2023 GeoStar Top Job
Geothermal Project Presentations

Moderator:
Joanne Coons / NY-GEO Member

Finalists:
Christie Reaves / Markland
Johannes Rosemann / Buffalo Geothermal
Steve Taylor / Historic Finch
Jim Thomas / Moonshot Farm
Claire Lukasiewicz / Zen Building

Presented Live at the NY-GEO 2023 Conference
Albany, New York on April 26, 2023
A BIG THANK YOU to This Year’s Sponsors!

PLATINUM - PRESENTING
NEW YORK STATE | NYSEDA

GOLD
WaterFurnace®
Smarter from the Ground Up™

CLIMATE CONTROL GROUP
A NIBE GROUP MEMBER

SILVER
CELSIUS ENERGY

TOP JOBS
GEOSTAR
AFFORDABLE RENEWABLE CLEAN

CORECHEM
ESSENTIAL CHEMISTRY, INNOVATIVE SOLUTIONS.

ROBCO SPECIALTIES
BRONZE
GROUNDHEAT
GEOTHERMAL PIONEERS SINCE 1951

MIX N MINGLE
CDM Smith
WIFI
SRS

LUNCH
Brightcore
BUILDING ENERGY PERFORMANCE™

DANDELION GEOThermal

EXHIBITOR BINGO
nationalgrid
ENERTECH

BREAKFAST
Pathfinder Engineers & Architects

COFFEE BREAK
subterra
VERSAPROFILES

We Couldn’t Do It Without You! ● www.ny-geo.org
Moonshot
Cut Flower Greenhouses
Farm

Thomas Geothermal Engineering
Jim Thomas
The Basics

Twin Long Tunnels
The Basics

• “Long tunnel” is 96’ long by 34’ wide – about 3264 SF
• Quonset hut style with steel tubular ribs
• Double layer 6 mil poly sheeting with air gap @ R 1.8
• Air gap maintained by small muffin fan
• 2’ deep vertical fiberglass band to inhibit heat transfer
• 8’ wide sliding doors on each end w-brush sealing
• Dual shuttered air vents with exhaust fans
• Manual rollup side curtains for fresh air
• Plants grown directly in floor soil – USDA requirement
Can this be done?

• First question is, would you want to do geo on a 3000+ SF home with almost no insulation and a soil floor?
• Propane unit heater rated input 200K Btuh @ 80% efficiency
• Consumed 2162 gallons during 2021-22 heating season Nov 1 – Mar 15 at a cost of $6775
• Wasted 35 million BTUs or 65% required to heat a NJ home
• Used Purdue University Controlled Environment Agriculture load model @ 15 deg design day = 10.86 tons
• Good match for two 6 ton residential single phase geo units
• Yes this can be done!
Financing

- 2022 USDA Rural Energy for America Program (REAP) offered 25% grant – almost all expected to be for solar
- Federal commercial 10% tax credit plus depreciation
- No New Jersey incentives
- Customer still wanted to move forward even after Build Back Better failed
- Fortuitously the Inflation Reduction Act boosted the Federal commercial tax credit to a 30% bonus rate gives 6 year ROI
- Rampant inflation in 2022 caused a 10% increased project cost but USDA grant based on original application proposal
The Design

- Winter flowers like 40 to 70 degree growing temperature
- Temperatures above 90 or below 32 can kill the crop
- Initial requirement was 50 degrees overnight @ 15 degrees OAT
- Decided to retain propane unit heater as backup
- Retained exhaust fans to help control temperature and humidity
- Conceived as a heating only system – very unbalanced load
- Added a custom “waterside economizer” to harvest compressor-less heat to charge the loop during summer
- Exploiting thermal energy storage!
The System

• Selected components for high reliability and performance
• USDA required 3 years of performance monitoring
• Easily fulfilled by WaterFurnace Aurora/Symphony system
• Chose a pair of high efficiency 6 ton WF Series 5 with variable speed ECM blowers + refrigeration & performance monitoring
• Modulating water valves at units to minimize pumping
• Easy logic to implement compressor-less cooling with WF “load shed” feature – low cost multisource – 1% of project
• Lightweight DuctSox fabric ductwork – removeable to clean
The System
The Loop

