perpetual harvest
- Maximizing production
- Balancing efficiency

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

Figure credit: Solar Therapeutics

Indoor VS Greenhouse Strategy

Indoor cultivation facilities rely on **sole-source lighting** designs to provide the required PPFD intensity for the plants growth stage.

The spacing of lighting fixtures can vary, but typical footprints range from 8-25 ft^2.

Greenhouse operations take advantage of existing sunlight – allowing for **supplemental lighting** designs.

These allow wider spacing of lighting fixtures with an average of 40-80 ft^2 footprint.

Image credit: Fluence by OSRAM

Designing Lighting Controls

Power and Light Planning

- Pre-install design, mapping, PPFD
- Configuration vs commissioning
- Post-install verification
- Ties to Rebates for SCE! (M&V)

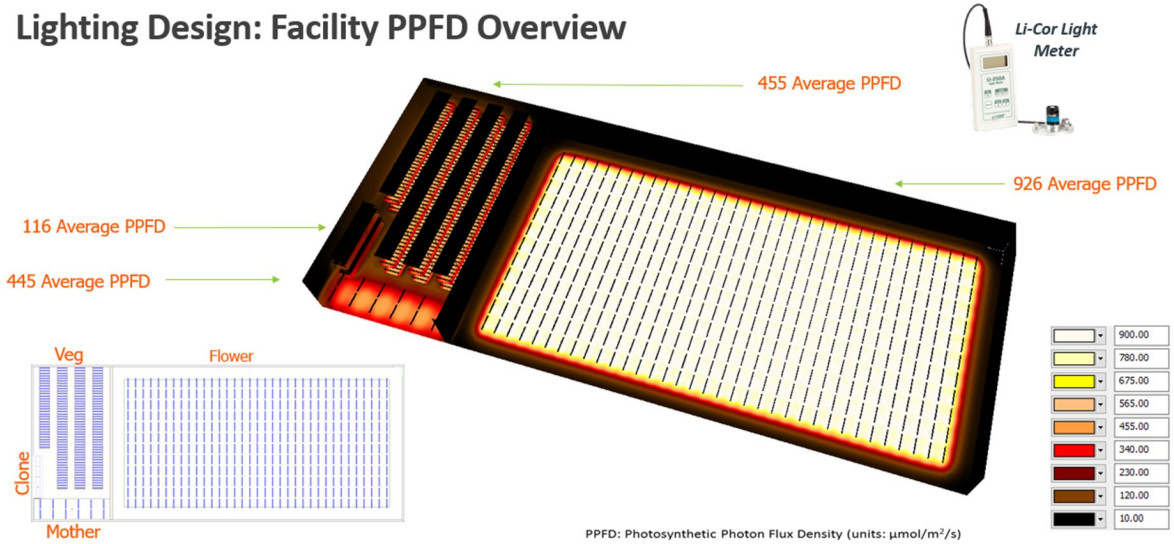


Image credit: Fluence by OSRAM

Specify Control Parameters

Target Ranges for Best Outcomes for Plants

- PPFD
- DLI

Determine the information sensors will use to modulate equipment output to meet thresholds

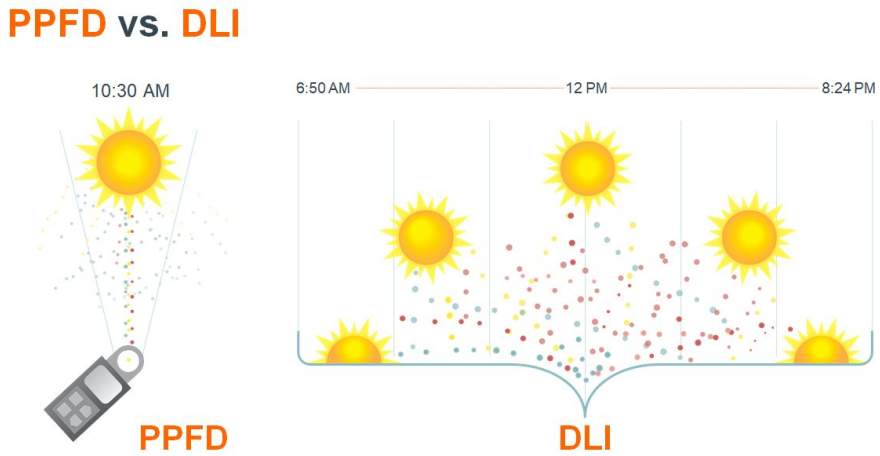
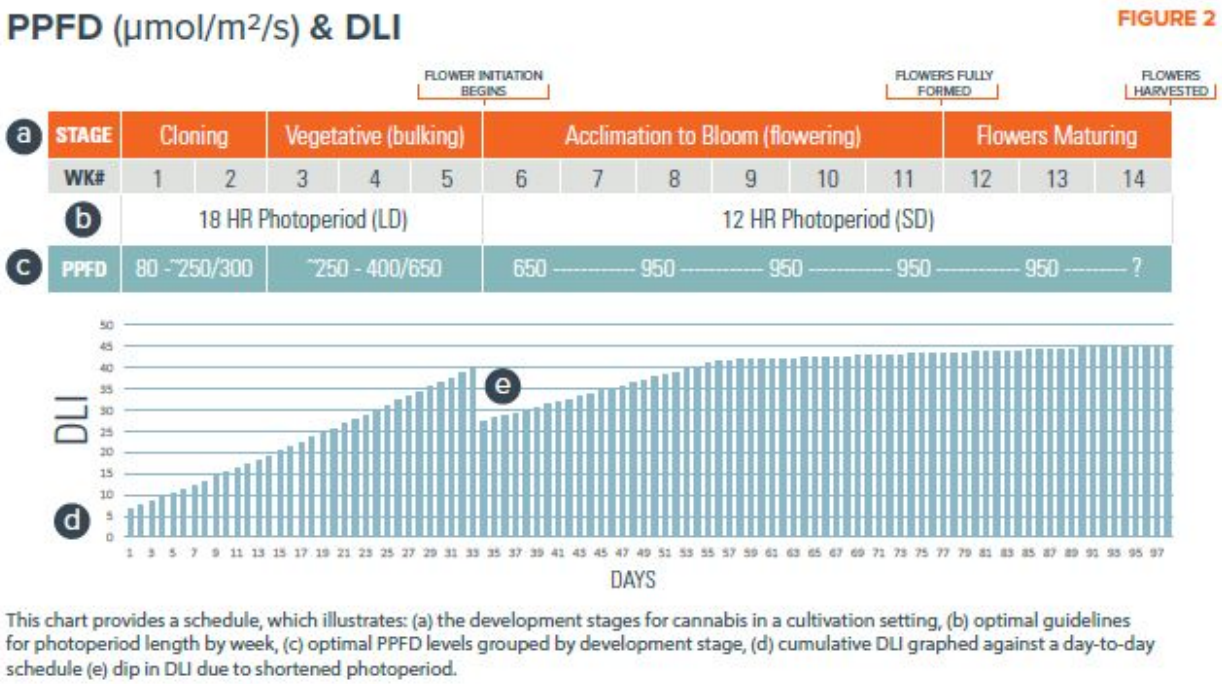


