MERCK WEST POINT, PA B45 OPTIMIZATION PROJECT

Leveraging the existing plant PLC, for a non-proprietary solution to chiller plant optimization

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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

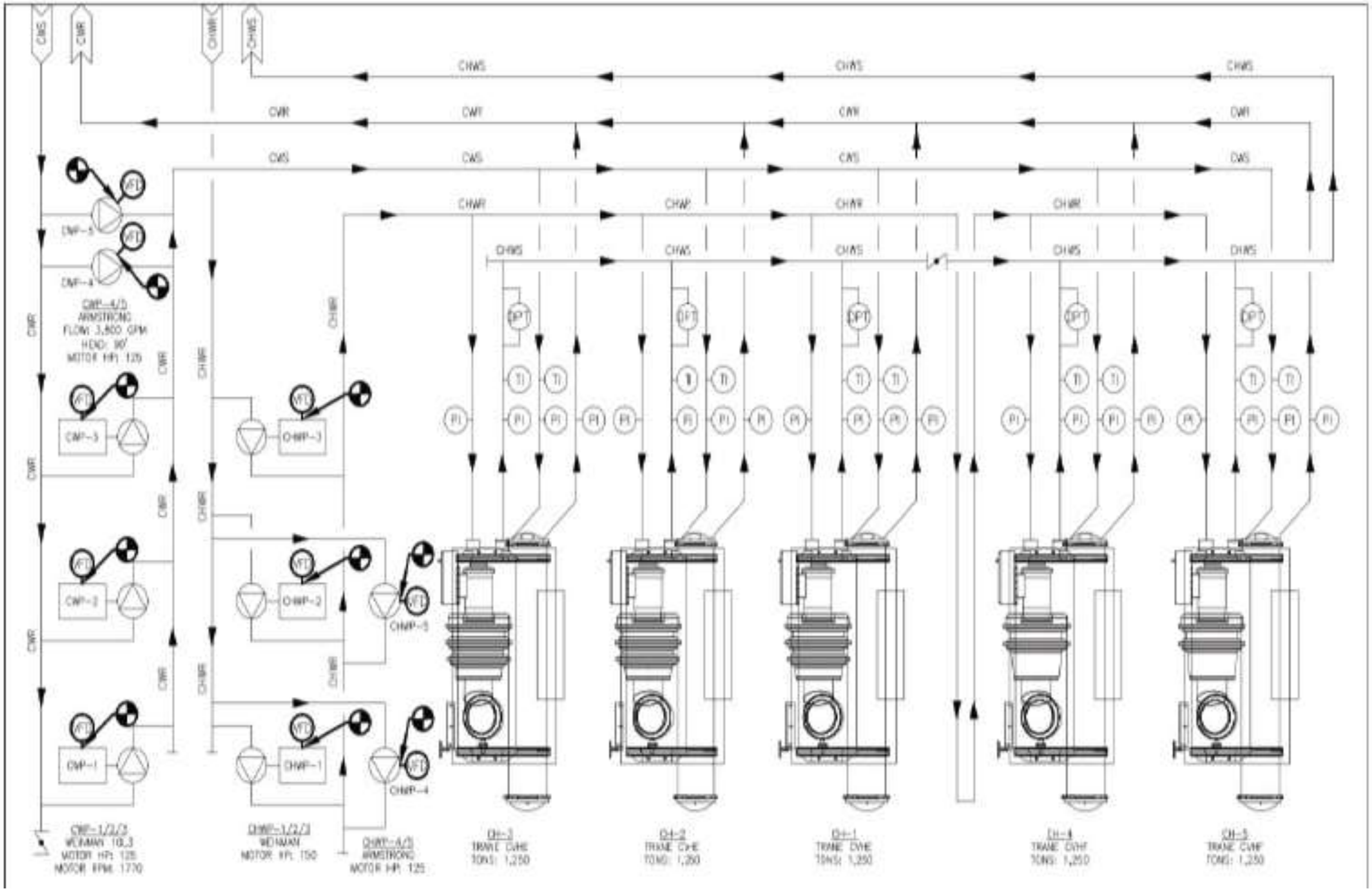
- Cost
  - $600,000
- Energy Savings
  - $161,000 or 2.4MM kW/hr
- ACT129 Rebate
  - $45,000 (prescriptive rebate only)
- ROI
  - 3.44 years

