LEVERAGING THE EXISTING PLANT PLC, FOR A NON-PROPRIETARY SOLUTION TO CHILLER PLANT OPTIMIZATION

Mike Nyhan P.E., Merck & Co., Inc.
Eric Silk CEM, Thermo Systems LLC
Outline

- Merck Facilities Background
- Economic Results
- Project Drivers
- Project Approach
- Optimization Results
- Conclusions
- Q & A
Background

• Merck WP campus is a mixed use manufacturing, research, and administration site with over 60,000 tons of chilled water cooling capacity across 8 chiller buildings

• Building 45 is a large standalone research building with its own dedicated chiller plant
  • (5) 1,200 ton electric Trane chiller
  • Air handlers are 100% OA / minimal process equipment load
Project Economics

Initial Estimate Stage

- Cost
  - $600,000
- Energy Savings
  - $161,000 or 2.4MM kW/hr
- ACT129 Rebate
  - $45,000 (prescriptive rebate only)
- ROI
  - 3.44 years

Project Completion

- Cost
  - $650,000
- Energy Savings
  - $186,000 or 2.7MM kW/hr
- ACT129 Rebate
  - $213,000 (custom rebate process)
- ROI
  - 2.34 years
B45 Complex

B45 Chiller Plant
Merck WP Utility Map (45)
Building 45 Operational Issues

- Low Delta T syndrome during winter and shoulder months
  - Chiller plant must provide 42F water throughout the year
    - Remember, most users are 100% outside air!
  - Loop cannot be shutdown because of intermittent chilled water users and validation constraints
  - Delta T ranging between 1-3F in the winter (very inefficient)
- High Delta P
  - Delta P was maintained at 30 psi all year and most of the flow was passing through a full size bypass from supply to return
  - Damage and poor control by temperature control valves on air handlers
  - Fear to change to the dP – operators did not understand
  - Tremendous waste of equipment energy
Building 45 Design Issues

• Unable to turn down equipment
  • All pumps were across the line

• Pumping excess flow = highly inefficient

• Operating chiller in the winter is lightly loaded
  • Typical winter tonnage is in the <200 tons range

• Poor control over tower water temperature with across the line pumps

• Building is overdesigned
  • At most, 3 chillers of the 5 are required during peak summer loads
Optimization Opportunity

- Merck Global Energy Team identified Building 45 as a prime candidate for a building optimization project based on low dT and high dP
- Investigated both proprietary and non-proprietary vendor solutions.
- Energy Conservation Measures (ECMs) focused on VFD drives for all chilled and condenser water pumps and advanced control sequencing
  - Staging of specific pumps and chillers based on outside air / building load conditions
Optimization Constraints

• No impact to building operation
  • Continuous chilled water supply
• Temperature reset was not part of the scope
• Leverage existing plant capitol investment
• Open box solution was preferred
  • No proprietary “black box” software or programming
  • Utilize existing industrial grade PLCs
• Desire to own system
  • Did not want a cloud based or licensed solution
Optimization Project Selection / Award

- **Vendor Selection**
  - ROI analysis based on the three vendor ECMs
  - Experience with critical, large chiller plants
  - Consideration to a non-proprietary solution
  - Initial project cost
  - Life cycle costs
System Operational Analysis *(baseline)*

- Data collection and site survey
  - Extracted validated data from existing site historian
  - Collect actual energy rate structure
- Develop operating model of existing plant *(using data)*
  - 8760 hourly analysis method
  - Water flow, dT, cooling load and load durations
  - Did not use bin data or simplified eff. Metrics such as NPLV
- Develop hydraulic model
- Existing equipment efficiency mapping
  - Used *metered data*, formulas used in equipment design and manufactures performance curves.
  - CW & CHW Pumps, Chillers, Fans
Operating Model

Graph 9 – Cooling Load Duration Curve

Load Duration (2012)

- Y-axis: Total Load (Tons)
- X-axis: Hours

- Data points and trend line showing the load duration over hours in 2012.
Existing Equipment Efficiency Mapping
Optimization Approach

• Run custom plant performance model
  • Model plant sequence modifications in performance model
• Compare baseline model with optimized model to determine energy savings
• Develop and deploy the optimized sequence of operations within the existing balance of plant PLC controller.
• Startup & functional checkout
• Measurement and verification
Optimized Sequence of Operations

- Optimized sequence of operations
  - A set of rules to operate equipment within the following constraints:
    - Safety and reliability.
    - The most efficient operating point while satisfying demand.
      - For every load there is an optimal plant operating point
    - Within owner defined constraints.
  - Combined rules and constraints to develop the optimized SOO. No added control system hardware or software
Equipment & System Changes

• 5 chilled water pump VFD drives
• 5 condenser water pump VFD drives
• Interface between plant control system (PLC) and building management system (Siemens)
  • AHU cooling coil valve positions for dP reset
• Optimized Sequence of Operations
  • *All code changes were well documented and implemented within the existing non-proprietary, industrial grade PLC.*
  • *All logic was turned over to system owner*
Optimization Results

- Plant average reduction in kW
  - 43%
- Chiller average reduction in kW
  - 28%
- CW pump average reduction in kW
  - 76%
- CHW pump average reduction in kW
  - 73%
- Tower average reduction in kW
  - 42%
- Average reduction in CW flow
  - 63%
- Average reduction in CHW flow
  - 60%
Graphics – Load CV Positions
Graphics - Dashboard
Graphics - Dashboard
Conclusions

• Merck achieved significant energy savings by performing chiller plant optimization within the existing control system.
• Merck was able to utilize their existing equipment smarter by applying good engineering practices, not a widget/black box
• Build a data driven model to accurately understand the plant
• Immediate energy savings
• Building operators satisfied
• Merck plans to implement optimization programs in all West Point campus chiller plants
Q & A