MEP Associates, LLC

The Evolution of Geothermal through Campus Conversions

Reducing Energy Cost and Optimizing Efficiency

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Agenda

- Master Planning Process
- Miami University Case Study
- Commissioning / Forensics
- Lessons Learned
- Questions?

Campus Master Plan Experience

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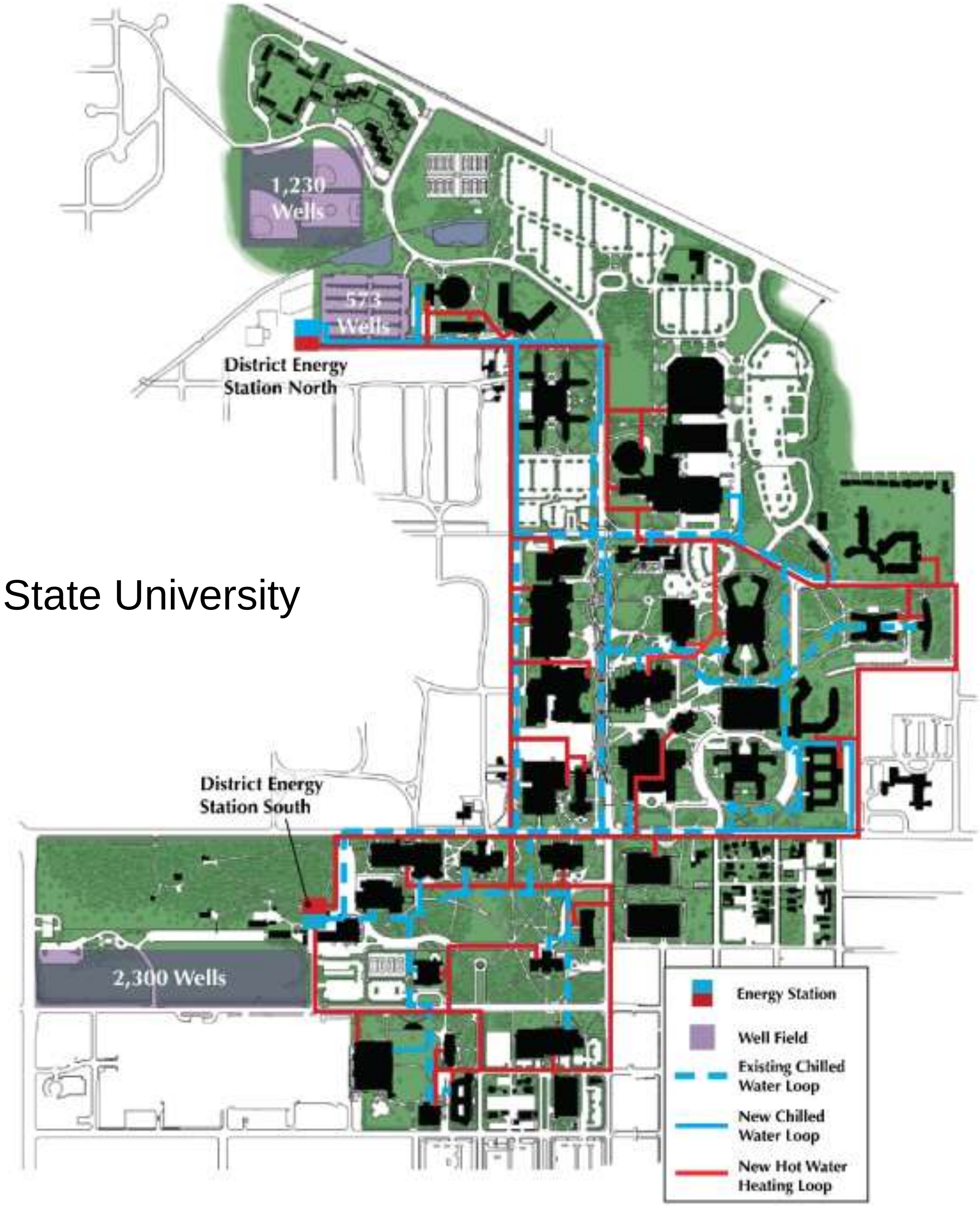
Campus Conversions to High Efficiency and Low Carbon

Ball State University



Master Planning Process

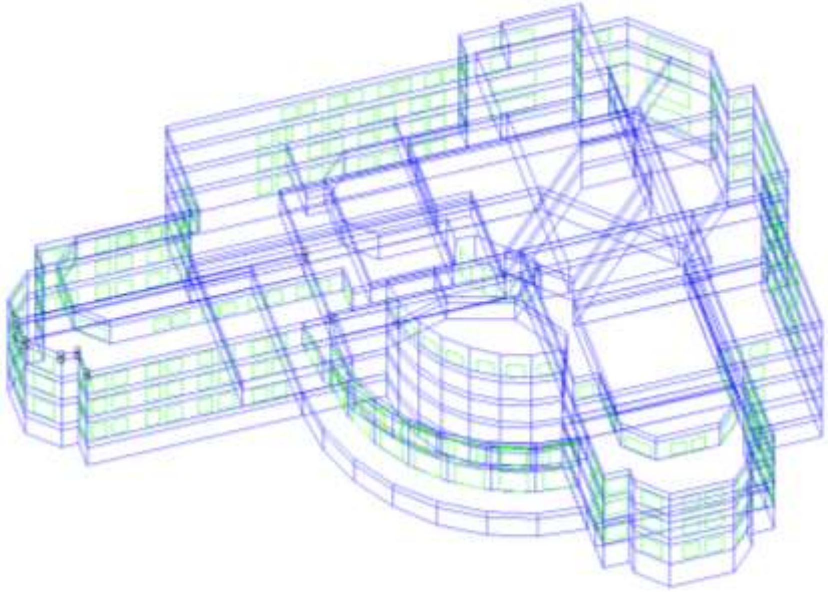
- Data and Information Gathering
- Develop Thermal Profiles
- Selecting Equipment
- Selecting Distribution System
- Selecting Geothermal Heat Exchanger

