



RESOURCE
INNOVATION
INSTITUTE



**Efficient
Yields**

Best practices on energy,
water efficiency, and productivity

Efficient HVAC & Dehumidification Strategies for Craft Cultivation Operations

In partnership with



July 11, 2022



WELCOME

Jim Megerson: Efficient HVAC + Dehumidification Strategies for Craft Cultivation Operations
7/11/2023





On-Line Safety

Please take care of yourself remember to stretch and hydrate



Call
911



Earthquake
Drop /
Cover /
Hold On

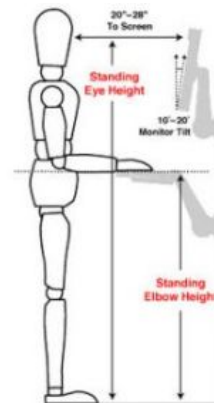


Active
Shooter
Get Out /
Hide Out /
Take Out



Evacuation
Plan and path
of egress

Follow Good
Ergonomics, please be
careful with screen
height, keyboard
position and posture!



Speak Up Now! See Something / Say Something

Please Call 811 Before You Dig!

Safety Message



Remember Your Go Bag. Create One, Keep One!

Go Bags



- Battery-operated or crank radio
- Cash and credit cards
- Emergency blanket
- Extra batteries for radios
- Extra keys to your house and car
- Extra change of clothes
- First-aid supplies
- Flashlight
- High-powered snacks
- Important documents in sealed plastic bags
- Knife
- Lighter and matches
- Medications
- Multi-tool
- Personal toiletry items
- Spare chargers for electronics
- Water purification tablets
- Waterproof bags



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QR Code to access 60 plus HVAC classes



<https://pge.docebosaas.com/learn/external-ecommerce;view=none?ctldoc-catalog-0=se-hvac>

Please scan with smart phone camera to access 60 plus HVAC classes via our website.





SECTION 01

INTRODUCTION

LET US KNOW IN THE CHAT!

What are you hoping to get from
this presentation?



Agenda

Introduction & Purpose

HVAC 101

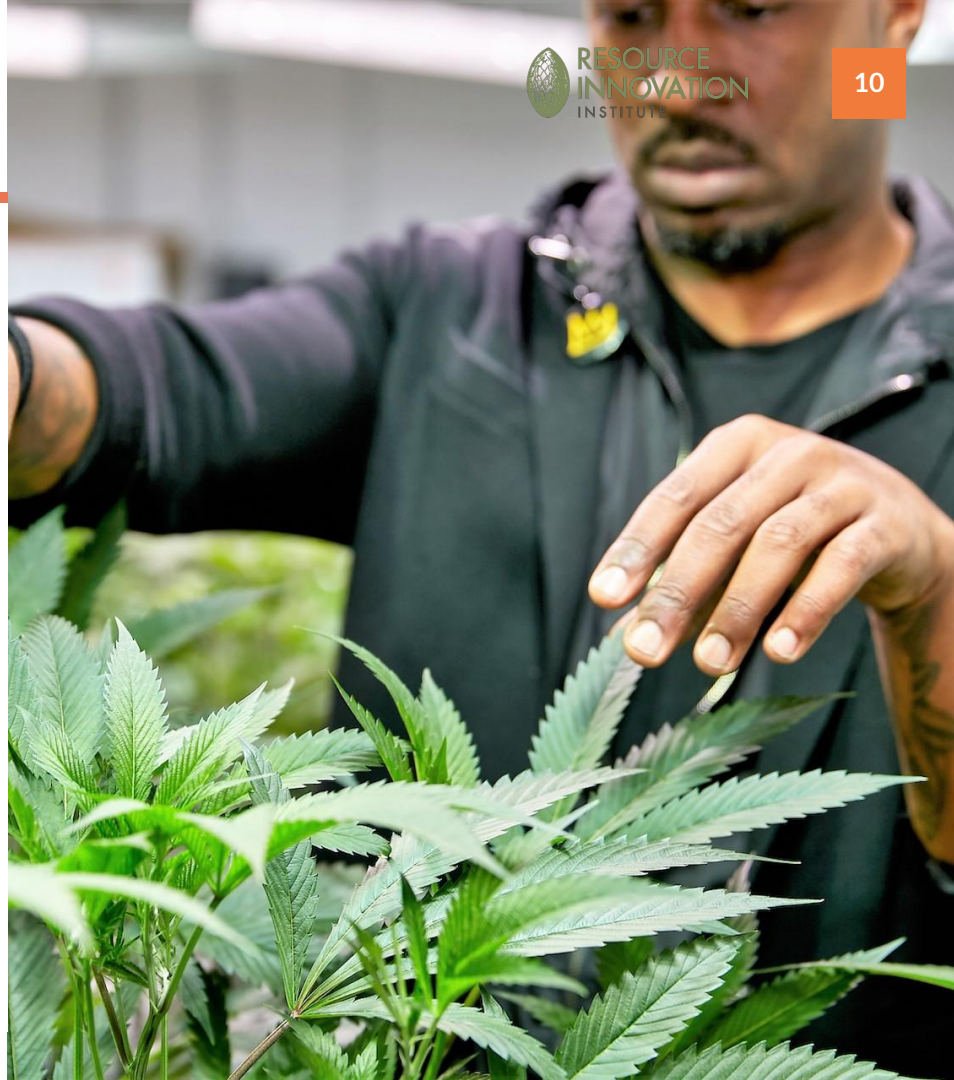
System Types for Craft Scale

Commissioning & Maintenance

Common Mistakes

Tips & Tools

Q&A



Today's Experts



Jim Megerson



Dan Dettmers



Josh Gerovac

SYMBIESCENT

Access Your California Virtual Classroom

Continue Learning Online

Free guidance on efficient cultivation

All live workshops are available for on-demand viewing!

