RESOURCE INNOVATION INSTITUTE

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

Operations & Maintenance for Controlled Environment Cannabis Cultivation

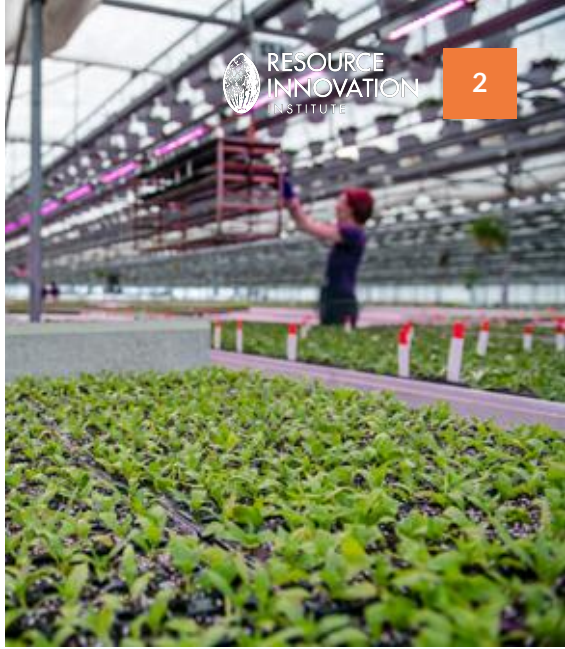
NYSERDA

Office of Cannabis Management

November 14, 2023

Agenda

Introduction & Context	1:30
HVAC Equipment Understanding, Selection and Maintenance	1:40
Climate Control Optimization & Equipment Tracking	2:05
Grower Perspective: Common Mistakes in Ops & Maintenance	2:30
Q & A	2:40
Sign Off	3:00



- Feel free to ask questions in the chat! The panel will try to get to as many as they can either by writing a response or during the Q & A.
- A recording of today's presentation will be available after the webinar! It will be emailed to all registrants this week.
- We'll be conducting polls and knowledge checks throughout the webinar

SECTION 01

Introduction

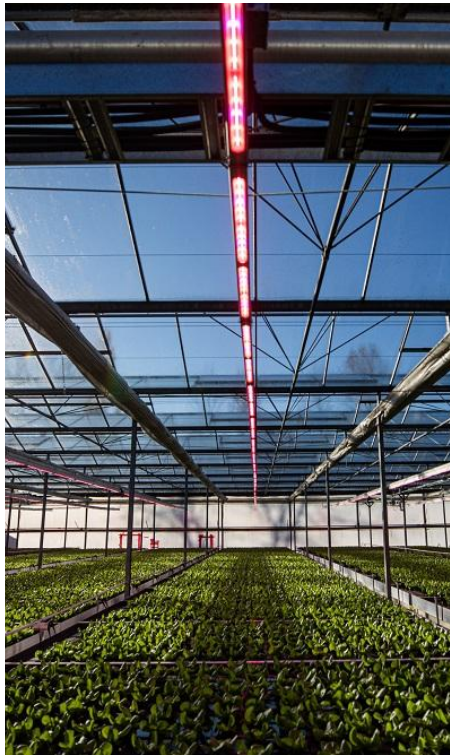
POLL ALERT!

What kind of facility are you cultivating in?

- Small indoor building
- Warehouse
- Standard, vented greenhouse
- Sealed, air-conditioned greenhouse
- Container farms or pods

About RII

- Non-profit, objective, data-driven organization
- Since 2020, USDA-funded and partner with US Department of Energy
- Founded 2016 in Portland, Oregon
- Spent first three years focused on the cannabis industry
- Help crop producers like you through Education, Training, Policy, Benchmarking



Our Network

INPUT from industry leaders and partners

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EDUCATION and advocacy about best practices for growers

RII Industry Working Groups

- **Guides** development of climate-smart methods
- **Publishes** free Best Practices Guides
- **Advocates** for fair, informed policies, incentives and regulations

Equipment/Service providers: Become a Member!

Free Best Practices Guides

Collaboration by Industry Experts

Free guidance on efficient cultivation

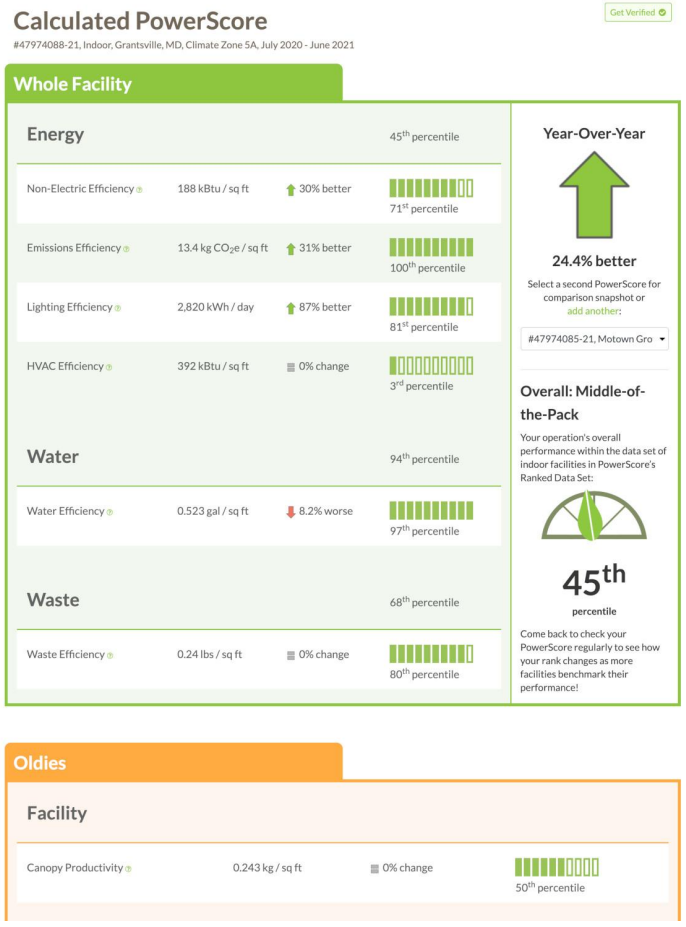
- Water Circularity for CEA Operations, 2023
- CEA Facility Design & Construction Best Practices, 2022
- CEA HVAC Best Practices, 2022
- Cannabis HVAC Best Practices, 2019
- CEA Lighting Best Practices, 2022
- Cannabis Lighting Best Practices, 2019

Start Collecting Data: Benchmarking

What data should you collect?

- Energy consumption
  - All fuel types
- Water consumption
- Water quality
- Production
- Use controls & automation systems to improve data collection
  - Improve understanding of subsystems

Benchmarking with RII is free to growers in partnership with the NY OCM! Learn more at resourceinnovation.org/powerscore



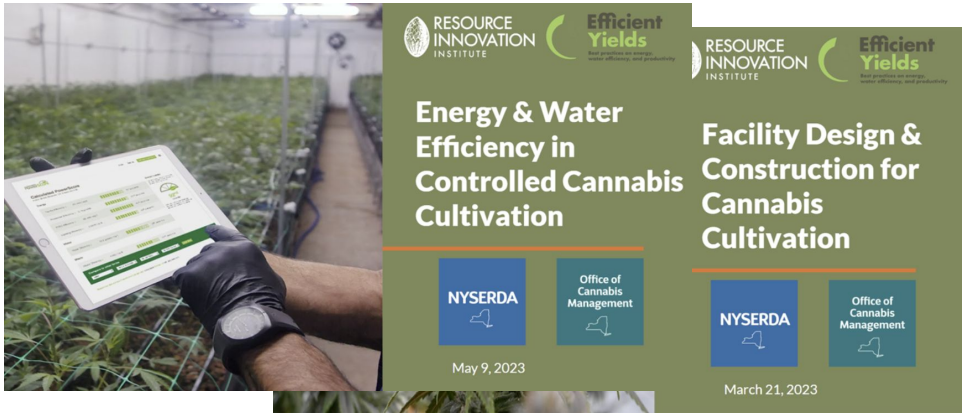
Access Your New York Virtual Classroom

Continue Learning Online

Free guidance on efficient cultivation

All live workshops are available for on-demand viewing!

- Recordings of live workshops
- Downloadable resources
- NY State program tools



Create an account at the NY Efficient Yields Classroom

Purpose of Today's Workshop

- Help NY cannabis growers improve energy and water efficiency in greenhouse and indoor facilities

- Convey scientific insights and industry expertise directly to producers and find the best ways to translate them in the context of their location

- Assist cannabis producers and their design and construction project partners with what they need to know to stay competitive and comply with regulations

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

Today's Experts

Rob Eddy

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Chip Seidel

DESERT AIRE

Robert Fisher

CERES GREENHOUSE SOLUTIONS

POLL ALERT!

What kind of facility are you cultivating in?

