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The University of Texas at Austin
Utilities and Energy Management

THE EVOLUTION OF THE UT AUSTIN UTILITY PLANTS

JUAN ONTIVEROS, P.E.
The University of Texas at Austin

BEN ERPELDING, P.E.
Optimum Energy

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DistrictCooling2018
Efficient Energy for Smarter Cities
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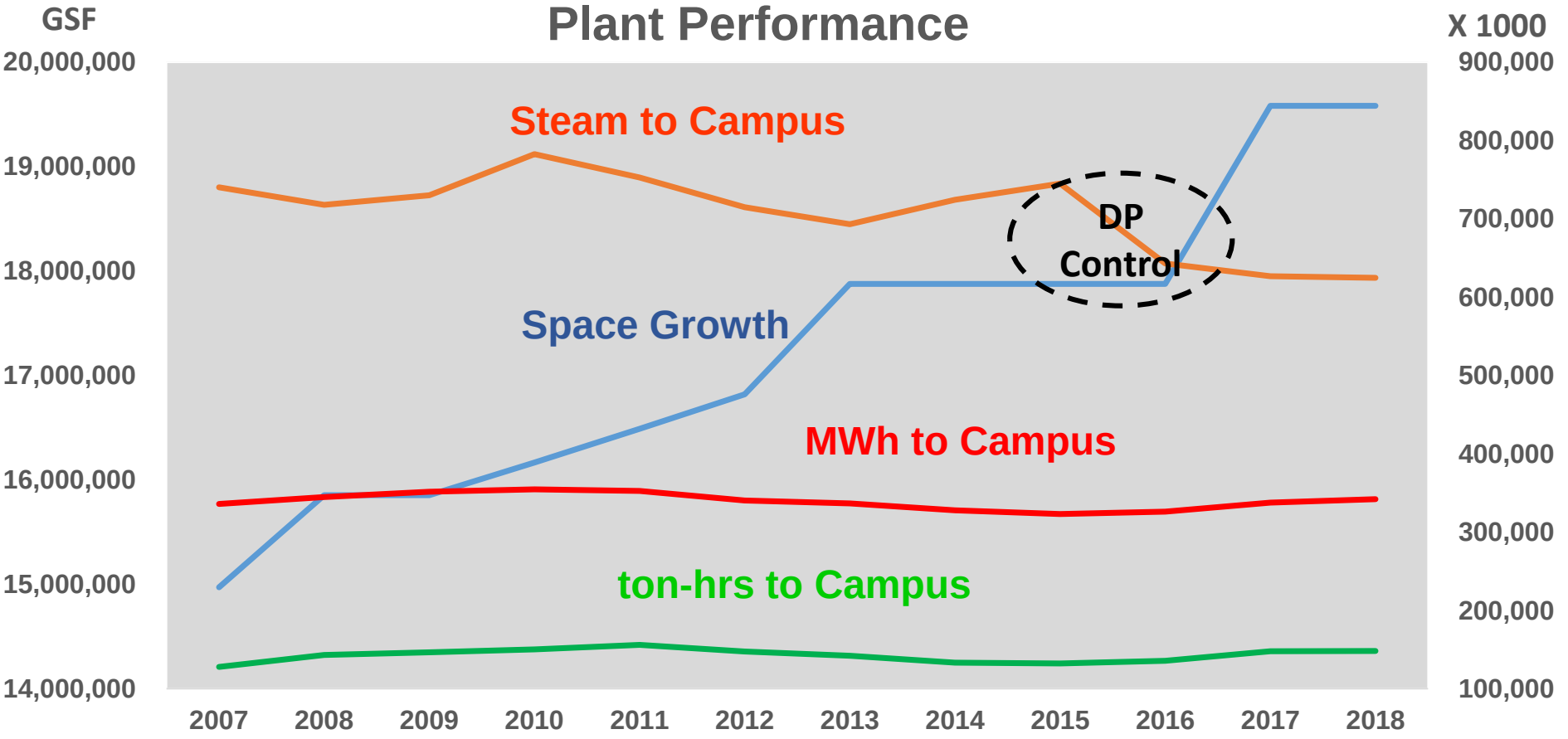
Organized by
INTERNATIONAL DISTRICT ENERGY ASSOCIATION

