UCSF
University of California
San Francisco

Zero Capital Chiller Plant and Parasitic Load Optimization

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WorleyParsons
resources & energy

EcoNomics

Project Objective

- Identify Energy and Cost Savings Projects at UCSF Parnassus Central Utilities Plant to Achieve UCSF energy and budget reduction goals while using limited(zero) capital
- Provide High Impact and Low Cost Solutions as first round of improvements while high cost capital projects are funded and planned
- Use in-House Expertise and Existing Equipment to limit capital costs
- Ensure Plant Reliability and Safety are not negatively impacted

UCSF Parnassus Campus Utilities

- Campus originated in 1896 with only 1 building
- Combined Medical, Research &, Academics
- CHP Plant Commissioned in 1997
- 4 million ft2 mixed space district energy system
- 14 MW Micro Grid w/ island & load shed capability
- 5,400 Tons Chilling, 120 klbs/hr Steam Capacity

Project Approach

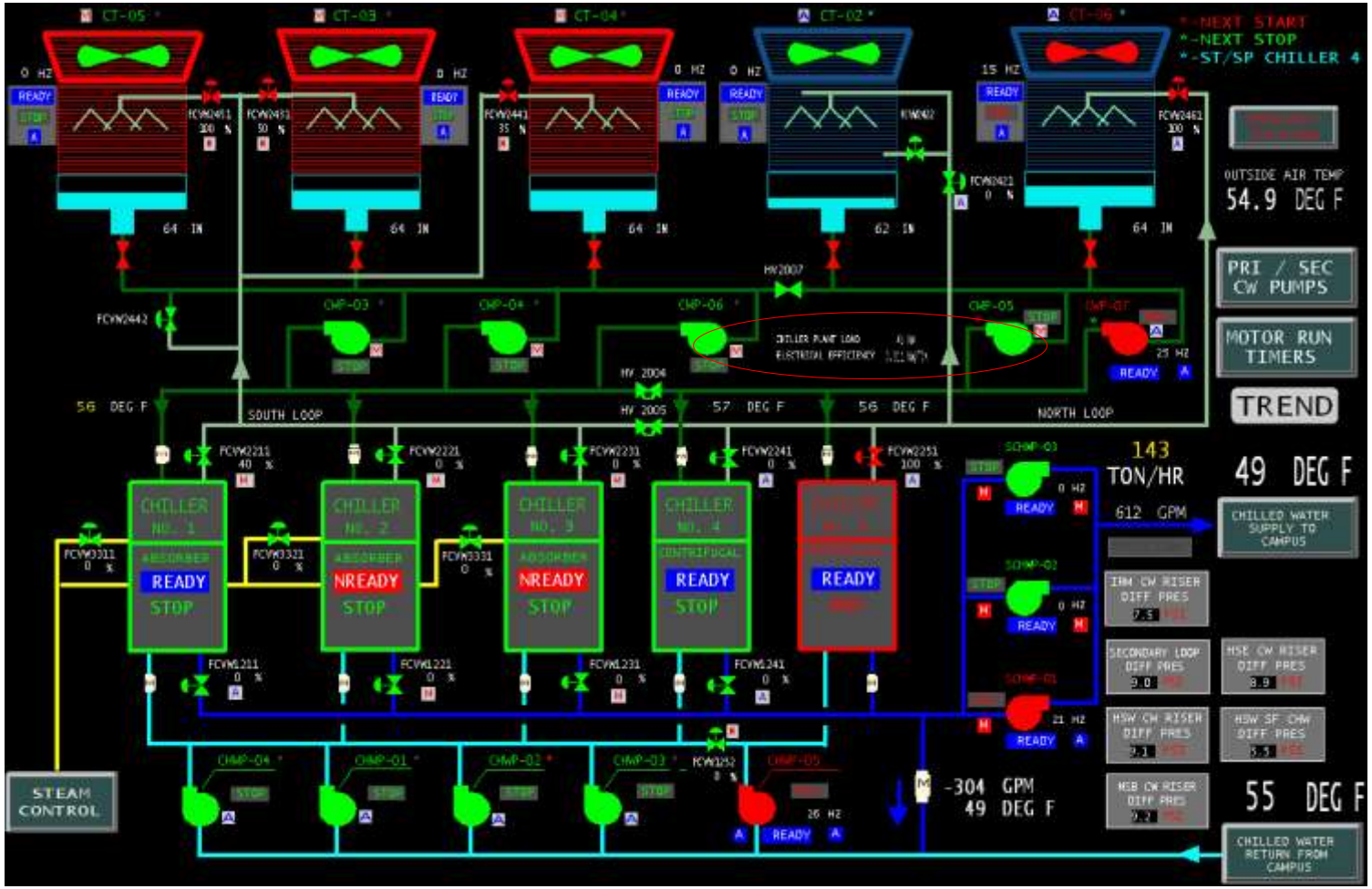
- Complete a Full Review of Plant Equipment
  - operating performance vs design
  - control system programming and operational strategy
- Identify Opportunities
  - Potential system changes and strategies for improved controls
  - Determine expected operating efficiency improvement
- Conduct Management of Change Review
  - Ensure no impacts to equipment reliability or personnel safety
  - Ensure existing system is designed to handle the proposed changes
  - Develop operating procedures that clearly explain new operating procedure and control strategy
- Train Plant Personnel Prior to Cutover
  - Ensure operators fully understand new control strategies and operating procedures so they can recognize potential issues and act accordingly to reduce potential plant reliability issues
- Implement Changes and Monitor
  - Monitor operational and performance changes to allow further optimization
  - Maintain active and open communication with operators to help work out control issues

