Customer Advanced Technologies Program
Technology Evaluation Report

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About the Customer Advanced Technologies Program

SMUD's Customer Advanced Technologies (C.A.T.) program works with customers to encourage the use and evaluation of new or underutilized technologies. The program provides funding for customers in exchange for monitoring rights. Completed demonstration projects include lighting technologies, light emitting diodes (LEDs), indirect/direct evaporative cooling, non-chemical water treatment systems and a wide variety of other technologies.

For more program information, please visit: http://www.smud.org/education-safety/cat.html.

Executive Summary

Although evaporative precoolers are not new to the energy efficiency scene, the current focus on green and environmentally friendly technologies has given rise to a wave of new products including one known as Evaporcool™. According to the Green HVAC Solutions (the manufacturer), Evaporcool reduces energy consumption and peak electrical demand while consuming minimal amounts of water. During 2009 SMUD hired ADM Associates Inc. to evaluate these claims at a local demonstration site.

Park Sacramento, an assisted living facility in Sacramento California, installed the Evaporcool system on their 80-ton chiller. The chiller was extensively monitored to determine the overall impact of the Evaporcool system. The results:

- Reduced peak demand on the hottest days by about 10 kW (reduction of 12.8%).
- Reduced average daily energy consumption of the chiller by 5,024 kWh per year. This translates to a savings of 6.9% for the analyzed period and 5.1% on an annual basis.
- Reduced energy use of the chiller during 4 PM to 7 PM peak period by 13.4%.
- Increased the cooling capacity of the chiller by 12.5%.
- Maximum water usage rate was 70 gallons per hour.
- Calculated annual water use is estimated to be 25,000 gallons (an average of 68.5 gallons per day). This usage was based upon measured water data projected onto Sacramento weather data for the whole year. To put this in proper perspective, a family of three uses an average of 100,000 gallons of water per year.
- Financial summary:

  Estimated annual utility bill reduction: $1,258

	Cost of Evaporcool system:	$18,633
-	SMUD research grant:	$9,316
	Net cost:	$9,317

  Simple payback = $9,317 ÷ $1,258 per year = 7.4 years

Although the simple financial payback for the Evaporcool is somewhat long, technologies that reduce peak electrical demand will play an increasing important role in the future. For now, SMUD may offer energy efficiency incentives for evaporative precoolers (on a case-by-case basis) under our custom rebate program. Please call SMUD Commercial Services at 1-877-622-7683 or visit www.smud.org for current program offerings.

Introduction

Park Sacramento, an assisted living facility, was experiencing problems with their air cooled chiller. On hot summer days, the chiller would trip offline due to high head pressures. The culprit was a group of cottonwood trees located in the neighborhood around the facility. Cotton from these trees would build up on the condenser coils and reduce air flow and unit capacity. To combat this problem, Green HVAC Solutions installed an Evaporcool pre-cooler on the chiller's air cooled condensers.

The installation included a screen to protect the evaporative pads. These screens may be easily hosed off to clean off cotton and other debris that restrict air flow across the condenser coils. This solved the maintenance problem, yet a question remained: how much energy would the Evaporcool save? To answer this question, SMUD hired ADM Associates Inc. (ADM) to monitor the chiller and prepare an estimate of the energy and electrical demand reduction.

Chiller / Evaporcool Information

The chiller at Park Sacramento is a Trane RTAA080 80 ton unit with two 40 ton screw compressors. The chiller uses variable speed compressors and air-cooled condensers. Green HVAC Solutions installed the Evaporcool water spray system in September of 2008.

When outside air temperatures rise above 100°F, air-cooled chillers, such as the one at Park Sacramento, operate at reduced efficiency levels. The Evaporcool system is designed to reduce energy consumption and increase efficiency by lowering the temperature of the air across the condenser coil. The system includes:

- A reverse osmosis water filtration system
- Evaporative cooling pads enclosed in externally mounted cabinets with protective screens (Figure 1)
- Water spray heads
- Water spray controller
- Water valves for spray heads (Figure 2)

Figure 1: evaporative cooling pads.

Figure 2: water control valve boxes.

The Evaporcool system filters tap water and pipes it to a series of spray heads that wet pads covering the air intake for the air cooled condenser coils. The evaporation of the water lowers the temperature of the air flowing across the condenser coil (Figure 3) thereby allowing the chiller to operate at lower pressures and higher efficiency levels.

