LABORATORY TESTING OF AN ENERGY EFFICIENT DEHUMIDIFIER FOR INDOOR FARMS

Laboratory test at the Western Cooling Efficiency Center-UC Davis

Assistant Engineer Derrick Ross instrumenting the MSP Dehumidifier in WCEC's environmental chamber.

ENERGY SAVINGS

30-65%

Forecasted energy savings compared to a traditional dehumidification system.

WATER RE-USE

100%

Amount of water removed from the air that can be re-used to water plants.

PROBLEM

In order to remove moisture and heat generated by plant transpiration and lighting, indoor farming operations require dehumidification and sensible cooling. However, the ratio of dehumidification to sensible cooling needed exceeds typical requirements for residential or commercial buildings. Energy intensive dehumidification systems are often necessary to maintain the indoor conditions required for indoor farming.

SOLUTION

Traditional dehumidification systems provide dehumidification and increase the air temperature, as opposed to the desired dehumidification and reduction of air temperature. An alternative is MSP Technology's dehumidification system that uses a plate air-to-air heat exchanger and a cooling coil that is part of a split compressor-based refrigeration system.

This process results in a ratio of sensible to latent cooling that is well suited for indoor farming applications. Experimental laboratory testing and numerical modeling were performed to estimate the annual projected energy savings from using MSP Technology's dehumidification system over a traditional dehumidification system. The results of this project forecast that implementation of MSP Technology's system has potential to save 30% or more of the energy used for dehumidification and cooling in indoor farming applications.

ABOUT THE TECHNOLOGY

Traditional dehumidifiers (Figure 1) remove moisture by cooling the air below the dewpoint using an evaporator coil, resulting in cold, dry air. The cold, dry air is then re-heated as it passes over the condenser coil, supplying warm, dry air to the space. The net result is an addition of heat into the conditioned space. This requires another air conditioning unit to be installed to remove both the heat from the lights and the heat from the dehumidifier.

The MSP dehumidifier (Figure 2) combines a plate heat exchanger, evaporator coil and a small, outdoor condensing unit. This technology (Figure 3) brings in (1) moist return air through a (2) plate heat exchanger to initially cool the return air. This allows the (3) evaporator coil to focus most of its energy on dehumidification, instead of both cooling and dehumidification like a traditional dehumidifier. The cool dry air then passes back through the plate heat exchanger to reduce the temperature of the incoming moist return air and pick up some of the heat as it is then (4) reintroduced into the conditioned space. The heat absorbed by the evaporator coil and from the compressor is rejected outside. The net result is dry air delivered to the space with a small reduction in temperature, which counteracts the heat from the lights. A building conditioning system for heating and cooling is then used to make minor adjustments to space temperature as needed.

TEST METHODOLOGY

Characterizing MSP's Performance

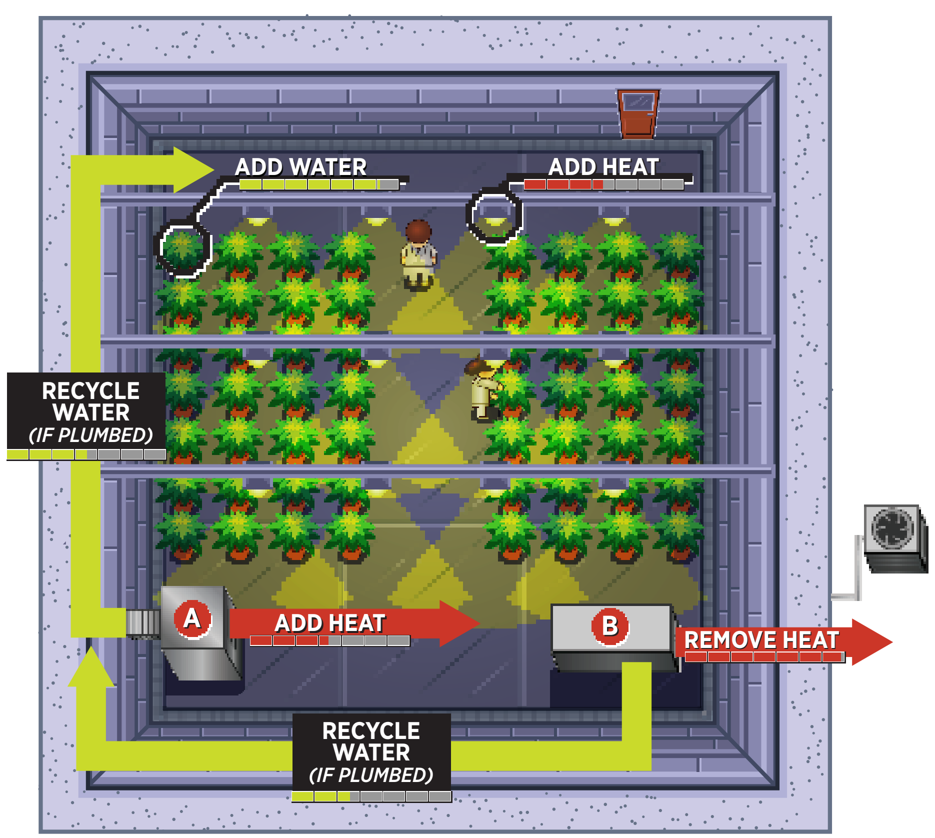
The unit was instrumented and tested in WCEC's environmental chambers to determine system power, capacity, and efficiency for each of 29 steady-state tests conducted at controlled outdoor air temperatures, indoor conditions, and indoor airflows.