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

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

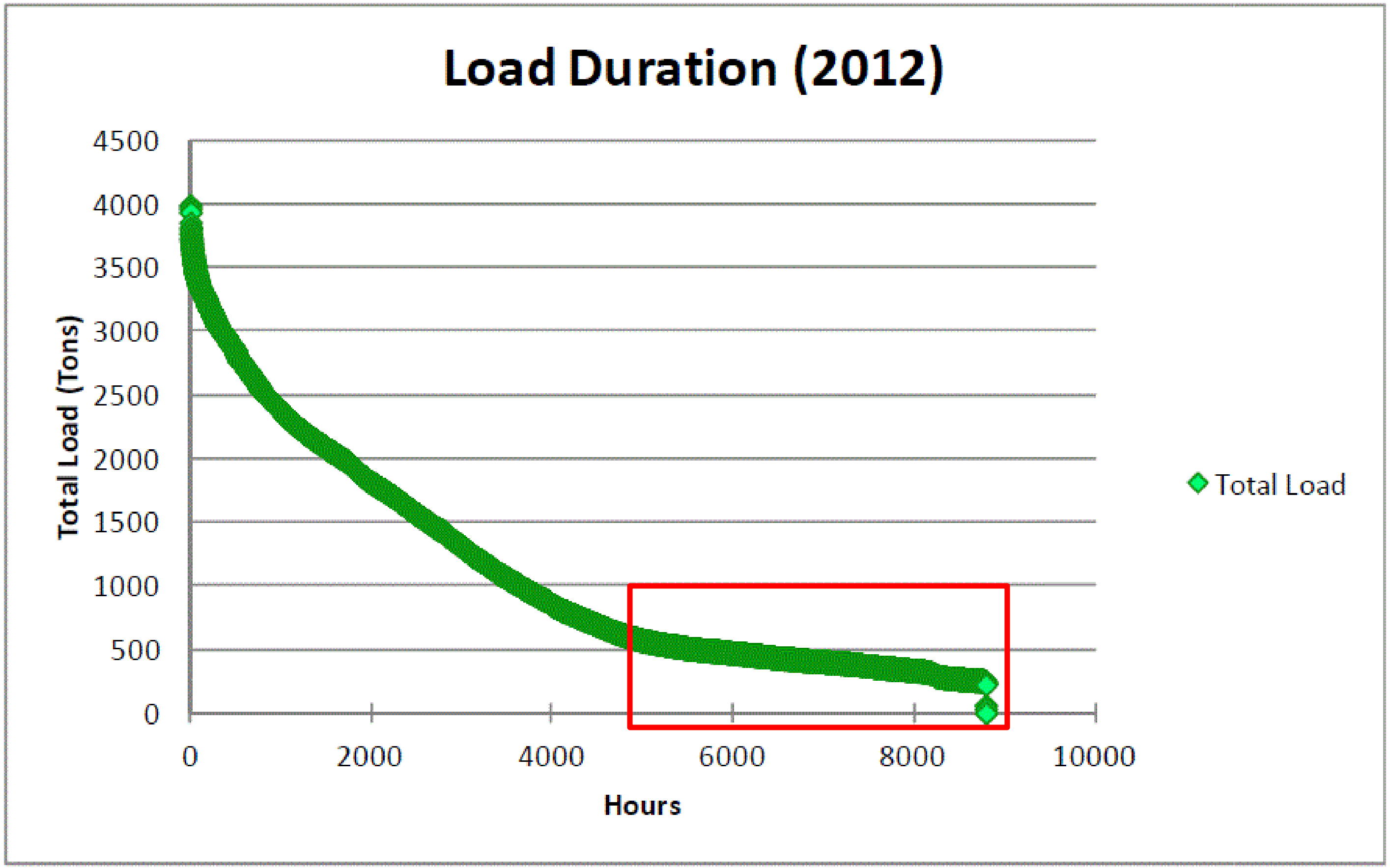
- Vendor Selection
  - ROI analysis based on the three vendor ECMs
  - Experience with critical, large chiller plants
  - Consideration to a non-proprietary solution
  - Initial project cost
  - Life cycle costs

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 <u>(using data)</u>
  - 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 <u>metered data</u>, formulas used in equipment design and manufactures performance curves.
  - CW & CHW Pumps, Chillers, Fans