Identified Plant Improvement Opportunities

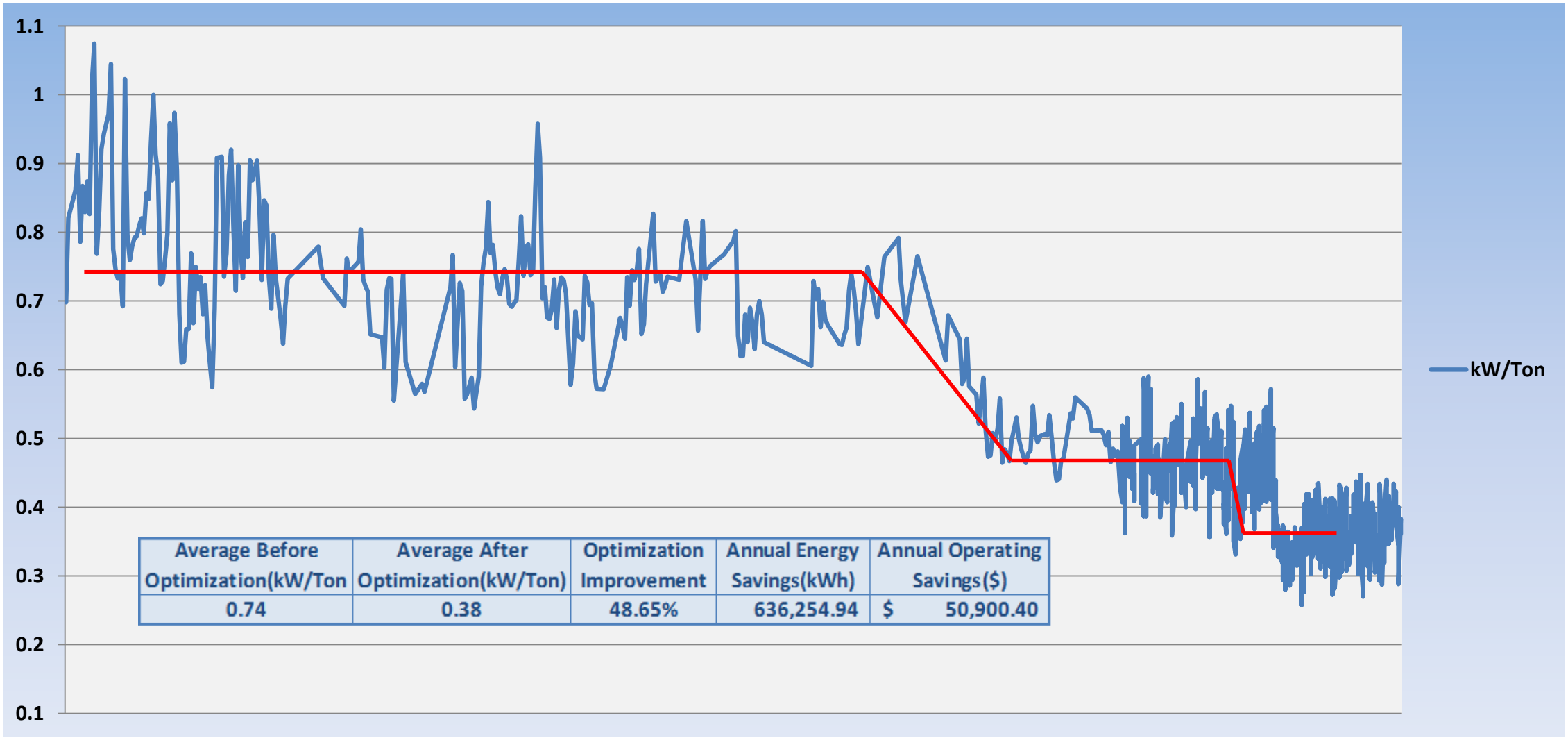
1. Chiller Plant Optimization - using existing VFD's and variable system setpoints at partial loads
2. Boiler Feedwater Pump - energy reduction using variable pressure setpoints to capitalize on existing pump VFD
3. Plant Ventilation System - energy reduction using plant DCS control strategy optimization
4. Condensate Receiver Transfer Pump - energy reduction using plant DCS control strategy optimization
5. HRSG's Economizer - efficiency performance improvement due to identified significant deterioration of efficiency from original design