Historically speaking, the long term success of evaporative pre-coolers has been hampered by hard water scale clogging the spray nozzles and pads. Fortunately the Evaporcool includes a water treatment and filtration system.

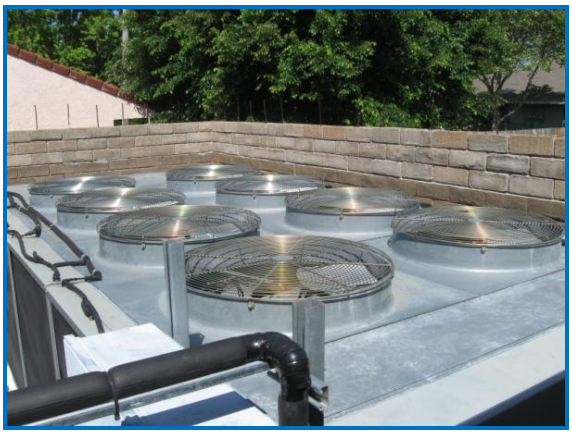

Figure 3: these fans draw air across the chiller's condenser coils.

Monitoring Approach

ADM installed monitoring equipment in early May 2009. Data was collected from mid May to the end of September 2009. An Enernet K-20 multi-channel meter recorder was used to collect the data in 5-minute intervals. The following parameters were monitored:

- Chiller power and energy use (compressors & condenser fans)
- Chilled water pump power and energy use
- Chilled water supply and return temperatures
- Condenser air temperatures (before and after the wetted pads)
- Water consumption (Figure 4)

Figure 4: water flow meter and irrigation valve used for monitoring.

Part of the monitoring strategy was to use an irrigation valve and timer to turn the water on and off on alternating days and measure the operating conditions of the chiller (Figure 4). Initially there were concerns that if the water was turned off on hot days the chiller would trip offline. However, as mentioned earlier, periodic cleaning of the Evaporcool's protective screens allowed the unit to operate even on the hottest days in the summer without incident. This by itself was a major benefit to the facility.

During the summer, Green HVAC Solutions replaced the original pads and increased the water flow to keep the pads wetter longer. Because of these two factors, analysis of the monitoring data is now focused on the period from July 29, 2009 to September 27, 2009. A discussion of the data is presented in the next section.

Monitoring Results

Energy Savings

The daily energy use of the chiller was analyzed with and without the water spray and plotted versus average 24 hour daily ambient temperature. The results are shown in Figure 5 below. Some observations:

- Based only on the analyzed period data, the average energy use for the baseline (no water spray) was 632 kWh/day. The average energy use for the chiller with the Evaporcool in operation was 588.5 kWh/day - an average savings of 43.5 kWh/day. This translates to an overall savings of 6.9% for the analyzed period.

- Using a linear regression for the two groups and projecting those results onto weather data for Sacramento, yields an annual savings of approximately 5,024 kWh per year (an annual energy savings of 5.1%). Although this is not a lot of energy savings for an 80-ton chiller, remember that the purpose of the Evaporcool is to reduce condenser air temperatures during the hottest periods of the year, which only occur during relatively few hours in Sacramento. Using this technology in hotter climates should produce considerably more energy savings.

