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Energy-Efficient Dehumidification Equipment for CEA

Additional submitted attachment is included below.

The UC Davis Western Cooling Efficiency Center (WCEC) recently conducted a field demonstration of an all-electric heating, ventilation, and air conditioning (HVAC) system that provides energy-efficient dehumidification. The study occurred at two indoor container farms growing lettuce. The two indoor farms are located in the same city in California Climate Zone 4. Both container farms are the same model and operated with similar loads and weather for the duration of the study. Both farms were initially equipped with a packaged air conditioning unit that provided space cooling, dehumidification, and space heating. In July 2025, WCEC retrofitted one indoor container farm with the energy-efficient system and monitored its performance relative to the other farm, which still operated with the baseline HVAC system, through mid-May 2026.

The energy-efficient system is TRL 9, as it is commercially available and currently installed at several indoor growing facilities on the east coast. However, the energy savings provided by this equipment relative to conventional HVAC approaches for CEA have not been quantified in the real-world, until now. The study found that the energy-efficient system provided approximately 41% energy savings relative to the baseline.

The baseline HVAC system in this study is a packaged unit consisting of a direct expansion, R-410a cooling coil, an electric resistance heater, and a fixed speed blower. It provides dehumidification by cooling the return air to its dewpoint, the temperature at which moisture condenses out of air, at the cooling coil. However, this overcools the air, and the air leaving the cooling coil must be re-heated before it enters the indoor farm. Reheat is provided with the electric resistance heater. This is an inherently inefficient process, as energy is removed from the air then added back.

In contrast, the energy-efficient system is an air handling unit that consists of a plate air-to-air heat exchanger, a cooling coil, and an electric resistance heater. The heat exchanger transfers sensible heat from the return air to supply air. The return air is thus pre-cooled close to its dewpoint before it reaches the cooling coil. As a result, the cooling coil provides mostly dehumidification, rather than sensible cooling. The supply air is reheated as it exits through the heat exchanger, reducing the reheat energy required. Although the system used in this study was outfitted with a reheat coil, it was rarely used. Note that the cooling coil in this system can be either refrigerant or chilled water-based. The equipment used in this study had a refrigerant-based cooling coil, but a chilled water-based cooling coil could increase the system’s load shifting potential through a buffer tank. Using chilled water would also facilitate the addition of a secondary cooling coil after the heat exchanger, which would enable greater control over the sensible heat ratio provided by the equipment.

Between January and mid-May of 2026, the energy-efficient system provided 40.9% energy savings relative to the baseline system, while maintaining similar indoor conditions. It also reduced on-peak energy use (between 4:00-9:00 PM) by 24.8% relative to the baseline.

1. Technology Readiness and Performance
    a. As mentioned above, the current TRL for this system is TRL 9, as it is commercially available and used in some indoor growing facilities. The study conducted by the UC Davis WCEC quantified the energy savings and peak demand reduction that the equipment achieved in an indoor container farm relative to a baseline HVAC system that provided cooling with a direct expansion refrigerant coil and heating with an electric resistance heater. However, future demonstrations could evaluate this system at larger indoor growing facilities or against other dehumidification strategies, such as integrated air conditioning equipment with hot gas reheat. This strategy is becoming increasingly popular in indoor growing facilities because it is very efficient and provides fine control over the supply air conditions. The equipment evaluated in the recent WCEC study has some advantages over this approach, including load-shifting through a chilled water-based cooling coil and buffer tank, so a demonstration evaluating these two approaches against each other could be quite informative.
    b. Previous laboratory testing of the energy-efficient system found that its dehumidification efficiency at an outdoor dry-bulb temperature of 95 °F, an indoor wet-bulb temperature of 69.5 °F, and a flow rate of 800 cubic feet per minute was 3.5 liters per kilowatt-hour. Dehumidification efficiency at these conditions was not calculated from field data because indoor wet-bulb temperatures that high were not observed in the field study. However, in the field study, it provided 40.9% average energy savings relative to the baseline and an average on-peak energy reduction of 24.8%.
    c. The energy savings and on-peak energy reduction were calculated from field data collected from January to May 2026 at two indoor container farms, one of which operated with the energy-efficient system and the other with the baseline. The dehumidification efficiency, as noted above, was calculated from laboratory data collected in 2016.
    d. The energy savings achieved by the energy-efficient system were substantial and have the most potential to make a large impact. The on-peak energy use was also notable and could be even greater with a chilled-water cooling coil.
2. Load Flexibility
    a. The energy-efficient system used 24.8% less energy from 4:00-9:00 PM, on average, than the baseline between January and mid-May 2026.

b. The energy-efficient system achieved this on-peak reduction through higher dehumidification efficiency than the baseline. However, when integrated with chilled water, the on-peak reduction could be even greater. A chilled water buffer tank could supply the chilled water for the equipment, eliminating or reducing the need for chiller runtime during peak hours. A secondary cooling coil, also supplied by chilled water, would enable fine control over the supply air temperature and humidity.
c. Chiller runtime would be flexible, but indoor fan and chilled-water pump would be must-run.
d. This system equipped with a chilled-water cooling coil is very promising for CEA.