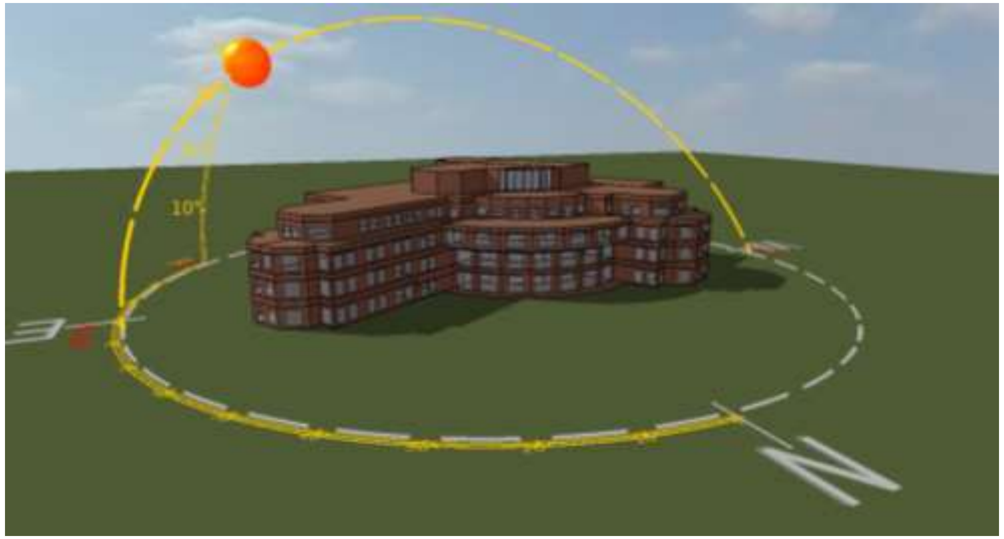
Data and Information Gathering

- Work with the Client to Analyze
  - Project energy needs
  - Site conditions / building information
  - End user goals and drivers
  - Utilization
    - Space concerns
    - Current infrastructure
    - Master planning
    - Utility information
- Existing or New Buildings
  - Review Existing infrastructure
    - Site Plan
    - Utility Drawings
    - Steam-to-hot-water
    - Building level metering
- Understand the FTE's to Operate Existing CEP
- Review All Future Master Planning / Expansion Plans

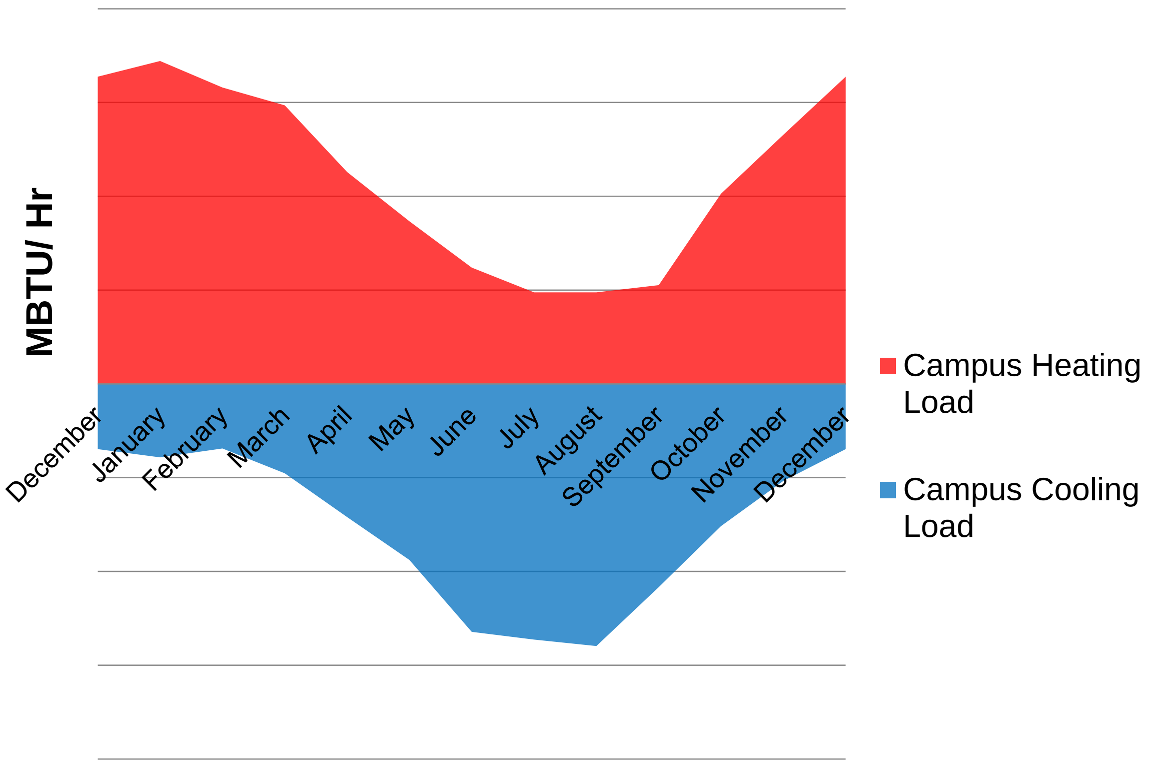
Developing Thermal Energy Profiles

- Energy Modeling and Utility Metering
  - Chiller/Boiler plant metering
  - Building level metering
- Thermal Peaks and Energy Consumed
  - Base and simultaneous loads
  - Unbalanced heating and cooling loads
- Diversity of Buildings
  - Aggregate loads
  - Simultaneous loads
- Scheduling/Occupancy
- Equipment Efficiency
- Incorporating Master Plan
  - Renovations
  - Upgrades