Comparison to Traditional Dehumidification Systems

In order to estimate the difference in energy expenditures of MSP Technology's dehumidification system compared to a traditional dehumidification system as applied to an indoor farm, WCEC created two numerical models based on:

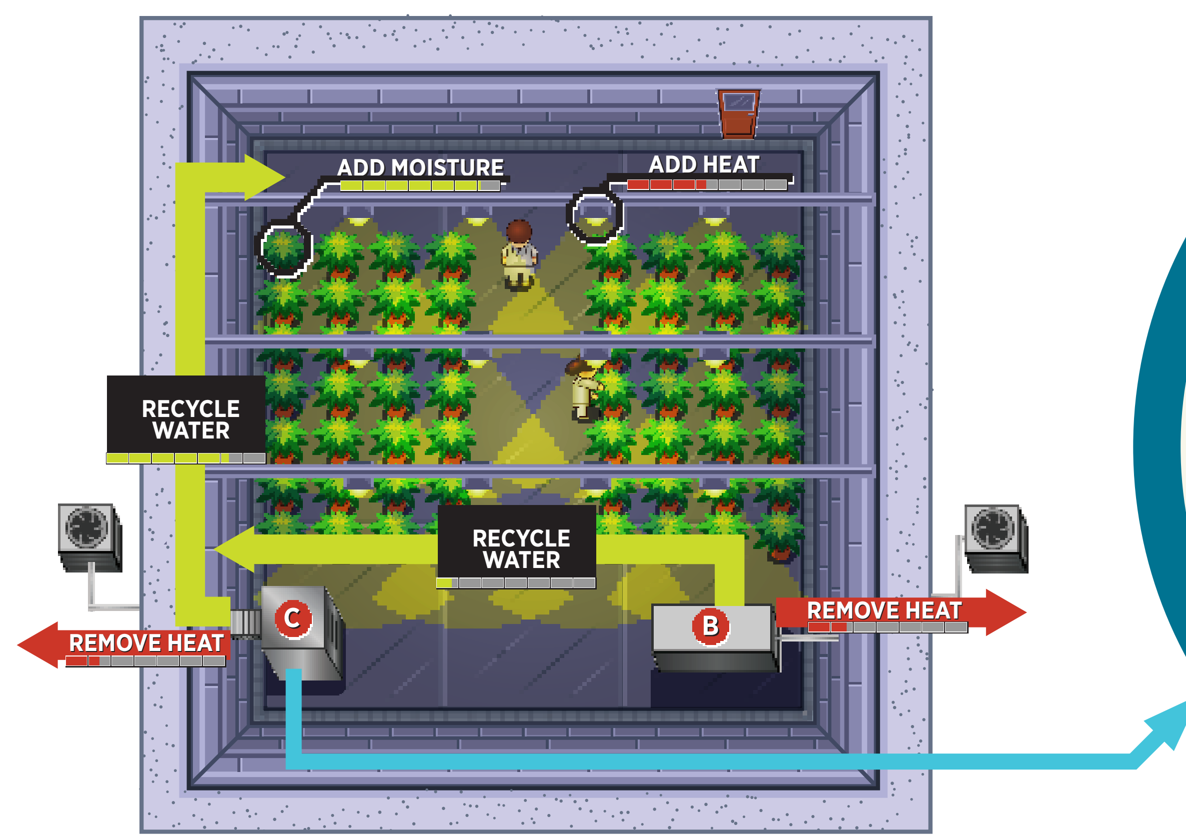
- Indoor building loads from plant transpiration and lighting
- Hourly weather forecast data
- Equipment performance data