- Recordings of live workshops
- Tip clips
- Downloadable resources
- PG&E and state program tools

Create an account at resourceinnovation.org/California



Product Type

ON DEMAND

California Efficient Yields: Lighting Best Practices for Efficient Controlled Environment Agriculture

Faculty: Kenda Branch | Rob Eddy | Casey Rivero

Duration: 1.5 hours

Format: Audio and Video

Original Program Date: Oct 18, 2022

Price: \$0.00 - Non-Members Rate

More info »

Save for Later

Register



Product Type

ON DEMAND

California Efficient Yields: Facility Design & Construction Best Practices for Efficient Greenhouses and Vertical Farms

Faculty: Brian Anderson | Rob Eddy | Holden Orler | Luis Trujillo

Duration: 2 hours

Format: Audio and Video

Original Program Date: Sep 20, 2022

Price: \$0.00 - Non-Members Rate

More info »

Save for Later

Register

A wide-angle photograph of a large-scale indoor hydroponic cultivation facility. The space is filled with long, parallel rows of leafy green plants, likely lettuce, growing in white trays. The plants are densely packed and appear healthy. The facility has a high ceiling with a complex network of metal beams and numerous rectangular LED grow lights suspended from it. Large circular fans are also visible on the ceiling. The walls are made of translucent panels, and the overall atmosphere is industrial and controlled.

SECTION 02

HVAC 101

POLL ALERT!

What is the typical size room do you work with?

- < 500 ft²
- 500 - 750 ft²
- 750 - 1,000 ft²
- > 1,000 ft²
- N/A



CA License Sizes

- Specialty cottage
 - Specialty cottage outdoor – up to 25 mature plants or up to 2,500 square feet of canopy
 - Specialty cottage indoor – up to 500 square feet of canopy
 - Specialty cottage mixed-light tier 1 and 2 – up to 2,500 square feet of canopy
- Specialty
 - Specialty outdoor – up to 50 mature plants or up to 5,000 square feet of canopy
 - Specialty indoor – 501 to 5,000 square feet of canopy
 - Specialty mixed-light tier 1 and 2 – 2,501 to 5,000 square feet of canopy
- Small
 - Small outdoor – 5,001 to 10,000 square feet of canopy
 - Small indoor – 5,001 to 10,000 square feet of canopy
 - Small mixed-light tier 1 and 2 – 5,001 to 10,000 square feet of canopy
- Medium
 - Medium outdoor – 10,001 square feet to 1 acre of canopy
 - Medium indoor – 10,001 to 22,000 square feet of canopy
 - Medium mixed-light tier 1 and 2 – 10,001 to 22,000 square feet of canopy

Start with the Plant

Business Plan Dictates Everything

- Revenue per month
- Lbs per month
- Grams per sqft
- Size of canopy'
- Grow schedule
- Number of benches/ racks
- Size of room
- Number of Flower rooms
- Number of Veg rooms



Start with the Plant

What affects Real Estate

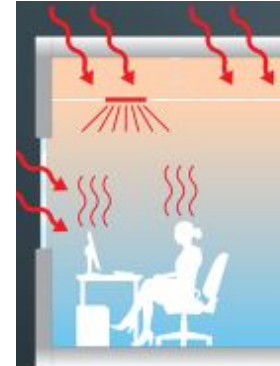
- Canopy size
- Size and number of the rooms
- Watering rates
- Number of lights
- HVACD
- Electrical service
- Equipment location
- Structural concerns



Cooling Load Calculations

Typical building with occupants

- Envelope heat gain and loss
- People
- Lighting, computers, printers etc.
- Ventilation load



Indoor agriculture

- Envelope loads are much lower (R20 walls/insulated panels)
- Lighting - much higher than normal (30 – 50 watts/sqft)
- Plants, water
- Fewer people per sqft
- Ventilation kept to a minimum
 - Pressurization
 - CO₂ Augmentation



Energy Balance Equation

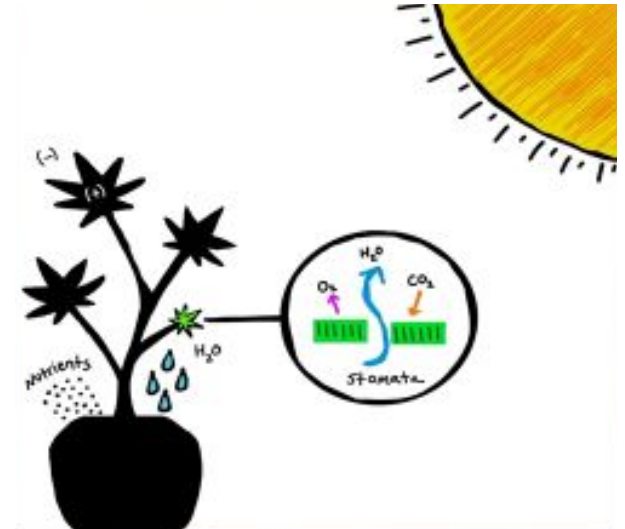
Moisture

Transpiration

- Release of Moisture to the space
- Exhalation of water vapor from the plant
- Delivered through the Stomata
- Evapotranspiration

Why is this important?

