Moderator: Nick Hice, Denver Relief Consulting
Panelists:
Paul Golden, Nexus Greenhouse Systems
Nick Earls, Wadsworth Control Systems
Mike Sacomano, Forever Flowering Greenhouses
Energy demand: Warehouse v. Greenhouse

- Light levels
- Cooling needs
- Humidity control and Dehumidification
Lighting differences between GH and WH grows

Greenhouses utilize 1,000 W of lighting every 36-81 ft\(^2\), but only run lights part of the year.

Warehouses utilize 1,000 W of lighting approx. every 16-20 ft\(^2\).

Power required for GH lighting ~ 18-30 W/ft\(^2\).

For a target Day Light Integral of 30 - 40 mol/m\(^2\)/day.

Summer months don’t require lighting.

Power required for WH lighting ~ 52-66 W/ft\(^2\).
Cooling differences between GH and WH grows

Warehouses have 1.5 – 3x the amount of light fixtures as greenhouses, & run these lamps 12, 18, or 24/7/365.

Every three 1,000 W lamps require one ton of cooling (approx. 30-60 W/ft² to cool).

Greenhouse evaporative cooling systems require little energy (approx. 1-2 W/ft²).

From 10-30 °F temperature reduction!

Total energy WH: 120-225kWh/ft²/yr  GH: 60-75% less
Humidity Control & Dehumidification

- Plant biology & humidity
- When and where is supplemental dehumidification necessary?
- When is humidity control most important in a GH?
- Types of supplemental dehumidification
Plant biology as it relates to humidity

- 50% RH is not an indicator of fungal disease conditions. If air and leaf temperature ≤ 60°F, humidity levels at 50% may be ideal for fungus.

- With proper GH air mixing mold can be prevented at 70% RH & 80°F.

- Vapor Pressure Deficit (VPD) is a better indicator than relative humidity.

- VPD can identify when condensation may occur in the canopy.
When and where to supplement dehumidification?

If VPD is less than 0.20 kPa, condensation and disease may occur.

The ideal range for plant productivity is a VPD from 1.0 kPa to 0.85 kPa.
When is humidity control most important in a GH?

Monitor temperature, humidity (VPD) conditions when entering blackout!

• Blackout occurs from 7PM to 7AM
• Slowly reduce light levels (slow transpiration)
• Prevent temp from quickly dropping when closing curtains due to lack of sunlight
• Operate all mixing fans
• Ventilate & purge humid air
• Heat air if necessary
• Use supplemental dehumidifiers
Types of supplemental dehumidification

• 2 primary systems used: Compressor and Desiccant

• Commonly only used in blackout or winter; fully-closed systems possible but very expensive

• Most reject heat into the space, a select few provide cooling

• Not standard HVAC sized equipment. Should be sized/designed by professionals
Optimal Climate Control for Greenhouses
Total Environmental Commercial Controls

- Branching out
- Hobbyist vs. commercial controls
- Multiple controls (poor choice - inefficient)
- Embracing new technology
- Flow and facility design
- Security and passwords
- Backup generator
Benefits of a Total Control

• All equipment under one interface
• Compare sensors and equipment readings
• Integrated equipment works better
• Alarm for any condition
• Remote in from outside location
• Multiple setpoints for trigger
• Hybrid (indoor & greenhouse)
Data Analysis

- Equipment vs. setpoint
- Past vs. future data
- Overrides
- Irrigation duration vs. moisture content
- Harvest vs. climate analysis
Full Potential of Control System

• Read manual and/or purchase training
• Climate plan (setpoint goals)
• Advantages of sensors
• Shade and light dep curtains
• Set overrides or if codes
  • Dehumidification
  • CO2/Heat
  • Moisture sensors
  • PAR + DLI
  • Roof vents and WS
  • Lights and heat
Variable Speed & Multiple Outputs Equipment

### Variable Speed
- Air circulation fans
- Exhaust fans
  - Two speed
  - Variable speed

### Multiple Outputs
- Exhaust fans on multiple outputs
- Lighting
- Heating
- Curtains (shade and blackout)
Greenhouse Systems
Questions?

Thank You!
LET THE SUN SHINE: GREENHOUSE DESIGN AND OPERATIONS

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