Chiller Plant Optimization

- Real-time kw/ton calc to allow for easy performance evaluation and optimization
- Original pump setpoints were at chiller max design capacity. Chiller minimum design flows determined pump VFD setpoint minimums. 80% to 42% average
- Function generators to allow automated setpoint changes
- Variable condenser water temperature chiller allowed floating setpoint based on chiller load
- OAT Secondary loop DP Reset and variable chilled water temp setpoint
- Cooling tower staging based on VFD optimal performance ranges
- Cooling tower cycling at low OAT
- Tower backwash strainer pumping system optimization due to sizing for full system



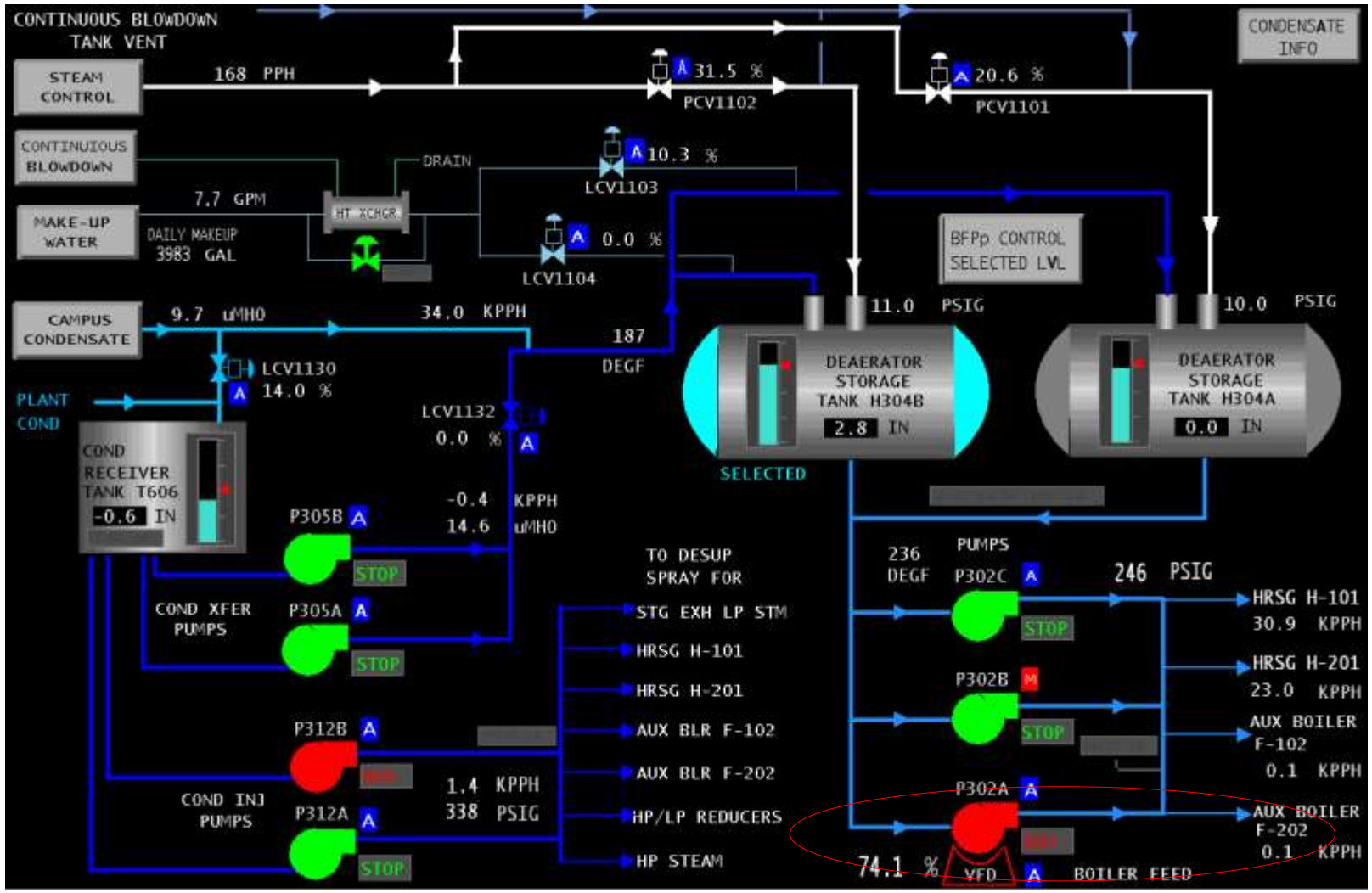
Chiller Plant Optimization Results



Average Before Optimization(kW/Ton	Average After Optimization(kW/Ton)	Optimization Improvement	Annual Energy Savings(kWh)	Annual Operating Savings($)
0.74	0.38	48.65%	636,254.94	$ 50,900.40