- How the plant receives nutrients
- Water moves through the plant
- Delivering nutrients from the soil



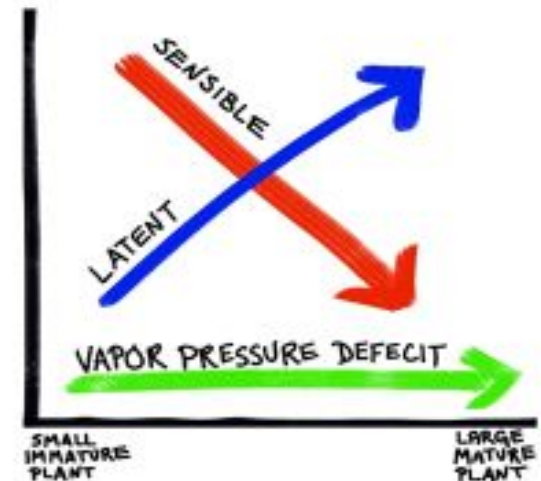
Temperature and Humidity drives Nutrient Delivery

Load Conundrum

Sensible Load: The energy stored in the air in your cultivation spaces as **heat**; "dry load"

Latent Load: The energy stored in the air in your cultivation spaces as **humidity**; "wet load"

- Load is highly variable
- Transpiration cools the room (approx 50% of lighting load)
- When plants are small latent is low, sensible is high
- As plants grow: more water, more transpiration, higher latent loads
- Sensible is less due to evaporative cooling



POLL ALERT!

What is the typical size room do you work with?

Discuss Results





SECTION 03

TYPES OF HVACD SYSTEMS FOR CRAFT SCALE

POLL ALERT!

What kind of HVAC systems do you work with?

- Packaged AC w/ dehumidifier
- Split system w/ dehumidifier
- Integrated HVAC
- Other/unknown?
- N/A



Grow Room Systems



Application – Plant Life Support

HVACD

High moisture removal rates

Air Changes per Hour

Deliver air above space dewpoint

82F / 60%RH ► 67F

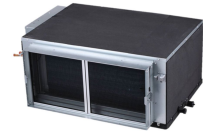
React to changing load conditions

Built to run 24/7

Be energy efficient

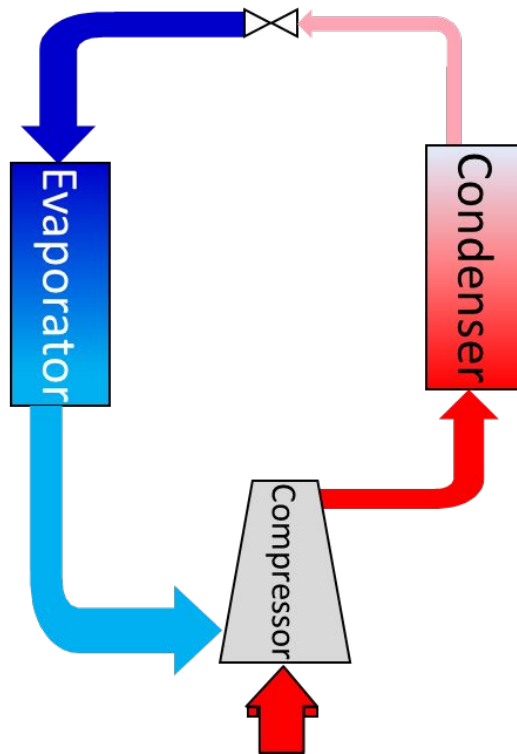
System Types for Craft Grows

- Decoupled
 - System for cooling
 - System for Dehumidification
- Integrated HVACD
 - Does both

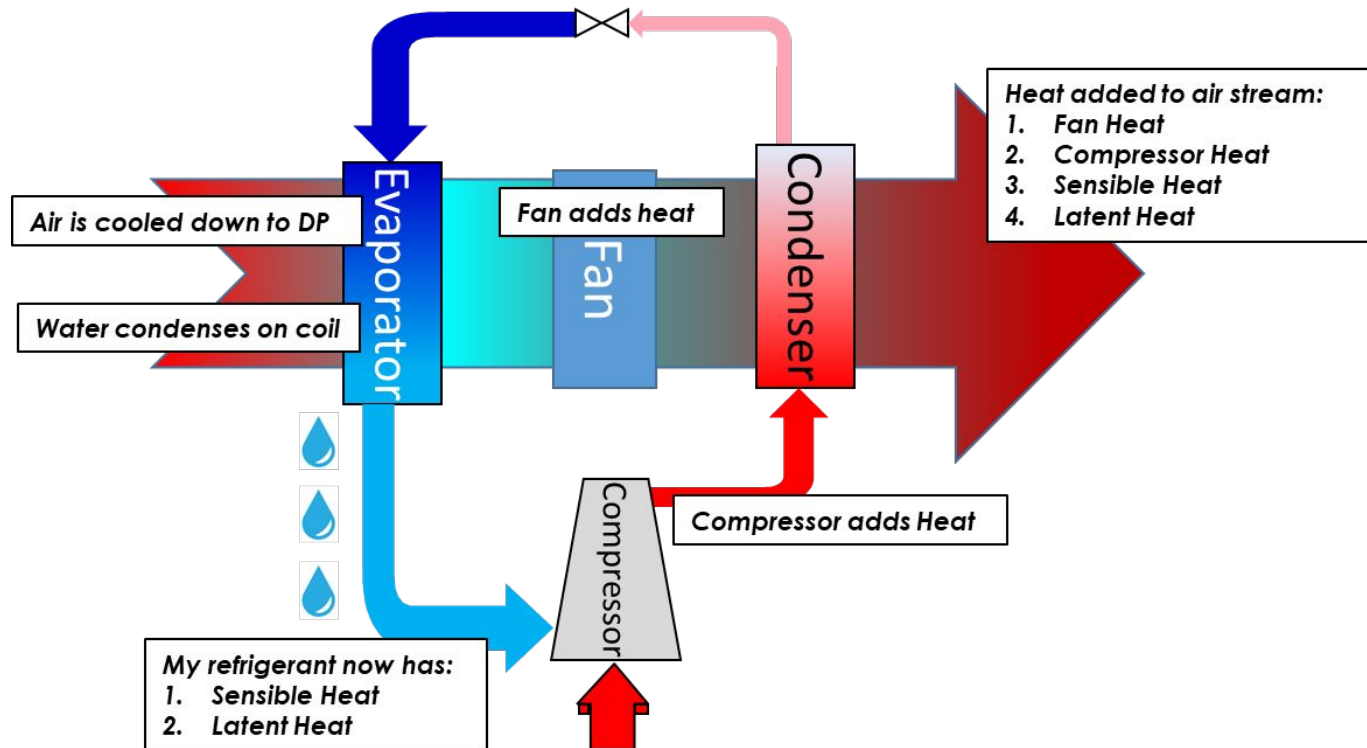


What is hot gas reheat?

