Data Driven Non-Proprietary Plant Optimization

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DEFINITIONS

- 1. Data Driven
 - Data drives the solution and not engineering rules of thumb
- 2. Non-proprietary
 - Code that is fully open, non-encrypted, modifiable by any programmer, and the end-user has full ownership

3. Plant

 Group of energy consuming equipment arranged in a process: Power plant, chiller plant, steam plant, water treatment plant, etc.

4. Optimization

- Webster's An act, process, or methodology of making something as fully perfect, functional, or effective as possible
- The combination of capital expenditures that results in the highest
 possible NPV

PRESENTATION OUTLINE

1. Optimization process

- A. Optimization Prerequisites
- B. Baseline the plant's energy use
- C. Complete understand of utility rate structure
- D. Proper Evaluation
- E. Understand the optimization contract
- F. Adhere to site standards
- G. M&V

2. Real world examples with results

- A. Merck Pharmaceutical West Point, PA
- B. Large Financial Institution Pittsburg, PA
- C. LEED Gold Data Center (Princeton University) Princeton, NJ

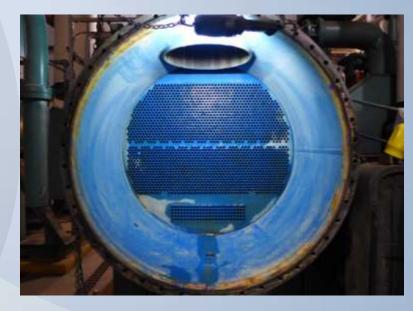


OPTIMIZATION PRE-REQ – MAINTENANCE

Energy savings from routine maintenance:

- 1. Punch chiller cond/evap tubes
- 2. Combustion analyses/tuning
- 3. Check chiller refrigerant levels
- 4. Clean strainers
- 5. Open balancing valves on VFD driven pumps
- 6. Unclog tower nozzles
- 7. Repair CW supply temperature reset
- 8. Utilize existing free cooling HX
- 9. Repair steam traps
- 10. Etc.

Do this before the plant baseline is established



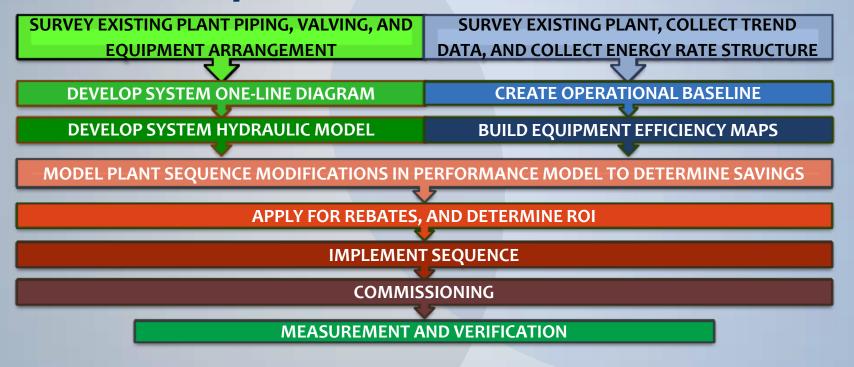


OPTIMIZATION PRE-REQ – INSTRUMENTATION, CALIBRATION, AND HISTORICAL TRENDING

- 1. Does the plant have adequate instrumentation?
 - A. Meters, PTs, TTs, etc.
- 2. Is the instrumentation calibrated?
 - A. Meters, valves, TTs, PTs, etc.
 - B. ABC (Always Be Calibrating)
- 3. Is the data trended?
 - A. Required to establish an energy baseline and used for rebates
 - B. One year or two years of trend data is optimal
 - If no existing data: establish trends or use operator hand logs



Optimization Process





BASELINE – COLLECT TREND DATA AND PERFORM RATE STRUCTURE ANALYSIS

1. Collect Trend Data

- A. Chiller, tower fan, CW pump, CHW pump, and fan power data
- B. CW and CHW flow data
- C. CHW and CW temperatures
- D. Start/stops on constant speed motors, if no power data
- E. Weather data
- 2. The largest driver of energy costs and potential energy savings is the rate structure
- A. Be very wary of blended rates
- B. Modeled savings for large financial client using blend rates resulted in \$100,000 per year
- C. Modeled savings for large commercial client using actual rate structure was \$55,000 per year