• 1.5 Acre pasture adjacent to tunnel – ideal for horizontal
• Selected high performance Twister pipe by Agreenability
• 2100’ pipe in 7 trenches 6’ deep
• Low outside Headloss @ 10 Feet of Head (FOH)
• Retained Twister center corrugated pipe above ground to dampen field with water
• High efficiency pumping with GeoFlo NP-Multi with Grundfos Magna3 variable ECM pump set at constant pressure
• Oversized HDPE to bring total head loss to about 40 FOH
The Loop
Early Discoveries

• Solar gain far above what we expected
• Tunnel would heat up to 90 degrees by 10 am when it was below freezing outside
• Owners would open sliding doors to cool off – but lost all reserve heat that had to be made up again
• But Heat load overnight was less from day soil charge-up
• High humidity a big problem - sometimes 85+% 
• Mold growth and fungus a concern
How’d it go?

• Customer wanted overnight temp higher @ 55 degrees
• Wanted active cooling mid-winter to control overheat
• Active cooling also aided humidity control
• Saw active cooling as efficient ground charging – would generally run the loop up +15 degrees during the day
• Heat loss through the soil was not a significant factor
• Cost savings over propane within the ballpark estimate
• Electric consumption Jan 12 – Apr 15 was $1238
• Ground charging over the summer should increase efficiency further next and subsequent winters
How’d it go?
The Future

- USDA REAP Grants up to 40% for 2023 Approved Projects
- Continue to enjoy Inflation Reduction Act tax benefits
- Helped Rutgers University apply this year to build two new greenhouses for educational purposes
- Moonshot looking to convert 2 more greenhouses and build another – customers like green growing concept
- Hydroponic farming and winter locally grown
- Biggest new opportunity could be cannabis growing in NJ
- Interest by Senator Cory Bookers office at Federal level
Questions?

thomasgeothermal@gmail.com

(609) 923-5424

Thank you!

C. Lukasiewicz

April 26, 2023
Outline

- ZEN at a Glance
- Energy Efficiency Measures
  - Architectural
  - Mechanical Equipment
  - Energy Harvesting
- Retro-Commissioning Efforts
- Funding
ZEN at a Glance

6 Stories
363,000+ sqft

10,000 sqft atrium

Fuel cell

*Tier-3 data center*

Originally constructed in 2015
Retro-commissioned beginning in 2022

Capacity for 1,500 individuals

2.4 megawatt, offsite PV farm

Largest proof of concept for zero energy mixed use space in it’s time!
Energy Efficiency Measures

• Architectural
  • Lighting

• Mechanical Equipment
  • HVAC
  • Controls

• Energy Harvesting Strategies
  • Data Center Heat Recovery
  • Chiller-Heaters
  • Heat Pumps
Energy Efficiency Measures – Architectural

• “Donut Design”
  • Reduce lighting electricity needs by more than 70%
  • Often only a small LED lamp is needed
  • ETFE “Pillow Roof”
View of “Pillow Roof” from outside
Energy Efficiency Measures – Mechanical Equipment

- Chillers with free cooling
- Energy recovery DOAS Units
- CO2 monitoring
- BMS paging and access
- VFDs on all motors (pumps, fans, etc.) for efficiency
Energy Efficiency Measures – Mechanical Equipment

- Data Center Cooling Towers
- Data Center Chillers
- Heat Exchangers
- Building Cooling Towers
- Boilers
- Air Handlers
- Water to Water Heat Pumps
- Cracs
- Building Chillers
- Heat Exchanger
Is this geothermal?

**True Geothermal** -
- Storing heat energy in the Earth
- Requires a ground well

**ZEN Building** -
- Recovering energy through water to water HXs
- Both sides of loop are utilized for HVAC so there is no need to “store” energy in ground

**Both** -
- Highly efficient
- Utilize heat pumps for seasonal cooling and heating as opposed to mechanical energy
Energy Efficiency Measures – Energy Harvesting

• Data Center Heat Recovery
  • Winter mode: Free cooling at cooling towers often eliminates need to run mechanical cooling; heat pumps reject heat to the condenser water loop
  • Summer mode: Utilize control strategies to optimize chiller staging
Energy Efficiency Measures – Energy Harvesting