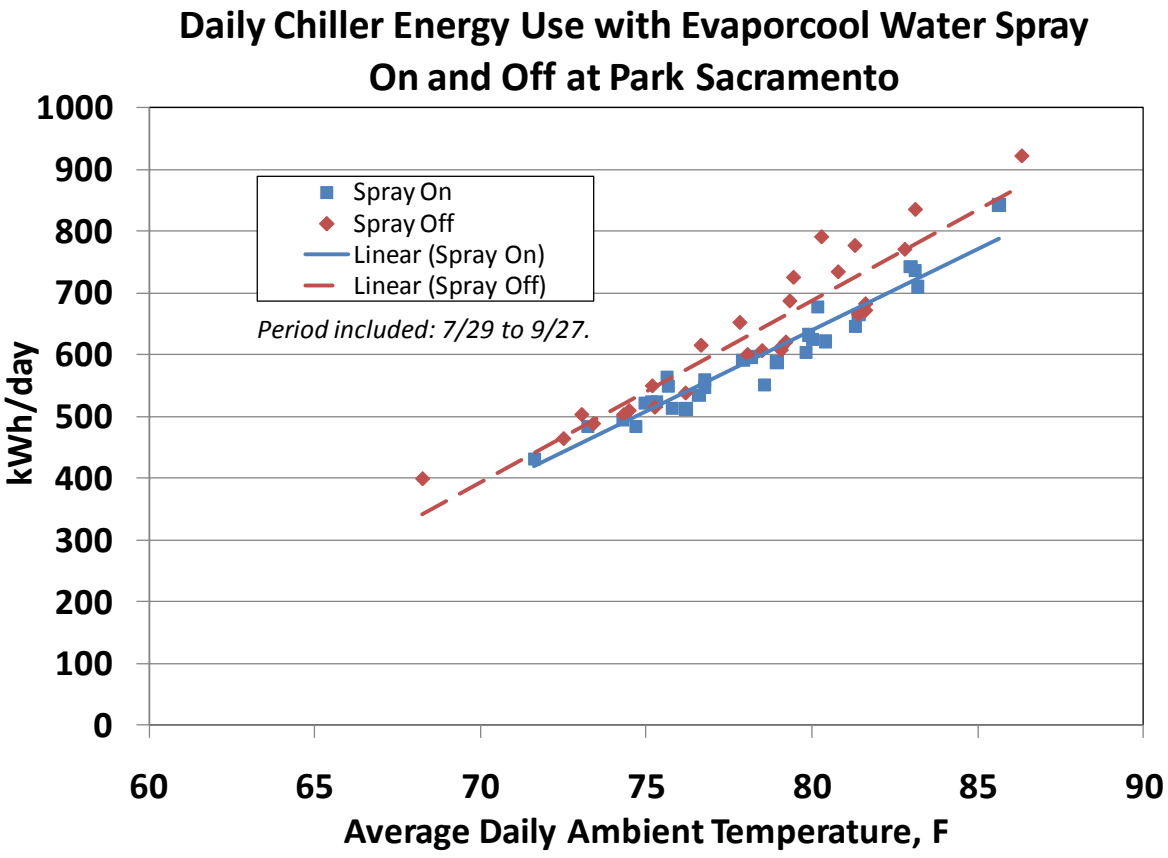

Figure 5: average daily energy consumption for the chiller at Park Sacramento. The Evaporcool reduced energy consumption by 6.9 percent during the analyzed period.

Peak Electrical Demand Savings

The chart in Figure 6 shows the chiller's electrical demand as a function of ambient temperature during the SMUD super peak period of 4 PM to 7 PM. Some observations:

- The ambient temperature at this location is approximately 5 degrees higher than the air temperature in the region
- On the hottest days the demand savings is about 10 kW (reduction of around 12.8%)

