University of California
San Francisco

Optimization and Ongoing Analytics of a Chilled Water System: From Plant to Building Loads

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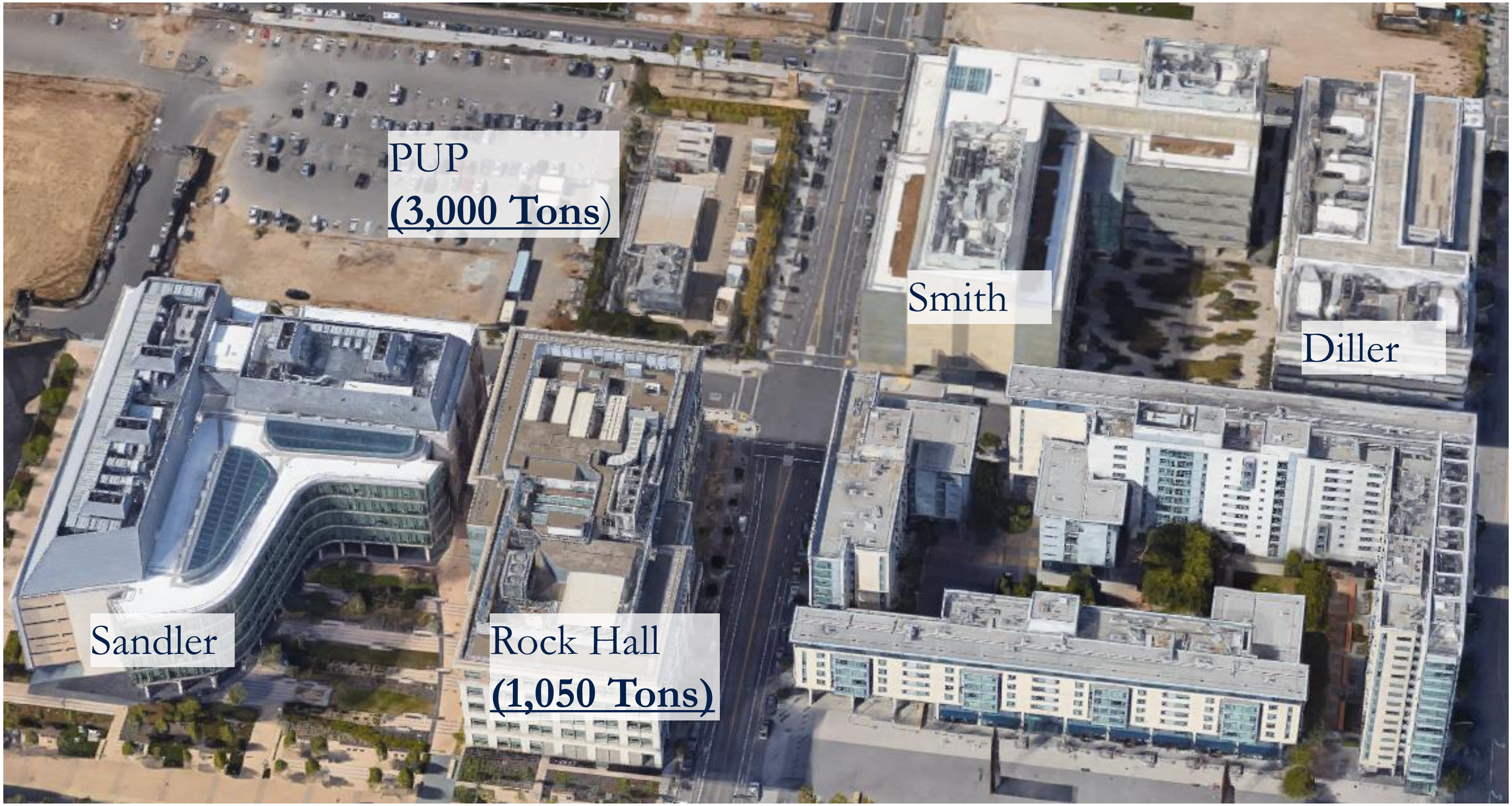
UCSF's Mission Bay North Campus



804,000 GSF served by plant (mostly 100% outside air lab)

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Project Drivers

- Energy efficiency and utility bill savings
- Improve plant delta T and staging
- Avoid need for additional capacity (additional lab buildings will tie into plant in ~2 years)
- Carbon Neutrality- 2025

Project Delivery

- PG&E's Monitoring Based Commissioning rebate program
- Bond financing
- Multiple projects. Each included a part of the Chilled Water System

Building	Year Built	Ft²	Budget	Savings: kWh / Year	Savings: Therms / Year	Annual Energy Savings	Rebate	Net Cost	Payback (Years)
PUP MBCx			$ 690,000	750,000	80,000	$ 178,100	$ 260,000	$ 430,000	2.4
Diller MBCx	2009	160,500	$ 500,000	490,733	12,000	$ 83,450	$ 129,776	$ 370,224	4.4
Smith MBCx	2010	236,000	$ 500,000	681,984	13,208	$ 113,128	$ 176,884	$ 323,116	2.9
Sandler MBCx	2012	237,000	$ 335,804	1,216,241	4,470	$ 186,102	$ 296,368	$ 39,436	0.2
Total			**$ 2,025,804**	**3,138,958**	**109,678**	**$ 560,780**	**$ 863,028**	**$ 1,162,776**	**2.1**

PUP Plant

- Constant primary, variable secondary, variable tertiary in buildings
- (3) 1,000 ton centrifugal w/ VSD
- (1) 500 ton centrifugal w/ VSD