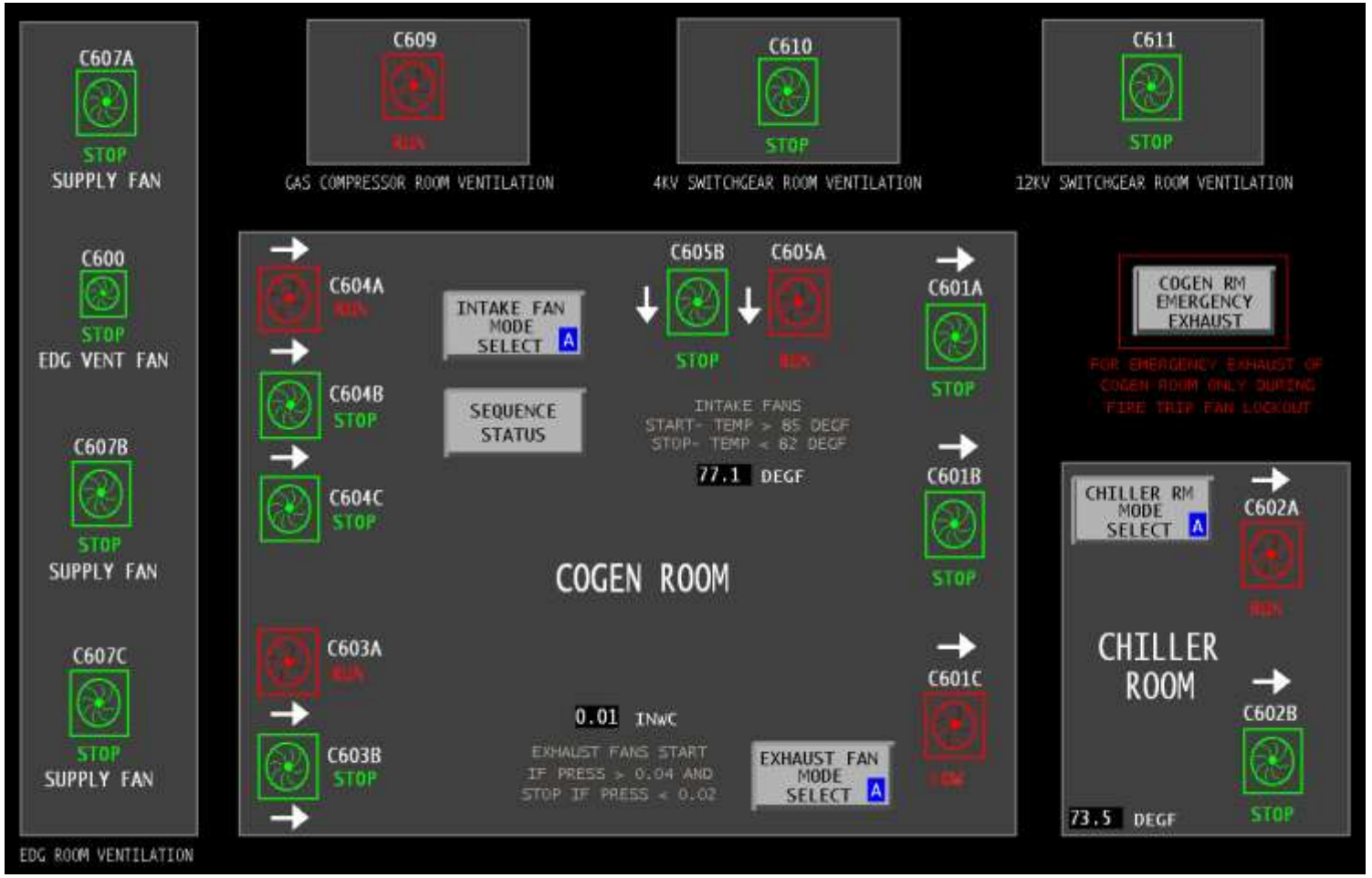
Boiler Feedwater Pump Optimization

- Original VFD pressure control setpoint of 290 psi was fixed to satisfy maximum HRSG feedwater flow design criteria.
- Variable pressure setpoint that follows drum pressure and steam flow of 6 drums allowed average VFD speed to go from 92% to 73% with pressure setpoint going from 290 psi to average of 242 psi.
- High select drum pressure of 6 drums with adders based on steam flow
- Built in protection to logic to revert to 290 psi anytime low drum level trip at risk
- 21% reduction in feedwater pump energy consumption



