There is an exciting new and emerging market out there that will challenge the monotony of commercial building construction and design. Not often do we as a design community get the chance to apply our expertise to something new and challenging. Welcome to the controlled environment agriculture (CEA) movement.

As the population increases, available farmable land decreases, and natural resources become more and more strained feeding people will become increasingly difficult. The CEA market is poised to solve these challenges by taking a technology-based approach to growing our food supply indoors. There are many variables to consider when growing crops outdoors, including draught, flooding, pests, labor, sun, pathogens...the list goes on and on. Many of these variables can be controlled by moving the crops into a controlled environment, creating predictability and enhancing yields, but as with any decision this trade-off comes at a cost.

As more and more CEA facilities are constructed, the industry is on a collision course with regulatory agencies over environmental concerns. The emergence of the cannabis industry as a major CEA player has served to accelerate these agencies taking notice of energy usage.

The technological advances in LED lighting have brought the energy consumption of CEA facilities down drastically, but not enough to avoid being under a microscope. With the lighting already optimized, it is time to look at the next largest energy-hog in the building, the HVAC system.

**System Sizing & Selection**

Designing a mechanical system for a CEA facility begins in the same place as commercial buildings: system sizing. The commercial building world has conditioned design teams to focus on the sensible load of the space as the basis to select the HVAC equipment. The result is that systems are sized around the calculated sensible heat ratio (SHR).

It is important to understand the SHR of the space in order to get the equipment sized correct. The typical sensible heat ratio of an office building falls around 0.85. That means for 20 tons of cooling, there are only 3 tons available for latent load. This load distribution is the basis for how standard, "off-the-shelf" HVAC equipment is designed.

As we all know, not all tons are created equal. Many of the early cannabis cultivation facilities applied these standard, commercial HVAC units as the primary means of cooling and dehumidification. Not surprisingly these facilities were plagued by increasing humidity and wild temperature swings. Why?

Cultivation facilities, due to irrigation and resulting transpiration, can have a sensible heat ratio around 0.50. That means the "off-the-shelf" 20-ton unit will be 7 tons SHORT on latent capacity. In order to properly take care of these facilities a more complex design must be used.

Latent heat is the most difficult and energy intensive to remove. The most widely accepted way to remove that moisture is by brute force...cooling the air down below its dewpoint. This is a function of the temperature of the coil and coil depth. Physics places certain limits on the coil temperature, so coil depth (number of rows) needs to be increased in order to properly dehumidify the grow space.

This leaves two real options regarding system selection. The first is a purpose-built, packaged, direct-expansion unit and the other is a chilled water system. Both systems have their pros and cons that facilities operators need to understand, but in the end, both will maintain the environment necessary for plants the thrive.
System Optimization

Once you have your system properly sized and selected, it is time to look at what further measures can be taken to reduce the energy consumption of the HVAC system. Items like high efficiency compressors and ECM fans are easy places to start but have a small impact on these systems that run 24/7. Much like in the commercial HVAC world, CEA facilities need to look towards economization to try and remove as much mechanical cooling and dehumidification as possible, thus saving energy.

In commercial HVAC design, we are already familiar with this concept. Not only does bringing in outside air dilute the toxins and contaminants being produced in a commercial building, on suitable days the outside air can even be used to condition the space itself. However, with CEA facilities we have moved the crop inside to try to limit exposure to the pests and pathogens commonly found outside, and to keep CO2 levels high. Traditional outside air economization works against the fundamental goals of a CEA facility, putting the predictability of the product at risk. As a result, alternative economization methods need to be considered.

To maintain the integrity of the environment, indirect economization is the best approach. For those not familiar, indirect economization utilizes a heat exchanger to do the economizing in the system. For a CEA facility, a recirculated air stream (in this case from the growing environment) flows across one side of the heat exchanger and the other side using the outside air as a heat sink running it, single pass, across the heat exchanger and exhausting it back into the atmosphere. Heat is transferred from the recirculated air stream into/thru the heat exchanger and then passed on to the outside air.

This approach is common and well understood when transferring sensible heat, however the latent heat of cultivation spaces further complicates indirect economization, limiting available options. Most experts are familiar with heat pipes, run around coils, or fixed plate heat exchangers. Application of these products transfer sensible heat but allow the latent heat in the space to build. The answer for indirect economization of a CEA facility is a heat exchanger that can transfer both sensible and latent heat.

There are two main types of energy recovery devices that accomplish this: total energy wheels and enthalpy cores. Both are commonly used in commercial buildings for recovering energy from relief air before being exhausted and transferring that energy to the outside air being brought into the space. When used as an indirect economizer, the energy recovery device sits between the return air and outside air streams. On one side of the device, return air is recirculated to the space and on the other outside air is pulled through and exhausted.

Sensible heat is absorbed and released by the aluminum frame of the total energy wheel or enthalpy core. Latent heat is transferred at a molecular level, water vapor, and only happens on the surface of the wheel. The vapor pressure difference between the opposing air streams is what drives the water vapor transfer. This transfer of moisture is achieved without the energy intensive process of mechanically cooling the air down to dewpoint. This means dehumidification can be achieved indirectly with simple fans and either a total energy wheel or an enthalpy core. The effectiveness of the heat exchanger maximizes the number of hours throughout the year capable of indirect economization. Depending on your location, you can expect to turn your compressors OFF up to 40% of the year.

Summary

Controlled environment agriculture is a rapidly growing segment of the agriculture market and is here to stay. The ability to control all aspects of the growing environment translates into predictability of yield and, by extension, predictable profitability. But controlling these variables comes at a significant energy cost that is beginning to be noticed by regulators.

LED lighting was the initial low-hanging fruit of energy optimization and has largely been played out. The next energy revolution in the CEA industry will focus on the HVAC systems. The industry needs to provide purpose-built equipment that can handle the unique environments presented in a CEA facility, but do so with energy efficiency in mind. The days of brute-force cooling to achieve proper dehumidification are no longer an option for these 24/7 facilities.

Increasing the efficiency of the compressors and fans only works to a point. It will take creativity to drastically reduce the energy efficiency of these HVAC systems while not affecting the growing environment. Indirect economization uses the outside air to cool the space, without introducing contaminants into the space. This allows the compressors to stay off and can save up to 75% on the energy expended by the HVAC unit. These savings not only please regulators but will add to the bottom-line profitability of the companies implementing the technology.

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