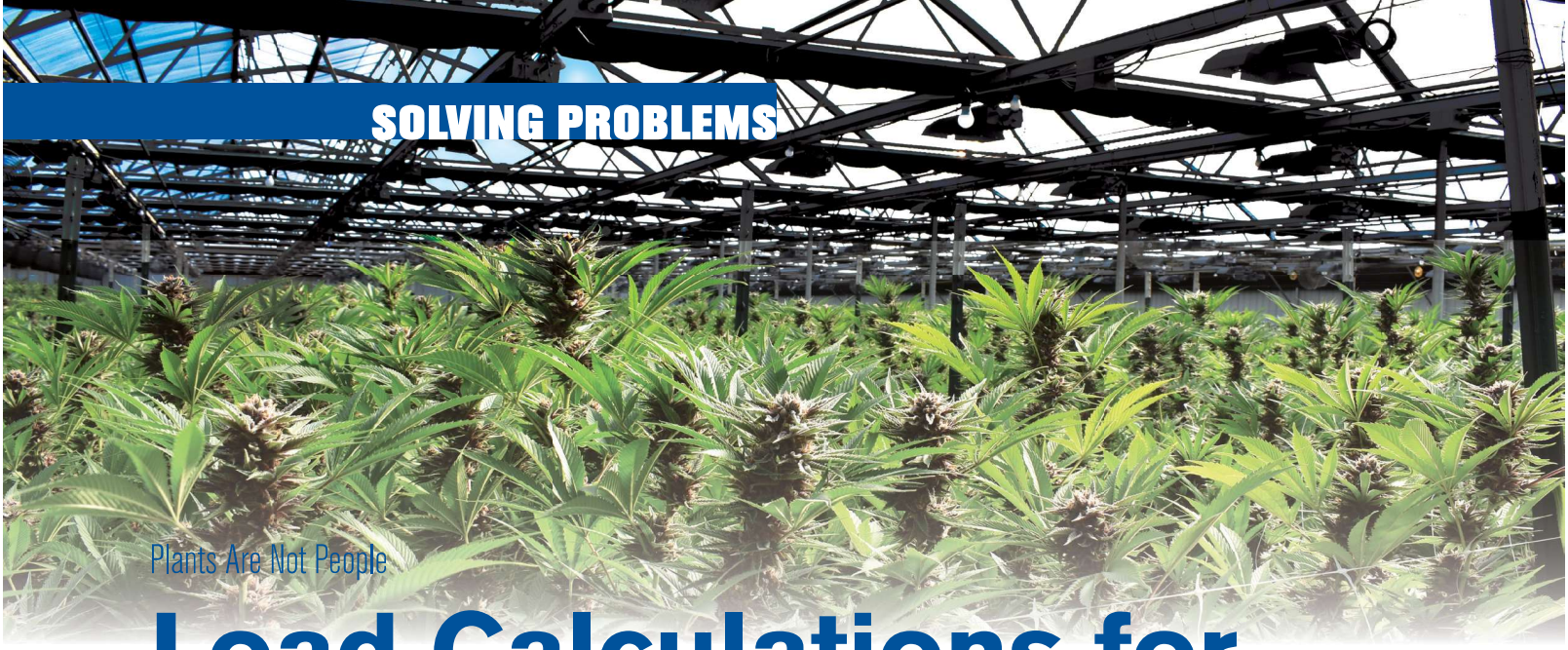

Plants Are Not People

Load Calculations for Cannabis Grow Facilities

BY MARY KATE MCGOWAN, ASSOCIATE EDITOR, NEWS

The cannabis industry is blooming. With the expected trend of increasing legalization, the demand for energy-efficient grow houses with effective climate control will increase. From temperature to humidity to light loads, cannabis grow houses require accurate HVAC load calculations to yield profitable crops.

HVAC load calculations are a fundamental consideration because HVAC systems indirectly control plant responses such as leaf temperature and transpiration—which affects photosynthesis—water and nutrient delivery, plant quality and growth rate, said Nadia Sabeh, Ph.D., P.E., Member ASHRAE, president of Dr. Greenhouse, Inc.