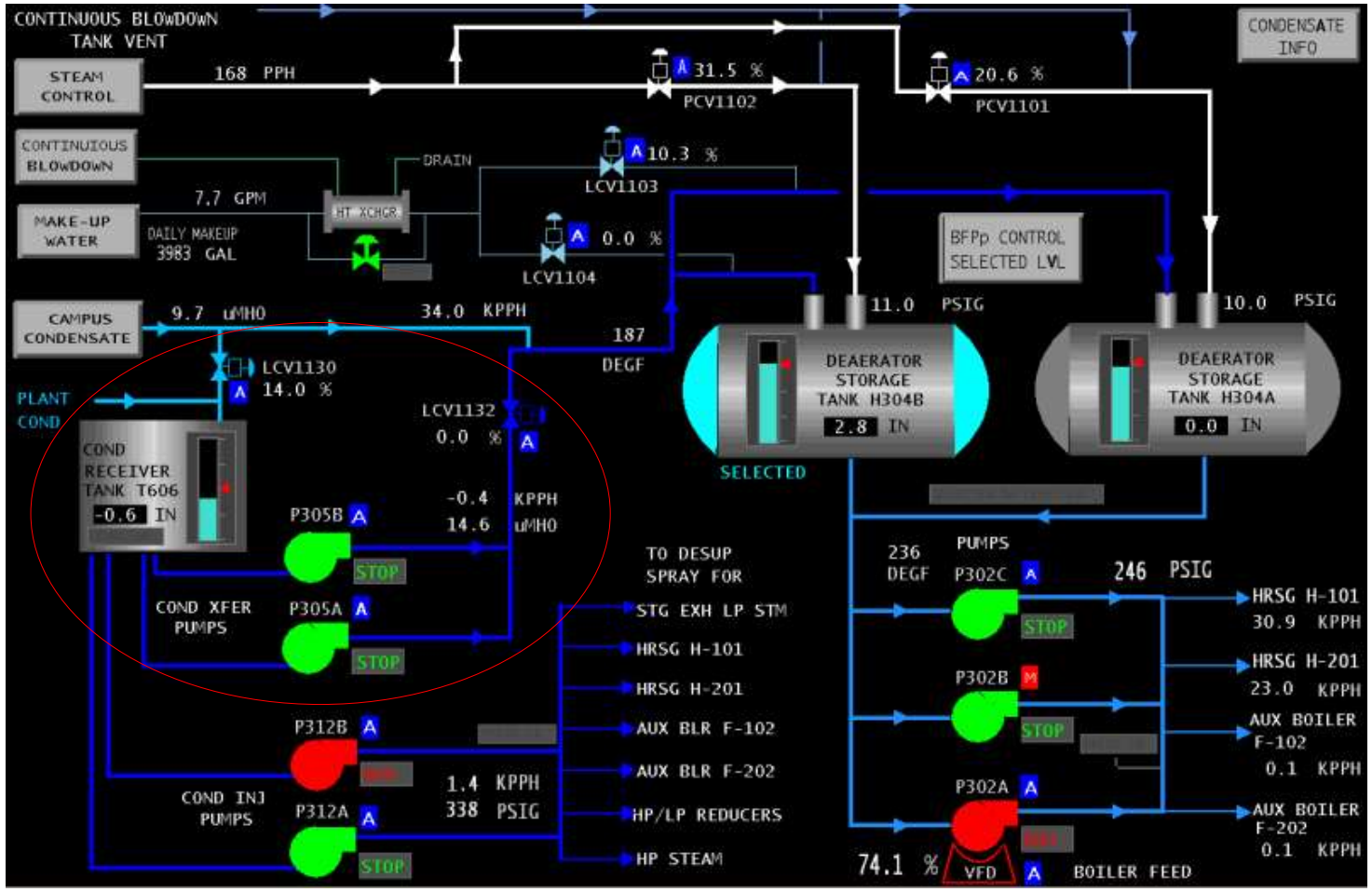
Plant Ventilation System Optimization

- Original programming always maintained all 3 generation floor exhaust fans on in low speed no mater the temperature or pressure. Temperature testing proved no concerns in running just 1 during cooler weather
- Identified changes had been made to temperature setpoint to 75 degrees causing excessive supply fan operation. Range changed to 85-82 degrees.
- Chiller room did not have automatic programming and always ran both exhaust fans
- Electrical room supply fans constantly ran even when it was jacket weather in room. Programing for auto start stop was added based on OAT.
- 42% reduction in plant ventilation system energy consumption

