SMART USE OF YOUR HVAC COOLING TOWERS

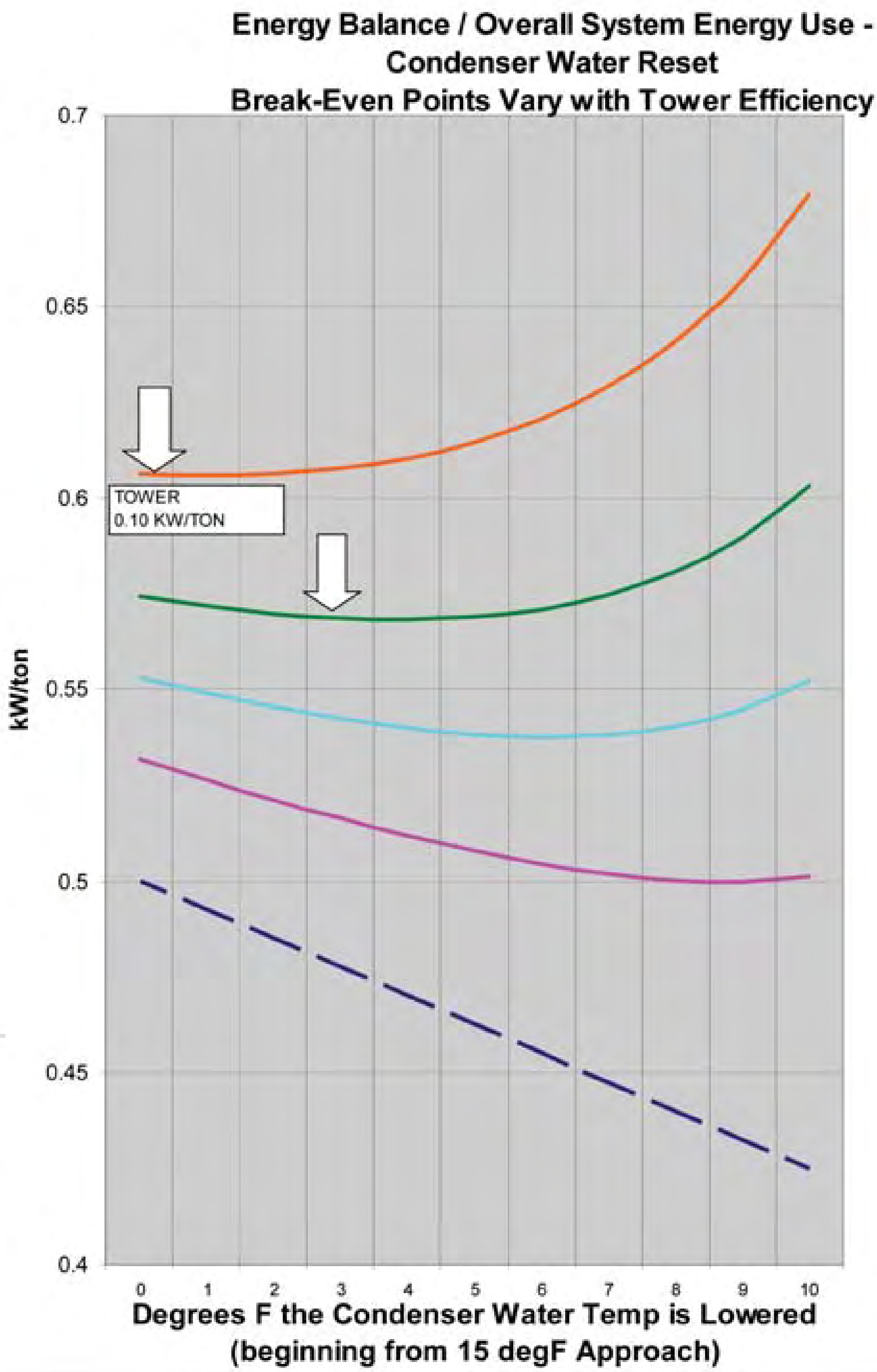
With the right chillers, smart cooling tower application can increase cooling system energy efficiency by 10 to 15 percent.

