



University of Wisconsin–Madison



Campus Energy 2016

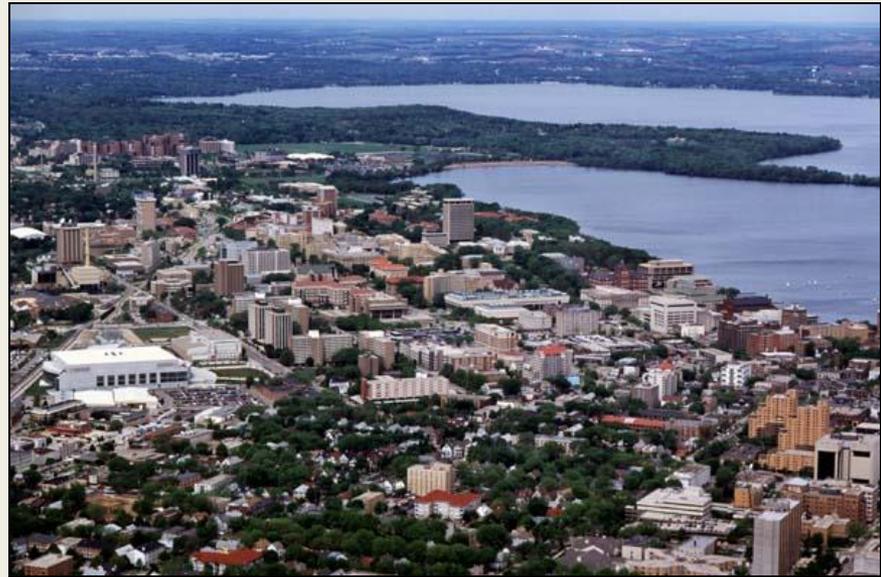
Chilled Water Plant Expansion and Dispatch Techniques
at the University of Wisconsin-Madison

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February 10, 2016

Agenda

- Campus Overview and Utility Summary
- Energy Conservation
- WCCF Chiller Plant Expansion
- Rate Structure and Economic Plant Dispatch
- Active Demand Management