Discuss Results

SECTION 02

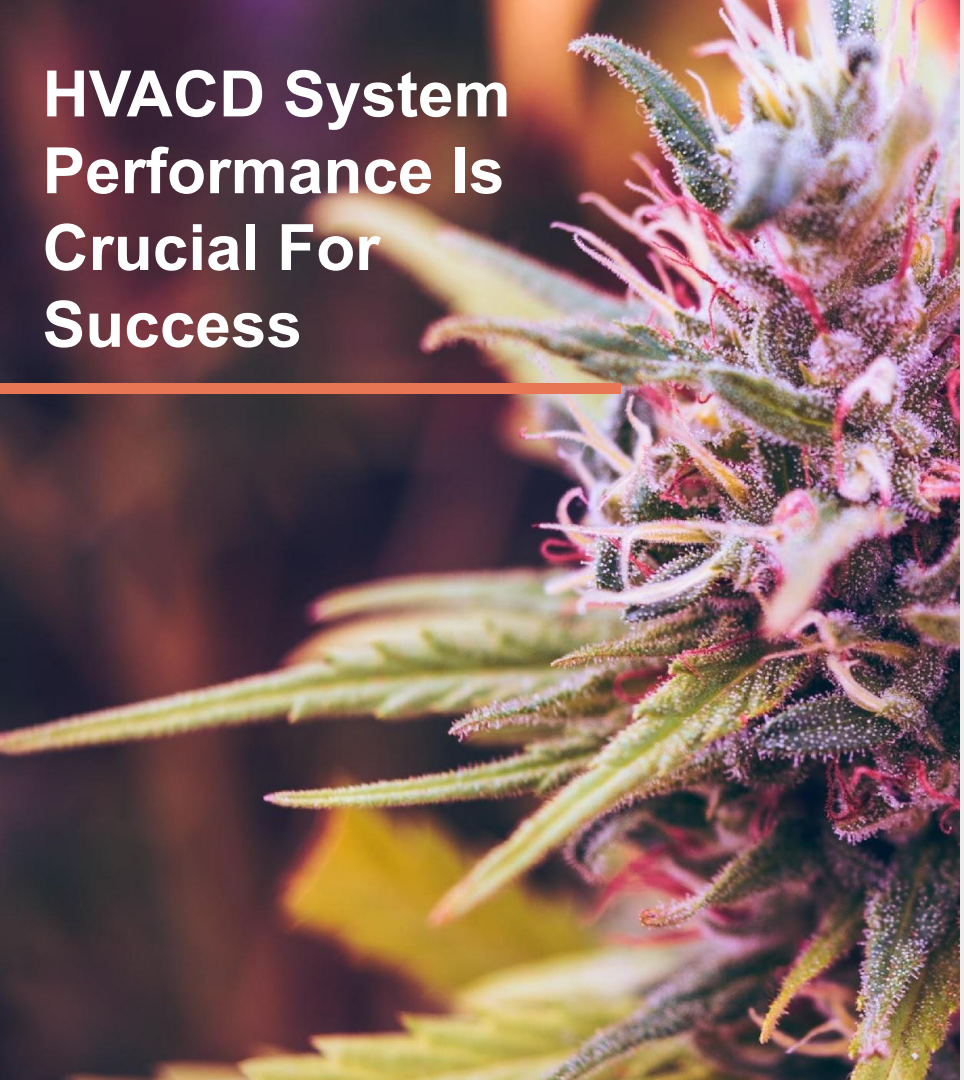
HVAC Equipment Understanding, Selection, and Maintenance

POLL ALERT!

Knowledge Check: Compared to field crop production in summer, a greenhouse…

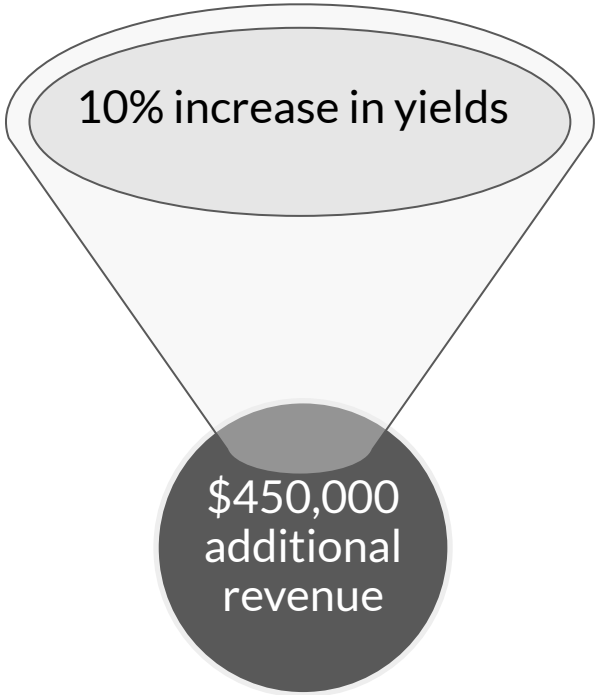
- Has about the same insect and disease problems
- Has less insect and disease problems
- Has more insect and disease problems

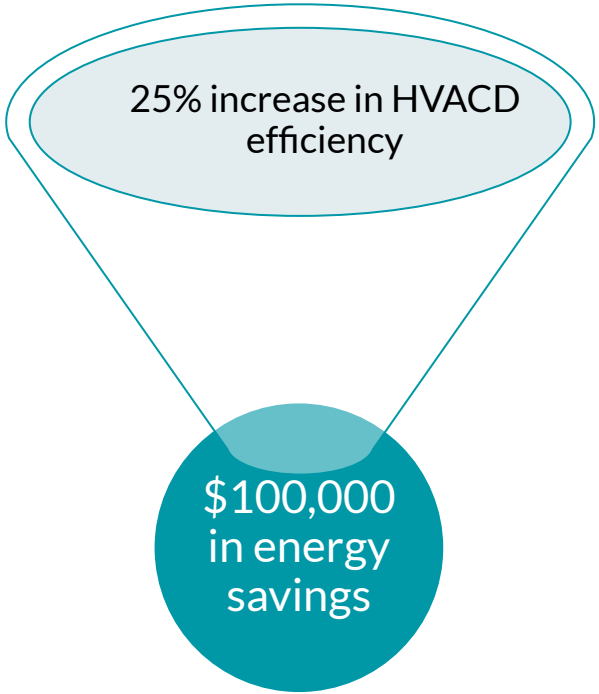
HVACD System Performance Is Crucial For Success



- HVACD Systems represent a very large capital expense, select wisely
- HVACD Systems consume a lot of energy- Efficiency Matters
- Tighter Control of VPD Increases Yields
- System Maintenance is crucial for optimal performance and max equipment life

