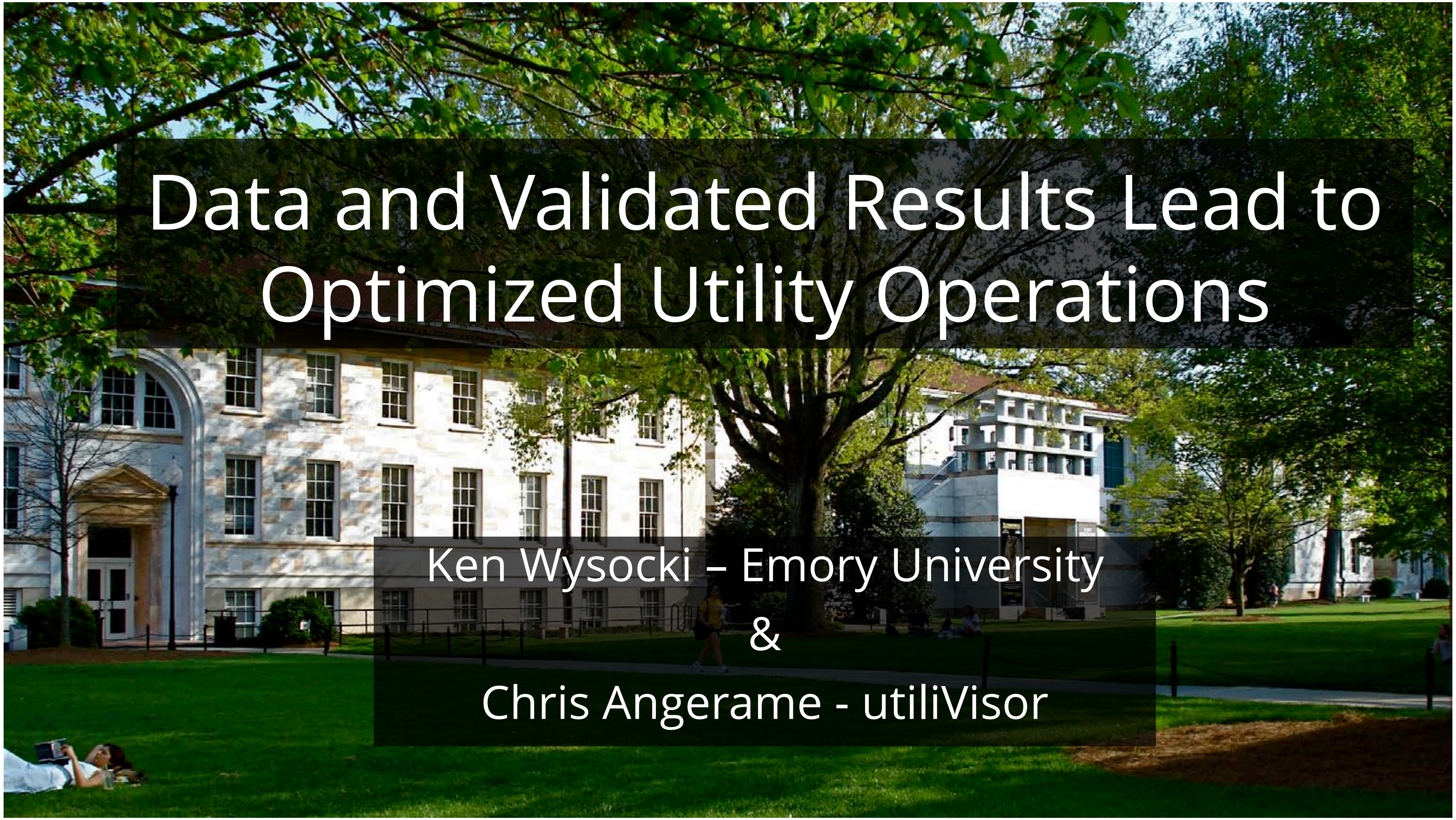


Data and Validated Results Lead to Optimized Utility Operations

Ken Wysocki – Emory University

&

Chris Angerame - utiliVisor

LEADING THE WAY
CampusEnergy2022
Feb.15-18 Westin Boston Seaport District Hotel Boston, MA

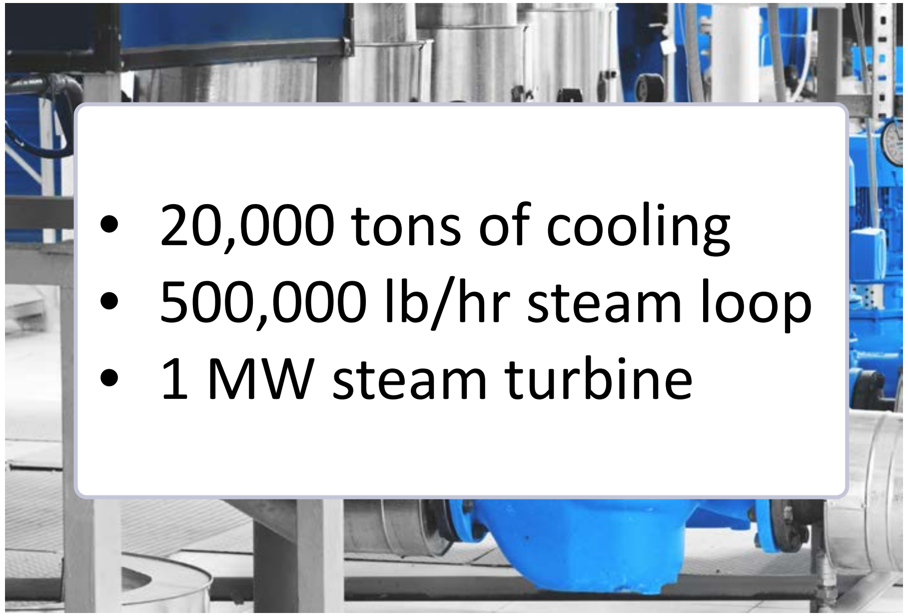
EMORY UNIVERSITY & utiliVisor

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

AGENDA

1. Can Data, Oversight and Action Result in Enhanced Operations and Optimized Plant Performance?
2. Description of Utilities on Campus
3. Operational Culture
4. Operational Constraints
5. Future Challenges of Campus Needs
6. Planning for Expansion
7. Implementation of Continuous Oversight and utiliVisor Operations Center
8. What utiliVisor and Emory University Accomplished
9. Benefits Beyond the Savings
10. Collaboration Moving Forward