"Load calculations are where everything begins," she said. "If you don't get the load calculations right, you're not going to get the equipment sizing right. You're not going to get the equipment selection right. You're not going to get the equipment operation right, and growers are going to really struggle to control not just temperature, but also humidity and airflow."

Plants Are Not People

Plants are not people, data servers or hospital rooms, said Sabeh, and this could affect how engineers approach grow facilities. Cannabis is a plant. Plants are living, dynamic organisms that grow from a seed or small seedling plant to full maturity. This introduces challenges for engineers designing and selecting HVAC equipment for grow houses.

Because plants grow and evolve, engineers must be able to design, manufacture and develop equipment that can respond to a changing environment over the course of a plant's life, she said.

"We need monitoring and control systems and equipment that can respond to and predict the changes in the environment," said Sabeh.

Common Challenges

Designers cannot calculate HVAC loads for grow facilities the same way they calculate HVAC loads for conventional office buildings, said Stephen Roth, P.E., Member ASHRAE, president of Carmel Software.

"When calculating HVAC loads for office buildings, sensible loads are the driving force for calculating total loads, determining airflow, and for equipment selection. When calculating HVAC loads for grow facilities, latent loads are the driving force. Therefore, using a conventional load calculation software tool for grow facilities may produce inaccurate results," he said.

Roth said designers need to consider peak HVAC loads for different stages of the plant.

"Cooling dry-bulb and relative humidity setpoints will

be higher when plants are smaller. When the plants get bigger, relative humidity setpoints will decrease," he said. "Different grow room types will require their own individual HVAC systems too."

This among other grow facility characteristics affect the buildings' loads.

Sensible and Latent Loads

Adding the sensible and latent loads together is a common error designers make when calculating loads for cannabis grow facilities, said Sabeh.

Engineers rarely consider the fact that the plants often act as their own mini-evaporative coolers, said Roth. This means the plants themselves cool the air, so the total calculated sensible load for sizing equipment must be reduced by the amount of sensible cooling the plants provide, he said.

"So all that water gets turned into water vapor, which are those latent loads that are so challenging for HVAC equipment to handle," Sabeh said. "Plant transpiration is an evaporative cooling process, so sensible heat gets converted to latent, reducing the overall sensible load of the room."

Roth said designers need to accurately know the quantity of plants. This determines how much water is being used, which will then determine the latent load.

"Make sure to consider 'net water,' which is the watering rate minus any wastewater (usually between 10–30%)," he said.

Plants generate a lot of moisture in the room. When growers irrigate their plants, the plants' root absorb anywhere between 60% to 90% of the water delivered to them, depending on the grow media and irrigation frequency. That water then moves to the stem, and then exits the leaves through transpiration, said Sabeh.

Vapor Pressure Differential

Designers need to understand the vapor pressure differential (VPD), which describes the pressure difference between at the surface of the leaf and the vapor pressure in the air, said Roth.

"VPD significantly affects the plant, just like temperature affects the plant," said Sabeh.

Research has shown for various crops that reducing VPD increases yield and quality of plants, which she said is good news for HVAC engineers because higher VPDs are hard on HVAC equipment.

Sabeh said some growers target low air temperatures and/or low relative humidities that result in a high VPD condition, but this could be detrimental to the crop.

"They're just so afraid of humidity that they think that the drier the environment is, the better it is, the more unlikely they are to get mildews and mold," she said. "But actually it can really stress the plant."

Undersizing and Oversizing Equipment

Because plant transpiration is an evaporative cooling process, sensible heat gets converted to latent heat, said Sabeh. This reduces the overall sensible load of the room. Not understanding this could result in oversized HVAC equipment, which increases both capital and operating costs. Oversizing equipment can cause HVAC equipment to short cycle, which affects its life expectancy. It can also cause unnecessary energy usage, which will increase utility costs, said Roth.

Sabeh said she has also seen a lot of equipment undersized for latent loads. Plants generate a lot of moisture in the room, and if not controlled, the humidity will continue to rise, creating risks for mold growth and condensation on cool surfaces.

Roth said web-based HVAC sizing software tools for cannabis grow facilities can be good resources for calculating required HVAC cooling and heating loads and sizing equipment and getting pricing. He advised designers to use software that is specifically designed for calculating grow facility cooling and heating loads.