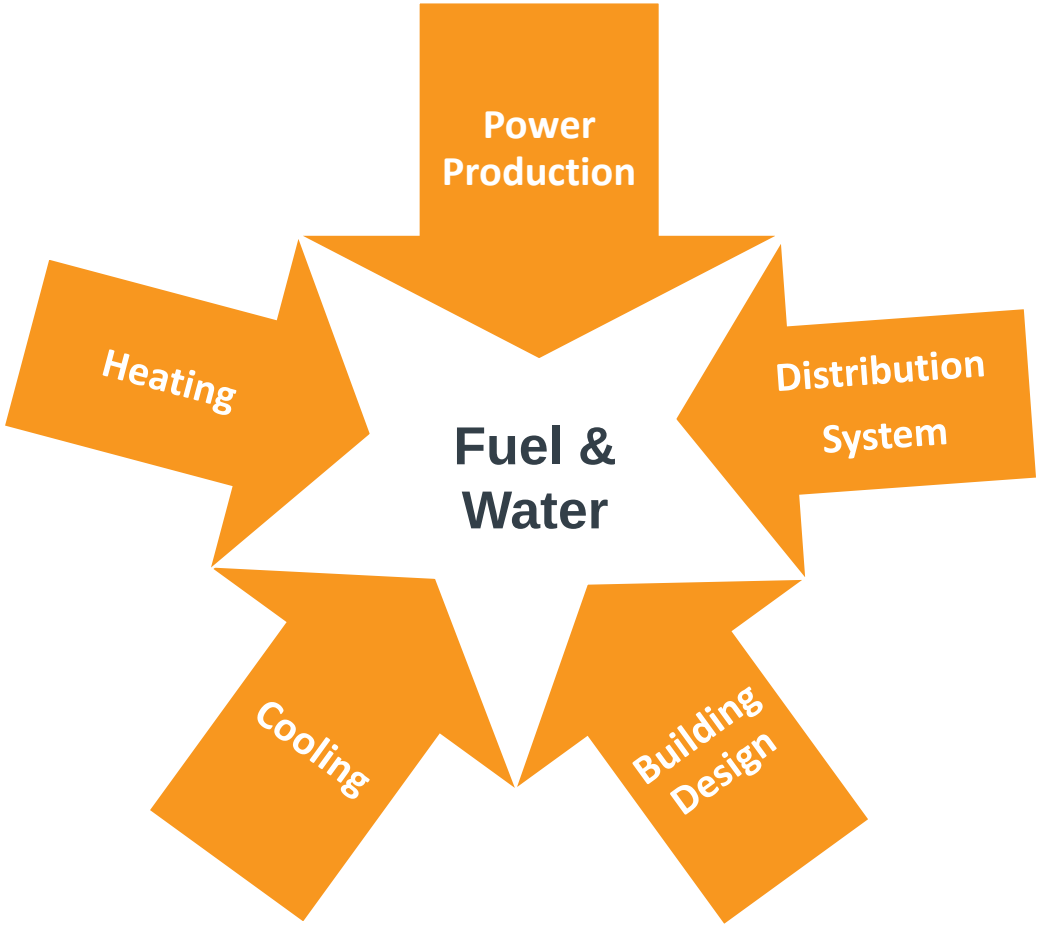
Presentation Objectives

- UT Austin's Philosophy for Cooling
- UT's Actual Historical Performance
- Impact to Power Generation
- UAE Plant Operation vs UT Plant Operation
- VFD vs Constant Speed

Plant Performance



Holistic Approach to Total Energy



Evolution of Optimization

2007
45K Tons - Eliminate Steam Turbine Chillers, Add 15K Electric Chillers w/VFD's but no Optimization

Annual Average kW/ton = 0.84
15 million GSF
MW = 59, Tons = 29.3k, Steam 200k

2008
45k Tons - Start Optimizing 15K ton plant

Annual Average kW/ton = 0.80
15.9 million GSF
MW = 60, Tons = 33.1k, Steam = 190k

2009
Evaluate Distribution DP control and VFD Pumps at CS3

Annual Average kW/ton = 0.77
15.9 million GSF
MW = 62, Tons = 34k, Steam = 191k

2013
Optimize Multiple Plant Dispatch, Reduce DP to 10 to 4 psi (summer vs rest of year) (4 plants)

Annual Average kW/ton = 0.66
17.9 million GSF
MW = 61, Tons = 33.4k, Steam = 188k

2014 – 2017
Start Using 4 MG TES

4-year Average kW/ton = 0.66
18.3 million GSF
MW = 61k, Tons = 33.6k, Steam = 203k

2018 - 60k Tons
Add 15k All VFD Plant, Add VFD to 5k ton OM Chiller, Start Using 6 MG TES

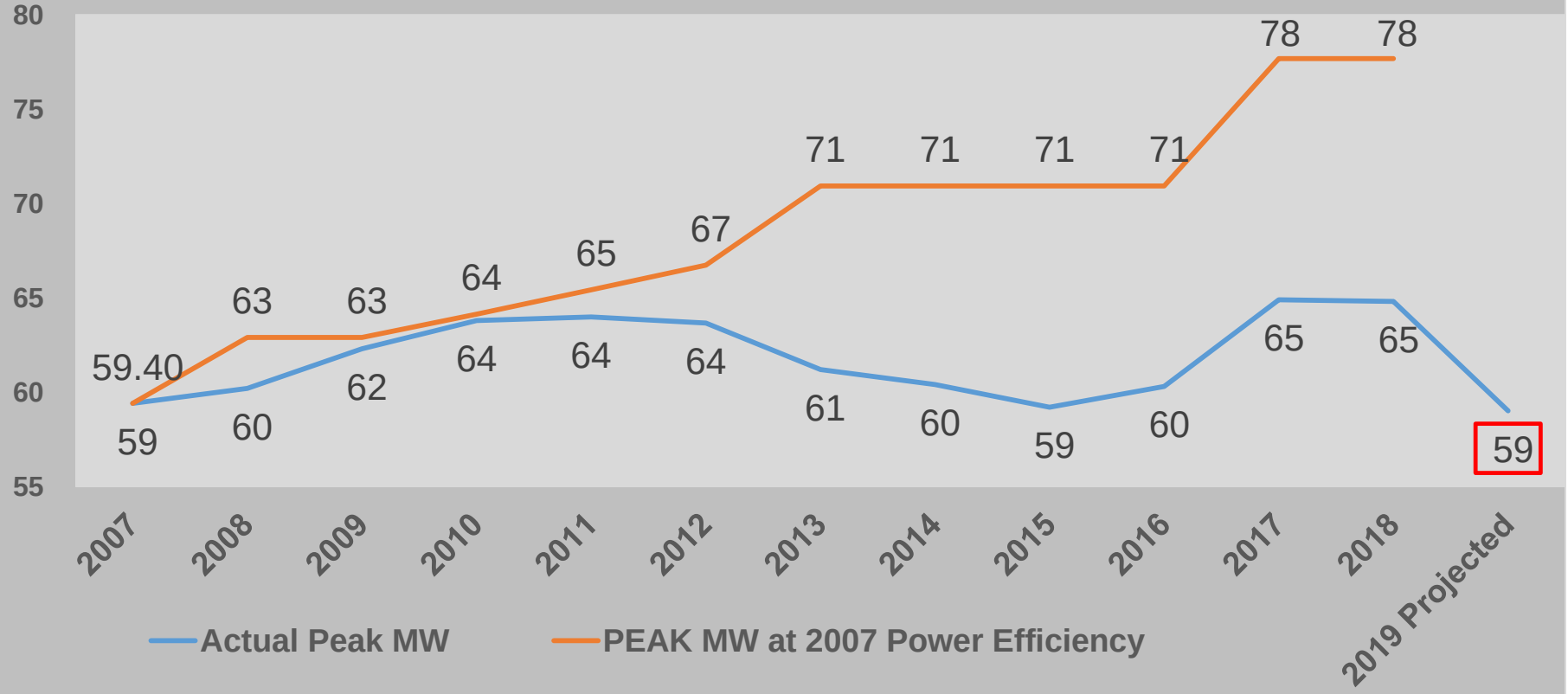
Annual Average kW/ton = 0.615
19.6 million GSF
MW = 65, Tons = 38.3k, Steam = 240k