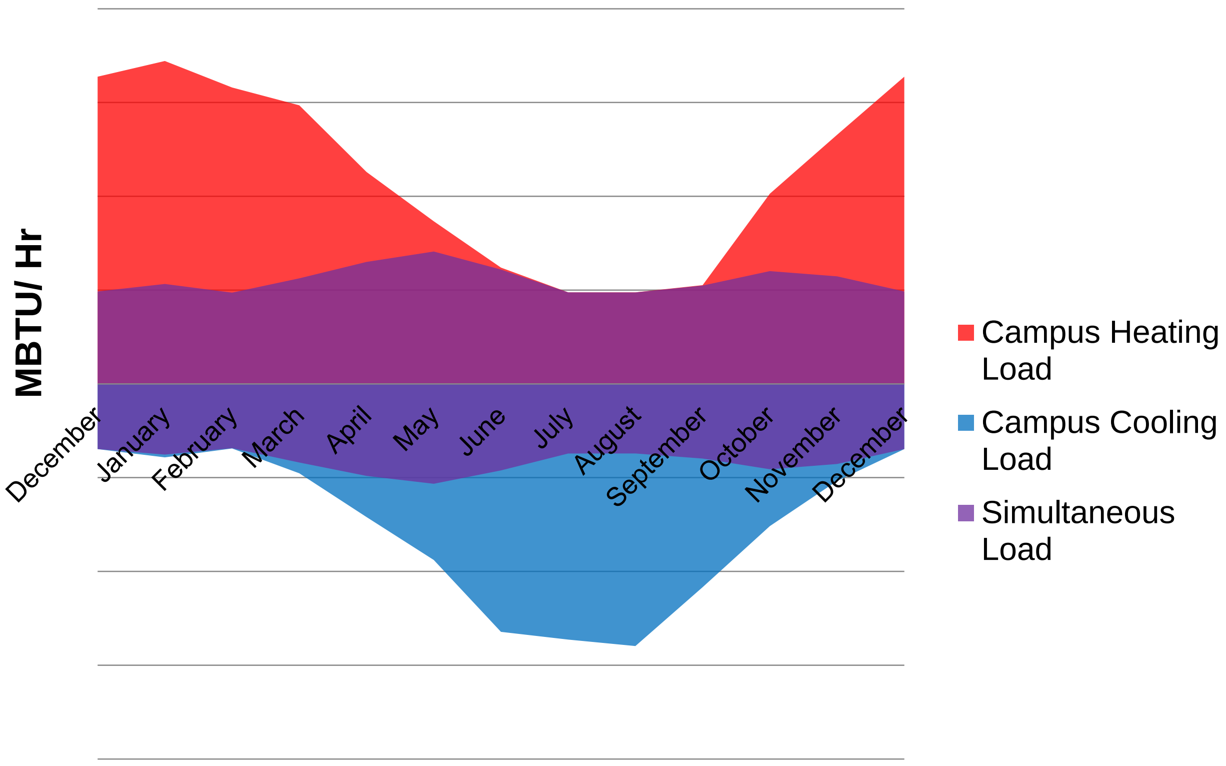




Thermal Energy Profile Results



Conventional Boiler/Chiller



Heat Pump Chiller

Selecting Equipment

- **Centrifugal Chillers**
  - Up to 2500 tons
  - Up to 155F HW temp
  - .30 - .50 KW/Ton

- **Screw Chillers**
  - Up to 450 tons
  - Up to 140F HW temp
  - .40 – .60 KW/Ton

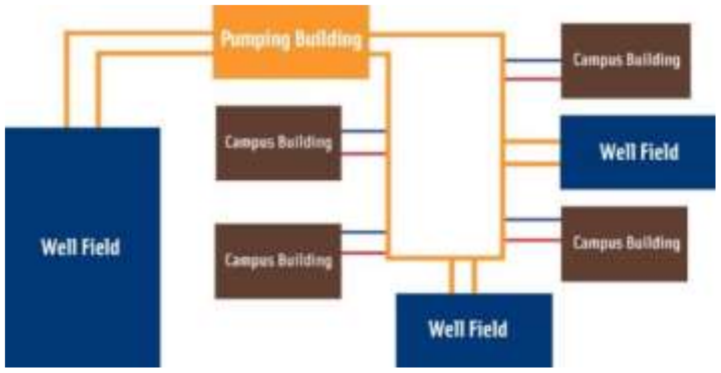
- **Scroll Chillers**
  - Up to 80 tons (modular)
  - Up to 135F HW temp
  - .50 – .70 KW/Ton

Note: Turn Down Ratio Extremely Important!

Selecting Distribution System

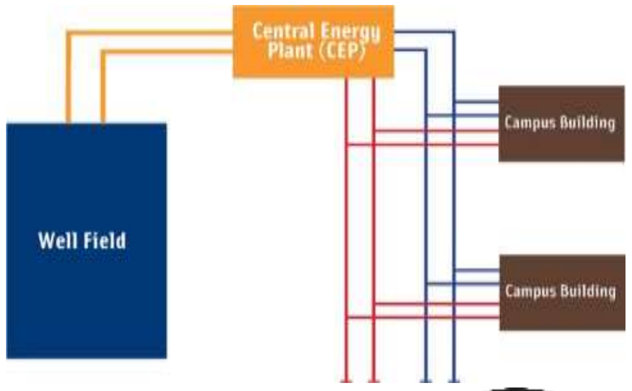
Client	Centralized System (Central Energy Plant)	Decentralized System *(w/equipment clusters to serve several bldgs.)*	Two Pipe Geo Distribution	Four Pipe Geo Distribution
Ball State University	X			X
Miami University	X			X
Corporate Client		X	X	

One Pipe Distribution



Two Pipe Distribution

Four Pipe Distribution

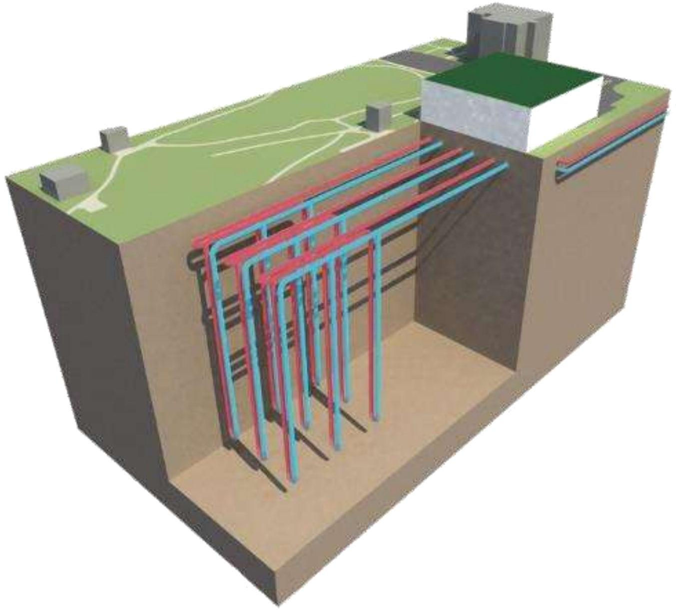


Note: Pumping energy and sizing is critical to system efficiency

Selecting Geothermal Heat Exchanger

Vertical:

- Unlimited Capacity
- Multiple Types
- Small Footprint



Horizontal:

- Limited Capacity
- Large Footprint
- One Primary type

Surface Water:

- Unlimited Capacity
- Average Footprint
- Multiple Types

Potential Geothermal HX Locations

After reviewing the existing site plan and utility drawings, the potential locations for GLHX fields are identified.

