DUALCOOL HYBRID ROOFTOP UNIT FIELD TEST

Ontario, CA

Trane Voyager unit with DualCool® at Ontario, CA

COOLING ENERGY & CO_2 SAVINGS
20%

PEAK ELECTRIC DEMAND SAVINGS
up to 66%

WATER USE INTENSITY
5 gallons per kWh energy saved

The Western Cooling Efficiency Center tested a new hybrid rooftop unit technology that employs dual evaporative pre-cooling to increase the cooling capacity and efficiency of vapor compression cooling. Three 12.5 ton Trane Voyager units with the DualCool, manufactured by Integrated Comfort, were installed at two different sites in Ontario, CA. This case study highlights the research and observation of this new HVAC system observed over a 14 month period from August 2014-October 2014. The results presented in this case study reflect real world operation for California Climate Zone 10 in September and October 2014.

PROBLEM

Cooling and ventilation account for more that 25% of annual 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 predominantly responsible for these large electrical loads in commercial buildings. These systems are inefficient and use a significant amount of energy for unnecessary dehumidification. Efficiency for these systems must improve in order to reduce energy use, peak demand and CO2 emissions attributed to cooling.

SOLUTION

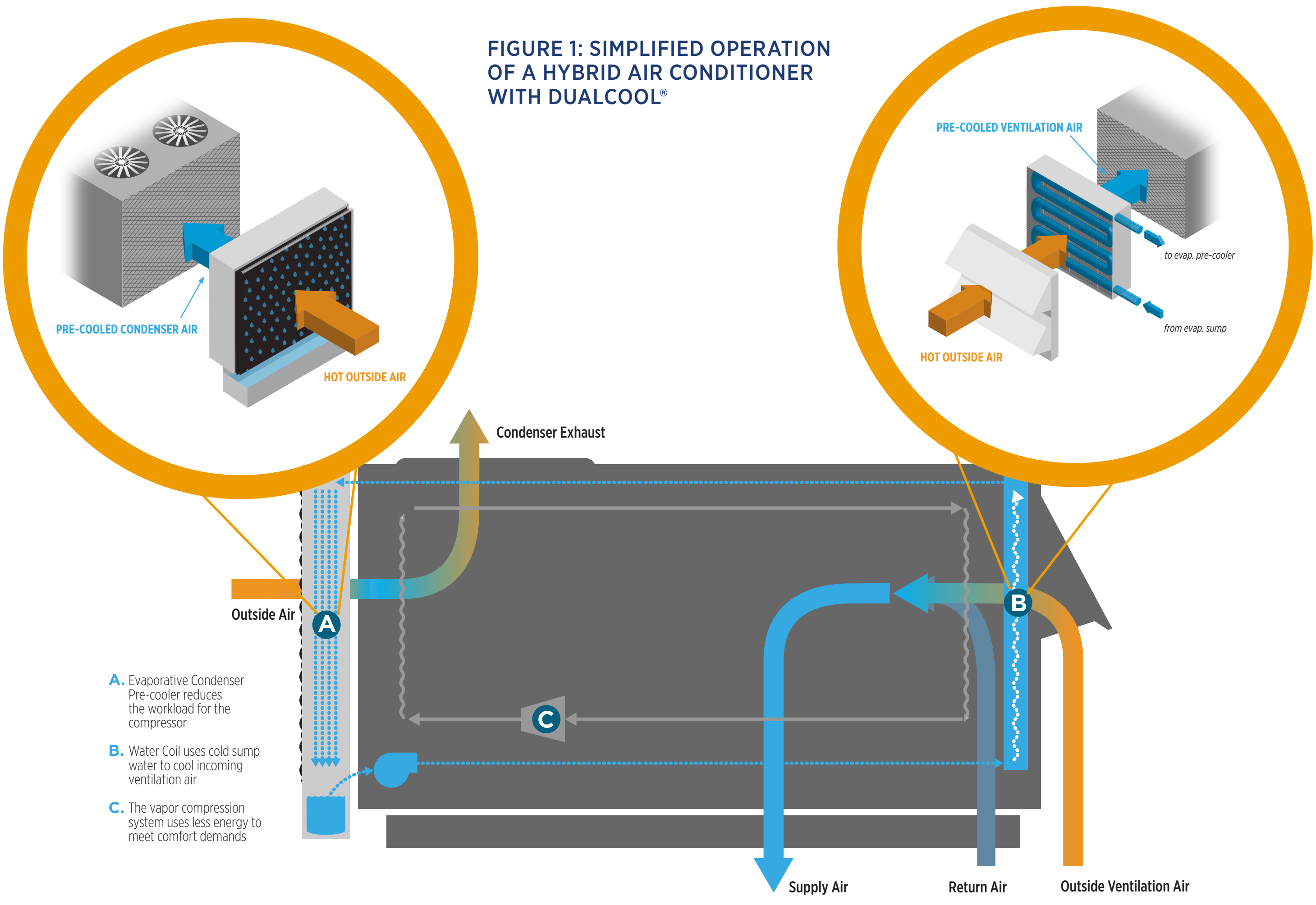
Hybrid air conditioners, like the variable speed multi-stage rooftop unit with dual-evaporative pre-cooling observed in this study, can significantly reduce overall cooling energy and reduce peak demand energy through a combination of climate appropriate technologies and efficient part-load operation. Previous laboratory testing for this technology demonstrated 43% peak demand savings compared to the stated performance for ASHRAE 90.1 compliant equipment operating in California's hot-dry conditions. The measured performance qualified this technology for the Western Cooling Challenge - a multiple winner competition hosted by UC Davis that encourages HVAC manufactures to develop air conditioners that reduce peak demand by at least 40% (Woolley 2012).

