The University of Texas Roadmap for Cooling System Improvements

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SHARING SOLUTIONS, SUSTAINING OUR FUTURE
CampusEnergy2018
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Agenda

- Background of Chilled Water System
- Review of Early Optimization Efforts
- Current Status of System
- Targeted Approaches Used

UT's Chilled Water System

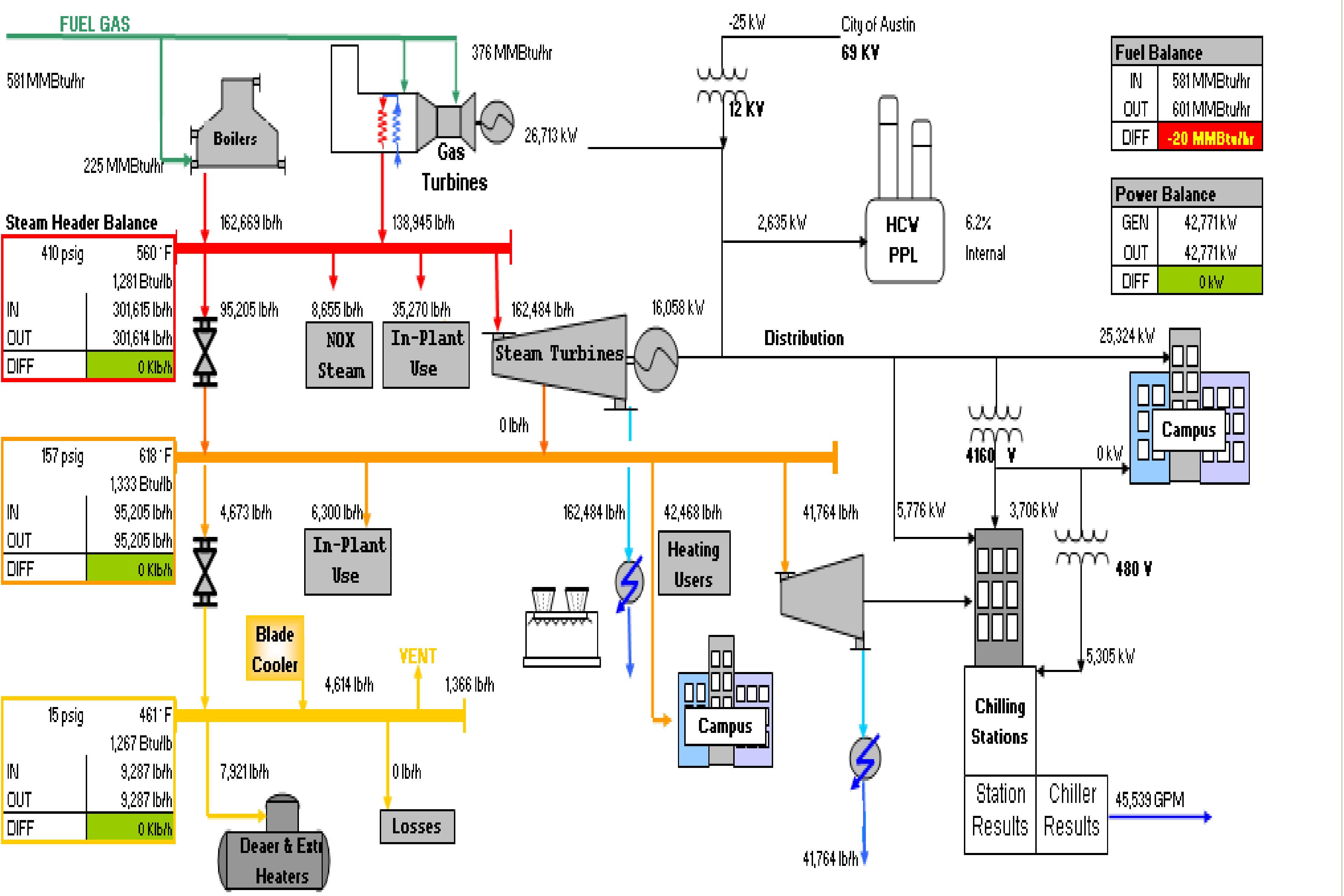
- 60,000 tons of capacity
- 5 chilled water plants
- 18 electrical centrifugal chillers (2,500 to 5,000 tons)
- 18 miles of loop piping
- 3.6 MG, 36,000 ton hour & 5.5 MG, 55,000 ton hour thermal storage tanks
- Nearly 200 connected loads
- Over 200 loop valves
- 35 primary chilled water pumps
- Variable primary pumps in plants
- Variable secondary pumps in buildings

Operations at a Glance

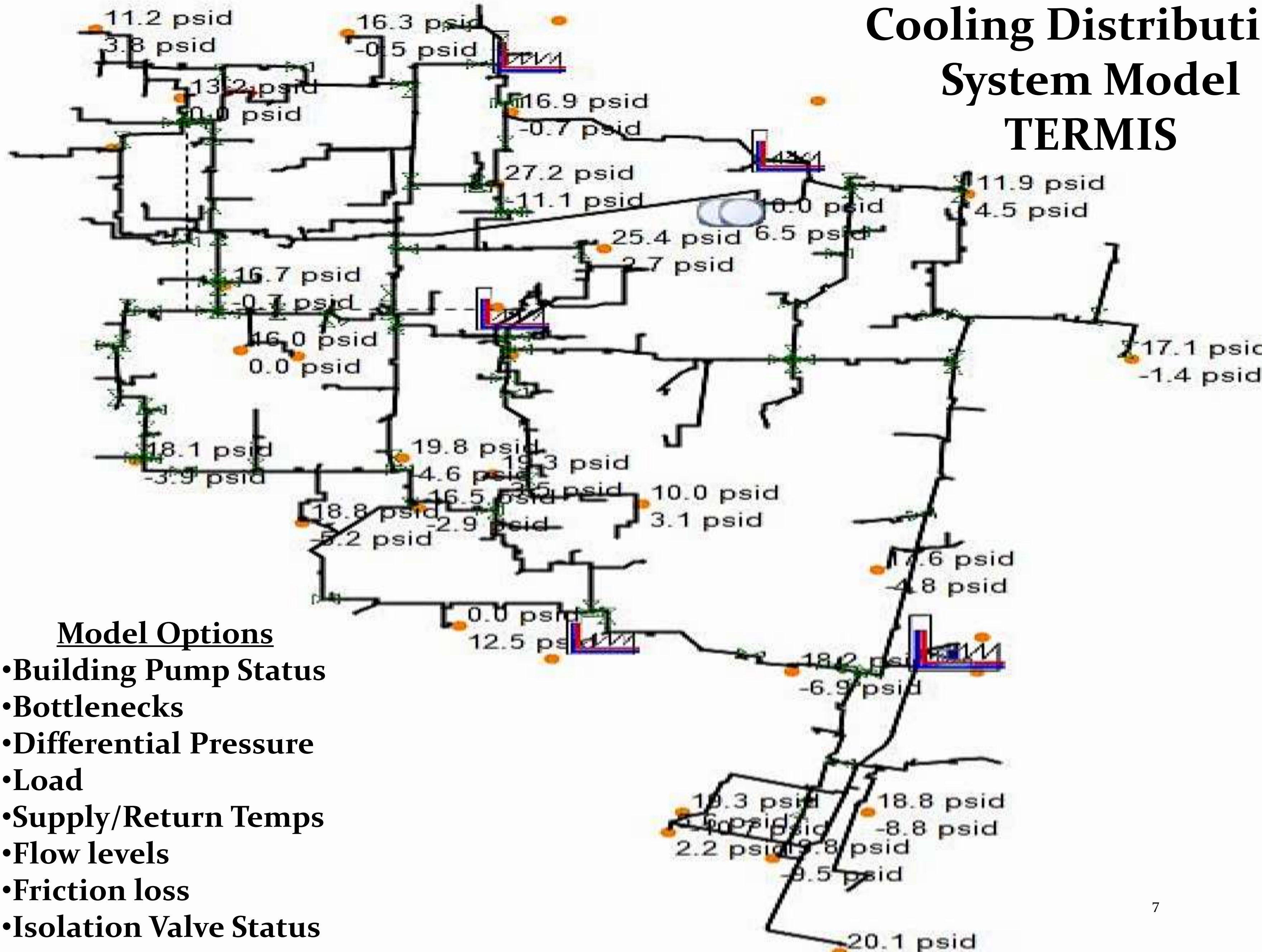
- Peak Cooling Load – 36,000 Tons
- Peak Chilled Water Flow – 45,000 gpm
- Average Supply Temperature - 39°F
- Average Return Temperature - 49°F
- Average Supply Pressure at Plants – 100 psig
- Peak Supply Pressure at Plants – 125 psig
- Total Annual Production 137,000,000 Ton-Hours
- Total Annual Power to Plants – 80,000,000 kWh