5,000 sq ft of canopy example





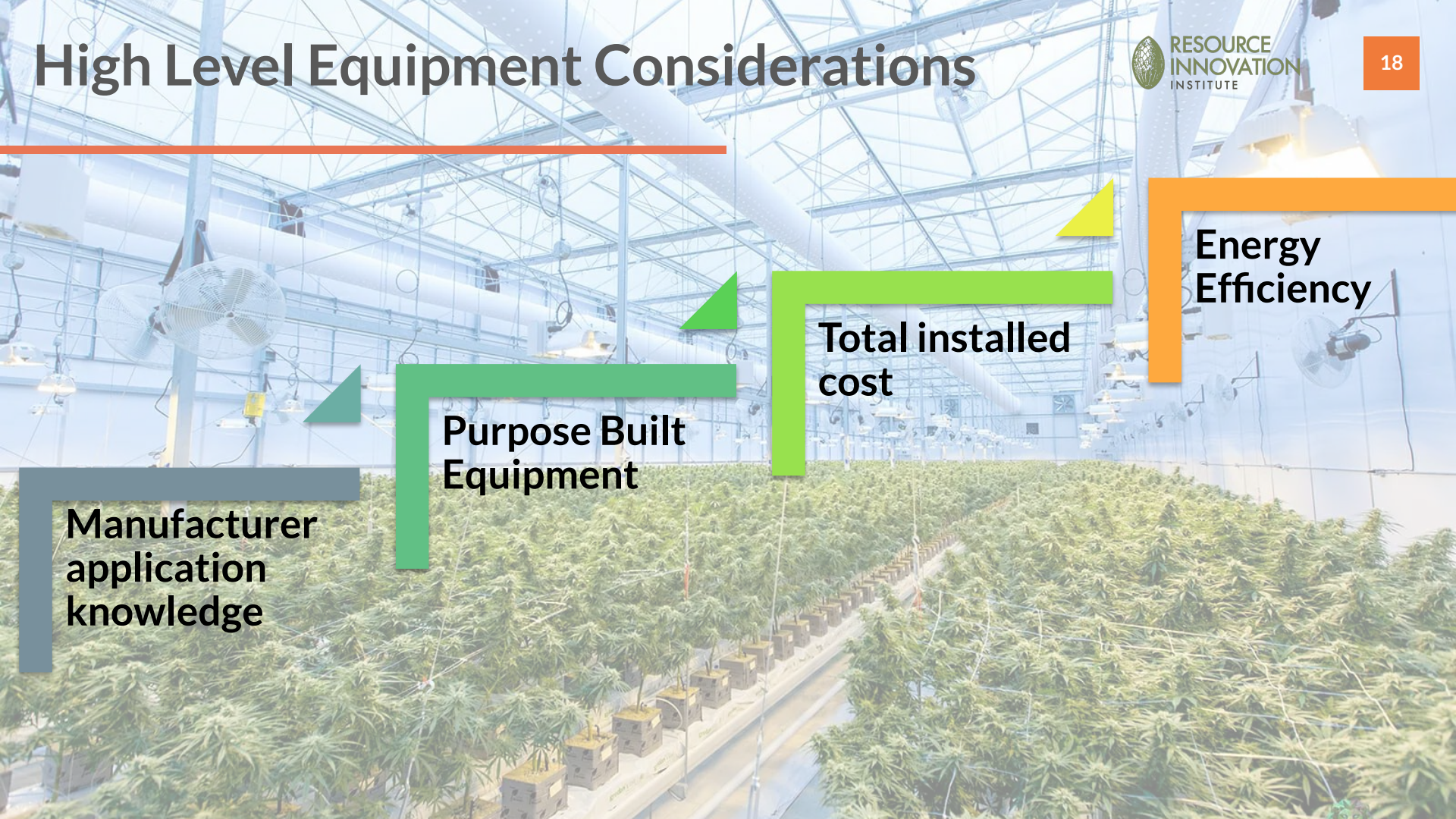
High Level Equipment Considerations

Manufacturer application knowledge

Purpose Built Equipment

Total installed cost

Energy Efficiency



Indoor Cultivation HVACD Systems

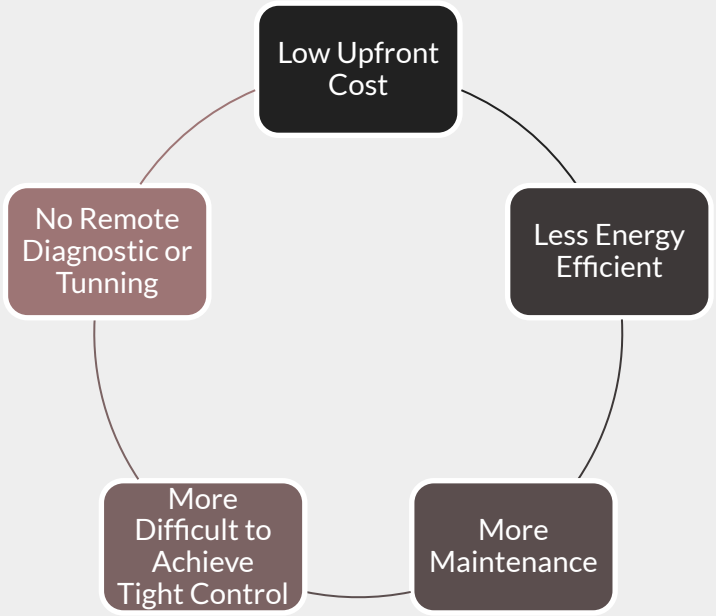
3 System Categories

AC + Dehumidifiers

2 Systems

AC Controls Temperature

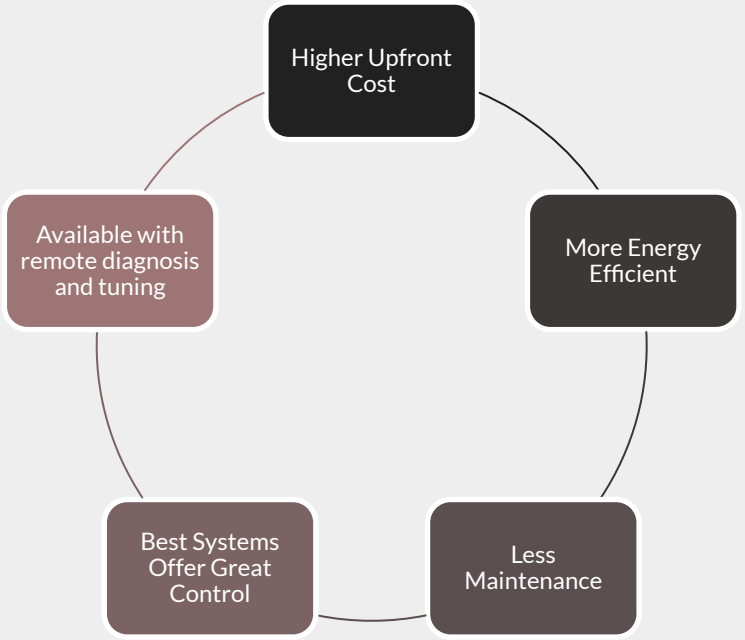
Dehumidifiers Control RH



Integrated DX HVACD System

1 System

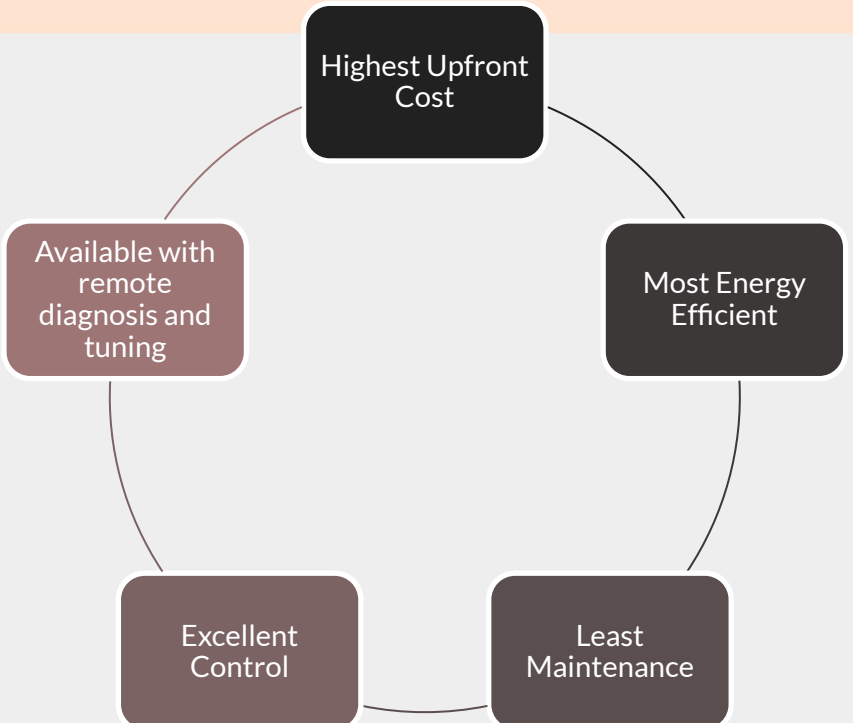
Controls Temperature and RH



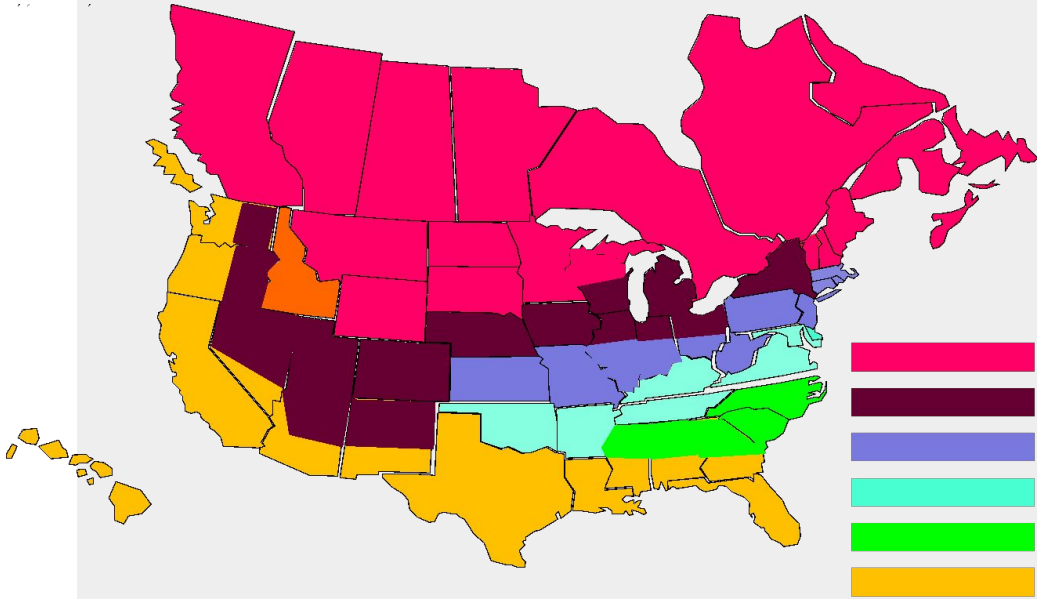
1 System

Controls Temperature and RH

Integrated Chilled Water HVACD System



Geographic Considerations

