

# COOLERADO H80 ROOFTOP UNIT FIELD TEST

Davis, CA



*Coolerado H80 hybrid indirect evaporative rooftop unit*



**COOLING ENERGY &  
CO<sub>2</sub> SAVINGS**

11%



**PEAK COOLING  
SAVINGS**

25%



**WATER USAGE**

50 gal/day-ton

*The SPEED team worked with UC Davis to pilot a new, hybrid indirect evaporative rooftop unit (RTU). The first of its kind, the Coolerado H80 replaced an old 7-ton RTU at the University House in Davis, CA. This case study highlights the research and observation of this new HVAC system during the initial beta phase in 2010 to the more finalized system in 2011. Most of the results presented here reflect operation in September 2011, for climate zone 12.*

## **PROBLEM**

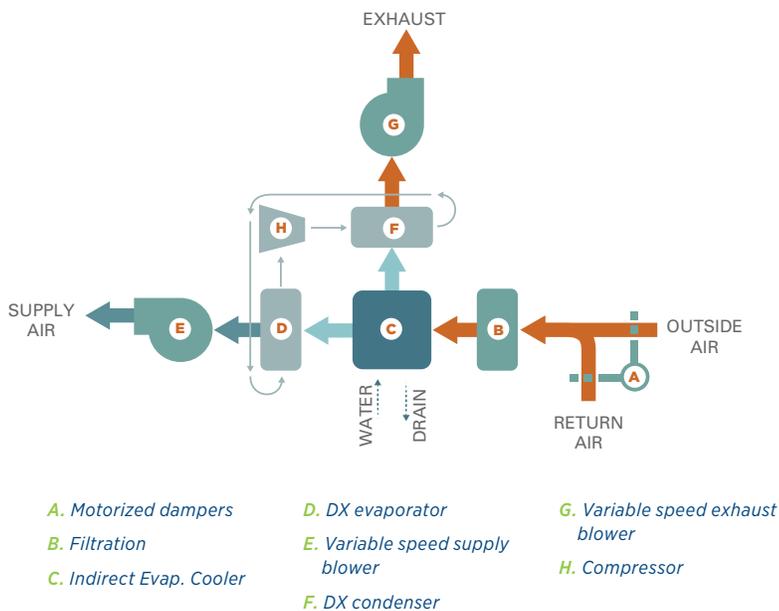
Cooling and ventilation account for more than 25% of electricity consumption in California commercial buildings and can add up to more than 50% of the summer time peak electrical demand. Conventional rooftop packaged units are at the center of these problems, and stand as a need for significant efficiency improvements. Especially in hot-dry climates, there are many opportunities to reduce energy use from these systems without sacrificing comfort.

## SOLUTION

Utilizing a combination of climate appropriate technologies and part-load operation, new hybrid RTUs, like the Coolerado H80 used in this study, can significantly reduce overall cooling energy and reduce peak demand energy. The recent increase in the development of these products is due to the Western Cooling Challenge--a multi-winner competition created by the Western Cooling Efficiency Center that encourages HVAC manufacturers to develop these hybrid RTUs to reduce electrical demand and energy use in Western climates by at least 40% compared to current federal standards. Technologies appropriate for the Challenge draw on strategies including: indirect evaporative cooling, variable speed fans, multiple stage compressors, evaporatively cooled condensers, and use of part-load operating modes that can provide reduced capacity cooling at much more efficient operating modes.

## PROJECT TECHNOLOGY FEATURES & BENEFITS

**FIGURE 1: SIMPLIFIED OPERATION SCHEMATIC OF THE COOLERADO H80**



- » Variable speed supply fan reduces energy used for continuous ventilation by more than 90%
- » Delivers more fresh air when cooling while demanding less energy
- » Indirect evaporative cooler conditions air without adding or removing moisture
- » Vapor compression system covers cooling load during hours when indirect evaporative capacity is insufficient
- » Indirect evaporative cooler extends economizer operating hours
- » Replaces conventional 5 ton rooftop package air conditioner
- » Does not require water treatment

## FIELD DEMONSTRATION

### University House at UC Davis

The Coolerado H80 was installed at the University House at the University of California Davis. The building is a single story wood structure. Originally constructed as a home in 1908, it has since been converted to an office which houses Services for International Students & Scholars. The hybrid was installed in place of an antiquated 7 ton RTU with vapor compression cooling and gas heating. The existing equipment was a constant volume machine, and delivered roughly 1,625 cfm supply air. The outside air damper position was fixed to provide some fresh air when the system was operating, and there was no economizer. The supply fan only operated in conjunction with a call for heating or cooling, rather than operating to provide continuous ventilation during all occupied hours. The existing equipment was monitored for six weeks prior to the replacement, and the baseline sensible space cooling COP was observed to range between 1.8 and 2.5 depending on outside air temperature, as plotted in Figure 2.

