Applying Geothermal Technology for Large Scale Projects

Breakout Session Category
(e.g. Residential)
Outline/Agenda

• Approach to Campus Geothermal Study & Planning

• Case Study – Largest Geothermal Campus in U.S.
  • Campus Overview & Statistics
  • Reducing Energy in your facilities
  • Recovering Energy from processes occurring in your facilities
  • Repurposing Energy within your facilities
  • Benefits

• Existing Geothermal Campus Systems & Applications

• New Geothermal Campus Systems & Applications
Approach to Campus Geothermal Study
Approach to Energy Stewardship

**REDUCE**
Reduce the initial required thermal energy to serve the building’s needs.
- Minimize Outdoor Air
- Cascaded Air Systems
- Thermal Decoupling
- Process Ventilation Controls

**REPURPOSE**
Repurpose thermal energy to be used again in lieu of discarding it.
- Simultaneous Heating and Cooling Loads

**RECOVER**
Recover thermal energy from waste streams to be reused in the facility.
- Energy Recovery

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*Energy Stewardship* is maximized by engineering solutions that Reduce, Repurpose and Recover energy.
Geothermal Study – Information Gathering

• Review Existing Site Plan and Utility Drawings

• Collect Building Information
  • Types of HVAC Systems
  • Operations of HVAC Systems
  • Current Heating and Cooling Coil Operating Temperatures

• Collect all Utility Information
  • Electric usage and peaks
  • Gas usage and peaks
  • Coal and tons of coal
  • Make-up water
  • Chemical Treatment

• Review all Future Master Planning / Expansion Plans
Geothermal Study – Identify Building Thermal Profile

- Energy Model & Utility Metering
  - Chiller/Heating Plant Metering
  - Building Level Metering

- Thermal Peaks & Energy Consumed
  - Base & Instantaneous simultaneous load
  - Unbalanced heating & cooling load

**OUTCOME /** Accurate monthly heating & cooling loads are used to calculate the equivalent heating & cooling hours.

Correct load calculations are very important in sizing the loop field.

1). Building Envelop
2). Window overhangs, if any
3). Miscellaneous equipment loads
   - Computer, printer, medical equipment
4). Lighting
   - Type of lighting, watts/SF
5). People
   - Activity, sensible/latent value
6). Ventilation
   - People, area and exhaust based CFM
7). Infiltration Rates
Outcomes of Test Wells

• Geological Conditions
• Conductivity
• Diffusivity
• Earth Temperature
• Ground Water Temperature
• Depth of Bedrock
• Depth of Vertical Loop
Using the monthly heating and cooling usage and peaks from the campus thermal profile, the equivalent full loads are calculated.

Combined with the results from the Test Well, we are able to:
  • Calculate the required well field size
  • Number of bores
  • Depth of each bore
After reviewing the existing site plan and utility drawings we are able to identify the potential locations for well fields. These spaces can include:

- Open Green Space
- Parking Lots
- Athletic / Recreation Fields
Geothermal Study – Building Conversions

• Determine the operating temperatures

**NOTE** / In order to properly determine the type of heat pump required to meet the campus heating needs. We recommend resetting the hot water supply temperature on a design heating day to the lowest possible setting. The setting is determined by the amount of cold calls you receive from each building.
Water-2-Water Heat Pump Types

Centrifugal Chillers
• 600 – 2500 Tons
• Up to 155 F HW temp for 600 – 2,500 Tons
• Up to 170 F HW temp for 2,500 – 4,000 Tons

Screw Chillers
• 50 to 430 Tons
• Up to 140 F HW temp

Scroll Chillers
• Up to 150 Tons
• Up to 120 F HW temp
Analysis & Receivables

- Construction Costs
- Life-Cycle of the equipment
- Energy Escalation Rate
- Annual Discount Rate

- Simple payback analysis / ROI
- Well field locations, type and size parameters
- Geological conditions of campus
- Analysis of energy model and savings
- Cost analysis of project (equipment and construction)
- Type and size of equipment needed
Existing Geothermal Campus Systems
Centralized 4-Pipe Distribution