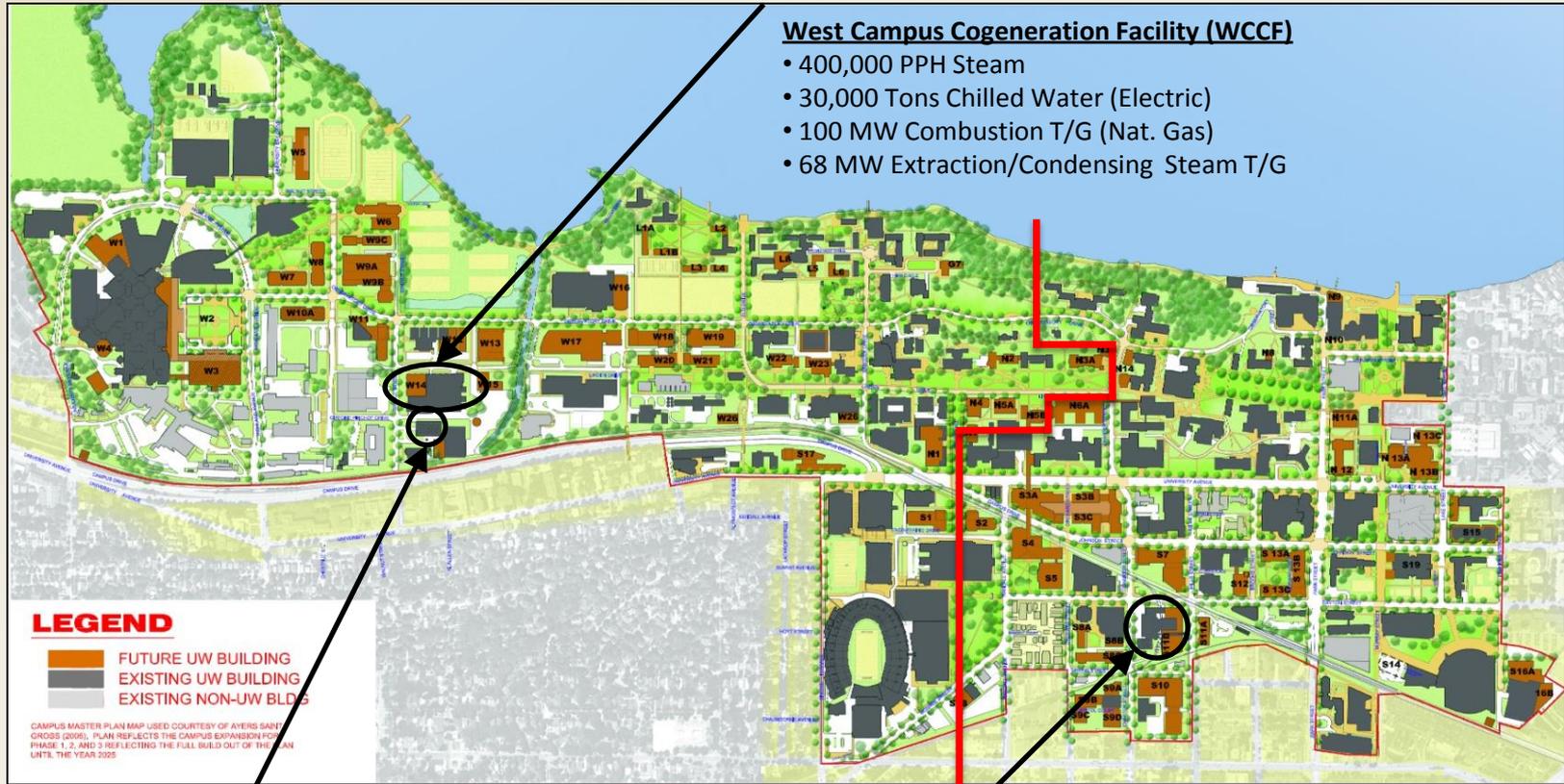


University of Wisconsin Overview

- Founded in 1848
- 13 Schools/Colleges
- Enrollment of 43,389
- 21,796 Employees and Faculty
- 23.3 Million GSF on 936 Acre Main Campus
- 7.0 Million GSF of Research Facilities
- \$2.92 Billion Budget
- Ranked 4th Nationally in Research Expenditures



Campus Utility Plants



West Campus Cogeneration Facility (WCCF)

- 400,000 PPH Steam
- 30,000 Tons Chilled Water (Electric)
- 100 MW Combustion T/G (Nat. Gas)
- 68 MW Extraction/Condensing Steam T/G

Walnut Street Heating Plant (WSHP)

- 600,000 PPH Steam (Nat. Gas)
- 11,500 Tons Chilled Water (Electric)
- 9,000 Tons Chilled Water (Steam)

Charter Street Heating Plant (CSHP)

- 1,200,000 PPH Steam (Natural Gas)
- 25,500 Tons Chilled Water (Steam)
- 9.7 MW Back Pressure T/G

Summer 2012 Hydraulic
Neutral Balance Point

Campus Utility Summary

- Steam Summary
 - 2.20 Million PPH Total
 - 1.90 Million PPH Firm
 - 1.30 Million PPH Maximum Peak
 - 0.875 Million PPH Current Peak
- Chilled Water Summary
 - 75,700 Tons Total
 - 67,200 Tons Firm
 - 64,000 Tons Maximum Peak
 - 53,000 Tons Current Peak
- Electrical Summary
 - 72.6 MW Maximum Peak
 - 65.7 MW Current Peak