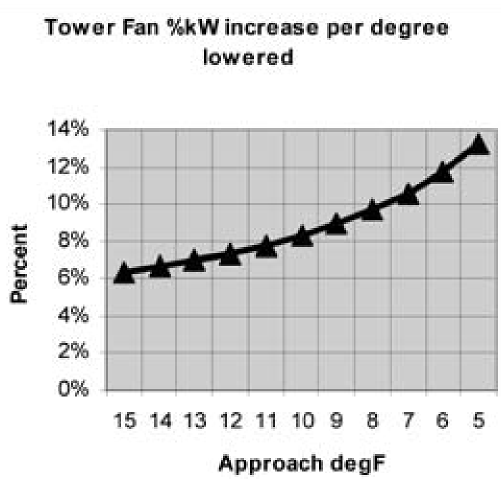
WHAT IS A COOLING TOWER?

For building HVAC use, a cooling tower is an auxiliary cooling device – it doesn't cool the building directly – but rather it helps other equipment do that job. Cooling towers are also used for other things like process water cooling and power plants. For this paper, the application is limited to building HVAC service.

A cooling tower evaporates a portion of a water stream to cool down the remaining water. This is done by spraying or spreading a thin layer of water and then passing air over it, usually with a fan. The dominant factor in cooling tower performance is the outdoor "wet bulb" temperature, which indicates how dry the air is. Since they are driven by wet bulb temperatures, cooling towers can produce quite cool water, even on warm days, as long as it's not too humid. The cooling tower "approach" temperature tells us how close the water temperature can be lowered toward the wet bulb temperature. If the cooling tower were infinitely large, the leaving water temperature would be at the wet bulb air temperature. The larger the approach, the smaller and less expensive the cooling tower can be, which is nice on the day the cooling tower is purchased. But the smaller the approach the greater the efficiency options for the equipment served by the cooling tower,

Continued on Page 16





Cooling Towers

Continued from Page 14

which has benefits for years and years. Approach temperatures lower than 7 degrees encounter diminishing returns and require larger investment in fan horsepower for each additional degree.

Refer to the chart of local weather patterns on the following page. In Colorado Springs, our "design day" wet bulb temperature is 58 degrees, and it is almost always lower than that. So, using an approach temperature of 7 degrees, we can expect 58 + 7 = 65 degree condenser water at the chillers on the "design day". During the three hottest months of the year, we can expect an average 60 degree cooling water to be available for use by the chiller. Why is this important?

As an auxiliary device, the cooling tower lives to serve the connected chiller. By comparison, an electric chiller will consume about 10 times as much power as the cooling tower. The cooling tower can reduce cooling costs if it can economically produce colder water that is then used by the chiller. At the chiller, each degree that the cooling water is lowered will reduce the chiller kW by 1 to 1.5 percent. So, controlling to 60 degrees instead of 70 degrees reduces the chiller energy and demand by 10 to 15 percent!

NOTE: some chiller manufacturers can accept colder condenser water, some cannot. An important consideration for chiller purchase for use in our semi-arid climate is how cold of condenser water the machine is designed to take. For maximum benefit from our dry climate natural resource, a chiller should be able to accept 60 degrees inlet cooling water at full water flow (10 degree rise) at all loads, and still produce standard 45 degree chilled water. For existing chillers, check with the chiller manufacturer to be sure you stay within their guidelines.

As an auxiliary device, the energy used by the cooling tower is considered a parasitic loss. To reduce the cooling tower energy consumption, we try to reduce fan horsepower. The fan horsepower is driven by the resistance to air flow – so selecting a "bigger box" allows the cooling tower to breathe the same amount of air with less energy. A good rule of thumb for auxiliaries is to not exceed 1/10th of the prime power consumption. Modern chillers are commonly selected at 0.5kW/ton or less, so the cooling towers should not consume any more than 0.05 kW/ton, in order to keep cooling tower energy use in proportion.

For existing cooling towers that are sized at higher than ideal per-ton energy rates (0.07-0.1 kW/ton), it may not always be economical to operate below 70 degrees. For cooling towers with proportionally large fan motors, there will be times that the added cooling tower fan horsepower offsets the chiller savings, and the balance of the two must be considered. Until a more generously sized cooling tower can be purchased, some savings opportunities will be out of reach with these cooling towers. This energy balance concept is illustrated below. From the graph, the energy advantages of an amply sized cooling tower are evident.