The H80 was installed in August 2010, and was observed for beta testing and troubleshooting over the following year, during which time numerous minor



**FIGURE 2: SENSIBLE ROOM COP OVER OUTSIDE AIR TEMPERATURE**

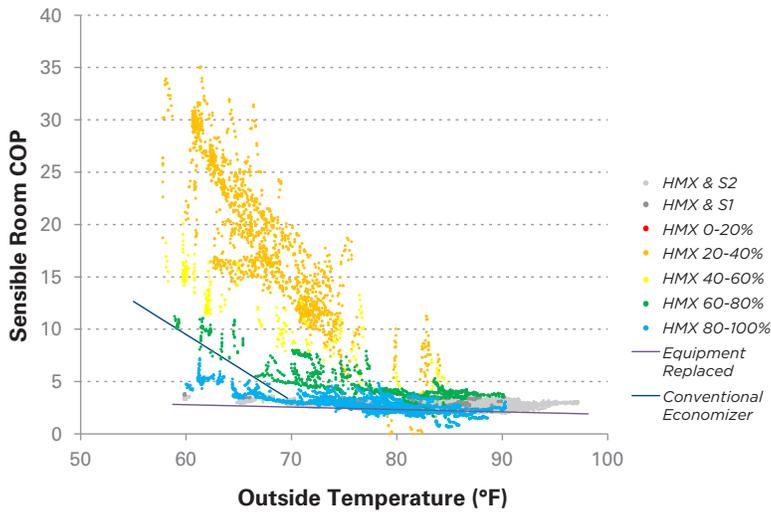


Figure 2: Sensible Room COP for the Coolerado H80 at different operating modes and outside air temperatures. Replaced equipment included.

**FIGURE 3: ROOM COOLING KBTU FOR MONTH OF SEPTEMBER**

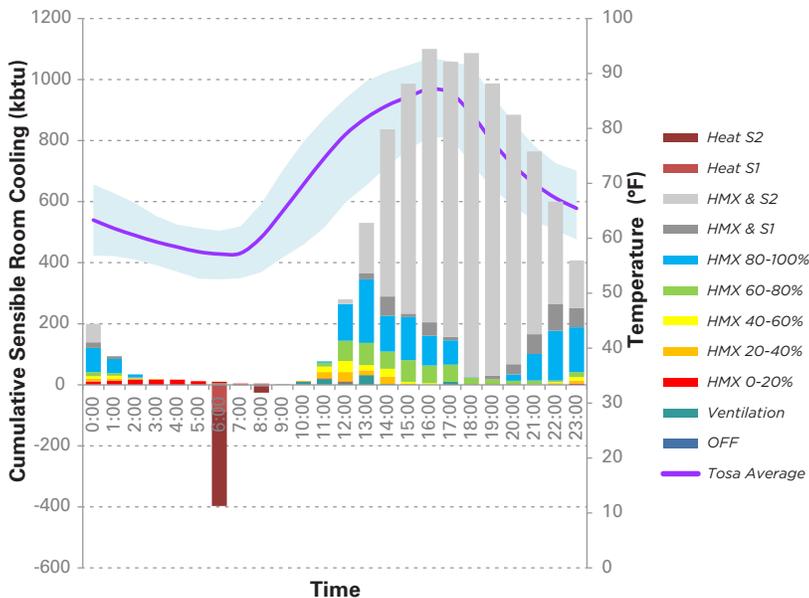


Figure 3: Average sensible room cooling in kbtu for month of September

changes were made to the system. In August 2011, Coolerado replaced the indirect evaporative heat exchanger to remedy a manufacturing defect that caused a minor water leak, and replaced the secondary fan with one that would move more air than the original. The results presented here reflect operation in September 2011, after these revisions were conducted.

