24th Annual Ohio

Energy Management CONFERENCE

Workshop M

University Excellence - Best Practices & Case Study: Win-Win Approach to Drive Positive Outcomes Managing District Energy Systems

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Tuesday, February 18, 2020
3:15 p.m. to 4:30 p.m.

Biographical Information

Doug J. Hammerle, Director of Energy Systems
Miami University, Physical Facilities
101 South Fisher Drive, Oxford, Ohio, 45056
513-529-1696 Fax: 513-529-1732 hammerd@miamioh.edu

Doug Hammerle is the Director of Energy Systems within the Physical Facilities Department @ Miami University. Mr. Hammerle came to Miami University 30 years ago in 1990 as a Project Engineer In 1997, Doug was promoted to Associate University Engineer and oversaw major infrastructure improvement projects. He has held his current position since 2012 and been instrumental in setting the vision for the Utility Master Plan with Geothermal being the cornerstone. Doug has a passion for energy and is always striving to improve efficiencies and eliminate waste. In Doug's current role he oversees the day to day operations of the High Voltage Distribution System, Steam Plant, Chiller Plants and Geothermal Plant and their associated distribution piping, along with the Building Automation System. In essence all the major energy systems that need to be managed on a University Campus.

Doug graduated from the University of Cincinnati with a Bachelor's of Science in Mechanical Engineering in 1985, and attained his Professional Engineers license in 1995.

Scott W. Lessing, Senior Electrical Systems Operations Manager
Miami University, Physical Facilities
101 South Fisher Drive, Oxford, Ohio, 45056
513-529-8036 Fax: 513-529-1732 lessinsw@miamioh.edu

Mr. Lessing started his electrical career in 1983 in Skilled Trades at the General Motors Fisher Body Plant in Hamilton Ohio. In 1989 he graduated from Miami University with an Associate in Electrical Engineering Technology, Magna Cum Laude. In 1990 he joined the City of Hamilton Municipal Electric as a Utility Engineer, designing for new commercial and industrial services.

Scott progressed to Miami University in 2004 to manage its Electric Utility comprised of 69kV transmission substation, 12kV distribution with automation, and 11MW generation. His duties include the efficient system operation, maintenance and day-to-day scheduling. He has promoted system reliability by developing and overseeing projects to upgrade, expand and complete the distribution. He strives to reduce the cost of electric through implementation of collaborative program strategies.

Scott graduated from Miami University with a Bachelor of Science in Electro-Mechanical Engineering Technology in 2010, distinguished with Cum Laude and Outstanding Engineering Technology Student. He also has taught as an Adjunct at Miami University, School of Engineering and Applied Science and continues to serve on its Advisory Council.

Miami University's Win-Win Approach to Drive Positive Outcomes Managing District Energy Systems

PRESENTED BY

Doug Hammerle, PE
Director of Energy Systems
hammerd@miamioh.edu

Scott Lessing
Senior Electric Operations Manager
lessinsw@miamioh.edu

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Agenda

- UEA Mission
- Master Plan Timeline
- UMP Implementation
- Performance to Date
- UMP Future Plans
- Expected Performance
- Managing Electric
  - Rainbow Chart
  - TES Tank Operation

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About Miami University

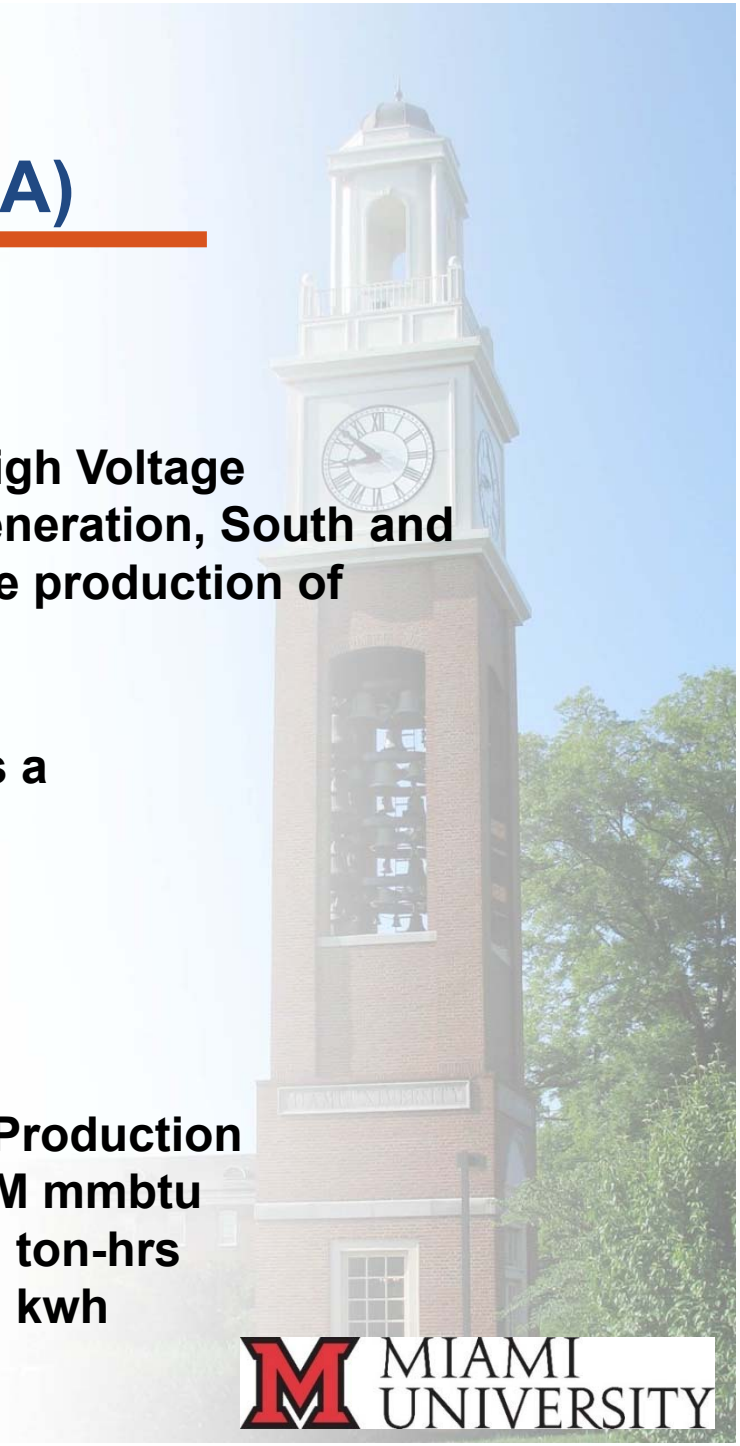
- **Public University Established in 1809**
- **Main Campus is in Oxford, OH**
  - Other regional campuses in Hamilton, Middletown, West Chester & Luxembourg
- **Main Campus has 17,174 undergraduates and 2,217 graduate students (2019 Enrollment)**
- **Focus on LEAN Management**
- **2,500 Acres of Grounds, 8 Million Square Feet of Buildings**
  - 9,000 trees
  - 76 acres of parking spaces
  - 32 miles of walks
  - 5.4 miles of utility tunnels

Utility Enterprise Auxiliary (UEA)

- Operates as own separate Business unit.
- Responsible for Day-to-Day operation of High Voltage Distribution and 4 Central Plants(Steam/Generation, South and North Chiller, and Geothermal plants for the production of Heating, Cooling and Electric on Campus.
- Building Automation Group which includes a Retrocommissioning Team.
- 25 employees
- $23 Million annual budget

  FY 20 Rates
  - Steam/HHW = $24.7/mmbtu
  - CHW = $0.133/ton-hr
  - Electric = $0.103/kwh

FY 19 Production
- 400M mmbtu
- 18M ton-hrs
- 90M kwh



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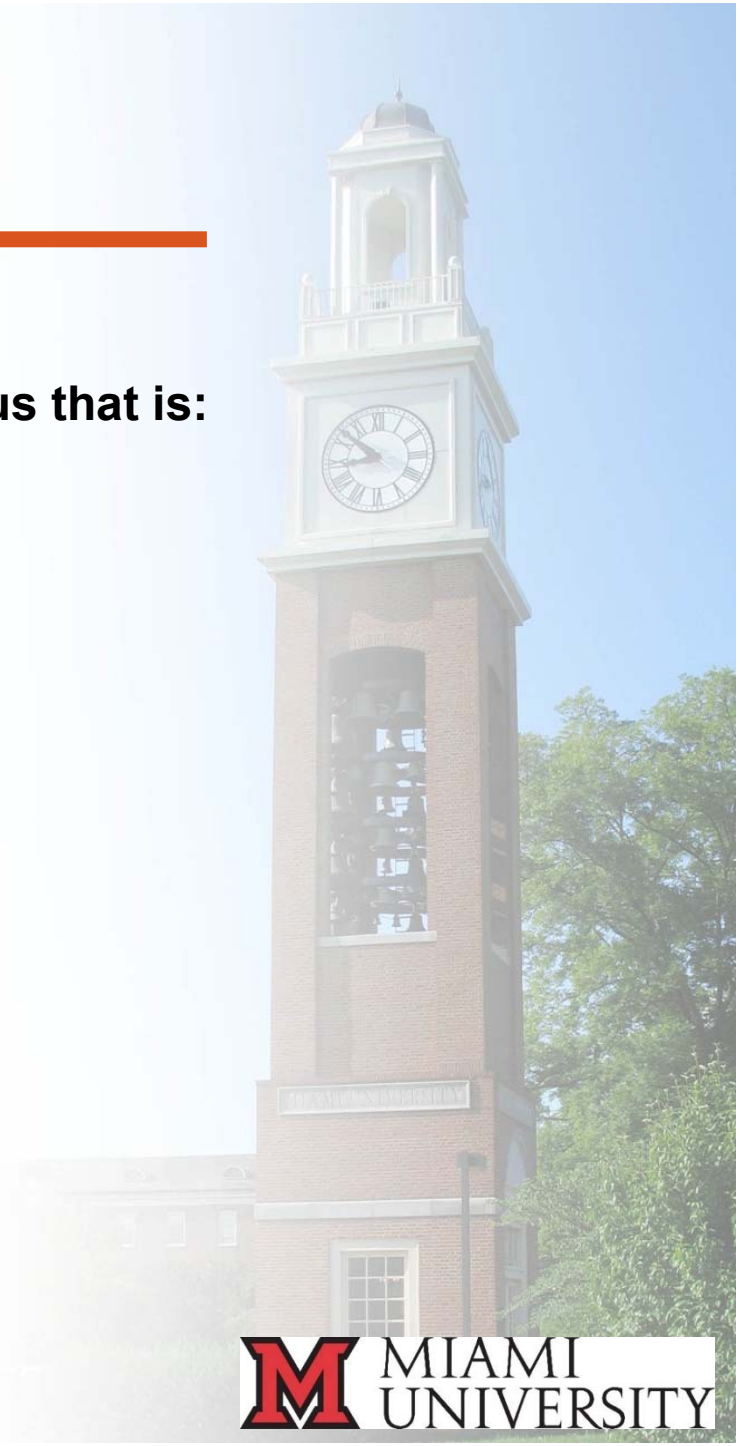
Mission Statement

Develop, operate and maintain a SAFE campus that is:

- **Sustainable**
- **Attractive**
- **Functional**
- **Efficient**



Energy Division KPI's

- **Customer Focus**
  - Reliability
- **Safety**
  - Recordable injury
- **Productivity**
  - Efficiency
    - *Examples: kbtu/gsf, COP ,Carbon Footprint, Water Consumption*
- **Cost**
  - $/mmbtu

Master Plan Timeline

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Master Plan Timeline

2010 Sustainability goal

2010 Long Range Housing Dining Plan

2011 Stormwater Master Plan created

2012 Utility Master Plan(UMP) Study and Plan approved using Simultaneous Heating & Cooling (SHC), Combined Heat & Power (CHP), and Geothermal

2014 Boiler MACT study

2016 Sustainability goals revised

2016 Feasibility Study to eliminate steam

2017 Revised UMP to eliminate steam and convert campus to heating hot water and convert South Chiller Plant to SHC.

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Factors in Decisions

- Paradigm shift on what Heating Hot Water Temperature is needed to heat a Building
- Pay relatively low electric cost < $.05/kwh
- Load Profile
  - Campus has year-round cooling and heating loads
- Residence Halls wanted cooling and heating available year round
- Price Volatility
- Reduce Maintenance

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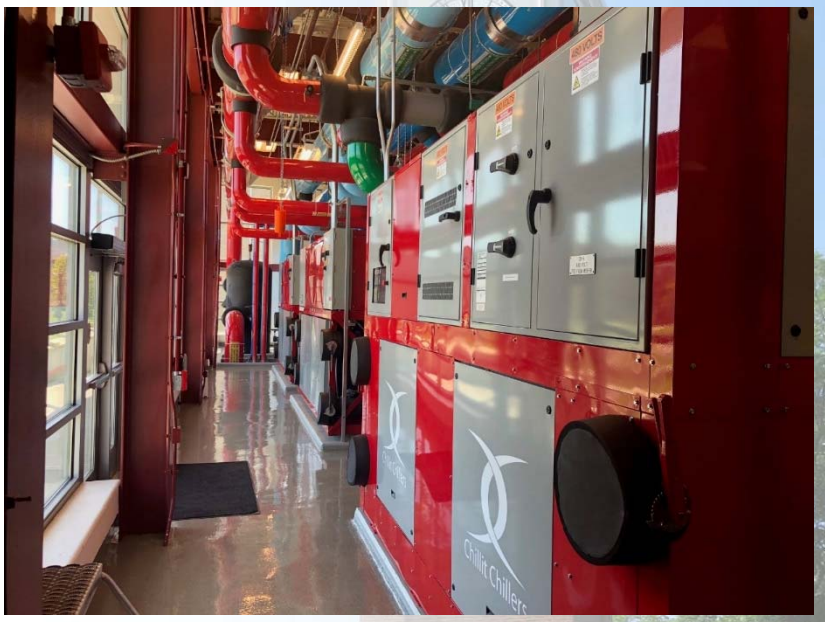
Screw HP Chiller Efficiency

Variable Speed Screw Chiller

% Load	Heating Mode COP	Simultaneous Mode COP	Condenser		Evaporator	
			EWT (°F)	LWT (°F)	EWT (°F)	LWT (°F)
100	3.66	6.3	112	130	54	44
75	3.96	6.9	112	130	54	44
50	3.66	6.3	112	130	54	44
25	4.15	7.3	112	130	54	44