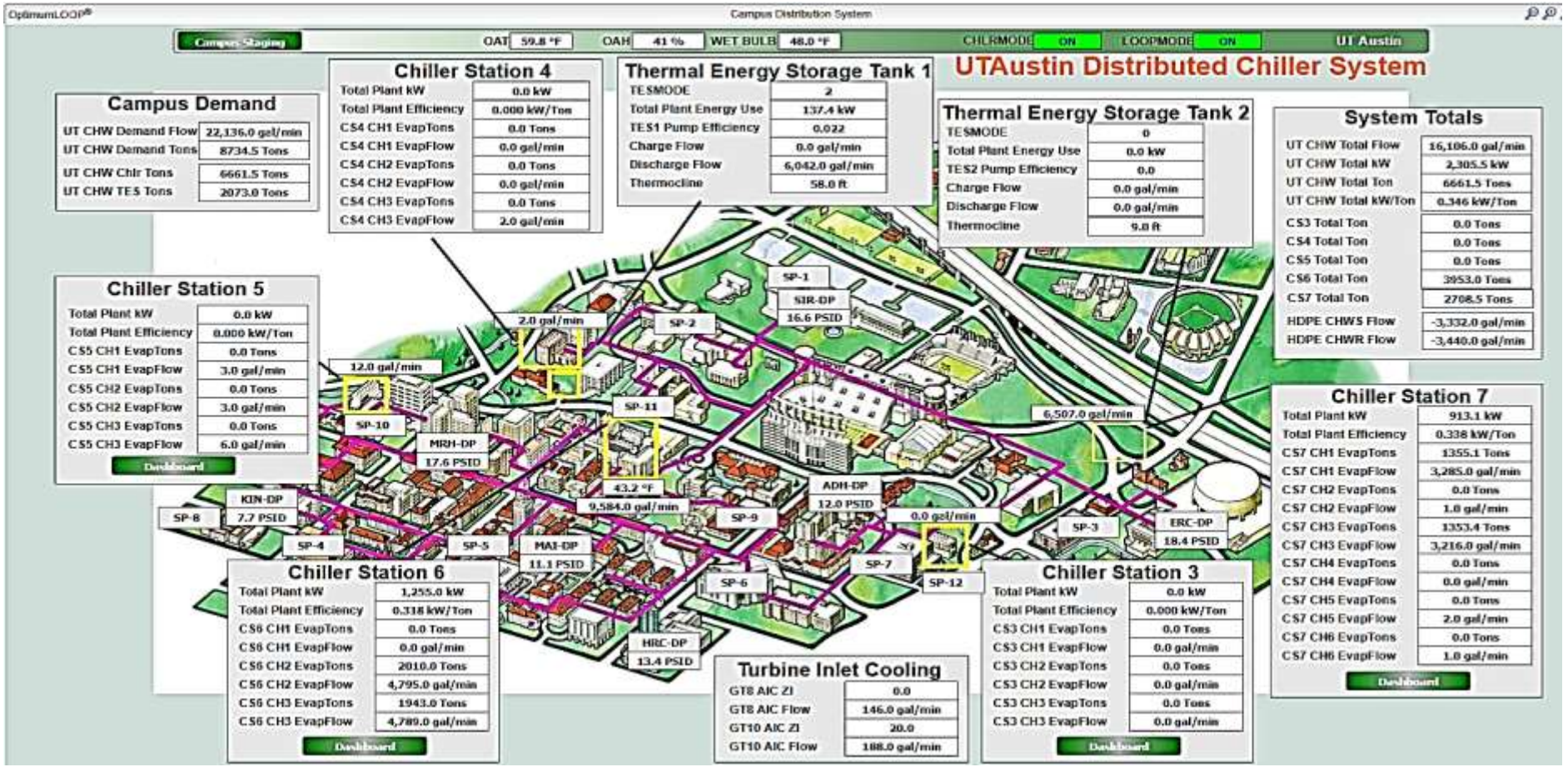
Total Cumulative Saved:

509.6K MWh

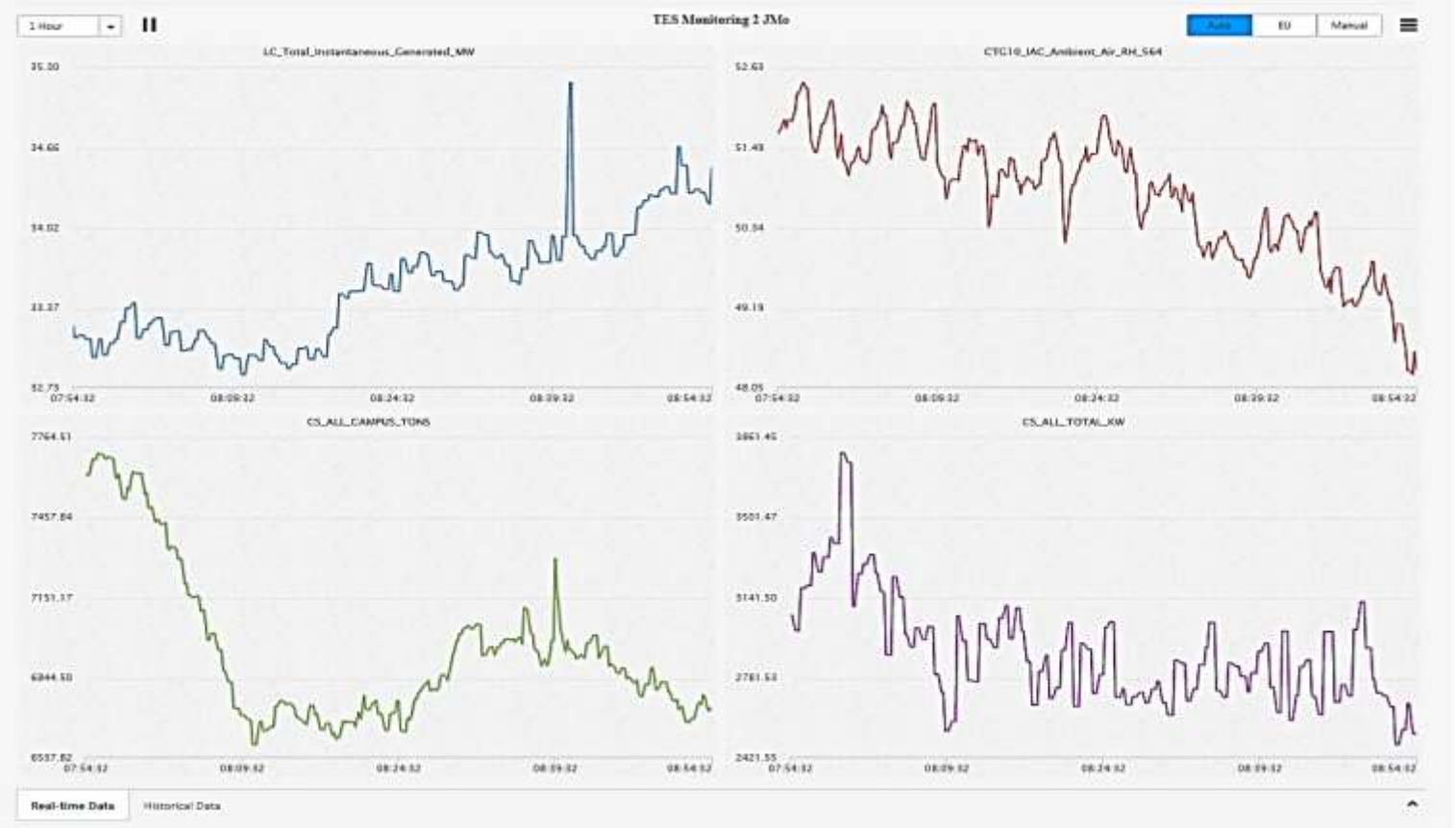
$21.3 Million

Peak MW Adjusted for Space Growth




OptimumLOOP®
Campus Distribution System
Campus Staging
OAT 59.8 °F
OAH 41 %
WET BULB 48.0 °F
CHLRMODE ON
LOOPMODE ON
UT Austin
UTAustin Distributed Chiller System
Campus Demand
UT CHW Demand Flow 22,136.0 gal/min
UT CHW Demand Tons 8734.5 Tons
UT CHW Chlr Tons 6661.5 Tons
UT CHW TES Tons 2073.0 Tons
Chiller Station 4
Total Plant kW 0.0 kW
Total Plant Efficiency 0.000 kW/Ton
CS4 CH1 EvapTons 0.0 Tons
CS4 CH1 EvapFlow 0.0 gal/min
CS4 CH2 EvapTons 0.0 Tons
CS4 CH2 EvapFlow 0.0 gal/min
CS4 CH3 EvapTons 0.0 Tons
CS4 CH3 EvapFlow 2.0 gal/min
Thermal Energy Storage Tank 1
TESMODE 2
Total Plant Energy Use 137.4 kW
TES1 Pump Efficiency 0.022
Charge Flow 0.0 gal/min
Discharge Flow 6,042.0 gal/min
Thermocline 58.0 ft
Thermal Energy Storage Tank 2
TESMODE 0
Total Plant Energy Use 0.0 kW
TES2 Pump Efficiency 0.0
Charge Flow 0.0 gal/min
Discharge Flow 0.0 gal/min
Thermocline 9.0 ft
System Totals
UT CHW Total Flow 16,106.0 gal/min
UT CHW Total kW 2,305.5 kW
UT CHW Total Ton 6661.5 Tons
UT CHW Total kW/Ton 0.346 kW/Ton
CS3 Total Ton 0.0 Tons
CS4 Total Ton 0.0 Tons
CS5 Total Ton 0.0 Tons
CS6 Total Ton 3953.0 Tons
CS7 Total Ton 2708.5 Tons
HDPE CHWS Flow -3,332.0 gal/min
HDPE CHWR Flow -3,440.0 gal/min
Chiller Station 5
Total Plant kW 0.0 kW
Total Plant Efficiency 0.000 kW/Ton
CS5 CH1 EvapTons 0.0 Tons
CS5 CH1 EvapFlow 3.0 gal/min
CS5 CH2 EvapTons 0.0 Tons
CS5 CH2 EvapFlow 3.0 gal/min
CS5 CH3 EvapTons 0.0 Tons
CS5 CH3 EvapFlow 6.0 gal/min
Dashboard
Chiller Station 7
Total Plant kW 913.1 kW
Total Plant Efficiency 0.338 kW/Ton
CS7 CH1 EvapTons 1355.1 Tons
CS7 CH1 EvapFlow 3,285.0 gal/min
CS7 CH2 EvapTons 0.0 Tons
CS7 CH2 EvapFlow 1.0 gal/min
CS7 CH3 EvapTons 1353.4 Tons
CS7 CH3 EvapFlow 3,216.0 gal/min
CS7 CH4 EvapTons 0.0 Tons
CS7 CH4 EvapFlow 0.0 gal/min
CS7 CH5 EvapTons 0.0 Tons
CS7 CH5 EvapFlow 2.0 gal/min
CS7 CH6 EvapTons 0.0 Tons
CS7 CH6 EvapFlow 1.0 gal/min
Dashboard
Chiller Station 6
Total Plant kW 1,255.0 kW
Total Plant Efficiency 0.318 kW/Ton
CS6 CH1 EvapTons 0.0 Tons
CS6 CH1 EvapFlow 0.0 gal/min
CS6 CH2 EvapTons 2010.0 Tons
CS6 CH2 EvapFlow 4,795.0 gal/min
CS6 CH3 EvapTons 1943.0 Tons
CS6 CH3 EvapFlow 4,789.0 gal/min
Dashboard
Turbine Inlet Cooling
GT8 AIC ZI 0.0
GT8 AIC Flow 146.0 gal/min
GT10 AIC ZI 20.0
GT10 AIC Flow 188.0 gal/min
Chiller Station 3
Total Plant kW 0.0 kW
Total Plant Efficiency 0.000 kW/Ton
CS3 CH1 EvapTons 0.0 Tons
CS3 CH1 EvapFlow 0.0 gal/min
CS3 CH2 EvapTons 0.0 Tons
CS3 CH2 EvapFlow 0.0 gal/min
CS3 CH3 EvapTons 0.0 Tons
CS3 CH3 EvapFlow 0.0 gal/min
Dashboard
SP-1
SIR-DP
16.6 PSID
2.0 gal/min
SP-2
12.0 gal/min
SP-10
SP-11
MRH-DP
17.6 PSID
43.2 °F
9,584.0 gal/min
6,507.0 gal/min
ADH-DP
12.0 PSID
0.0 gal/min
SP-9
SP-3
ERC-DP
18.4 PSID
KIN-DP
7.7 PSID
SP-8
SP-4
SP-5
MAI-DP
11.1 PSID
SP-7
SP-12
SP-6
HRC-DP
13.4 PSID