Chilled Water System Roadmap

- Started with Power Plant Optimization
- Linked Chilled Water System to Optimization
- First all VFD cooling plant in 2007
- Learned the value of primary pumps in 2009
  - Used Termis (real time model) to investigate DP reduction
- Used OE to link plants to loop optimization


FUEL GAS
581 MMBtu/hr
376 MMBtu/hr
225 MMBtu/hr
Boilers
Gas Turbines
26,713 kW
-25 kW
City of Austin
69 KV
12 KV
2,635 kW
HCV PPL
6.2%
Internal
Fuel Balance
IN 581 MMBtu/hr
OUT 601 MMBtu/hr
DIFF -20 MMBtu/hr
Power Balance
GEN 42,771 kW
OUT 42,771 kW
DIFF 0 kW
Steam Header Balance
410 psig 560 °F
1,281 Btu/lb
IN 301,615 lb/h
OUT 301,614 lb/h
DIFF 0 Klb/h
162,669 lb/h
138,945 lb/h
95,205 lb/h
8,655 lb/h
NOX Steam
35,270 lb/h
In-Plant Use
162,484 lb/h
Steam Turbines
16,058 kW
Distribution
25,324 kW
Campus
0 lb/h
157 psig 618 °F
1,333 Btu/lb
IN 95,205 lb/h
OUT 95,205 lb/h
DIFF 0 Klb/h
4,673 lb/h
6,300 lb/h
In-Plant Use
162,484 lb/h
42,468 lb/h
Heating Users
41,764 lb/h
5,776 kW
4160 V
3,706 kW
0 kW
480 V
5,305 kW
Blade Cooler
VENT
4,614 lb/h
1,366 lb/h
15 psig 461 °F
1,267 Btu/lb
IN 9,287 lb/h
OUT 9,287 lb/h
DIFF 0 Klb/h
7,921 lb/h
0 lb/h
Losses
Deaer & Extr Heaters
Campus
41,764 lb/h
Chilling Stations
Station Results
Chiller Results
45,539 GPM

Cooling Distribution System Model TERMIS



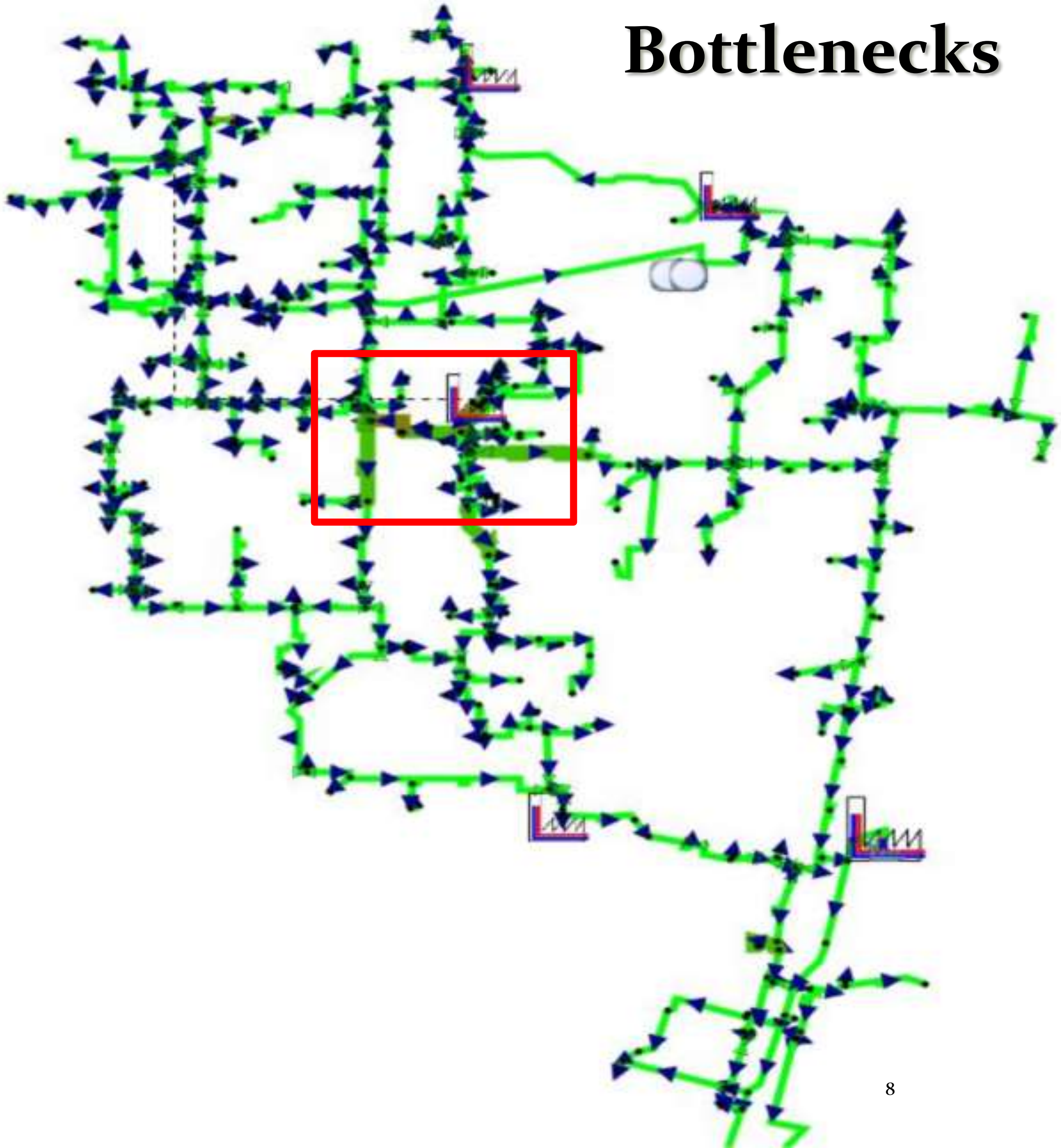
Model Options

- Building Pump Status
- Bottlenecks
- Differential Pressure
- Load
- Supply/Return Temps
- Flow levels
- Friction loss
- Isolation Valve Status