Description of Utilities at Emory University



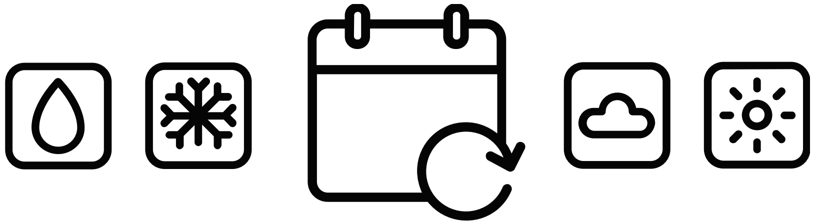
- WMB Plant
  - (6) PCHWPs-30 to 75 HP
  - (6) CWPs-40 to 100 HP
  - (9) CTs-25 to 30 HP
  - SCHWPs-40 to 250 HP
  - WMB 1-650 Tons (0.605 kW/ton)
  - WMB 2-950 Tons (0.642 kW/ton)
  - WMB 3-1250 Tons (0.60 kW/ton)
  - WMB 4-950 Tons (0.642 kW/ton)
  - WMB 5-1000 Tons (0.579 kW/ton)
  - WMB 6-1200 Tons (0.60 kW/ton)
- Quad Plant
  - (5) PCHWPs-125 to 150 HP
  - (5) CWPs-40 to 100 HP
  - (4) CTs-40, 50, 75 and 100 HP
  - Quad 2-1250 Tons (0.631 kW/ton)
  - Quad 3-1000 Tons (0.546 kW/ton)
  - Quad 4-1250 Tons (0.660 kW/ton)
  - Quad 5-1250 Tons (0.660 kW/ton)
- Michael Street Plant
  - (8) PCHWPs-20 to 60 HP
  - (7) CWPs-100 HP
  - (6) CTs-40 HP
  - (6) SCHWPs-100 to 200 HP
  - MSP 1-1000 Tons (0.627 kW/ton)
  - MSP 2-1000 Tons (0.627 kW/ton)
  - MSP 3-550 Tons (0.611 kW/ton)
  - MSP 4-1000 Tons (0.546 kW/ton)
  - MSP 5-1250 Tons (0.631 kW/ton)
  - MSP 6-1250 Tons (0.555 kW/ton)
  - MSP 7-1300 Tons (0.560 kW/ton)

