Use Cooling Tower to Replace Chiller Cooling
(Arc 2.2614)

(The analysis below was extracted from one of the assessment reports by the Clemson University Industrial Assessment Center (IAC). This is only an example recommendation and hence, not all the background information and sources for numbers are included here.)

Est. Electric Consumption Savings	= ***351,234kWh/yr***
Est. Electric Consumption Cost Savings	= ***$17,561/yr***
Est. Electric Demand Savings	= ***600kW/yr***
Est. Electric Demand Cost Savings	= ***$16,560/yr***
Est. Total Cost Savings	= ***$34,121/yr***
Simple Payback Period	= ***14.8 months***

Recommended Action:
It is recommended that a cooling tower is installed to replace the chillers used to supply the cooling water.

Background:
The plant uses two CVHP Model Trane Chillers with 500kW of capacity to supply the cooling water for the plant. The chiller units are shut off during the winter months of December, January, and February. The cooling water required in the heat exchanger is around 55°F in average. The assessment team recommends installing a cooling tower unit to provide the cooling water requirements of the plant for most part of the year to achieve electricity demand and consumption savings. Cooling towers are heat rejection devices that reject waste heat to the atmosphere through the cooling of a water stream to a lower temperature (see Figure 1. below).

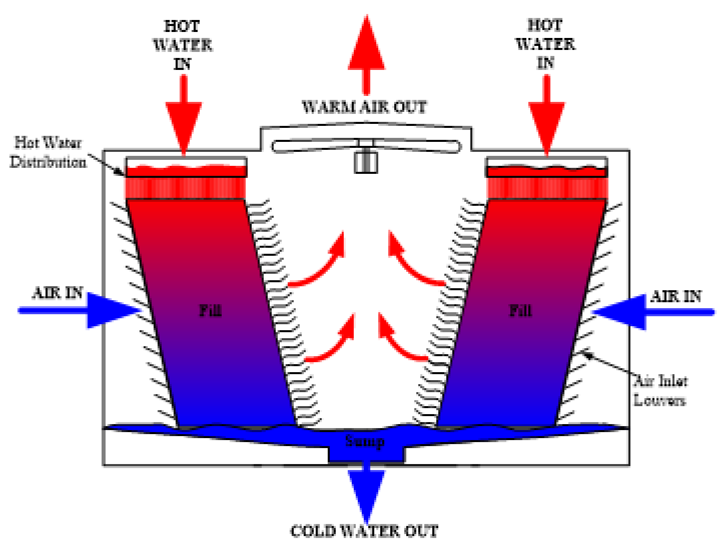

Figure 1. Typical cooling tower schematic

We used a cooling tower simulation software called CoolSim to estimate the number of hours during a year that cooling tower can be effectively used to provide the cooled water needs of the plant. The software is available from University of Dayton's Industrial Assessment Center free of charge (http://academic.udayton.edu/kissock/http/RESEARCH/EnergySoftware.htm). We uploaded a weather data file that contains the typical meteorological and temperature data for Anderson County in the state of South Carolina (".EPW" format). The weather data for our analysis is taken from
https://energyplus.net/weatherregion/north_and_central_america_wmo_region_4 .

By assuming a cooling tower water temperature range of 10°F, and target set-point temperature of 55°F, the input parameters for CoolSim is shown in Figure 2:

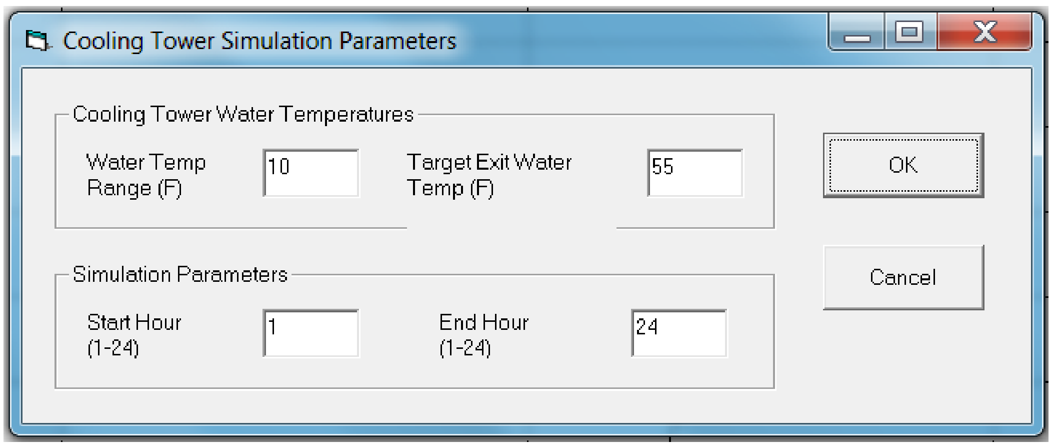

Figure 2. Input parameters for CoolSim cooling tower simulation

The plant is operating in three shifts for 52 weeks in a year, so the total annual operational hours is 8760. The plant is charged \$0.05/kWh for electric consumption and \$9.2/kW for electricity demand.