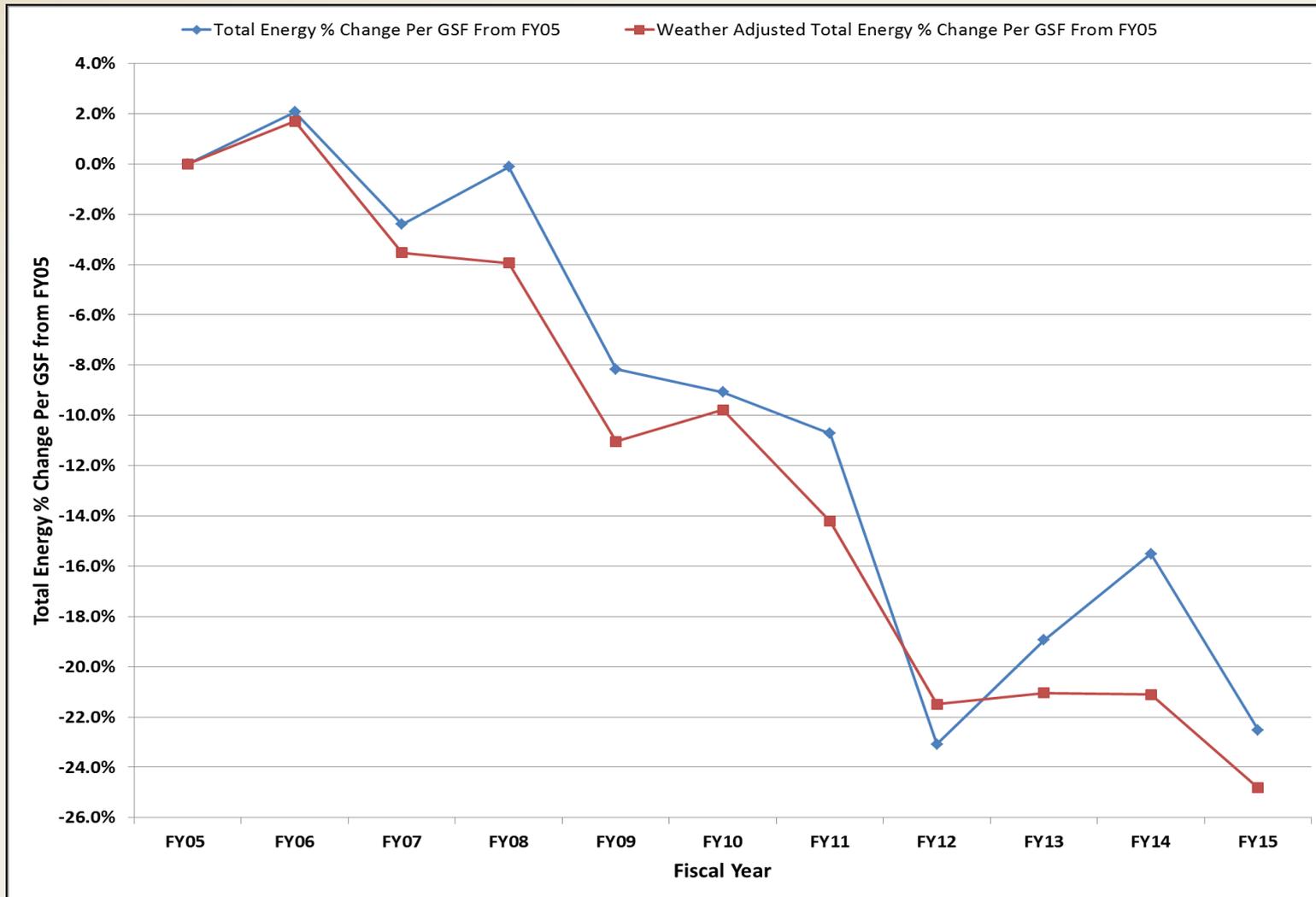


Energy Conservation

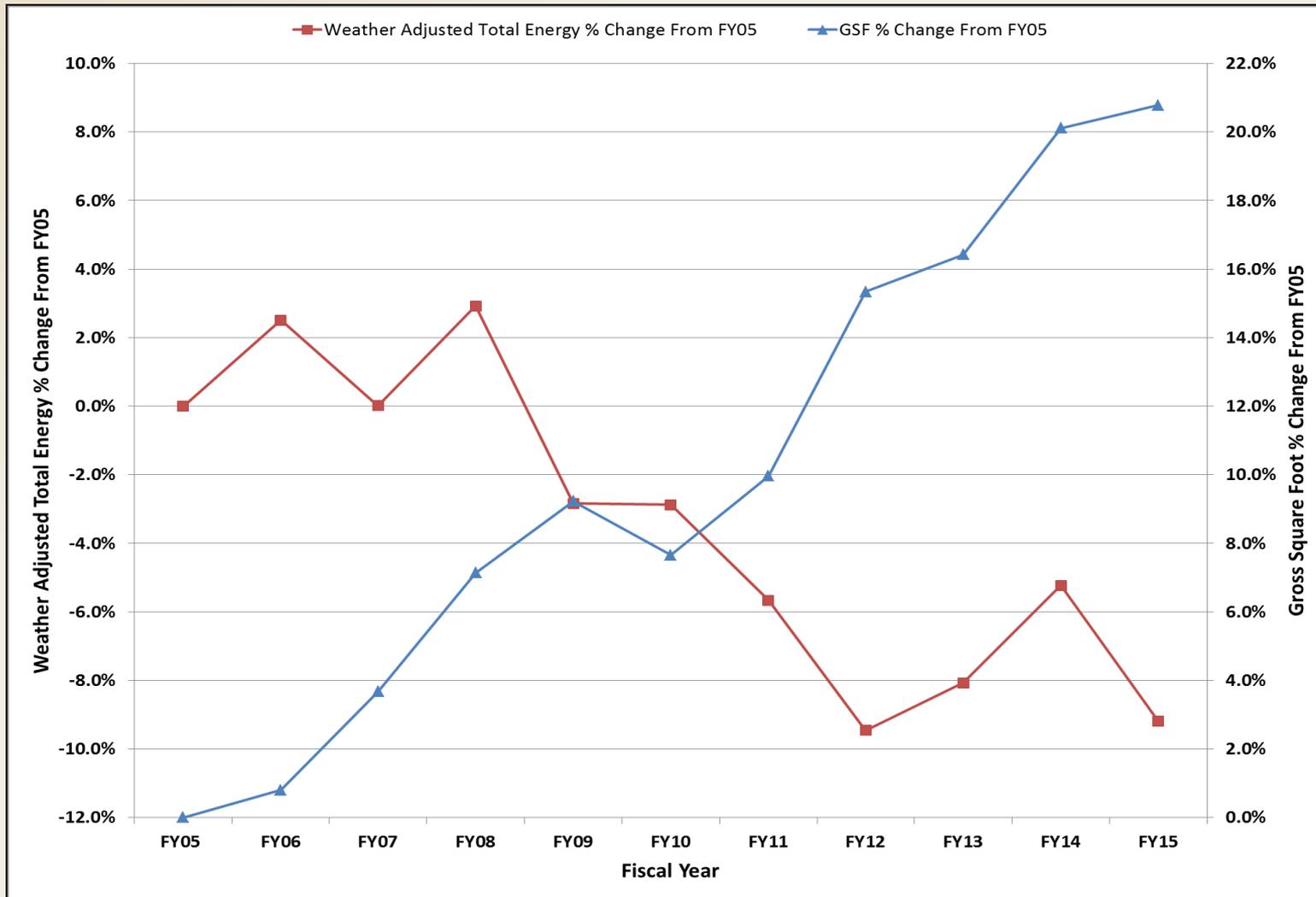
- Current Program Began in 2007
- Performance Contracting Partnership with JCI
- Invested Over \$60 Million With Simple Paybacks Less Than 10 Years
- Focused Mostly on Energy Conservation in Buildings
- Two Utility Energy Conservation Projects
 - Tunnel Upgrade and Recondition Now (TURN)
 - Central Plant Optimization (On Hold)



Energy Conservation – Net Per GSF



Energy Conservation – Total





WCCF Chiller Plant Expansion

- 20,000 Tons Existing Capacity
- Build-Out of WCCF Site for 30,000 Tons Additional Capacity (50,000 Tons Ultimate)
- Scope
 - Two 5,000 Ton Dual Compressor Chillers
 - Headered Pumping With VSD's
 - Two 25,000 GPM Chilled Water Pumps
 - Two 25,000 GPM Condenser Water Pumps
 - Four Cooling Tower Cells (Two Extra)
 - Piping, HVAC and Digital Controls
 - 54" Diameter Chilled Water Piping
 - 84" Diameter Condenser Water Piping



WCCF Chiller Plant Expansion



WCCF Chiller Plant Expansion



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WCCF Chiller Plant Expansion



WCCF Chiller Plant Expansion



WCCF Chiller Plant Expansion





WCCF Chiller Plant Expansion

- Construction/Commissioning Challenges
 - Excavation Around Active Chilled Water Piping
 - A 2 Inch Hole Can Reduce The System Pressure from 105 PSIG to 40 PSIG in Less Than 5 Minutes!
 - Essentially Four (4) Chilled Water Plants Serving Campus Distribution System
 - Equipment Dispatch and Distribution Control Accomplished Manually
 - Historically All Plants Controlled by ΔP
 - Implementing Flow Control Strategies
 - Local Control Strategy Designed Around Chiller Plant Optimization
 - Flow/ ΔP Interaction With Three (3) Hydraulically Adjacent Chilled Water Plants
 - Schedule