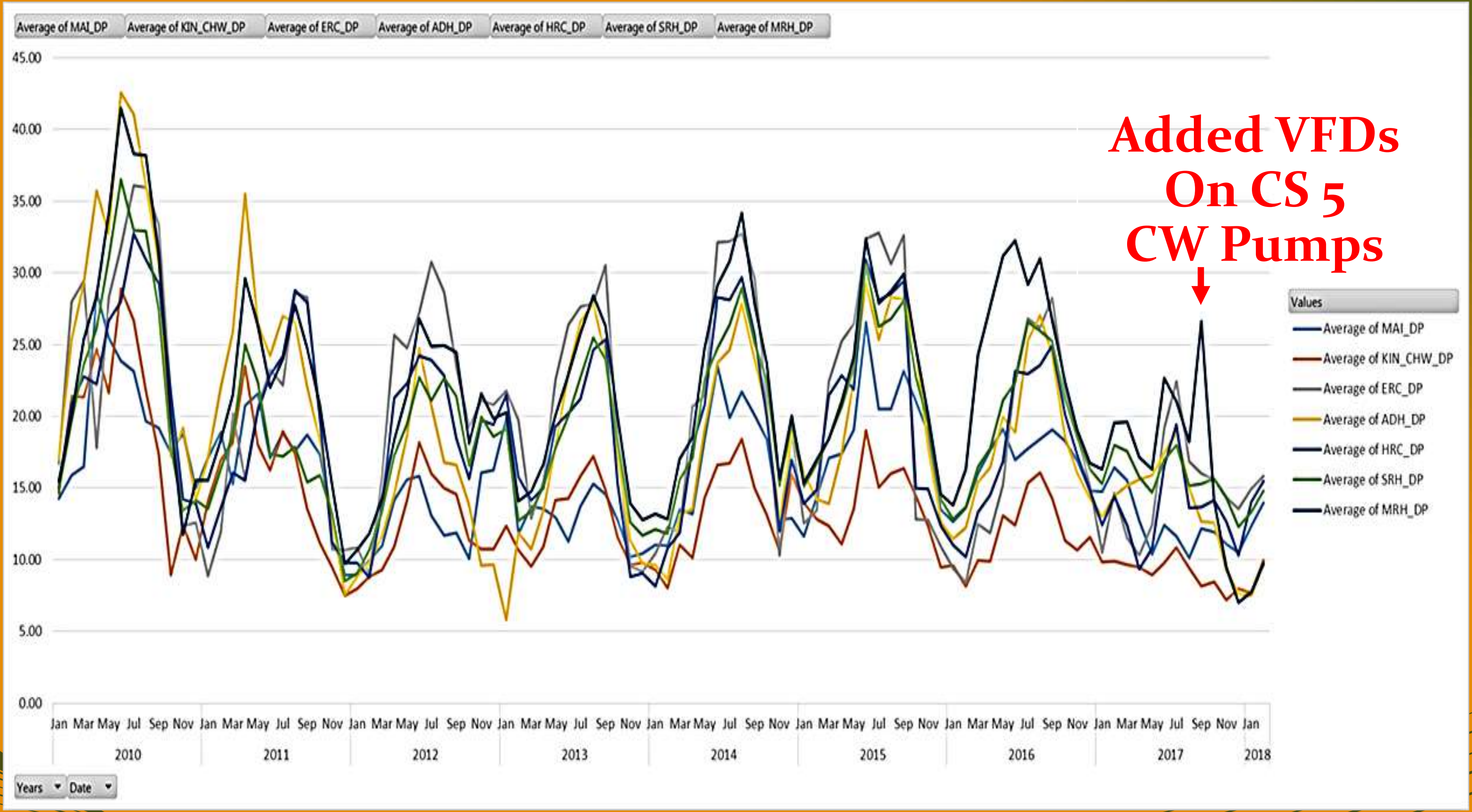
Bottlenecks

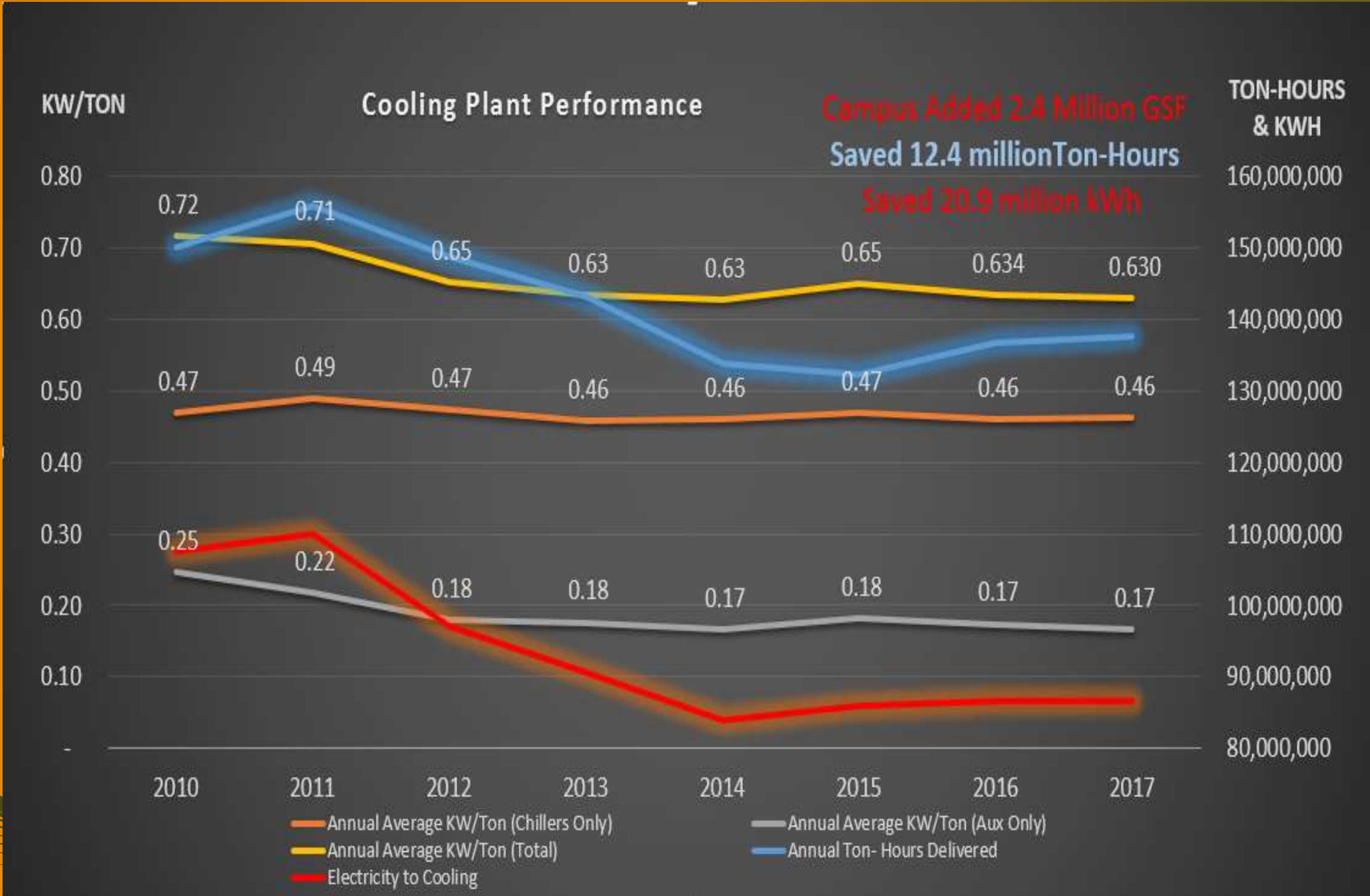
Pressure Gradients [TONS]

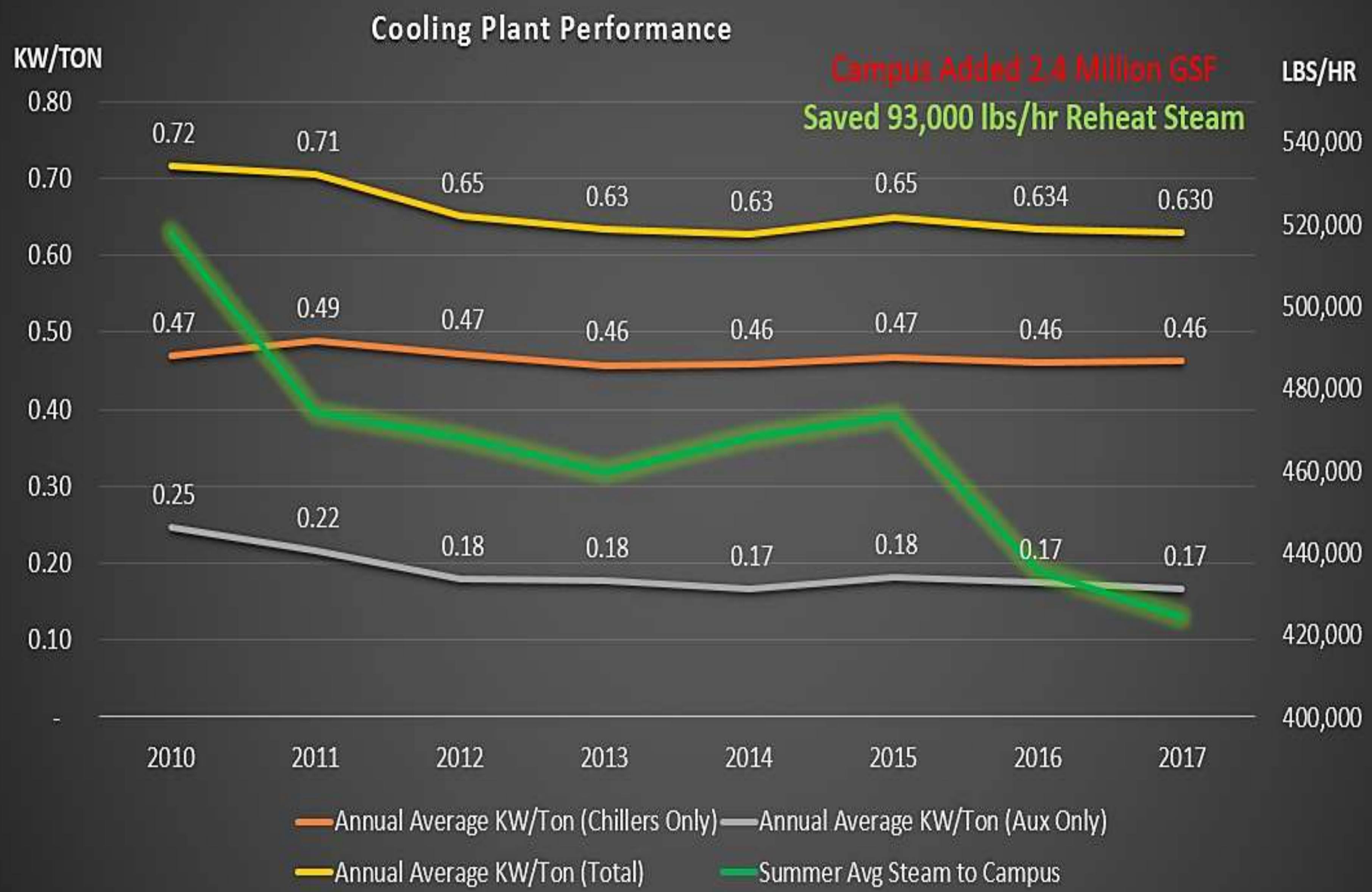
10.0	-		3
7.0	10.0		2
3.0	7.0		2
1.0	3.0		2
-	1.0		1