Image credit: Fluence by OSRAM

Recommended PPFD and Photoperiod by Stage of Development



This chart provides a schedule, which illustrates: (a) the development stages for cannabis in a cultivation setting, (b) optimal guidelines for photoperiod length by week, (c) optimal PPFD levels grouped by development stage, (d) cumulative DLI graphed against a day-to-day schedule (e) dip in DLI due to shortened photoperiod.

Image credit: Fluence by OSRAM

Lighting Controls Strategies

Scheduling

- Adjust photoperiod
- Strategic time-of-use scheduling →

Dimming

- Modulate light intensity by zone of control
  - Daily
  - By stage of plant growth
  - Gradually vs “On/Off” (aka Sunrise/Sunset)

Spectral Tuning

- Modulate photon output from wavelength ranges

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

Feed-Forward Controls for Lighting

Lighting Benefits from Predictive Controls

- Predictive controls and cost-effectiveness
  - Weather
  - Peak demand
  - Shade control integration
  - Photoperiods
  - DLI

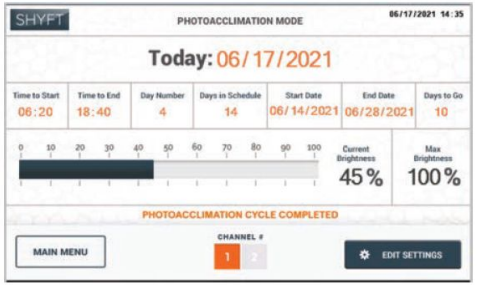
Map Your Controls and Responses

  - Zones
  - Dimming
  - Response rates
  - Ambient conditions and interactive effects

Commissioning Lighting Controls

Target Setpoints

- Set Zones
- Control Ranges
- Identify Targets:
  - Photoperiod / DLI
  - Photoacclimation
- Manage plant needs + energy needs



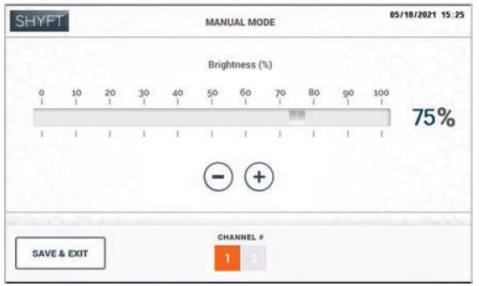


Image credit: Fluence by OSRAM

Commissioning Lighting Controls

Advanced Lighting Systems

- Verification of installation
- Remote monitoring
- Integrated startup and commissioning
- Networked interface
- Interactive GUI
- Reporting and metrics and verification

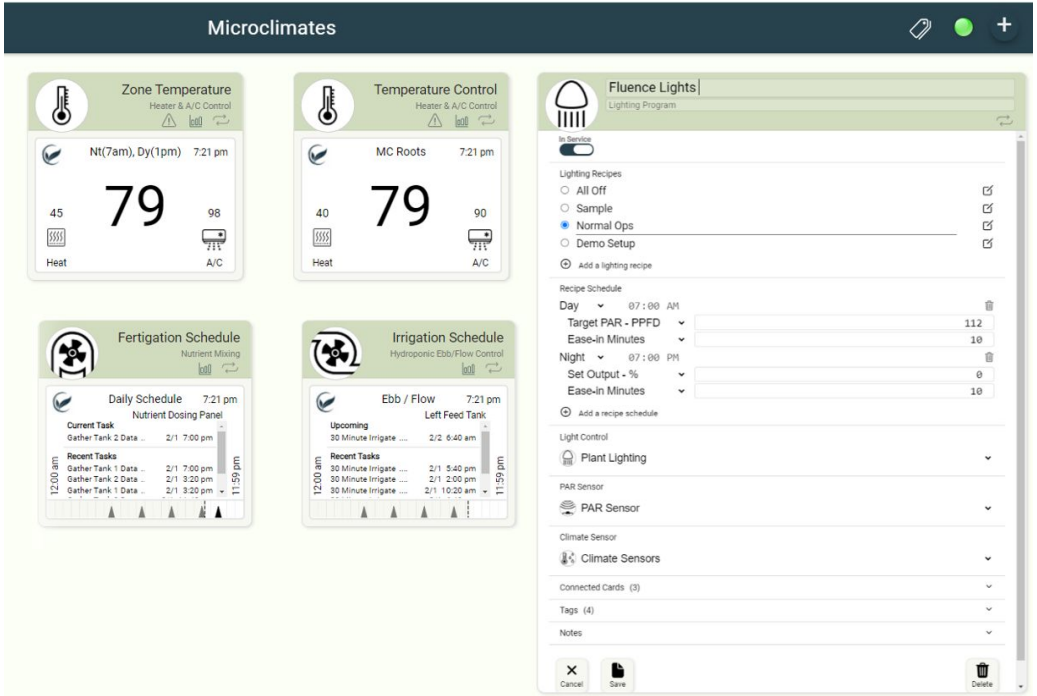


Image credit: Microclimates

Lighting and Environmental Controls

Lighting Interactive Effects

- Ambient conditions can affect demand for lighting (schedule and intensity)
  - Greenhouses have dynamic temperature, humidity, CO_2