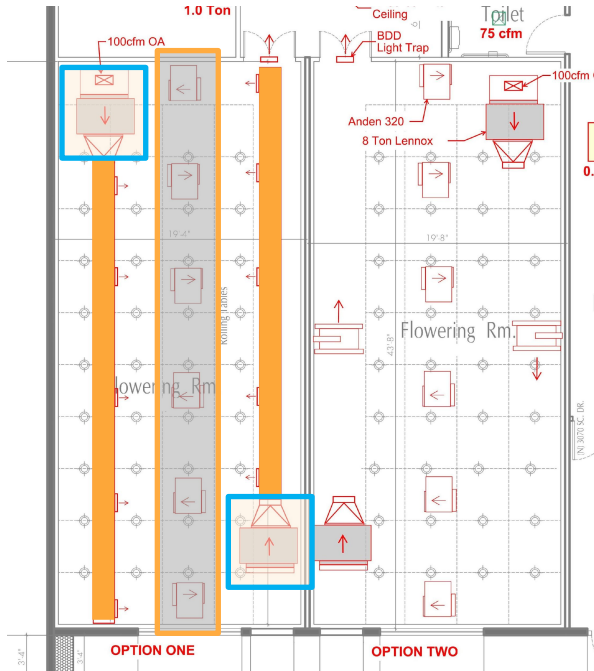
Basic refrigeration cycle



What is hot gas bypass?

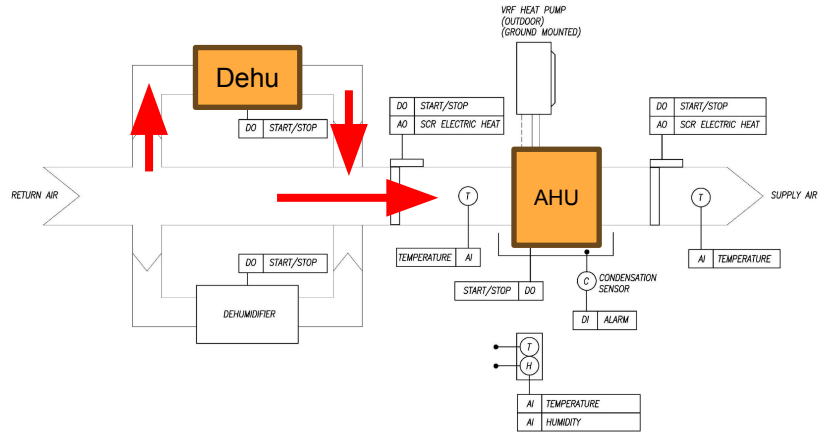


Decoupled Systems



- Typical DX cooling for sensible loads
- Dehumidifiers for moisture removal
 - Delivers hot air to space (80-90F)
 - 6,000 – 24,000 btuh
- Cooling delivers cold SA space (55F)
 - Duct will sweat
 - Fabric duct will not sweat
- Mixing is needed
- May require additional fans
- Energy inefficient
- High Maintenance
- Not 24/7 capable
- Low first cost

Side Stream Dehumidifiers



- Provide cooling and dehumidification
- Mix supply air very well
- Will not maintain a constant SAT
- Recommend reheat for temp control

