How Green is Your Cooling System?

The green building movement, championed by the U.S. Green Building Council (USGBC), is focused on mitigating negative environmental impacts and implementing best management practices regarding the use of our natural resources with respect to the construction, operation, and management of buildings. The heating, ventilation, and air conditioning (HVAC) systems of buildings are some of the most significant factors influencing this objective. Not only how much of our natural resources are used – but also what are the environmental and energy impacts of how we use them – are the central concerns of HVAC systems.

With respect to cooling systems in particular, there can be a debate on which cooling methodology best meets USGBC objectives: water-cooled or air-cooled? This article offers a comprehensive analysis of these methodologies in meeting green building goals.

For example, cooling the condenser coil of a 300-ton chiller plant can be accomplished by either air cooling with a finned coil or water cooling with a cooling tower. California recently has changed Title 24 to require that any building with more than 300 tons of cooling use no more than 100 tons of air-cooled condensers. The driver for this regulation is energy savings. Water-cooled condensers operate at a significantly lower head pressure and use much less energy. A study conducted by Pacific Gas and Electric (PG&E) in California [ref 1] showed that on a typical 100,000 sq. ft. building in Fresno, an air-cooled condenser system would use 440,000 KWH per year compared to 190,000 KWH per year for a water-cooled system. An air-cooled system requires 250,000 KWH more per year than a water-cooled system to perform the same cooling. These numbers result in an energy penalty of 130% over a water-cooled system. While the first-cost for an air-cooled system is lower, the PG&E study showed that the life-cycle cost strongly favors the water-cooled system.

In spite of this overwhelming energy efficiency, why do some green buildings chose air-cooled condensers over water-cooled? The following perceptions of operators and some design engineers are among the reasons that air-cooled condensers are sometimes selected.

1. Cooling towers use large quantities of water (saving water is green).
2. Water-cooled systems require much more maintenance than air-cooled.
3. Water treatment is difficult and environmentally unsound.

Each of these perceptions is wrong.

Cooling Tower Water Use

The PG&E study shows that a 100,000 sq. ft. Fresno building with a water-cooled condenser would evaporate 576,985 gallons per year, with blowdown using an additional 144,246 gallons at 4 cycles of concentration. The reasonable maximum cycles that could be reached are 8 cycles, which would reduce the blowdown to 82,426. Thus, the total water required to run this tower would be between 659,411 and 721,231 gallons per year.

This water usage is usually compared to zero water required by an air-cooled system. This comparison is not valid. A recent study by the National Renewable Energy Lab [ref. 2] (managed for the U.S. Department of Energy by the Midwest Research Institute and Battelle) determined that, on average, each KWH of energy generated in the U.S. consumes 2 gallons of water.

Therefore, an air-cooled system using 250,000 KWH more per year than a water-cooled system forces the utility company to consume 500,000 gallons more water per year. The water use favors the air-cooled but much less than one would assume without a thoughtful study.

In California and other parts of the west, the consumptive water required for power generation is 4.42 gallons per KWH, double the national average. In these regions, air-cooled condensers will consume considerably more water than water-cooled condensers when utility water consumption is factored into the equation.

Maintenance Requirements

A cooling tower, like any piece of equipment, requires maintenance. Logically then, an air-cooled condenser is not maintenance free. Air-cooled manufacturers recommend that at least once—and usually twice—per year the coils on an air-cooled condenser be cleaned [ref. 3]. To clean a 200-ton air-cooled condenser requires two people for a full day using 5 to 10 gallons of concentrated, caustic chemical cleaners. Because of environmental concerns about these chemicals and the residue that is removed, many sites require that the 200 plus gallons of wastewater generated by this cleaning operation be collected and shipped to a hazard waste site. In comparison, a water-cooled condenser should be cleaned once per year by punching the condenser tubes. This operation uses no chemicals and, for a 200-ton chiller, can be performed by one person in one day. Annual cleaning of a water-cooled condenser is 25% the work of cleaning an air-cooled condenser.

A 200-ton, water-cooled system will have a condenser water pump, a back-up water pump, and one or two tower fans and one compressor, all of which will require routine maintenance. A similarly sized air-cooled condenser typically has no water pumps but 14 condenser fans and 2 to 4 compressors. Every fan and pump requires routine maintenance; however, a water-cooled system has much less equipment and requires much less maintenance than an air-cooled system.

Jamie Downie, a former supervisor at EMCOR's commercial HVAC services, says that "A 200-ton water cooled system needs less than half the maintenance that a 200-ton air-cooled system requires."

Cooling Tower Water Treatment

A cooling tower uses water to transfer heat from the condenser and then evaporates a portion of water to keep the water cool. An air-cooled condenser uses no water on site.

An air-cooled condenser requires no on-site water treatment while a water-cooled system, of any size, requires that the open-loop be treated. Left untreated, the open loop can scale, corrode, and provide an encouraging environment for biological growth. To control this degradation, traditional water treatment uses a variety of mutually compromising chemicals. These chemicals interact with each other and must be periodically adjusted based on changes in load, make-up water, and ambient conditions. Many of the chemicals are hazardous in their concentrated form. There are environmental issues with drift, tower splash-out, chemical air emissions, and blowdown. Chemical pump failures are common, and the overfeeding or underfeeding of any chemical can upset the delicate balance of the treatment. Once upset, the chemical systems are difficult to bring back into control. The environmental and economic impact of misusing these

chemicals can be profound, as the movie *Erin Brockovich*, which concerned contamination from PG&E cooling towers, exemplified

Chemical water treatment is the most compelling reason that customers shy away from water cooled to the less energy-efficient—*and more maintenance-intensive*—air-cooled condensers. A HPAC magazine article [ref. 4] describes the first LEED-certified supermarket as choosing air-cooled over water-cooled, with the issue of water treatment being the deciding factor.

However, as hundreds of supermarkets and HVAC customers can attest, using water-cooled condensers with a pulsed-power physical water treatment system will result in better performance, energy savings, water savings, and environmental health and safety benefits, while eliminating the problems associated with using chemicals to maintain the water system.

Pulsed-Power Physical Water Treatment

Pulsed-power physical water treatment has changed the paradigm for treating evaporative cooling systems. Pulsed-power uses pulsed-electric fields (a technology developed by the food industry for pasteurization) to control scaling, biological growth, and corrosion. This completely chemical-free approach to water treatment eliminates all the environmental and health-and-safety issues associated with water treatment chemicals. Pulsed-Power Systems have no pumps to break down or chemical tanks to run dry. Pulsed-power systems are forgiving of operational upsets and promote cooling tower operation at higher cycles of concentration (therefore, less blowdown and less water usage) than standard chemical treatment. Independent studies have shown not only that the method is effective for cooling towers, but that the performance of pulsed power systems is superior to standard chemical treatment in biological control and water usage [ref.5].

With the elimination of the problems associated with chemical water treatment, the advantages of water-cooled condensers make them the environmental, energy, and economic choice, dovetailing with the all the goals of the green building movement.

References:

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