Energy Conservation vs. Plant Expansion

- Was Expansion Necessary?
- Both Efforts Began in Late 2000's
- 2012 Chilled Water
 - 65,700 Tons Installed
 - 57,200 Tons Firm
 - 64,000 Tons Peak
- 2015 Chilled Water
 - 75,700 Tons Installed
 - 67,200 Tons Firm
 - 53,000 Tons Peak
- Economic Dispatch Now Possible with 46%/54% Steam/Electric Drive





Rate Structure – Energy

- Campus Usage Charges (MG&E SP-3):
 - \$0.0386/kWh (Summer On-Peak)
 - \$0.0250/kWh (Summer Off-Peak)
 - \$0.0371/kWh (Winter On-Peak)
 - \$0.0250/kWh (Winter Off-Peak)
 - * Billable kWh = Usage minus CSHP Turbine kWh production
- WCCF Usage Charges (MG&E SP-3):
 - Gas Rate X 8,500 Btu/kWh (Winter On-Peak Only)
 - Firm Natural Gas Service, Daily Price (MGE LS-1)
 - \$0.0386/kWh (Summer On-Peak)
 - \$0.0250/kWh (Summer and Winter Off-Peak)
- Campus Natural Gas Charges (DOA – Constellation Energy):
 - \$3.66/MMBtu (2015 Average)





Rate Structure – Demand

- WCCF <17MW Demand Charges:
 - \$0.00000/KW/Day (All Periods)

- Campus & WCCF >17MW Demand Charges (SP-3):
 - \$1.16017/KW/Day (\$34.8/kW) – Summer On-Peak
 - \$1.00767/KW/Day (\$30.2/kW) – Winter On-Peak

- Campus Demand Credit (SP-3):
 - \$0.46/KW/Day (Nominated Generator Output)





Chilled Water Plant Dispatching

- Chilled Water Production Costs (\$/Ton-Hour)

	<u>On-Peak</u>	<u>Off-Peak</u>	<u>Cost/Month</u>
• WCCF (New <17 MW)	\$0.031	\$0.020	\$ 87,600
• WCCF (Existing <17 MW)	\$0.033	\$0.021	\$ 93,000
• CSHP/WSHP Steam	\$0.099	\$0.042	\$ 226,500
• WSHP/WCCF (New >17 MW)	\$0.150	\$0.020	\$ 231,400
• WCCF (Existing >17 MW)	\$0.159	\$0.021	\$ 245,900

Notes: Production costs for steam turbine drive chillers estimated using natural gas at \$3.66/MMBtu.
Cost/Month is based on 5,000 Tons of capacity and design energy/steam input.