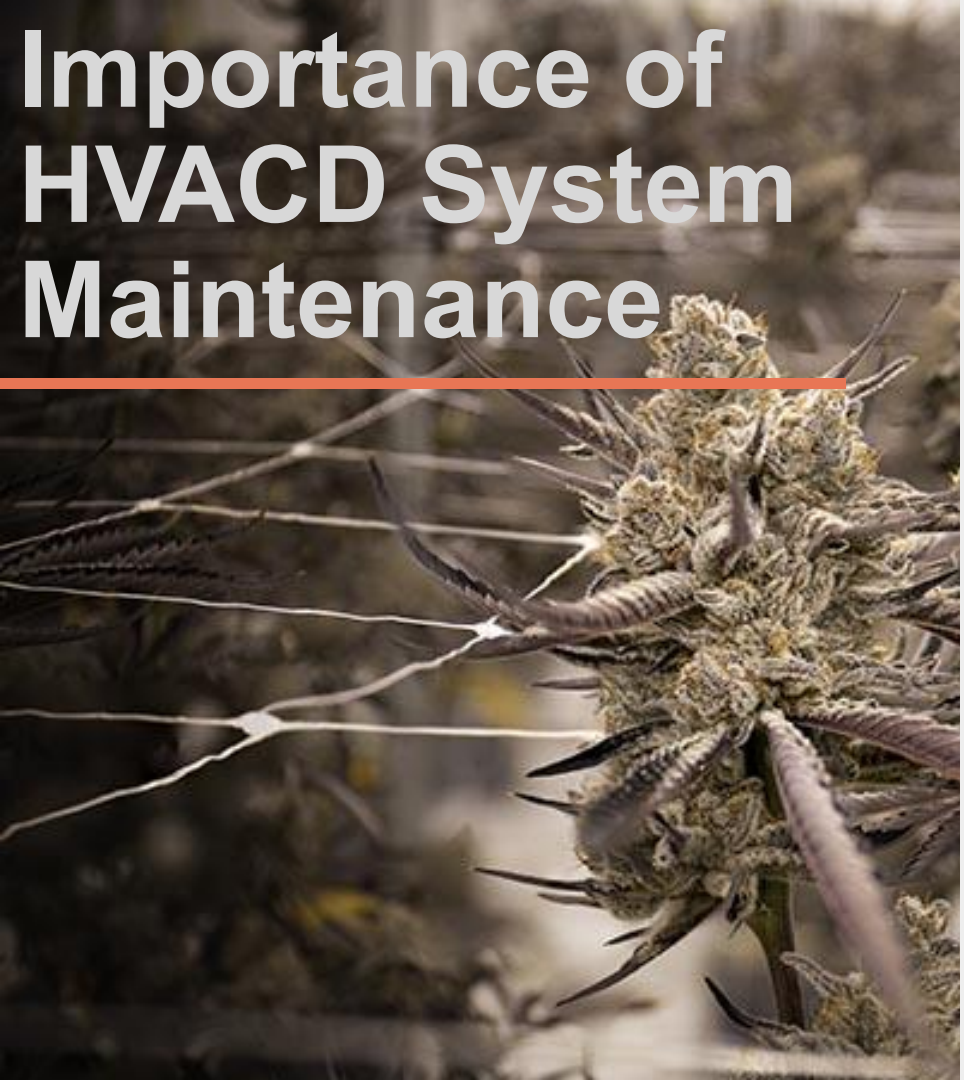


Equipment Type

Equipment Placement

Proactive Maintenance

Importance of HVACD System Maintenance



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Energy Efficiency

Stability Of Control

Equipment Reliability

Contamination Control

HVACD System Critical Maintenance Points

- Refrigeration System
- Coil Cleaning
- Filter Replacement
- Sensor Calibration
- Fan Maintenance

The Benefits Of Remote System Interface

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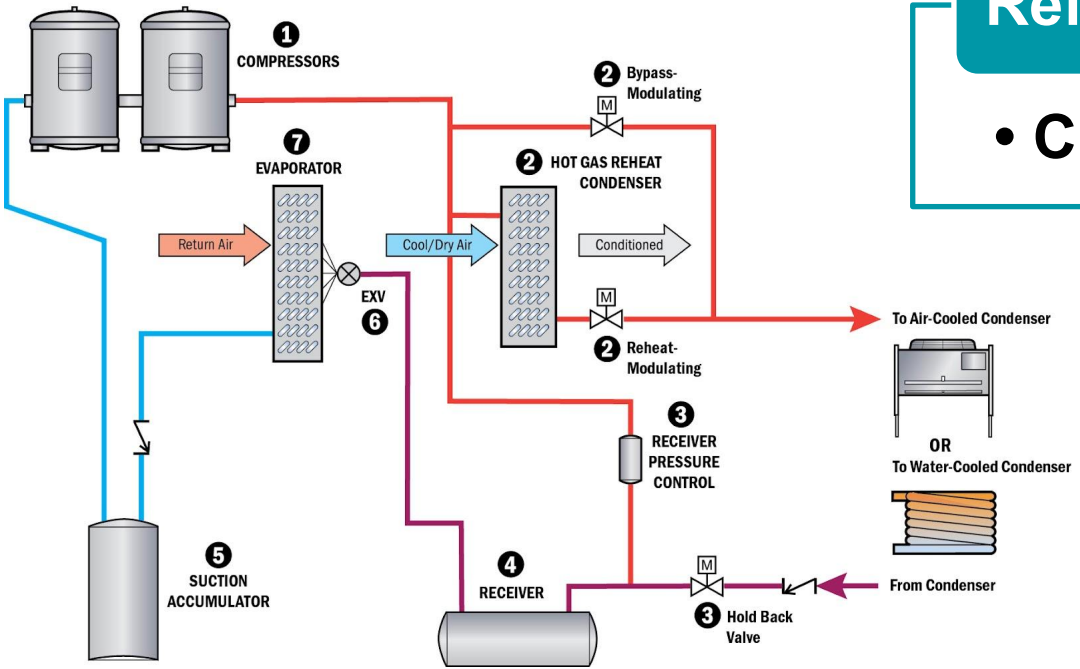
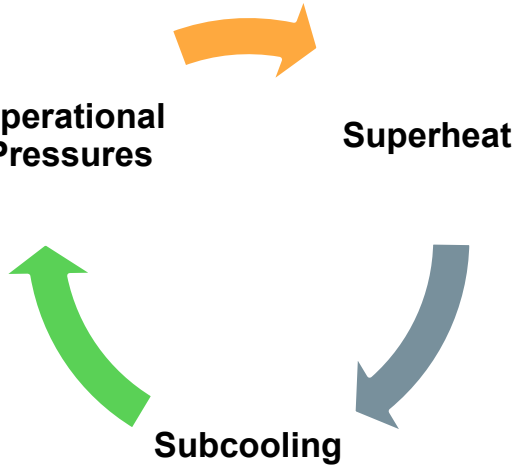
- Alarms via e-mail or text
- Refrigeration system diagnostics
- Refrigeration system tweaks
- Huge labor and maintenance cost savings