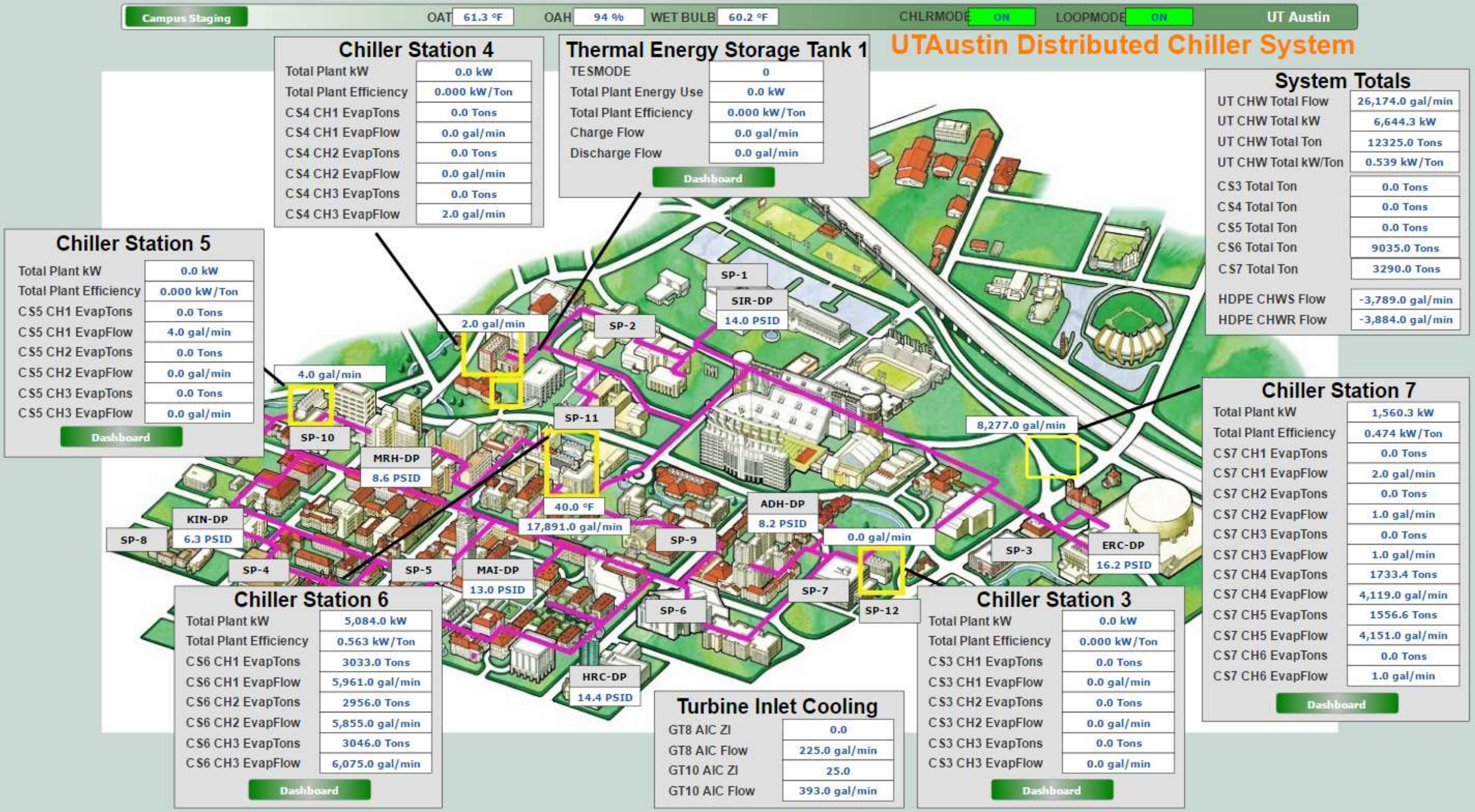
DP Reduction History




KW/TON
Cooling Plant Performance
Campus Added 2.4 Million GSF
Saved 12.4 millionTon-Hours
Saved 20.9 million kWh
TON-HOURS & KWH
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
-
160,000,000
150,000,000
140,000,000
130,000,000
120,000,000
110,000,000
100,000,000
90,000,000
80,000,000
0.72
0.71
0.65
0.63
0.63
0.65
0.634
0.630
0.47
0.49
0.47
0.46
0.46
0.47
0.46
0.46
0.25
0.22
0.18
0.18
0.17
0.18
0.17
0.17
2010
2011
2012
2013
2014
2015
2016
2017
Annual Average KW/Ton (Chillers Only)
Annual Average KW/Ton (Aux Only)
Annual Average KW/Ton (Total)
Annual Ton- Hours Delivered
Electricity to Cooling


Cooling Plant Performance
KW/TON
LBS/HR
Campus Added 2.4 Million GSF
Saved 93,000 lbs/hr Reheat Steam
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
-
540,000
520,000
500,000
480,000
460,000
440,000
420,000
400,000
0.72
0.71
0.65
0.63
0.63
0.65
0.634
0.630
0.47
0.49
0.47
0.46
0.46
0.47
0.46
0.46
0.25
0.22
0.18
0.18
0.17
0.18
0.17
0.17
2010
2011
2012
2013
2014
2015
2016
2017
Annual Average KW/Ton (Chillers Only)
Annual Average KW/Ton (Aux Only)
Annual Average KW/Ton (Total)
Summer Avg Steam to Campus

