MEP Associates, LLC

The Evolution of Geothermal through Campus Conversions
Reducing Energy Cost and Optimizing Efficiency

PRESENTED BY
Jeff Urlaub, PE
Principal | CEO
jeffu@mepassociates.com

Brian Urlaub, CGD
Director of Geothermal Operations
brianu@mepassociates.com
Agenda

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

<table>
<thead>
<tr>
<th>Client</th>
<th>Centralized System (Central Energy Plant)</th>
<th>Decentralized System (w/equipment clusters to serve several bldgs.)</th>
<th>Two Pipe Geo Distribution</th>
<th>Four Pipe Geo Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball State University</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Miami University</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Corporate Client</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

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
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
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

FY 2018 Load Profile for Geothermal Plant

- COOLING 49%
- HEATING 51%
- Chilled Water from Heat Recovery
- Heating Water from Heat Recovery

Monthly Energy Use (MMBTU)

- July
- August
- September
- October
- November
- December
- January
- February
- March
- April
- May
- June
Geothermal Plant Monthly COP FY 2018
Central Plant Annual COP Efficiencies

- Steam Plant: 0.74
- South Chiller Plant: 6.1
- North Chiller Plant: 4.29
- Geothermal Plant: 5.1
CHW/HHW/STEAM Production Cost Comparison 2018 FY

South Steam Plant: $6.29
South Chiller Plant: $4.47
North Chiller Plant: $4.77
Western Campus Geothermal Plant: $2.79

CHW Percentage: 78%
HHW Percentage: 22%

HHW Percentage: 49%
CHW Percentage: 51%
Chemical/Water/Salt Cost FY18

<table>
<thead>
<tr>
<th>Plant</th>
<th>2018 Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Plant</td>
<td>$213,781</td>
</tr>
<tr>
<td>South Chiller Plant</td>
<td>$220,533</td>
</tr>
<tr>
<td>North Chiller Plant</td>
<td>$221,252</td>
</tr>
<tr>
<td>Geothermal Plant</td>
<td>$4,081</td>
</tr>
</tbody>
</table>
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 than predicted
Thank you!

Questions!