CONDENSER AIR PRE-COOLER RETROFITS

Beale Air Force Base, Marysville, CA

Evaporcool condenser air pre-cooler retrofit for air-cooled chillers installed at Contrails Dining Facility at Beale Air Force Base in Marysville, California

COOLING ENERGY & CO_2 SAVINGS
22%

PEAK COOLING SAVINGS
20%

ENERGY REDUCTION
280 kWh/yr-ton

WATER USAGE
0.9 gal/day-ton

The SPEED team worked with the California Smart Grid Center at CSU Sacramento to implement energy efficiency measures at Beale Air Force Base in Marysville, California. As part of this work, evaporative condenser air pre-coolers were installed in a 50-ton air-cooled chiller at the 15,000 sq. ft. Contrails Dining Facility. The project demonstrated the peak-time energy savings, energy savings per year and dollar savings per year for a condenser air pre-cooler over a multitude of possible facility sizes served, and over a large range of chiller and RTU capacities (25-tons to 200-tons) for climate zone 11.

PROBLEM

Standard air-cooled, vapor-compression cooling systems become less efficient and less effective when they are needed most: when it's hot outside. This is because the compressor must work harder to produce a refrigerant temperature high enough to cause heat to flow from the condenser to the hot outside air. This hard work means more energy consumption and more part wear—both lead to increased costs. It also means that cooling causes building electrical demand to peak on hot afternoons—this stresses the grid and can increase building operating costs.

SOLUTION

Evaporative pre-coolers are effective retrofits to reduce the temperature of air that cools the condenser coil in air-cooled chillers, RTUs and other DX equipment. In these systems, the outside air stream passes over a wetted surface before it reaches the condenser, heat from the outside air is absorbed by water evaporation thus cooling the air stream. Evaporative condenser pre-coolers are applicable to most all climate zones, but have even more energy impact in lower humidity areas, such as California.

Evaporcool is one such evaporative condenser-air pre-cooler. The system uses a microprocessor controller to manage the spray of filtered domestic water onto an evaporative media. The flow rate of water delivered changes with outside air temperature and relative humidity so that the system delivers roughly only as much water as is needed for evaporation. The system has no sump, and no drain or water bleed.

PROJECT TECHNOLOGY PACKAGE

PLUMBING AND FILTRATION

EVAPORATIVE PANELS

SENSORS & CONTROL SYSTEM

DEMONSTRATION RESULTS

Beale Air Force Base

An Evaporcool system was installed as a retrofit at Beale Air Force Base Contrails Dining Facility, near Marysville, CA. The unit retrofitted was a 50 ton Trane Air Cooled Cold Generator, or 'chiller' with two refrigerant circuits and four compressors. The four compressors are programmed to actuate sequentially as required to maintain a target chilled water supply temperature. The system chills water to provide cooling for the commercial kitchen and dining facility.

Water temperature was measured at the inlet and outlet of the chiller. Since chilled water is circulated with a constant speed pump, the difference between supply and return water temperature was used as a proxy for the cooling capacity delivered within each 5 minute measurement interval. Electric power consumption, outdoor temperature and outdoor relative humidity were measured on similar intervals. These measurements allow for a complete assessment of equipment efficiency.

Baseline performance data was collected for several weeks prior to the retrofit, from September 1st 2011—October 10th 2011. Post retrofit data was collected the following summer from August 2nd—September 9th 2012. Post retrofit data preceding August 2012 was not used because one refrigerant circuit in the chiller needed repair.

Figure 1 compares electric energy use for the chiller during the pre and post-retrofit periods. Regression models for the data in each period were developed to model chiller energy consumption as a function of outside air temperature and humidity. A projection of these trends across typical annual meteorological conditions indicates that the complete SPEED suite of efficiency measures installed in the facility reduced chiller energy use by 18,000 kWh/year, or 29% of the baseline. The annual energy savings that can be attributed to the Evaporcool is 14,000 kWh/year or 22%.

Chiller electric power consumption was analyzed as a function of cooling capacity, as plotted in Figure 2. The figure shows that electricity use in the post-retrofit period is significantly lower than the baseline period for any given cooling capacity. The energy used to carry a particular chilled water temperature difference has a much higher variance during the post retrofit period. This is due in part to the impact of humidity on condenser pre-cooler performance. The high variance is also likely due to a more highly variable cooling load as a result of the other SPEED variable capacity retrofits in the building. Some of the efficiency measures deployed include constant volume to variable speed fan retrofits, and the addition of demand controlled ventilation for kitchen exhaust and occupied dining spaces. Since the impact of evaporative pre-cooling increases with temperature, the energy savings will be greater for high chilled water temperature differences and less when the load is smaller.