These spaces can include:

- Open green space
- Parking lots
- Athletic/recreation fields
- Ponds/Rivers/Lakes

Note: In-situ TC Test Bore is required!

Miami University Case Study

Master Plan Process

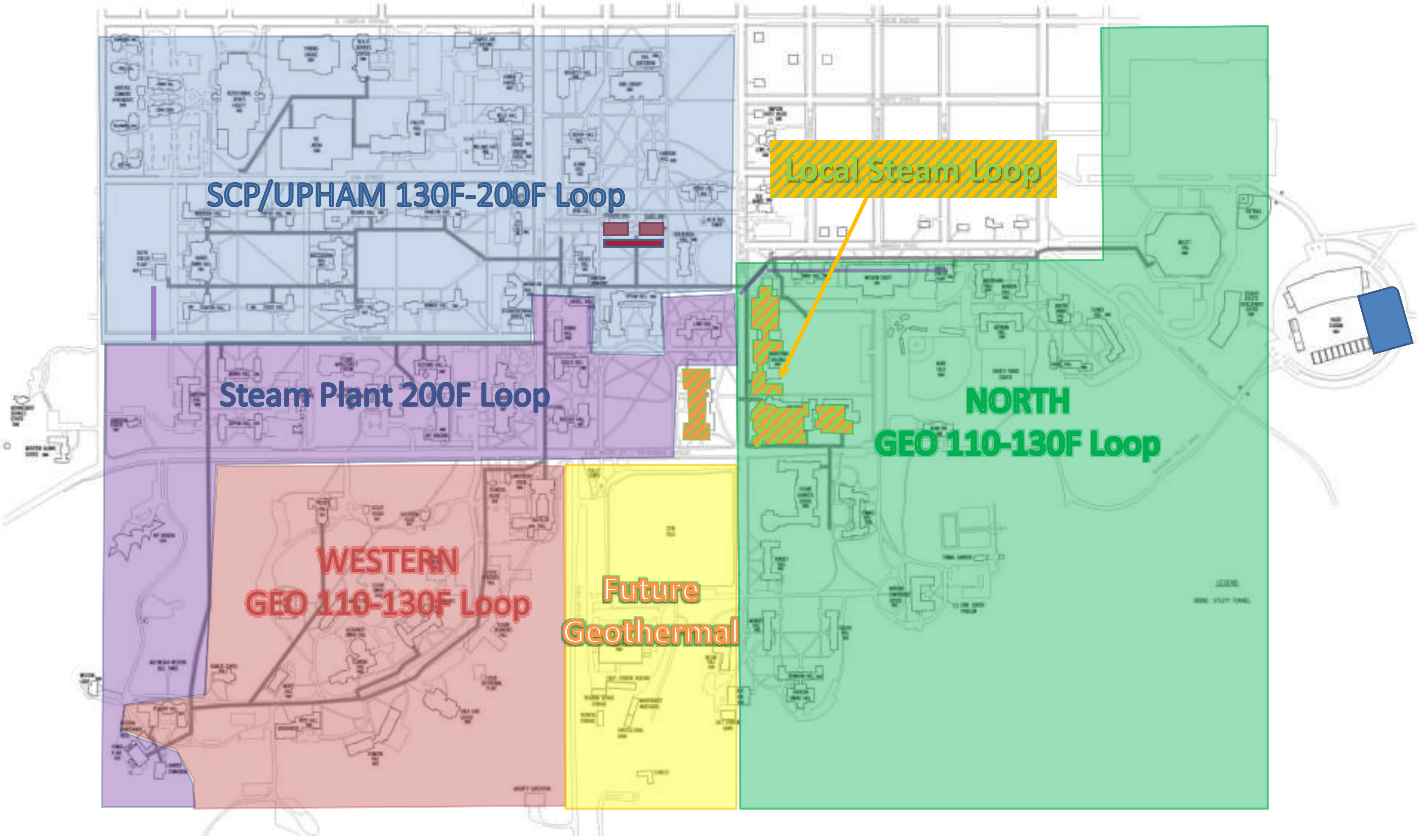
Master Plan Timeline

2010	Sustainability goals
2010	Long Range Housing Dining Plan
2011	Stormwater Master Plan created
2011-12	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.

Project Timeline

2012-2016	Project 1: Western Campus Geothermal Infrastructure Phase 1 & 2
2013-2015	Project 2: North Chiller Plant and East Quad Infrastructure/Renovations
2018-Present	Project 3: South Quad Hot Water Conversion
2022	Project 4: Central Quad HHW Conversion
2024	Project 5: Expand Western Geothermal to all Western Bldgs
2025	Project 6: North Chiller Plant Conversion to Geothermal
2026	Project 7: Steam Plant Conversion to Heating Hot Water

Miami 2026



Local Steam Loop
SCP/UPHAM 130F-200F Loop
Steam Plant 200F Loop
NORTH
GEO 110-130F Loop
WESTERN
GEO 110-130F Loop
Future
Geothermal

Utility Master Plan Development & Goals

- Analysis of Emerging Systems & Technology
  - Simultaneous heating & cooling (SHC)
  - Combined heat & power (CHP)
  - Distributed steam production
  - Geothermal
  - Biomass
  - Wind
  - Solar
- Goals
  - Reduce carbon by 43% by 2026 using a baseline of 2008
  - Reduce KBTU/GSF to 76 by 2026 from 2008 baseline of 166