BASELINE DATA COLLECTION

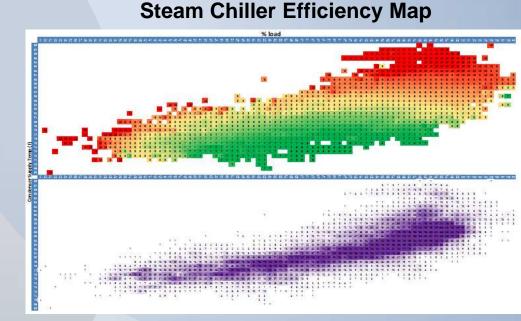
															Tag		CH-1					
Chiller Plant Operational Data Measure: Baseline - Thermosystems Data Tag CH-1 CH-2 CH-3 Equip Chiller Chiller Chiller Make/Model Trans/CVHF770 Trans/CVHF770								Basis / Installed Conceptual F CH-4 Chilar Trans/CVH9720			Design	Equip Make/Model Capacity/Hp CHW CW	Chiller Trane/CVHF770 700/ 1,400 2,100			Date: 5/9/2013 roject: Nanufacturer Dynam	utility Elec Demand	Bank of NY Mellon nt Optimization Utility Rate Data Blend Rate \$ 0.052 \$/kWh \$ 8.61 \$/kW				
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OPTIMIZATION ENERGY ANALYSIS – EQUIPMENT AND SYSTEM PERFORMANCE

- 1. Use real data, no models, no IPLV
 - A. Develop Efficiency Maps for:
 - Chillers
 - Pumps
 - Towers
 - Boilers
 - CTGs
 - STGs

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Compressors



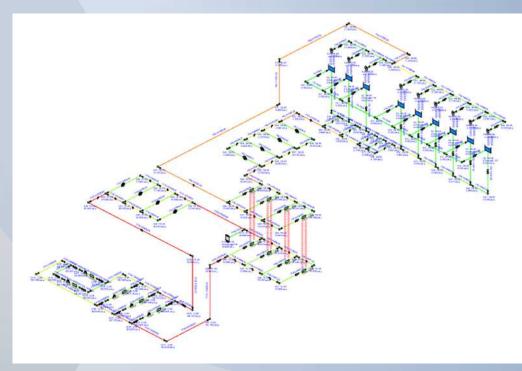
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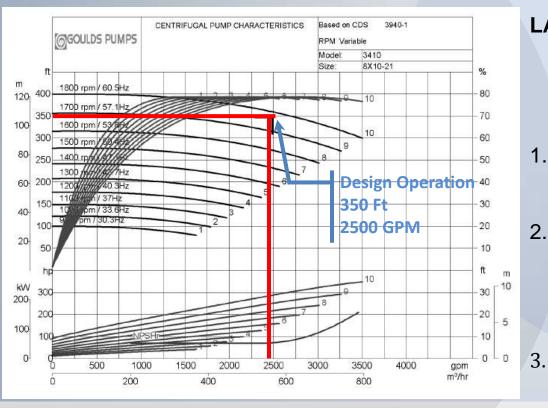
- 2. Model Actual Proposed Sequence
 - A. Sequences are code, use the actual code to model the plant improvements

HYDRAULIC MODELING

- 1. Compressible and Non-Compressible
 - A. Pipe Flo
 - B. Fathom
 - C. Termis
- 2. Requires extreme detail, otherwise don't spend the money
 - A. All valves, strainer, elevations, coil dp
 - B. Calibrate with actual test data