<u>Anticipated Savings</u>:
The output of the CoolSim simulation for cooling tower is shown in Figure 3. This output represents the plot of monthly percentage of time that cooling tower can provide the cooling water requirement of the plant.
According to CoolSim, there are 741 hours per year during which cooling tower water exit temperature is below 55°F. Given that for winter months the chillers are not in use, the total number of hours that a cooling tower can be used instead of chiller units is around 585 hours. By assuming that the chillers are 60% loaded on average over the operating hours in a year, we can estimate the amount of *energy consumption saving*, *ECS,* as

$$\text{ECS} = \text{Total chiller capacity(kW)} \times \text{Load(\%)} \times \text{Cooling tower usage hours}$$

$$\boldsymbol{ECS = 1000\ kW \times 60\% \times 585h = 351{,}234\ kWh}$$

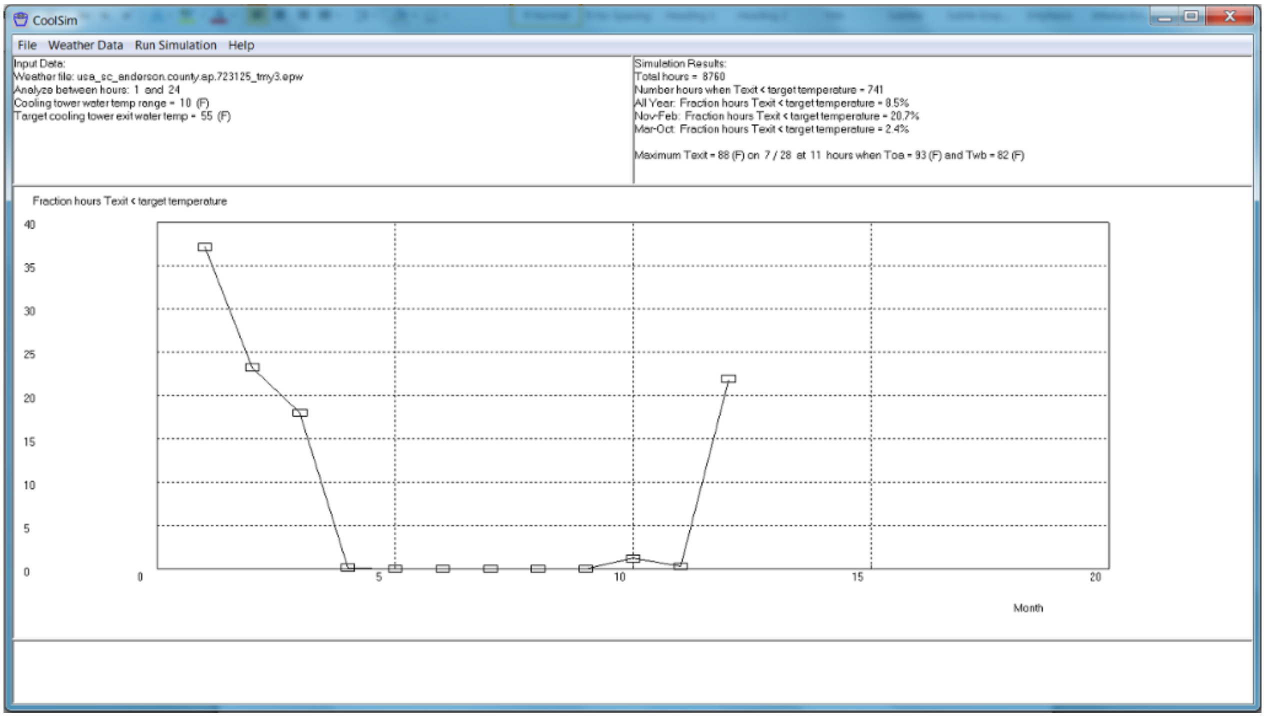

Figure 3. The output of CoolSim simulation using Anderson County, SC weather data

Accordingly, the annual *energy consumption cost saving, ECCS*, can be calculated as follows

$$ECCS = ECS \times \$0.05/kWh$$

$$\boldsymbol{ECCS = 351{,}234\ kWh \times \$0.05/kWh = \$17{,}561}$$

Electrical demand savings can be realized during months when the chiller can be shut off during peak demand hours. According to CoolSim output shown above and the existing electricity rate structure, during about 3 months of the year, the cooling tower can provide plant needs for most hours of the day. Therefore, during the 3 months period *estimated demand saving, EDS*, would be around

$$\boldsymbol{ECS = 1000\ kW \times 60\% = 600\ kW}$$

The estimated demand cost savings, *EDCS*, by using the electricity demand charge for 3 months of the year can be obtained as follows:

$$EDCS = \text{Total capacity reduction (kW)} * 3\ \text{months/yr} * \text{Demand charge (\$/kW)}$$

$$\boldsymbol{EDCS = 600\ kW \times 3\ months/yr \times (\$9.2/kW) = \$16{,}560}$$

Finally, the *total cost savings, TCS*, associated with using cooling tower in place for chillers is equal to

TCS = (ECCS + EDCS)

TCS = ($17,561 + $16,560) = $34,121

Implementation Cost:

Due to the complexity of the implementation, we are unable to accurately estimate the implementation cost. We use the cost estimation recommended in Energy Efficiency Guidebook [1]. According to this reference, main challenges of installing cooling towers include the three-way valves to bypass the water and a heat exchanger between the cooling loop and cooling tower loop. The amount of capital that can be spent on this project would be around

Implementation Cost (IC) = 42,000$

Simple Payback Period:

The *simple payback period, SPP*, is the time required to pass before the estimated total cost savings equal the estimated implementation cost, and is calculated by:

$$SPP = \frac{IC}{AECS} \times 12\, months/yr.$$

$$SPP = \frac{\$42{,}000}{\$34{,}121/yr.} \times 12\, months/yr.$$

SPP = 14.8months

References:

1. Kissock, J.K. Energy Efficiency Guidebook. 2018; Available from: http://academic.udayton.edu/kissock/http/RESEARCH/EnergySoftware.htm.