TECHNOLOGY FEATURES & BENEFITS

TRANE VOYAGER WITH DUALCOOL® DUAL EVAPORATIVE PRE-COOLING

The product tested in this project takes advantage of indirect evaporative cooling to cool the ventilation air stream on a conventional rooftop unit, and uses direct evaporative cooling to cool air at the condenser inlet. This dual design reduces energy consumption by reducing the temperature of incoming ventilation air and by lowering the condensing temperature. Since the dual evaporative pre-cooling technology can incorporate with any conventional air conditioner, the combined system still maintains latent cooling capacity for applications where dehumidification is required. These two cooling processes work together to increase cooling capacity and to improve efficiency for the vapor compression system. The second effect is mainly caused by a lower heat sink temperature for the refrigeration cycle.

FIGURE 1: SIMPLIFIED OPERATION OF A HYBRID AIR CONDITIONER WITH DUALCOOL®



FIELD DEMONSTRATION

Ontario Mills, Ontario, CA

Three variable speed Trane Voyager units with DualCool® were installed in Ontario CA for the purposes of this study. Two were installed on the administrative offices for a mall (M12-14, M15-15), and one was installed to cool the kitchen for a restaurant and bakery (AC7).

FIGURE 2: WATER CONSUMED PER HOUR AS A FUNCTION OF OUTSIDE AIR TEMPERATURE

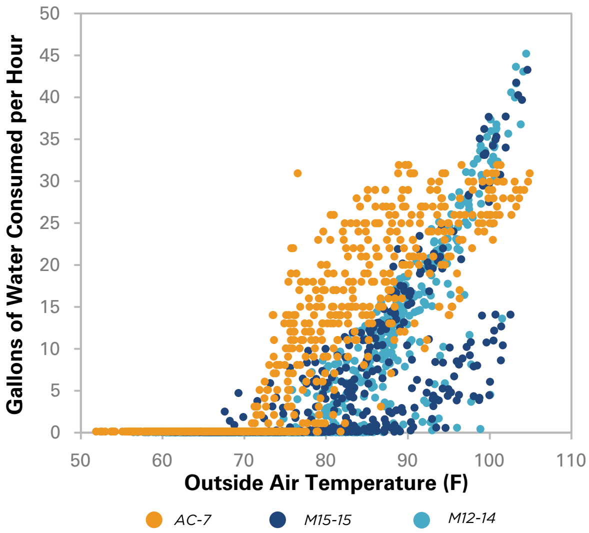


Figure 2: Water consumed per hour as a function of outside air temperature for all 3 units

RESULTS

Water Consumption

Since consumption of water for evaporation and for bleed only occurs when the pump is running, water consumption is restricted to periods with outside temperature above the point where the DualCool® is enabled.