## RESULTS

Figure 2 illustrates the variation in the sensible room coefficient of performance (CoP) for each operating mode as a function of outside air temperature. Sensible room performance accounts for the true capacity of a system by incorporating the power used to cool the incoming ventilation air. The Coolerado's efficiency is greater than the equipment replaced even though it brings in a significantly larger volume of ventilation air that it then must cool to set-point. Another interesting takeaway from this data is the CoP of the Coolerado is, in most cases at 4 different HMX modes, more efficient than a modeled conventional economizer.

The Coolerado H80s' systems operate at a multitude of varying speeds depending on capacity demand. This variance is the key to much of the efficiency gains over constant speed systems. What is of particular interest is the percentage of cooling time for the more efficient operating modes (ie: HMX only) are running versus the runtime when full capacity is demanded and the second stage compressor kicks in. Measured performance for the Coolerado H80 shows significant energy saving compared to the 7-ton system that was replaced. In particular, peak demand savings for periods above 95°F were 25%

Figure 3 shows the Coolerado responding to capacity demands at specific outside air temperatures by varying cooling modes to meet the required kBTU of capacity. As shown in Figure 3, a significant portion of the cooling when outside air temperatures are below 85°F in the early afternoon is served by the HMX system alone.

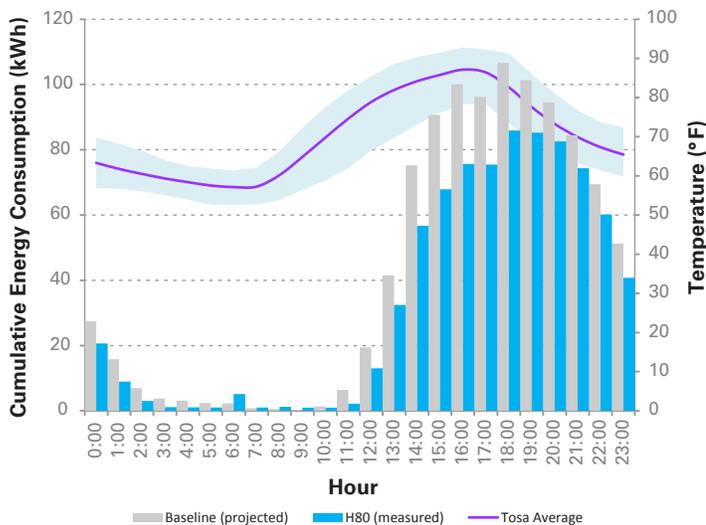
One would expect the HMX system to handle more of the cooling needs when outside air temperatures are below 80°F in the late afternoon, but this is not the case in this field study. In fact,

the Coolerado spent roughly 55% of cooling hours operating with the vapor compression system and was not able to maintain the set point during all cooling hours. The likely reason is due to the increased building loads due to built up heat during the peak hours. The system's capacity requires full operation even past 21:00 (outdoor temperature average of 70°F) because it is still working to reduce the built up load during the peak hours. This is likely a result of the system being sized slightly smaller than required, the thermal loads in the building are much greater than expected due to duct or envelope leakage, or both. The opposite effect is also observed at 13:00 when the building has been cooled the night before, thus not requiring as much compressor power even though the average outdoor temperature is 85°F.

Even though the 5-ton Coolerado may have had capacity issues in this application and ran at full tilt for the majority of cooling hours, the Coolerado H80 used roughly 11% less energy as the RTU that was replaced and energy during peak hours was reduced by 25% (during periods of 95°F and above). Given that the indirect evaporative cooler in this system can generally achieve a 4°F wet bulb approach, one would expect much larger savings if the system was installed to serve a smaller load, thus reducing the vapor compression operating hours.

Water use in this system was observed to be more than 250 gallons per day, depending on the outdoor air conditions and cooling load. It should be noted that globally, the amount of energy saved through improved efficiency may more than offset the water consumed by displacing upstream water consumption for power generation. Scale formation due to hard water was not observed to cause any performance degradation.

**FIGURE 4: CUMULATIVE ENERGY CONSUMPTION IN SEPTEMBER H80 VS. BASELINE**



**ABOUT THE WESTERN COOLING EFFICIENCY CENTER:** 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 stimulate the development of cooling technologies that can reduce energy demand, and water consumption in buildings.

Any questions about this project, including technology costs, can be directed to:

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