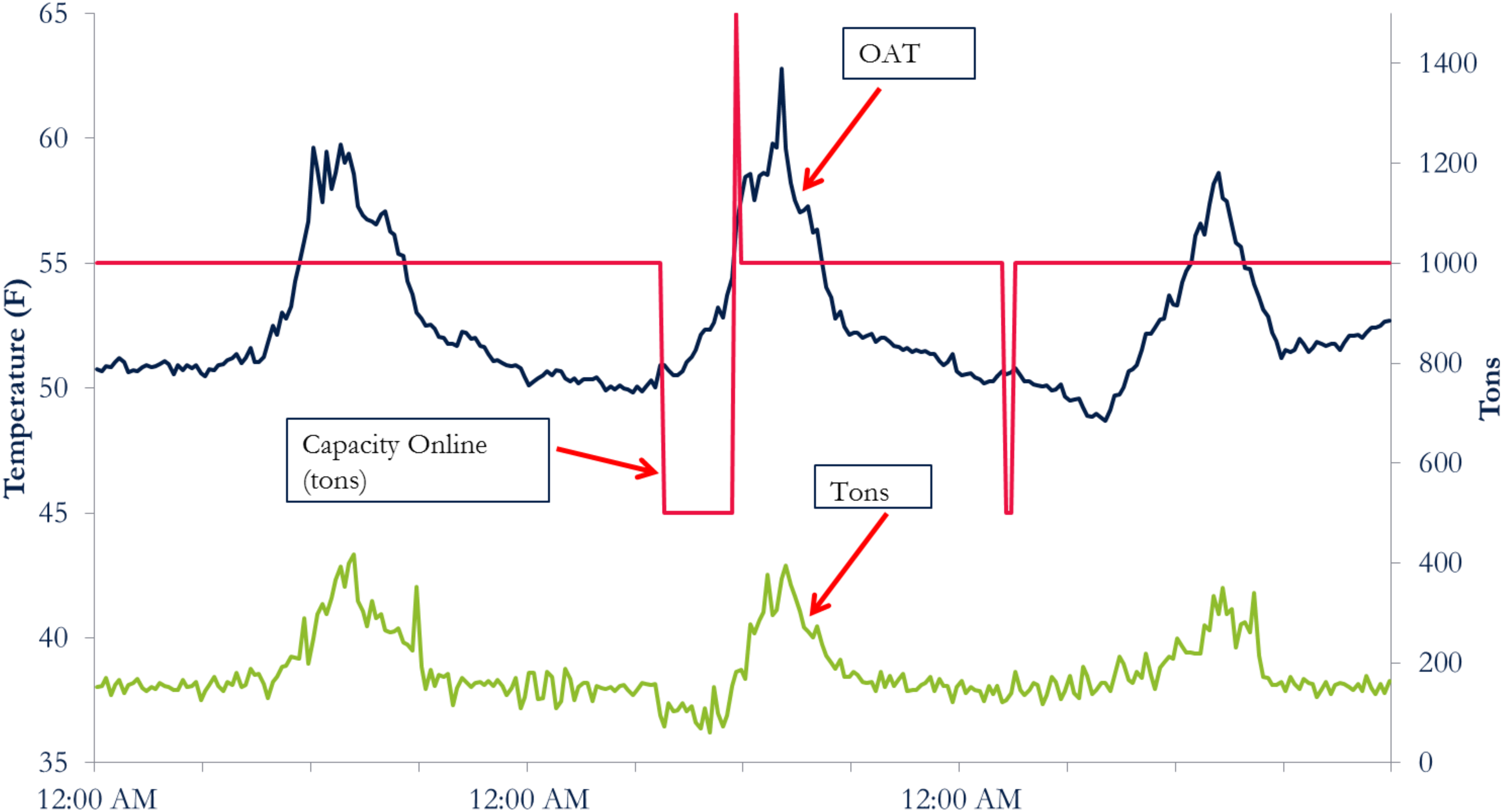
Rock Hall Plant

- Variable primary
- (3) 350 ton centrifugal w/ VSD

Initial Conditions

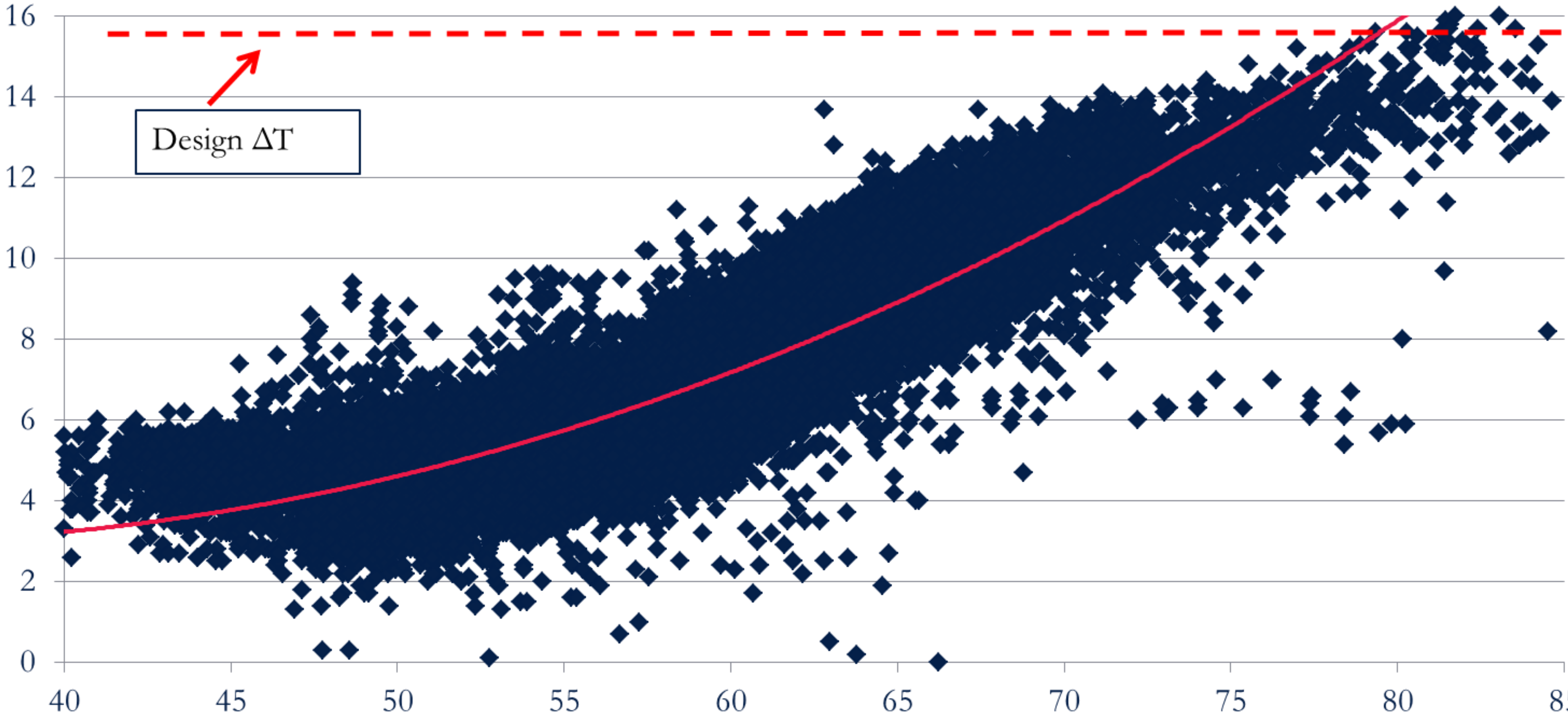
- PUP CHW plant ran 24/7
- On hot days;
  - Rock Hall plant turns on and building isolates from campus loop
  - Design had additional modes, but never commissioned or automated
- Chiller staging per original design
  - Stages up based on either flow or tons
  - Stages down based on both flow and tons
    - Due to low delta T, high secondary flow, often running with extra capacity