Conversion Facts
- 10,000 Tons Cooling
- 152,000,000 BTU/HR Heating
- 5,600,000 GSF Heating Conversion
- 47 Building Heating Conversion
- Includes 300,000 GSF of Expansion
- 2 District Energy Stations
- 150°F HWS
- 20°F HW Delta T
- 80,000 Tons per/year Carbon Reduction

Campus Energy Use Intensity
- Prior to Geothermal Conversion – 175 Kbtu/SF/Yr
- Fiscal Year 2013 / 2014 – 123 Kbtu/SF/Yr
- Anticipated at Project Completion – 105 Kbtu/SF/Yr

The Nation's Largest Geothermal Campus Conversion

DISTRICT ENERGY STATION - NORTH
- 12,000 SF
- (2) 2,500 Ton Compound Centrifugal Compressor Heat Pump Chillers and accessory components
- 1,000 Ton Fluid Cooler
- LEED Gold Certified

DISTRICT ENERGY STATION - SOUTH
- 16,480 SF
- (2) 2,500 Ton Compound Centrifugal Compressor Heat Pump Chillers and accessory components
- (2) Centrifugal Chillers
- (4) 1,000 Ton Cooling Towers
Miami University – Oxford, OH

Western Campus - Conversion Facts
• 2,800 Tons Cooling
• 49,355,000 BTU/HR Heating
• 15+ Buildings
• Vertical Bore Field – 710 Bores
• Matt Pond Loop – 133 Loops

East Quad - Conversion Facts
• (2) 350 Ton Heat Pump Chillers
• 12 Buildings Connected
• 536 Ton Cooling
• 6,121 MBH Heating
Case Study
Largest Geothermal Campus
• Approximately 1051 Acres
• Over 7.0 Million SF occupied space
• Over 9,000 employees to keep happy and productive
• 27 Existing Buildings
• 12 Buildings under construction
• 7,338 Underground parking stalls (4 multi-level garages)
• 1.5 MW Solar PV
• 10 MW Wind Generation
Campus Overview

Various Systems

- Water-to-air source heat pumps with dedicated outside air system equipped with total energy recovery
- VAV air-distribution systems with dedicated total energy recovery units
- Distributed Central Energy Plants (CEP)
- Water-to-water heat pumps chiller/heaters
- VAV air-distribution systems with integral total energy recovery wheels
- Central pumping station
- Geothermal bore fields
- Geothermal pond
- Variable primary-secondary pumping
- Variable primary-secondary-tertiary pumping
- Variable-primary pumping
- Domestic water heating system that utilizes geothermal water
- Snow/ice melt systems
- Exhaust fan arrays for parking structures
- Commercial kitchen exhaust systems
- Onsite photovoltaic solar panels
- Off-site wind farm
Campus Overview

Energy Conserving Building Design

• Geothermal Heating & Cooling
• Heat Recovery systems
• Variable flow ventilation & pumping systems
• Daylight Harvesting / automatic dimming
• Occupancy control of lighting and HVAC
• Motion activated parking lot lighting
• Operable windows for natural ventilation
• Green Roofs (22 Acres)
Campus Overview

Geothermal System (15,000 ton Cap.)

- Bore Fields (vertical bore shafts)
  - Bore Field 1: 576 bores @ 300 feet
  - Bore Field 2: 1,000 bores @ 300 feet
  - Bore Field 3: 2,000 bores @ 420-480 feet
  - Bore Field 4: 2,596 Bores @ 500 feet

- Storm Water / Geo Pond
  - 1,296 slinky loops @ 600 feet each
  - Pond Depth: 10-15 feet
Recover

Recovering energy from processes occurring in your facilities

• Energy Recovery Wheel
  • Reduces plant sizing (chiller, pumps, geo fields)
  • Efficiencies
    • Winter – 79%
    • Summer – 79%
Repurpose