CONTROLS

Cooling tower fans are controlled from a thermostat that senses water temperature. When the water temperature rises, the fan is started (or sped up). The most common form of control uses a fixed temperature setting.

Using modern Digital Controls, it is relatively easy to optimize the cooling tower and the overall cooling system, by monitoring the ambient wet bulb temperature and continuously changing the fan control setting. For a fully loaded chiller, the 'best' condenser temperature setting (within the chiller manufacturer's limits) will then be

"Ambient Wet Bulb Temp + Approach Temp"

To properly apply this relationship, the correct 'approach' temperature value must be determined, such that the cooling tower fan consumption remains an appropriately small portion of the total. If the cooling tower was picked to run at 15 degrees approach, forcing it to run at 7 degrees will result in continuous cooling tower fan operation and wasted energy. Generally, by using the approach value of the cooling tower initial design selection, and allowing the water temperature to move around with the ambient wet bulb, a good balance of system savings will be achieved, even when the chillers are at reduced load. The key concept is not to force a cooling tower to do something it wasn't made to do, but to capitalize on the low wet-bulb hours to make colder condenser water economically whenever possible. After making a control change like this, it is always a good idea to check the combined chiller-tower energy consumption to verify the results are as predicted.

To summarize, here are some cooling tower hot buttons:

- 7 degree approach max.

SAMPLE CHILLER LOAD PROFILE (100 tons)

	0-25% load	25-50% load	50-75% load	75-100% load	Annual Total
Pct time at this load	10%	40%	40%	10%	100%
Time at load	130 hours	520 hours	520 hours	130 hours	1300 hours
Load	13 tons	38 tons	63 tons	88 tons	**50.5 tons avg**
Average evaporation					**1.5 gpm**
Blow down (20%)					**0.3 gpm**
Total water use					**1.8 gpm**
Estimated Annual Water Use					**140,400 gallons**

AVAILABLE CONDENSER WATER TEMPERATURES FROM A COOLING TOWER - COLORADO SPRINGS

COOLING TOWER PERFORMANCE IS DRIVEN OFF WET BULB.

THIS IS WHAT THE COOLING TOWERS CAN DO ANNUALLY (7 DEG APPROACH)

<37 WB 55 deg CW easily. 2880 hours				37-48 wb **55 deg CW** 2790 hours		49-53 WB **56-60 deg CW** 1950 hours		54-58 WB **61-65 deg CW** 1050 hours				
WETBULB	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0		23.9	34.3	39.1	45.0	48.5	50.8	50.8	47.3	41.4	34.3	23.9
100	17.1	23.2	33.6	38.5	44.4	48.0	50.3	50.3	46.8	40.8	33.7	23.2
200	16.3	22.4	33.0	37.9	43.9	47.5	49.9	49.9	46.3	40.3	33.0	22.4
300	15.8	21.8	32.5	37.4	43.4	47.1	49.5	49.5	45.9	39.8	32.5	21.8
400	15.1	21.4	32.0	37.0	43.1	46.8	49.2	49.2	45.5	39.4	32.1	21.4
500	15.0	21.2	31.9	36.9	43.0	46.7	49.1	49.1	45.4	39.3	31.9	21.2
600	15.3	21.5	32.2	37.1	43.2	46.9	49.3	49.3	45.7	39.6	32.2	21.5
700	16.1	22.3	32.9	37.7	43.8	47.4	49.8	49.8	46.2	40.2	32.9	22.3
800	17.6	23.6	34.0	38.8	44.7	48.3	50.8	50.6	47.1	41.2	34.1	23.6
900	19.7	25.5	35.7	40.3	46.1	49.6	51.8	51.8	48.4	42.7	35.7	25.5
1000	22.1	27.6	37.6	42.1	47.7	51.0	53.2	53.2	49.9	44.3	37.6	27.6
1100	24.6	29.9	39.8	43.9	49.3	52.6	54.7	54.7	51.5	46.1	39.8	29.9
1200	26.9	32.0	41.4	45.7	50.9	54.0	56.1	56.1	53.0	47.7	41.5	32.0
1300	28.5	33.6	42.8	46.9	52.0	55.1	57.1	57.1	54.0	48.9	42.8	33.6
1400	29.6	34.6	43.7	47.7	52.7	55.7	57.8	57.8	54.7	49.7	43.7	34.6
1500	30.0	35.0	44.0	48.0	53.0	56.0	7.0	58.0	55.0	50.0	44.0	35.0
1600	29.6	34.6	43.7	47.7	52.7	55.7	57.8	57.8	54.7	49.7	43.7	34.6
1700	28.7	33.7	42.9	47.0	52.1	55.1	57.2	57.2	54.1	49.0	42.9	33.7
1800	27.2	32.3	41.7	45.9	51.1	54.2	56.3	56.3	53.1	47.9	41.7	32.3
1900	25.3	30.6	40.2	44.5	49.8	53.0	55.2	55.2	52.0	46.6	40.2	30.6
2000	23.4	28.9	38.6	43.1	48.5	51.8	54.0	54.0	50.7	45.3	38.6	28.9
2100	21.8	27.4	37.3	41.8	47.5	50.8	53.0	53.0	49.7	44.1	37.3	27.4
2200	20.2	26.0	36.1	40.7	46.4	49.8	52.1	52.1	48.7	43.0	36.1	26.0
2300	18.9	24.8	35.1	39.8	45.6	49.1	51.4	51.4	47.9	42.1	35.1	24.8