Refrigeration System Maintenance



Refrigeration System Vitals

- **Check Quarterly**



Fan Maintenance

Check Quarterly

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Check Airflow

- CFM

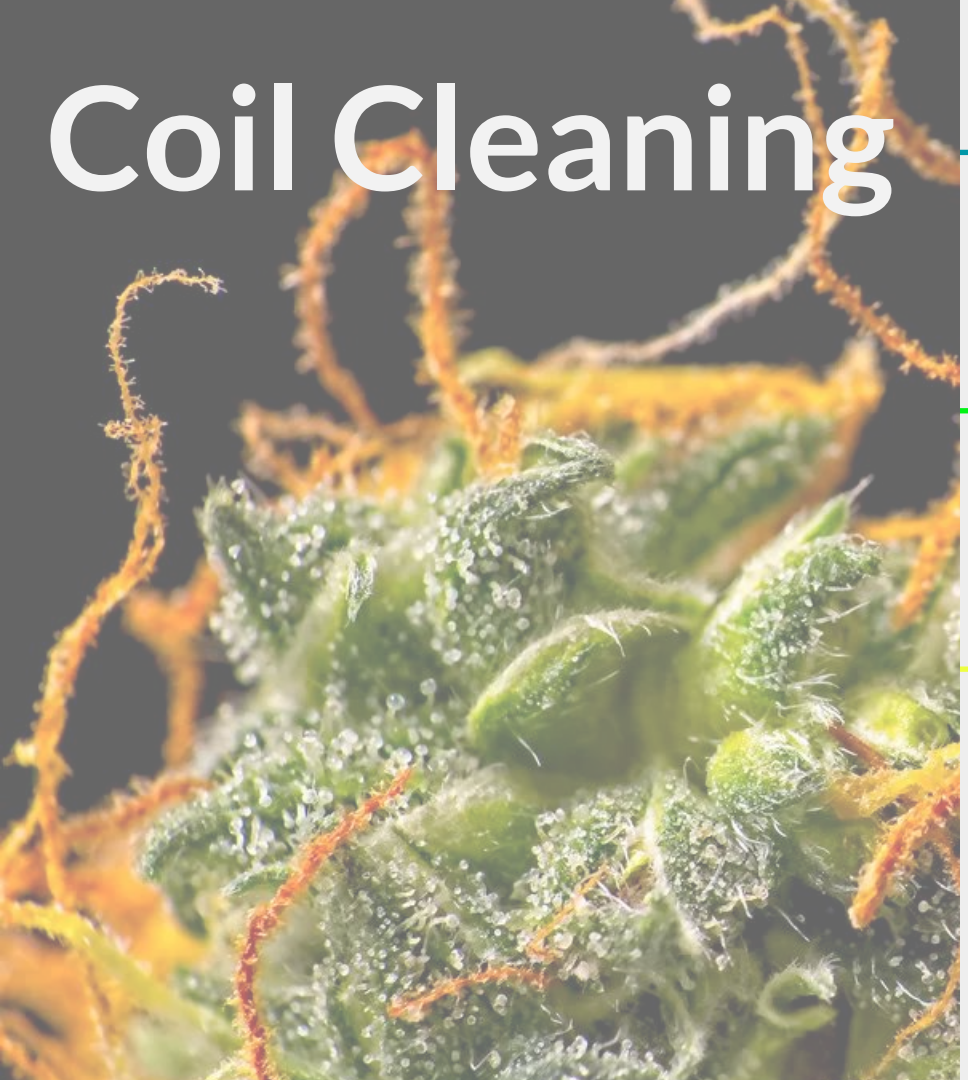
Check Belts

- Tension

Check Bearings

- Lubricate

Coil Cleaning



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Clean Condenser Coils

Clean Evaporator Coils

Clean Drain Pan

Filter Replacement

Change Filters Every Grow Cycle

Sensor Calibration

Calibrate Grow Room Sensors Annually

Maintenance Labor

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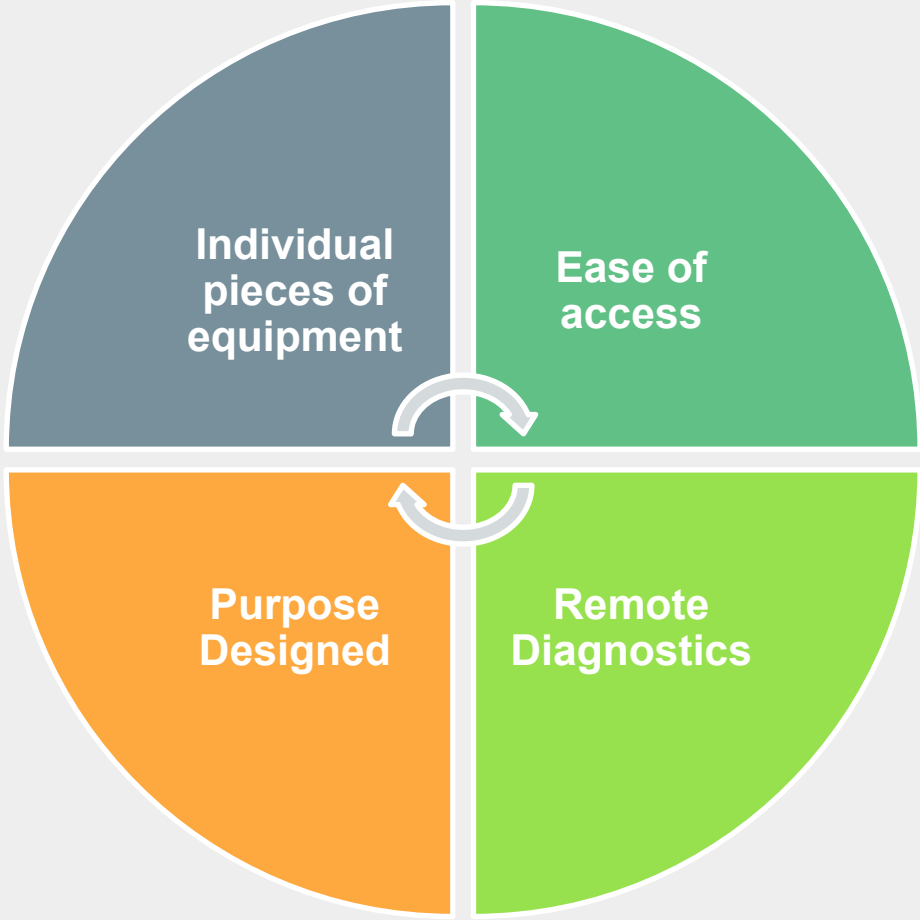


Who Is Going To Service?

- Commercial HVAC experience needed
- Larger facilities can save with inhouse expertise
- Quality manufacturers have Grow Room training classes
- Service personnel should be on site for commissioning

NATE

Certifying the finest in HVACR.

Importance Of HVACD Equipment Commissioning

- High quality manufacturers offer commissioning
- Factory confirmation of installation and operation
- Room specific system tunning/ optimization

Tips for minimizing HVACD downtime

Knowledge Check: Compared to field crop production in summer, a greenhouse…

- ~~Has about the same insect and disease problems~~
- ~~Has less insect and disease problems~~
- Has more insect and disease problems

SECTION 03

Climate Control Optimization & Equipment Tracking in Cannabis Facilities

POLL ALERT!

What is your focus for the upcoming year within your cultivation practices?

- I’m just starting out!
- Saving Energy
- Temperature control
- Humidity control
- Light control

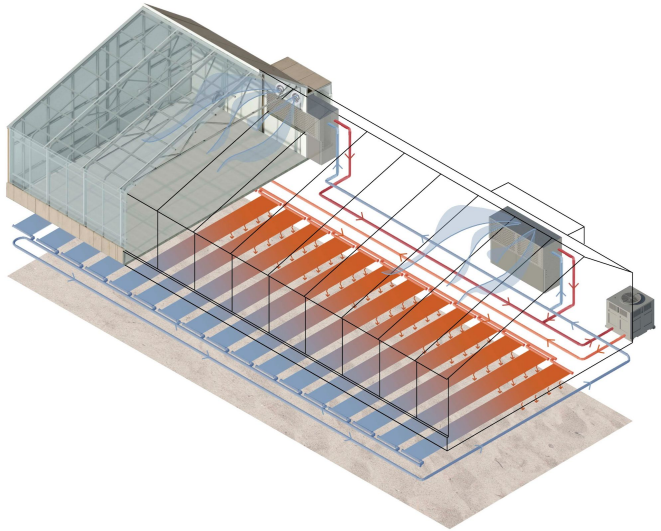
Considerations for Selecting Equipment and Controls

It is imperative that you **understand the systems** that you are purchasing or currently own?

Energy-Efficient HVAC design starts by selecting HVAC systems that are specifically designed for the unique needs of cannabis cultivation. This includes systems that can efficiently manage **high humidity and temperature** requirements.

- **RTUs:** Versatile, suitable for medium-sized operations.
- **DOAS:** Conditions outdoor air, energy-efficient.
- **Chilled Water Systems:** For large-scale facilities, efficient.
- **Geothermal Systems:** Energy-efficient, costly to install.
- **Commercial Central ACs:** Powerful, for large facilities.

- **Mini-Split ACs:** For small operations, offers temperature control.
- **Wet Walls:** Ideal for large operations, this method requires an arid climate.



Considerations for Selecting Equipment and Controls

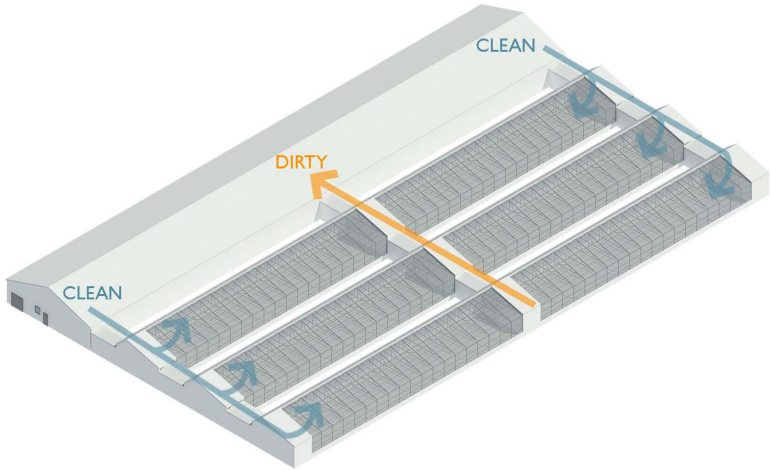
In a grow facility there are **both process** and **comfort zones.**

Zoning and Segmentation: Creating different climate zones within the facility to provide precise environmental control based on the specific stage of plant growth or strain requirements.

Process: Growth
Clones
Mother
Vegetative (early - late)
Flower (early - late)
Dry / Cure

Process: Post
Trim
Kitchen
Extraction

Comfort: Human
Office
Break
Storage



Considerations for Selecting Equipment and Controls

Consider the **locality**, complexity, and required expertise.