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 reduced.
- **Productivity**
  - Labor efficiency improvements
  - Overall energy efficiency improved, 600% in heating with geothermal
  - Carbon reduction
- **Cost**
  - Water usage minimized
  - Chemical usage minimize
  - Less environmental regulation and compliance
  - Flexibility for fuel (sourcing) options

Implementing the Master Plan

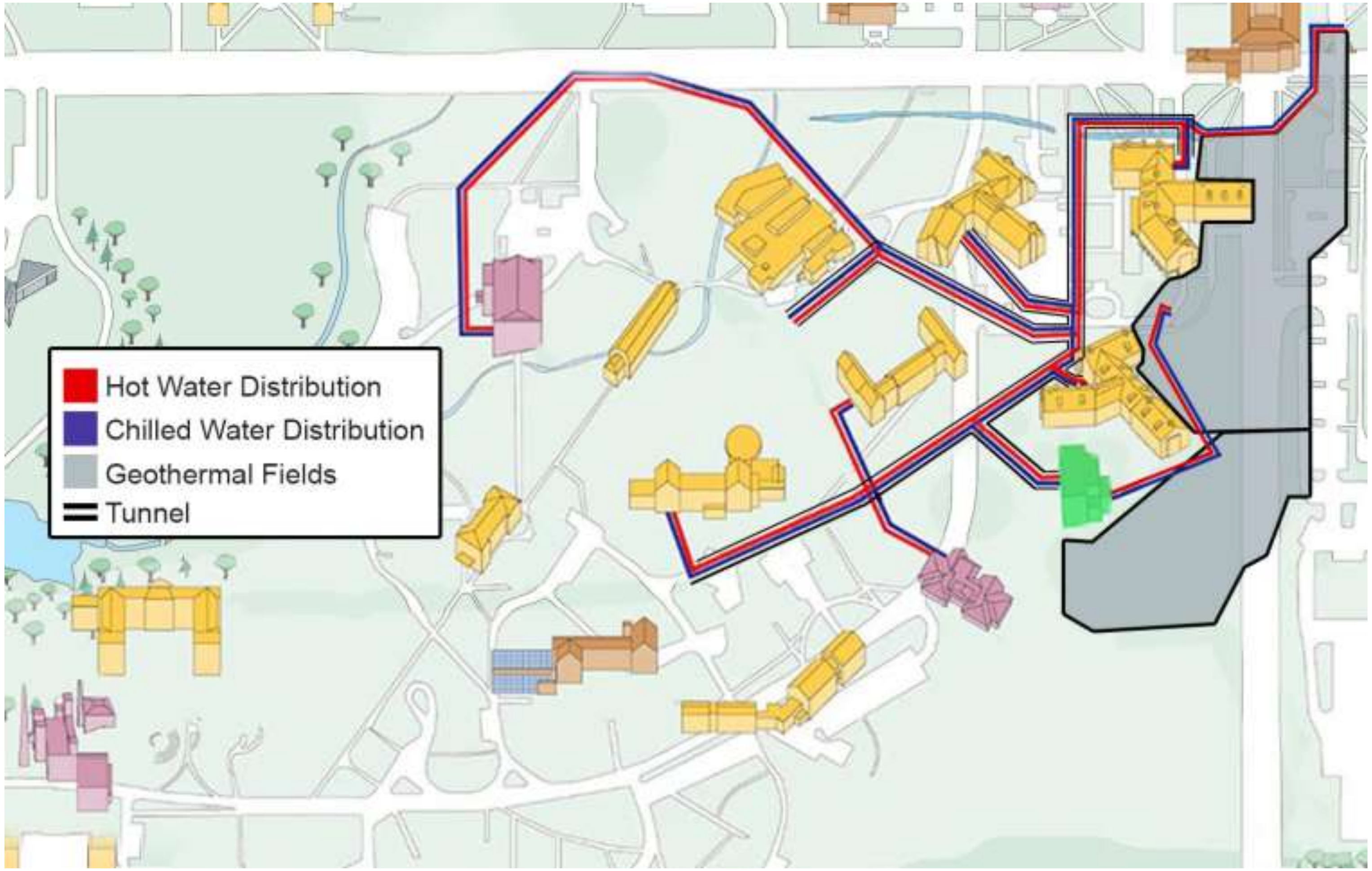
Building Conversion Challenges

- Goggin Ice Arena
- Natatorium and Athletics
- 130 Degree Domestic Water

Western Campus Geothermal Infrastructure Phase 1 & 2

Campus Loop

- 8,300 LF new HW & CW piping
  - Piping materials: **HW** PP-RCT (direct buried)
  - Carbon steel **HW and CHW** (tunnels)
  - **CHW** HDPE (direct buried)
- 690 vertical geo heat exchangers at 600 feet deep
- 133 geo pond loops
  - 1.77 acre irrigation ponds



Facilities Connected to New GEP

New Buildings:

- Western Dining Commons
- Stonebridge Hall
- Beechwoods Hall
- Hillcrest Hall
- Central Energy Plant

Converted Buildings

- Hoyt Hall (IT Services)
- Presser Hall (Academic)
- Child Development Center
- Havighurst Hall

Remodeled Buildings

- Clawson Hall

Clawson Hall

Hillcrest Hall

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: 2,300 tons
  - Heating capacity: 30,000 MBH