The models calculated the annual energy expenditures of each dehumidification system required to meet the humidity set point for the greenhouse, as well as any additional energy expenditures necessary to recondition the air to the desired indoor air temperature after dehumidification loads were met. The difference in the energy expenditures per square foot as well as the percent difference in energy expenditure per square foot were calculated.



A. STANDARD DEHUMIDIFIER **B.** AIR CONDITIONER

Figure 1: Traditional Dehumidification and Conditioning Strategy/Loads



C. MSP DEHUMIDIFIER **B.** AIR CONDITIONER

Figure 2: MSP Dehumidification and Condtioing Strategy/Loads

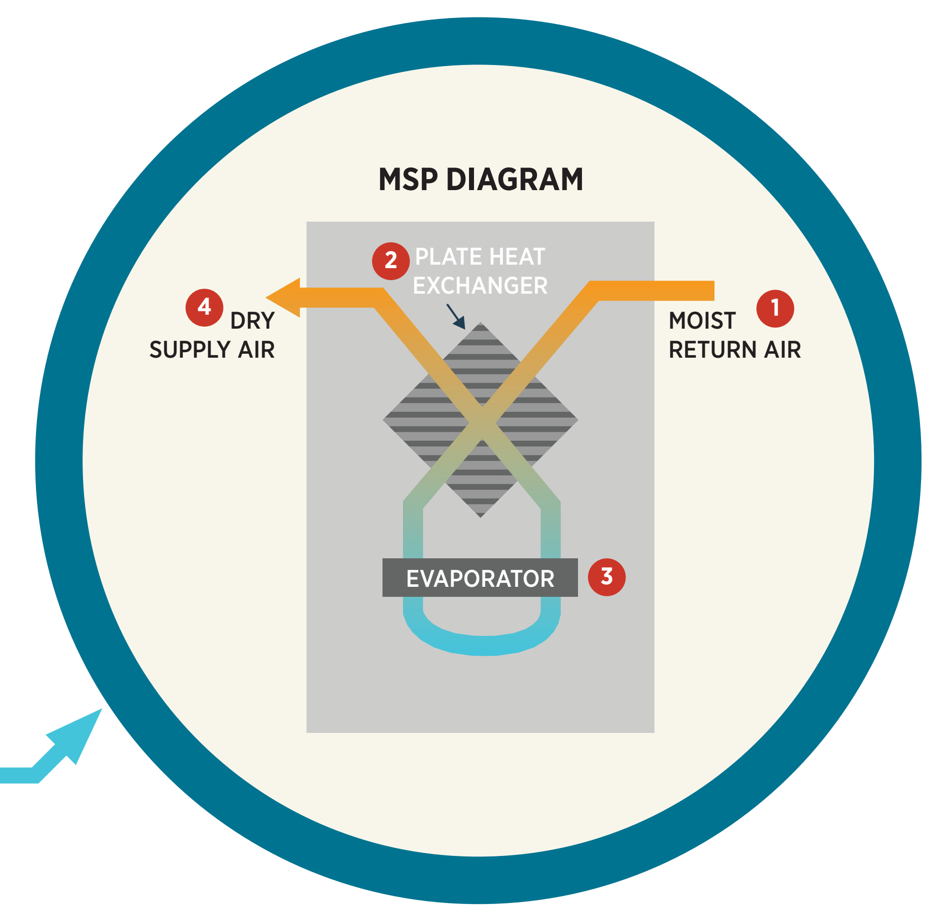


Figure 3: MSP Diagram of Operation

RESULTS

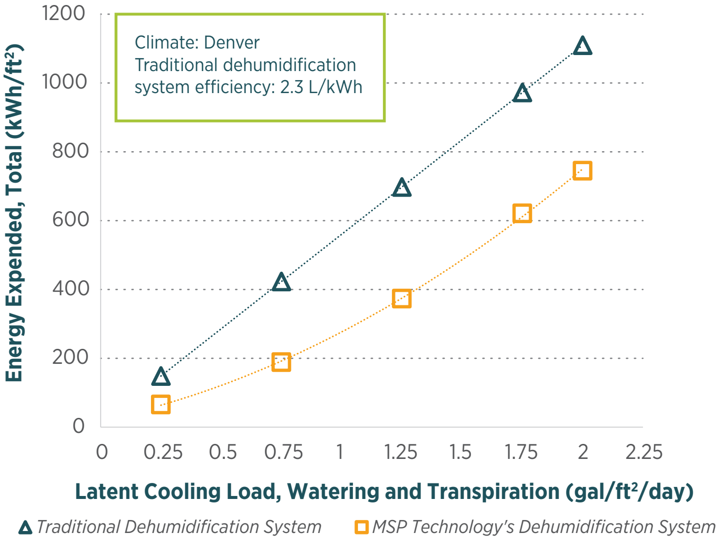


Figure 4: Latent load from watering and transpiration versus annual energy expended for dehumidification and reconditioning of air

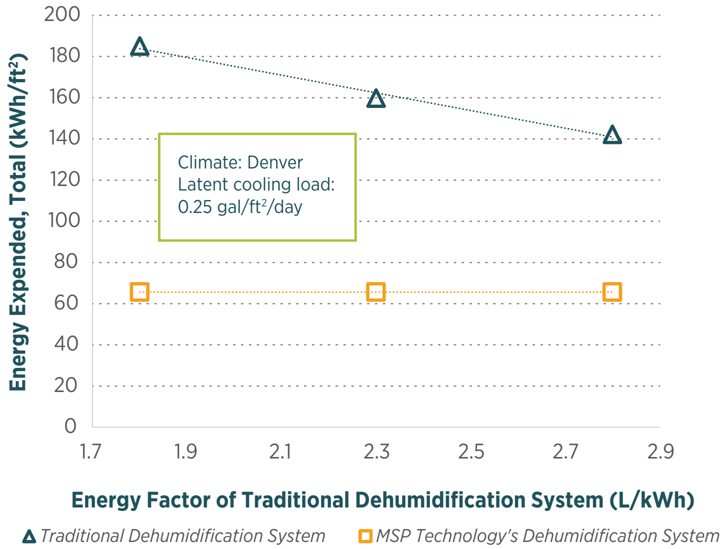


Figure 5: Traditional dehumidification system energy factor versus annual energy expended for dehumidification and reconditioning of air

The results for the city of Denver, Colorado have been summarized and presented to demonstrate the relationships studied.

- Energy expended per square foot as a function of latent cooling load, which is affected by plant type, spacing, watering and lighting schedules (Figure 4). Increasing latent load increased the total energy expended for both systems and decreased the percent energy savings attainable from MSP Technology's Dehumidification system, although in all cases the projected energy savings was greater than 30%.

- Energy expended per square foot as a function of the energy factor of the traditional dehumidification system. The expected savings from MSP Technology's Dehumidification System decreased as the efficiency of the traditional dehumidification system efficiency increased, however, the savings in all three scenarios was more than 50%.

RECOMMENDATIONS

WCEC recommends conducting field testing of the technology to further assess and quantify the energy savings that can be achieved with the new MSP Technology's dehumidification system. Due to the recent legalization of recreational cannabis in California, there is a pressing need to address energy efficiency in indoor farming operations.

ABOUT WCEC

The Western Cooling Efficiency Center was established along side the UC Davis Energy Efficiency Center in 2007 through a grant from the California Clean Energy Fund and in partnership with California Energy Commission Public Interest Energy Research Program. The Center partners with industry stakeholders to advance cooling-technology innovation by applying technologies and programs that reduce energy, water consumption and peak electricity demand associated with cooling in the Western United States.

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