Persistent Monitoring



Performance To Date vs Last Year

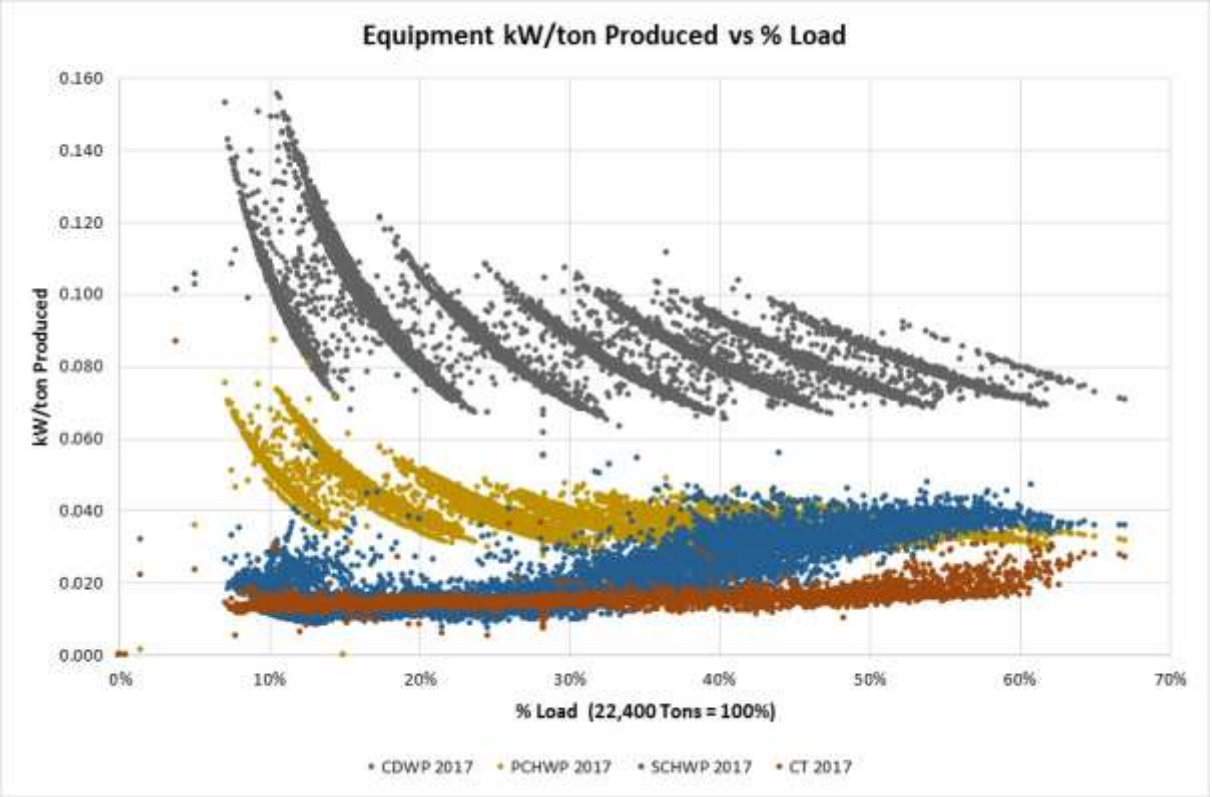
- Using Both TES for First Time (80,000 ton-hrs)
- Started TES & Chilling Station Optimization
  - Working through transitions:
    - Charging to Discharging & Vice Versa
    - Multiple Chilling Station Dispatch
  - Optimize Power Generation vs Chilled Water Production
    - Shift load to Nighttime – Increase Electrical Generation Efficiency (~3% Better)
- Peak Electrical Load and Cooling Load is August to September
  - Peak Power = 59 MW vs last year at 65 MW
  - Peak Cooling Demand = 34,118 vs last year at 38,300 (includes TES Dispatch)
  - **30,000 tons are Spare (CS3, CS4 & 5-2500 ton Chillers at CS7)**