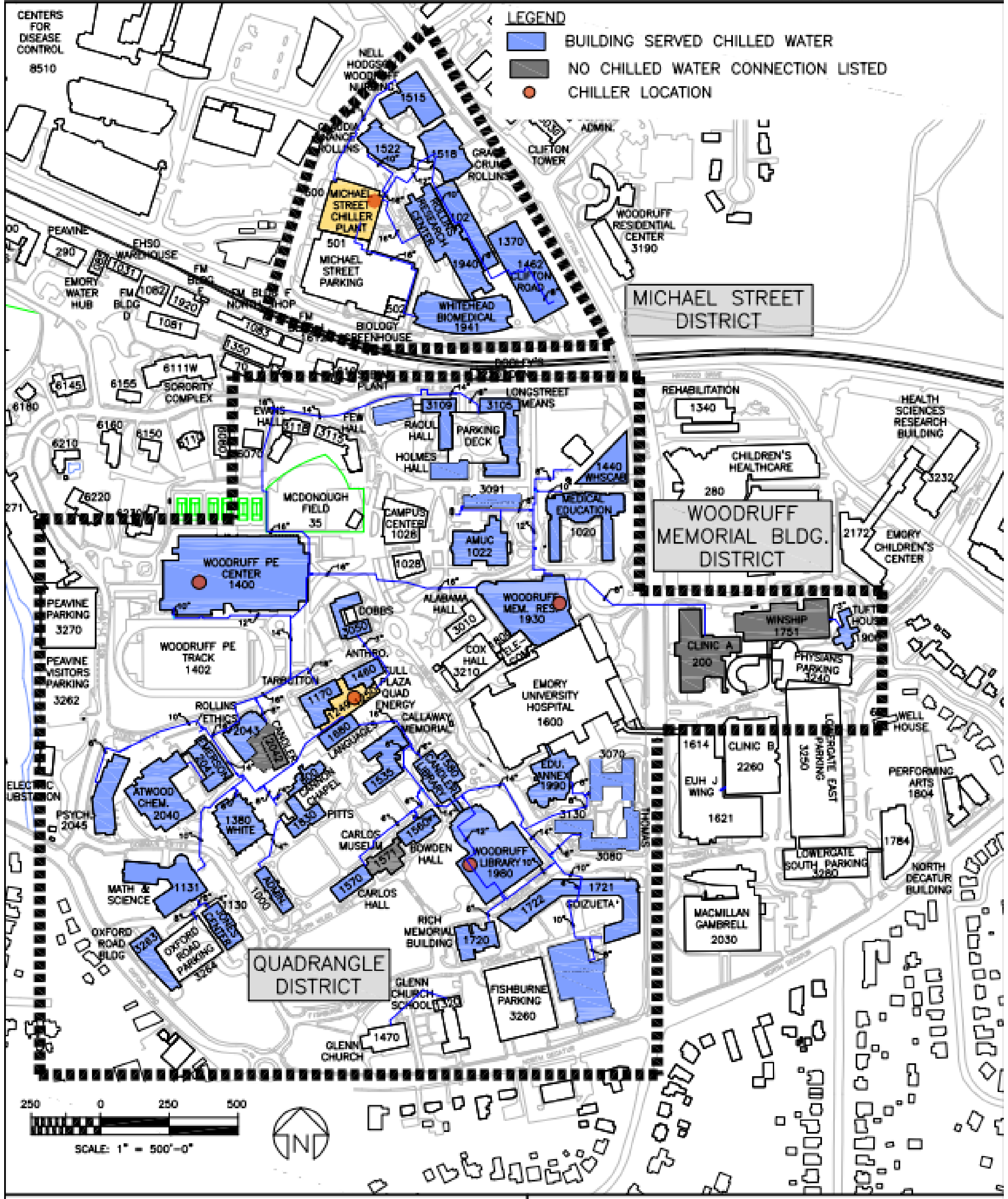
Operational Culture

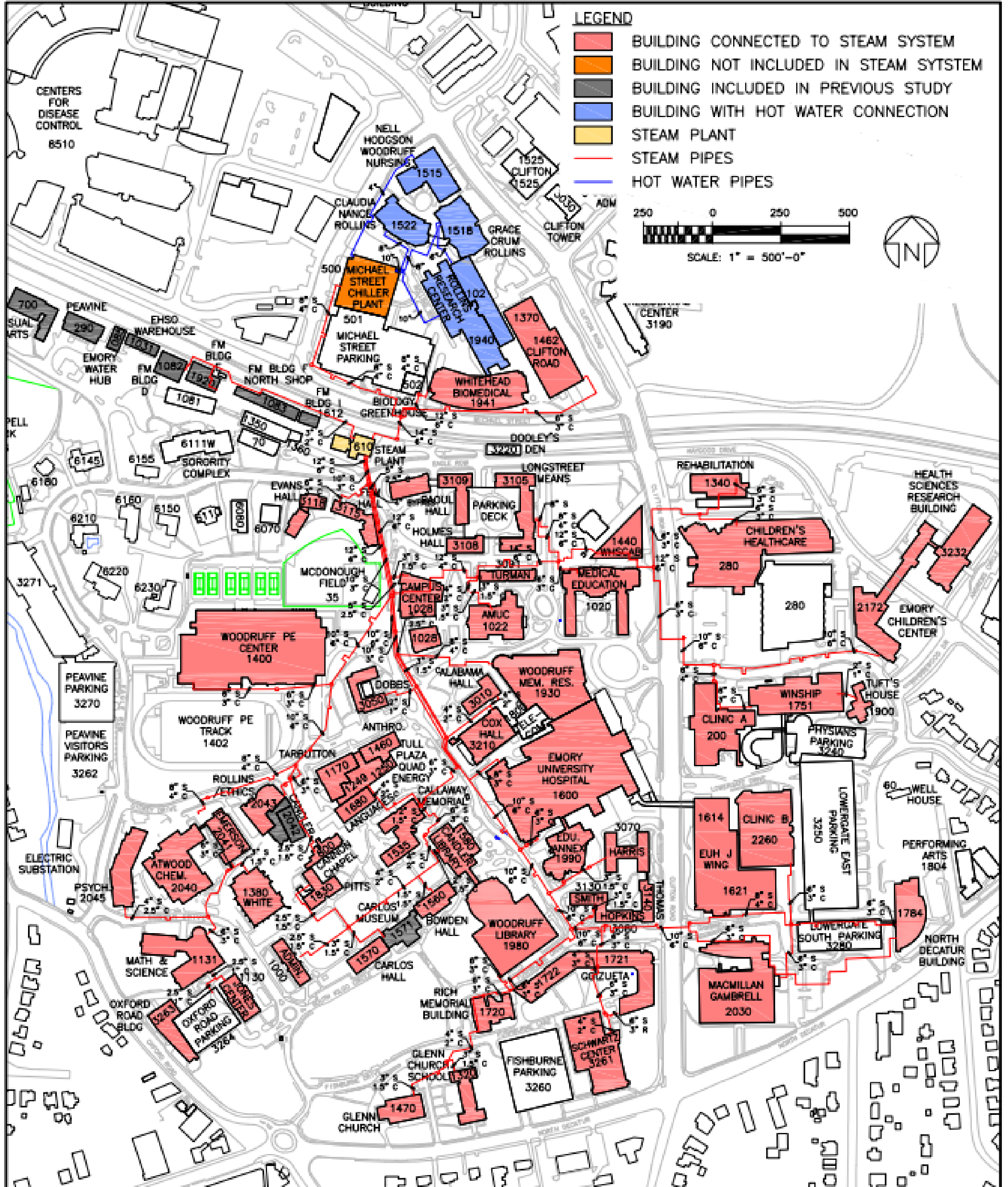
- Motivate the staff by showing positive outcomes and benefits of taking action
- Address any tribal myths about operations
- Enhance operational knowledge with continuous education for staff with energy engineering
- Communicate using KPIs, data, and graphical representation with staff and engineers on campus
- Help short-staffed operations team be effective in their efforts
- Reward the team with validated results

Operational Constraints

- Understanding campus performance from multiple plants
- Developing 8760 that reflects holistic performance of utility plants with granular detail on every subsystem
- Validating PID operational strategies
- Addressing tribal myths and methodologies around operations
- Maximizing variable speed drive investments
- Substantiating the cost of deficiencies and/or workarounds
- Effectively communicating with documentation on observations
- Identifying, calculating, and ensuring effective deployment of energy conservation measures
- Communicating to non-technical shareholders and executives the cost of decisions as they relate to utility plant production and distribution




LEGEND
BUILDING SERVED CHILLED WATER
NO CHILLED WATER CONNECTION LISTED
CHILLER LOCATION
MICHAEL STREET DISTRICT
WOODRUFF MEMORIAL BLDG. DISTRICT
QUADRANGLE DISTRICT
CENTERS FOR DISEASE CONTROL 8510
MICHAEL STREET CHILLER PLANT
MICHAEL STREET PARKING
WHITEHEAD BIOMEDICAL 1941
WOODRUFF RESIDENTIAL CENTER 3190
CLIFTON TOWER
MCDONOUGH FIELD 35
WOODRUFF PE CENTER 1400
WOODRUFF PE TRACK 1402
PEAVINE PARKING 3270
PEAVINE VISITORS PARKING 3262
MEDICAL EDUCATION 1020
WOODRUFF MEM. RES. 1930
EMORY UNIVERSITY HOSPITAL 1600
CLINIC A 200
WINSHIP 1751
CHILDREN'S HEALTHCARE 280
REHABILITATION 1340
HEALTH SCIENCES RESEARCH BUILDING
EMORY CHILDREN'S CENTER
WOODRUFF LIBRARY 1980
ATWOOD CHEM. 2040
MATH & SCIENCE
FISHBURNE PARKING 3260
MACMILLAN GAMBRELL 2030
LOWERGATE SOUTH PARKING 3280
PERFORMING ARTS 1804
NORTH DECATUR BUILDING
CLINIC B 2260
EUH J WING 1621
ELECTRIC SUBSTATION
GLENN CHURCH
250 0 250 500
SCALE: 1" = 500'-0"


LEGEND
BUILDING CONNECTED TO STEAM SYSTEM
BUILDING NOT INCLUDED IN STEAM SYTSTEM
BUILDING INCLUDED IN PREVIOUS STUDY
BUILDING WITH HOT WATER CONNECTION
STEAM PLANT
STEAM PIPES
HOT WATER PIPES
250 0 250 500
SCALE: 1" = 500'-0"
CENTERS FOR DISEASE CONTROL 8510
MICHAEL STREET CHILLER PLANT
STEAM PLANT
WHITEHEAD BIOMEDICAL 1941
WOODRUFF PE CENTER 1400
WOODRUFF PE TRACK 1402
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ATWOOD CHEM. 2040
MACMILLAN GAMBRELL 2030
FISHBURNE PARKING 3260
SCHWARTZ CENTER 3261
GLENN CHURCH
ELECTRIC SUBSTATION