Systems Affected by Lighting

- HVAC and humidity management
- Fertigation
- Curtain controls

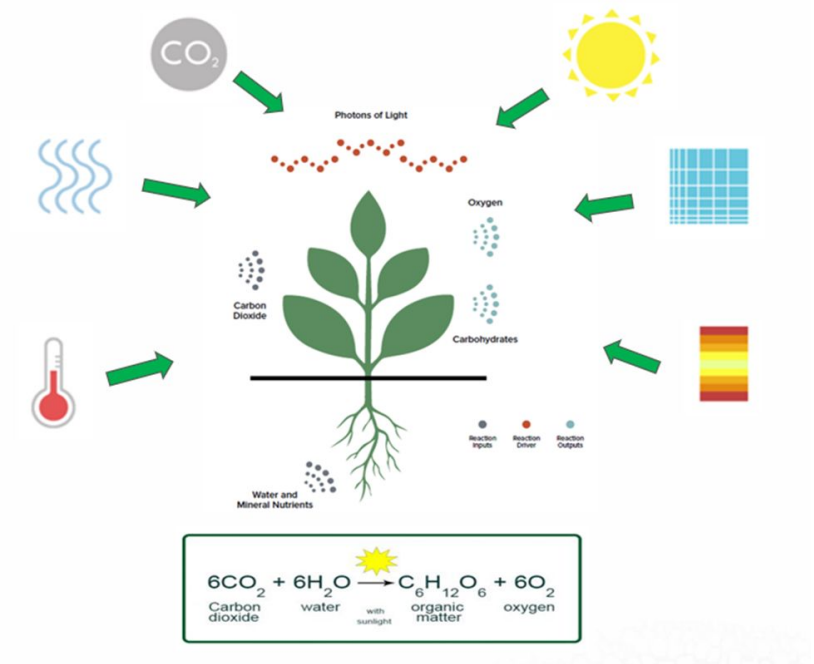


Image credit: Fluence by OSRAM

Dive Deeper into Lighting Controls

The Right Light

CANNABIS BUSINESS TIMES

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How Manipulating Light Treatments Affects Plant Expression

CANNABIS BUSINESS TIMES

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

cannabis science and technology
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SECTION 06

ENVIRONMENTAL CONTROLS: AVOIDING MICROCLIMATES

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

Image credit: The Grove

HVACD for Controlled Environment Agriculture

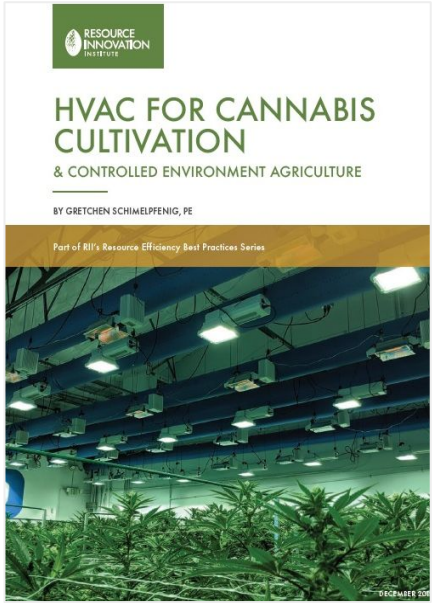
Demystifying Key Terms

- Cultivation
- Energy & Power
- Environmental Conditions
- General HVAC
- Energy Efficiency
- Construction
- Cultivation Key Performance Indicators (KPIs)

Key Concepts

Understand HVAC options

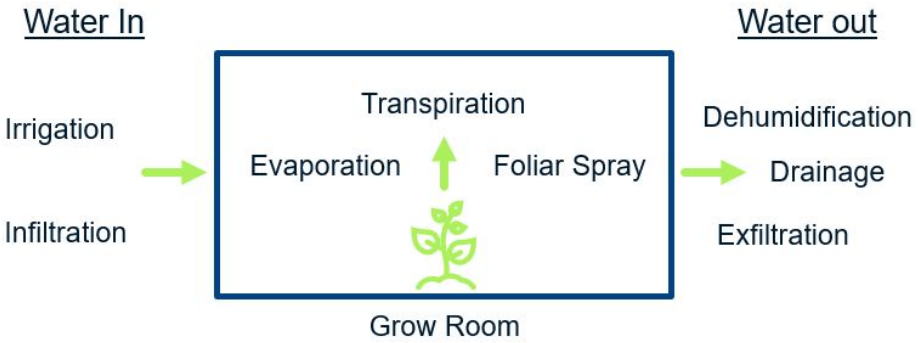
Learn tips for optimizing design, installing equipment, and operating HVAC systems effectively



DOWNLOAD NOW

HVAC Design: Dynamic Spaces

- Sealed cultivation spaces, particularly cannabis flower/bloom areas, generate substantial and dynamic loads.
  - Loads shift dramatically during the lights on to off transition periods.
  - Loads change throughout the course of a flowering cycle as plants mature and transpiration rates increase



To design and operate efficient HVACD systems, we need to understand what is happening in these spaces throughout the harvest cycle.