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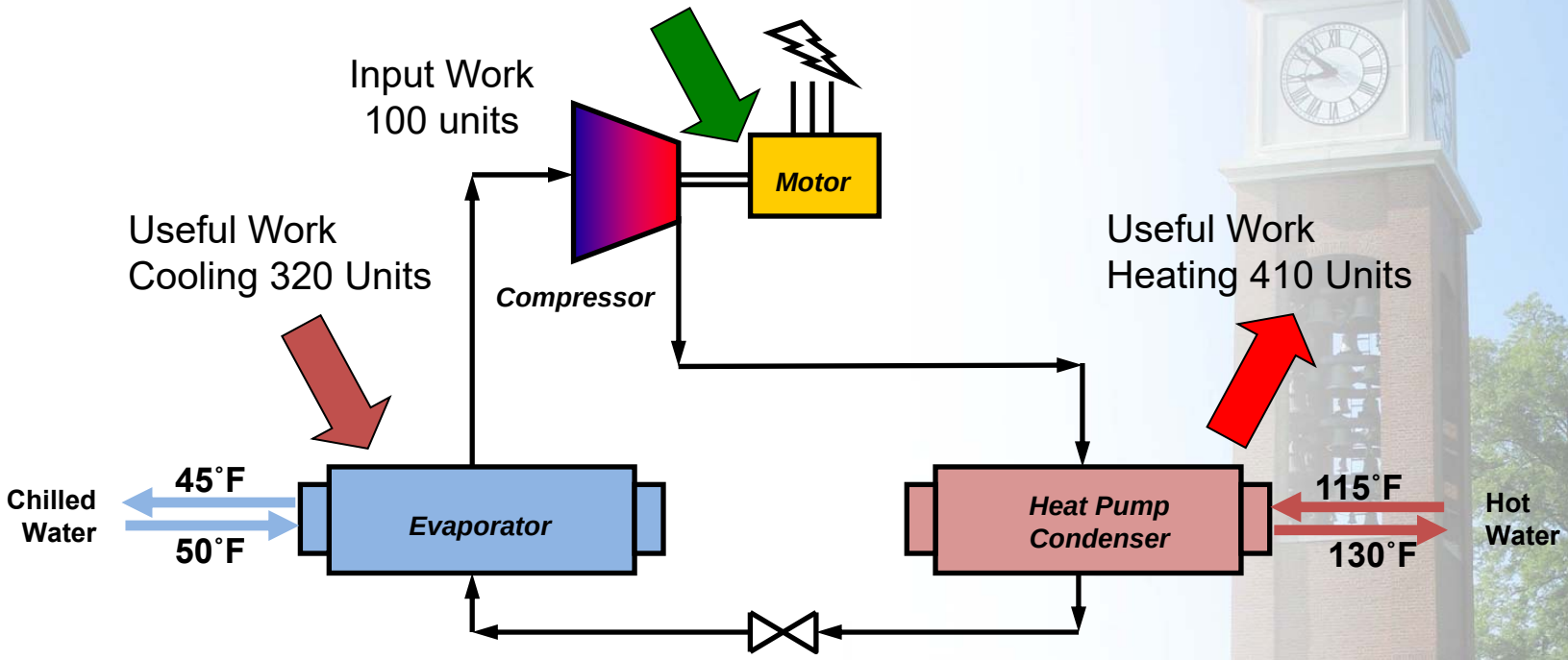
Simultaneous Heating & Cooling



COP (Coefficient of Performance) = $\frac{\text{Useful work}}{\text{Input work}}$ $\frac{\textbf{730 units}}{\textbf{100 units}}$ **= 7.3**

Cost = $1.72/mmbtu

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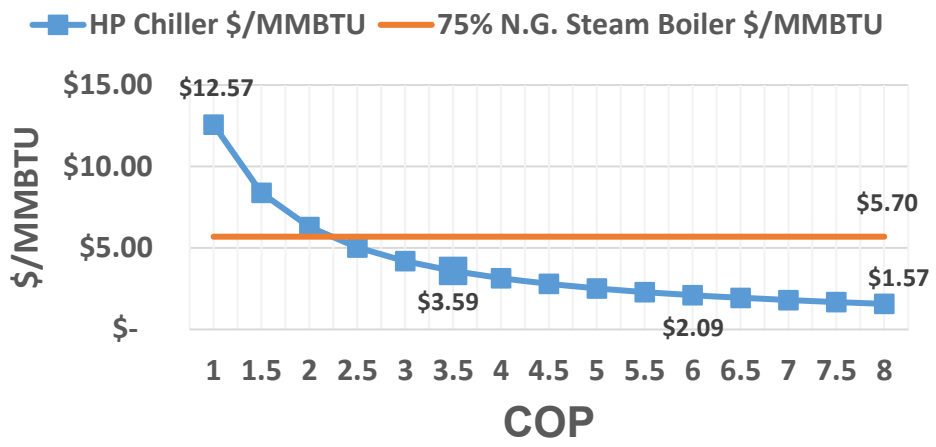
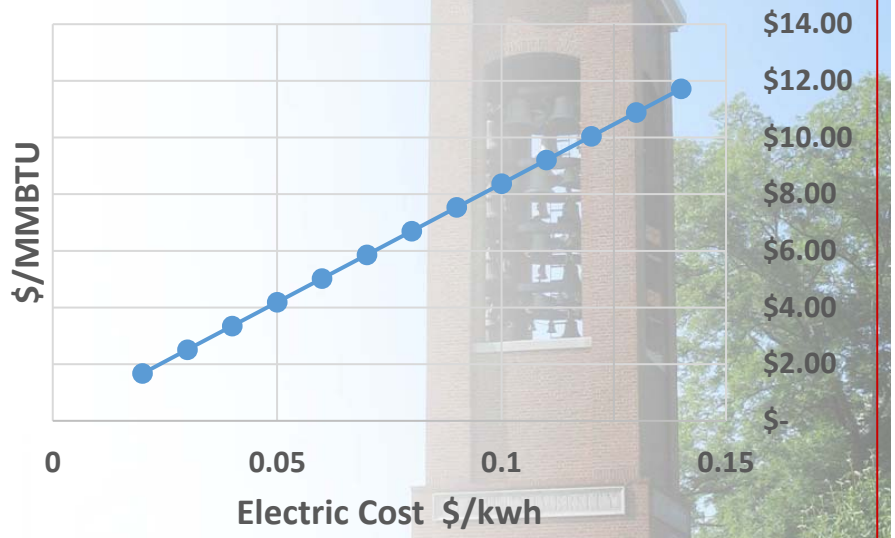
Heat Pump Chiller Cost of Operation

Electric Cost = $ 0.0429/kwh
Natural Gas = $ 4.38/MCF

HP Chiller vs. N.G. Steam Boiler



HP Chiller @ 3.5 COP



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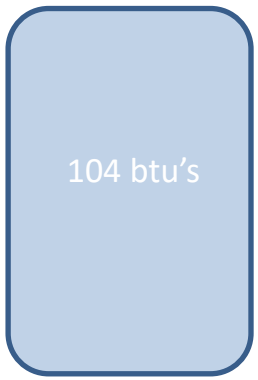
BAU vs. SHC



60 btu's Heating

N.G. Boiler

75 btu's

COP 0.8

44 btu's Cooling

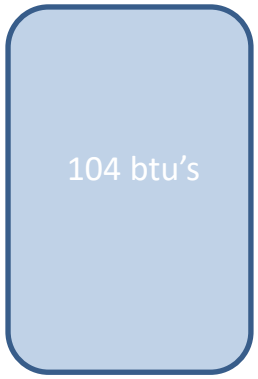
Chiller

8.8 btu's

COP 5.0

Overall COP 1.24
$3.37/mmbtu
0.0515MTCO2/mmbtu

$1.14/mmbtu in Water/Chemical Cost



60 btu's Heating

Heat Pump Chiller

16.5 btu's

44 btu's Cooling

COP 6.3

Overall COP 6.3
$1.99/mmbtu
0.0247MTCO2e/mmbtu

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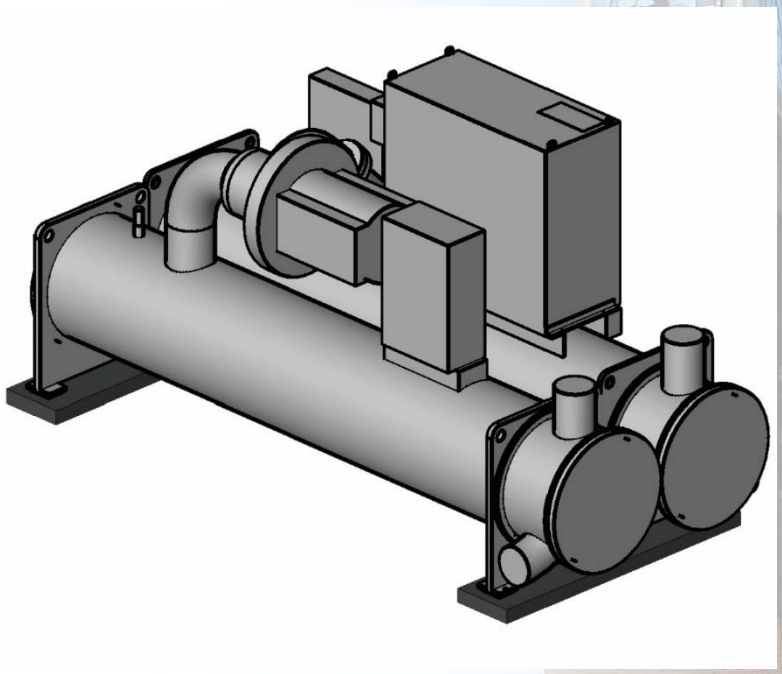
Centrifugal Magnetic-Drive Chiller Efficiency

Centrifugal Magnetic Drive Chiller

Condenser EWT (°F)	% Load	kW/Ton
60	100	0.307
60	75	0.255
60	50	0.220
60	25	0.234
70	100	0.402
70	75	0.353
70	50	0.330
70	25	0.387
75	100	0.449
75	75	0.406
75	50	0.391
75	25	0.470
80	100	0.503
80	75	0.462
80	50	0.463
80	25	0.556



COP Range = 6.3 - 16 **Cost Range = $0.79/mmbtu - $1.99/mmbtu**

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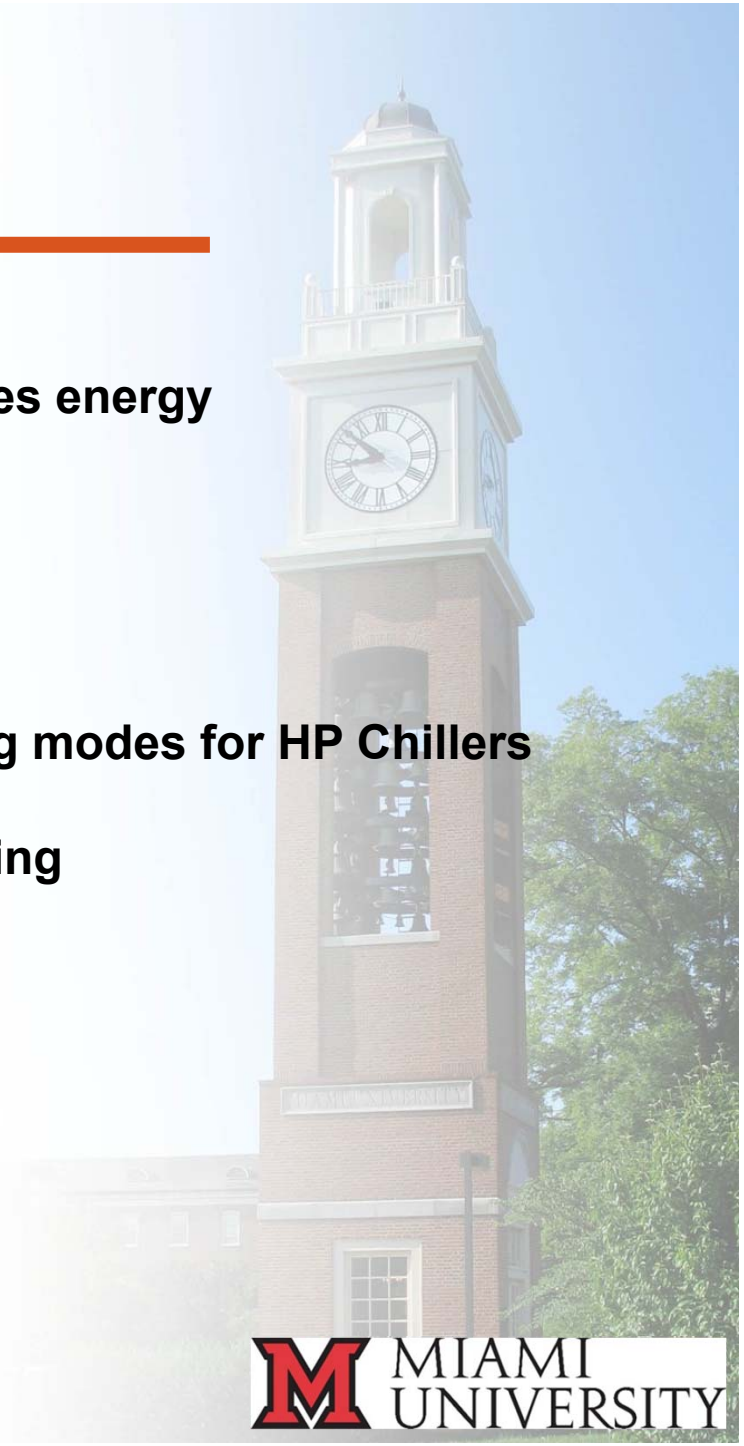
Geothermal