Current Conditions and Future Planning for Expansion

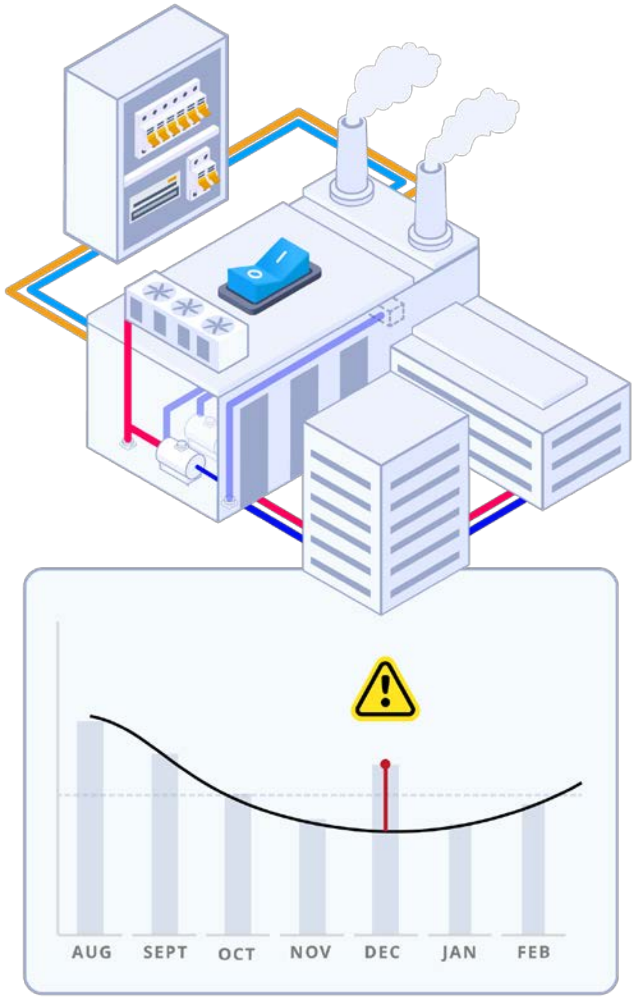
1. Spring 2021 – Replaced 2 centrifugal chillers and 1 air-cooled chiller for main campus network cooling facility
2. Winter 2021/2022– Replacing 3 chillers (#1,2,3) at Michael Street chiller plant
3. Spring 2022– New Health Science Research Building coming online with 2 centrifugal chillers
4. Spring 2022– New Rollins Research Building coming online, which will be connected to Michael Street chiller plant
5. Three-year plan
    a. Fully automate Quad-WMB chiller loop cross-connect
    b. Begin upgrading chiller plant controls to Rockwell PLC (currently Siemens BAS)
    c. Perform update to campus-wide chiller master plan for capital planning
    d. Replace 1–2 chillers in Quad chiller plant

Concerns from the University

Owner Benefits:

- Protect capital spend on equipment. (Maximizing the benefit of $ spent on equipment purchases)
- Holistically produce lowest cost of utility production. (Maximizing technologies across all systems: chillers, pumps, cooling towers, etc.)
- Provide a system where resources and technology could be applied to enhance building engineers' operational knowledge and support a learning environment for utility shareholders.
- Qualify and maximize utility/regulatory incentives.
- Validate operational excellence and identify implementations and paybacks (pre and post) to continuously plan for the future.

Emory’s Plan and Goals



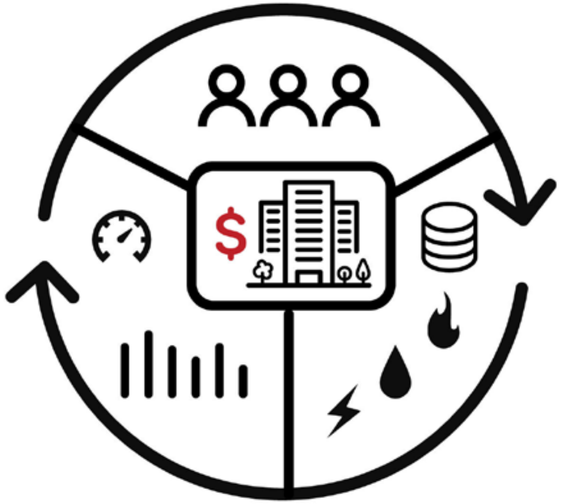
Energy Plant Oversight

1. Looks at granular relationship of plant equipment to the BOP (balance of plant)
2. Makes recommendations to the SOP or PID controls operator to be implemented into the BAS based on site’s operational data
3. Identifies drift & energy conservation measures and allocates an unobtained cost associated with the deficiencies and ECMs
4. Graphically explains and validates savings from implemented strategies
5. Allows for pre- and post-benchmarking on operational conditions from yearly maintenance
6. Scales to other building operations for holistic optimization

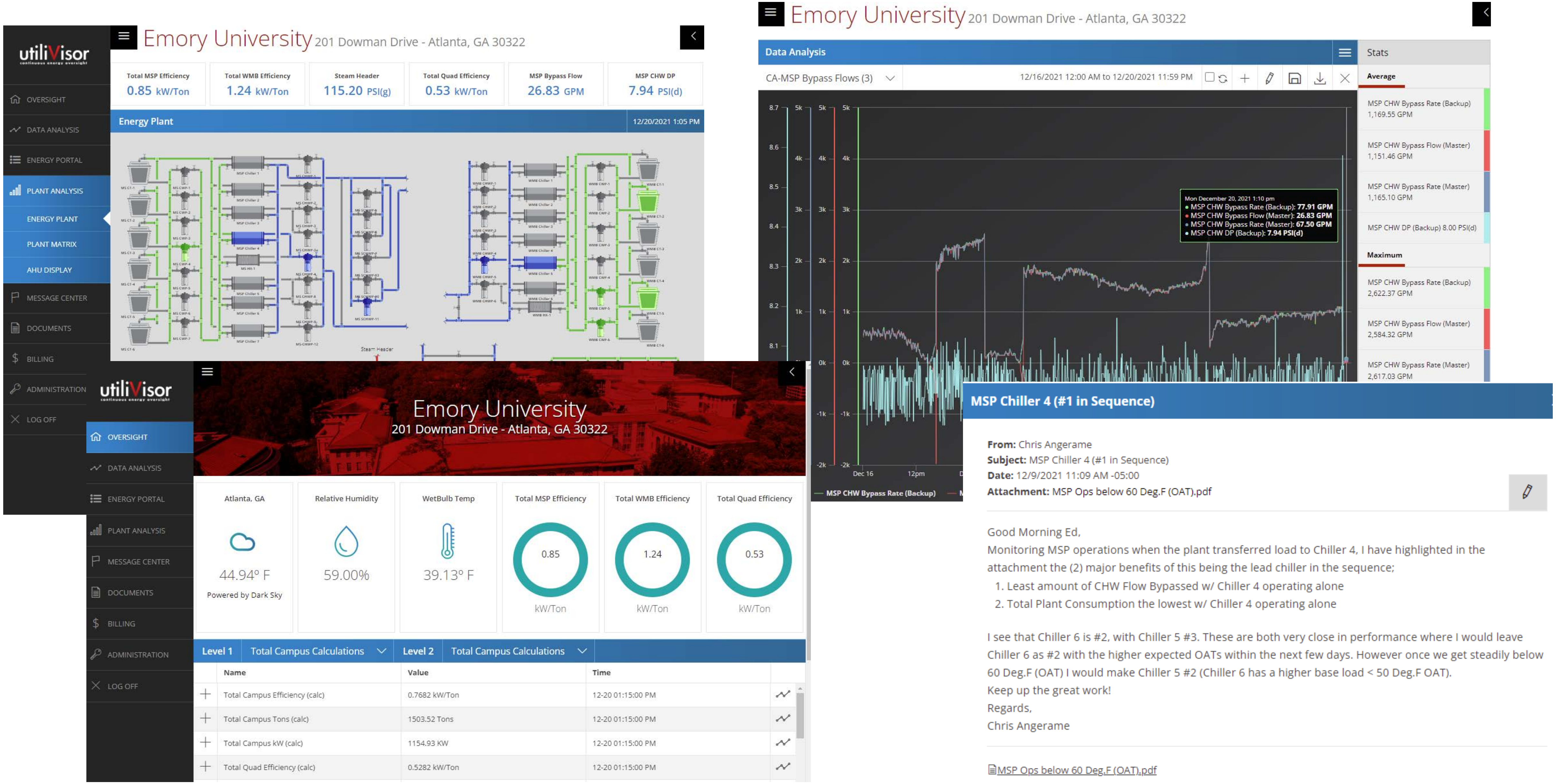
Multiple Utilities = Multiple Meters = Multiple BMS Systems