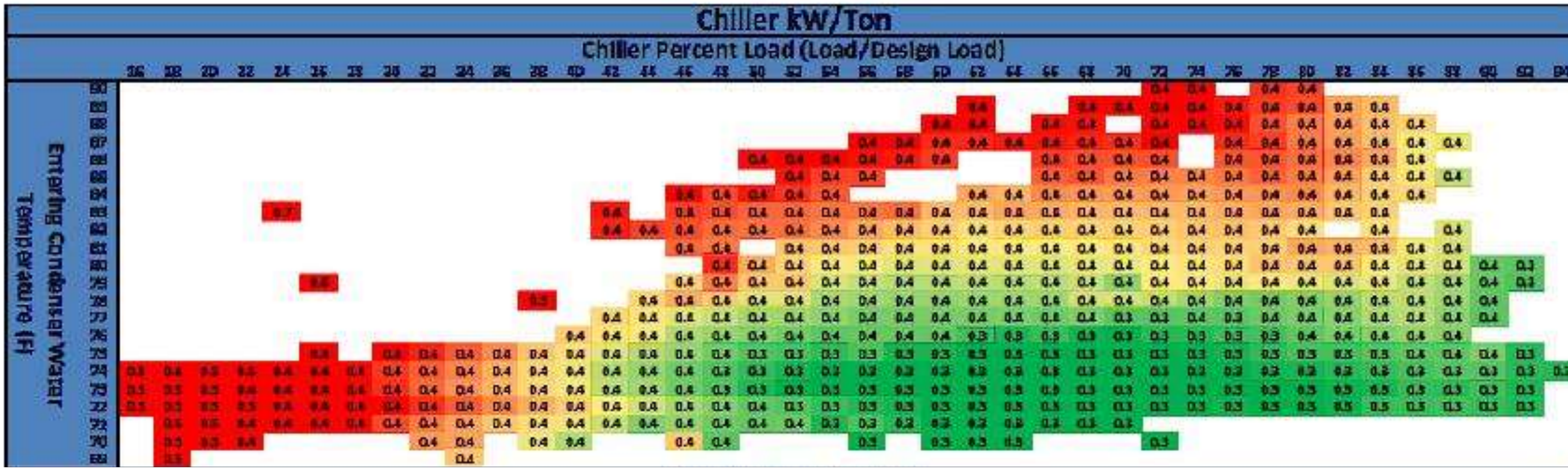
Operating Model

Graph 9 – Cooling Load Duration Curve

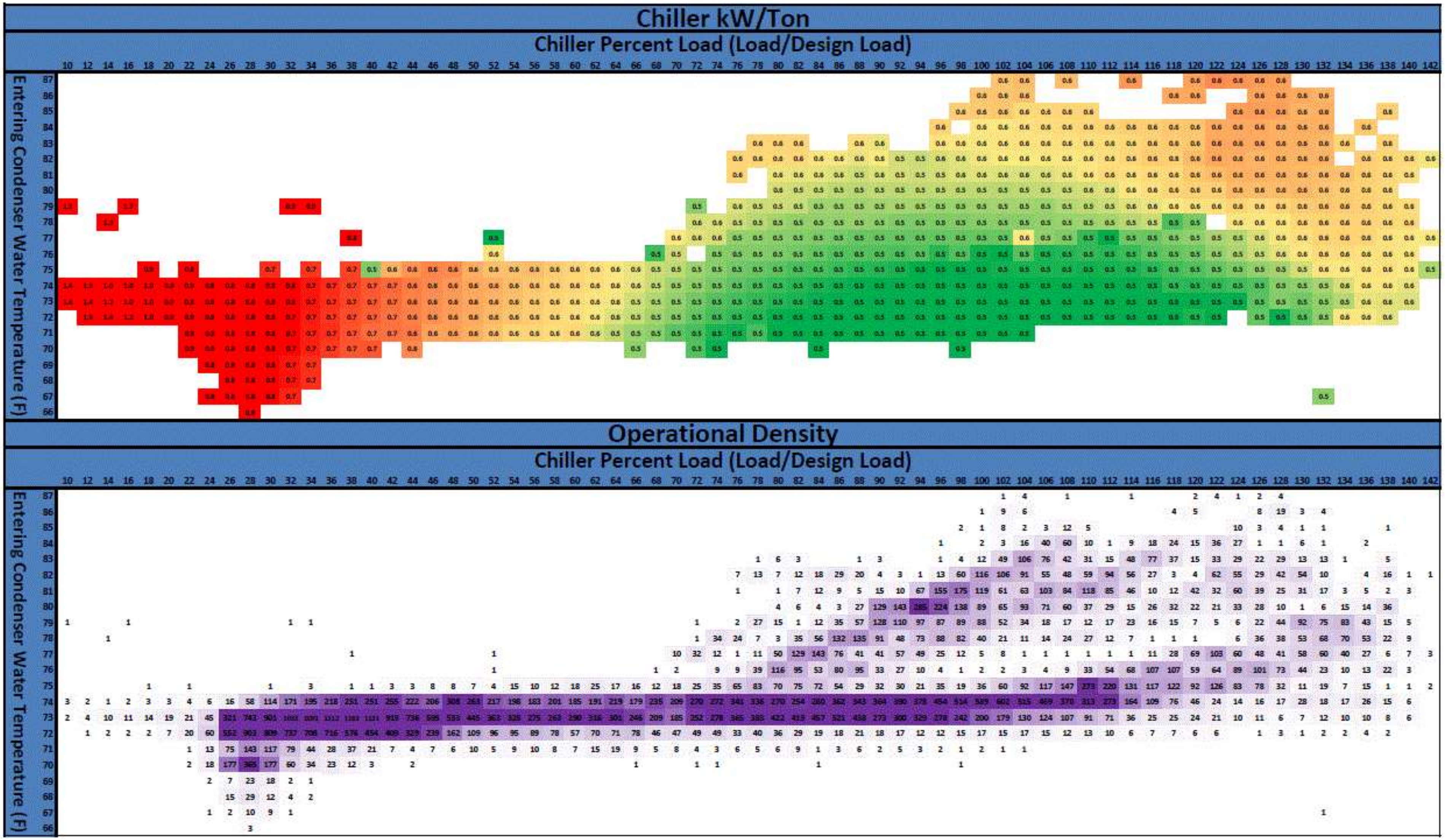


Existing Equipment Efficiency Mapping

Graph 13 – Chiller 4 (CH-4) Efficiency Plot



Graph 10 – Chiller 1 (CH-1) Efficiency Plot



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 <u>within the existing balance of plant PLC controller</u>.
- Startup & functional checkout
- Measurement and verification