Takes advantages of the seasons, stores energy

Closed hydronic loops, 4 in all

No Glycol in Wellfield

At one time can run 2 out of 4 operating modes for HP Chillers

- Simultaneous Heating and Cooling
- Heating only
- Cooling only
- Free Cooling

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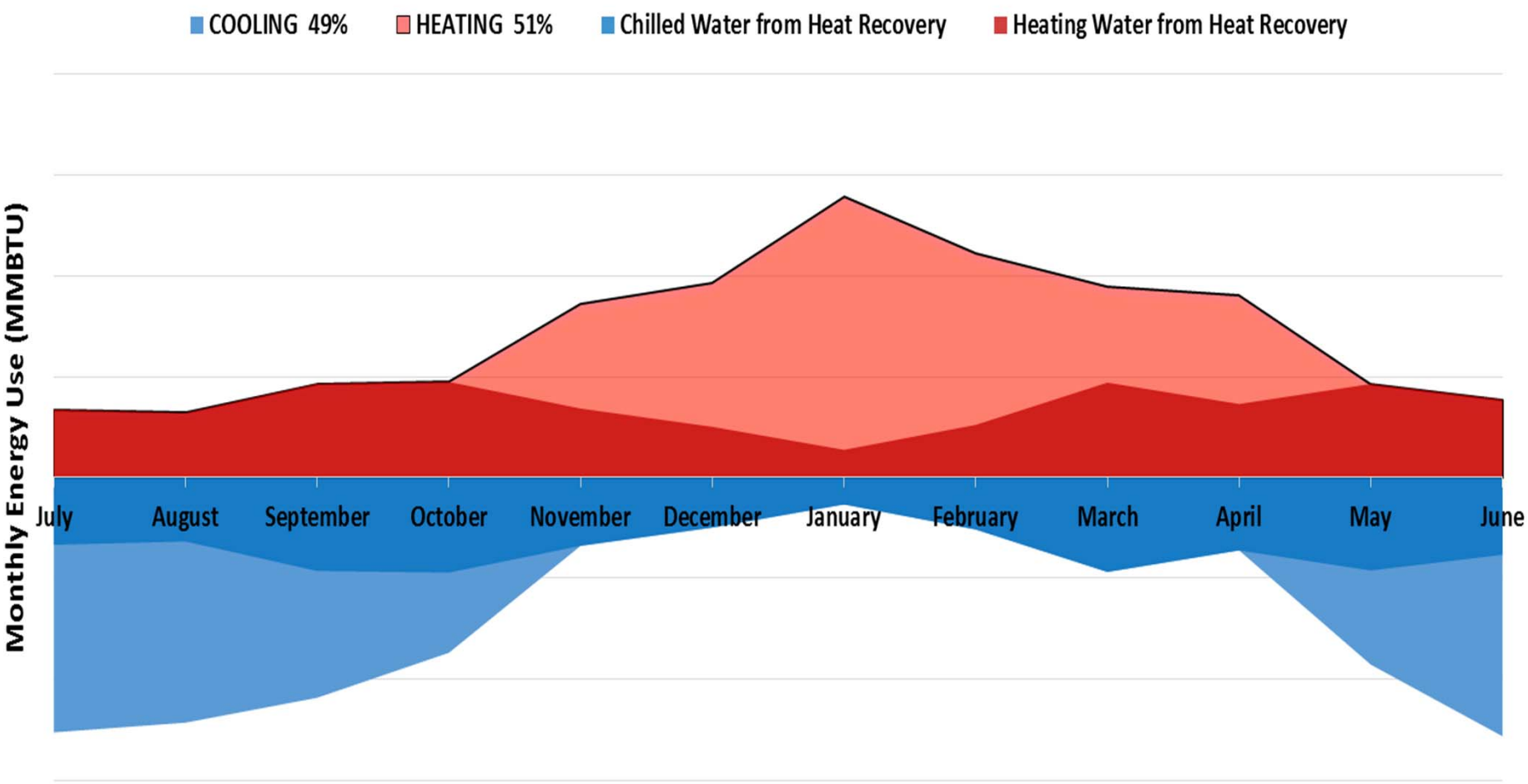
FY 2018 Load Profile for Geothermal Plant



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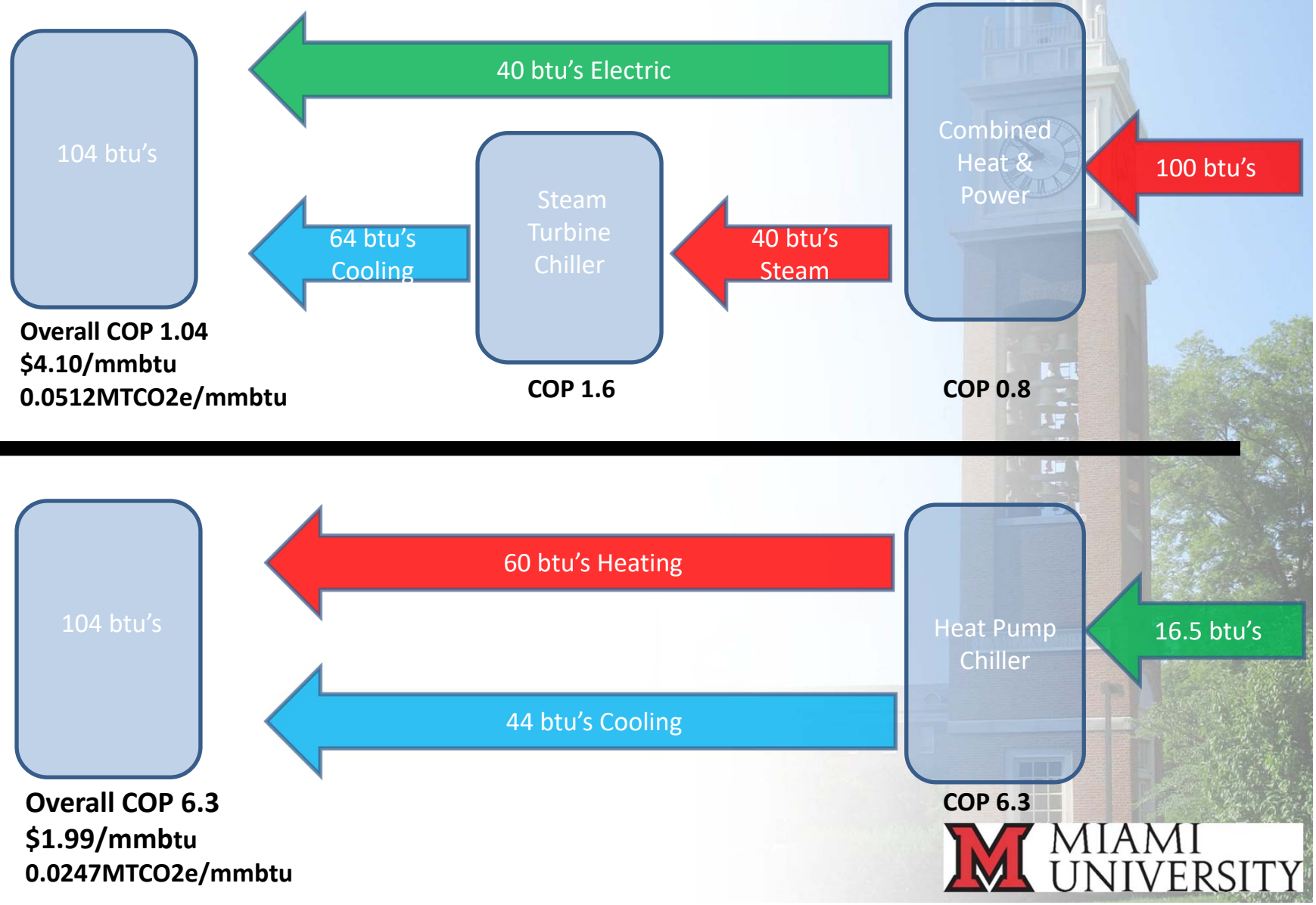
CHP vs. SHC



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Utility Master Plan Implementation

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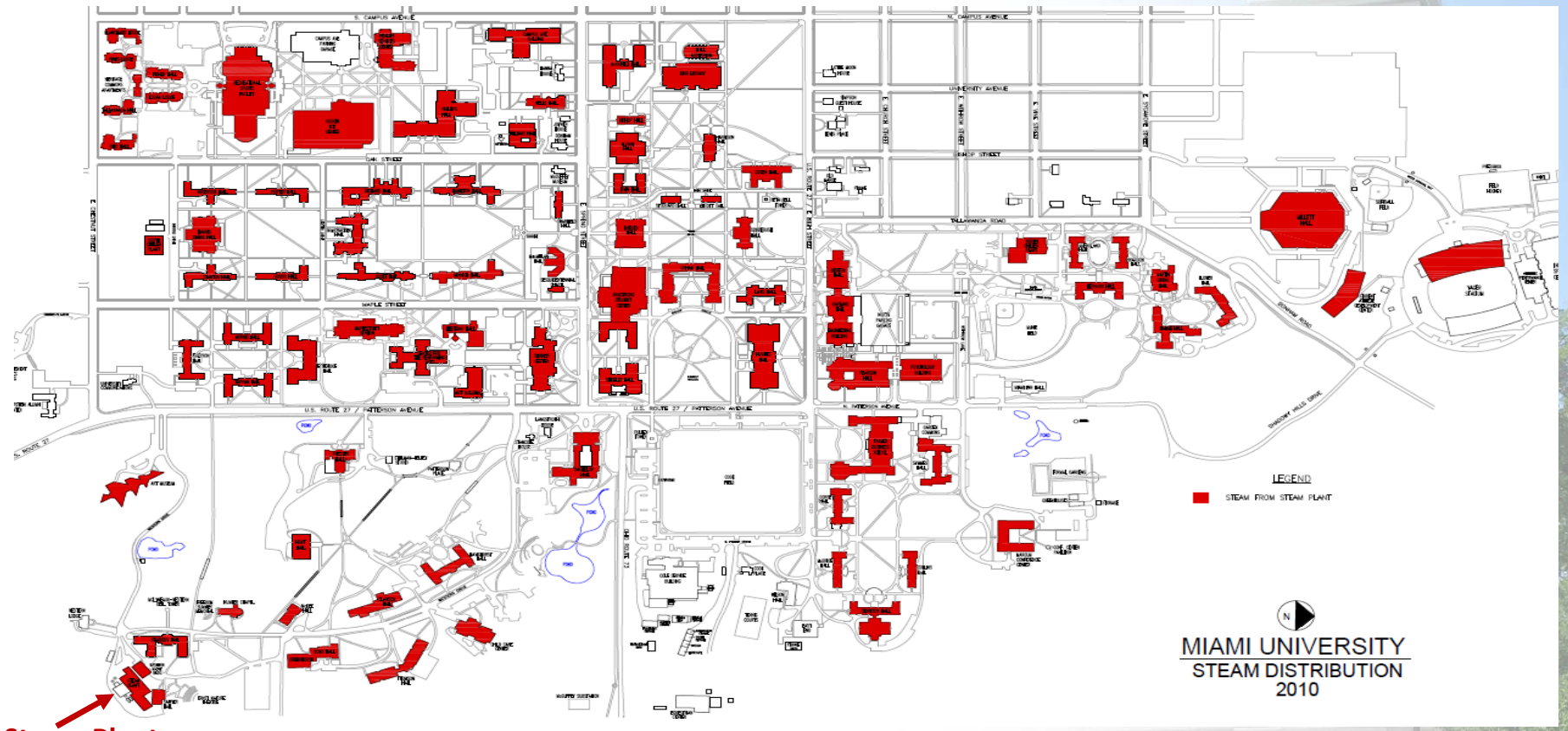
2010 Central Steam Buildings



- **Expected service life for majority of central steam plant equipment ends around 2025**

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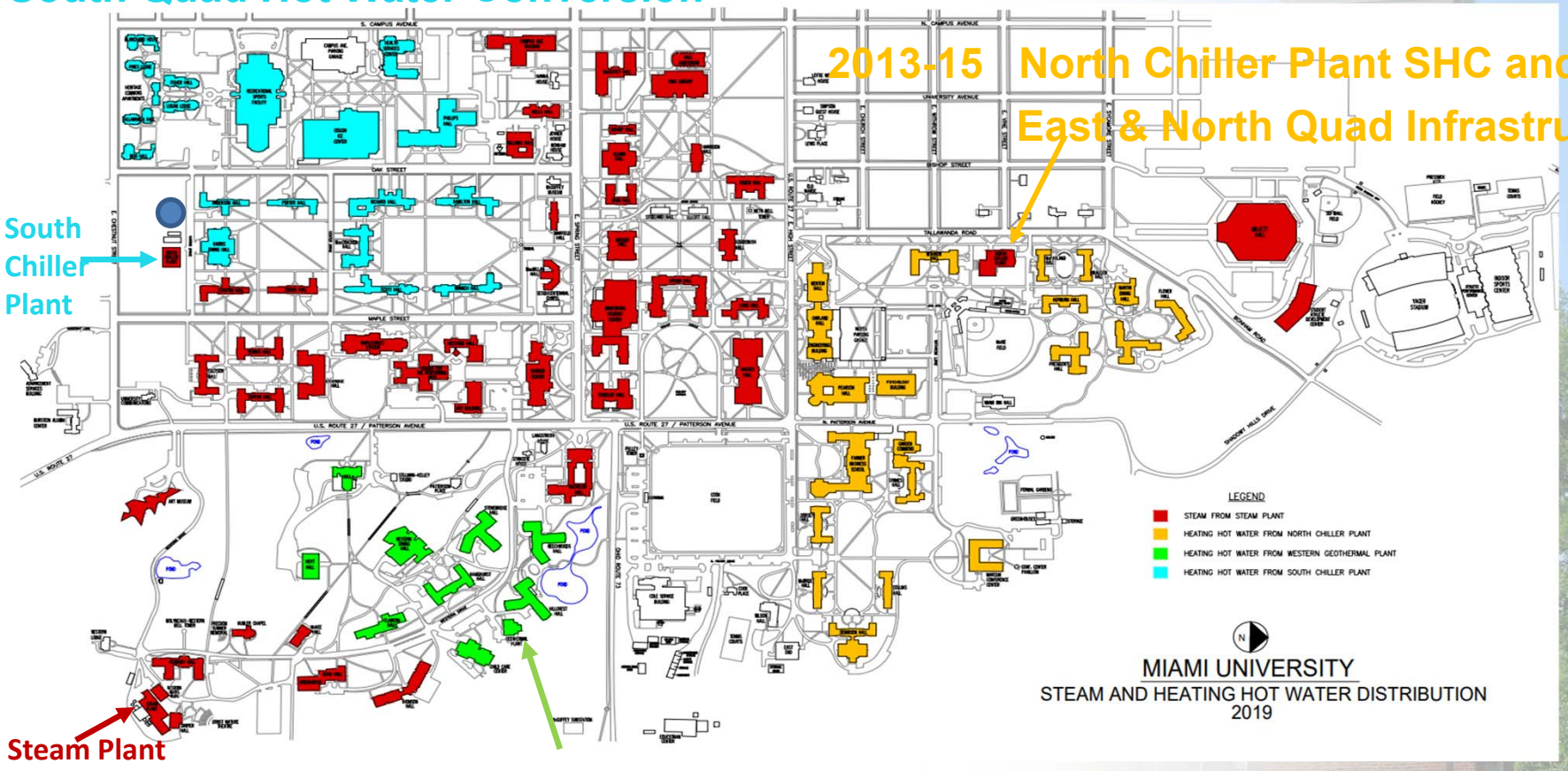
2019 Steam and Heating Hot Water Buildings

2018-2019

South Quad Hot Water Conversion



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Geothermal Energy Plant (GEP)

Mechanical Features:

- (3) 250-Ton Screw Heat Pump Chillers
- (3) 300-Ton Variable Speed Screw Heat Pump Chillers
- (1) 700-Ton Magnetic Bearing Chiller
- (2) 4,000 MBH Back-Up Boilers
- Plant Capacity
  - Cooling Capacity: 2,350 Tons
  - Heating Capacity: 26,000 MBH

WellField:

- 690 boreholes 600’ deep

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Performance

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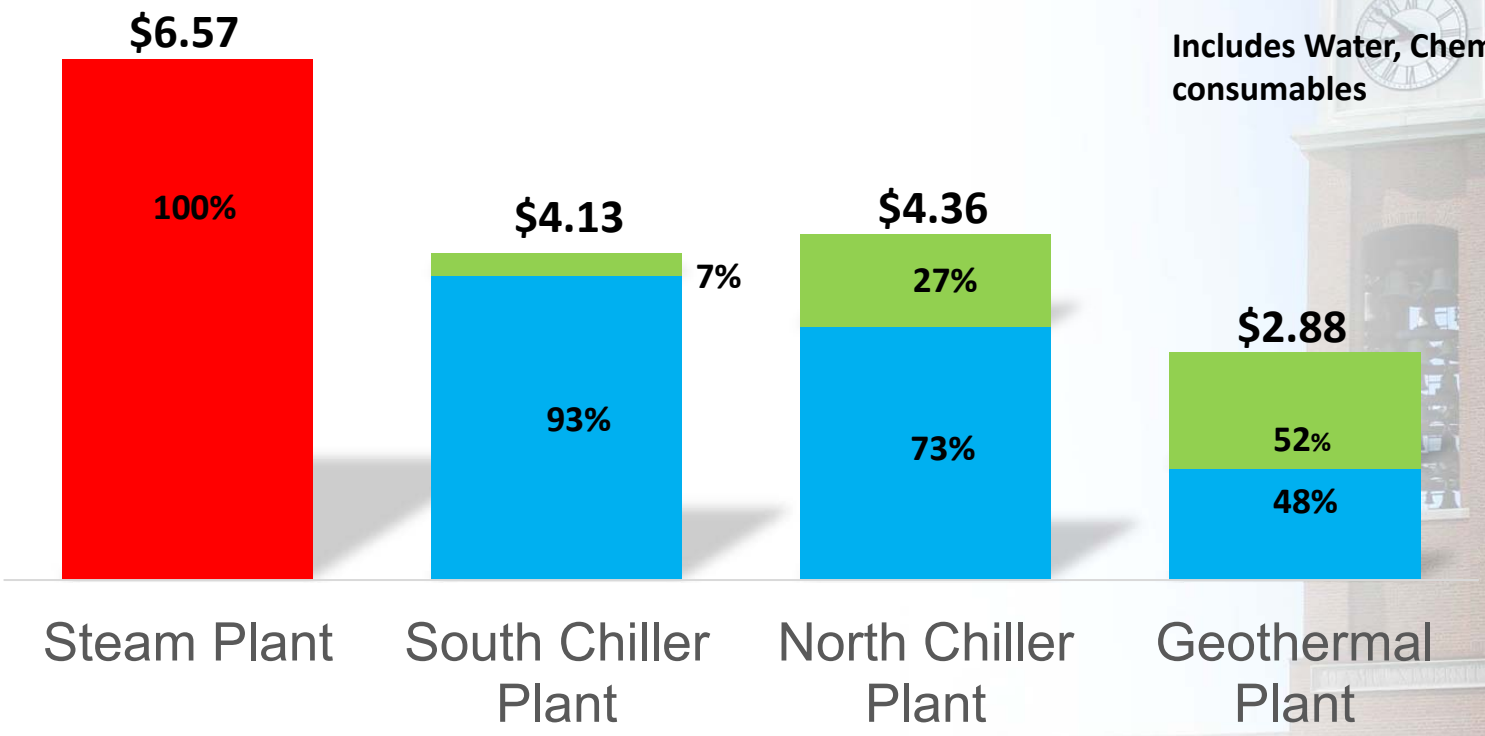
CHW/HHW/Steam Production Cost
FY 19 $/mmbtu's

Electric Cost = $ 0.0429/kwh
Natural Gas = $ 4.38/MCF

Includes Water, Chemical, Salt consumables



- Steam from Natural Gas Boilers
- HHW from Heat Pump Chillers
- Chilled Water from Chillers and Heat Pump Chillers

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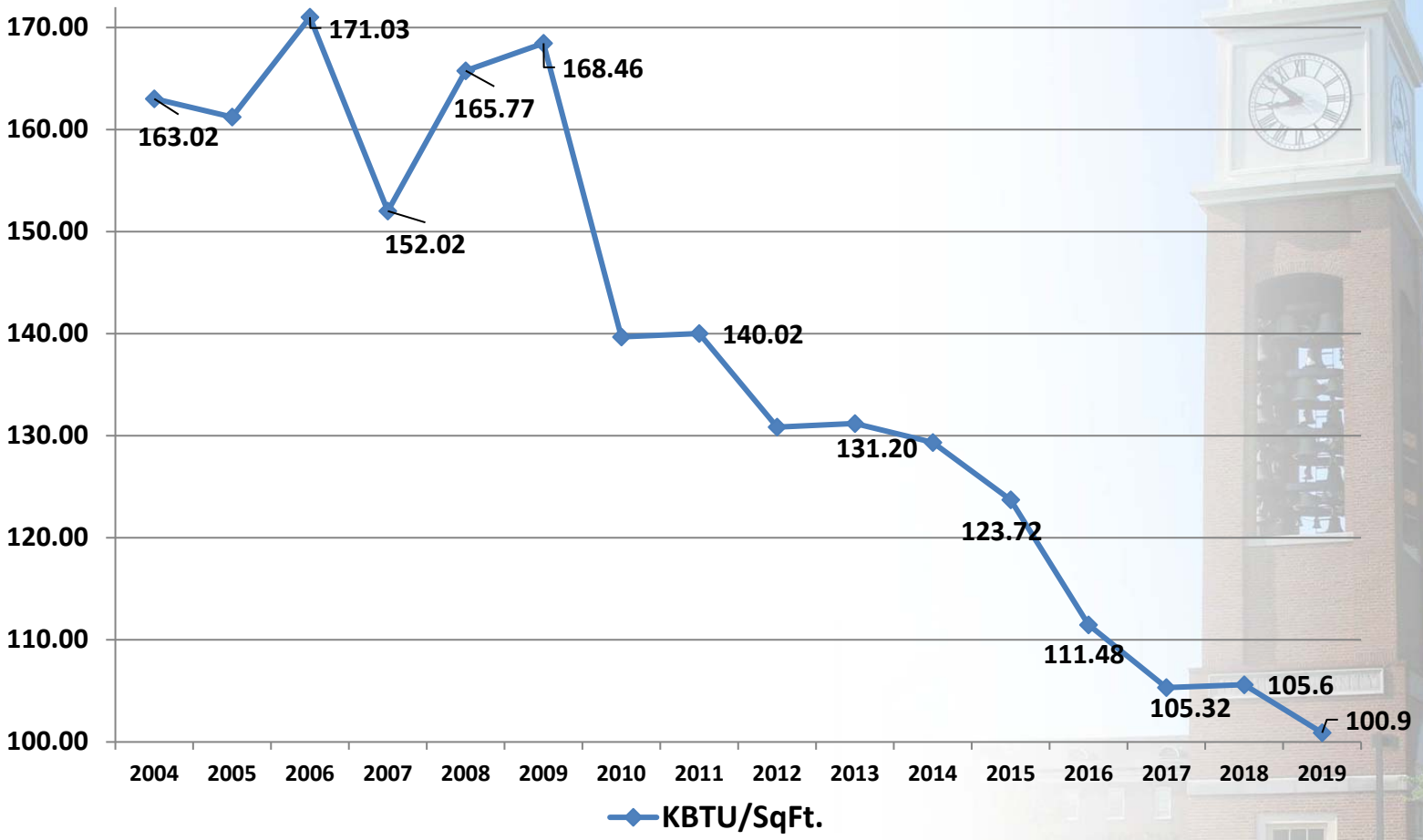
KBTU/GSF PROGRESS CHART



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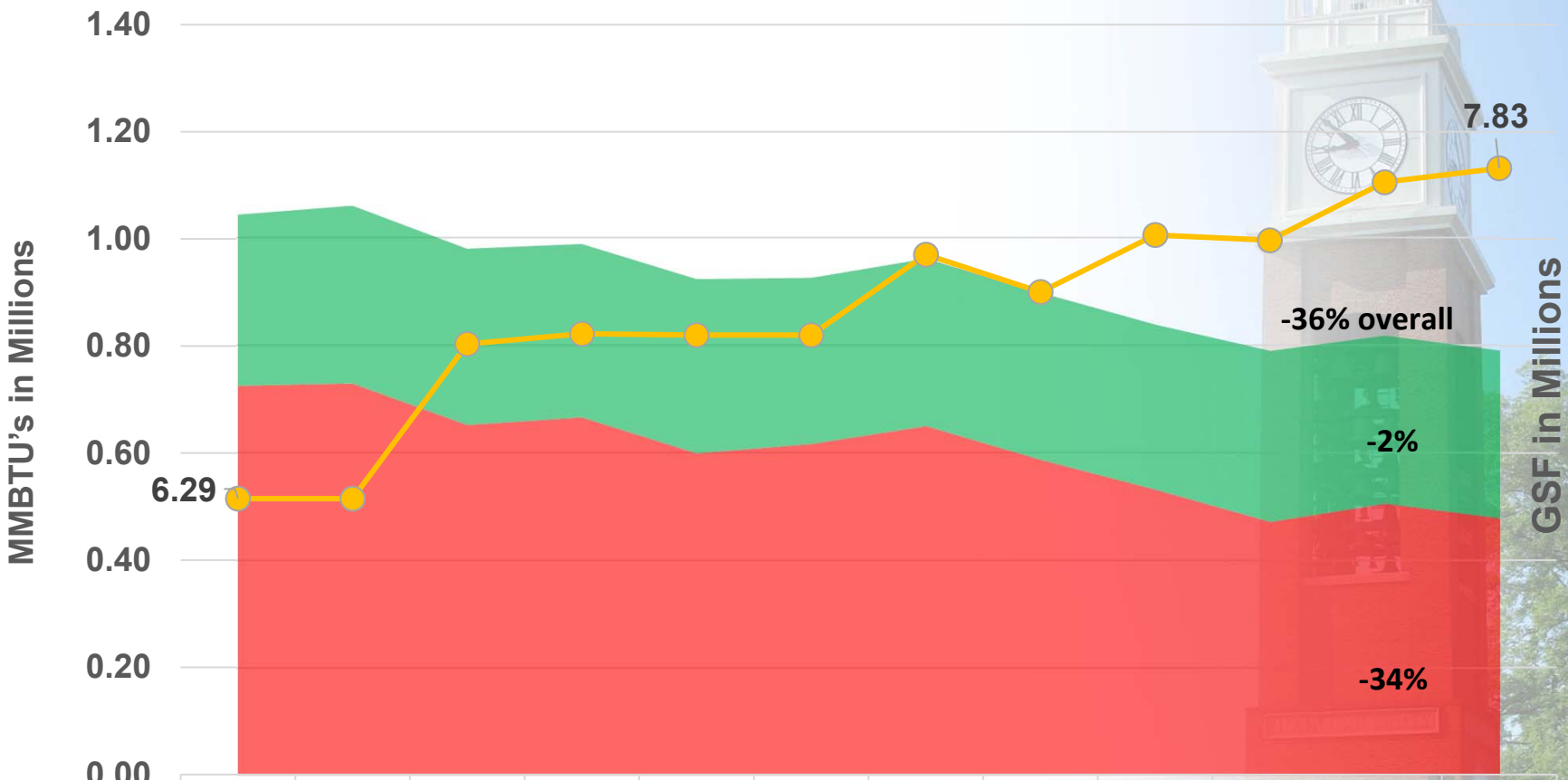
Oxford Campus Energy 2008-2019 MMBTU's



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Electric (MMBTU)	318,214	330,531	327,717	322,633	323,779	309,081	311,344	310,663	306,840	317,924	312,429	311,861
Fossil Fuel MMBTU	724,113	728,683	651,358	665,484	598,833	615,999	649,240	586,570	531,243	471,295	505,258	478,042
SqFt.	6,287,767	6,287,767	7,009,149	7,056,967	7,050,833	7,050,833	7,426,682	7,251,940	7,518,061	7,493,419	7,764,288	7,829,630

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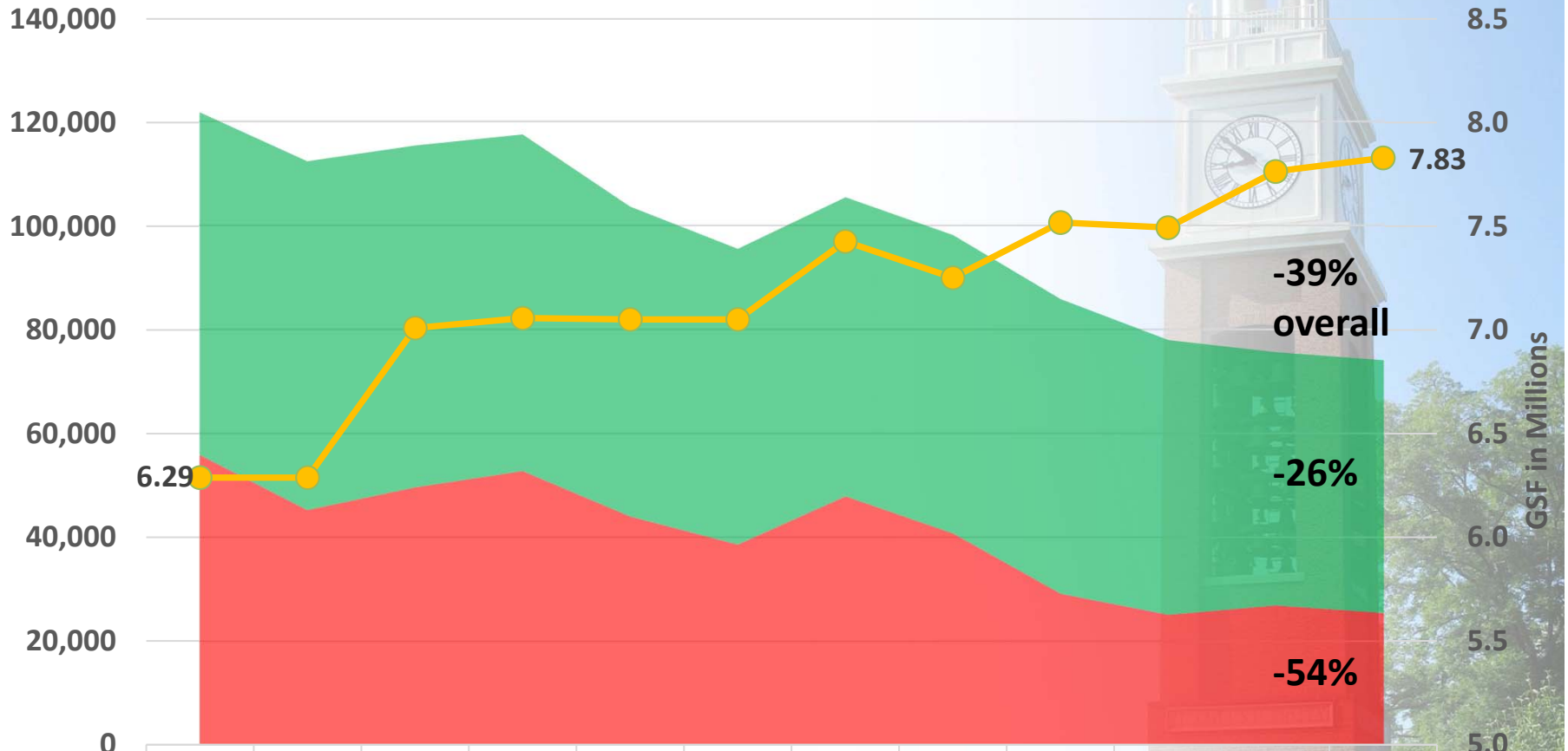
Oxford Campus Carbon 2008-2019 MTCO2e