Figure credit: InSpire Transpiration Solutions

Traditional Indoor HVAC Systems

Non-Integrated Systems

- Standalone Dehumidifiers
- Air Conditioning Units
  - RTU's, Splits, VRF, or CW FCU's
- Oscillating Wall Fans

Considerations

- A/C units must overcome heat rejected by dehumidifiers
- Standard commercial HVAC cannot handle unique load profiles
- Difficult to control/integrate; lack of homogeneity

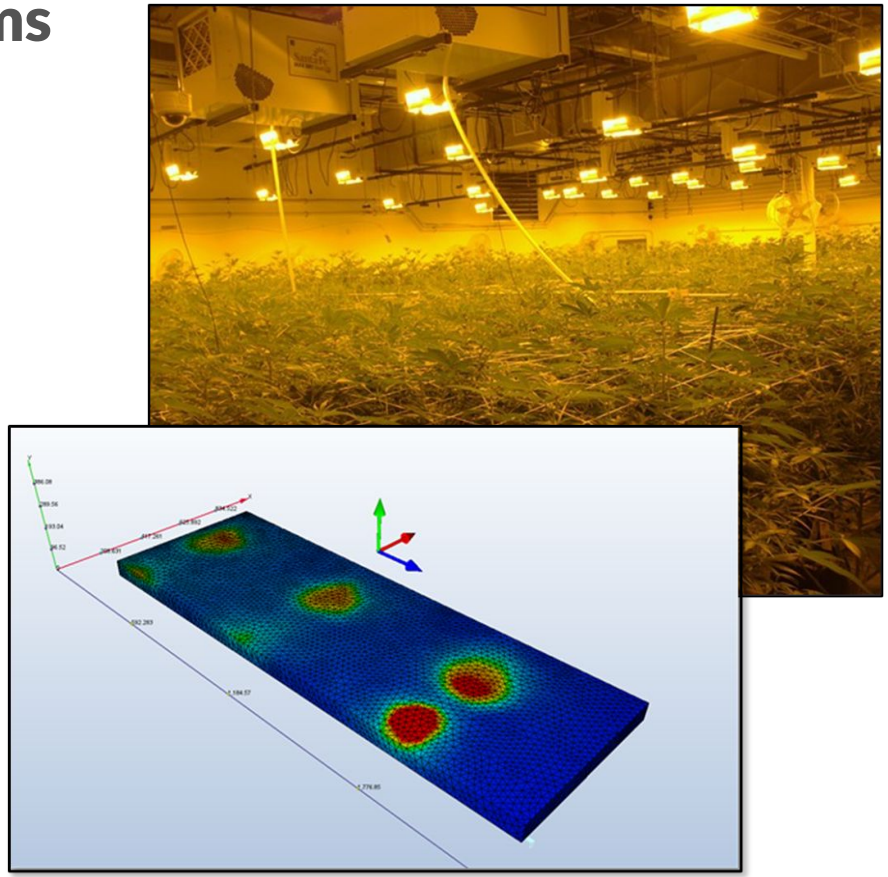


Figure credit: InSpire Transpiration Solutions

High-Performance Indoor HVAC Systems

Integrated Systems

- One system to handle cooling, heating, and dehumidification.
- System types include: DX w/ reheat, desiccants, and CW/HW

Considerations

- Purpose built for indoor horticulture
- Modulating components to match load profiles
- Proper room airflow design for good mixing & homogeneity
- Opportunities for energy efficiency

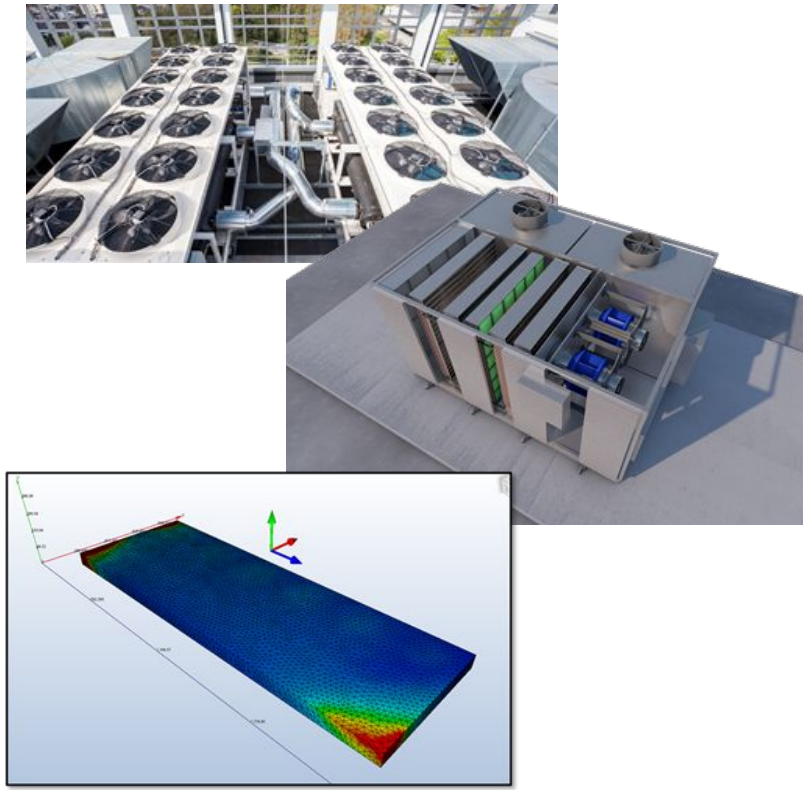


Figure credit: InSpire Transpiration Solutions

HVAC Controls Parameters

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 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%