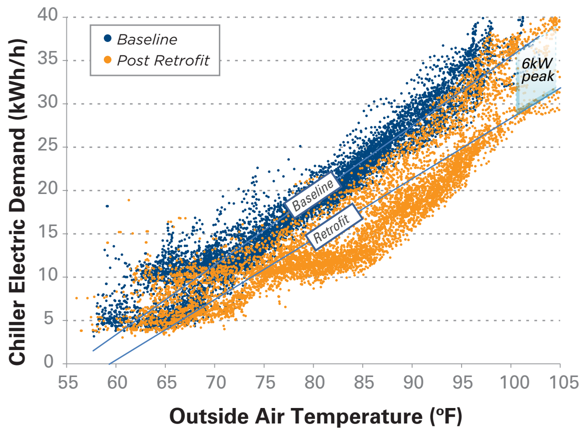


Figure 1: Chiller electric demand as a function of outside air temperature

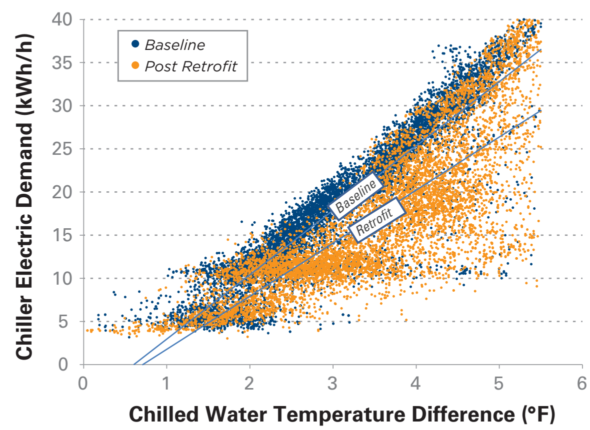


Figure 2: Chiller electric demand as a function of chilled water temperature difference

To control for the independent impact of the Evaporcool retrofit, the trends in Figure 2 were used together with trends for cooling load as a function of outside air temperature to predict the annual energy savings that could be attributed to the condenser air pre-cooler. A regression model to describe the pre-retrofit cooling load as a function of outside air temperature was used to predict the baseline cooling load for every hour of a typical year in California Climate Zone 11. The cooling load in each 5 minute interval was used together with the trends in Figure 2 to predict the total annual chiller electricity use for operation with and without the Evaporcool. Comparison of the annual sum of electricity use for each scenario indicates that the Evaporcool reduced annual chiller electricity use by 14,000 kWh/year, or 22%. At peak cooling load conditions, on average, the Evaporcool saves 20% on electric demand or roughly 6kW for this application. The calculation of peak cooling savings is based on the reduction of average power required at the highest outdoor air temperatures, and may be different than that which is calculated for utility incentives.

These results should be applicable for evaporative condenser air pre-coolers of different sizes installed on the condenser sections of a variety of air cooled equipment, such as roof top package units or split systems in similar climates. Even better performance can be expected in hotter and drier climates zones.

ECONOMIC EVALUATION

Economic value of a condenser air pre-cooler retrofit depends on the cost of installation, water and electricity rates, annual meteorological conditions, and the amount of energy used for cooling in a particular facility. Typical costs will range from 150 $/ton to 200 $/ton depending on the size of the unit being retrofit, this estimate does not include the labor involved in installing the system and plumbing water to the Evaporcool system. Once all costs are factored in, a system installation on systems less then 100 tons might cost somewhere around 300 $/ton - 400 $/ton. The Evaporcool system demonstration at Beale Air Force Base cost a total of $17,260 including equipment, installation, and commissioning; this amounts to roughly $345 per ton. The installation cost for this project on a secure military base were somewhat higher than most sites due to the remote location for team mobilization and site access restrictions. The marginal cost for materials and services that scale with equipment size is such that cost-per-ton should be less for larger capacity systems. Much of the cost is for hardware and services that are independent of system size. A more typical cost for large commercial installations greater than 100 tons may

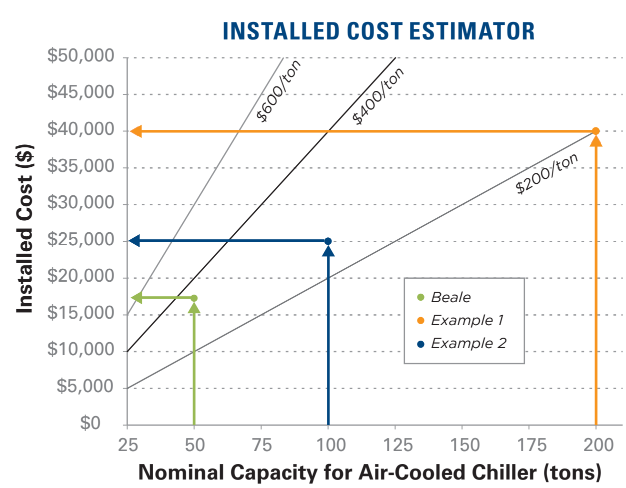


Figure 3: Installed Cost Estimator. Use nominal size of air-cooled chiller or RTU, and cost-per-ton for retrofit to estimate project cost