Goal is to Absorb Campus Growth With No New Plants

Auxiliary Energy Performance

UAE District Energy Plant

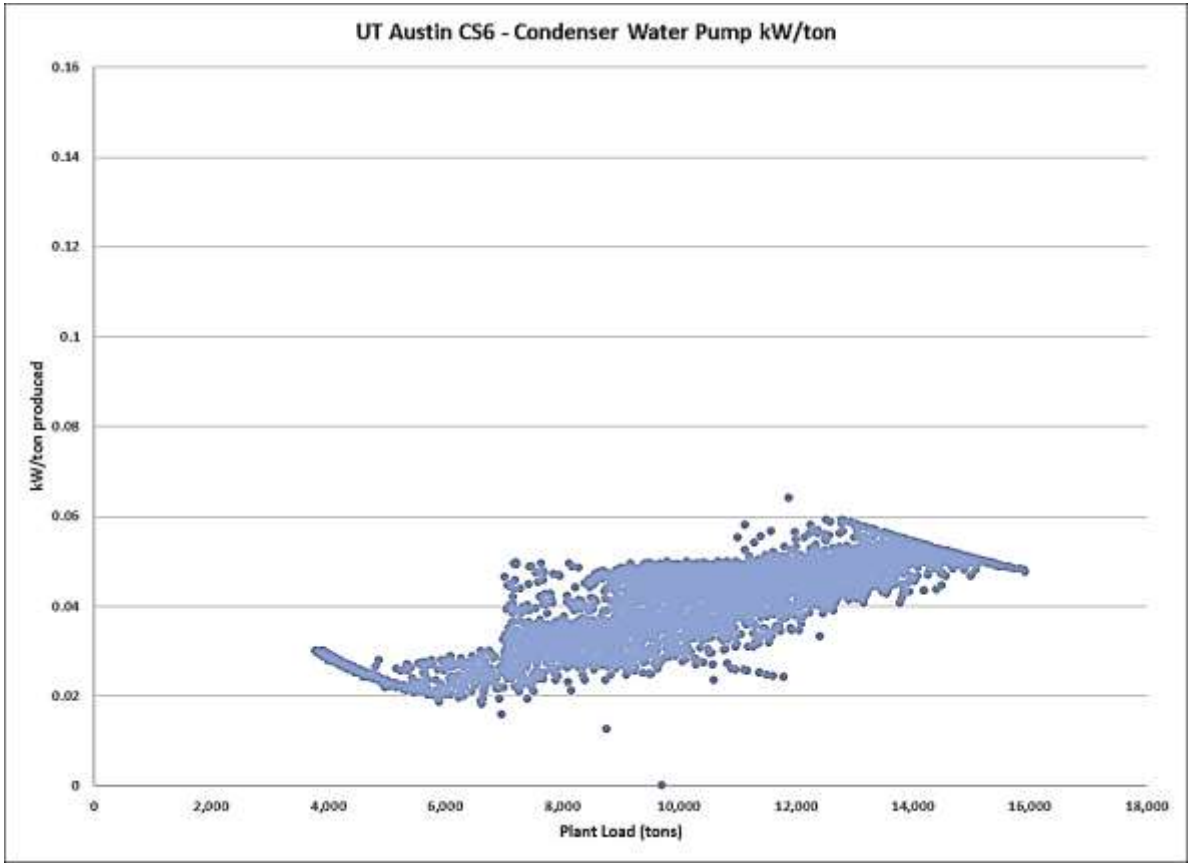
- **Condenser water pump efficiency decreases as load decreases**
- **Primary pumps behave exactly the same**
- **This is the result of constant speed pumping and lack of VFDs**
- **Pumps cannot adjust with load so efficiency is a step function based on the number of pumps running**
- **# Pumps On = # Chillers On**
- **Chiller staging becomes a critical factor in overall efficiency**



Variable Speed Condenser Water Pumps

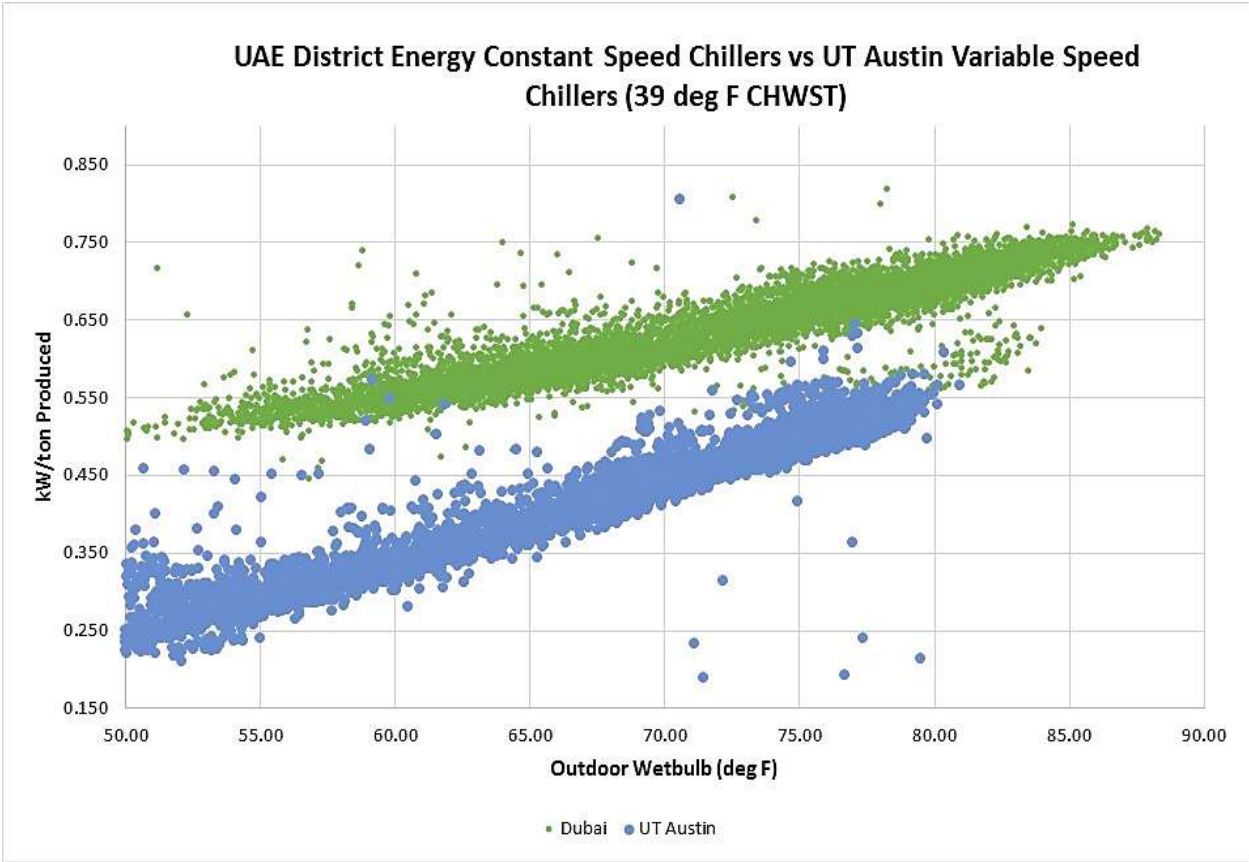
UT Austin

- **Condenser water pump efficiency increases as load decreases**
- **Variable CHW primary-only plant (no primary secondary)**
- **Pumps adjust with load**
- **# Pumps on does not equal # Chillers On**
- **Chiller staging becomes less of a factor in overall efficiency**