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

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

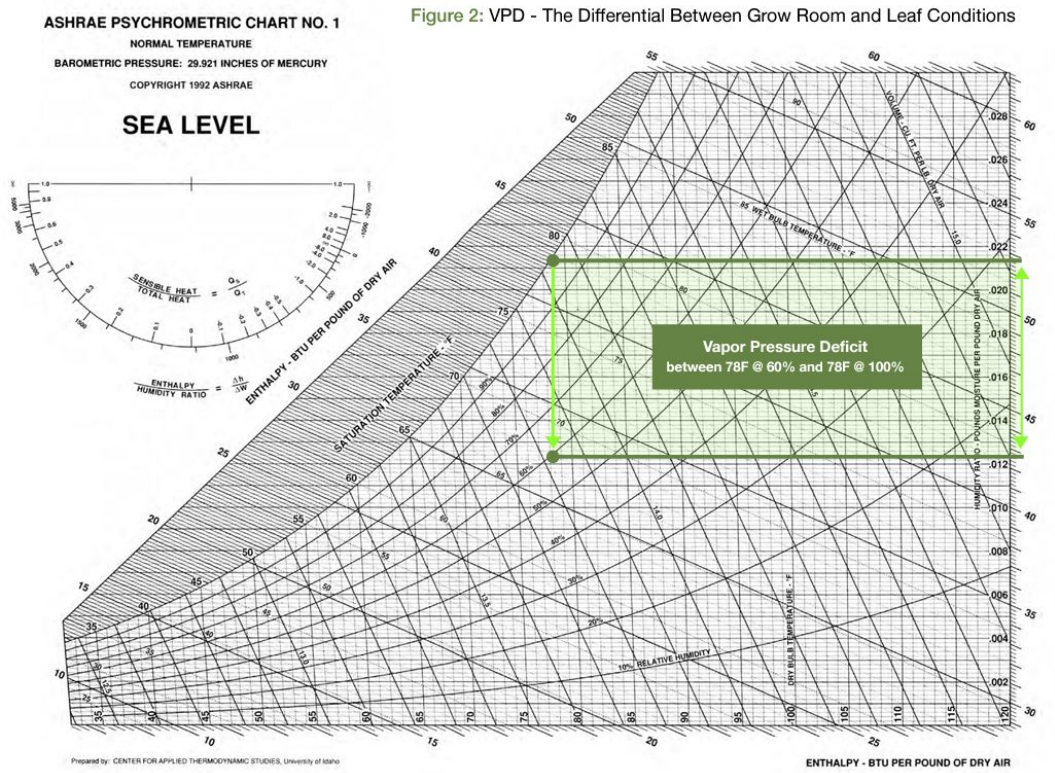


Figure credit: Desert Aire & ASHRAE

HVAC Controls: VPD Controls

Moisture Removal Rate Depends on Room Conditions

- Moisture removal capacity decreases as room conditions become more aggressive
- Pounds/Hour Moisture Removal (lb/hr)
- 1 Gal of H_2O = 8.33 lb
- From 33.8 lb/hr to 2.9 lb/hr is a 91.4% decrease in moisture removal capacity

		Relative Humidity			
		70%	**60%**	**55%**	**50%**
Temperature	**82F**	33.8	26.8	23.7	20.9
	75F	26.1	21.8	18.8	15.5
	70F	22.8	17.6	14.2	10.2
	65F	19.4	12.3	6.5	2.9

Use VPD controls to select efficient room conditions while maintaining plant performance

Figure credit: InSpire Transpiration Solutions

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

HVAC Controls: Interactive Effects

Respond to light and water

- Orchestrate your envelope HVAC controls to call and respond to daily and seasonal solar variation and your supplemental lighting controls
- When the sun sets, humidity spikes, and control strategies give envelope and 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

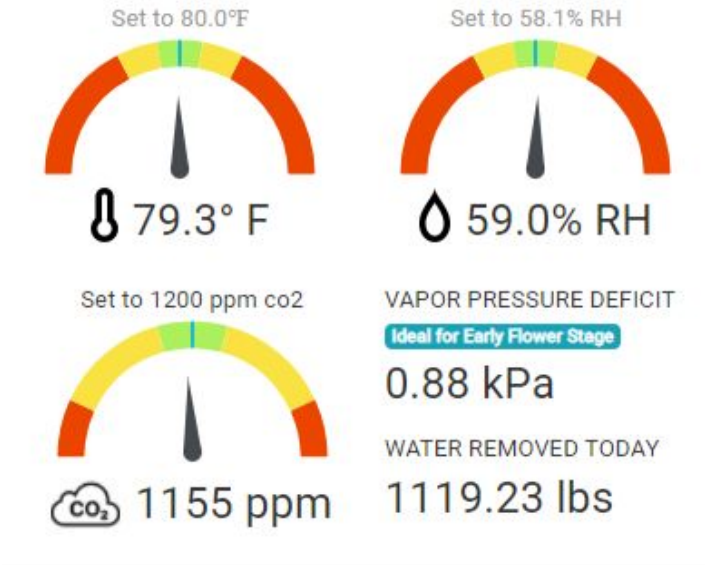


Figure credit: InSpire Transpiration Solutions

Precise Microclimates Control

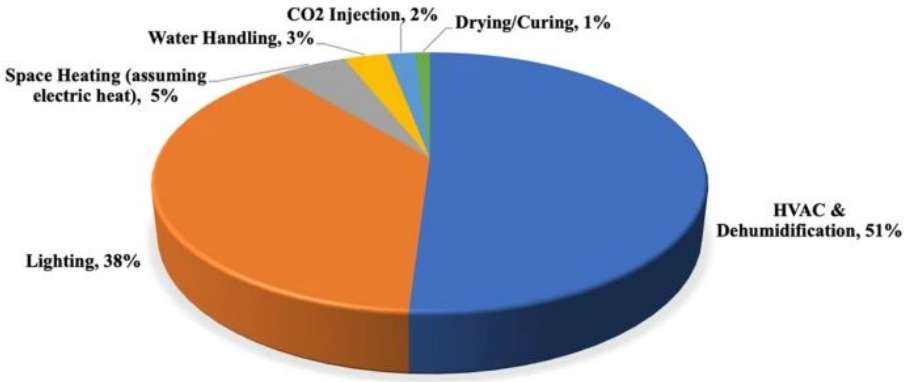
Energy Use - Range of Equipment

- 2 Major categories
  - Lighting
  - Precise microclimate control

Electricity Consumption

- Lighting, HVAC and dehumidification
  - 89% of total end-use electricity consumption