"Conventional HVAC load calculation software may return incorrect results since they solve for sensible loads to calculate airflows. Software specific to grow facilities solves for latent loads to calculate airflows," he said.

Nighttime Conditions

Sabeh said most of the water is generated when the lights are on when the plants are actively photosynthesizing. Plants continue to transpire when the lights are off, but at lower rates.

"This nighttime condition has caused a lot of challenges for growers. When the lights are on, the AC unit operates trying to meet the temperature setpoint and subsequently dehumidifies the air. But when lights shut off, the sensible load goes away, the thermostat setting is satisfied and the AC unit shuts off, subsequently shutting down dehumidification," she said.

To avoid these errors, Sabeh advised designers to ask

the grower how much water they will use to irrigate their plants.

"But don't stop there. Typically, about 30% of the irrigation water is drained away from the planting media. Therefore, the plant transpiration rate will be about 70% of the total irrigation water," she said.

Sabeh said it is important to select equipment that operates to meet both a temperature and a humidity setpoint, which helps avoid loss of humidity control when lights are off.

"In cases where humidity control drives operation of the unit, it's important to have a reheat coil after the cooling coil so that the room is not over-cooled. Also, we don't really want to deliver sub-50°F (10°C) degree air to the plants," she said.

Airflow Volume

Proper airflow volume is important in grow facilities because cannabis plants need correct amounts of airflow over the leaves to help induce evapotranspiration, said Roth. He said designers should calculate airflow according to latent load first. Then, designers can size for a specific cfm/ton since airflow quantity is important for ensuring that plants do not get mildew and mold.

"Often, you'll size for around 350 cfm/ton (47 L/s per kW) for flower rooms. This will then affect the coil leaving temperature which may not be at the conventional 50°F to 55°F (10°C to 13°C)," he said.

Designers need to consider mold and mildew. Not having enough airflow over the plants may cause mold and mildew to form which will destroy the plants, said Roth.

Designers also need to pay attention to ventilation and filtration strategies.

"If the facility needs to be ventilated, then there will need to be some type of exhaust system (to maintain equalized pressure or slightly negative pressure)," said Roth. "Because cannabis is so pungent, the exhaust system requires some type of filtration so that the odors do not escape the facility and cause complaints from neighboring businesses and residences."

To avoid introducing mold spores into the grow room from the air, Sabeh says that MERV 11 and MERV 13 filters are enough. "We don't need to install HEPA filters to remove the particles that growers care most about—dust, pollen and mold." Not only are MERV filters enough for grow operations, they also use require less fan energy than using HEPA filters.

Different Rooms

Grow facilities have different rooms for various stages of the cannabis plant life cycle. These rooms include the flower room, vegetative room, cloning room and mother room.

"One size does not fit all in grow facilities," said Roth. "Each of those rooms requires different sensible and latent setpoints so each room requires its own dedicated piece of HVAC equipment. One rooftop unit cannot serve all these different room types at once."

The conditions for each room differ based on the cannabis plants' needs. Younger flowers require a higher relative humidity while older, flowering flowers require a lower relative humidity, said Roth. Airflow levels could also vary in the different rooms.

Designers need to understand the control sequences of operation, said Roth.

"Different grow rooms require different sensible and latent setpoints along with different lighting schedules. All of this will affect how and when the HVAC equipment manages cooling and heating," he said.

Lighting

Roth said designers should consider the types of lights being used in the grow facilities. High-intensity discharge (HID) lights give off a lot more heat than LED lights, he said, but designers should consider whether lights will be changed from HID to LED down the road.

"If so, the HVAC equipment will need to be updated," Roth said.

Resources and Tips

As the legalization of marijuana grows in the U.S. and around the world, the need for HVAC solutions for grow houses will increase.

Sabeh said there is considerable activity in ASHRAE and ASABE, the American Society of Agricultural and Biological Engineers, to develop standards and guidelines to help growers, engineers and other industry professionals understand the unique characteristics of the indoor plant environment. She is the co-chair of a new standard—X653: HVAC for Indoor Plant Environments—that ASHRAE and ASABE are co-sponsoring.

ASHRAE recently granted TC 2.2, Plant and Animal Environments, approval for a research request to study the energy impacts of indoor plant environments, said Sabeh.