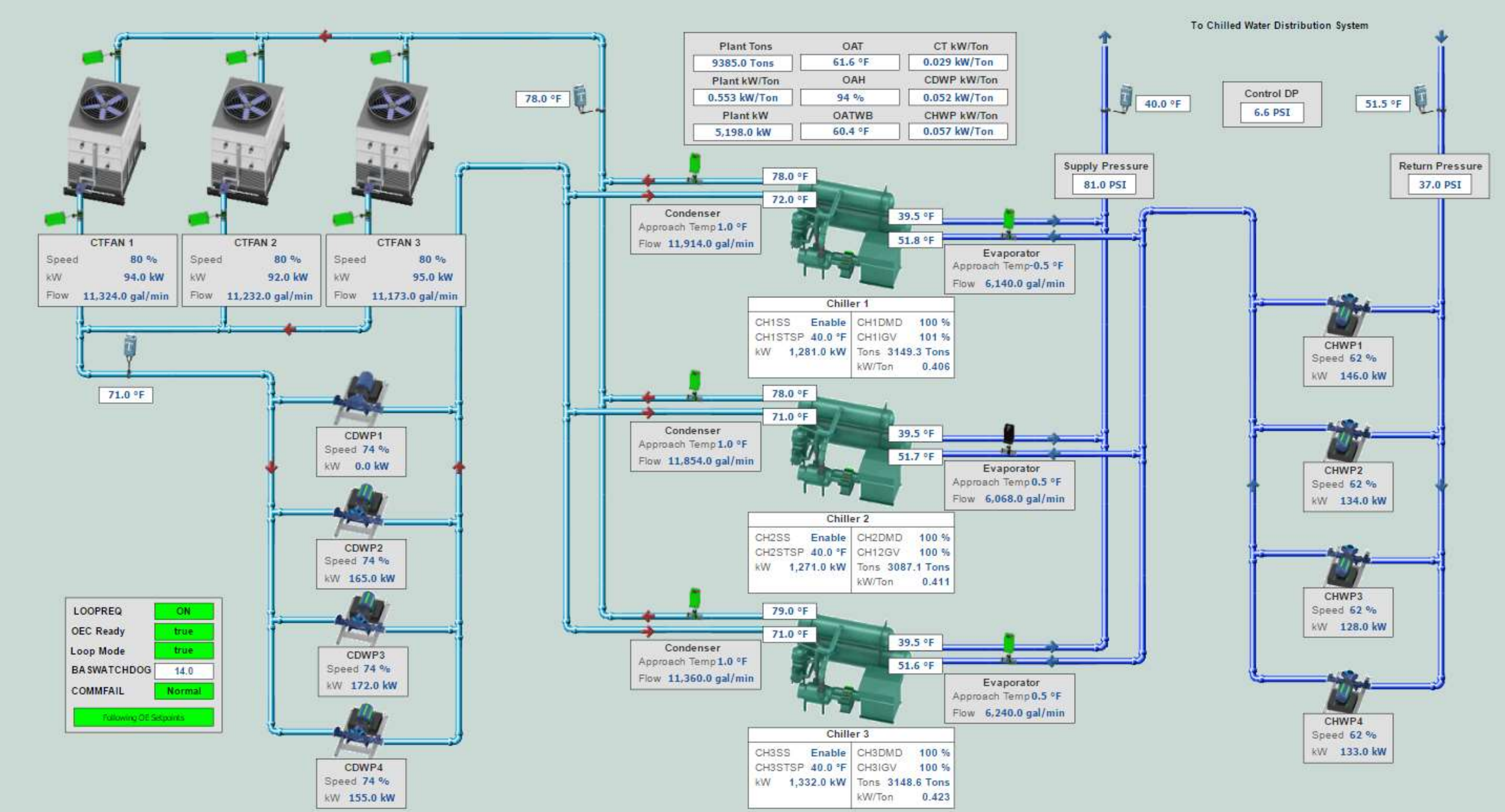
The Foundation of UT's Optimization


Campus Staging
OAT 61.3 °F
OAH 94 %
WET BULB 60.2 °F
CHLRMODE ON
LOOPMODE ON
UT Austin
UTAustin Distributed Chiller System
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 0
Total Plant Energy Use 0.0 kW
Total Plant Efficiency 0.000 kW/Ton
Charge Flow 0.0 gal/min
Discharge Flow 0.0 gal/min
Dashboard
System Totals
UT CHW Total Flow 26,174.0 gal/min
UT CHW Total kW 6,644.3 kW
UT CHW Total Ton 12325.0 Tons
UT CHW Total kW/Ton 0.539 kW/Ton
CS3 Total Ton 0.0 Tons
CS4 Total Ton 0.0 Tons
CS5 Total Ton 0.0 Tons
CS6 Total Ton 9035.0 Tons
CS7 Total Ton 3290.0 Tons
HDPE CHWS Flow -3,789.0 gal/min
HDPE CHWR Flow -3,884.0 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 4.0 gal/min
CS5 CH2 EvapTons 0.0 Tons
CS5 CH2 EvapFlow 0.0 gal/min
CS5 CH3 EvapTons 0.0 Tons
CS5 CH3 EvapFlow 0.0 gal/min
Dashboard
SP-1
SIR-DP 14.0 PSID
2.0 gal/min
SP-2
4.0 gal/min
SP-10
SP-11
MRH-DP 8.6 PSID
8,277.0 gal/min
40.0 °F
17,891.0 gal/min
ADH-DP 8.2 PSID
KIN-DP 6.3 PSID
SP-8
SP-4
SP-5
MAI-DP 13.0 PSID
SP-9
0.0 gal/min
SP-3
ERC-DP 16.2 PSID
SP-7
SP-6
SP-12
HRC-DP 14.4 PSID
Chiller Station 7
Total Plant kW 1,560.3 kW
Total Plant Efficiency 0.474 kW/Ton
CS7 CH1 EvapTons 0.0 Tons
CS7 CH1 EvapFlow 2.0 gal/min
CS7 CH2 EvapTons 0.0 Tons
CS7 CH2 EvapFlow 1.0 gal/min
CS7 CH3 EvapTons 0.0 Tons
CS7 CH3 EvapFlow 1.0 gal/min
CS7 CH4 EvapTons 1733.4 Tons
CS7 CH4 EvapFlow 4,119.0 gal/min
CS7 CH5 EvapTons 1556.6 Tons
CS7 CH5 EvapFlow 4,151.0 gal/min
CS7 CH6 EvapTons 0.0 Tons
CS7 CH6 EvapFlow 1.0 gal/min
Dashboard
Chiller Station 6
Total Plant kW 5,084.0 kW
Total Plant Efficiency 0.563 kW/Ton
CS6 CH1 EvapTons 3033.0 Tons
CS6 CH1 EvapFlow 5,961.0 gal/min
CS6 CH2 EvapTons 2956.0 Tons
CS6 CH2 EvapFlow 5,855.0 gal/min
CS6 CH3 EvapTons 3046.0 Tons
CS6 CH3 EvapFlow 6,075.0 gal/min
Dashboard
Turbine Inlet Cooling
GT8 AIC ZI 0.0
GT8 AIC Flow 225.0 gal/min
GT10 AIC ZI 25.0
GT10 AIC Flow 393.0 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