Local Climate Conditions: Select climate-appropriate equipment and consider local weather patterns for energy efficiency in cannabis cultivation facilities.

- **Regulatory Compliance:** Ensure that the selected equipment complies with local regulations and standards, particularly in terms of energy consumption, emissions, and safety.

- **Choosing Equipment Specially Suited to the Environment:** It's incredibly important to choose and invest in equipment that is specifically designed and built to deliver optimal performance within the unique conditions of the climate where your facility is located.

  Different climates necessitate different types of machinery - for example, in a region with a particularly humid climate, it would be beneficial to invest in dehumidifiers and HVAC systems which are specifically designed and equipped with the necessary mechanisms to efficiently manage and handle high moisture levels. These are absolutely crucial to ensure the smooth running of operations and to prevent any potential damages or breakdowns due to the adverse effects of high humidity.

Considerations for Selecting Equipment and Controls

Consider the locality, **complexity**, and required expertise.

Complexity of Systems: While advanced systems offer more features and control, they also come with increased complexity. It's important to balance the need for advanced functionality with the practicality of managing and maintaining these systems. **DX or Hydronics?**

- **Direct Expansion (DX)** systems operate by circulating refrigerant directly to the air handling unit. The refrigerant absorbs heat from the air and changes from a low-pressure gas to a high-pressure liquid. This heat is then transferred outside, and the refrigerant is changed back into a low-pressure gas, ready to start the cycle again.

- **Hydronic systems,** on the other hand, use water as the heat transfer medium. In cooling modes, the water absorbs heat from the air in your space and is then cooled by refrigeration machines before being recirculated back. For heating, the water is heated up by boilers and then circulated to provide warmth.

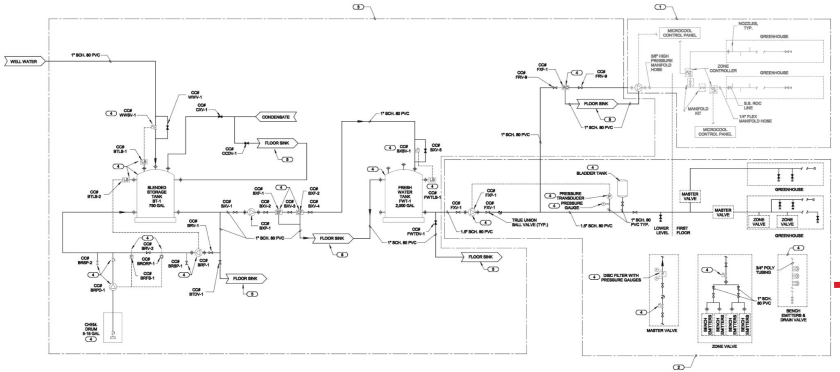
- **Variable vs Step Capacity:** Variable capacity systems adjust their output based on a cultivation facility needs, providing precise environmental control and energy efficiency. Step capacity systems operate in stages, offering less precision but more flexibility than fixed systems.

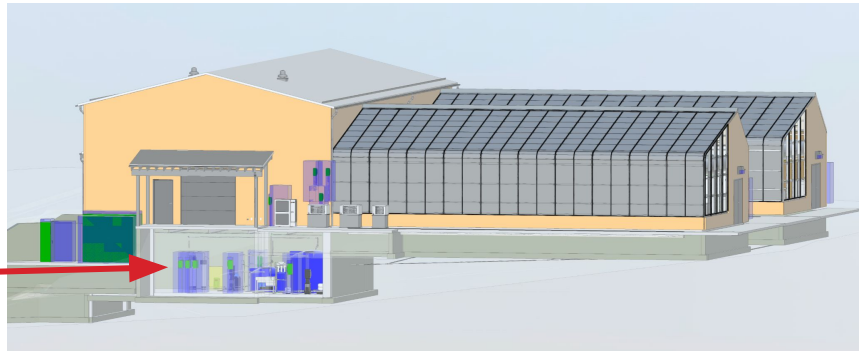
Considerations for Selecting Equipment and Controls

Consider the locality, **complexity**, and required expertise.

Integration into infrastructure:

- **Integration Capability:** It's crucial to consider how seamlessly new equipment integrates with the existing systems, especially in terms of the facility's current structure and operational plans. The selected equipment should blend smoothly with the current infrastructure, minimizing disruptions while enhancing overall efficiency. Moreover, it's also advisable to consider future operational plans. Will the new equipment support expansion or technological upgrades? Answering such questions will ensure that the chosen equipment supports not just the present needs but also accommodates future growth and advancements.





Considerations for Selecting Equipment and Controls

Consider the locality, complexity, and **required expertise**.

Required expertise: At a grow facility, both growers and facility engineers play crucial roles, each with distinct responsibilities:

- **Grower**: The grower is primarily responsible for the cultivation of plants. This includes tasks such as planting, watering, pruning, pest management, and harvesting. Growers need to have a deep understanding of plant biology and the specific needs of the plants they are growing. In a cannabis cultivation facility, growers would be responsible for ensuring the cannabis plants are healthy and that their growth conditions (light, temperature, humidity, nutrients) are optimal. They may also be involved in selecting the strains to be grown and determining the best cultivation techniques for each strain.

- **Facility Engineer**: On the other hand, the facility engineer is responsible for the operational aspects of the facility. They ensure that all the systems and equipment in the facility (such as irrigation systems, lighting systems, HVAC systems) are working correctly and efficiently. They would also be involved in the design and layout of the facility to ensure optimal workflow and conditions for plant growth. In the event of equipment failure or other issues, the facility engineer would be responsible for troubleshooting and resolving these problems. In some cases, they may also be involved in planning for future expansions or upgrades to the facility.

Climate Control Optimization:

Grow facilities **require** environmental controls.

Environmental Controls: Environmental Controls involves the optimization and careful monitoring of cultivation conditions to ensure optimal plant growth and yield.

- **Customized Climate Profiles**: Developing specific climate profiles for different stages of plant growth or for different strains, which include optimal temperature, humidity, CO2 levels, and air circulation patterns.
- **Automated Control Systems**: Utilizing advanced automated systems that can adjust climate conditions in real-time based on sensor data, reducing manual intervention and ensuring consistent environmental conditions.
- **Energy Efficiency**: Implementing energy-efficient programming, such as staggered lighting schedules or adaptive HVAC operation, to minimize energy consumption while maintaining optimal growth conditions.

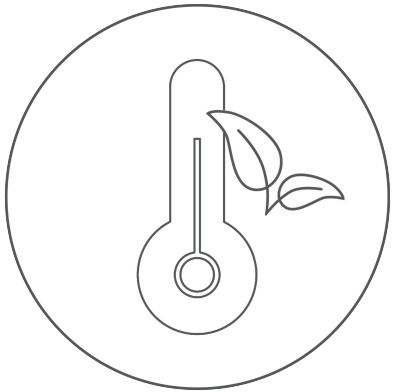
Climate Control Optimization:

Selecting **sensors** and sensor **location**.

Sensor Selection and Location: Choosing the right sensors and placing them appropriately is crucial in optimizing HVAC systems in cannabis cultivation.

- **Sensor Importance:** Sensors are essential for maintaining ideal cannabis growth conditions, monitoring temperature, humidity, CO2 levels, and light intensity. This data influences the HVAC system's adjustments. High-quality, accurate sensors are crucial for precise environmental control.

- **Sensor Location:** Proper sensor placement in the cultivation facility is vital for accurate readings, which guide optimal conditions. Incorrect placement, like near HVAC, could cause false data and overcompensation. Sensors should be at canopy level, representing the overall environment and away from equipment.



Climate Control Optimization:

Facility commissioning and staff training is critical.

- **Commissioning:** is a process that ensures that all system operate as intended from the start. This process involves checking all equipment, calibrating controls, and testing the system under various conditions to confirm it can reliably maintain the required environmental conditions.

- **Educating Staff**: Training ensures that all staff members are familiar with all of the system in an operation, enabling them to maintain optimal environmental conditions for cannabis growth. This involves understanding the system's controls and settings, knowing how to troubleshoot common issues, and being aware of the maintenance routines necessary to keep the system running efficiently.

- **Encouraging Proactive Engagement**: Promoting a culture where staff are vigilant and proactive in reporting any anomalies in environmental conditions or equipment performance.

Performance Derate

Understanding how **equipment performance** can affect your facility.

Causes of Performance Derate:

- **Wear and Tear**: Continuous operation causes gradual wear and tear on equipment, leading to reduced efficiency. For example, HVAC systems may lose cooling or heating efficiency as components wear out.
- **Dust and Debris Buildup**: Accumulation of dust and debris, especially in systems like fans, filters, and ducts, can significantly reduce performance.
- **Corrosion and Material Degradation**: In environments with high humidity or exposure to chemicals, corrosion and material degradation can occur, affecting the functionality of equipment.
- **Outdated Technology**: As technology evolves, older systems may become less efficient compared to newer, more advanced models.