Variable Speed Chillers vs. Constant Speed Chillers

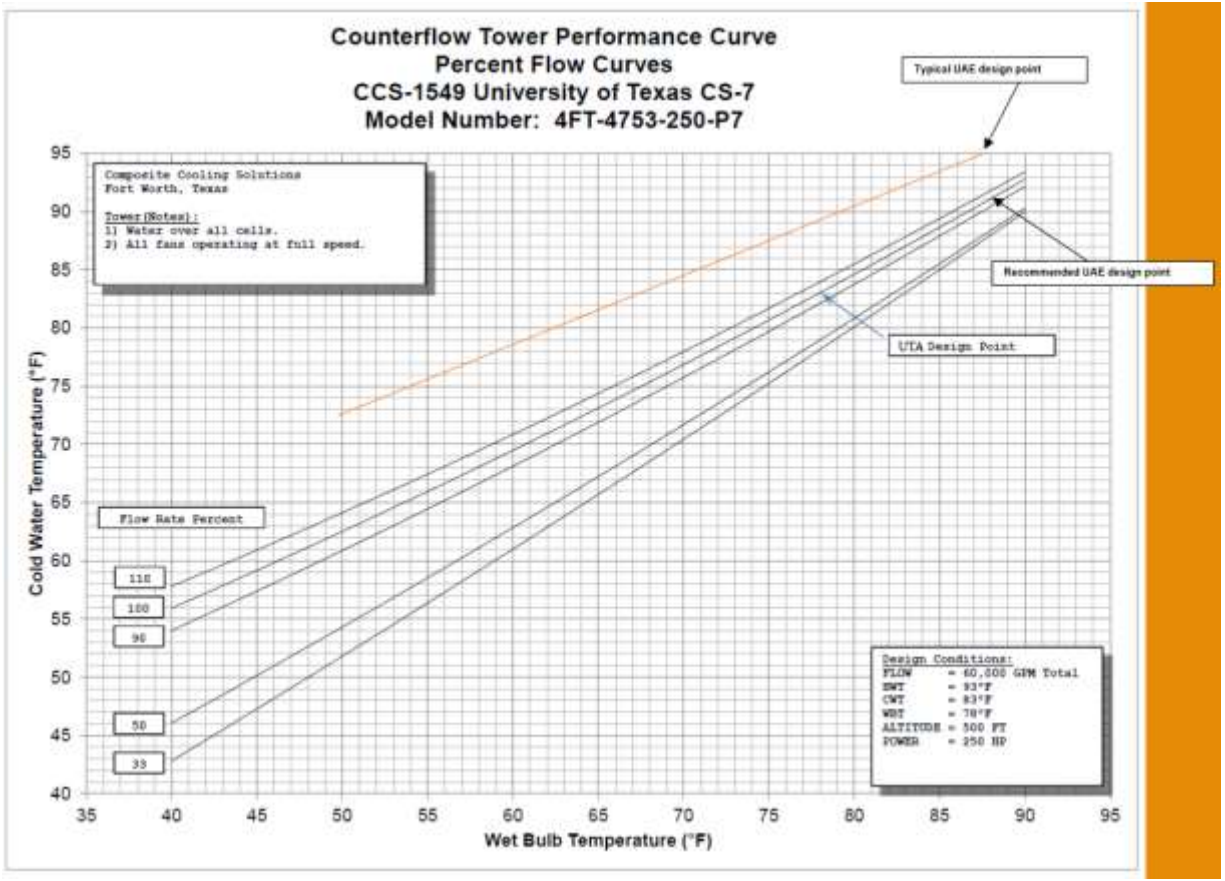
- **Chiller efficiency is linearly proportional to lift**
- **Variable speed chillers are more efficient at all loading due to redundant equipment.**
- **Constant speed chillers use constant speed condenser water pumps**
- **Variable speed chillers are operating at variable condenser water flow**
- **> 20% savings even at high wet bulbs**



Cooling Tower Selection

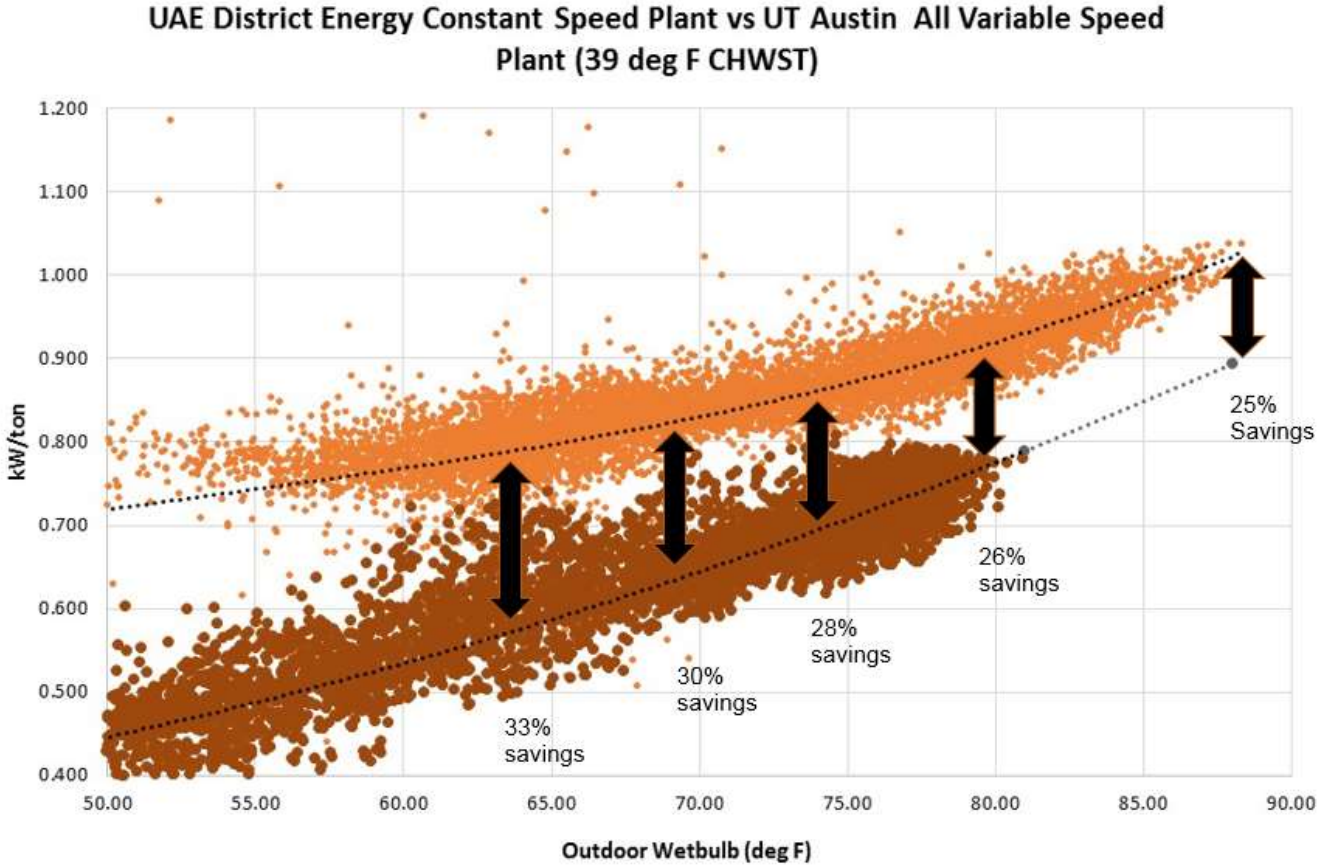
Site	Entering (deg F)	Leaving (deg F)	Wet bulb (deg F)	Approach (deg F)
UT Austin CS7	93	83	78	5
UAE site 1	103.1	93	86	7
UAE site 2	105.1	95	88	7
UAE site 3	105	95	86	9
UAE site 4	104.9	95	87.62	7.38
UAE site 5	103.1	93.2	87.8	5.4
UAE site 6	102.38	93	87.8	5.2
UAE site 7	107.6	96.8	91.4	5.4
UAE site 8	105	95	86	9
Recommended design for UAE	101	91	88	3