Integrated HVACD

DX with hot gas reheat

6 & 8 row coils

Fully modulating hot gas reheat

Fully modulating compressors

Capable of discharge air temp control

Air & water cooled

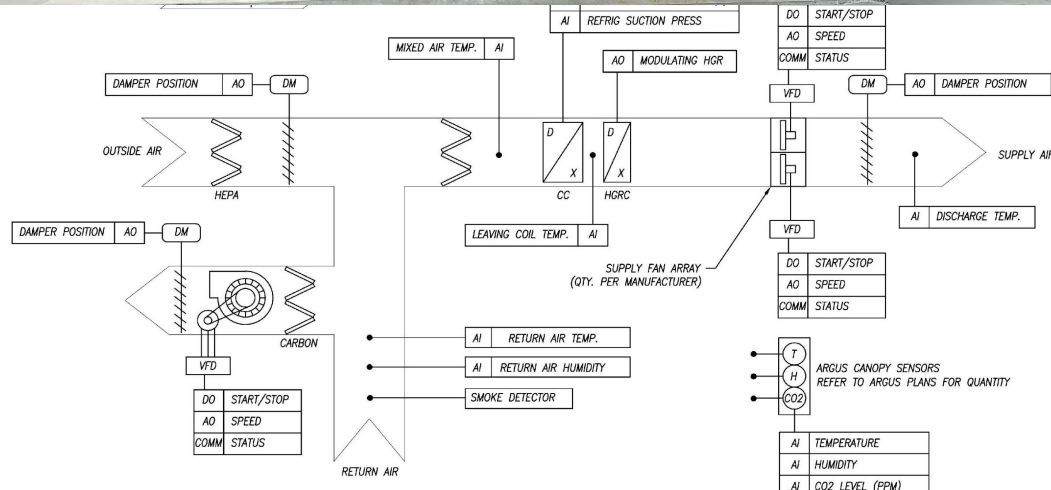
All flavors available

Very Energy efficient

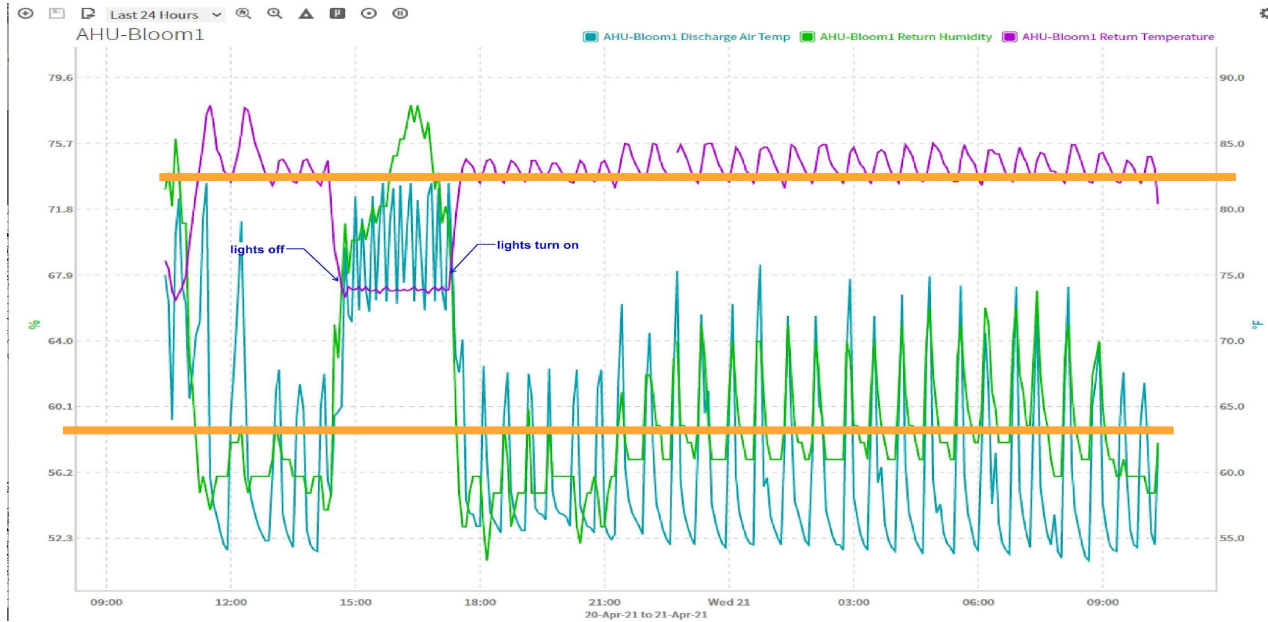
Very 24/7 capable

High equipment cost

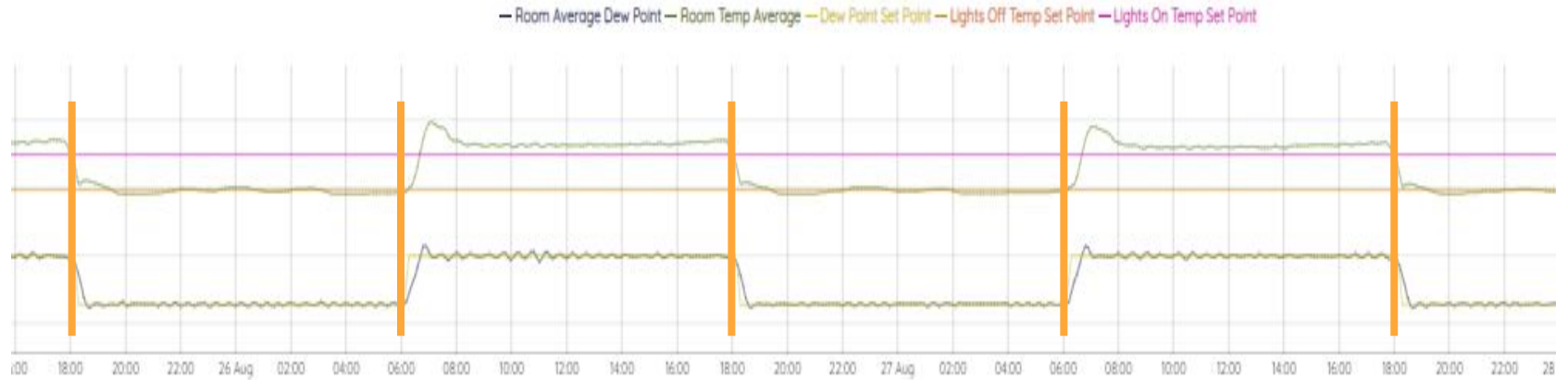
Lower installed cost



Controls



Controls



Air Movement

- The plants uses the CO₂ around the leaf's surface in 4 minutes
- Air Movement helps avoid the formation of microclimates and replenishes the much needed CO₂ where photosynthesis takes place
- The leaves should flutter but not be windblown (idealy below 200 fpm)
- Not enough airflow can lead to the proper conditions for mold and mildew to set in.
- Methods for achieving proper airflow are wall mount, inline, and de-stratification fans

Air flow in Grow Rooms

- Supply air to the space
 - Supply Air temp above space dewpoint
 - If the space SP is 82F/ 58% correlates to approx. 68F SA temp
- Air Changes per Hour
 - 30 to 50
 - De-coupled fans in space
 - Attempting to minimize Micro-climates



Air Flow

- Supply and return air high
 - Short circuiting of air
 - Supply air very close to room temp
 - Air is very velocity dependent
- Supply high, return low
 - This insures best air movement
 - Difficult to blow air through canopy
 - Air tends to bounce off
 - Best to draw air through canopy
 - Velocity @ plant 0.5-1m/s or 100-200fpm
 - Max of 2m/s or 400fpm
 - Very difficult to penetrate canopy

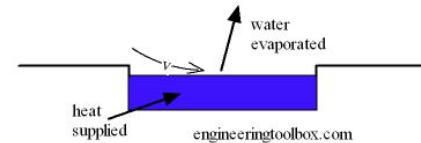


Another Aspect of VPD

Open water evaporation is greatly governed by the velocity over the surface.