Geothermal Pond Loop

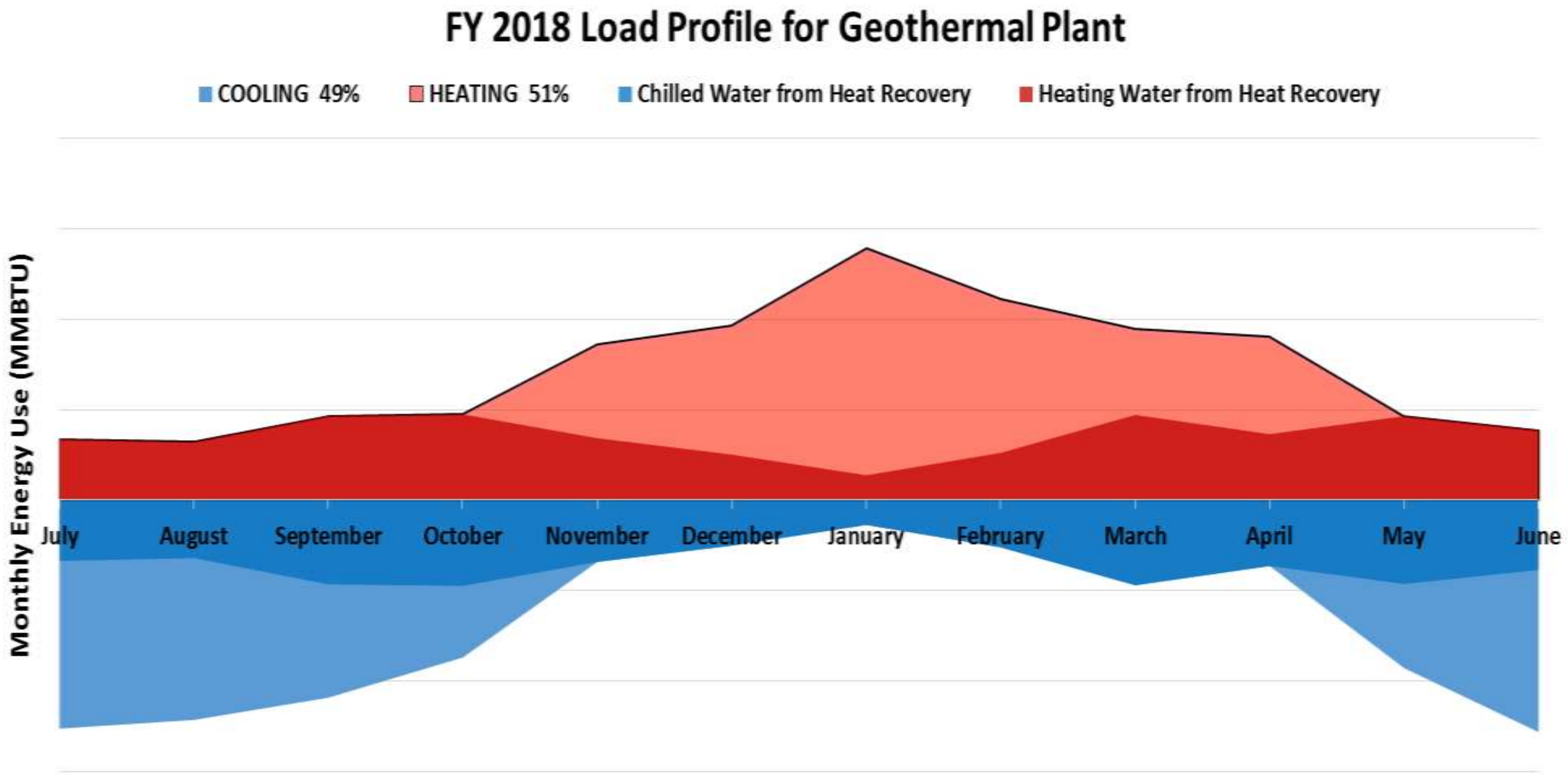
Benefits of Pond Loop:

- Free cooling in the spring
- Heat rejection sink in the winter to balance the geothermal vertical heat exchanger
- Lower cost than adding more vertical heat exchangers