Simultaneous Heating & Cooling
- Office Buildings Cooling Dominant
- VAV Reheat
- Domestic Water Heating
- Snow Melt
Repurpose

Repurposing Energy throughout your campus

Energy Usage Loops

Energy Exchange Loop
Repurpose

4 Central Energy Plants

• Farm Campus
• Campus 2
• New CEP
• Epicenter / Pluto
## Chiller Comparison

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• Heat rejection used for building heat
• Excess heat is transferred through Campus Geo Loop and can be used by other campus buildings.
Central Energy Plant

• Energy transfer between campus buildings
• Excess energy transferred to other campus Central Energy Plants
Energy Source

• Utilized when the campus energy loop is out of balance

• Stand-alone Pump House
  • 6 Pumps designed to pump 60,000 gpm through 6,127 vertical bores and 1296 pond loops (designed for 8 Pumps)
  • 6 Pumps designed to pump 60,000 gpm of loop water around the campus to serve stand-alone heat pump chiller plants
Stand-Alone Pump House
Geothermal Loops

**Bore Field Loop**
- Water circulates between bore fields and central pump station
- All borefields (1, 2, 3 & 4) and the Geo Pond are interconnected
- 36” HDPE piping mains and many geo vaults

**Building Distribution Loop**
- Water circulates between central pump station and campus buildings
- Piping connects all the CEPs
- 36” HDPE piping mains
- Vaults located throughout

**CEP Distribution Loop**
- Water circulates between campus building distribution loop and water-to-water heat pumps / chillers
- Heat Pump Chiller / Heater generates chilled water and/or heating water to serve the buildings
• 502 miles of vertical piping in geothermal wells
• 16 miles of horizontal underground piping (6” – 36” diameter)
• 300 miles of piping resting at bottom of Geo Pond
• 1100 miles total pipe length
• 4 million gallons of water to fill system (No glycol)
• 6,172 Vertical Bores 300 ft. to 500 ft. in depth
• 15,000 tons cooling capacity
• Maximum design flow is 80,000 gallons per minute
Utilizing a Geothermal System

• Benefits

• Reduced Maintenance
  • 0.3 FTE
  • Closed loop System – Water Only (no glycol)
  • No Boilers or Cooling Towers to Maintain
  • Oil-Free Centrifugal Chillers

• Energy Footprint Reduction

• Carbon Reduction
New Geothermal Campus Systems
Carleton College – Northfield, MN

Utility Master Plan

• Utilities Addressed
  • High pressure steam
  • Chilled water
  • Natural gas
  • Electrical distribution
  • Domestic water

• Production Systems
  • Natural gas boilers
  • CHP
  • Chillers
  • Dry coolers
  • Ground Source Heat Pumps
  • Solar thermal
  • Hybrid systems

The new system would reduce central plant carbon emissions by over 70%
Cornell NYC Tech – Roosevelt Island, NY

**Campus Geothermal**
- 150,000 SF First Academic Building
- 80 Bores – 350 ft deep
- Modeled peak load on the ground heat exchanger of 265 Tons of cooling
LOW ENTROPY CAMPUS DESIGN WITH CENTRAL ENERGY PLANT (CEP)

• Status: Phase 1 - 2019
• CEP design includes combination of central heat pumps, chillers, cooling towers, heat exchangers, boilers, and cogeneration
• Engineering Services: Development of low entropy campus with highly-efficient Central energy plant

New Central Energy Plant

Ford Campus Utilities Plan
Hunters Point – San Francisco, CA

Eco-District Campus Design
• Status: Schematic Design
• Engineering Services: Sustainable mechanical infrastructure development & system design
Under Armour – Baltimore, MD

Master Plan – Phase 1
• Size: 3.9M SF Total Building
• 50 Acres of Development Area
• Parking Structures: Up to 5,000 cars
• 4 Building Stages
• Bay Heat Exchange
Questions?

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