Why should air movement over a leaf not have the same effect?

Another Aspect to VPD



The amount of evaporated water can be expressed as:

$$g_s = \Theta A (x_s - x) / 3600 \quad (1)$$

or

$$g_h = \Theta A (x_s - x)$$

where

g_s = amount of evaporated water per second (kg/s)

g_h = amount of evaporated water per hour (kg/h)

$\Theta = (25 + 19 v)$ = evaporation coefficient (kg/m²h)

v = velocity of air above the water surface (m/s)

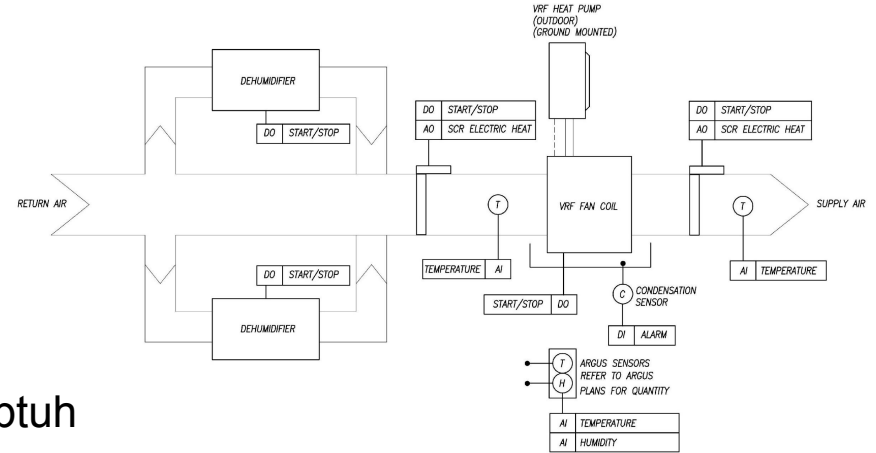
A = water surface area (m²)

x_s = maximum humidity ratio of saturated air at the same temperature as the water surface (kg/kg) (kg H₂O in kg Dry Air)

x = humidity ratio air (kg/kg) (kg H₂O in kg Dry Air)

Dry Rooms

- Room with no sensible load
 - 60-65F/ 50%RH, no lights
 - All moisture removal
 - 4000lbs – remove 88% = 3520 lbs
 - Over 10 days
 - 1.76 gal/hr = 14.67 lbs/hr = 15,476 btuh
- Very difficult with conventional HVAC
 - Return air must be above 65F



Dry Room Air Flow



- Airflow in dry rooms
 - Usually, SA is warmer than room temp
 - 60F room may require 63F SA
 - Laminar flow is best
 - Less than 250 fpm
 - Across entire cross section of space

Dry Room Air Flow



Tellus Health Corp
Butler, MO

Airflow Demonstration
Drying Room

Test 2.1
Inject tracer smoke in center
of room, at center height of
supply/return banks.



POLL ALERT!

What kind of HVAC systems do you work with?

Discuss Results

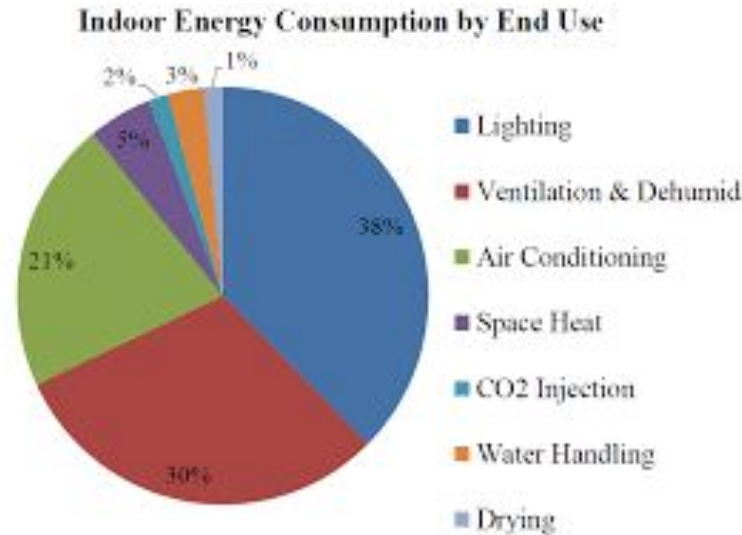


A photograph of three men standing in a greenhouse, looking at tall green plants. The man on the left is gesturing with his hand. The man in the middle is holding a green cup. The man on the right is looking up. The background shows rows of plants and hanging lights.

SECTION 08

SUSTAINABILITY

Sustainability

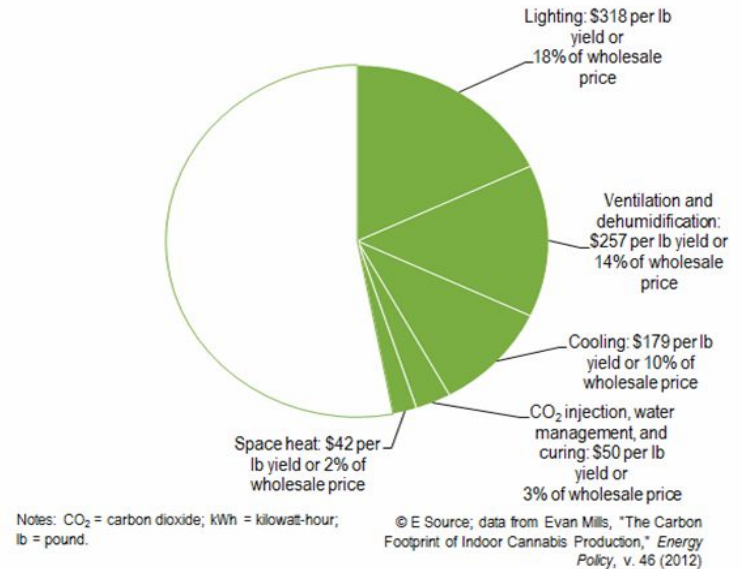


- 30% Ventilation & Dehumidification
- 21% Air Conditioning
- 5% Space Heating
- 1% Drying
- HVACD is 57% of total energy
- Lighting is 38% of total energy