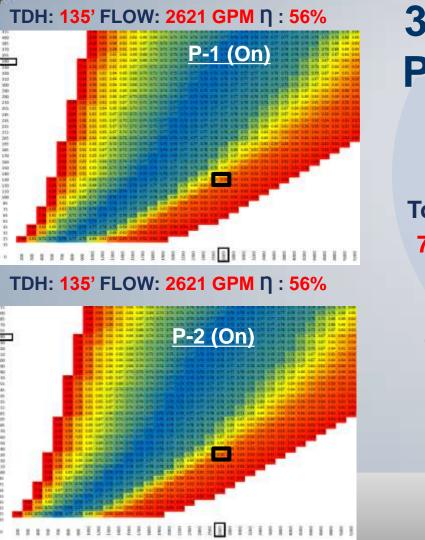
OPTIMIZATION

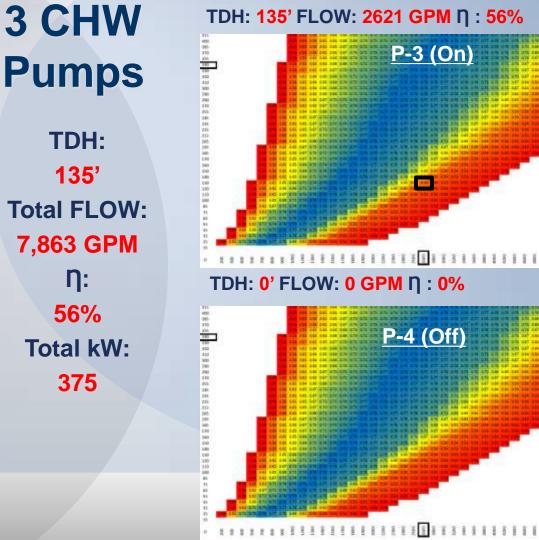


LARGE CAMPUS CHILLED WATER PUMP

 $HP = \frac{Flow \ x \ Head}{3960 \ x \ \eta}$

- 1. Flow: Campus dictates ΔT and thus flow
 - Head: Too many valves to poll to perform DP reset; therefore hydraulically remote DPT determines pump head
 - η can never be greater than pump+motor+VFD **BEP** ~80%





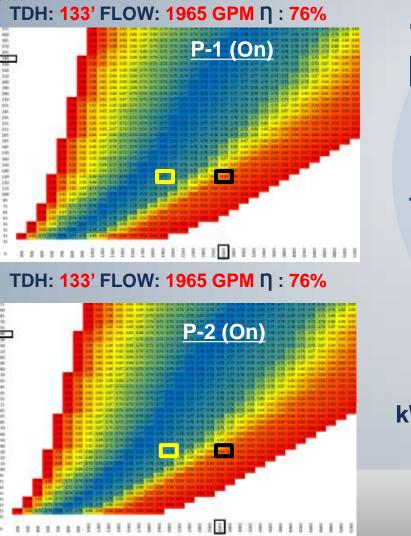
TDH:

135'

ח:

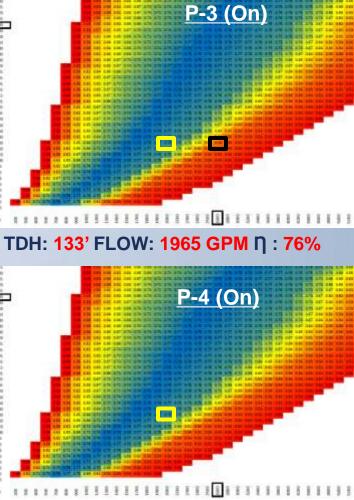
56%

375





TDH: 133' FLOW: 1965 GPM በ : 76%



ENERGY ANALYSIS

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OPTIMIZATION - FINANCIAL ANALYSIS

1. First Cost

- A. Use contractor GMP quotes, do not use engineering estimates
- B. Include all ongoing contract costs
- C. Include all maintenance costs
- 2. Useful Life
 - A. Project VFDs and BAS controllers may be obsolete in 5-10 years
- 3. Separate equipment from controls optimization
 - A. ECM-1 Controls optimization
 - B. ECM-2 Free cooling heat exchanger
 - ECM-2 should use ECM-1 as a base



OPTIMIZATION - IMPLEMENTATION

1. Service Provider

A. Ask for **relevant** project and client references for the project manager that will be on your project, the brand is less important

2. Site Standards

- A. Packaged bundles must adhere to site quality standards
- B. Examples:
 - VFD IEEE-519
 - Chillers marine water box
 - Meters magnetic, ultrasonic, etc.
 - TT & PT Rosemount, etc.





<u>Case Study:</u> Merck Pharmaceutical West Point, PA

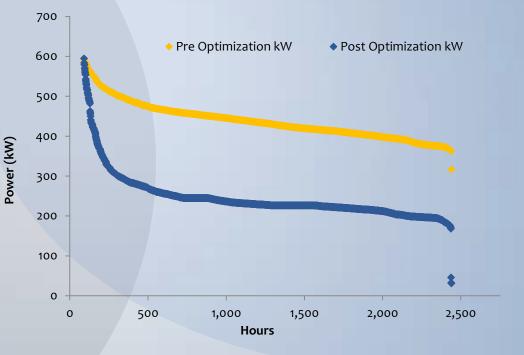
- 1. Plant 6,250 Tons (Total Site 80,000 Tons)
 - (3) 1,250 Ton Trane CVHE Chillers, (2) 1,250 Ton Trane CVHF Chillers
 - Variable Volume Primary
- 2. Rates
 - \$0.065 per kwh
- 3. Controls System
 - Allen Bradley PLCs



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%

Plant kW Duration Comparison (First 3 Months)



OPTIMIZATION RESULTS

	Controls Optimization
All in First Cost (\$)	\$548,000
Rebate (\$)	\$213,296
Net CapEx (\$)	\$334,704
Energy Savings (\$)	\$173,303
Simple Payback	1.93 Years





