FIELD RESULTS: DUAL-EVAPORATIVE PRE-COOLING RETROFIT

Palmdale, CA

Dual evaporative pre-cooler installed in, Palmdale, CA

COOLING ENERGY & CO_2 SAVINGS
15%

PEAK COOLING SAVINGS
up to 40%

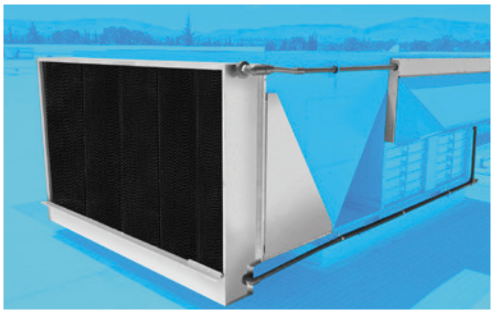
WATER USE INTENSITY
3.5 gallons
per kWh
energy saved

The Western Cooling Efficiency Center tested the DualCool®, dual evaporative pre-cooler retrofit for rooftop units (RTUs). 13 RTUs on a big box store in Palmdale CA were retrofitted with the solution. This case study highlights the results from measurements of 4 of these systems observed over a 12-month period from October 2012-October 2013. The results presented here reflect operation for climate zone 14.

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. Efficiency for these systems must improve in order to reduce energy use and peak demand from cooling in commercial buildings, and stand as a need for significant efficiency improvements. There are many opportunities to reduce energy use from these systems without sacrificing comfort.

SOLUTION



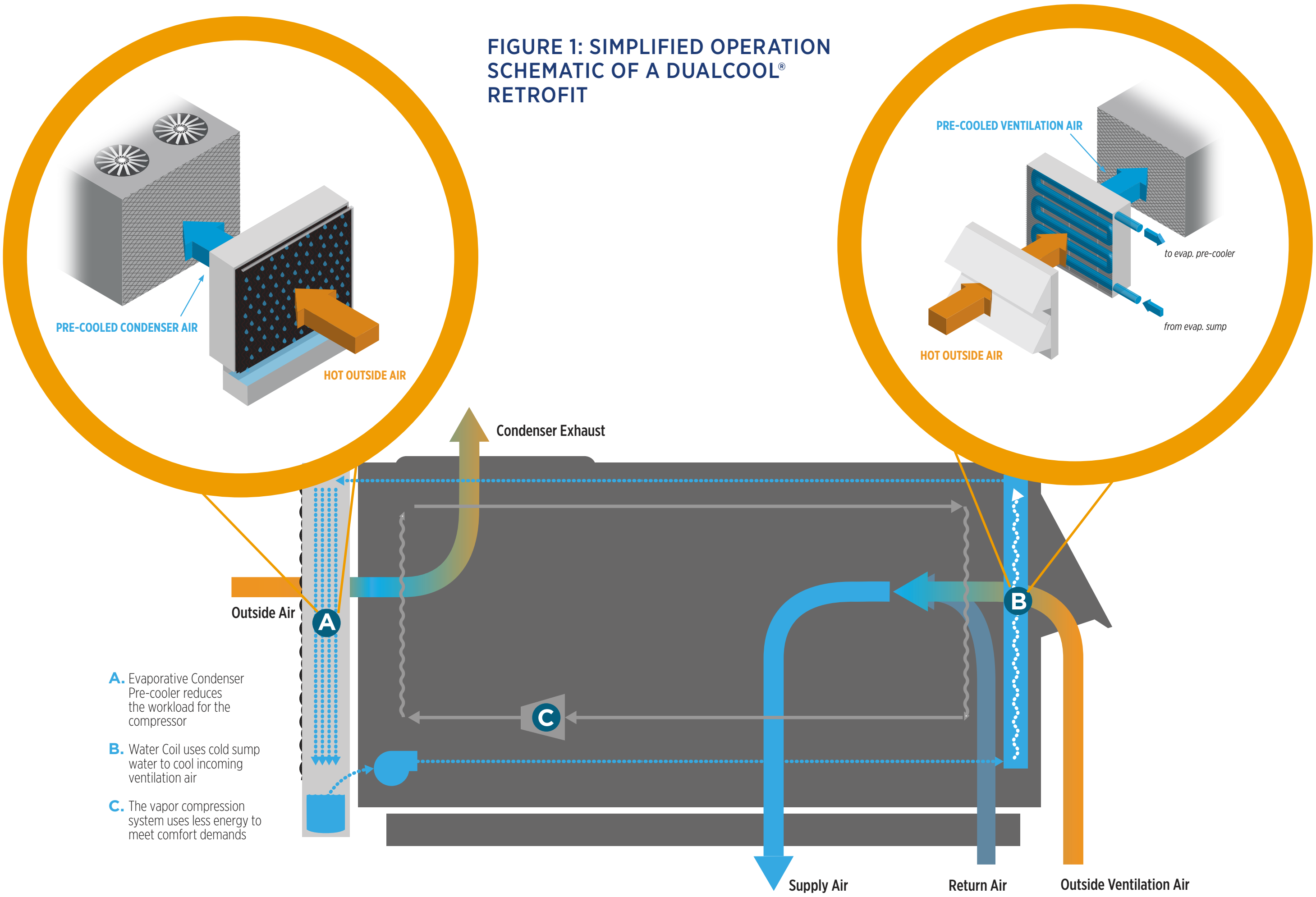
Rooftop packaged air conditioners server more than 65% of the commercial floor area in California. Unfortunately, these systems are inefficient. The dual-evaporative pre-cooling retrofit studied here increases cooling capacity for conventional rooftop air conditioners while also reducing the electrical power input. At peak, the technology has been measured to reduce peak electrical demand for cooling by more than 40%.