Sustainability

- 30% of the wholesale price is used for air treatment energy cost

B. Energy Cost as a Fraction of Wholesale Price of Cannabis



CPC Savings					
	Baseline IECC 2018		LED and Efficient HVAC		
	Baseline HVAC ai		Efficient HVAC and LED Lighting		
	Energy (kWh)	Demand (kW)	Energy (kWh)	Demand (kW)	
Cooling	8,541,867.00	1,595.76	3,149,048.00	670.23	
Exterior Lighting	0.00	0.00	0.00	0.00	
Exterior Receptacles	0.00	0.00	0.00	0.00	
Fans	623,306.60	125.32	578,986.30	114.54	
Heat Recovery	0.00	0.00	0.00	0.00	
Heat Rejection	0.00	0.00	0.00	0.00	
Heating	695,863.40	293.84	626,409.50	697.51	
Humidification	0.00	0.00	0.00	0.00	
Interior Lighting	9,788,960.00	2,071.60	5,712,076.00	1,211.35	
Interior Receptacles	83,950.09	12.84	106,131.80	17.71	
Pumps	0.00	0.00	0.00	0.00	
Refrigeration	0.00	0.00	0.00	0.00	
Service Water Heating	0.00	0.00	0.00	0.00	
Grand Total	19,733,947.09	4,099.37	10,172,651.60	2,711.35	
			Savings kWhs	Rate/kWh	
	19,733,947.09	10,172,651.60	9,561,295.49 \$	0.10	
Incentive Estimate>>>>>>>>		Process	\$	956,129.55	

- HVAC 55% energy savings
 - Lighting 41% energy savings
 - Total of 48% energy savings
-
- Lighting Schedule
 - Staggering room light schedules
 - Saves in Elec. Demand Charges
 - 15,000 CSF - \$187,000 savings

Table credit: Anvil Agrinomics

Sustainability

- Water reclamation
 - 756 gal/ day
 - 9 rooms
 - 6,804 gal/day

Flower			
Parameters		Values	Units/Notes
Room Dimensions	W	42.0	Ft
	L	80.0	Ft
	H	12.0	Ft
Room Area		3360	Sq Ft
Room Volume		40320	Cu Ft
Quantity of Plants		1680	# of Plants
Watering Rate		0.45	Gallons/ plant/ day
Total Water		756	Gallons/ day
		6297	Lbs/ Day
		484	Lbs/Hour
Watering Method		Drip Irrigation	---
Grow Light Type		LED	---
Quantity of Lights		180	# of lights
Watts per Light		620	Watts per Light
Total Watts		111600	Total watts in room
Lighting Schedule	On	12	Hours per day
	Off	12	Hours per day
Room Conditions lights on	T	82	'F DB
	H	65	% RH
	LTA	-2	'F DB
	VPD	1.2	kPa
Room Conditions lights off	T	65	'F DB
	H	50	% RH

A photograph of three men standing in a greenhouse, looking at a large plant. The man on the left is gesturing with his hand. The man in the middle is holding a green cup. The man on the right is looking up. The background shows rows of plants and hanging lights.

SECTION 08

COMMISSIONING & MAINTENANCE

POLL ALERT!

Do you offset your light schedule?

- Yes
- No
- N/A



Monitoring, Calibration, Commissioning

Monitoring

- You can't manage what you don't measure...and you can't measure what you don't monitor
- Collect data to solve problems and support savings claims

Calibration

- Ensure sensor accuracy so 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

Maintenance Planning

- Budget
- Schedule system downtime or reduced capacity
- Schedule resources from vendors
- Common parts and consumables on hand
- Access to equipment
 - Aisle size
 - Overlapping equipment
 - Vertical access
 - Replacement of larger systems
 - Safety

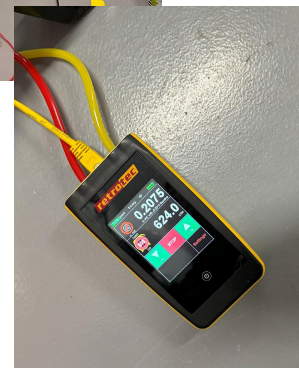


HVAC Maintenance

- Filter maintenance
 - Filters do help to clean the air but the main purpose in grow room applications is to keep the internal components of the dehum and A/C clean
 - At a minimum filters should be replaced after every harvest.
- Drain lines
 - Drain lines should also be cleaned or treated when filters are replaced.
- Schedule routine HVAC clean and checks as recommended by the Manufacture
- Common parts and consumables on hand
- When spraying in a room
 - Turn off dehumidifiers
 - Turn off the A/C
 - Bag all controls and sensors

Room Integrity

- Airtight room is imperative
- Energy Leakage
 - Vapor pressure travels from high to low
- Worse at night and in the winter
 - Dehumidification without compressors
- Over dehumidification
 - 624 cfm / 0.84 ACH
 - Losing 84 lbs/hr



POLL ALERT!

Do you offset your light schedule?

Discuss Results



A large indoor cannabis cultivation facility. Rows of cannabis plants are growing in a greenhouse-like structure with translucent walls. The ceiling is equipped with numerous bright, rectangular LED grow lights. A white vertical support pole with a black cable is visible in the foreground on the right. The plants are densely packed and appear to be in the flowering stage.