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Electric (MTCO2e)	65,964	67,142	65,822	64,801	59,652	56,944	57,562	57,436	56,729	52,892	48,747	48,658
Fossil Fuels	55,845	45,221	49,591	52,731	43,988	38,576	47,883	40,724	29,101	25,065	26,871	25,424
SqFt.	6,287,767	6,287,767	7,009,149	7,056,967	7,050,833	7,050,833	7,426,682	7,251,940	7,518,061	7,493,419	7,764,288	7,829,63

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UMP Future Plans

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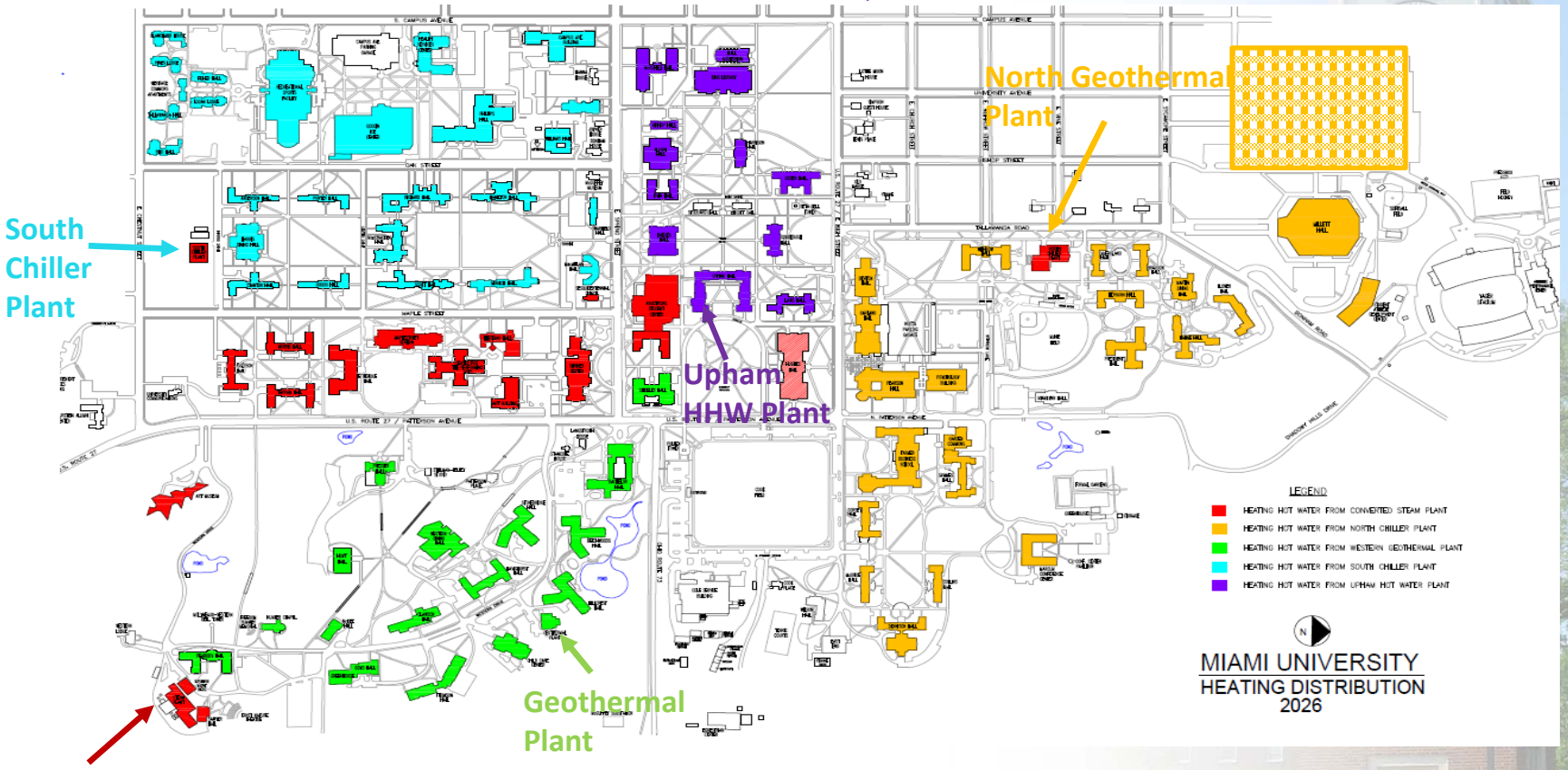
2026 Heating Hot Water Buildings

2020-22 Central Quad HHW Conversion Phase 1, 2 & 3

2025 North Chiller Plant Conversion to Geothermal



2026 Steam Plant Conversion to Heating Hot Water

2024 Expand Western Geothermal to all Western Bldgs

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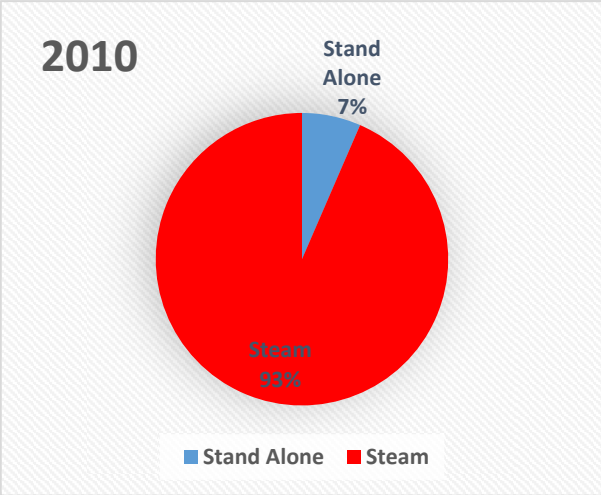
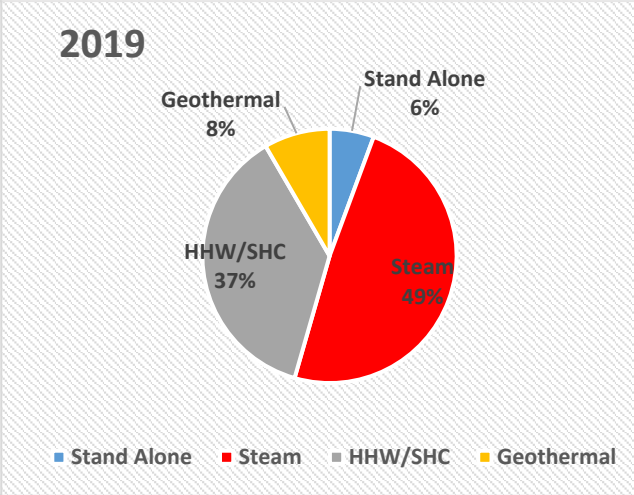
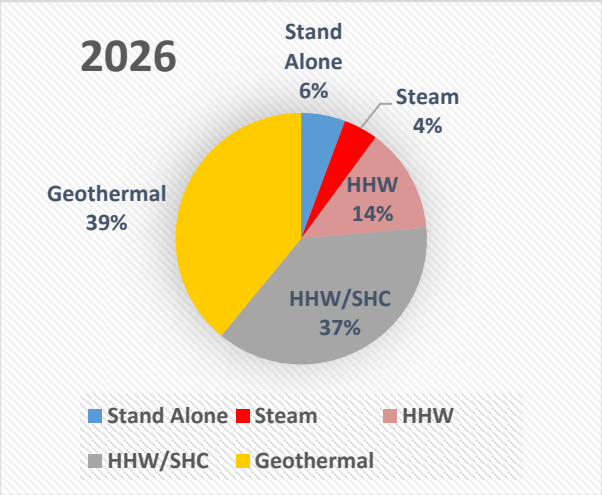
Heating Centralization Steam to HHW Migration







	2010		2019		2026	
Stand Alone	19	413,537	19	413,537	19	413,537
Steam	89	5,947,290	54	3,565,595	2	323,942
HHW	0	-	0	-	16	987,270
HHW/SHC	0	-	35	2,716,037	41	2,730,838
Geothermal	0	-	13	613,163	43	2,852,745
	108	6,360,827	121	7,308,332	121	7,308,332

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Expected Performance

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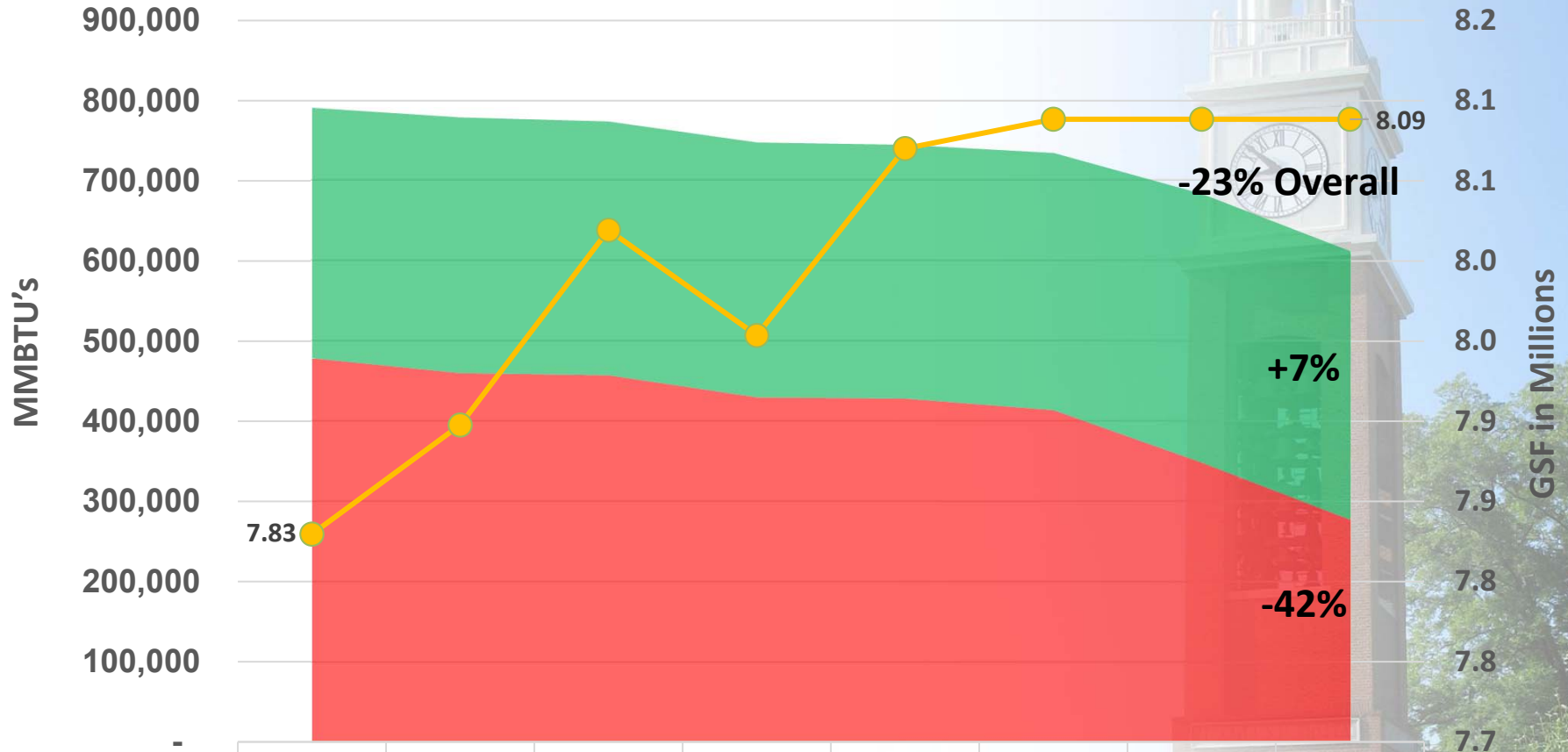
Projected Oxford Campus Energy 2019-2026 MMBTU's



	2019	2020	2021	2022	2023	2024	2025	2026
Electric (MMBTU)	311,861	318,433	316,044	317,409	316,044	320,139	334,645	334,645
Fossil Fuel MMBTU	478,042	459,536	456,768	429,353	427,760	413,374	347,942	276,766
SqFt.	7,829,630	7,897,752	8,019,290	7,953,621	8,070,151	8,088,480	8,088,480	8,088,480

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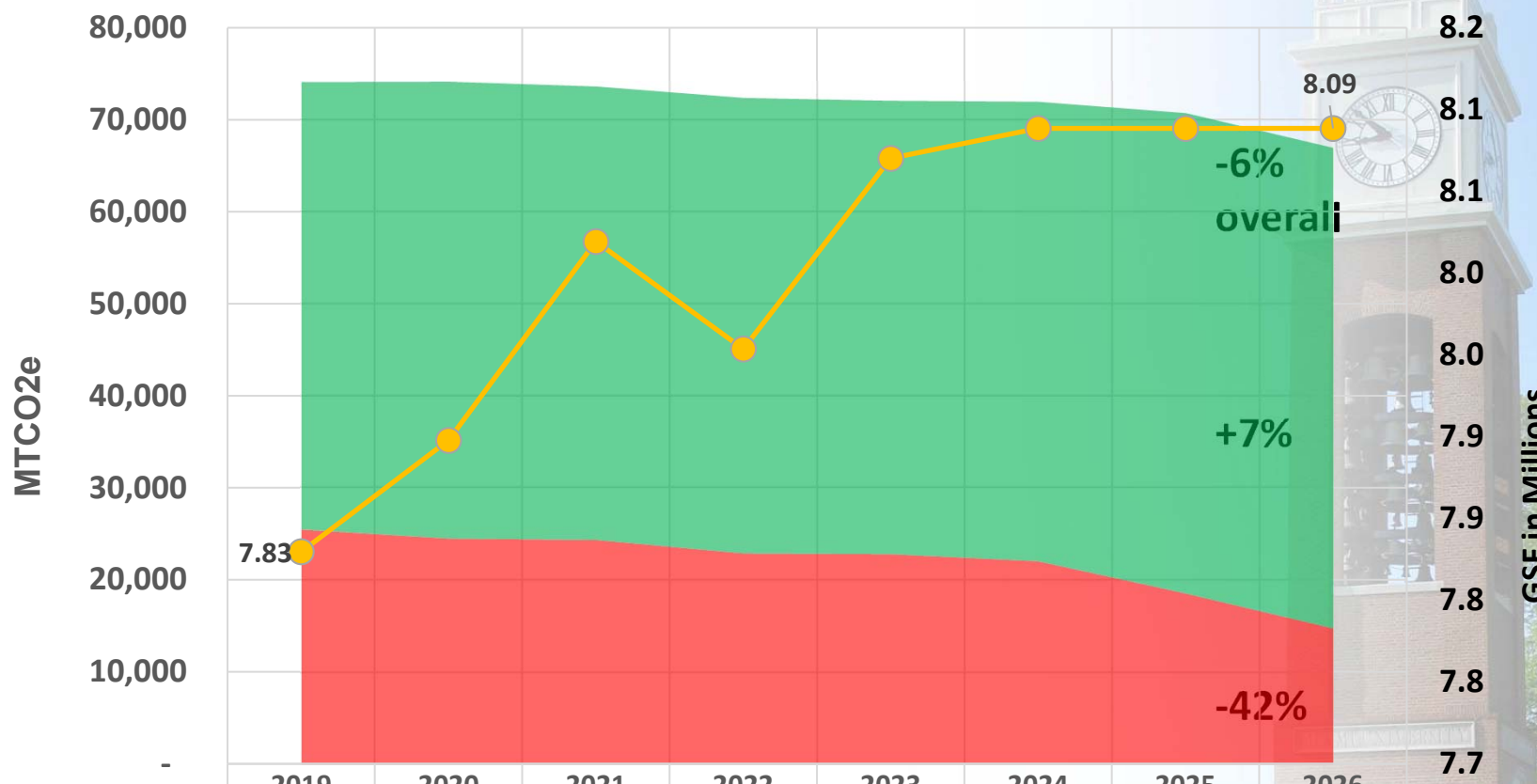
Projected Oxford Campus Carbon 2019-2026 MTCO2e