Often running 1000 ton unit for <200 ton load



Source: excel ‘Old PUP Data 1-28’ tab = Oct 2013 dat

Primary Issue: Low ΔT on Secondary Loop



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System Improvements

Plant

- Staging and cutover to RH plant
- Temp and Pressure reset
- Optimize constant speed pumps

Distribution

- Bypass flow

Buildings

- Reduce bypass flow and loads
- Improve delta T

Smith Improvements

- Eliminate 3-way valves (~90gpm at one AHUs)
- Server room build-out 6” bypass line (not on drawings)
- IT/Server room FCUs: Raise setpoints. Cycle fans units on/off
- AHU supply temperature reset (with deadband)
- Freezer/refrigerator corridor served by VAV and FCU units. Min ACH is 6, so VAVs are stage 1. FCUs kick on as temp increases. VAV cooling setpoint 2F higher (last stage of cooling)
- Tertiary pump dP reset based on valve feedback

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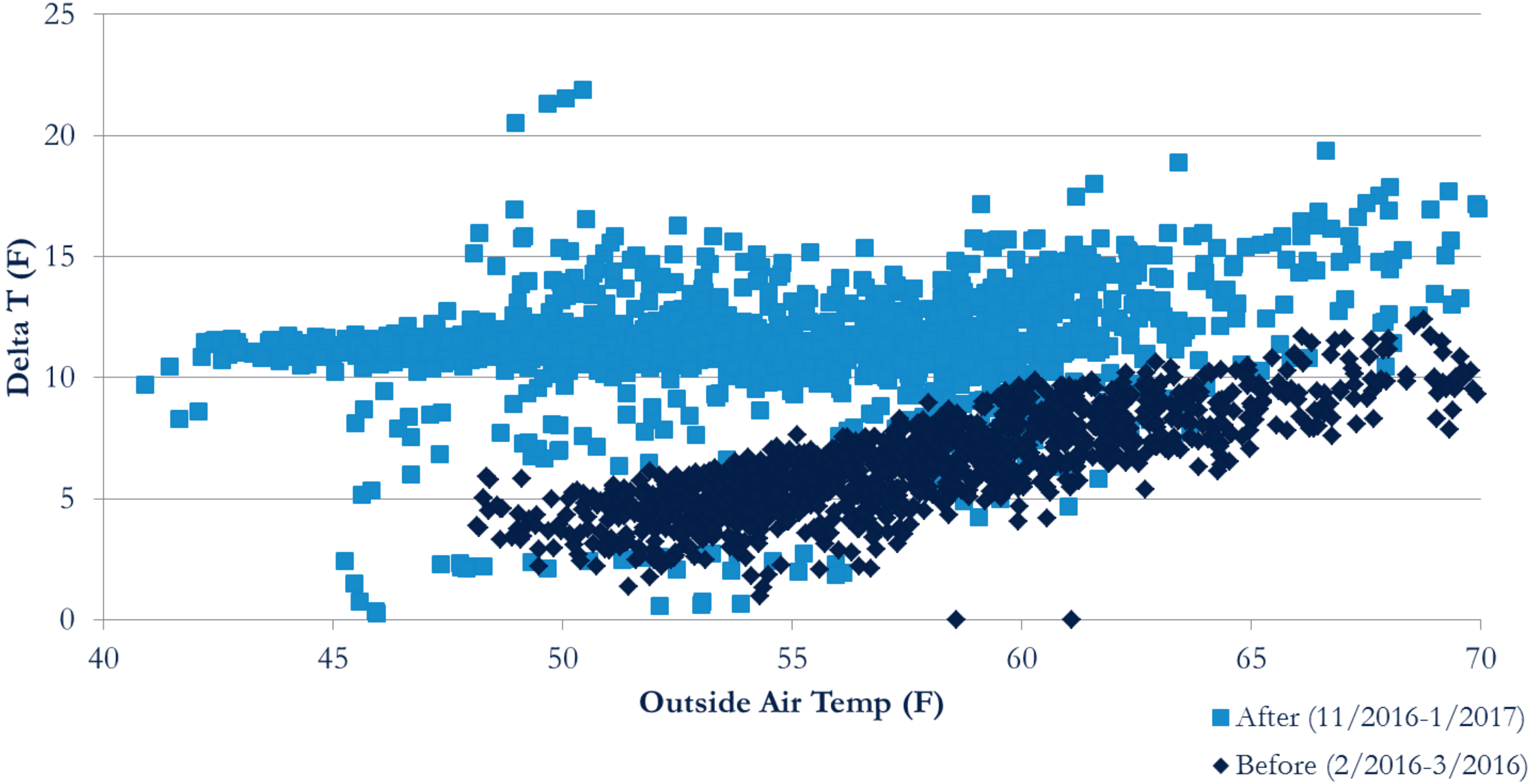
Smith: Load Reductions

- Reduce air change rates (labs and offices)
- Demand controlled ventilation (CO2 and motion sensors), zone level scheduling
- Setpoint management
  - Open labs have 3+ zones and often, one unit in heating while others are in cooling. Lock cooling setpoint ~74 during occupied periods
  - T-stats in many newer buildings allow users to change setpoint from 62F-78F. Limit adjustability to +/-2F.
  - Increase temp deadband to 4F in most spaces
  - Mech and Elec rooms

Smith Results (to-date)



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Diller Additional Measures

- 2-pipe DOAS system optimization (still being fixed)
  - Found excessive system change-over
  - Water temp reset based on zone feedback
- 2-pipe radiant floor- reduce change over. Larger temp deadband

Sandler Additional Measures

- Bypass tertiary pumps when conditions allow
- Integrate lighting motion sensors with BMS, use to set operating mode of VAV boxes