Water use efficiency for the equipment is generally consistent with targets for regionally neutral water consumption from the statewide perspective – depending on the assumptions made about water use intensity for electricity generation. Hourly water consumption increases predictably with outside temperature, and water use measured for these systems is only 25% larger than the predicted water evaporation rate. For savings of 7 kWh/h, as measured for M12-14 at on-peak conditions, the coincident rate of water consumption equates to 5 gallons/kWh savings. For context, estimates of the water use intensity for electricity generation range from 0.5 – 10 gallons/kWh, depending on the source mix for electricity generation (Pistochini 2011, Torcellini 2003).

Cooling Capacity

Operation with the dual-evaporative pre-cooler influences equipment performance such that room cooling capacity remains more or less steady across a range of outside temperatures. This is most apparent for AC7. The behavior is significantly different from what would be expected for a conventional rooftop air conditioner. For the amount of ventilation air supplied in these scenarios, sensible room cooling capacity for a conventional system would decrease by more than 30% on a shift from 70°F to 100°F.

FIGURE 3: SENSIBLE ROOM COOLING CAPACITY (AC7)

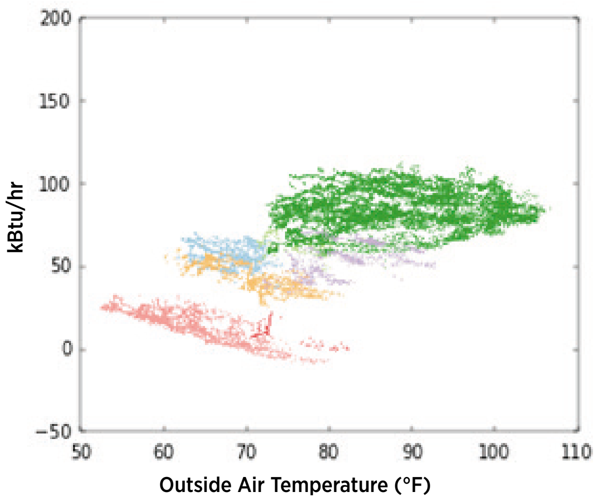
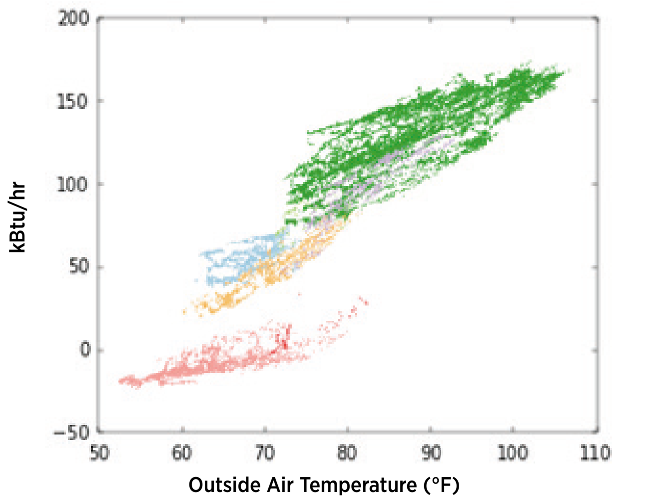


FIGURE 4: SENSIBLE SYSTEM COOLING CAPACITY (AC7)



LEGEND: DX1, DX1 +Pump, Econ+DX1+Pump, Econ+DX1, Econ, Ventilation, DX2, DX2 +Pump, Econ+DX2+Pump, Econ+DX2, Econ+Pump, Ventilation+Pump

Energy Savings

Figure 5 compares the energy use signatures for each system during September 2013 with a similar period from October 2014 when the dual-evaporative pre-coolers had been disabled.