	2019	2020	2021	2022	2023	2024	2025	2026
Electric (MTCO2e)	48,658	49,684	49,311	49,524	49,311	49,950	52,213	52,213
Fossil Fuels	25,424	24,440	24,292	22,834	22,750	21,985	18,505	14,719
SqFt.	7,829,630	7,897,752	8,019,290	7,953,621	8,070,151	8,088,480	8,088,480	8,088,480

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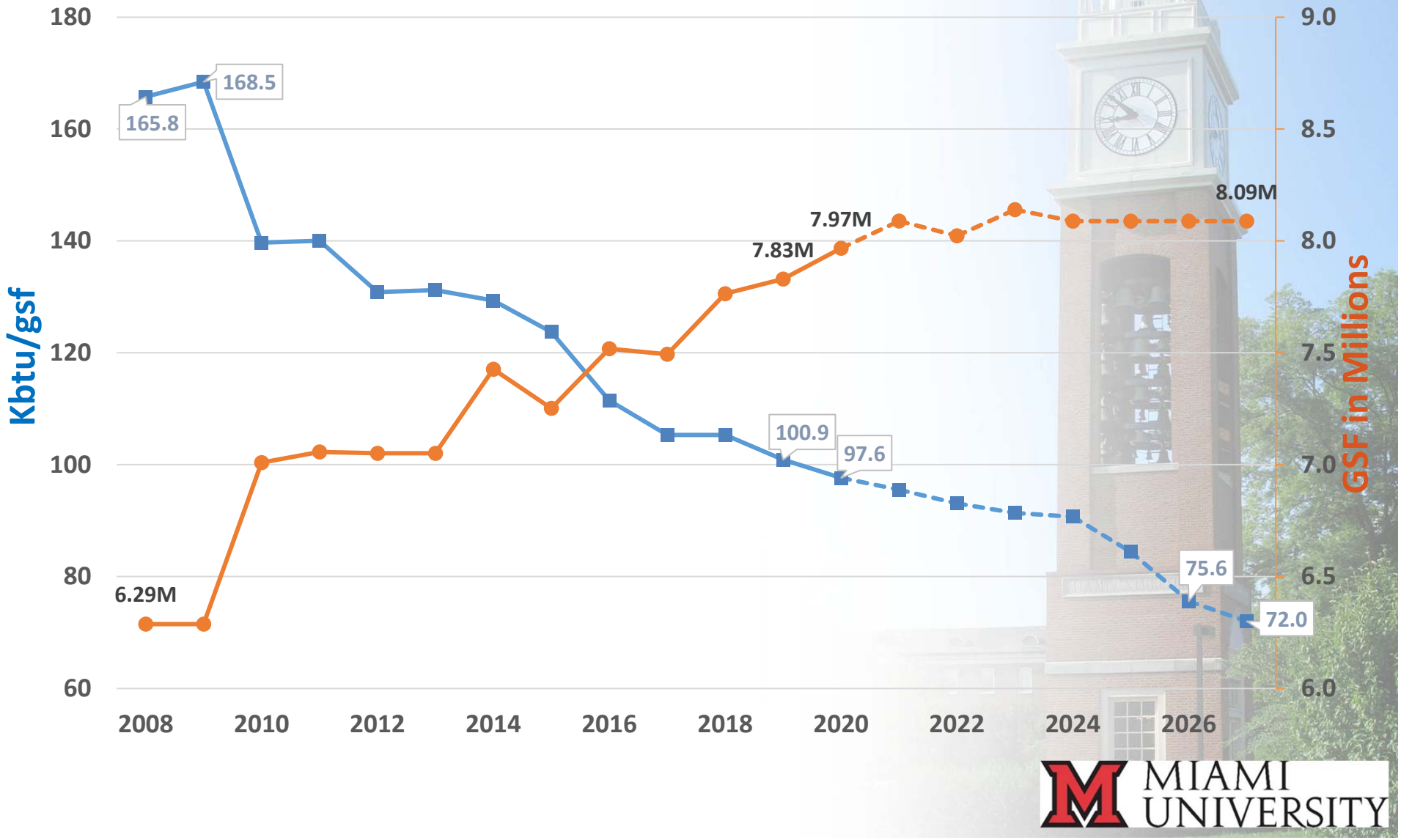
KBTU/GSF Future Progress Chart



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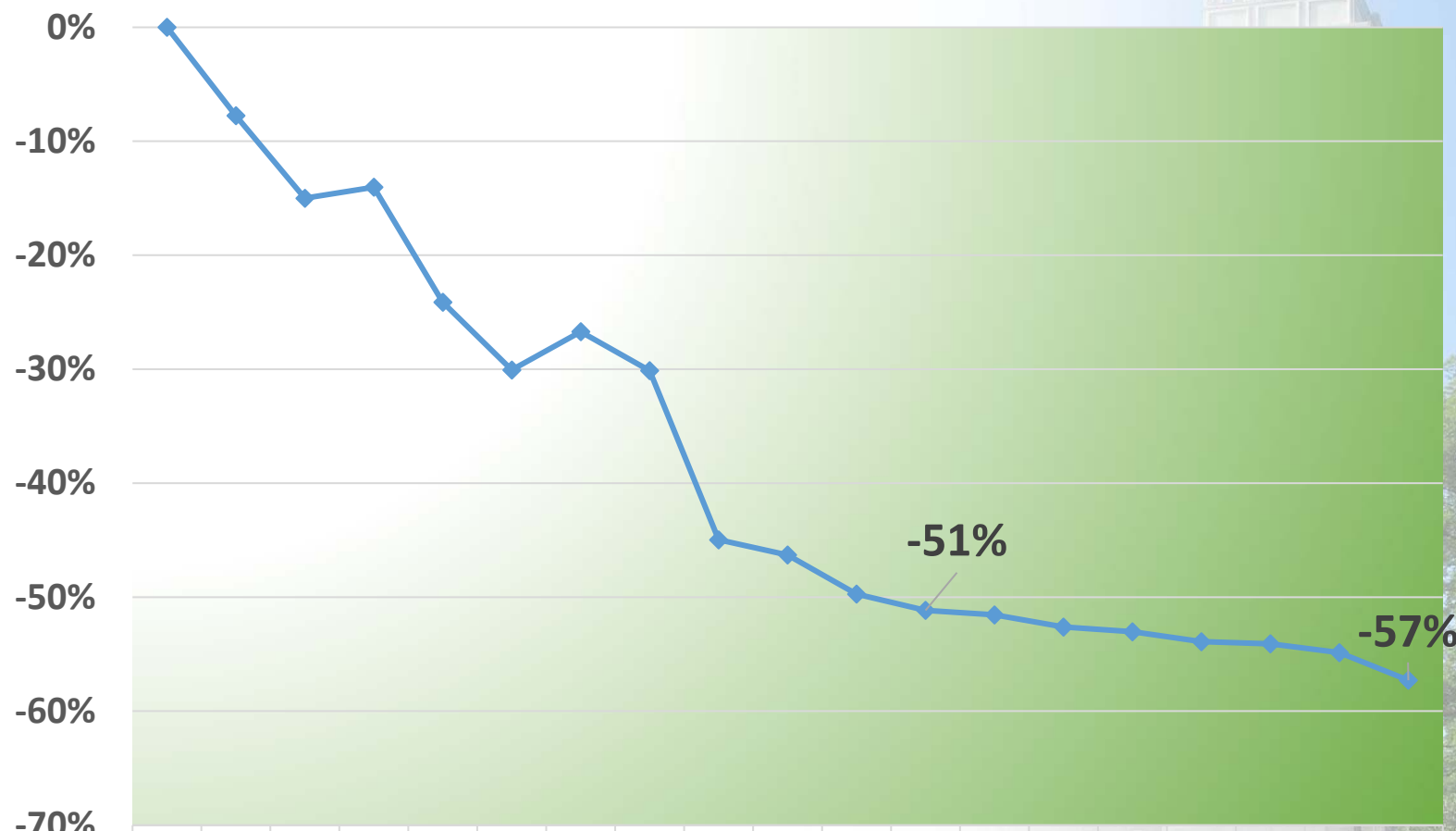
Carbon Reduction MTCO2e/GSF



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
% carbon reduction per gsf	0%	-8%	-15%	-14%	-24%	-30%	-27%	-30%	-45%	-46%	-50%	-51%	-52%	-53%	-53%	-54%	-54%	-55%	-57%

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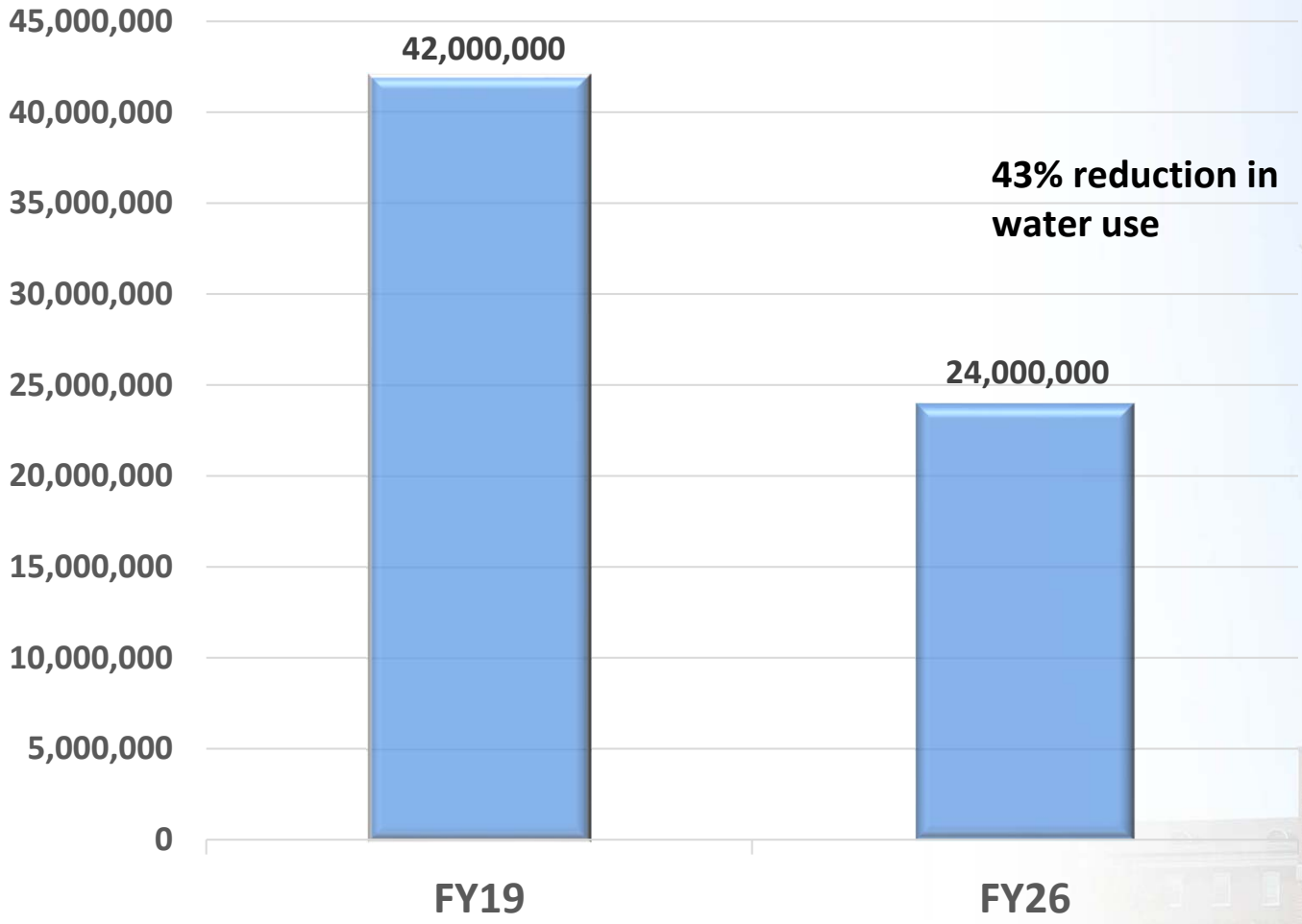
Central Plant Water Consumption Gallons