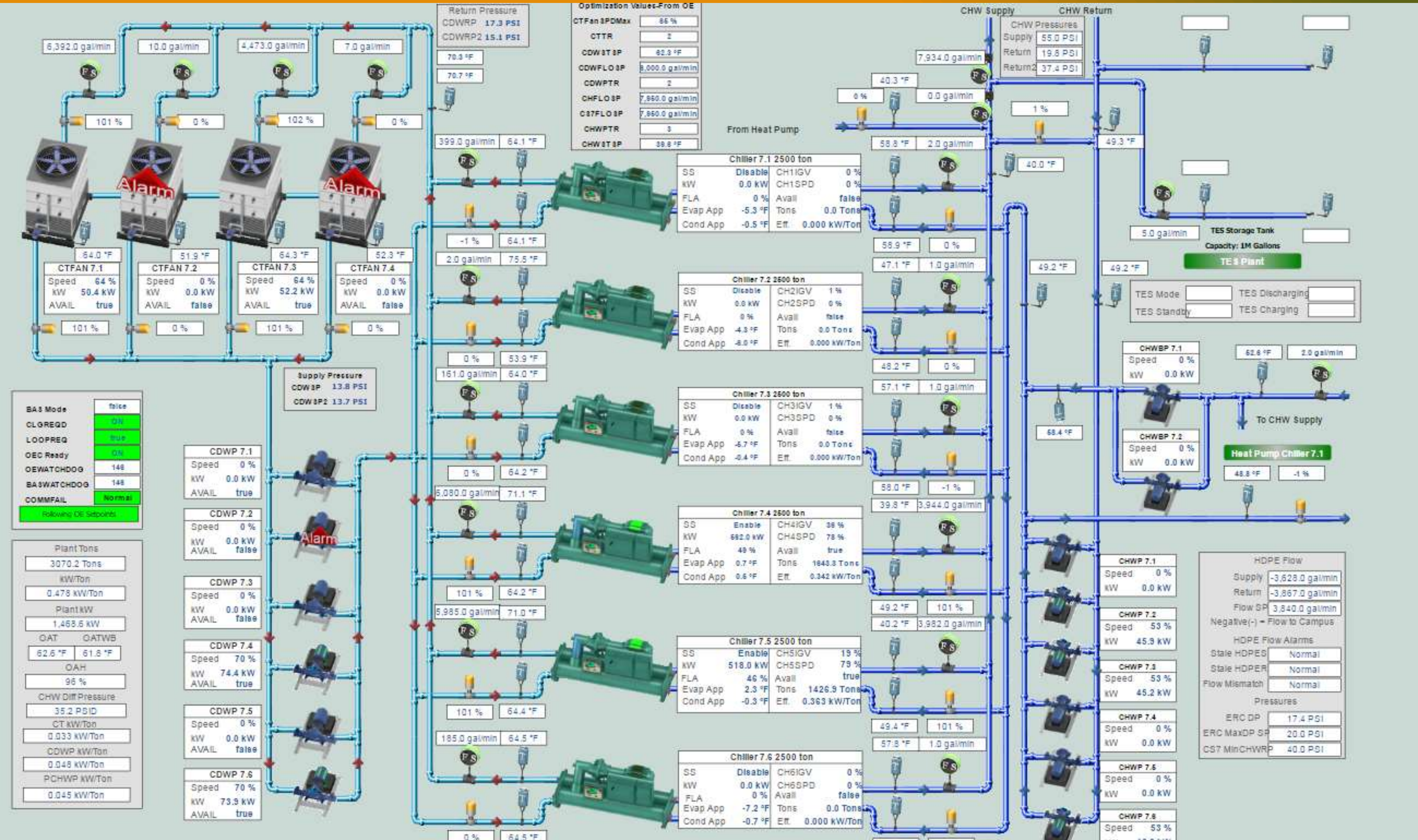
Step 1: CS6 – Master DP Control

Campus CHWDP Control at CS6

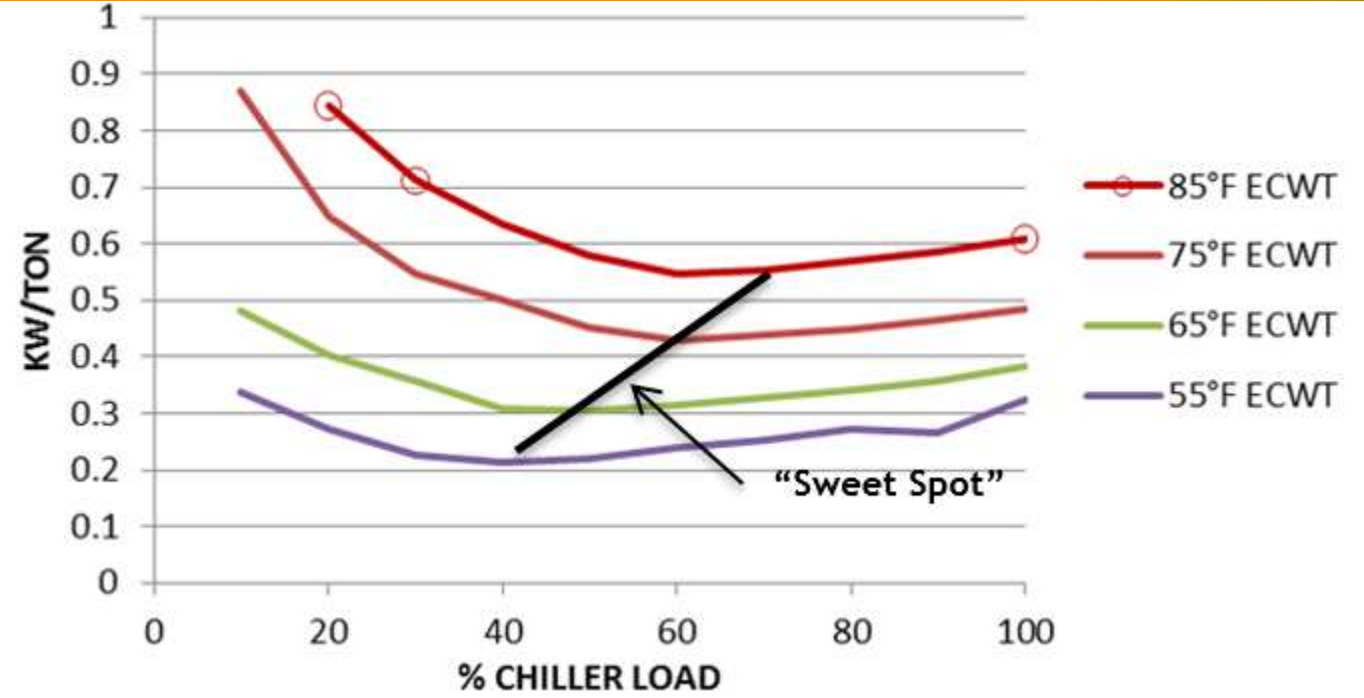
1	KIN	6.5 PSID	OE DP Setpoint	6.2 PSID
2	MAI	13.3 PSID	Control DP	6.5 PSI
3	HRC	15.1 PSID	Pump Speed	62 %
4	ERC	17.4 PSID		
5	MRH	9.1 PSID		
6	SIR	14.5 PSID		
7	ADH	8.2 PSID		