Optimized Sequence of Operations

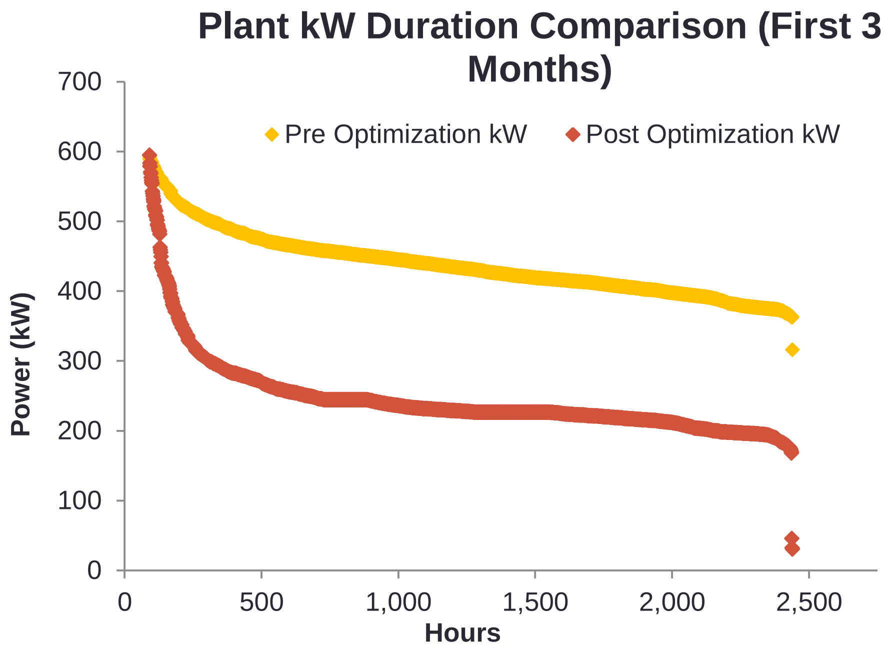
- Optimized sequence of operations
  - A set of rules to operate equipment within the following constraints:
    - *Safety* and *reliability*.
    - The most *efficient* operating point while satisfying demand.
      - For every load there is an optimal plant operating point
    - Within *owner defined* 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%**