METER	DATA COLLECTION		
TYPE	SYSTEM	TRANSFER METHOD	FREQUENCY
Electric	Delta V	Real-time HTTP Post	5 minutes
Stm, Cond, CHW & HW	TRIDIUM	Daily Auto FTP	15 minutes
Stm, Cond, CHW & HW	SIEMENS		15 minutes
	iPad App		

utiliVisor



UTILIVISOR'S INTERFACE



Three Main Chilled Water Loops

Initial Focus – Michael Street

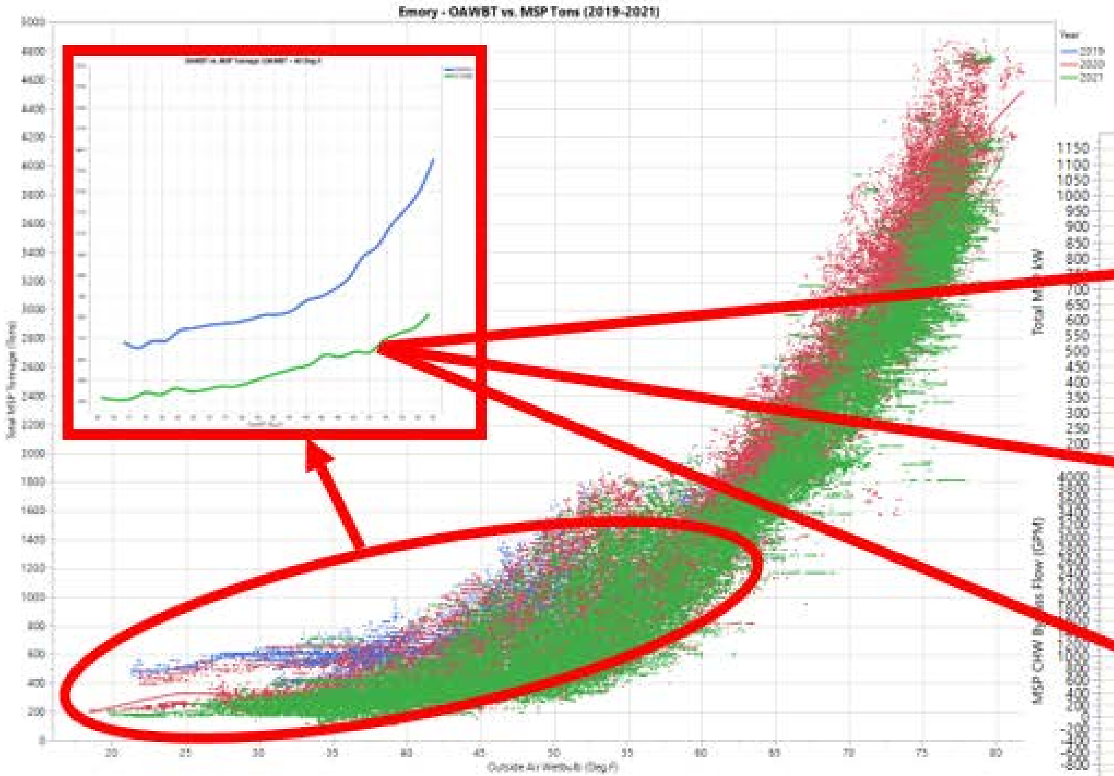
- Profile Load (Tons) vs. OAT, OAWBT, Day of Week, and Time of Day
- Profile Tons vs. Total Plant kW & Cost/Hr and/or Cost/Ton
    - Utilized interval data within utiliVisor's application (data analysis graphs) and statistical software (JMP)
    - Outliers are the focus, as they indicate the following:
        - Operating incorrect chiller at specific loads
        - Operating too many chillers/pumps/cooling towers
        - Excessive CHW bypass flow
        - Enhance automatic reset schedules (if in place)