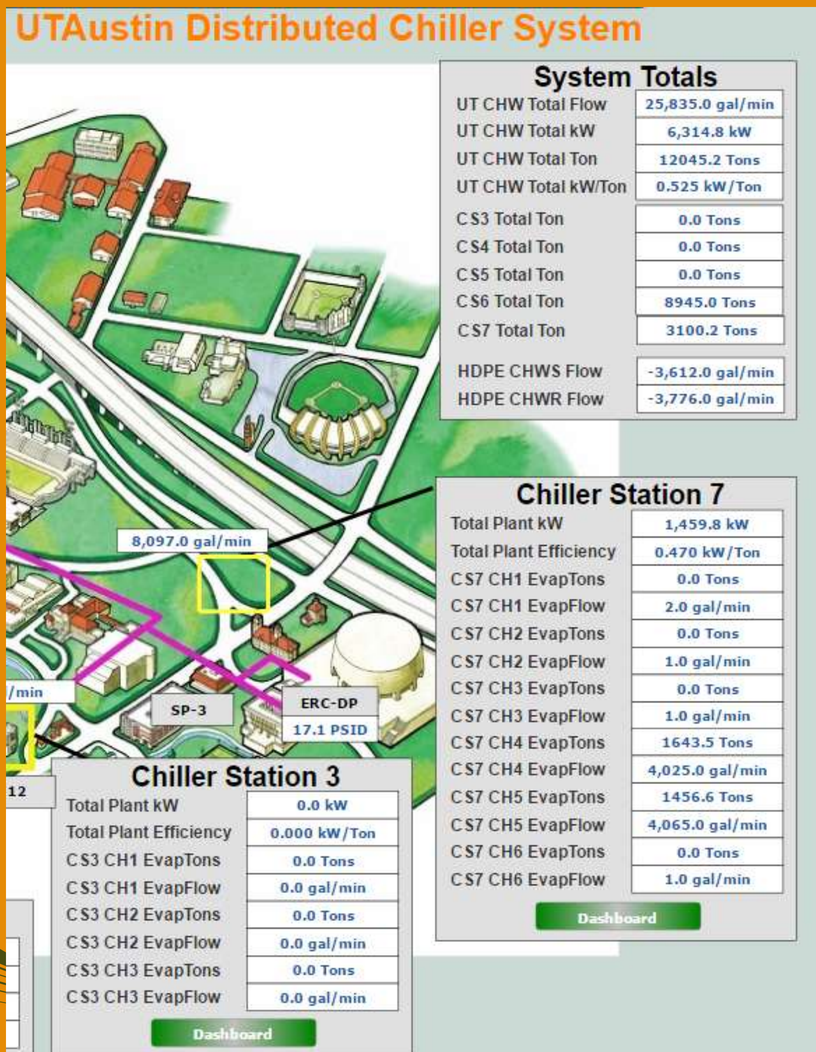
Step 2: CS7 – Sweet Spot Optimization



Step 2: CS7 – Sweet Spot Optimization



Step 3: CS7 – Maximize Output



HDPE Flow

Supply	-3,680.0 gal/min
Return	-3,792.0 gal/min
Flow SP	3,819.9 gal/min

Negative(-) = Flow to Campus

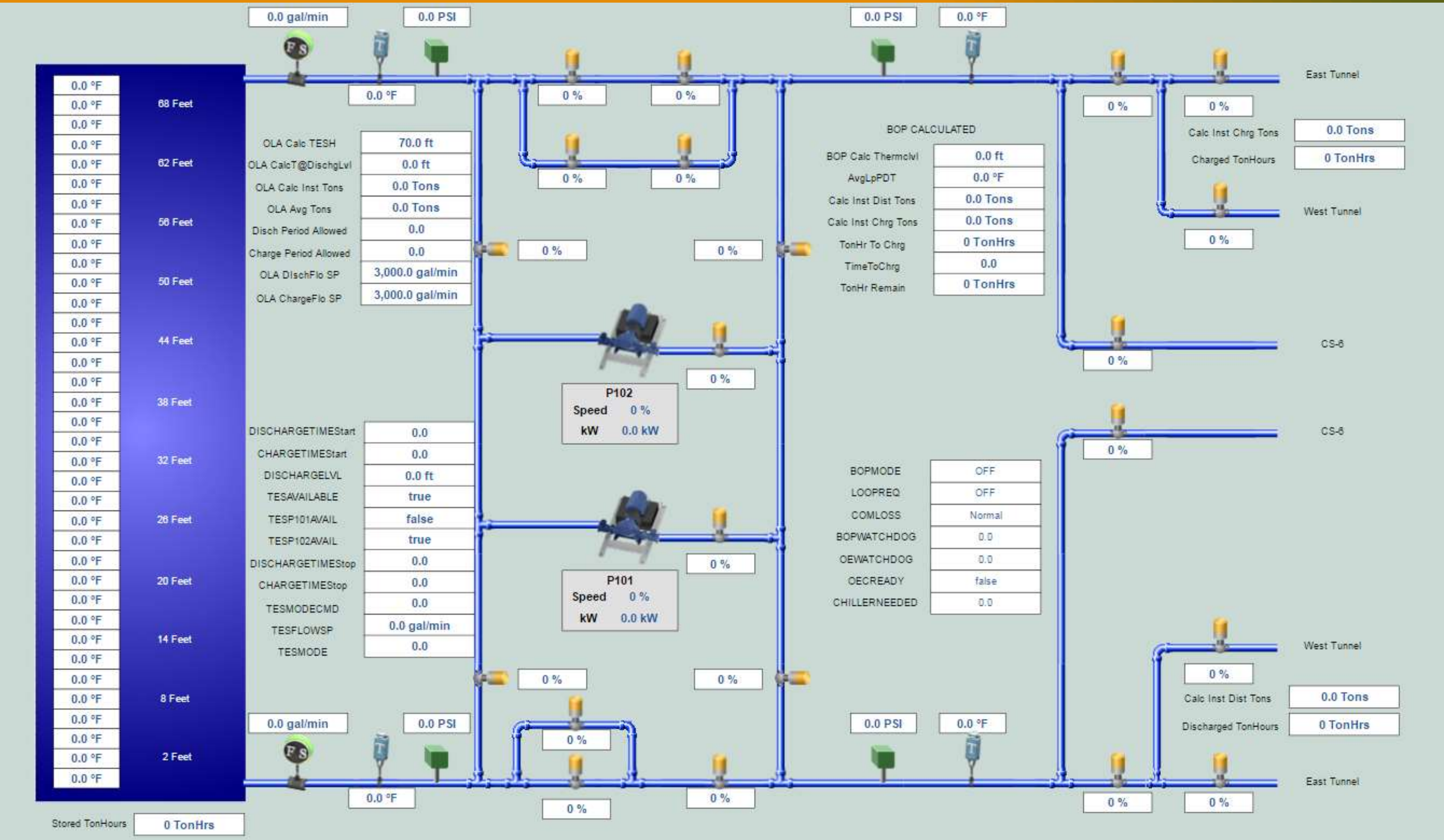
HDPE Flow Alarms

Stale HDPES	Normal
Stale HDPER	Normal
Flow Mismatch	Normal

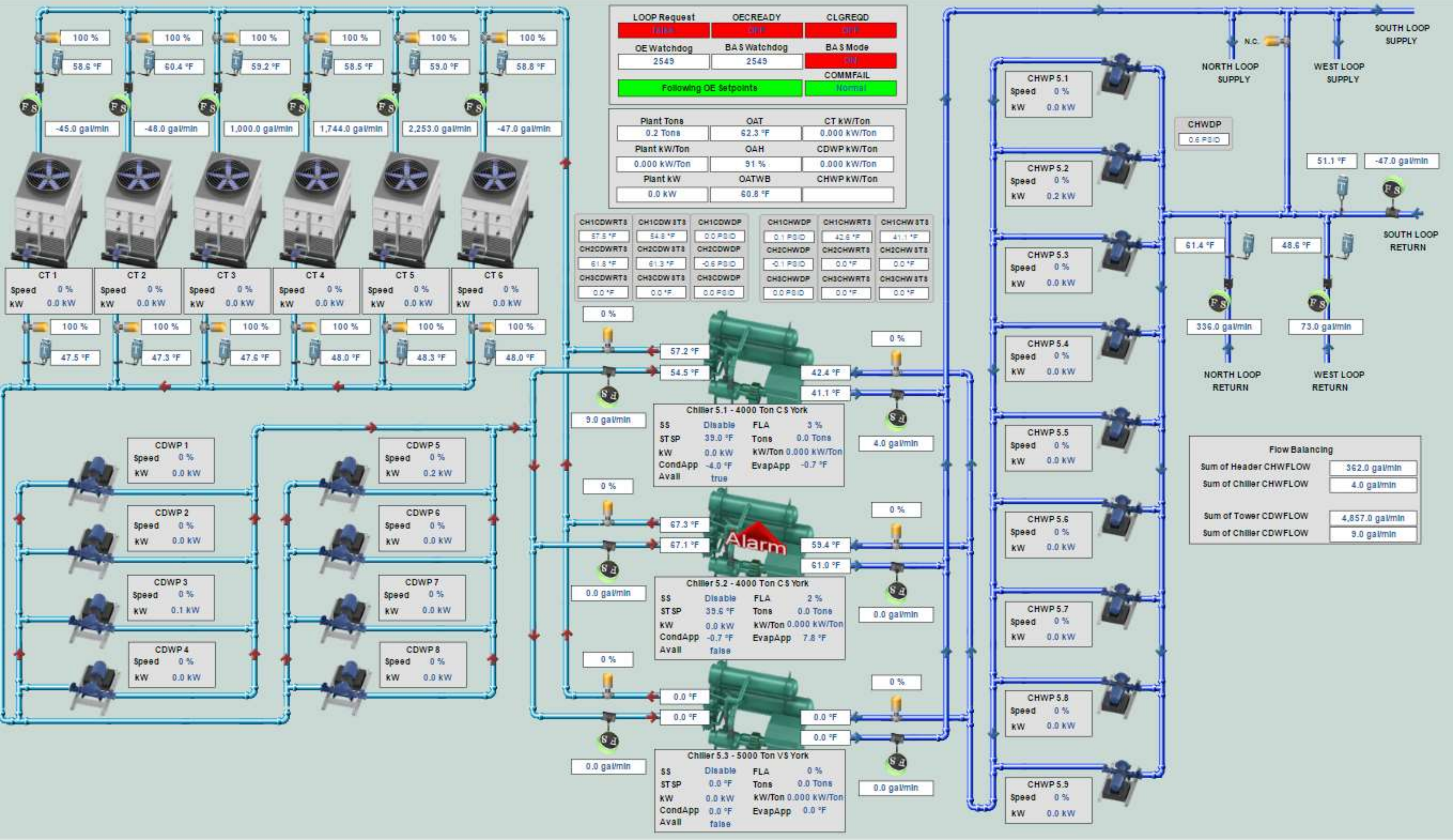
Pressures

ERC DP	17.0 PSI
ERC MaxDP SP	20.0 PSI
CS7 MinCHWRP	40.0 PSI

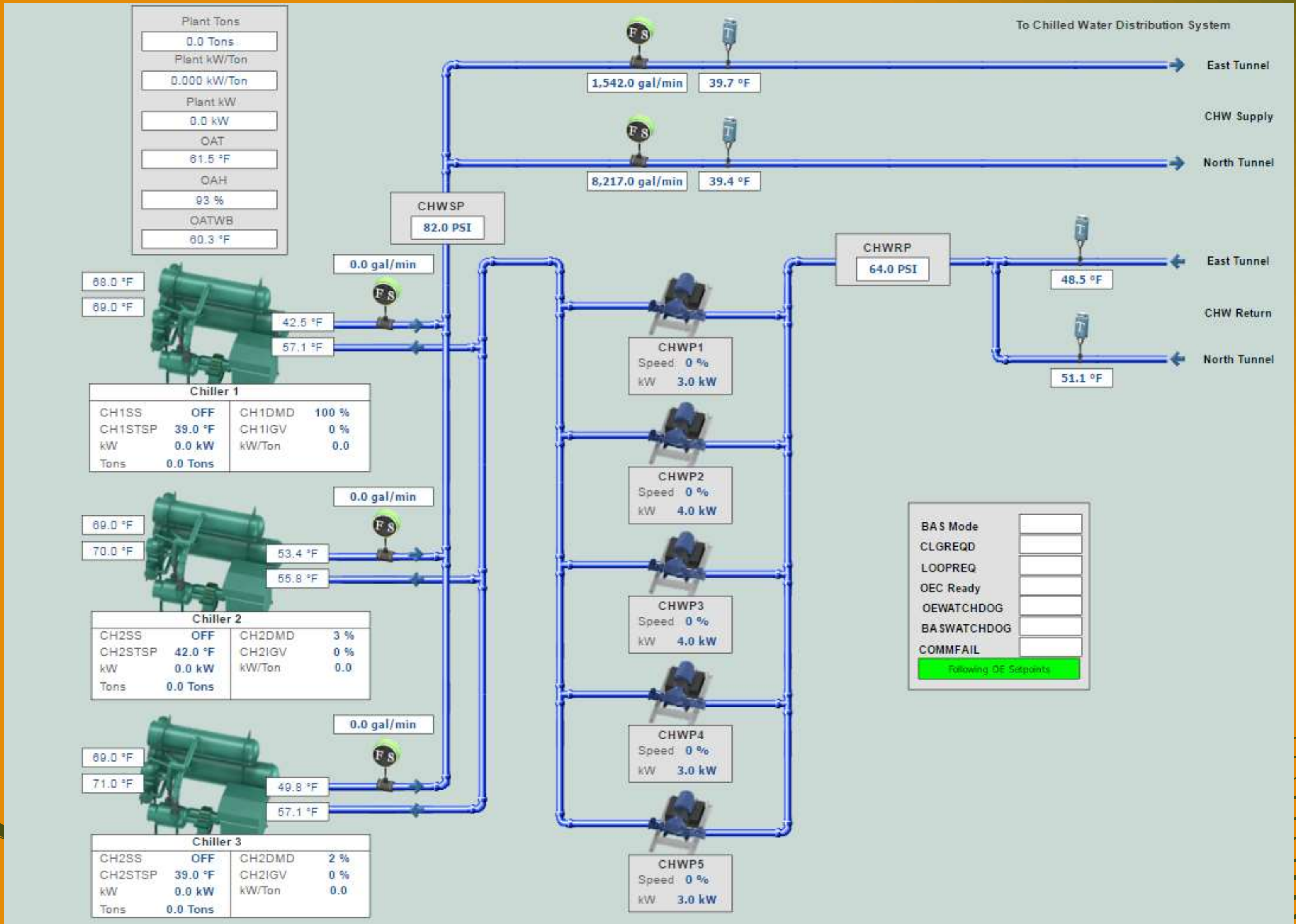
Step 4: TES Discharge



Step 5: CS5 – Flow Control (imitate CS6)



Step 6: CS3 – Flow Control (maximize CS Chiller output while keeping CS6 at 12,500 tons)



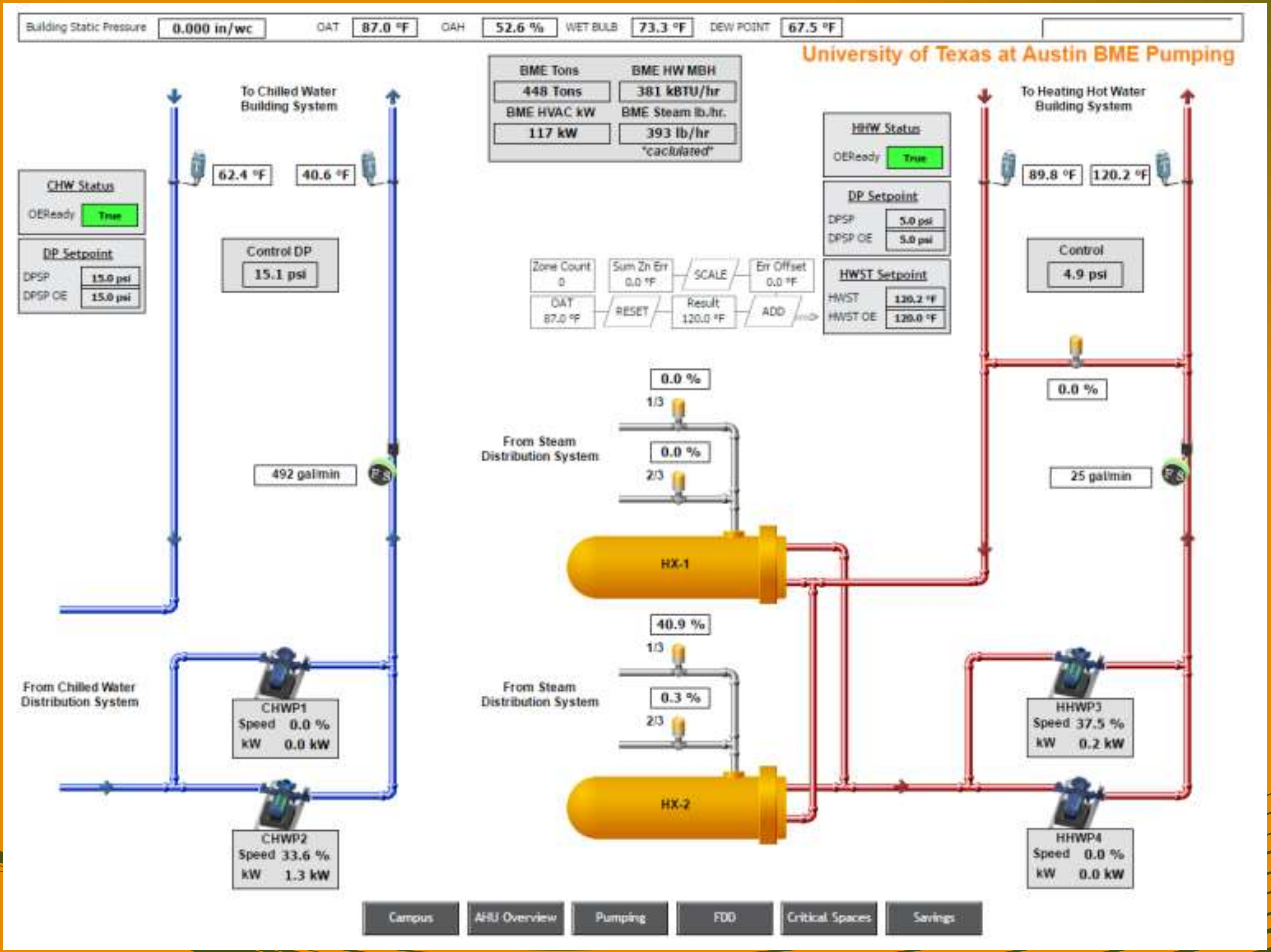
Step 7: Campus Chiller Shed (excess tons)

UT Austin Campus Chillers

	Tons	Desired Max Tons	Excess Tons	CHW Flow	Availability	CHWST
CS6			4266.0 Tons			
CH6.1	2935.2 Tons	4333.0 Tons	1390.0 Tons	5,817.0 gal/min	true	39.5 °F
CH6.2	2840.7 Tons	4333.0 Tons	1484.0 Tons	5,710.0 gal/min	true	39.6 °F
CH6.3	2954.2 Tons	4333.0 Tons	1392.0 Tons	5,953.0 gal/min	true	39.5 °F
CS3			0.0 Tons			
CH3.1	0.0 Tons	5500.0 Tons	0.0 Tons	0.0 gal/min	true	42.5 °F
CH3.2	0.0 Tons	3500.0 Tons	0.0 Tons	0.0 gal/min	true	53.3 °F