Fig. 1



End-use electricity consumption

Figure credit: Journal of Cannabis Research

Integrated Controls: Value Proposition

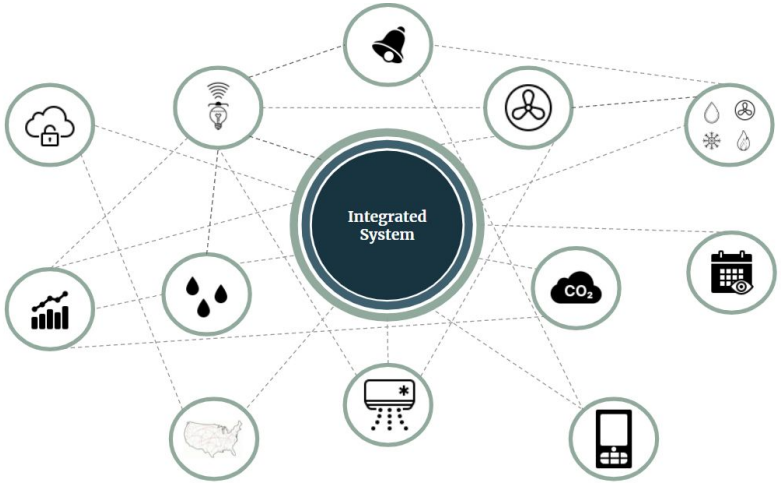
Integration creates consistency across facility systems

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

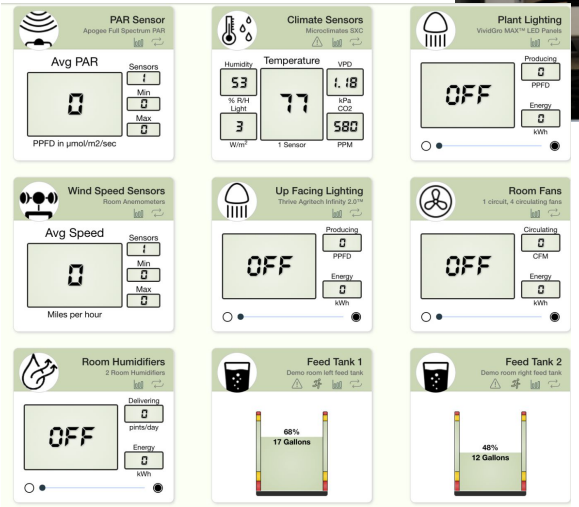


Figure credit: Microclimates

Integrated Controls: Roof Top Unit

Roof Top Unit (RTU)- Staging

WA Cannabis Producer

- 3 RTUs - Functioning independently
  - 2 Stage system (low / high)
- Integrate unit - work in harmony
- Software to support staging

  Ex: RTU 1-3 - Turn on low, but only RTU1 turn on high. Wait. Measure room before RTU2 high is turned on

- Ability to set specified waiting period before turning on

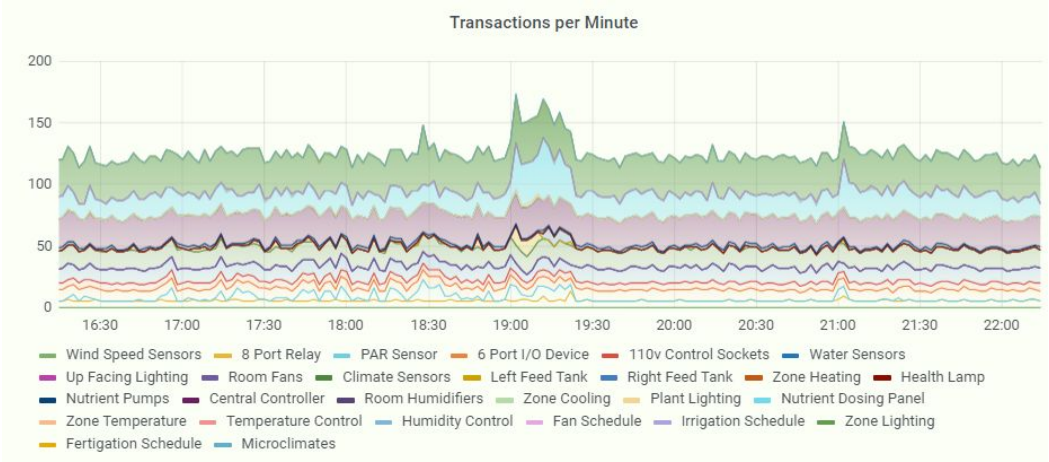
Integrated Controls support energy management & unit longevity

Figure credit: Microclimates

Data: Collecting Data

Consistent & granular data

- Collect as much data as possible
- Ability to set data collection interval within seconds
- From as many sources as possible
- Into one platform
- Transform data into actionable insights



Consistent & granular data will support the future of AI for your facility

Figure credit: Microclimates (Ex. 12X12 ft demo site collecting hundred of data points / minute)

Data: Trending Data

Back up stored data regularly

- Hundreds of sensors measuring various conditions and collecting data at regular intervals(seconds) 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