6a-6p	24X7	AVERAGE CONDENSER WATER TEMP AVAILABLE
34.7	32.6	DECEMBER THROUGH FEBRUARY
54.2	52.9	MARCH THROUGH NOVEMBER
56.5	55.3	APRIL THROUGH OCTOBER
58.4	57.4	MAY THROUGH SEPTEMBER
59.3	58.6	JUNE THROUGH AUGUST
65.0	65.0	DESIGN DAY

TABLE BASED ON 7 DEGREE APPROACH
FOR EACH DEGREE ABOVE 7 DEGREES,
ADD ONE DEGREE TO AVAILABLE
CONDENSER WATER TEMPERATURE

- 0.05 kW/ton max
- Using colder tower water reduces chiller kW by 1 to 1.5 percent per degree – so the colder the better, as long as the chiller can accept it.
- diminishing returns will reduce much of the chiller savings.

WHAT ABOUT THE WATER?

Cooling towers consume water. Most of the water use is from evaporation, since this is what does the cooling work. For HVAC cooling, the water use in gallons per minute is approximately 0.03 * Tons. This means for each 100 tons of cooling work, the cooling tower will evaporate about 3 gallons each minute. Of course, a 200-ton chiller operating at 50 percent load only causes cooling tower evaporation for 100-tons worth of work. For estimating annual water consumption, a load profile is required.

BLOW DOWN

In addition, the evaporation leaves behind minerals, etc that build up in the basin. These must be treated; otherwise they can form damaging scale and corrosion inside equipment and piping. An easy way is to simply bleed off (also called "blow down") a portion of the water and replace it with new, thereby continuously diluting the minerals. Some amount of blow down is usually required, but this can be reduced by a variety of methods – the most common being chemical treatment. Through water treatment, the mineral content in the water can be allowed to rise somewhat without detriment to the connected equipment. Using conventional water treatment, the blow down adds 10 to 30 percent to the total water consumption. Other systems electro-statically 'strip' the minerals out of the water to reduce or eliminate blow down. Always remember that the cooling tower is an auxiliary device and mated to some other — more expensive — equipment. When you look into the basin of the cooling tower, whatever you see in there is what is also inside the connected chiller. If the cooling tower water is allowed to get fouled, it will cause fouling and loss of efficiency in the chiller. Keep it clean!

EVAPORATION CREDIT

The utility charges for cooling tower evaporated water represent an opportunity for customer savings. This is because the water coming into each building is assumed to end up back in the sewer - but for cooling towers this is not entirely true. Some of it does go to drain (the blow down part), but most of it is evaporated. With separate metering of the cooling tower intake and outflow, it is allowed to receive an "evaporation" credit for the amount of water that doesn't go to the waste treatment system.