SECTION 07

COMMON MISTAKES

Lessons Learned

- Business plan drives everything
- Operate and design around the plant
- Don't sacrifice quality for quantity
- Seal your rooms
- Not all hot gas reheat is the same
- Don't use internal liner in ductwork
- Make sure equipment will operate below lowest OA temp
- Schedule lighting to minimize demand charges
- Make sure there is good mixing of air
- If using Integrated systems best supply air is 2F above dewpoint

TABLE 1: Application Limitations

Ambient Air Temperature on Outdoor Coil		Air Temperature on Indoor Coil	
Min. DB	Max. DB	Min. WB	Max. WB
50°F	115°F	57°F	72°F

4. The unit should not be operated at outdoor temperatures below 50°F without an approved low ambient operation accessory kit installed.



SECTION 10

MAXIMIZING FINANCIAL INCENTIVES

Get in Touch with Our Sponsor

Program Offerings

- [Agriculture Energy Savings Action Plan](#)
 - No Cost Technical Assistance
 - [Rebates](#)
 - Custom Incentives
 - Site-specific analysis
 - Financing
 - [Cannabis Specific](#)
 - [CEA Specific](#)
- Learn more & apply: agenergysavings.com



What is AESAP

TRC's **Agriculture Energy Savings Action Plan (AESAP)** offers incentives and financing for energy-saving projects involving the retrofit or installation of energy consuming equipment.

AESAP:

- Provides rebates and incentives on energy efficient equipment upgrades
- Offers technical assistance and incentives for more complex projects
- Provides Integrated Demand Side Management support and services
- Provides services at no cost to customer

Sectors Served



**Crop
Production**



**Controlled Environment
Agriculture (CEA)**



**Wineries &
Breweries**



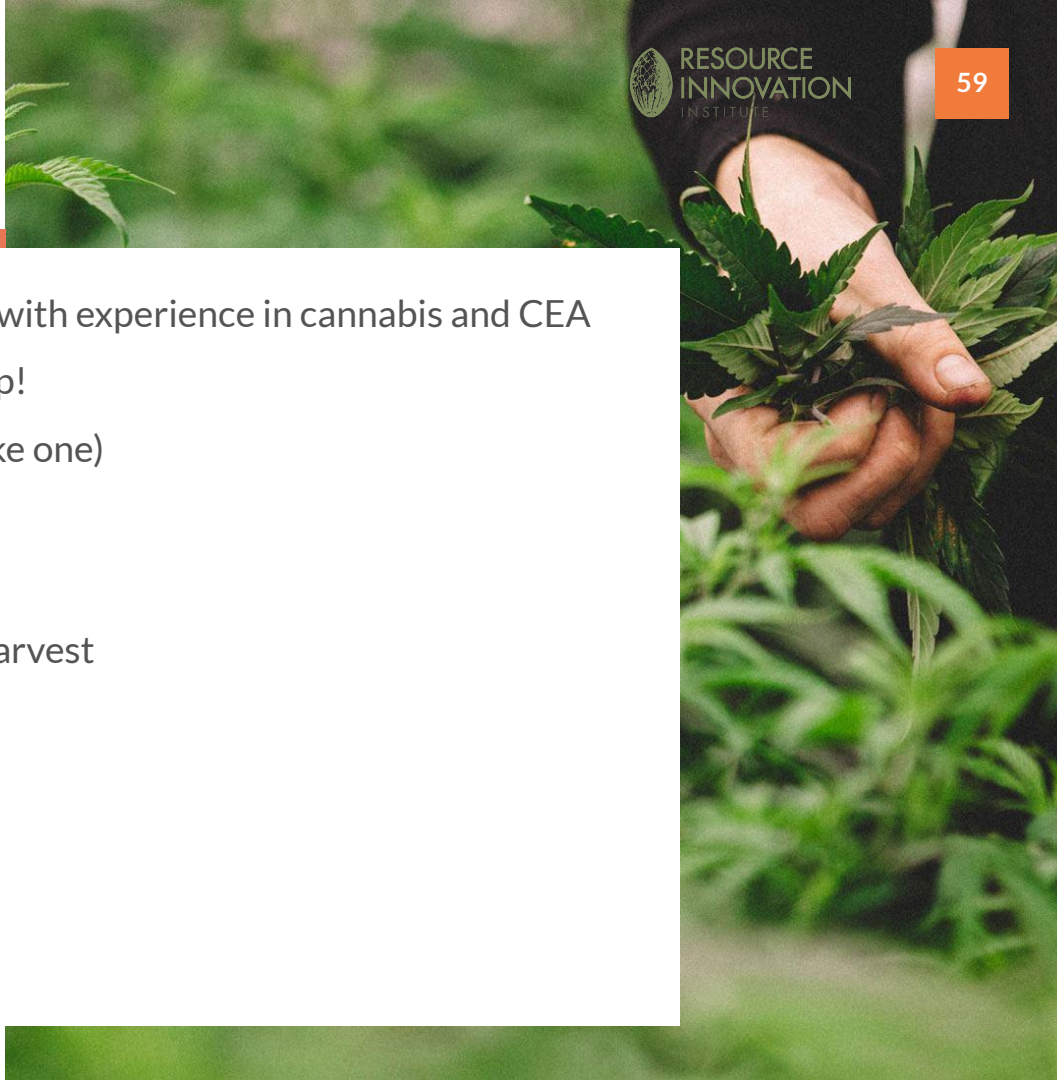
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Actionable Takeaways

- Choose design & installation professionals with experience in cannabis and CEA
- Schedule a blower door test (PG&E can help!)
- Review your maintenance schedule (or make one)
 - Change filters
 - Clean
- Plan comprehensive maintenance during harvest
- Opaque tubing on your fertigation system
- Check your circulation fan airflow patterns
- Check your equipment calibrations





Q & A

CONTACT US



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THANK YOU



Together, Building
a Better California

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