Continual Energy Inc. **Nov 2015**

Exhaustive Search Optimization Program (ExSOP) White Paper

Introduction

HVAC system optimization has long been a mystery to many controls contractors and engineers. As a result, optimization is often misapplied or not applied at all. Commonly available proprietary solutions often bring high price tags making them inaccessible to many applications, especially smaller systems (800 Tons [2,800 kW] and under). These proprietary solutions seldom provide any ability for the engineer or controls contractor to perform their own analysis as these systems are considered "black boxes".

This document presents a non-proprietary solution that meets or exceeds the performance of all known proprietary methods with the added bonus of also providing performance estimation of each piece of cooling equipment. The optimization modules have been written in Java and compiled for Tridium's Niagara platform (market leading open architecture/framework BAS solution).

What the ExSOP module does:

1. Determination of ideal operating mode (wet-side economizer, mechanical cooling, and thermal energy storage).
2. Prediction of utility usage and cost up to 7 days ahead.
3. Calculation of optimal cooling tower setpoint and optimal number of tower cells to operate.
4. Calculation of optimal condenser water flow per chiller if variable condenser water pumping is applied.
5. Calculation of ideal number of chillers to operate, applicable to dissimilar sized chillers, absorption, and steam-driven chillers.
6. Calculation of ideal number of condenser water pumps to operate.
7. Calculation of ideal number of primary, secondary, and tertiary chilled water pumps to operate.
8. Ideal balance between chilled water pumping power and chilled water setpoint (building pumps).
9. Determination of target ideal power levels for all devices.

The ExSOP module is applicable to:

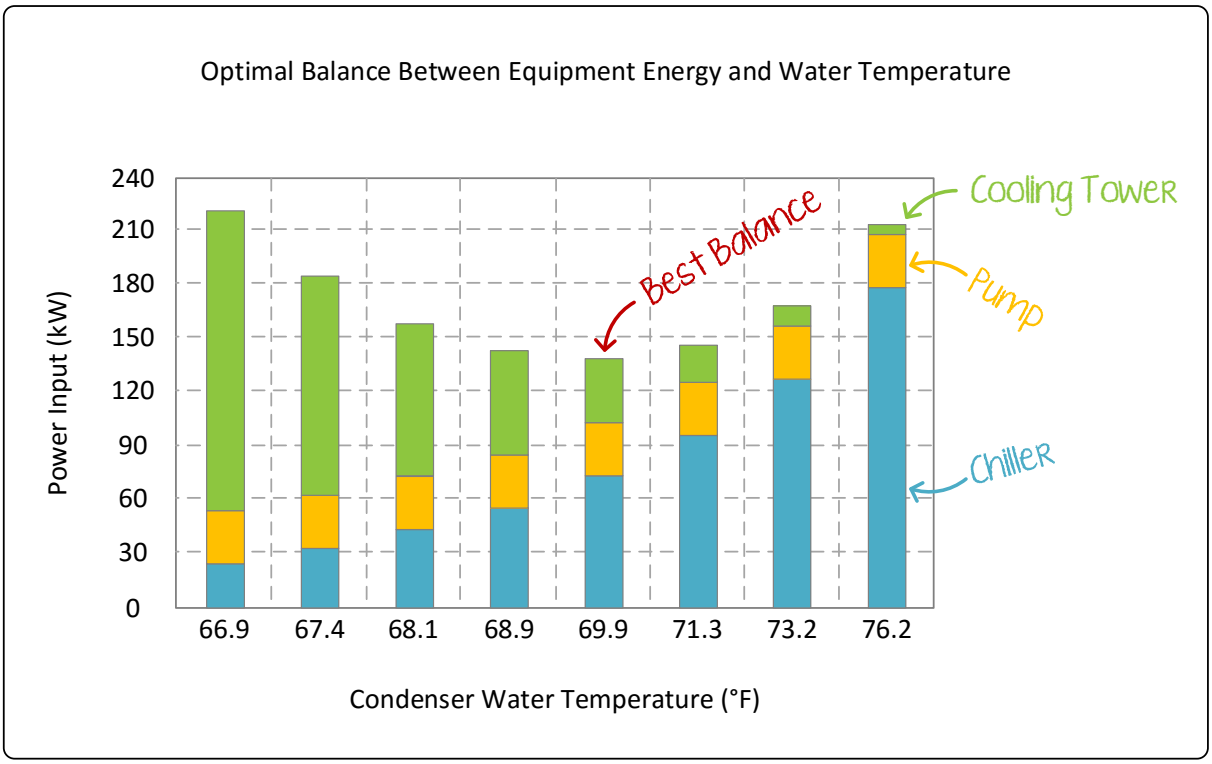
- Constant condenser water pumping systems
- Variable condenser water pumping systems
- Variable speed electric chillers
- Constant speed electric chillers
- Absorption and steam-driven chillers
- Systems with wet-side economizers
- Thermal energy storage systems
- Heat recovery systems
- Primary/secondary chilled water pumping configurations

How it Works (Basic Electric System)

The simulation engine contains chiller performance models, cooling tower performance maps created from full and part load design conditions, pump curve design information, and heat exchanger thermal models.

The ExSOP simulation engine uses inputs of actual cooling capacity as measured by a BTU meter installed in the chilled water supply lines, supply chilled water temperature setpoint and outside air wet bulb temperature. The ExSOP engine iterates through each available chiller sequence, tower combination, operational mode, and condenser water flow and cooling tower setpoint to find the combination that results in the lowest plant power demand. In the case of thermal storage systems, the simulation may be run over many hours instead of in real-time in order to target lowest daily operational cost rather than instantaneous demand savings.

For a given set of operating conditions, condenser water flow rate is stepped in small intervals from the chiller design condenser flow to the minimum flow rate (minimum defined as the highest between condenser and cooling tower minimum flow rates). At each interval of condenser flow the ideal cooling tower temperature is searched for. The combination of chiller(s) online, tower(s) online, condenser pump(s) online, chilled water pump(s) online, and condenser flow and tower setpoint that produces the lowest total power consumption is saved and presented as the optimal value along with all system variables.



The above chart shows simulation calculations indicating that the optimal balance between chiller, pump, and tower energy occurs at a cooling tower water setpoint of 69.9°F with a pump flow rate of 66% of chiller design. This simulation method is not power demand, delta-T, or adaptive-based; rather it performs its optimized search using public domain equipment performance models and requires no information from the chiller to operate.