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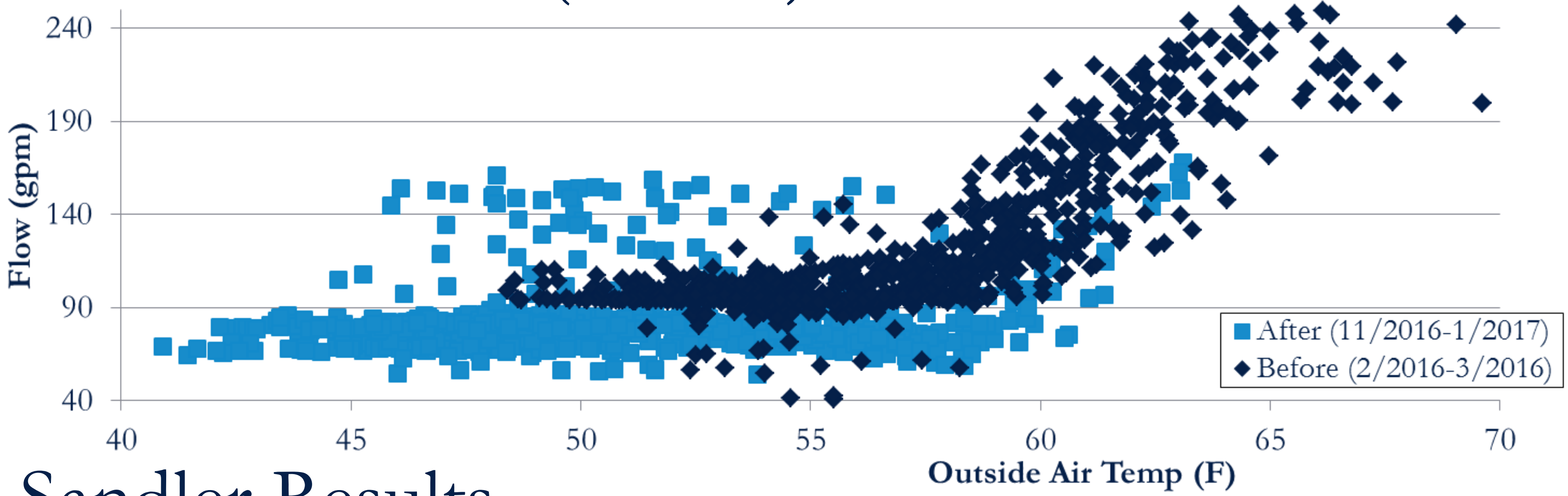
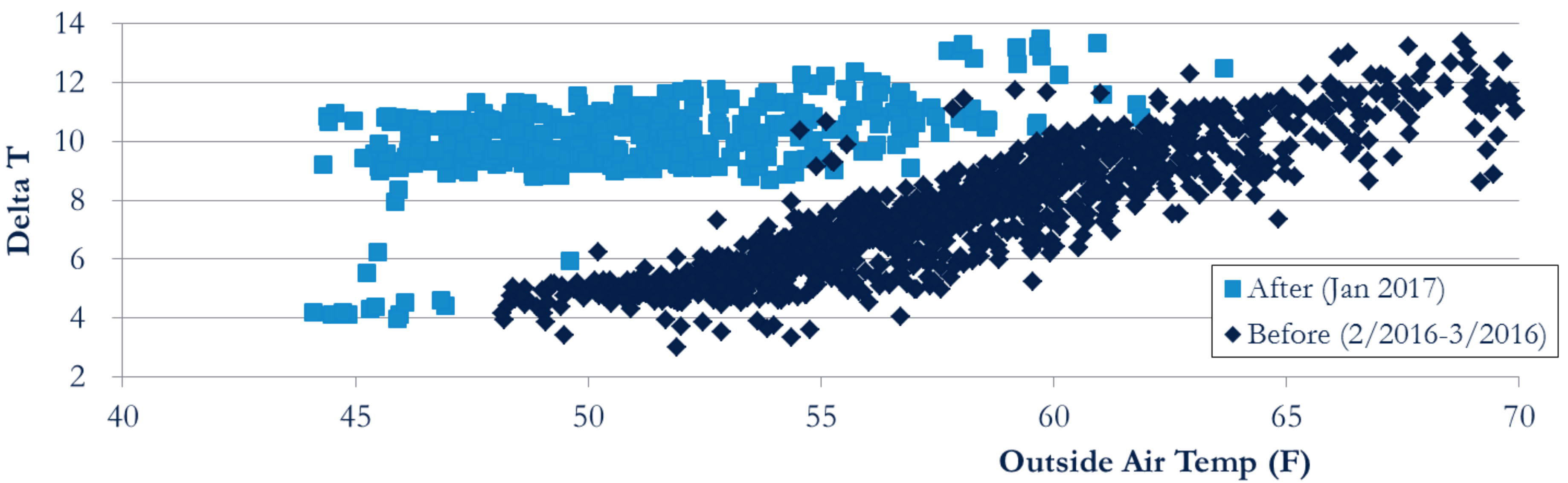
Diller Results (to-date)