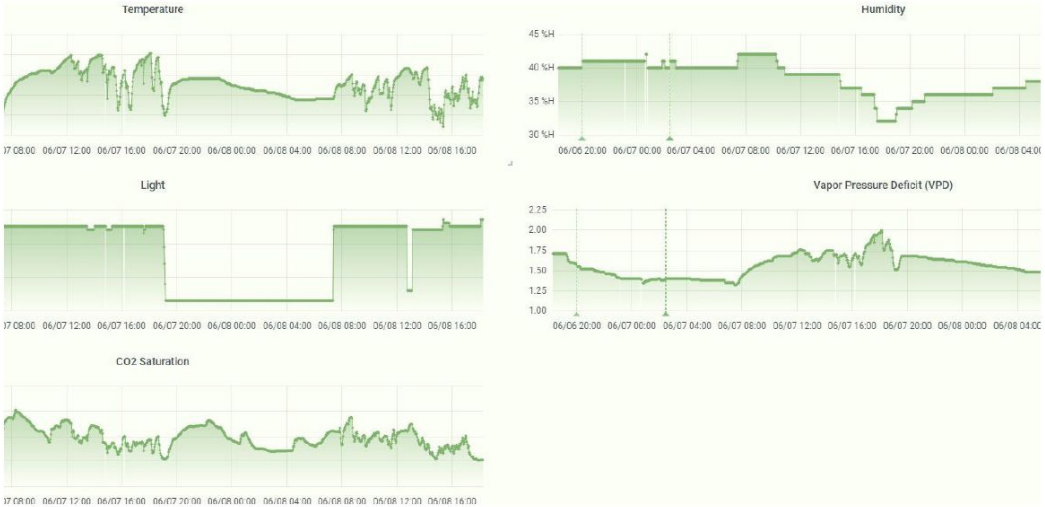


Figure credit: Microclimates

HVAC Controls Trends: VPD Controls

Validate actual conditions are within target ranges

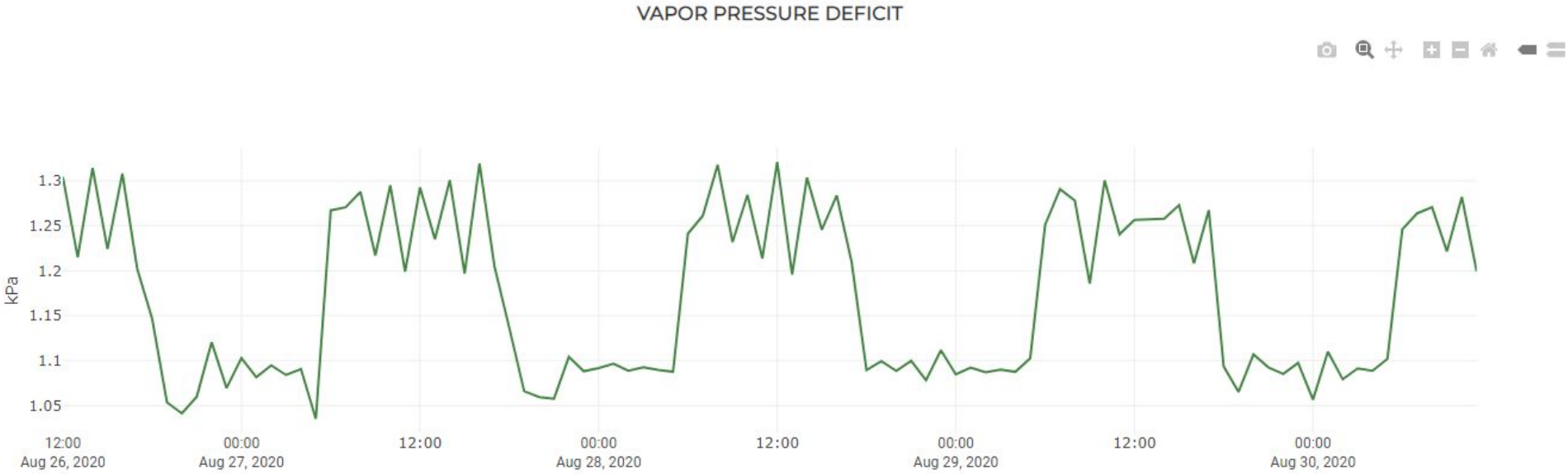


Figure credit: InSpire Transpiration Solutions

HVAC Controls Trends: Temperature, RH, CO2

Understand how parameters affect environment

- Observe the interaction between control points

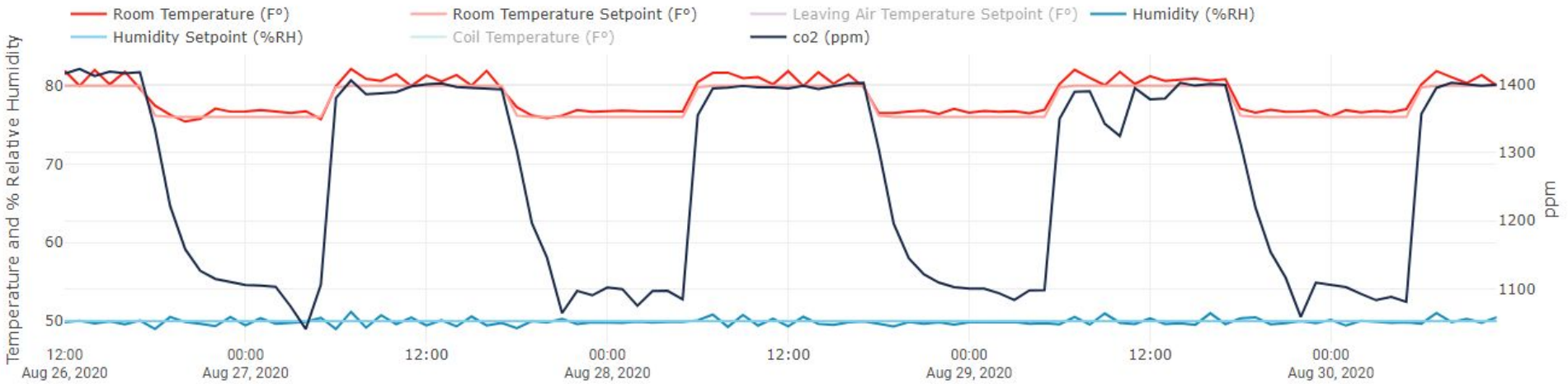


Figure credit: InSpire Transpiration Solutions

Commissioning Environmental Controls

1. 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

2. Calibration

- Gain confidence in sensory accuracy & your HVAC controls/ responses
- Assure data consistency across facilities and over time