"Other groups, too, are sponsoring or engaged in research to understand the metrics, baselines, and

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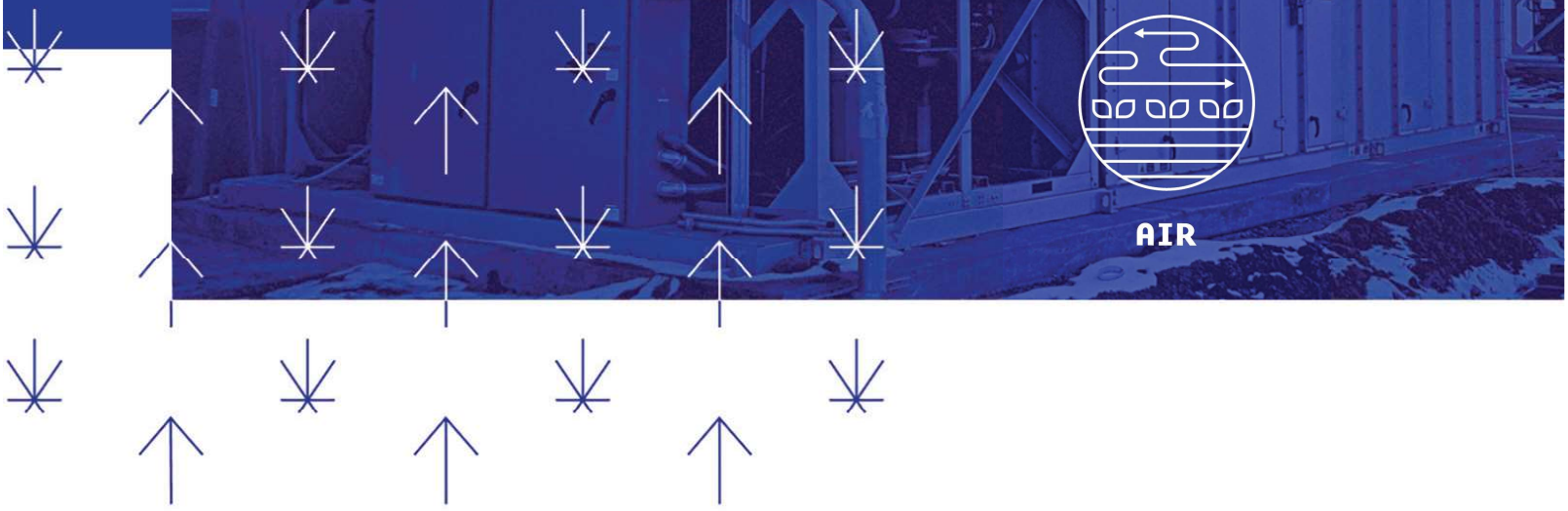

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best practices for growing cannabis, leafy greens, and a whole host of other crops in vertical farms, warehouses and greenhouses," she said.

In the meantime, Roth suggested for designers to consult with the "Environmental Control for Animals and Plants" chapter in the 2019 ASHRAE Handbook—HVAC Applications. Roth also advised designers to consult with HVAC manufacturers that specialize in grow facilities consultants who are experts in HVAC grow facility design. He said TC 2.2 also has members who are experts.

Working with Growers

After determining the local calculations, the next step is identifying equipment that can meet both the sensible and the latent loads. And that can be a real challenge, said Sabeh, because a lot of the conventional commercial or even residential equipment is just not built to handle both of those types of loads really well.

"For these grow rooms, the sensible heat ratio can be less than 0.5, which is jaw dropping for a lot of engineers," she said.

Then, engineers work with the project like they would do in any commercial building. But growers can be a different kind of client from other commercial building projects. Understanding growers as farmers and the challenges they face with market pressures is critical, she said.

"Growers are a totally unique type of customer and client for us," she said. "They're very focused on farming… They're making money by how productive their plants are and how much they can sell that product to their customers for."

Sabeh said growers rely on designers to provide the best environment possible to make them productive and profitable.

"Although cannabis has a high market value today, as supply increases, prices will go down and so will profit margins," she said. "By figuring out how to best design the HVAC system (and other systems) using the least amount of energy, water, and other resources, we are helping them cut their costs and remain profitable so we can all enjoy the fruits of their labor." ■

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