Sandler Results



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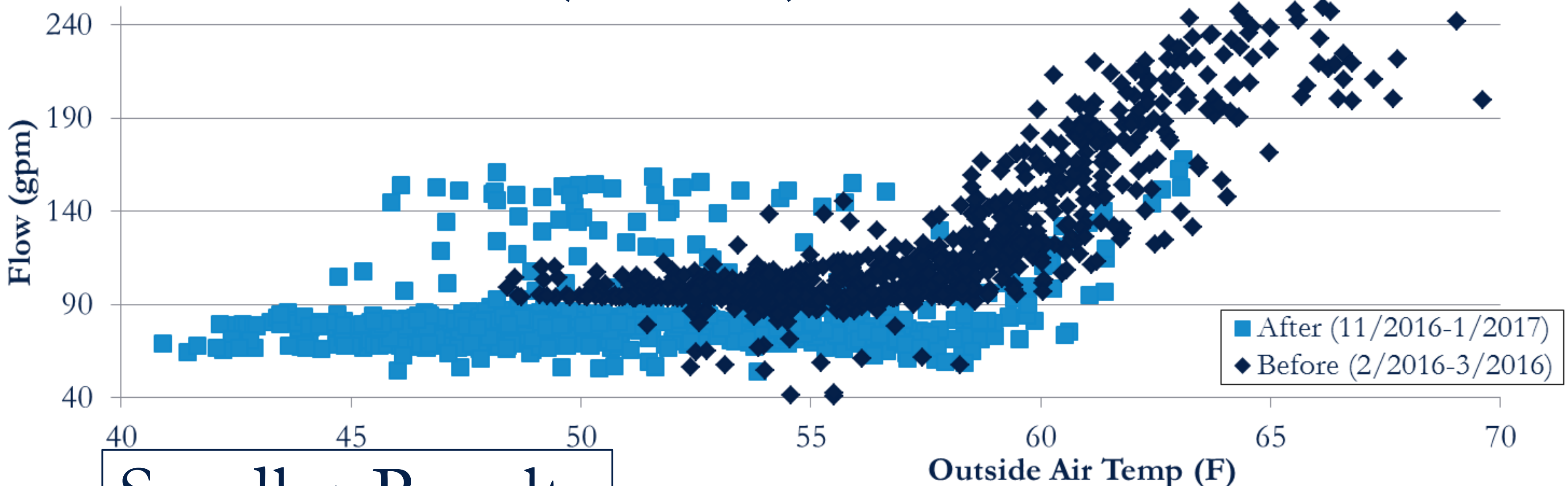
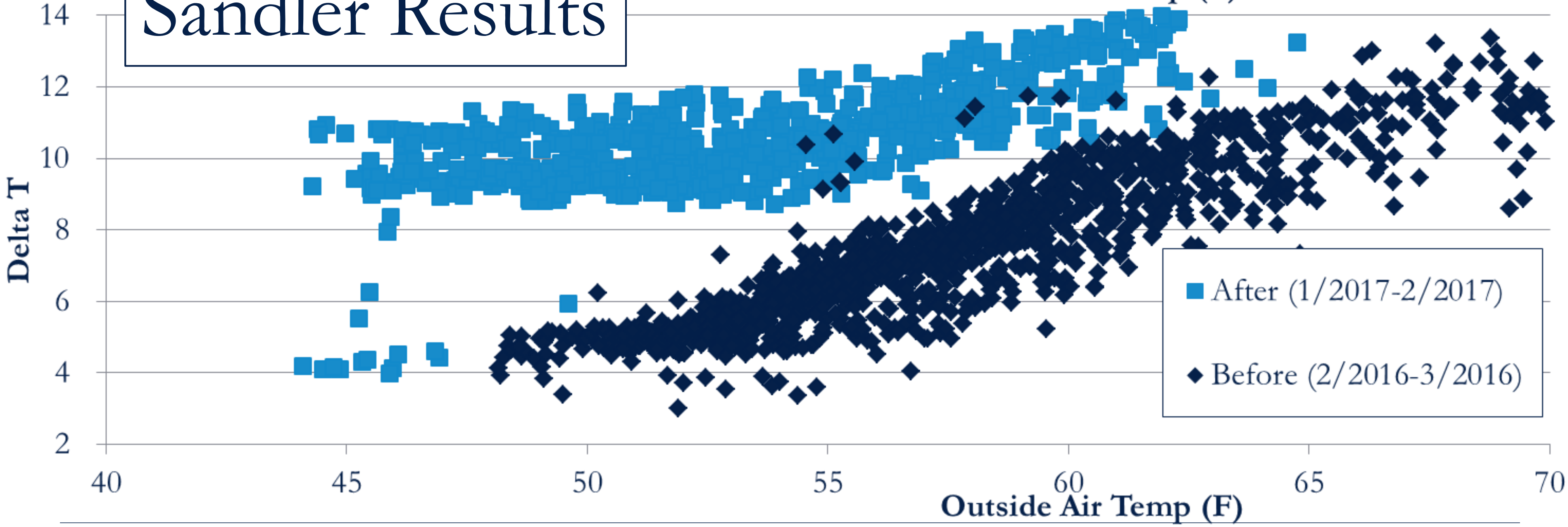
Diller Results (to-date)