<u>Case Study:</u> Large Financial Institution CHW Plant Pittsburgh, PA

1. Plant

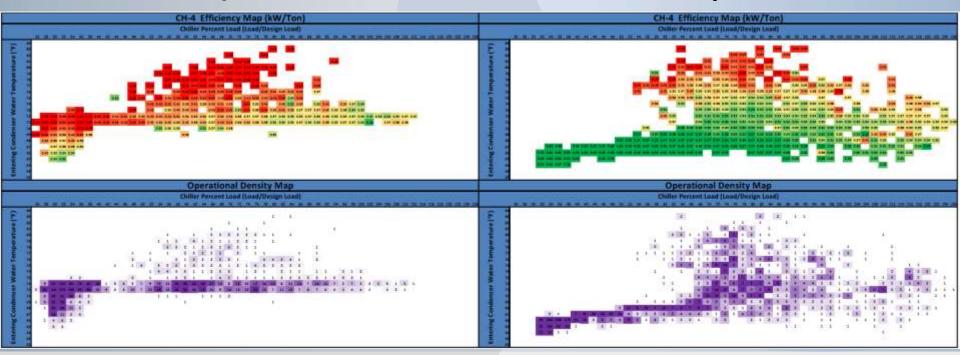
- (4) 700 Ton Trane CVHF Chillers
- Primary secondary system
- Data Center
- 2. Rates
 - \$0.052 per kwh and \$8.61 per kw
- 3. Controls System
 - Allen Bradley PLCs



OPTIMIZATION - CHILLER EFFICIENCY MAPPING

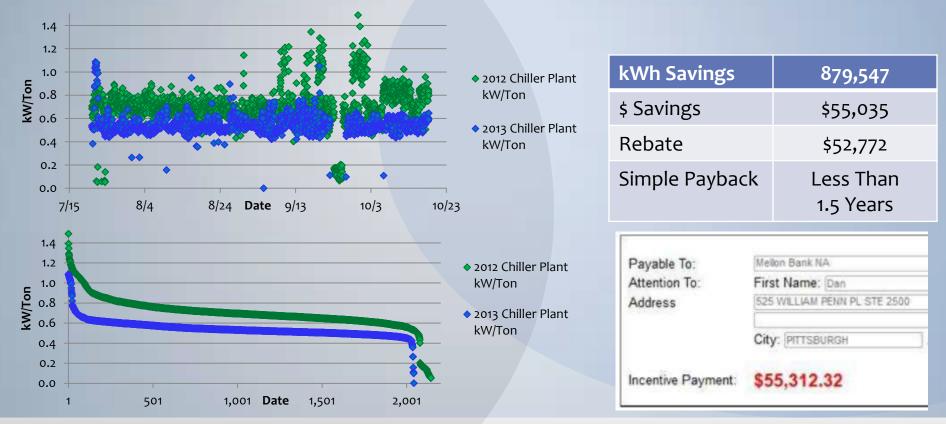
Pre-Optimization

Post-Optimization



SMITH Sengineering

OPTIMIZATION RESULTS – M&V





<u>Case Study:</u> LEED Gold Data Center Princeton, NJ

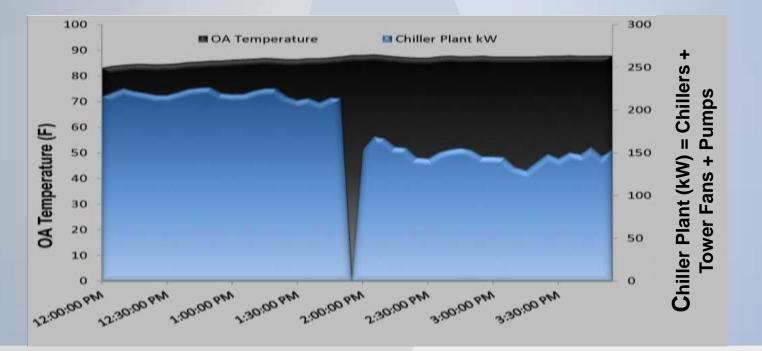
1. Plant

- (3) 500 Ton Trane CVHF chillers
- Primary-secondary system
- Data center



LEED GOLD DATA CENTER.

Plant energy demand pre and post enhanced control logic (zero demand spike is from bringing the controller down to install the new logic)



CLOSING

- Plant efficiency improvement decisions should be based on product agnostic, data-driven, rigorous analysis. A full understanding of the complete system, utility rates, component efficiencies, feasibility, and implementation cost is required.
- Optimization is not a "magic pill" it requires an investment in the time of highly qualified people. The more complex the plant and process, the more time and "hands-on" attention required.
- The terms of the contract may be more important than the level of optimization.