3. Control

- Begin when you have confident in monitoring
- Functionally test HVAC sequences of operation to ensure persistent energy savings

Figure credit: Gro iQ / InfiSense

Dive Deeper into Integrated Controls

Fine-Tune Environmental Controls to Drive Your Competitive Edge

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SECTION 07

EFFICIENCY PROGRAM EXAMPLES

Statewide CEDA Program for Producers

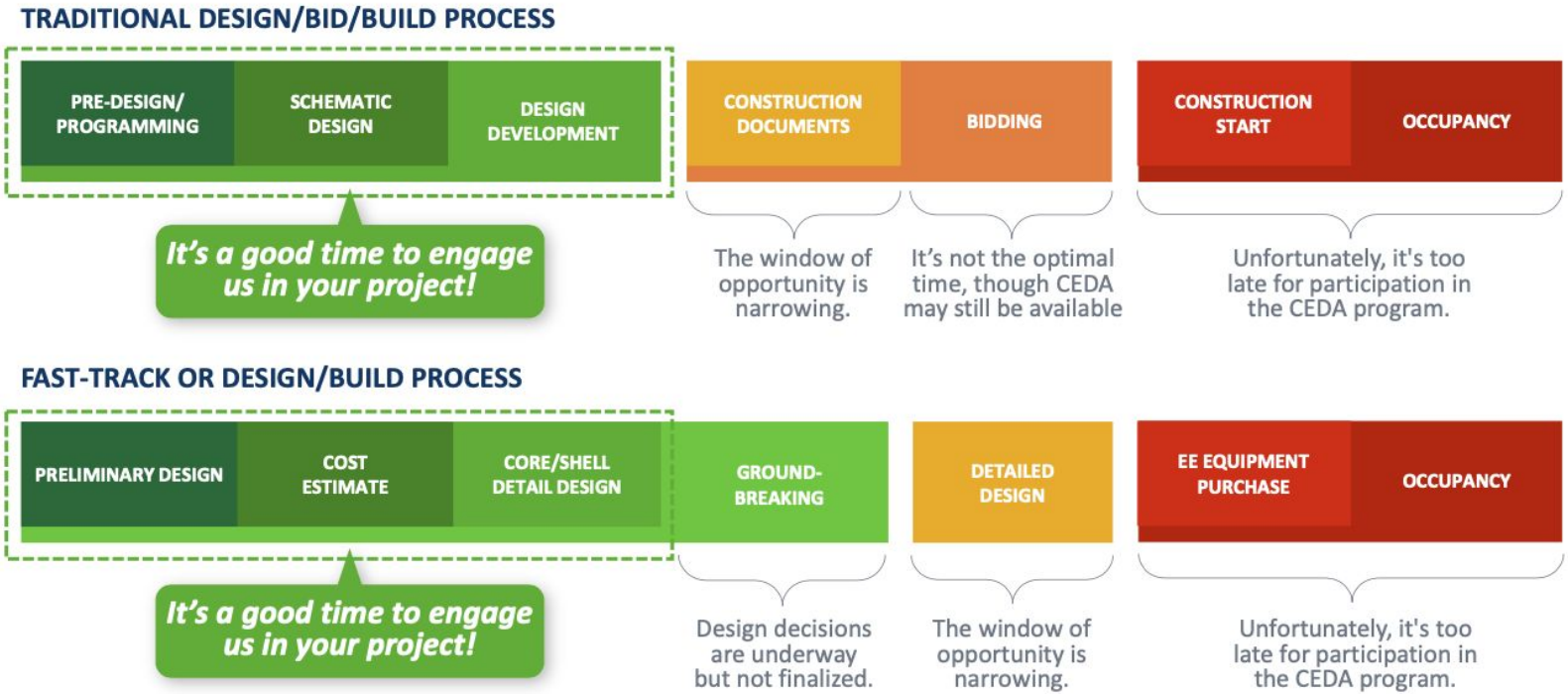
California Energy Design Assistance (CEDA)

New Construction Program

Visit CaliforniaEDA.com

- Statewide Program serving PG&E, SCE, SoCal Gas, SDGE
  - Program participants receive the following complimentary services:
    - Comprehensive Whole Building Energy Analysis
    - Assistance identifying and evaluating energy-saving measures
    - Analysis of energy costs and paybacks
    - Incentives for New Construction and Major Renovations projects
  - CEDA Pathways: Mixed Fuels or All-Electric
    - Mixed Fuels for customers who want the option of both gas and electricity
    - All-Electric program option offers higher incentives if customers do not install gas service

Statewide CEDA Program for Producers



Efficiency Utilities Serving Tri-County

Three Regional Utilities with Efficiency Programs

- Utility service territories determine eligibility
- Growers in Tri-County region can benefit from technical assistance and financial incentives
- Incentives reduce the first cost of high-performance technology

PG&E Pacific Gas and Electric Company®

SOUTHERN CALIFORNIA EDISON®

SoCalGas

PG&E Program for Producers

Agriculture Energy Savings Action Plan (AESAP)

Retrofit Program

Visit AgEnergySavings.com

- Cash incentives for energy-saving retrofit projects
  - Installation of new, high-efficiency equipment or systems.
  - Incentives structured to achieve customer's simple payback requirements
- Financing options available
  - On-bill financing
  - Go Green financing

SoCal Program for Producers

Agriculture Energy Efficiency (AgEE)
Retrofit Program

Visit caenergyprograms.com/AgEE

- SoCalGas program currently active
- SCE program projected to launch mid-2022
- Rebates and custom incentives available for retrofit projects


Q & A

CONTACT US

RESOURCE INNOVATION INSTITUTE

Visit us at
www.ResourceInnovation.org

P.O. Box 5981
Portland, Oregon 97228
derek@resourceinnovation.org
gretchen@resourceinnovation.org
carmen@resourceinnovation.org