Sandler Results



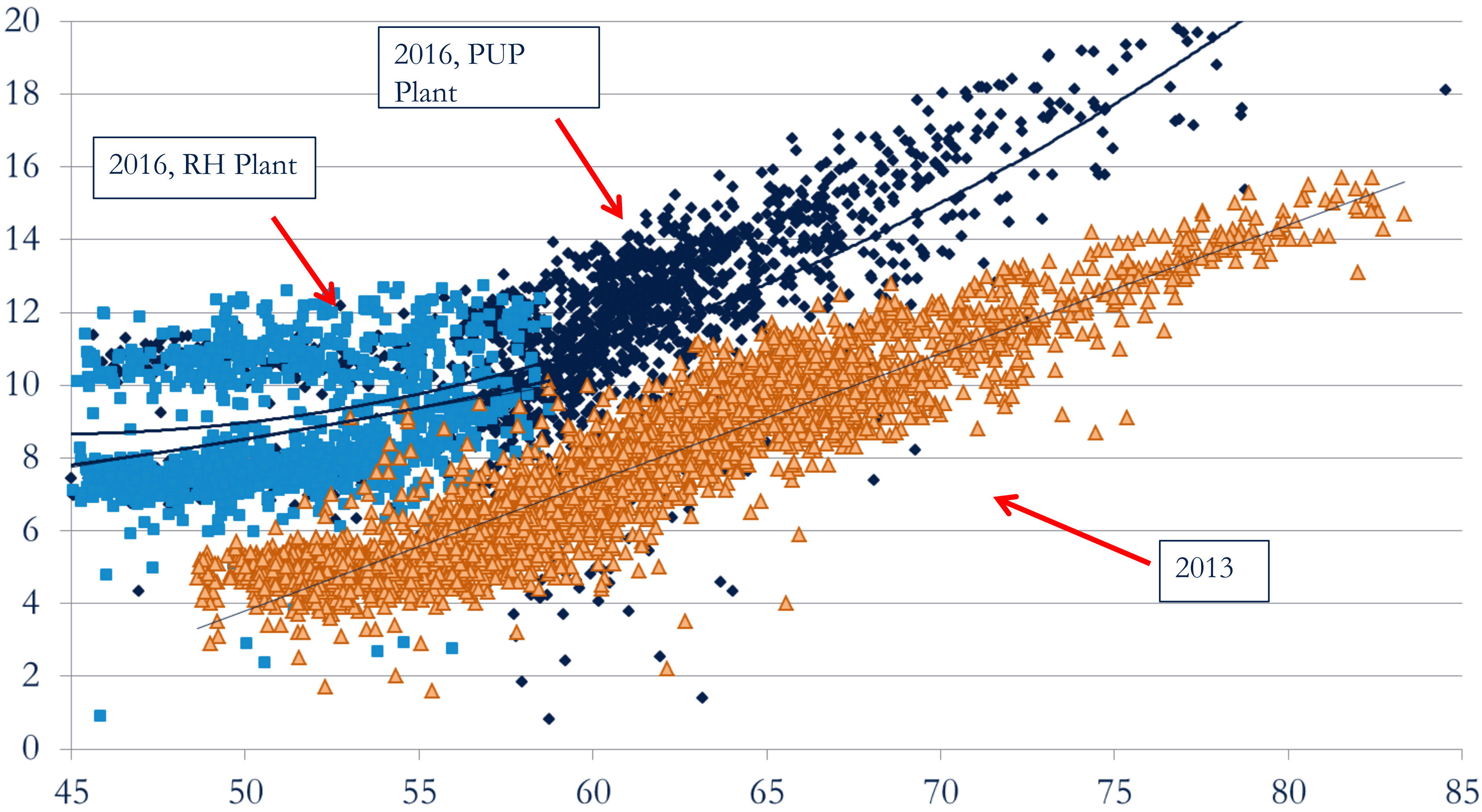
PUP Improvements

- Chiller staging
  - Revised conservative staging setpoints (gpm and tons)
    - 500 ton chiller has 750 gpm on primary loop, but plant would not stage down to 500 ton chiller until secondary flow was less than 600 gpm and 350 tons
- RH to PUP plant staging
  - Smaller auxiliaries mean that RH is much more efficient at low load conditions (~44kW less at RH than 1000 ton unit, ~23kW less than 500 ton unit)
  - At ~57F OAT, RH plant can carry load
  - ~3,700 hours when RH plant can carry campus
  - This required reductions of secondary flow

PUP- Additional Measures

- Distribution: At future stub-out, 1” bypass was circulating ~110gpm. Installed circuit setter to maintain ~10 gpm to ensure circulation of chemicals
- Secondary dP setpoint reset based on building feedback (tertiary pump speed)
- Supply temperature reset (same control loop)
- Cooling tower side stream filter pumping used to run 24/7. Added automation to cycle pumps based on tower demand.
- Unthrottled secondary pump valves
- Constant speed pumps. Replace impeller to meet design flow with little/no throttling (debated using VFDs)

Improved Delta T



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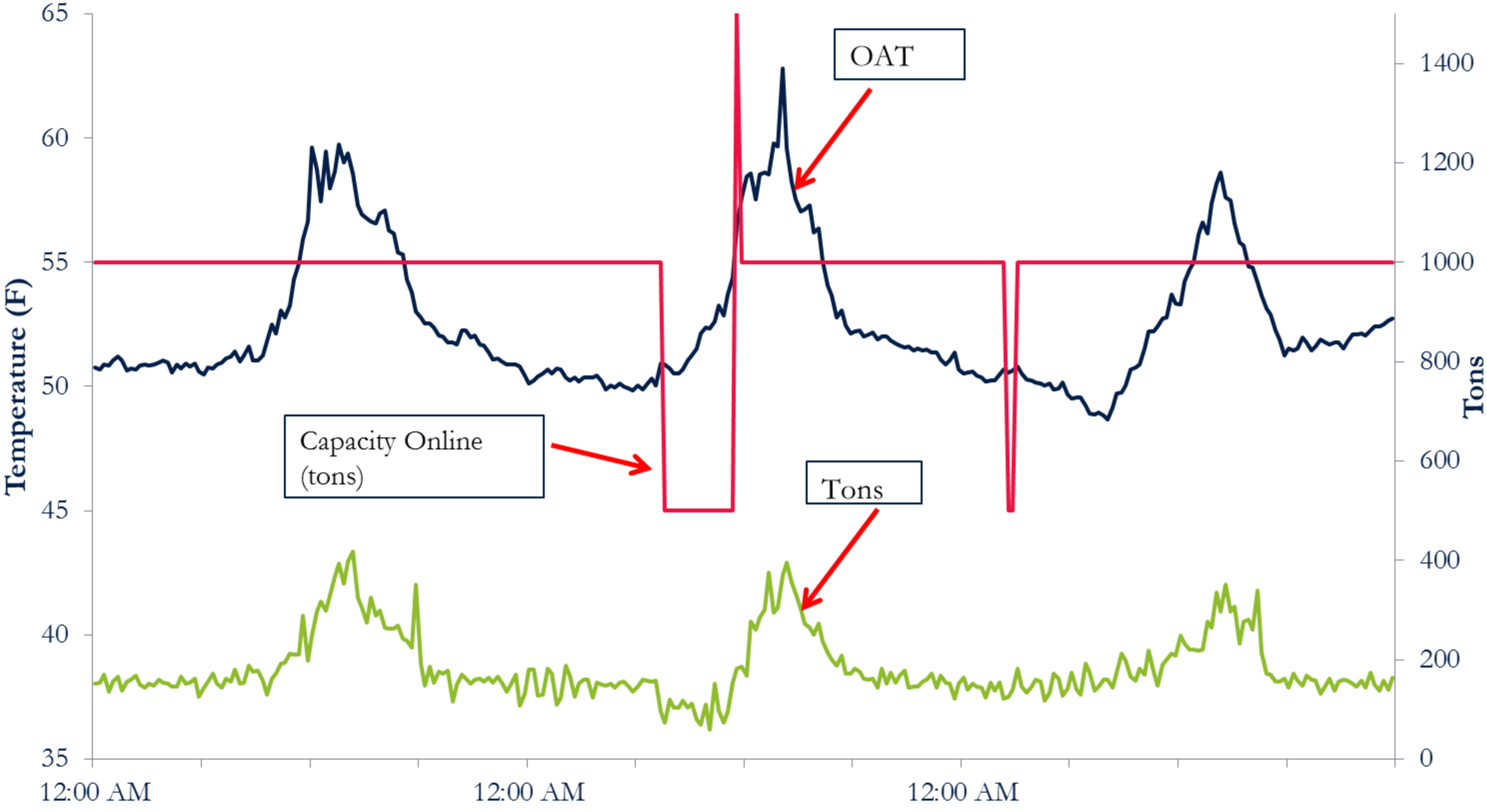
2013: Often running 1000 ton unit for <200 ton load