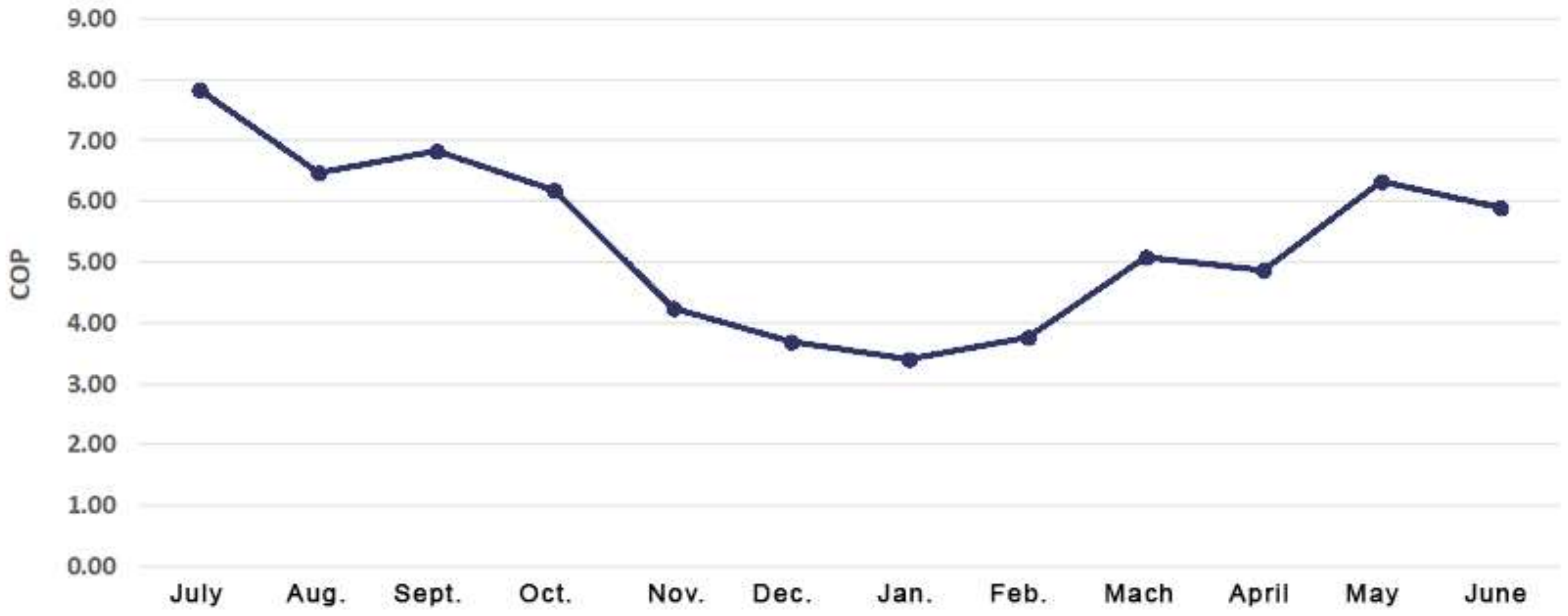
Performance

- Performance
- Cost

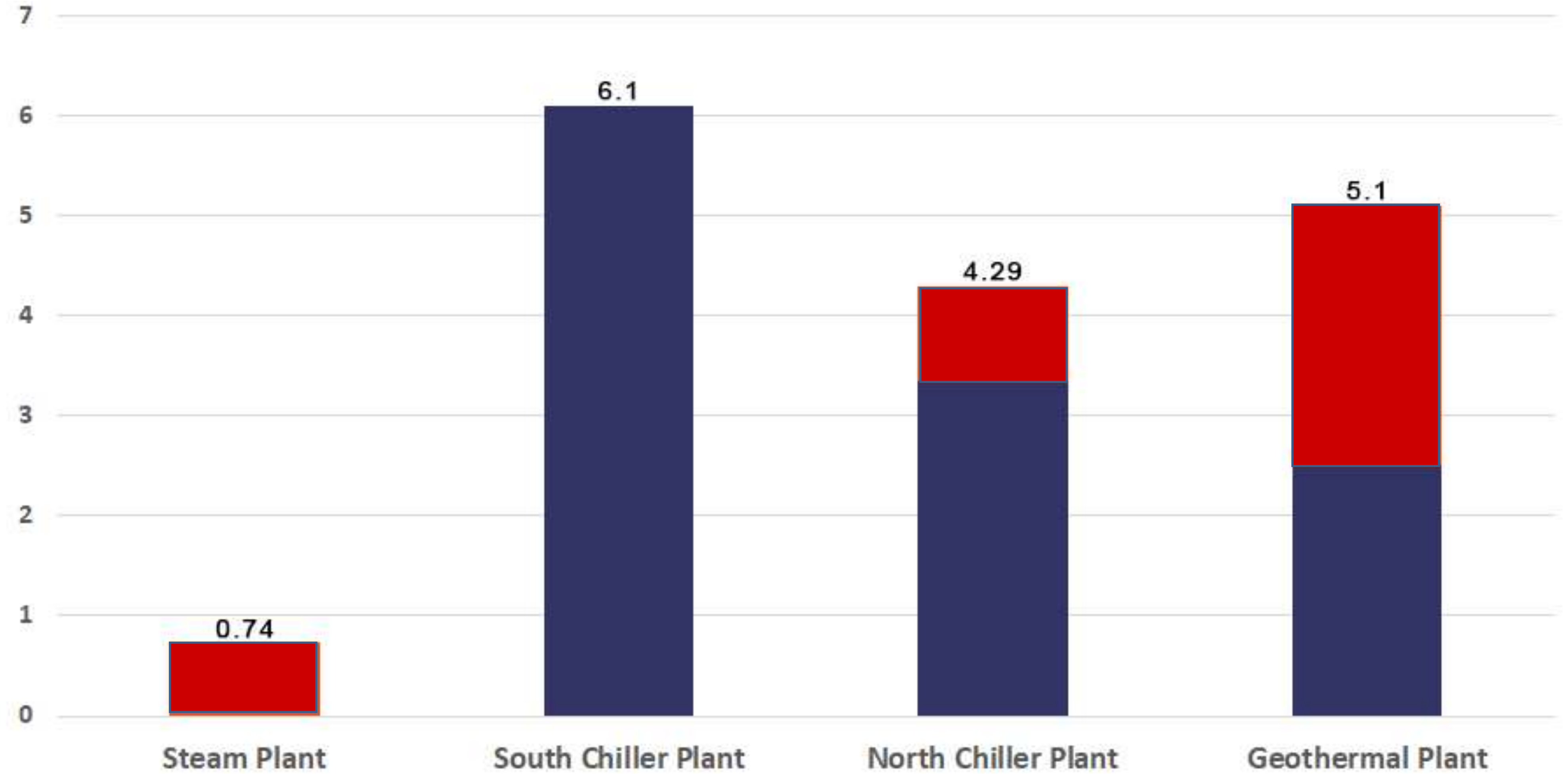
Geothermal Load Profile



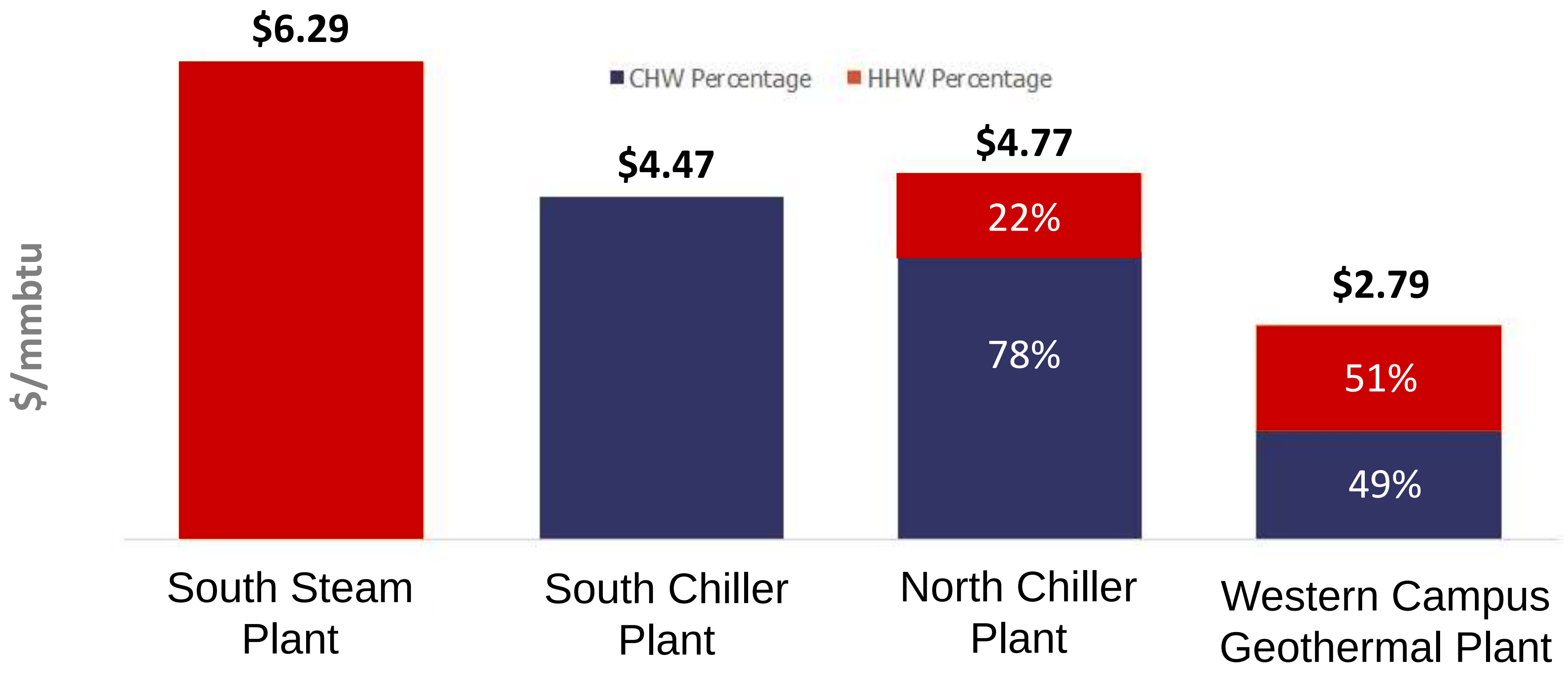
Geothermal Plant Monthly COP FY 2018



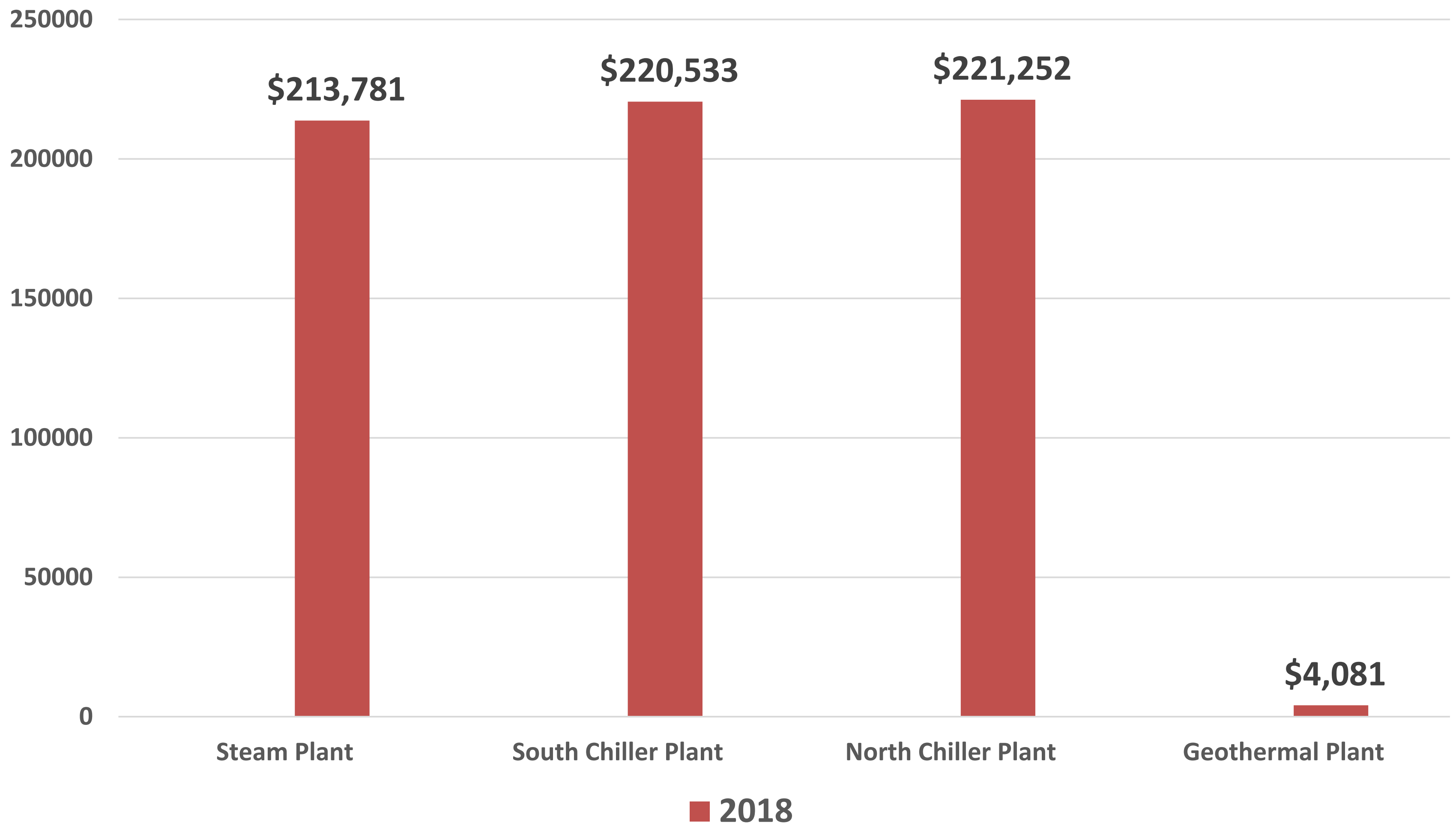
Central Plant Annual COP Efficiencies



CHW/HHW/STEAM Production Cost Comparison 2018 FY



Chemical/Water/Salt Cost FY18



Commissioning / Forensics / Lessons Learned

Forensics Steps

- Debrief with Client on Current Issues
- Determine Origin of Issues and Relationship to Other Systems
- Review Existing System Plans Compared to Installation
- Monitor and Document Performance
- Calibrate Energy Profiles

Lessons Learned

- Keep the system clean!
- Know your true heating and cooling loads for good balance
- Equipment turn down & phasing of construction
- Obtaining hot water deltaT at the buildings
- Campus can operate at lower hot water temperature then predicted

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Thank you!

Questions!