Performance Derate

Understanding how performance **derate** can **affect your facility**.

Impact of Performance Derate:

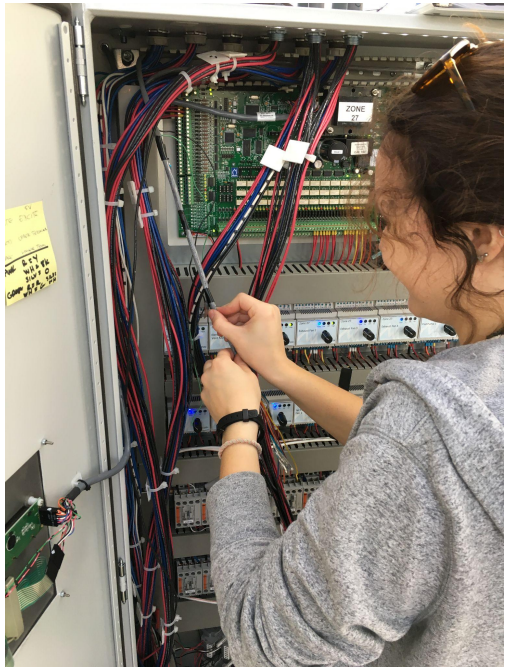
- **Increased Energy Consumption**: Degraded equipment often requires more energy to perform the same tasks, leading to higher operational costs.
- **Reduced Crop Yield and Quality**: Inconsistent or inefficient environmental control due to equipment degradation can adversely affect plant growth and crop yield.
- **Increased Maintenance and Repair Costs**: Equipment operating below optimal efficiency may require more frequent repairs.

Performance Derate

Understanding strategies to **prevent performance derate** over time..

Strategies for Mitigating Performance Derate:

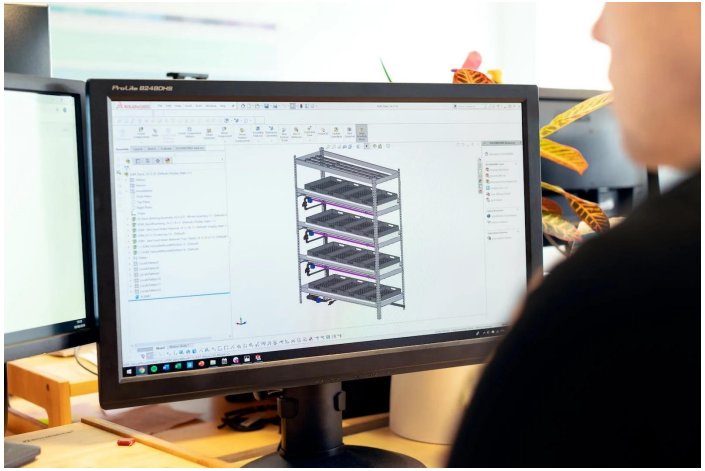
- **Regular Maintenance and Servicing**: Scheduled maintenance is crucial for keeping equipment in top condition. This includes cleaning, lubricating moving parts, replacing worn components, and ensuring all systems are operating as intended.
- **Performance Monitoring**: Implementing systems to monitor the performance of key equipment can help identify when they begin to operate below their optimal effi
- **Calibration and Adjustment**: Regular calibration of sensors and control systems is necessary to ensure accurate readings and optimal operation.
- **Upgrades and Replacements**: Periodically upgrading equipment to newer, more efficient models can prevent performance derate.
- **Training Staff on Equipment Care:** Educating the cultivation facility staff about the importance of equipment care and how to identify signs of wear and inefficiency is crucial. This empowers the team to be proactive in reporting potential issues.



Equipment Usage Tracking and Maintenance

Why track equipment usage?

- **Operational Efficiency**: Tracking equipment usage helps in understanding how often and how intensely different pieces of equipment are used. This information is crucial for optimizing operational efficiency and identifying potential overuse or underutilization.
- **Predictive Maintenance**: By monitoring usage patterns, facilities can move from a reactive to a predictive maintenance model, addressing potential issues before they lead to equipment failure or significant downtime.



Equipment Usage Tracking and Maintenance

How do we track equipment usage?

- **Automated Monitoring Systems**: Implementing automated systems that can track the usage of key equipment in real-time. This might include software that logs operating hours, environmental conditions, and performance metrics.

- **Manual Logs and Checklists**: In smaller operations or for certain types of equipment, manual logging of usage can also be effective. This involves staff members recording usage times and conditions as part of their routine.

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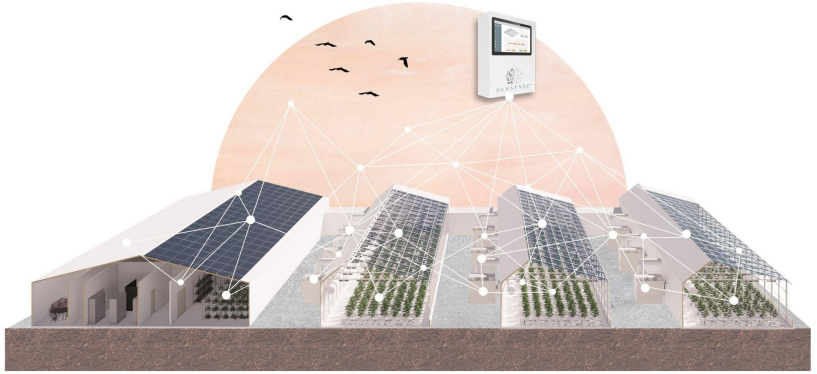


Equipment Usage Tracking and Maintenance

Maintenance **Scheduling**

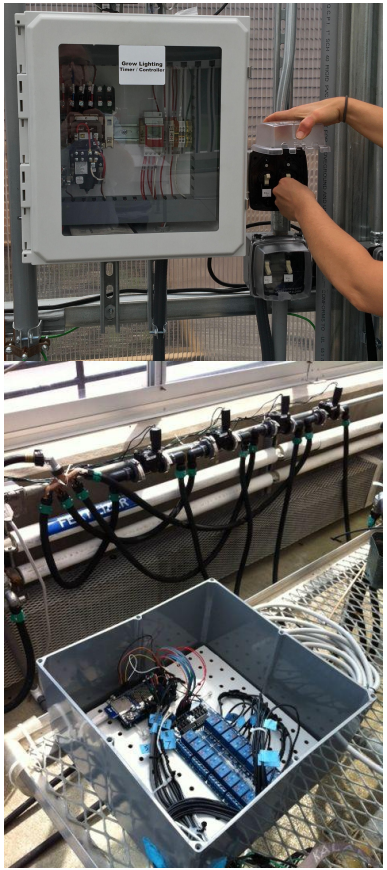
- **Preventive Maintenance**: Establishing a preventive maintenance schedule based on the manufacturer's recommendations and real-time usage data. This includes regular inspections, cleaning, part replacements, and system checks.
- **Seasonal Adjustments**: Adapting maintenance schedules to account for seasonal variations in equipment use. For example, HVAC systems may require more frequent maintenance during periods of peak usage.

Equipment Usage Tracking and Maintenance

Maintenance **Prioritization**

- **Critical Equipment Focus**: One of the key strategies we employ is prioritizing maintenance for equipment that is critical to the cultivation process. This involves focusing our efforts on systems that play a pivotal role in the growing process, such as climate control systems that regulate temperature and humidity, and lighting systems that are essential for photosynthesis and plant growth. By doing so, we ensure that the most crucial components of our operation remain in optimal condition.

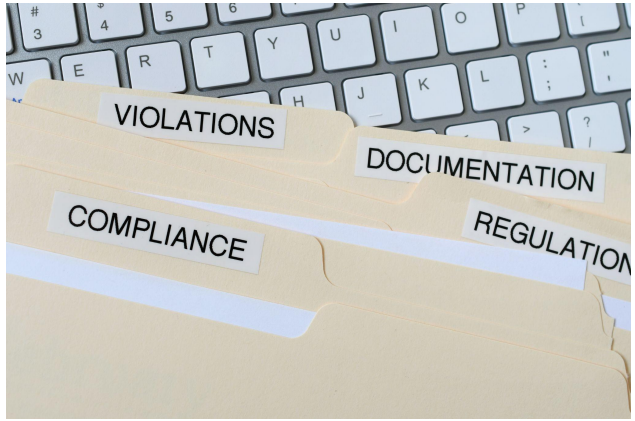
- **Risk-Based Maintenance**: Additionally, we use a risk-based approach to maintenance. This means identifying which pieces of equipment pose the highest risk to our operation in case of failure. We then prioritize the maintenance of these high-risk items to prevent any potential disruption or damage. This approach allows us to effectively manage risk and ensure the smooth operation of our cultivation process.



Equipment Usage Tracking and Maintenance

Documentation and Record-Keeping

- **Maintaining Accurate Records**: Keeping detailed records of all maintenance activities, including dates, actions taken, and any parts replaced. This helps in tracking the history of each piece of equipment and planning future maintenance activities.
- **Review and Analysis**: Regularly reviewing maintenance records to identify trends, such as increasing repair needs, which can indicate that equipment is nearing the end of its useful life.