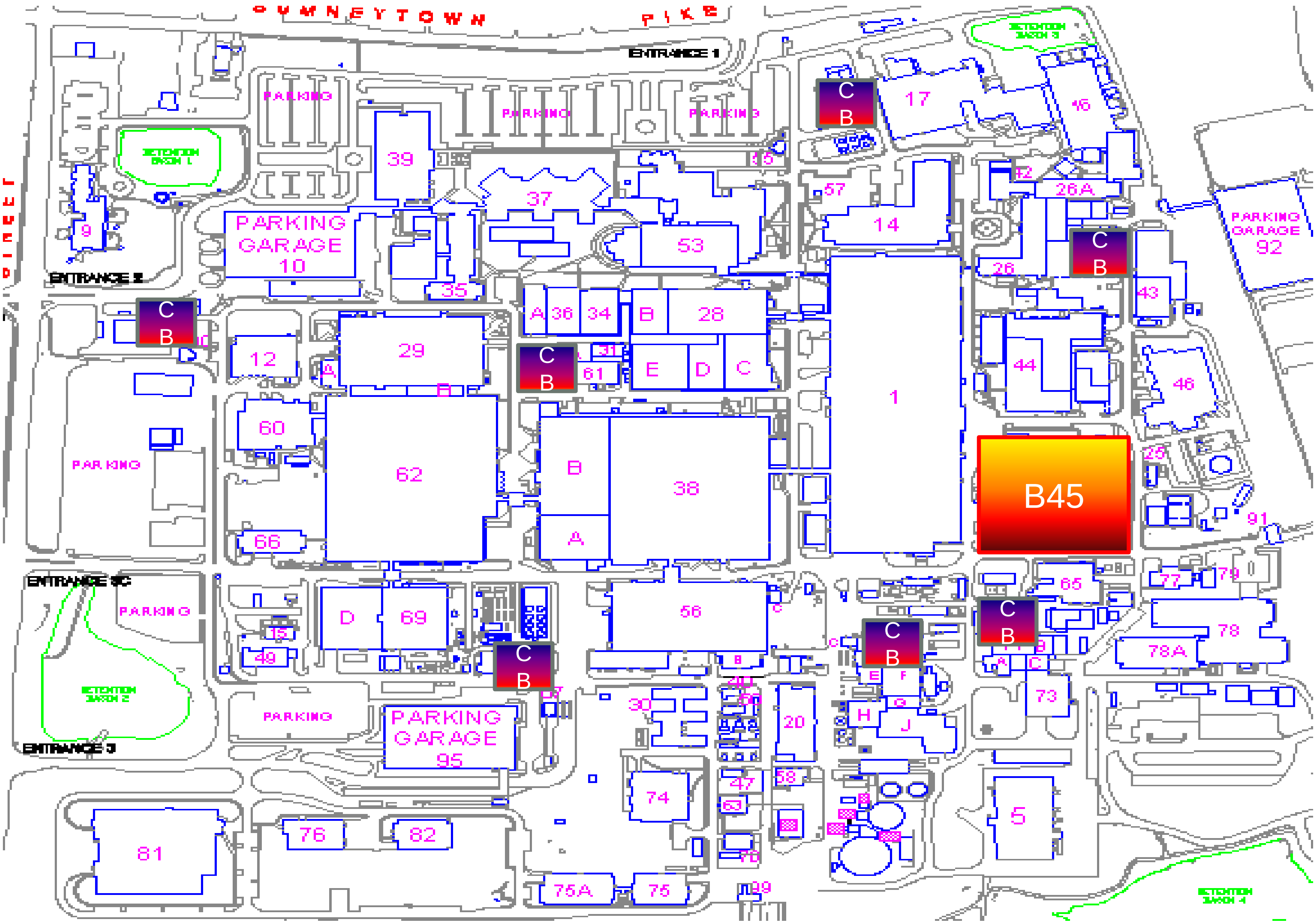


Graphics – Load CV Positions

Graphics - Dashboard

Graphics - Dahsboard

Merck WP Utility Map (Other CHW Plants)



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