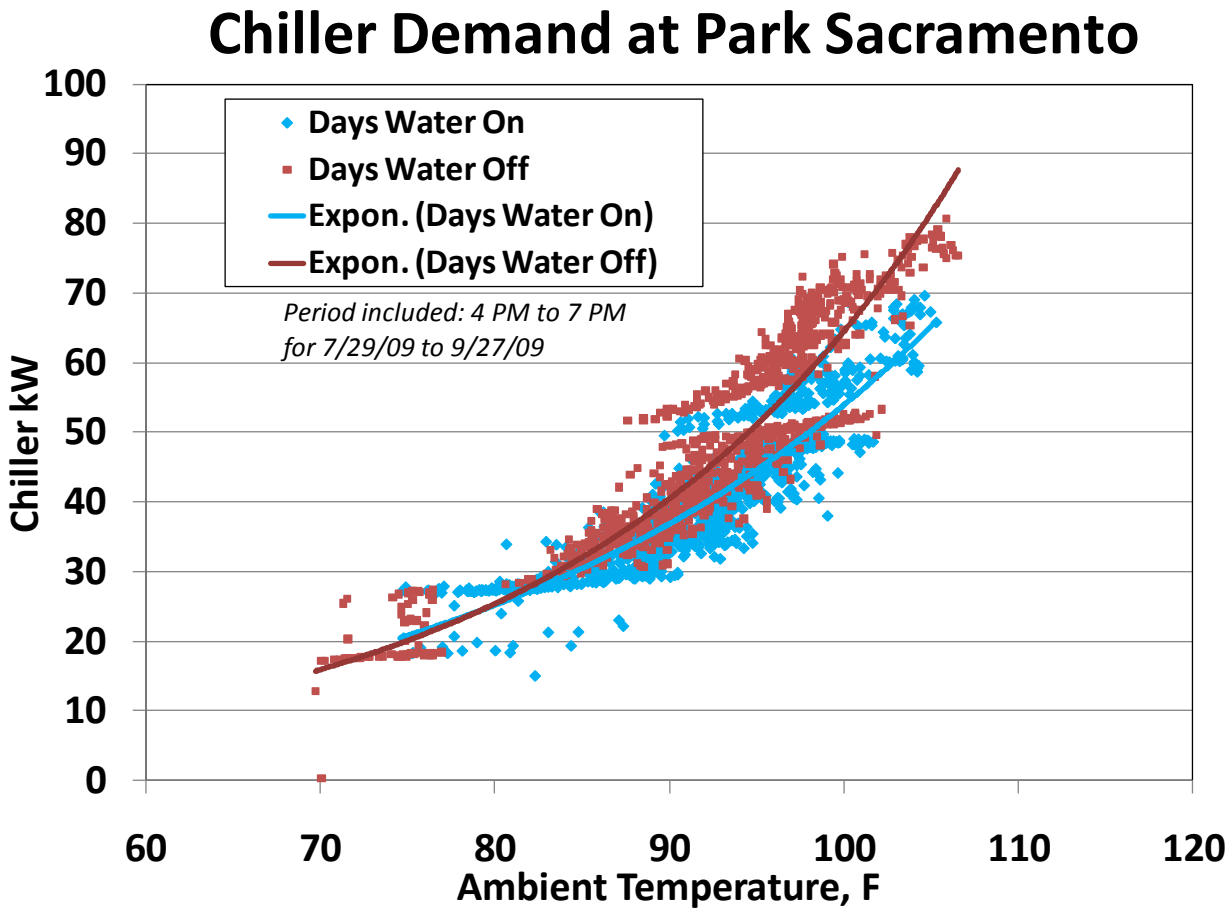

Figure 6: on the hottest days the Evaporcool reduced the chiller's peak electrical demand by about 10 kW – a reduction of around 12.8% during SMUD's super peak period.

Condenser Air Temperature and Capacity

When outdoor ambient temperatures rise, air-cooled chillers experience a reduction in cooling capacity. In addition to saving energy and reducing electrical demand, evaporative pre-coolers may also increase cooling capacity. Although attempts to directly measure cooling capacity at this site were unsuccessful, air temperatures entering the condenser coil (after the pad) were obtained throughout the monitoring period. These temperatures will be used in conjunction

with performance data from the chiller manufacturer data to estimate the net impact upon cooling capacity.

The chiller at Park Sacramento is surrounded by a cinder block enclosure. This causes the air temperatures around the chiller to be around 5°F higher than the nearby official weather recording stations. The chart below (Figure 7) shows air temperatures after the pads versus ambient temperature for the 4 PM to 7 PM time period for days with and without the water spray on. Each point is an average temperature over a 5-minute interval. The temperatures measured are dry-bulb temperatures. When the ambient air temperature was 105°F, the wetted pads lowered the air temperature across the condenser coils by 20°F.