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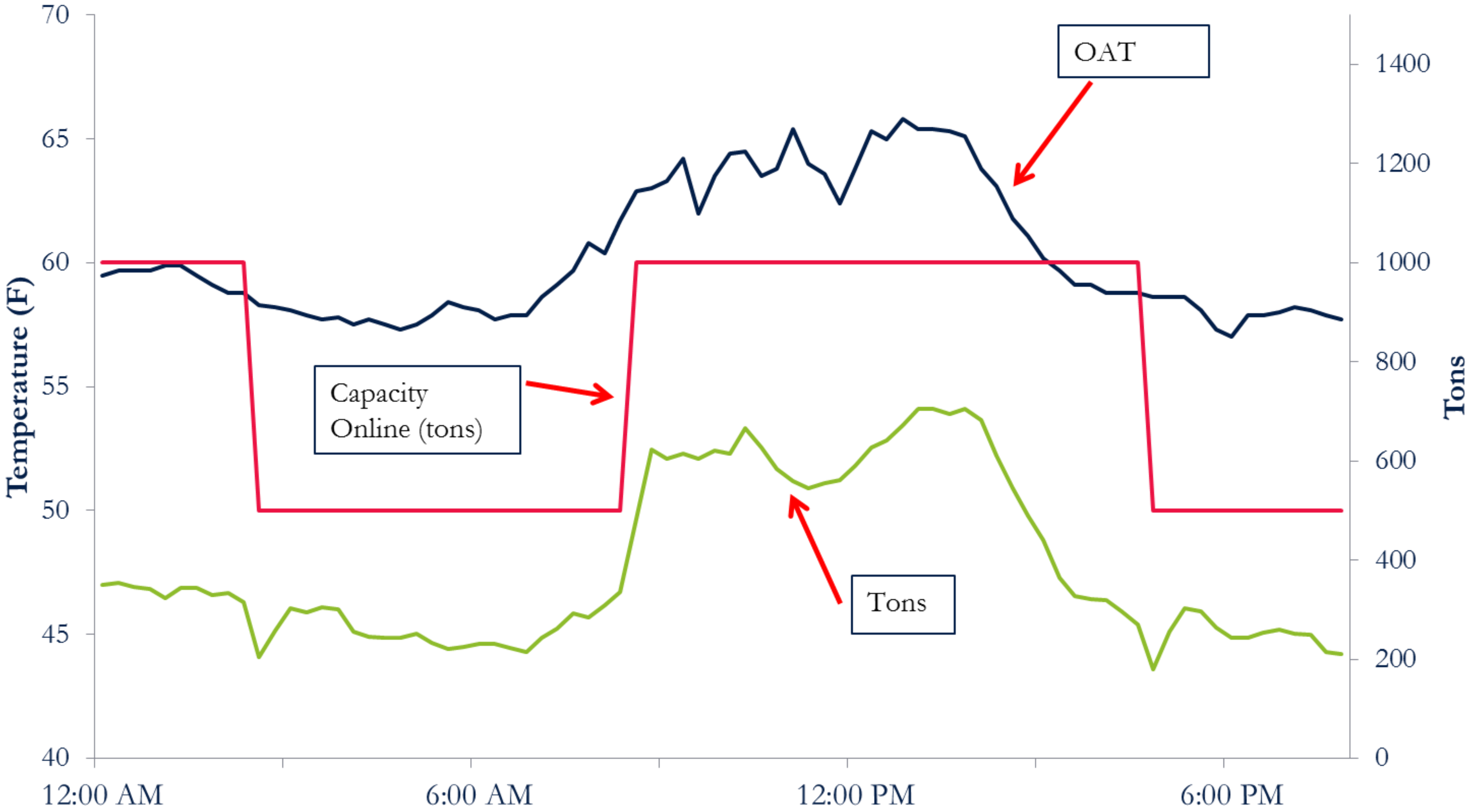
2016: On-line capacity better matches load



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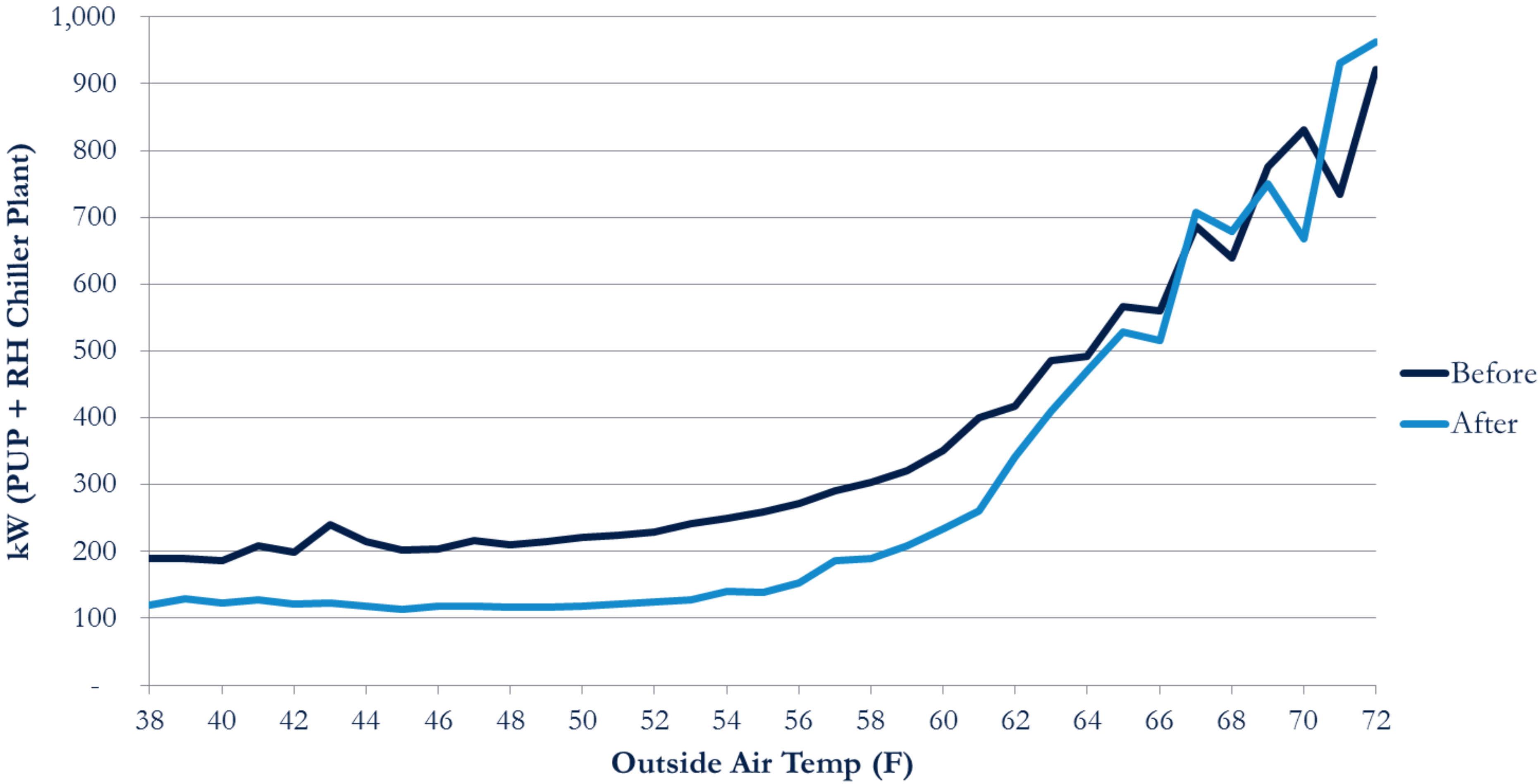
~750,000 kWh/year saved (25%)