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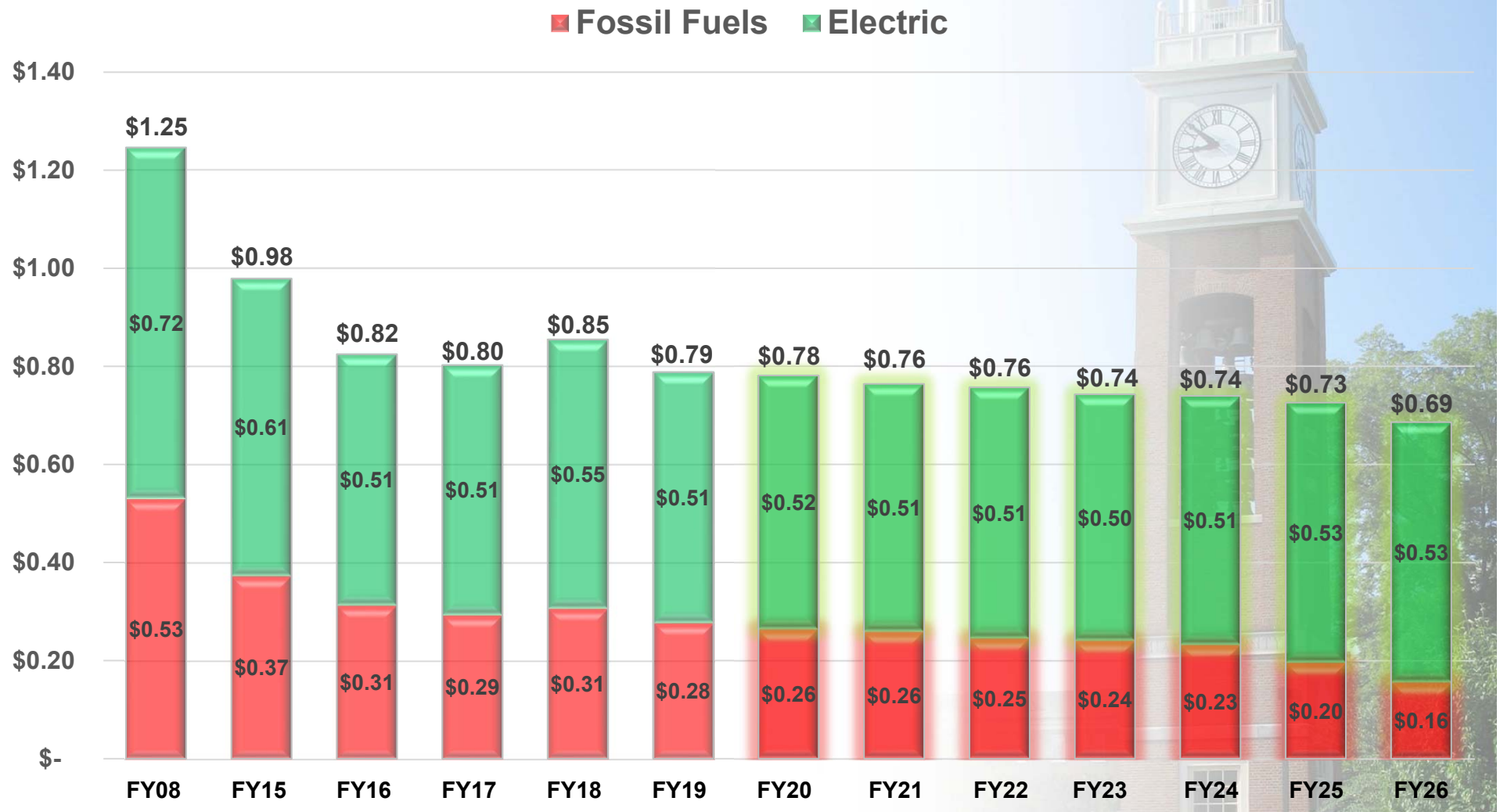
Energy Cost $/GSF



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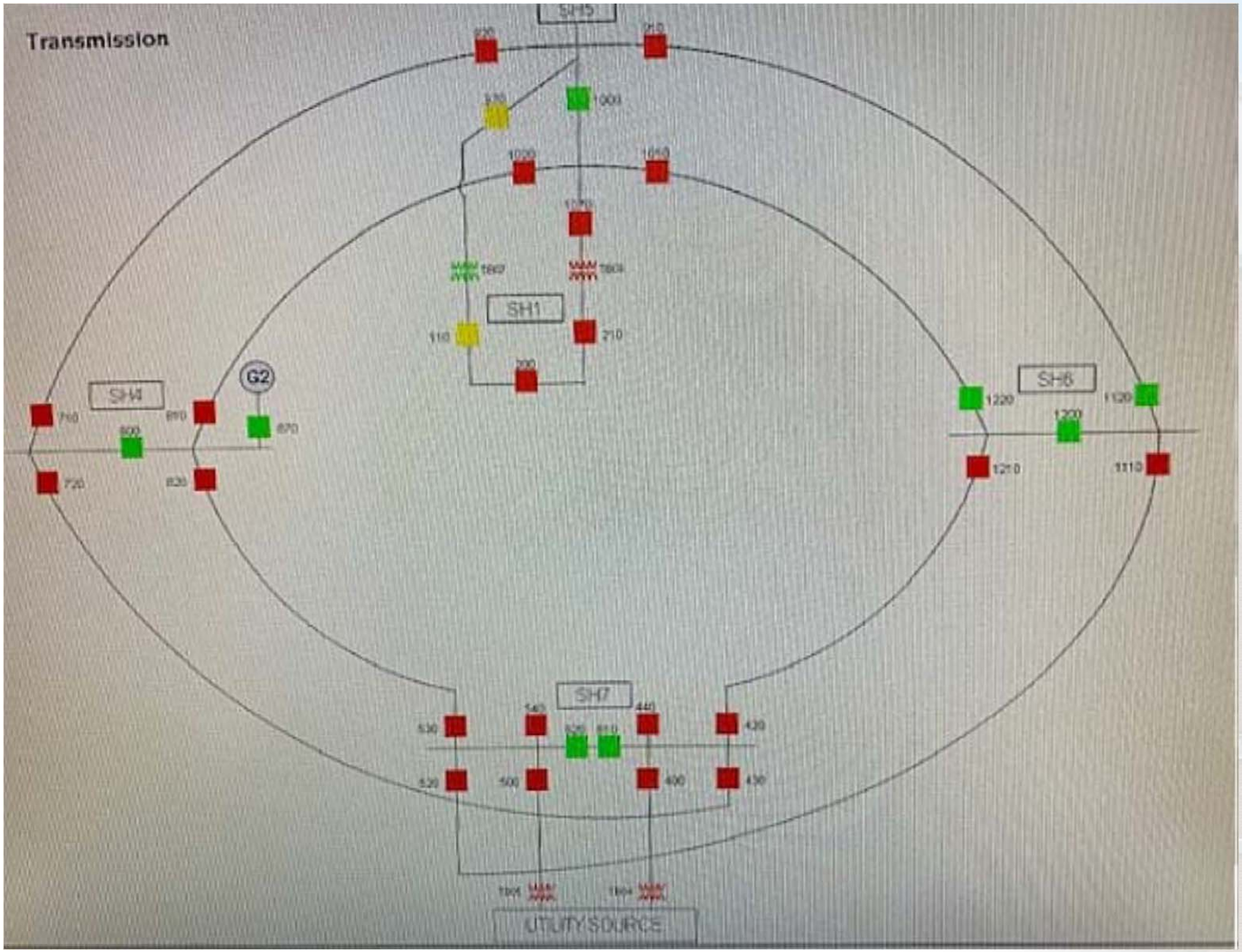
UMP Expected Outcomes

- **Customer Focus**
  - N+1 redundancy reliability
  - Year round cooling and heating availability
  - Aesthetically pleasing
- **Safety**
  - Migration to heating hot water is safer than steam, both from a property/personnel standpoint.
  - Chemical handling risk reduced.
- **Productivity**
  - Labor efficiency improvements
  - Overall energy efficiency improved, up to 600% in heating with geothermal
  - Carbon reduction
- **Cost**
  - Water usage minimized
  - Chemical usage minimize
  - Less environmental regulation and compliance
  - Flexibility for fuel (sourcing) options

12kV Dual Loop Distribution



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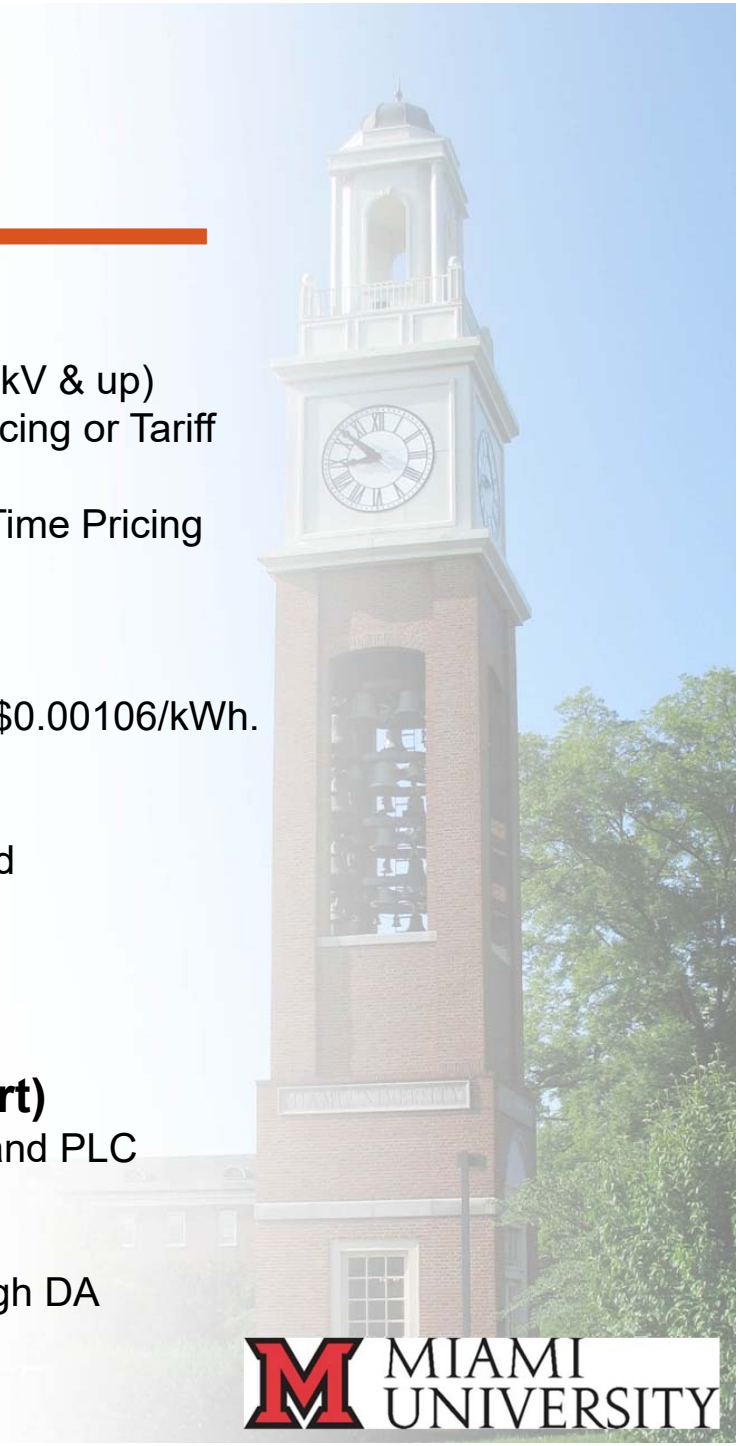
Managing Cost of Electric

- **Subaccount on PJM**
  - Own Substation, Become Transmission Customer (69kV & up)
  - Buy Power by the Hour and pay Capacity vs. All-in-pricing or Tariff
  - Assume more Risk, But Enjoy More Reward
  - Nominate DA (Day Ahead), Settle deviations at Real Time Pricing
  - Manage own PLC and Peak demands
- **Ohio Excise Tax Rider**
  - If over 45 million kWh/yr., then Self-Assess and save $0.00106/kWh.
- **Load Management Rider**
  - Off-Peak demand can be double the On-Peak demand
- **HB6: Duke Opt-Out EE-PDR & AER-R Riders**
  - Eligible Customers expanded Jan. 1st, 2020
- **Monetizing Generation Assets (Rainbow Chart)**
  - Utilize Generators, TES, and BAS to manage Peaks and PLC
  - Participate in DR Program
  - Generate when RT LMP prices Spike
  - Reduce Nomination and Generate when anticipate high DA
  - Price Sensitive Demand Bid



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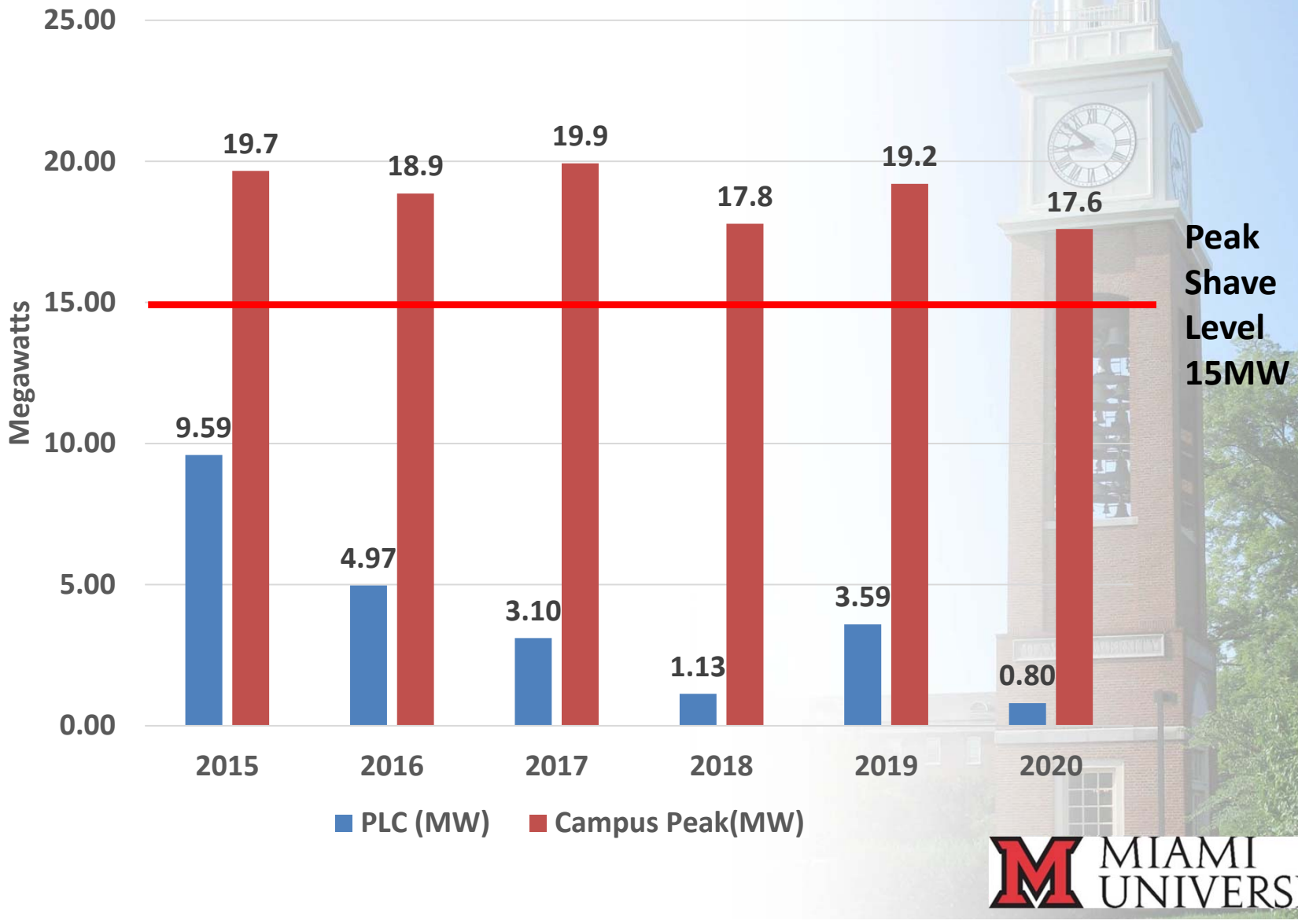
ELECTRIC POWER GENERATION PROGRAMS AND PARAMETERS