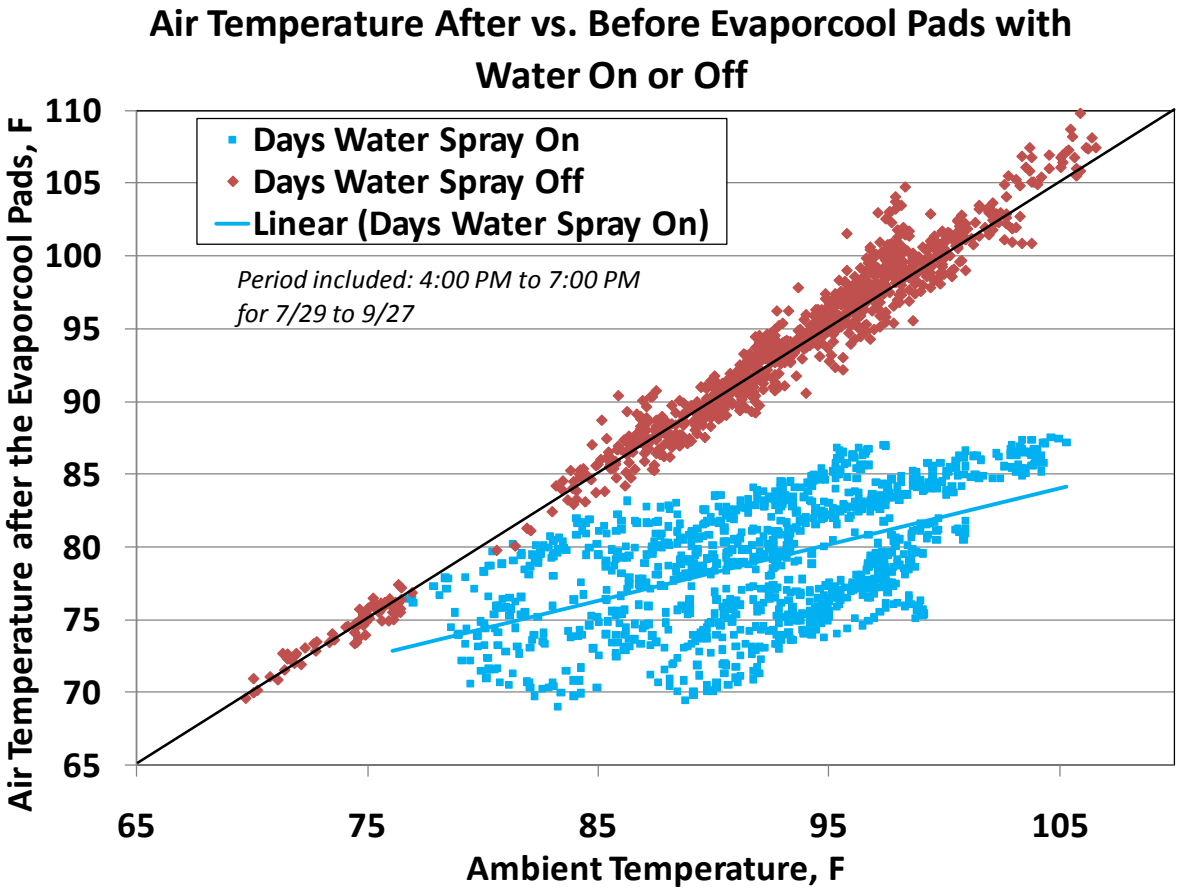

Figure 7: during the hottest days of the year, the Evaporcool significantly reduced the dry bulb temperature of the air drawn across the condenser coils.

The manufacturer's rating of 80 tons for the chiller in this study occurs when the entering condenser air temperature is 95°F and the leaving water temperature is 44°F. Since the leaving chilled water temperature for this site is controlled at 50°F, the rated cooling capacity is substantially higher. In fact, at 105°F ambient air temperature (entering condenser air) and a leaving chilled water temperature of 50°F, the cooling capacity is 83 tons. However, if we apply the measured 20°F drop in ambient air temperature to the manufacturer's performance data, the capacity of the chiller when the outside air temperature is 105°F increases to 93.4 tons. This increases the cooling capacity by 10.4 tons or 12.5%.

Water Usage

Water usage is an ever growing concern in California. There are some trade offs to using water to increase the efficiency of air cooled chillers. It is important for these types of systems to use water in a very efficient manner. After analyzing the measured water consumption the following observations were made:

- At this demonstration site, the water spray was set to operate only when the ambient temperature was above 85°F (as measured by the controls on the unit), yet the system still operated when the ambient air temperature was only 80°F. To optimize water usage, the controls may need to be adjusted.

- Average water usage during the monitoring period was 245 gallons per day (on days the water spray was on). This includes water used for periodically flushing the water treatment system.

- Maximum water usage rate was 70 gallons per hour.

- Calculated annual water use is estimated to be 25,000 gallons (an average of 68.5 gallons per day). This usage was based upon measured water data projected onto Sacramento weather data for the whole year. To put this in proper perspective, a family of three uses an average of 100,000 gallons of water per year.

Financial Summary

Estimated energy savings: 5,024 kWh per year x $0.10 per kWh = $502 per year

Estimated demand savings: 10 kW x $6.30 per kW x 12 months per year = $756 per year*

Total estimated energy bill savings: $502 + $756 = $1,258 per year

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*SMUD Rate Schedule GSS

Conclusions

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Acknowledgements

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