- 80% of hours are between 45F and 65F
- Data to-date indicate PUP operates ~.59 kW/ton (above 57F)



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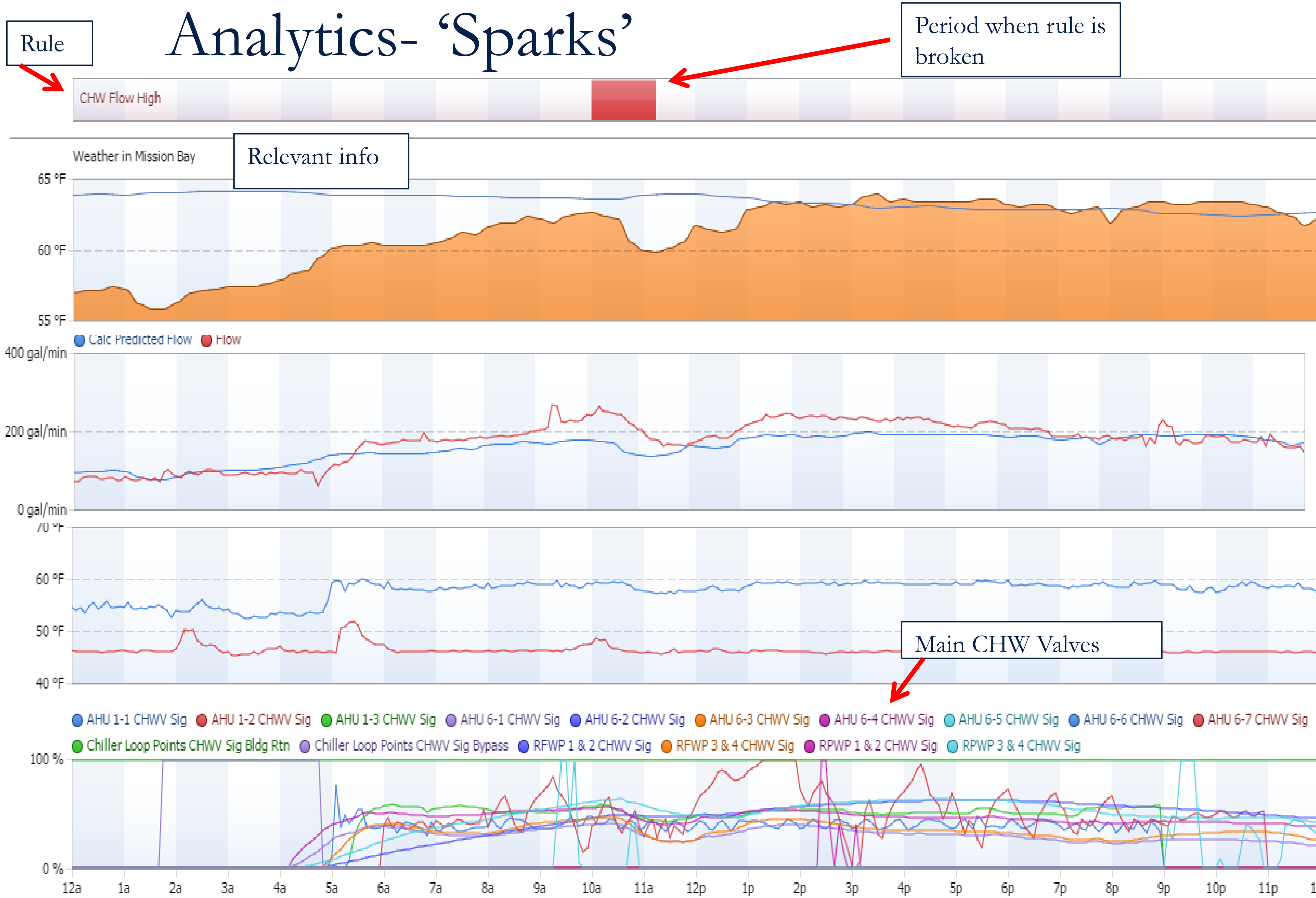
Additional Measures

- Most flow reductions have been completed
  - Have not had much warm weather since improvements
- Some load reductions are still in progress. We expect additional savings at higher loads
- Unsure yet weather load reductions will be enough to avoid adding capacity

Ongoing Analytics

- Need to ensure that plant continues to perform
- We use SkySpark platform
  - Pulls data from BMS
- Analytic ‘Rules’ check for customized conditions and create ‘Sparks’ when rule is met
- Simply regression model used to predict flow and tonnage at each building and the plant (based on OAT)

Analytics- ‘Sparks’



Lessons Learned

- Need to get into details of building operations to ensure success
  - Physically inspect system components and develop system diagram
  - Don't overlook small flow reductions
- Significant improvements possible with little-to-no hardware changes and simple measures
- Metering and Data- needs to be easy to access
- Analytics
  - Use simple rules
  - Get key diagnostic info on single page

Questions

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