PROJECT TECHNOLOGY FEATURES & BENEFITS

DUALCOOL®

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 by reducing the temperature of incoming ventilation air and by lowering the condensing temperature. Since the dual evaporative pre-cooling technology incorporates with a conventional air conditioner, the combined system still maintains latent cooling capacity for applications where dehumidification is required. These dual 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. Laboratory measurements for the dual evaporative pre-cooling technology installed on a similar rooftop air conditioner indicated 43% reduction in power draw at peak.

FIGURE 1: SIMPLIFIED OPERATION SCHEMATIC OF A DUALCOOL® RETROFIT

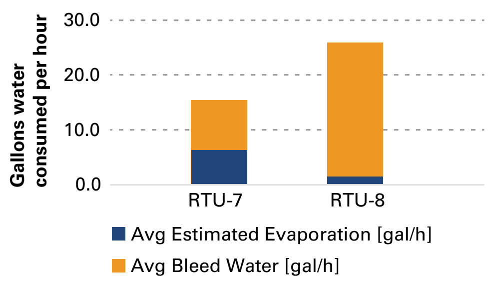


FIELD DEMONSTRATION

Palmdale, CA

13 DualCool® retrofits were installed on a big box store in Palmdale, California, serving capacities ranging from 13-ton to 20-ton units. This building is conditioned by 21 RTUs produced by the same manufacturer, all of which utilize V-shaped condenser coils. 4 of the retrofitted RTUs serving the sales floor were monitored (RTU-7, RTU-8, RTU-10 and RTU-11), and 2 non-retrofitted RTUs serving the warehouse were monitored (RTU-20, and RTU-21) as the baseline. The DualCool® only provided condenser air pre-cooling for the outer half of the V-coil, so not all vapor compression circuits benefitted from the condenser pre-cooling portion of the system. The results presented here reflect operation for one year between October 2012 and October 2013.

FIGURE 2: WATER CONSUMPTION



RESULTS

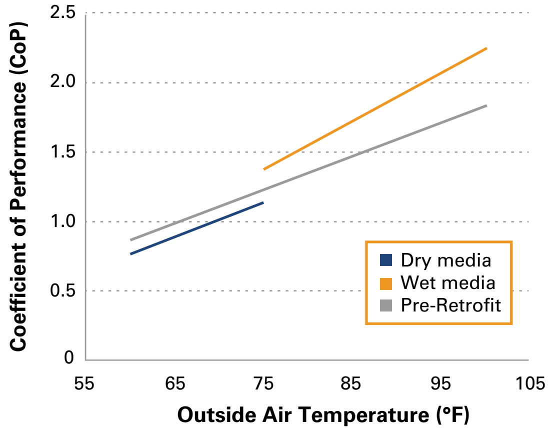
Water Consumption

For the installations in this case study, water-use rates for evaporation were consistent with previous studies but the bleed water rates were much different. Two of the units monitored used dramatically more water than necessary (Figure 2) while two others used practically zero bleed water. The units that only used a very small amount of bleed water show no evidence of consequential scaling over an entire year of operation, despite having essentially zero bleed water use.

The retrofit's estimated water consumption for evaporation was relatively modest, corresponding to a cost penalty of roughly 5% of the electricity savings for the unit with the best pre/post retrofit data (RTU-7). However, since bleed water was not adequately controlled, the estimated water cost for those units with excessive water use represents 14% of the electricity savings. Using appropriate levels of bleed water (15% of evaporated water) would result in a total water cost of 6% of electricity savings, or 3.4 gal/kWh savings.