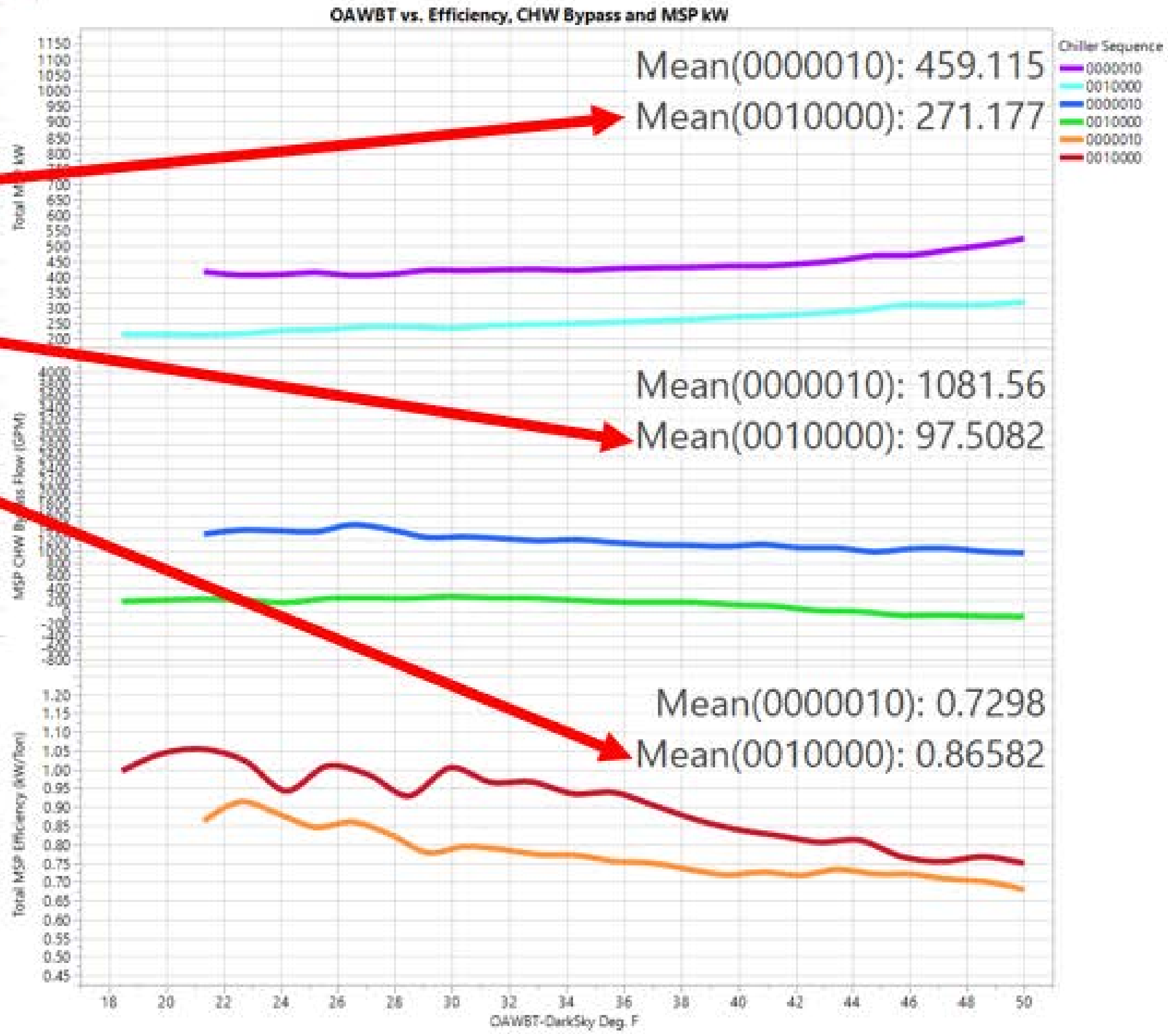
Three Main Chilled Water Loops (Cont'd)

Initial Focus – Michael Street

- utiliVisor implemented optimal chiller sequence
  - Less water bypassed (reduced tonnage profile)
  - Auxiliary savings achieved from smaller pumps combined w/ seasonal CHW DP reset
- utiliVisor also identified “overlapping” – chillers ON for extended hours when tonnage reduced overnight/weekends
- Once ECM is implemented, in addition to tracking in our monthly energy report, utiliVisor created real-time performance calculations (which forecast expected load/operating costs based on upcoming weather conditions). If outside a user-defined threshold, our operations center receives this alert and will contact the client to adjust current operating strategy.