CH3.3	0.0 Tons	3500.0 Tons	0.0 Tons	0.0 gal/min	true	49.8 °F
CS5			0.0 Tons			
CH5.1	0.0 Tons	4000.0 Tons	0.0 Tons	4.0 gal/min	true	41.1 °F
CH5.2	0.0 Tons	4000.0 Tons	0.0 Tons	0.0 gal/min	false	0.0 °F
CH5.3	0.0 Tons	5000.0 Tons	0.0 Tons	0.0 gal/min	false	0.0 °F
CS4			0.0 Tons			
CH4.1	0.0 Tons	0.0 Tons	0.0 Tons	0.0 gal/min	BOP Only	0.0 °F
CH4.2	0.0 Tons	3000.0 Tons	0.0 Tons	0.0 gal/min	BOP Only	0.0 °F
CH4.3	0.0 Tons	3000.0 Tons	0.0 Tons	2.0 gal/min	BOP Only	0.0 °F
TES						
TES1	0.0 Tons	0.0 Tons	0.0 Tons	0.0 gal/min	true	0.0 °F

4549.0 Tons	-	0.0 Tons	-	0.0 Tons	=	0.0 Tons		
Sum Excess Tons		- Max Tons (Non CS6)		- Max Excess Tons (Non CS6)		= Shed Event Tons		> 500

Buildings – reducing DP and temperatures



High delta T Syndrome?

- Prior to 2010 – Campus delta T used to average between 7.5 and 11.5 deg F with maximum flow requirement of 70,000 gpm (12 deg F delta T)
- CS5 and CS6 were installed with no low flow chilled water bypass
- 2017 maximum flow requirement is 45,000 gpm (19.2 deg F delta T)
- Chillers are going into minimum flow control (campus pressures increase)
- Possible Solutions we are debating
  - Increase chilled water set point from 39 deg F to 42 deg F
  - Decrease minimum flow to 2 ft/sec in evaporators

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