The conclusion here is that the evaporative water use of this retrofit is reasonable as compared to the water used to generate electricity in California, but that bleed water-use is an important factor that needs to be set up properly at the outset, and maintained on a regular basis (e.g. on the media maintenance schedule), or perhaps be controlled in more reliable manner.

FIGURE 3: PRE/POST-RETROFIT COP (RTU-7)



Pre- and Post-Retrofit Comparison (RTU-7)

Figure 3 provides a comparison of pre- and post-retrofit COP for one of the RTUs in this study. This comparison shows that sensible capacity increases by approximately 15-20% at 95°F OSA due to the retrofit, and that efficiency increases by 25-30% at 95°F OSA. These regressions clearly illustrate that the retrofit reduces capacity and efficiency somewhat when the media is dry as a result of added airflow resistance across the condenser. They also clearly show immediate increases in capacity and efficiency when the water is turned on, as well as ever increasing improvements in capacity and efficiency as the outdoor air temperature increases.

Coefficient of Performance for All Monitored RTUs

FIGURE 4: COP FOR BASELINE, NON-RETROFIT RTUS

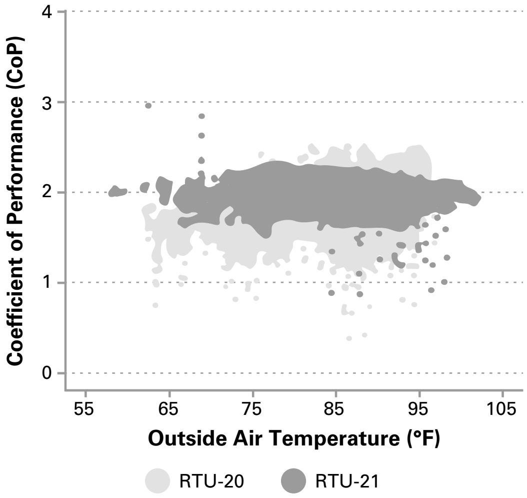


FIGURE 5: COP FOR 4 RETROFITTED RTUS

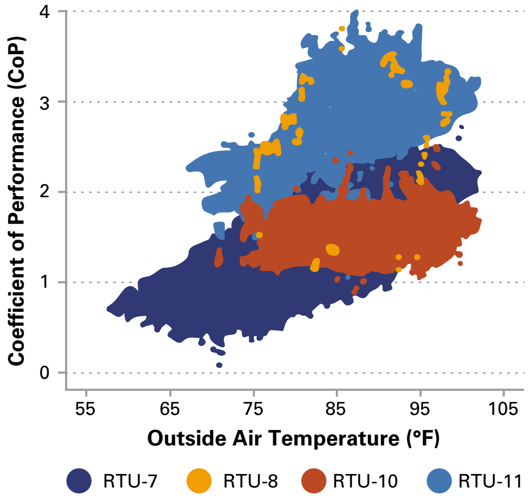


Figure 4 and 5 plot the CoP for all 6 RTUs monitored for this study. Figure 4 shows the CoP for two RTUs that were not retrofit with the dual-evaporative pre-cooler, indicating that the COP for both units is roughly 2.

Figure 5 shows the CoP for the four retrofitted RTUs:

RTU-7: This RTU shows a clear increase in CoP as the outside air temperature rises. The increase in CoP is due in part to the fact that performance of the DualCool® increases as outside air temperature increases. At 95°F outside temperature, the DualCool® reduced ventilation air temperature by 28°F.

RTU-8: RTU-8 only operated rarely during the study period. For the periods when it did operate, the measured CoP was substantially higher than both baseline units.

RTU-10: All instances of compressor operation for RTU-10 occurs at temperatures when the pump is in operation, and the efficiency appears to be pretty much independent of outdoor air temperature. However, this RTU had the lowest outdoor air fraction, which means that there is less potential for: a) capturing indirect evaporative cooling of the ventilation air, and b) the evaporator inlet temperature increasing with outdoor air temperature. This can explain why the efficiency did not increase with outdoor temperature, as was seen for RTU-7.

RTU-11: RTU-11 shows the clearest increase in efficiency for all compressor modes when the evaporative media is activated. Though not noticeable on this plot, RTU-11 without the DualCool® in operation shares a similar CoP with the baseline units. When the DualCool® is in operation, the efficiency advantage is clear, with an average CoP of over 3 as outside air temperatures rise past 85°F, equating to roughly over a 33% increased capacity, reducing energy use to meet demand compared to the observed baseline units.

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:

JONATHAN WOOLLEY
Western Cooling Efficiency Center,
UC Davis
jmwoolley@ucdavis.edu
wcec.ucdavis.edu

For more resources and information, including reports, case studies and HVAC related news, visit WCEC.UCDAVIS.EDU.

1/2015