FIGURE 4: ENERGY SAVINGS ESTIMATOR

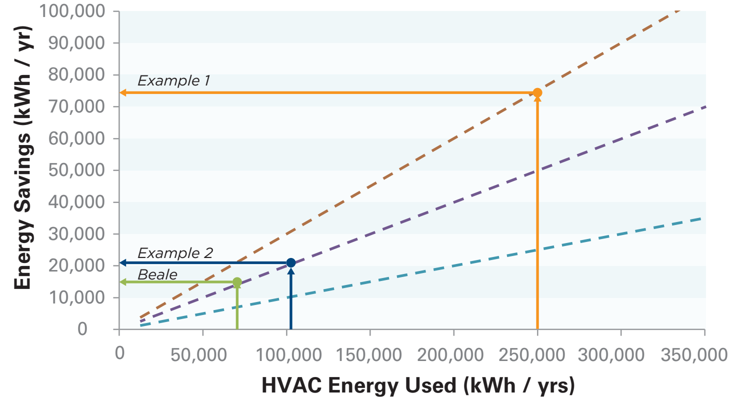
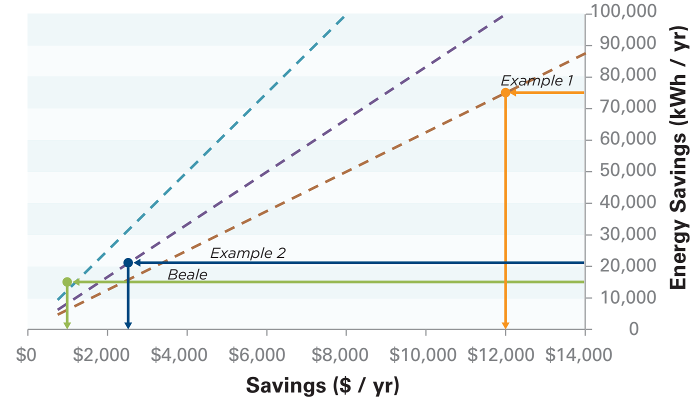


FIGURE 5: DOLLAR SAVINGS PER YEAR



be $200-$250/ton. A more precise cost estimate can be obtained from the vendor who will be installing the equipment.

Figure 3 charts the total installed cost as a function of equipment capacity serviced for three cost-per-ton possibilities. The Beale Air Force Base installation (electricity rate of $0.07 per kWh) is located on the plot, along with two hypothetical scenarios for larger systems. Example 1 (orange) locates the annual savings for a 50,000 ft^2 facility with 5 kWh/ft^2-yr annual cooling energy intensity and an assumption of 30% annual energy savings. Example 2 (blue) is for a 30,000 ft^2 facility and 3.5 kWh/ft^2-yr cooling energy intensity, this example assumes 20% annual energy savings. These examples where chosen to demonstrate the potential range of savings that might be expected by using the Evaporcool retrofit in various climates on different sizes of equipment. The annual cooling energy used will vary significantly by building use and climate zone, and the specific application must be considered in detail before installation.

Figures 4 and 5 can be used to estimate the annual savings that can be expected by installing an evaporative condenser air pre-cooler. The savings can be determined by locating the annual electricity used by current HVAC equipment (estimated from current billing or by floor space and use type as outlined above) along with an appropriate savings factor. For the installation at Beale AFB, located in California Climate Zone 12, the savings factor was found to be roughly 22%. Greater savings can be expected in hotter drier climates. The Beale Air Force base retrofit and the two hypothetical examples are plotted. The estimated results for the three examples shown in Figures 3, 4 and 5.

This economic evaluation does not account for the value of peak demand savings, equipment lifetime extension, or the potential to reduce equipment size due to added cooling capacity at peak. The calculations also ignore the cost of water consumed. Average water consumption for the demonstration was 44 gal/day in August – September 2012. Currently the most expensive water in California is found in San Diego. Using a worst case estimate of $0.006/gal, this equates to roughly $48 over a 6 month cooling season, and can be considered negligible. A full financial evaluation would also include lifetime maintenance considerations and any potential rebates that might be available through programs such as the UC/CSU/IOU Partnership and financing options such as utility On Bill Financing and through the Statewide Energy Partnership program.

For details visit program websites at:

http://workingsmarter.universityofcalifornia.edu/projects/statewide-energy-partnership/overview/

http://www.uccsuiouee.org

ABOUT THE STATE PARTNERSHIP FOR ENERGY EFFICIENT DEMONSTRATIONS (SPEED) PROGRAM: The SPEED program is supported by the California Energy Commission and managed through the California Institute for Energy and Environment (CIEE). SPEED demonstrations are coordinated by the CIEE in partnership with the California Lighting Technology Center and the Western Cooling Efficiency Center, both at the University of California, Davis.

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

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For more resources and information, including technology catalogs, business case studies and demonstration maps, visit PARTNERSHIPDEMONSTRATIONS.ORG.