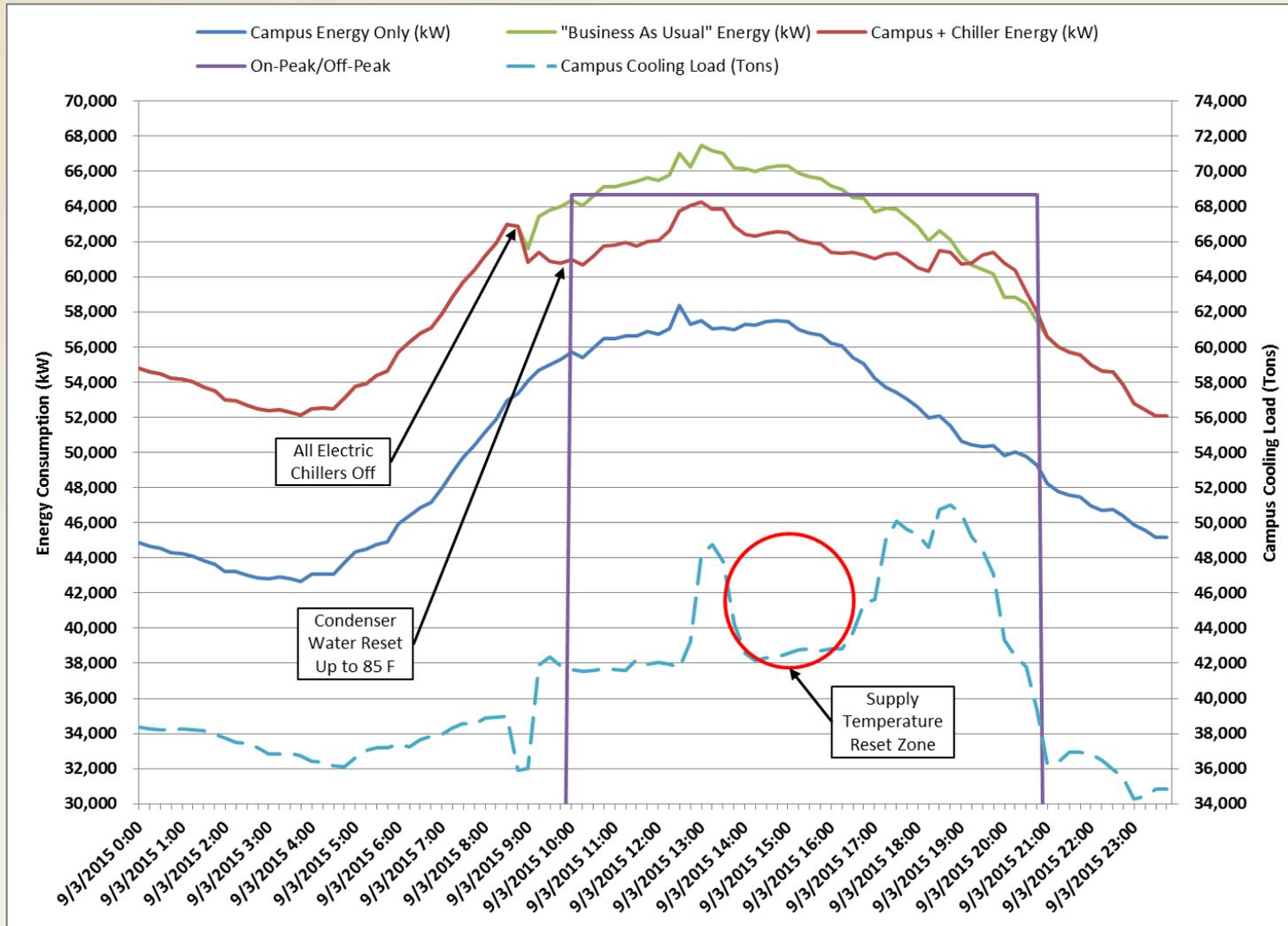


Forecast vs. Actual Demand

- Prior to 2015, Electric Meters Were Not Totalized By Campus
- January Through March Higher Than Forecast Due to Campus Demand Charges for Chiller Operation at WSHP vs. WCCF
- “Business As Usual” Chiller Dispatch in June Through August
- Active Demand Reduction In September
 - No On-Peak Campus Electric Chiller Operation
 - Condenser Water Temperature Reset from 70°F to 85°F For All Steam Turbine Drive Chillers
 - Supply Air Temperature Reset from 55°F to 62-65°F in Select Campus Buildings

Month	2015 Forecast Demand (kW)	2015 Actual Demand (kW)
Jan	54,387	57,435
Feb	54,790	58,198
Mar	54,555	57,467
Apr	54,096	54,713
May	58,728	57,689
Jun	61,481	60,080
Jul	63,647	65,515
Aug	63,337	64,435
Sep	63,108	64,671
Oct	58,994	56,121
Nov	56,839	55,410
Dec	55,123	54,475
Sum	699,085	706,209

Demand Reduction (September 3, 2015)



Summary

- Campus GSF Has Increased Nearly 21% Since FY05
- Energy Reduction of 25% Per GSF and 9% Total Since FY05
- 10,000 Ton Plant Addition Becomes Year Around Baseload Variable Primary Chilled Water Flow Plant
- WCCF is Most Cost Effective Chilled Water Plant With No Demand Charge up to 17.0 MW On Peak
- Energy Conservation and Chilled Water Plant Expansion Has Allowed UW-Madison to Economically Dispatch Chilled Water Assets for the First Time in Many Years
 - Manual Presently, Hoping For Automated Optimization in Future
- Credibility With Local Utility in Electric Rate Case Discussions
- Future ?
 - Chiller Plant Optimization
 - East Campus Electric Chiller
 - Thermal Storage





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