Cooling Tower Selection

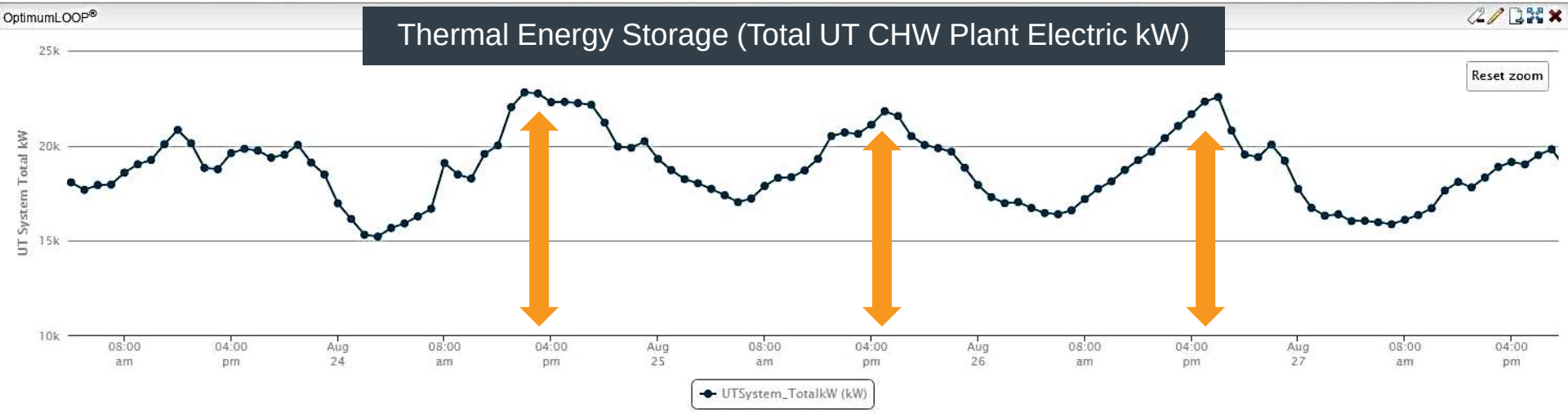


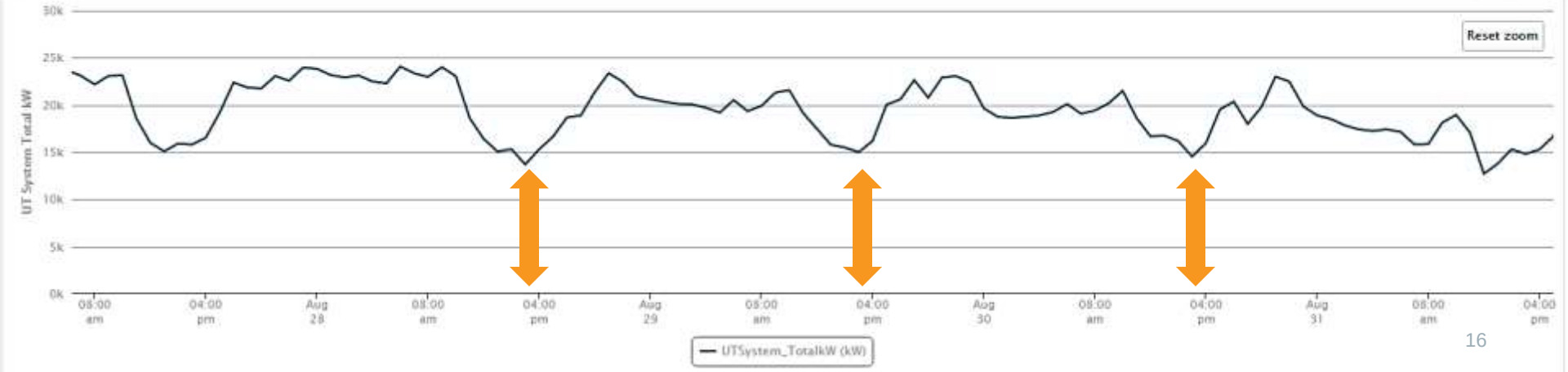
- **Approach gets worse as wet bulb decreases**
- **Approach improves significantly at part flow conditions**
- **It is possible at 33% flow to operate at less than a 1 deg F approach**
- **Towers at UT Austin are consistently operating at 1.5 to 2.5 deg F approaches year round.**

All Variable Speed Chilled Water Plant



Thermal Energy Storage (Total UT CHW Plant Electric kW)





Questions?

JUAN ONTIVEROS, P.E.
The University of Texas at Austin
Juan.Ontiveros@austin.utexas.edu

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BEN ERPELDING, P.E.
Optimum Energy
ben.erpelding@optimumenergyco.com

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