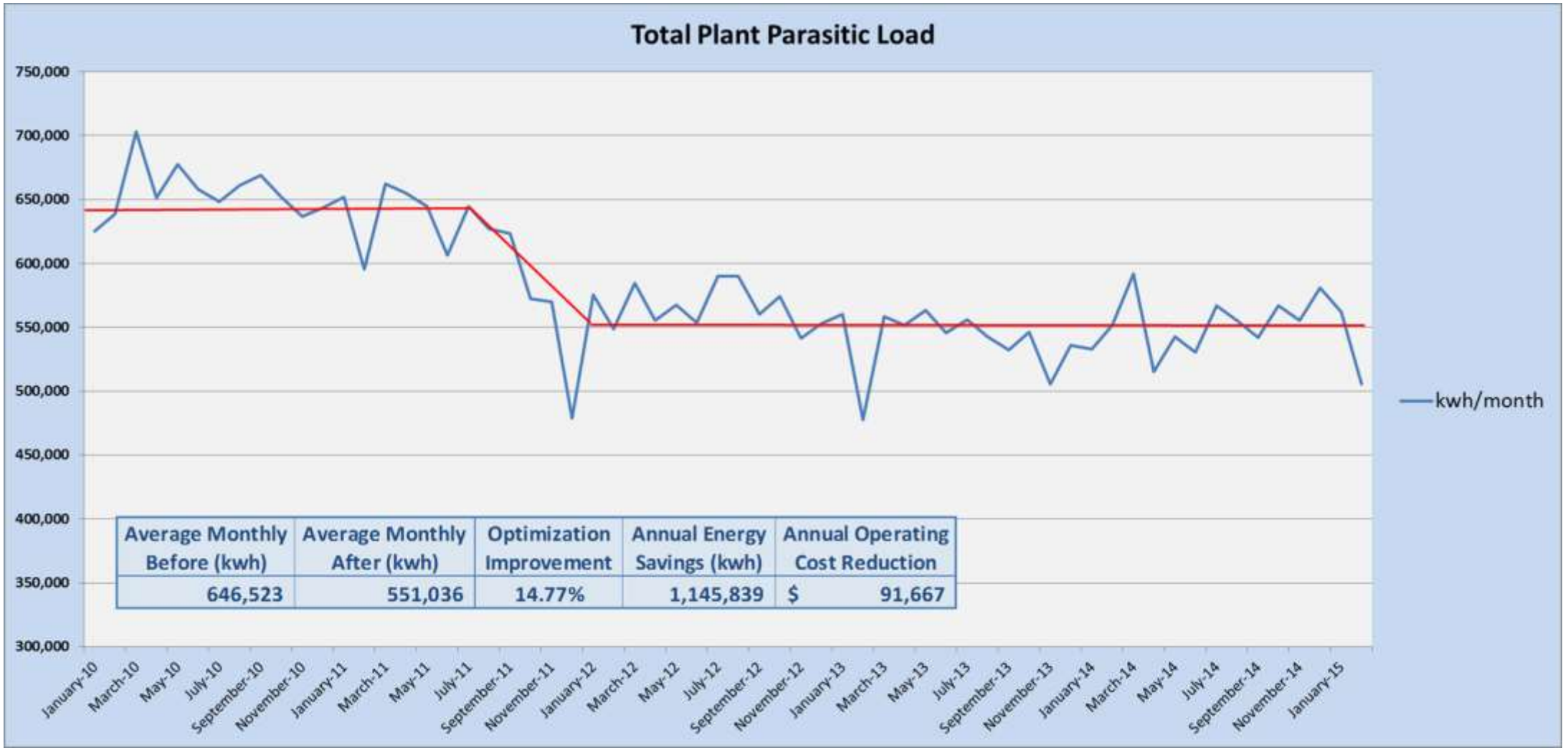


Condensate Transfer Pump Optimization

- Original programming had transfer pump running continuously with discharge level control valve maintaining level by throttling
- Campus condensate return level control valve was found to leak by.
- Fix of leaking control valve by re-zeroing it and adding programming to cycle pump on/off between + 6” and - 4 “ while driving level control valve to 50% allowed pump operating time to be reduced by 87% annually and reduce pump energy consumption by 72% energy annually.



Plant Parasitic Load Optimization Results



Average Monthly Before (kwh)	Average Monthly After (kwh)	Optimization Improvement	Annual Energy Savings (kwh)	Annual Operating Cost Reduction
646,523	551,036	14.77%	1,145,839	$ 91,667