WHAT UTILIVISOR AND EMORY UNIVERSITY ACCOMPLISHED

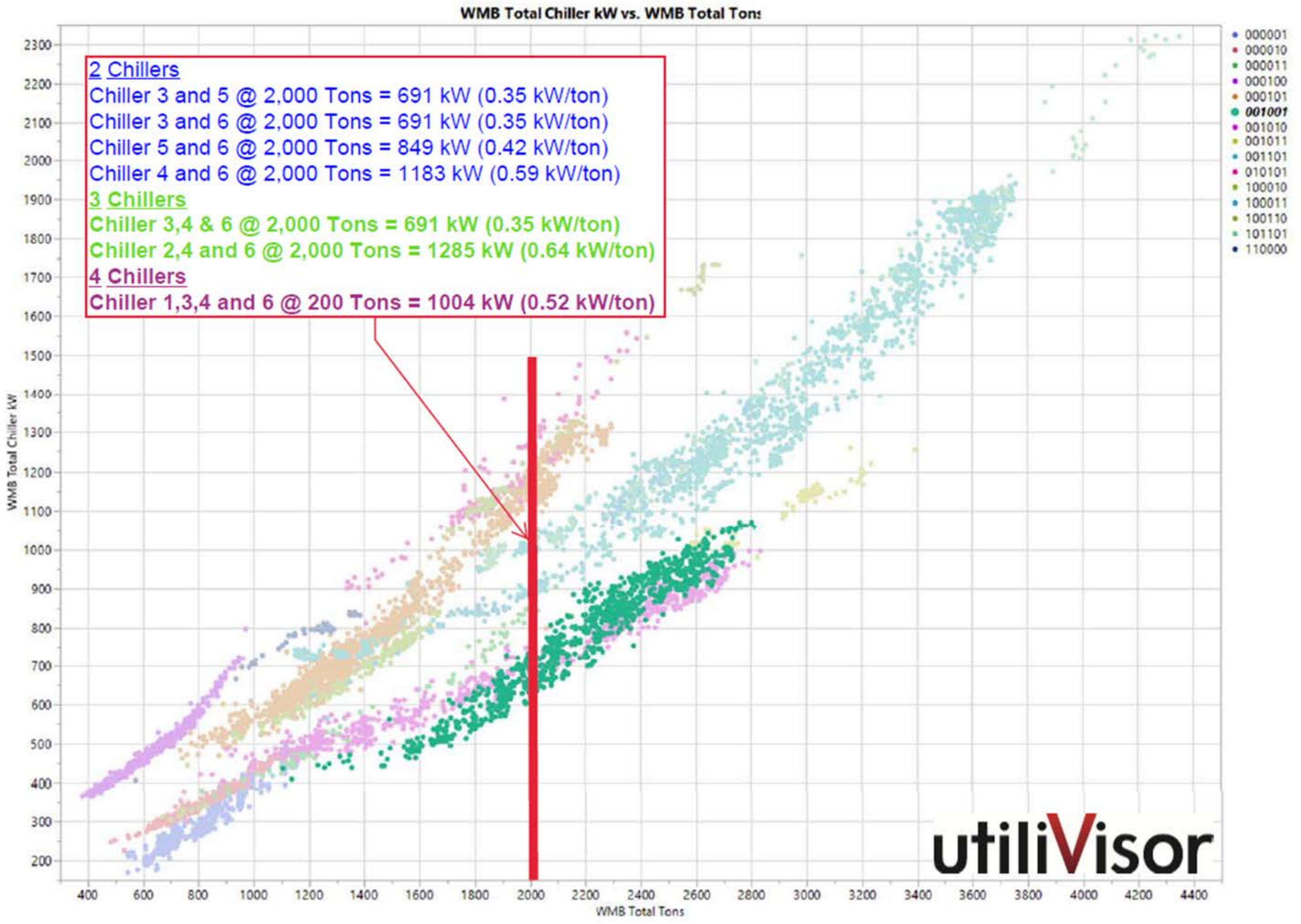


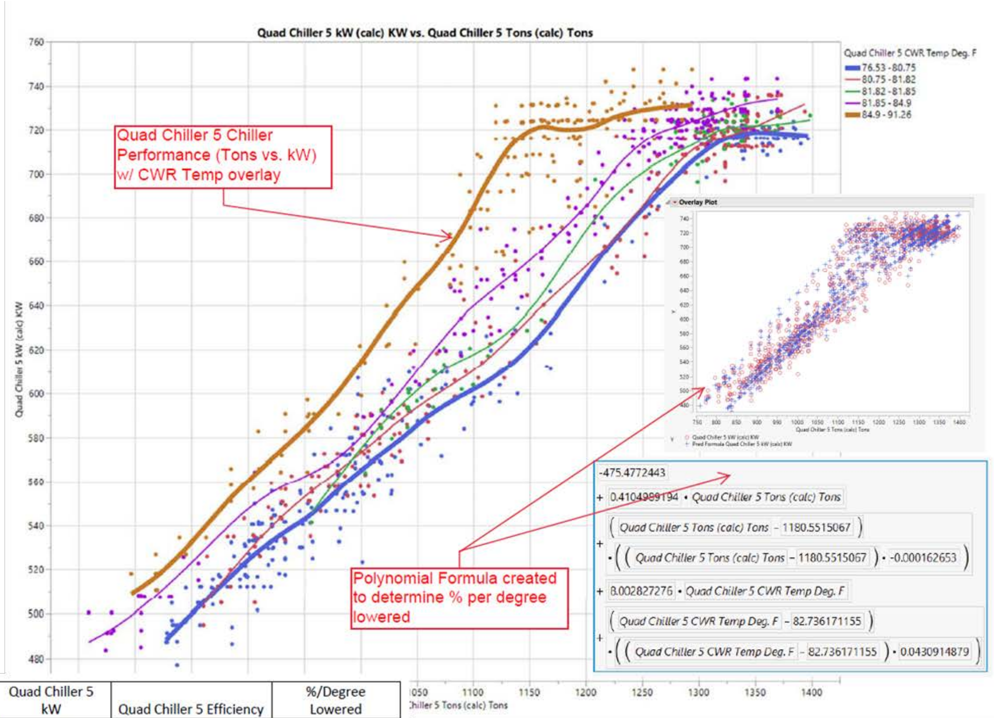


Expansion to the Additional Plants

- Adjusted condenser water return temperatures for chiller head pressure control
- Reduced condenser water flow on newer chillers
    - Increased CWP efficiency without any impact on chiller part load performance
- Cooling tower sequencing utilizing different size fans/tower based on total GPM flow
    - Provided breakpoints in chiller efficiency vs. increase in CT consumption
    - Profiled CT performance for %flow/cell vs. condenser water delta T

WHAT UTILIVISOR AND EMORY UNIVERSITY ACCOMPLISHED





Quad Chiller 5 Tons	Quad Chller 5 CWR Temp	Quad Chiller 5 kW	Quad Chiller 5 Efficiency	%/Degree Lowered
1000	85	610	0.6102	
	84	602	0.6020	-1.34%
	83	594	0.5940	-1.34%
	82	586	0.5860	-1.34%
	81	578	0.5781	-1.35%
	80	570	0.5703	-1.35%
	79	563	0.5625	-1.35%
	78	555	0.5549	-1.36%
	77	547	0.5474	-1.36%
	76	540	0.5399	-1.36%
	75	533	0.5325	-1.37%

			Tonnage	Quad Design Chiller CW Flow
Chiller 2	York	SEJM-964800 / 2000	1250	3000
Chiller 3	Trane	L95H08225 / 1995	1000	2400
Chiller 4	York	YFAM882154 / 1992	1250	3000
Chiller 5	York	YFAM882153 / 1992	1250	3000

GPM	CTs	HP	kW
3750	CT-1	50	37.3
3750	CT-2	40	29.84
7500	CT-3	100	74.6
4500	CT-4	75	55.95

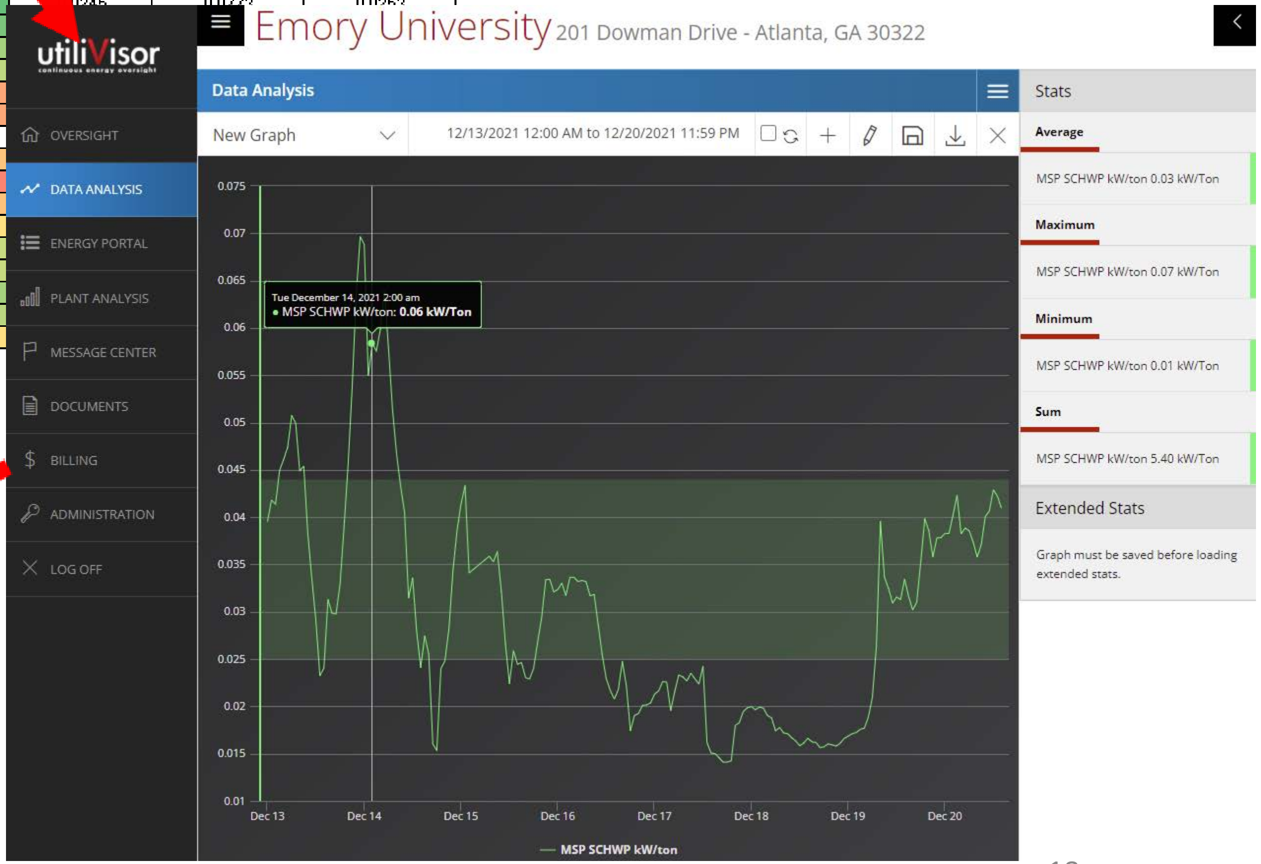
	Flow/Cell 80.00%
%Speed	CT-2 Operating
25	0.47
30	0.81
35	1.28
40	1.91
45	2.72
50	3.73
55	4.96
60	6.45
65	8.19
70	10.24
75	12.59
80	15.28
85	18.33
90	21.75
95	25.58
100	29.84