NAME OF PROGRAM	PEAK SHAVING	PLC	EMERGENCY DEMAND RESPONSE	AEP PRICE SENSITIVE DEMAND BID
INTENT	To limit demand during summer on-peak hours to reduce Duke yearly demand ratchet and monthly demand bill.	To limit campus Total Import on the 5 highest hours on separate PJM demand days during summer peak months	To limit campus demand on the grid during PJM declared power emergency	To generate power when Day Ahead (DA) price is higher than cost of generation to net savings or extreme Real Time
START DATE	June 1, 2019	June 1, 2019	June 1, 2019	June 1, 2019
END DATE	September 30, 2019	September 30, 2019	September 30, 2019	May 30, 2020
CONTROL DAYS	Monday thru Friday	Monday thru Friday	Monday thru Friday	Monday thru Friday
CONTROL HOURS	9	4	8	9
PROGRAM START TIME	11:00 AM / 11:00:00	2:00 PM / 14:00:00	NOON / 12:00:00	11:00 AM / 11:00:00
PROGRAM END TIME	8:00 PM / 20:00:00	6:00 PM / 18:00:00	8:00 PM / 20:00:00	8:00 PM / 20:00:00
TRIGGER OF EVENT	When MU operating engineer determines Total Import load is approaching 15,000 kVA during control period	Scott Lessing call to run based on PJM hourly load forecast over 140,000 MW	Text/Email from Duke to Doug Hammerle and 5 others	Scott Lessing call by 9AM morning of to run based on day ahead price.
NOTIFICATION/ RESPONSE WINDOW	Beginning of Summer	Morning of planned run	A minimum of a 60 minutes prior to start of event	Morning of planned run
RUN ORDERS	GOAL: IMPORT to 15,000 kVA Operate Wartsila gens to limit Total Import.	GOAL : IMPORT to 1,000 kW Operate Wartsila gens to max output, DO NOT EXPORT.	GOAL : IMPORT to 3,000 kW Operate Wartsila gens AND Thermal Storage to limit Total Import. Min. Import 2,000KW.	GOAL: GENERATE 11,000 kW Operate both Wartsila Gens to reduce load.
MONITORING METHOD	15 minute block average/ ie 00:00:00 to 00:15:00	One hour block average/ ie 00:00:00 to 01:00:00	One hour block average/ ie 00:00:00 to 01:00:00	One hour block average/ ie 00:00:00 to 01:00:00
FINANCIAL IMPACT FOR FAILURE TO MEET LEVELS	~$7,500/ 1,000kW	~$10,000/ 1,000kW	~$5,000/ 1,000kW	VARIES: ~$150/ 1,000kW

Rainbow Chart

- **[Blue] Peak Shaving**
  - Peaking Engine Generators: (2) 5.7MW Natural Gas Reciprocal
  - TES Tank (Thermal Energy Storage)
- **[Orange] PLC (Peak Load Contribution)**
  - Peaking Engine Generators: (2) 5.7MW Natural Gas Reciprocal
  - TES Tank (Thermal Energy Storage)
  - Load Curtailment with BAS (Building Automation System)
- **[Red] DR (Demand Response, e.g. PowerShare Program)**
  - Utilize Generators, TES, and BAS to reduce Load to set Amount
- **[Green] Generate for Dollars**
  - Generate when RT LMP prices Spike
  - Reduce Nomination and Generate when anticipate high DA
  - Price Sensitive Demand Bid

Peak Demand vs. Peak Shaving and PLC



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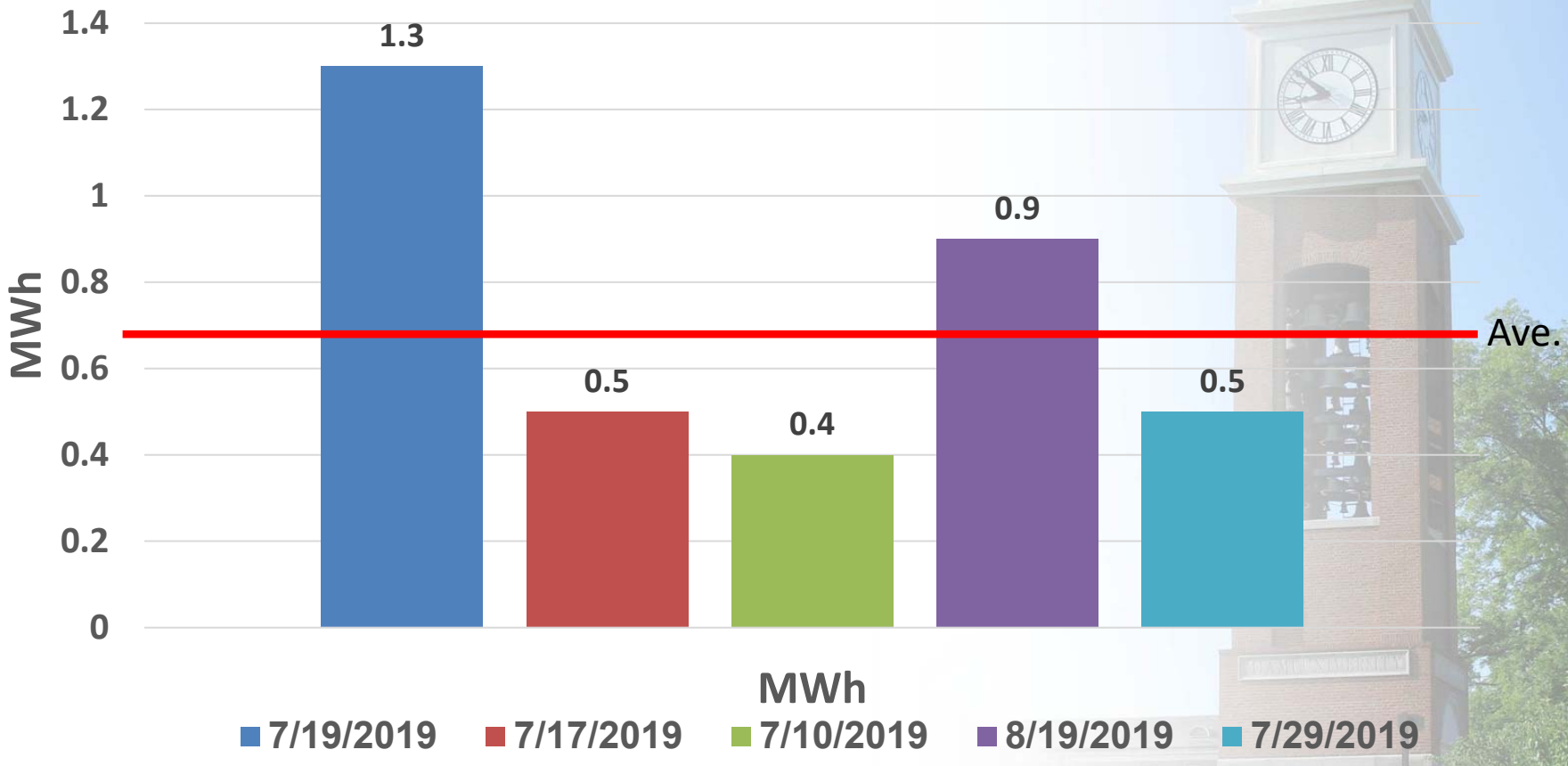
2019 Peak Load Contribution Management



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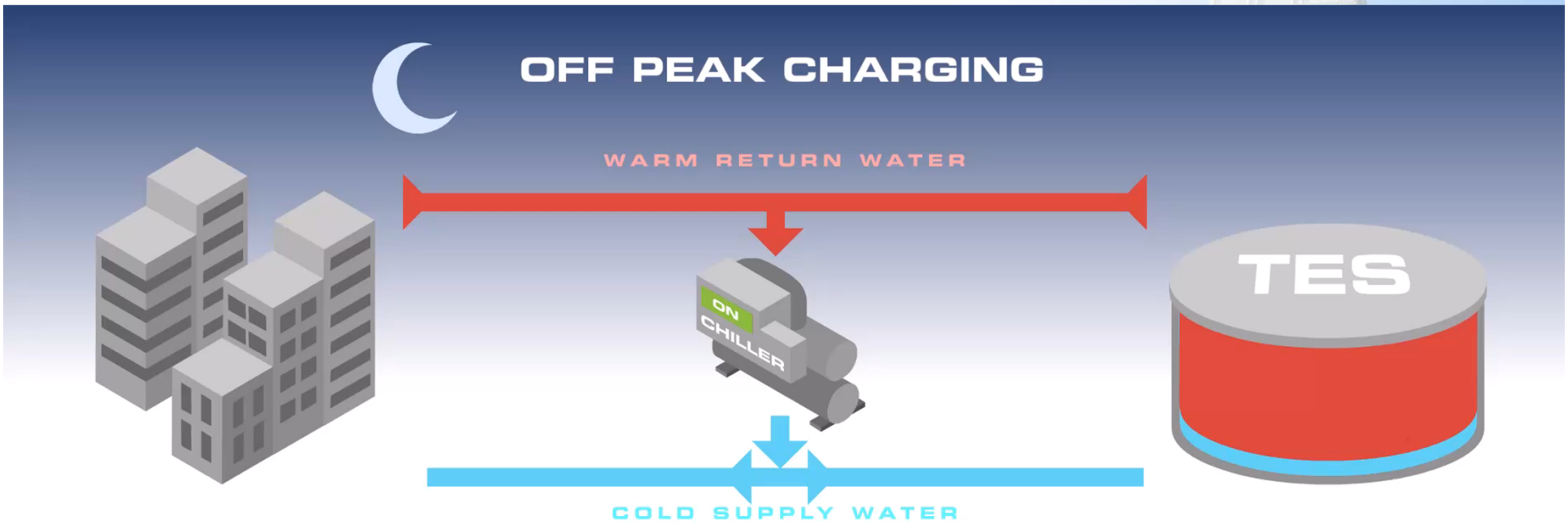
Thermal Energy Storage



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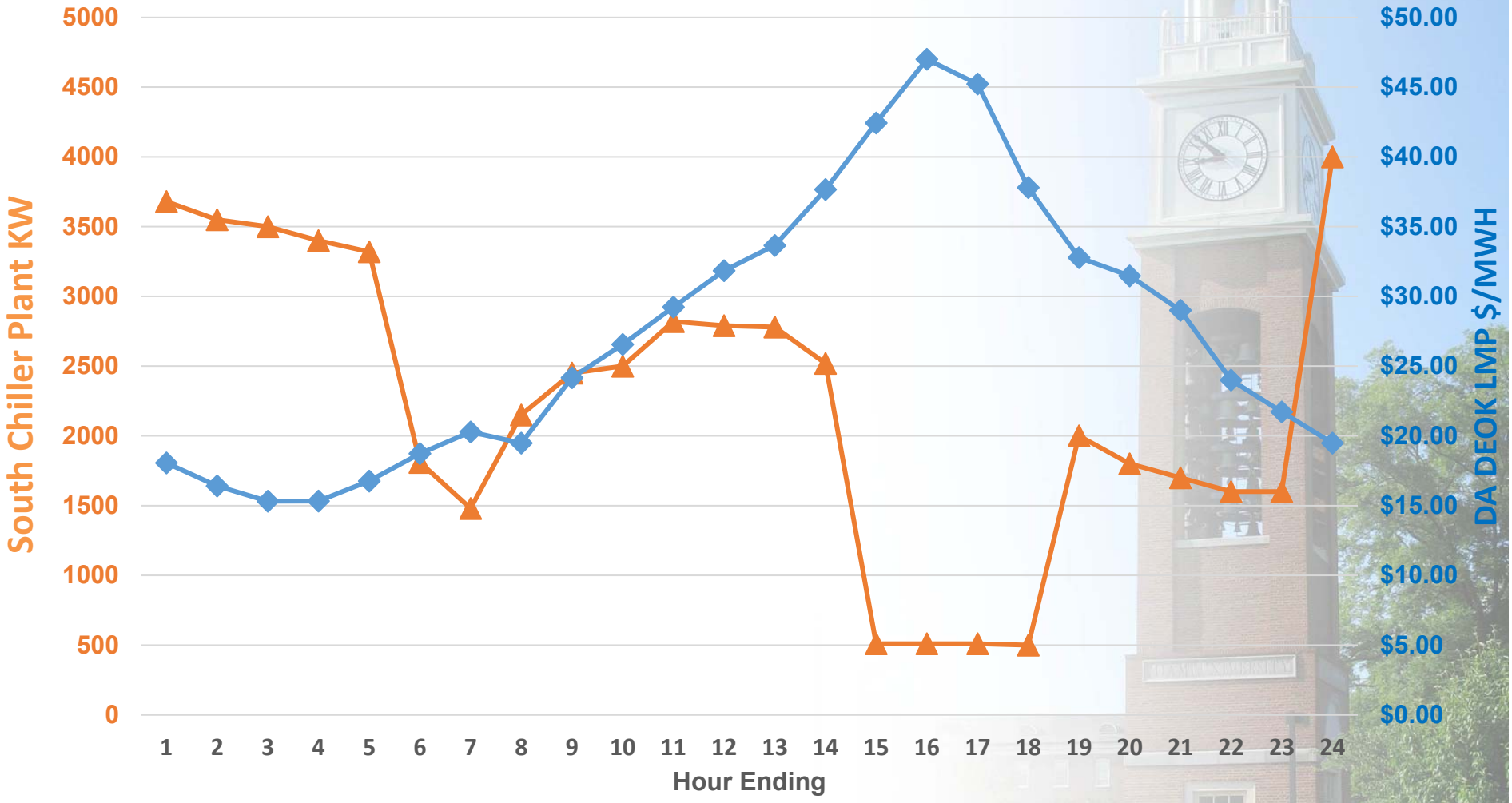
PLC Called Day 6-27-19 TES Tank Charging/Discharging



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Thank You

PRESENTED BY
Doug Hammerle, PE
Director of Energy Systems
hammerd@miamioh.edu

Scott Lessing
Senior Electric Operations Manager
lessinsw@miamioh.edu

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