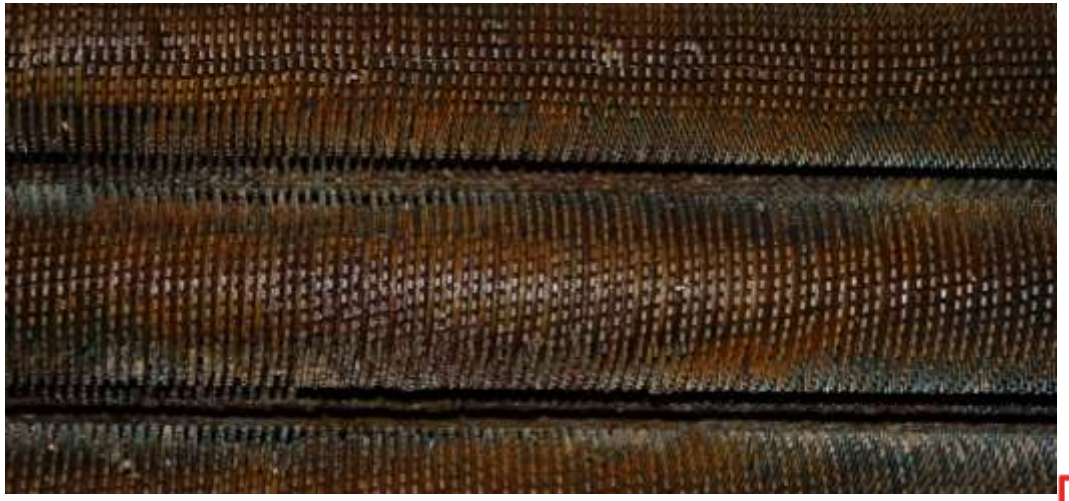
HRSG's Economizer Performance Restoral

- Review of HRSG Economizer performance vs. design showed significant efficiency drop in the magnitude of ~20%.
- Stack exit gas temperatures were running 50 degrees above design temperature
- HRSG overall DP was running 4" above original commissioning data causing Turbine backpressure and negative efficiency impact
- Plant logs review showed change in performance dating back 8 years
- Prior O&M provider did not inspect the economizer outlet section due to scaffolding requirement to access
- Inspection identified multiple pinhole leaks were present on the last 2 passes causing build up that blocked the fins on the top 3 passes of the 12 pass economizer
- Cleaning of the economizer section and repair of leaking tubes increased overall boiler efficiency by 3.6%. CTG efficiency improved by an average of 0.7% due to reduced backpressure on turbine exhaust.

HRSG #1 Economizer Tubes

Before Cleaning

After Cleaning



HRSG #2 Economizer Tubes

Before Cleaning

After Cleaning

HRSG's Economizer Performance Improvement

Economizer Repair/Cleaning Savings		
GTG Performance Improvement	**HRSG/GTG #1**	**HRSG/GTG #2**
HRSG Overall Diff Pressure Before Cleaning	11.7	11
HRSG Overall Diff Pressure After Cleaning	7.6	7.3
GTG Average Heatrate 52-65 degrees Before Cleaning (BTU's/kWh)	11,962	12,259
GTG Average Heatrate 52-65 degrees After Cleaning (BTU's/kWh)	11,917	12,137
Heatrate Improvement (BTU's/kWh)	45	122
Natural Gas Therms Saved Per Year	19,718	53,780
Annual Operating Cost Savings	$ 12,028	$ 32,806
HRSG Performance Improvement		
GTG Exhaust Heat Transferred Before Economizer Cleaning (BTU's/hr)	25,641,183	27,317,736
GTG Exhaust Heat Transferred After (BTU's/hr)	27,122,262	29,031,043
Boiler Efficiency Improvement	3.44%	3.81%
Natural Gas Therms Saved Annually	153,411	160,317
Annual Operating Cost Savings	$ 93,580.98	$ 97,793.60
Total Annual Operating Cost Savings	**$ 236,208.71**	

Project Summary and Lessons Learned

- Original equipment control logic programming may have significant room for improvement toward efficiency gains through low cost in house programming efforts.
- Without periodic re-commissioning of systems, performance can change due to changes in the operation or the equipment health.
- Systems are often originally designed and programmed to match full load needs with little effort to provide programming to take advantage of partial load opportunities.
- Total Annual Electrical Savings = 1,780,000 kwh
- Total Annual Gas = 314,000 Therms
- Total Annual Operating Budget Improvement = $379,000
- Total Capital Cost = $0