		Flow/Cell 72.00%
%Speed	CT-2	CT-1 & 2 Operating
25	0.47	1.05
30	0.81	1.81
35	1.28	2.88
40	1.91	4.30
45	2.72	6.12
50	3.73	8.39
55	4.96	11.17
60	6.45	14.50
65	8.19	18.44
70	10.24	23.03
75	12.59	28.32
80	15.28	34.38
85	18.33	41.23
90	21.75	48.95
95	25.58	57.56
100	29.84	67.14

	Flow/Cell 66.67%
%Speed	CT-4 Operating
25	0.87
30	1.51
35	2.40
40	3.58
45	5.10
50	6.99
55	9.31
60	12.09
65	15.37
70	19.19
75	23.60
80	28.65
85	34.36
90	40.79
95	47.97
100	55.95

WHAT UTILIVISOR AND EMORY UNIVERSITY ACCOMPLISHED

	Michael Street Chiller Efficiency										
	0.6270	0.6270	0.6110	0.5460	0.6310	0.5550	0.5600	MSP PCHWP kW/ton	MSP SCHWP kW/ton	MSP CWP kW/ton	MSP CT kW/ton
	MSP Chiller 1	MSP Chiller 2	MSP Chiller 3	MSP Chiller 4	MSP Chiller 5	MSP Chiller 6	MSP Chiller 7				
Oct-19	0.7137	0.7552	0.5174	0.5308	-	0.3966	0.5445	0.0409	0.0447	0.0805	0.0163
Nov-19	-	-	0.4560	0.6849	-	0.4186	0.5530	0.0538	0.0509	0.0911	0.0096
Dec-19	0.8023	0.7752	0.4739	0.5068	-	0.4129	0.7136	0.0529	0.0404	0.1010	0.0117
Jan-20	0.8136	0.7330	0.4927	0.5393	-	0.4436	0.6122	0.0583	0.0462	0.1367	0.0163
Feb-20	-	0.7944	0.4965	0.5130	0.7214	0.3946	0.5335	0.0425	0.0349	0.1511	0.0200
Mar-20	0.8003	0.7900	0.4889	-	0.5570	0.3692	0.5234	0.0443	0.0352	0.0985	0.0235
Apr-20	0.9370	0.7482	0.4870	0.5683	0.5285	0.3749	-	0.0449	0.0361	0.1110	0.0209
May-20	-	0.7310	0.4954	0.6408	-	0.3701	0.5236	0.0381	0.0283	0.0920	0.0211
Jun-20	0.7632	0.7865	0.5248	0.5885	0.6272	0.3798	0.5372	0.0365	0.0273	0.0750	0.0236
Jul-20	0.8975	0.7947	0.5447	0.6007	0.6264	0.3909	0.5599	0.0366			
Aug-20	0.8277	0.7659	0.5454	0.6274	0.6330	0.4008	0.5726	0.0376			
Sep-20	0.8259	0.7689	0.5393	0.6220	0.5855	0.3935	0.5620	0.0394			
Oct-20	0.7641	0.7232	0.5046	0.7892	0.5771	0.3823	0.5724	0.0405			
Nov-20	0.7373	-	0.4833	-	0.5812	0.4001	0.5949	0.0513			
Dec-20	0.6932	1.2868	0.4991	1.1136	0.5867	0.5404	-	0.0512			
Jan-21	0.7571	1.0874	0.5241	-	0.6077	0.4660	-				
Feb-21	0.6860	-	0.5267	-	-	0.4038	0.7047	0.0479			
Mar-21	0.7611	0.7866	0.5102	0.7035	0.5615	0.5102	0.5615	0.0552			
Apr-21	0.8085	0.7933	0.5035	-	0.5125	0.4789	0.6158	0.0482			
May-21	0.7926	-	0.5176	-	0.5639	0.4829	0.5673	0.0447			
Jun-21	0.8087	0.7530	0.5330	-	0.6193	0.4940	0.5974	0.0410			
Jul-21	0.8295	0.8439	0.5676	-	0.6332	0.4864	0.6158	0.0410			
Aug-21	0.8746	0.8559	0.5492	0.5286	0.6261	0.4770	0.5904	0.0394			
Sep-21	-	-	0.5360	0.5231	0.5930	0.4746	0.5803	0.0404			
Oct-21	-	-	0.5360	0.5576	0.5583	0.4719	0.5865	0.0448			



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Building: 9West57 Solow

Level 1 Name: Total Campus Calculations
Level 2 Name: MSP Secondary Chilled Water Pumps
Level 3 Name: **MSP SCHWP kW/ton**

Point values above (0.045) and/or below (N/A) 6 time(s) in the past 2 hour(s).

Login to utiliVisor and View in Data Analysis

Regards,
utiliVisor Operations Center

Plant Monitoring Savings to Date

$668,648

Since 11/2019

18%

of Chiller Plant Cost

1. Increased plant efficiency from revised chiller sequencing
2. Revised load profiles from reducing excessive CHW bypass flows and implementing a seasonal CHW differential pressure reset
3. Revised auxiliary sequencing based on tonnage profile (chilled & condenser water pumps/cooling towers)
4. Extended operations with reduced differential pressures from returning AHU CHW valve control and revised occ/unocc scheduling

Collaboration Moving Forward

1. Encourage continuous validation of operational conditions
2. Analyze from the cloud; make changes at the plant
    - Collaboration between the data, energy engineers, and operators is critical for successful outcomes.
3. View the system as a campus that incorporates the CHP + boiler plant
4. Validate new plant projects on campus
5. Continue working with the operations staff and training on the system

THANK YOU

EMORY UNIVERSITY

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