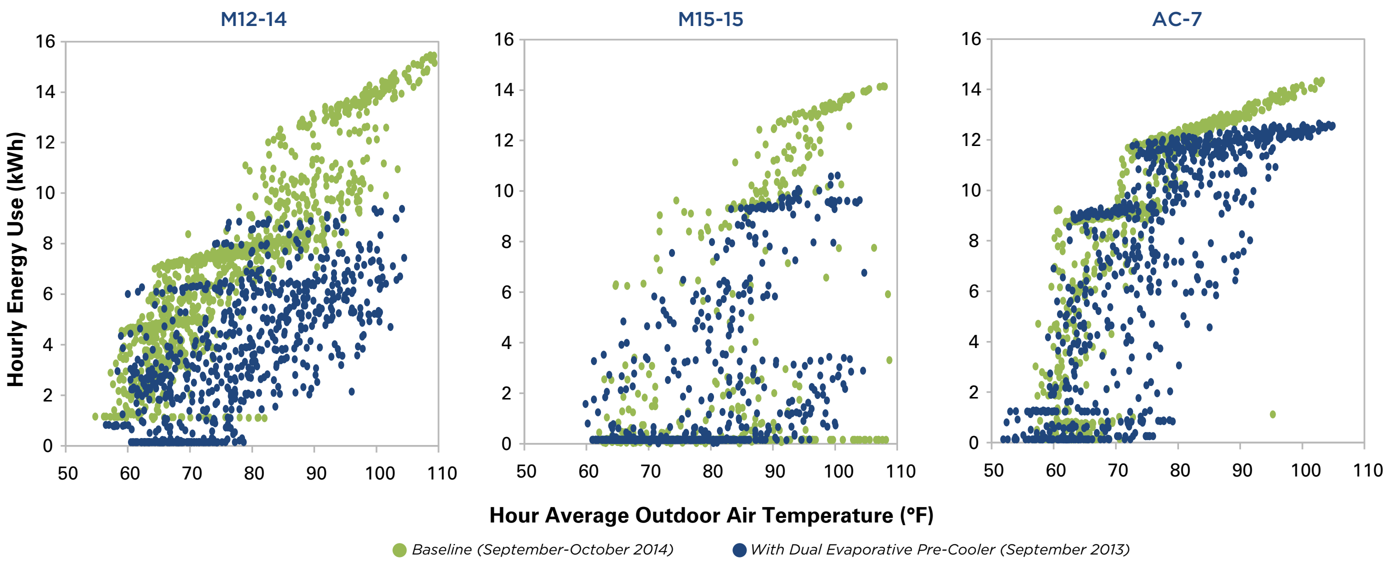
The energy use signature plots the hourly sum of energy consumption as a function of the corresponding hour average outside temperature. Comparison of the energy use signature from periods with and without the DualCool® in operation provides a straightforward assesssment of the energy savings achieved by the measure for each system.

Below about 75°F the differences are minor, but as outside temperature increases energy savings clearly increases. For periods above 100°F, M12-14 and M15-15 show hourly energy use reduction of 66% and 45% respectively. Peak savings for AC7 was only about 13%. The lower savings from AC7 appears to result from the fact that the system is not able to meet the set point for the kitchen during peak periods. Since the unit runs flat out with or without the DualCool®, the added capacity afforded by the measure does not increase energy savings. Instead, part of the efficiency for this enhanced system is invested in increased level of service.

System Longevity

After almost two full years of operation, the dual-evaporative pre-cooler systems show very little physical degradation. The evaporative media is not degraded or damaged and shows no significant accumulation of mineral scale. In this test, and all other installations that the research team is familiar with, the technology does not result in any damage to the condenser coil. The technology is robust and reliable; it stands as a good opportunity to provide persistent energy savings and substantial peak demand reduction.

FIGURE 5: ENERGY USE SIGNATURE FOR THREE ROOFTOP AIR CONDITIONERS WITH AND WITHOUT DUALCOOL



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 can be directed to:

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