Equipment Usage Tracking and Maintenance

Integrating Maintenance with Operations.

Minimizing Disruption: Scheduling maintenance activities in a way that minimizes disruption to the cultivation process, such as performing major maintenance tasks during non-peak cultivation periods.

Standard Operating Procedures (SOPs)

The role of SOPs for ensuring consistent, efficient, and compliant operations in cannabis facilities

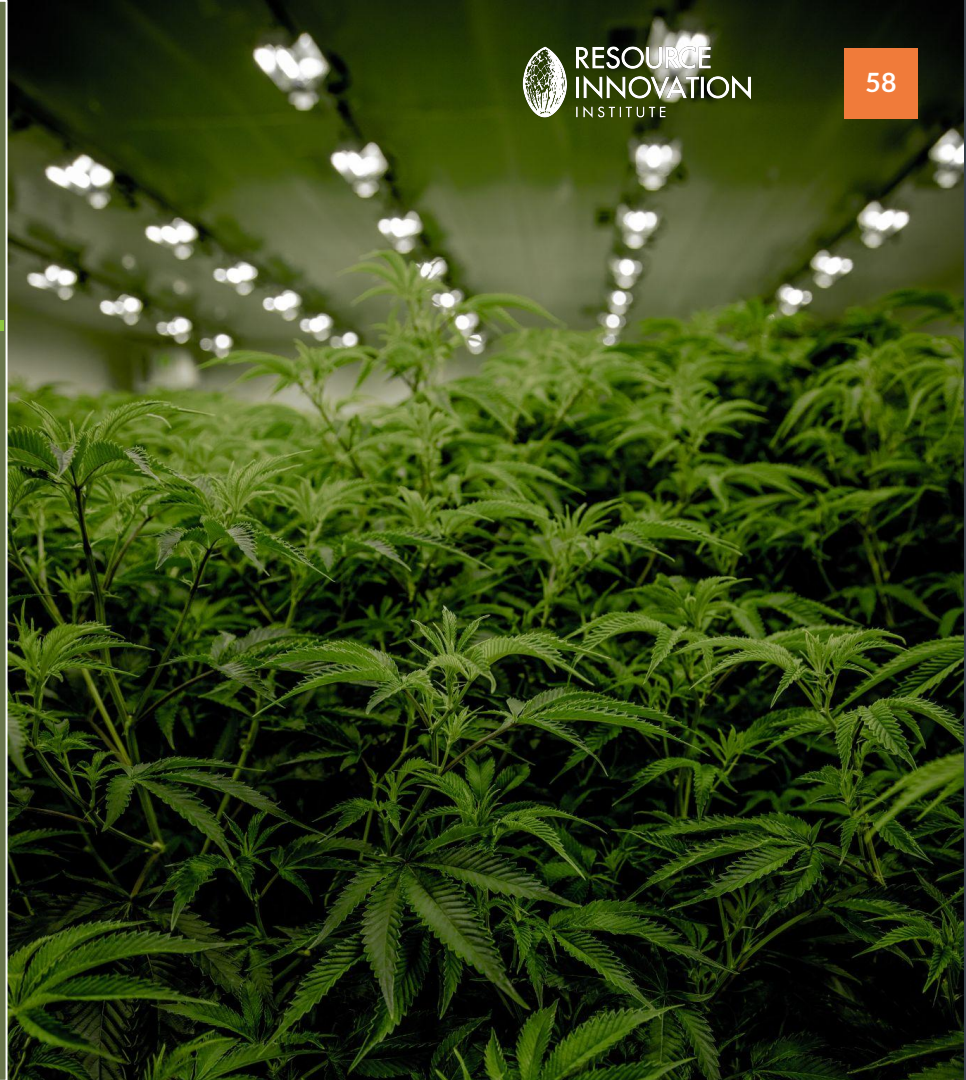
Standard Operating Procedures (SOPs) are vital for efficient and compliant cannabis cultivation. They provide clear guidelines for processes such as cultivation, equipment handling, pest management and more. SOPs not only mitigate risks and standardize quality, but also ensure regulatory compliance, guide staff training and provide a roadmap for emergencies, making them essential for the smooth operation of a cannabis cultivation operation.

1. **Cultivation Practices SOP**: This includes guidelines for seed germination, cloning, planting, nutrient and water management, lighting schedules, and maintaining optimal environmental conditions.
2. **Equipment Handling and Maintenance SOP**: This covers the proper use of equipment, maintenance and calibration schedules, and safety protocols for handling equipment.
3. **Pest and Disease Management SOP**: This includes preventive measures against pests and diseases, regular inspections, and treatment protocols in case of an outbreak.
4. **Harvesting and Post-Harvest Handling SOP**: This details the methods for harvesting, curing, and storing the harvested cannabis.
5. **Compliance and Documentation SOP**: This ensures that all processes are compliant with relevant laws and regulations and establishes protocols for record-keeping.
6. **Staff Training and Management SOP**: This serves as a training guide for new staff and provides a basis for monitoring staff performance.
7. **Quality Control SOP**: This includes steps for regular quality checks to ensure the final product meets desired standards.
8. **Emergency Procedures SOP**: This outlines the steps to be taken in emergencies, such as equipment failure, power outages, or natural disasters.

POLL ALERT!

What is your focus for the upcoming year within your cultivation practices?

Discuss Results



SECTION 04

Grower Perspective: Common Mistakes in Operations & Maintenance

KNOWLEDGE CHECK!

True or False?

Ideally, the Grower is responsible for both the cultivation of plants *as well as* the commissioning, maintaining and repairing all equipment and systems.

More Machine Than Building

From first transplant, plant growth facility climate control equipment is constantly running, responding to a dynamic environment, both within and without.

Like many machines, they are not designed with ease of repair in mind.

Planning Ahead

Design:

- CO2 enrichment capability for market-responsive cultivation
- Design for future water regulation
- Design for future growers; expect turnover

Commissioning:

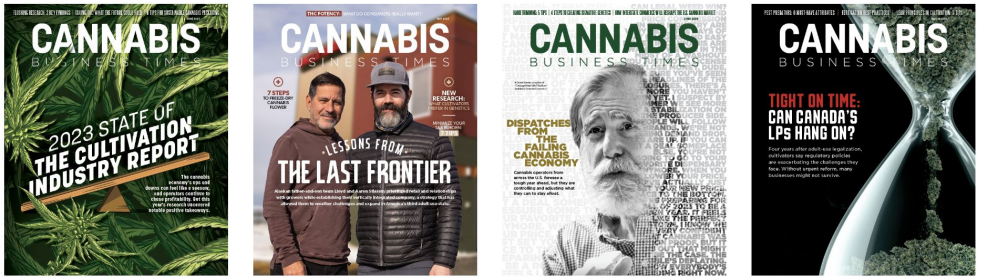
- Create a Commissioning Plan
- Create a consensus *early* for a **commissioning and training week** at occupancy

Maintenance and Repair:

- Spare parts, both budget *for* and organization *of*
- Plan on a forklift, single-person powerlift and safety ladders, depending on facility
- Plan and test a Power Outage SOP
- Grab n' Go tool kits customized for repair type: electronics, plumbing, irrigation

Reducing Wear and Tear

- Limits on how often lights and shade curtains can cycle per day
- Lubrication as part of preventative maintenance plan: fans, curtain gears, conveyance
- Evaporative pad cleaning and reservoir monitoring of EC
- Alternating redundant cooling stages (fans) and heating (unit heaters) to spread duty



See:
'24 Tips to Improve Greenhouse Efficiency'
CBT, March 2021, by Robert Eddy
...and 20 more articles!

When Failure of a <$40 Component Can Lead to Ruin…

Sensor Box Aspiration Fan
Exhaust Fan Belt
Damper Motor
Hose Clamp
Cooling Pump
Irrigation Pump or Solenoid
Lighting Relay
Inflation Fan for Polyhouse

Train you staff to know when something looks, sounds or smells wrong and reward them–meaningfully and personally–for reporting anomalies, even for false alarms.

KNOWLEDGE CHECK!

True or False?

Ideally, the Grower is responsible for both the cultivation of plants *as well as* the commissioning, maintaining and repairing all equipment and systems.

FALSE

Takeaways

- Integrated HVACD (dehumidification built into an HVAC unit) has higher upfront costs but great benefits: more energy efficient, requires less maintenance, provides better climate control and can be diagnosed/tuned remotely
- Critical maintenance points for HVACD (and most HVAC) need to be conducted by a trained professional in refrigeration, either hired or contracted, not a grower.
- Grow facilities require environmental controls with properly placed high-quality sensors. It's not something you can do manually by switching on/off yourself.
- For selecting equipment and controls, consider the locality, complexity, and required expertise. Both simple and advanced systems can be effective.
- Preventative maintenance is a MUST DO, and should be prioritized for equipment critical to crop survival and most at risk of failure

SECTION 5

Q & A

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