- Heat Pumps (DTWS)
  - Winter mode: Create warm water for AHU coils to act as “pre-heat,” heat rejection to the data center’s chilled water loop (free cooling)
  - Summer mode: Reject heat to the building condenser water loop, supply chilled water to AHU coils
Energy Efficiency Measures – Energy Harvesting

• Chiller-Heaters
  • Winter mode only: when ambient conditions allow, chillers may operate in “reverse”
  • Condenser and evaporator swap rolls
  • Allows ZEN to be heated with a chiller
  • “cold side of this loop” supports ZEN data center cooling
  • Conserves natural gas as there is no need to run a boiler
Retro-Commissioning

- Timing drove the need-
  - Design for this project: Summer 2013
  - Data Center majority loaded: Winter 2021

- Focus on BMS and control programming

- Implementation of Facility Connex
  - 1,000+ Fault Detection & Diagnostics
  - Hundreds of analytics
  - Web based access to site information 24/7, 365
Funding

• Original Project totaled ~$200 Million
  • Over 4+ years from design to completion

• Retro-commissioning largely grant funded

• Participating Parties
  • National Grid
  • NYSERDA
  • Japan’s New Energy and Industrial Technology Development Organization
  • State and Federal Grants

• Aligned on goal to install, commission and demonstrate state of the art technologies including solar photovoltaics, lighting, fuel cells and smart building energy management systems to achieve a net zero capable facility

• High visibility project focused on setting worldwide example, keeping NY Forefront of scientific research, create jobs, stimulate economy
While the ZEN Building may be the first of its kind, let’s not make it the last!
Steven Taylor
Installation Manager
Historic Fitch Tavern

FITCH TAVERN
1710
Rallying place of the Militia
and the Minute Men
April 19th, 1775
Home of
Sgt. JEREMIAH FITCH
Militia Company
Historic Fitch Tavern

Project Goals

• Eliminate fossil fuel
• Reduce carbon footprint
• Restore historic exterior
• Increase occupant comfort
• More control over individual living areas
• Remote access
• Equipment monitoring
• Improve efficiency of home
Historic Fitch Tavern

Existing Conditions: Heating

Oil fired hot water boiler
- 90% main living area
- Domestic hot water
- Kitchen wing radiant heating

Natural gas furnace
- In-law suite
- Grossly oversized for the space
Historic Fitch Tavern

Existing Conditions: Cooling
Historic Fitch Tavern

Steps to Success

- Manual J load calculation
- Define heating/cooling zones
- Choose Technology
  - GSHP
    - Higher installed cost
    - Lower operational cost
    - Utility incentives and Tax credits
  - ASHP
    - Lower installed cost
    - Higher operational cost
Steps to Success

- Manual J load calculation
- Define heating/cooling zones
- Choose Technology
  - GSHP
    - Higher installed cost
    - Lower operational cost
    - Utility incentives and Tax credits
  - ASHP
    - Lower installed cost
    - Higher operational cost
Historic Fitch Tavern

- Water Furnace 5 Series Water to Water
  - Kitchen wing radiant heating
  - Unico Air Handlers Hot/Chilled Water Coils
    - Childrens bedrooms
    - Kitchen wing
    - Main first floor

Equipment Selection

- The Unico System®
  Small-Duct Central Heating & Air Conditioning
- Water-Furnace
  Smarter from the Ground Up™
Historic Fitch Tavern

• Water Furnace 5 Series Split
  • 2 Stage equipment to better match loads
  • Second floor Primary Suite
  • Third floor Office/Guest bedroom

Equipment Selection

The Unico System®
Small-Duct Central Heating & Air Conditioning

Water-Furnace®
Smarter from the Ground Up™
Historic Fitch Tavern

- Water Furnace 5 Series Package
- 2 Stage equipment to better match loads
- Family room
- New connector

Equipment Selection

The Unico System
Small-Duct Central Heating & Air Conditioning

Water Furnace
Smarter from the Ground Up
Historic Fitch Tavern

• **Space constraints**
  - Third floor completely is finished
  - Preserve historic look of home
  - Some systems already in place

Equipment Selection

[The Unico System](#)
Smaller Duct Central Heating & Air Conditioning

[Water Furnace](#)
Smarter from the Ground Up
Historic Fitch Tavern

- **Water Furnace**
  - Refrigerant/Performance monitoring options
  - Aurora Web Link
  - Symphony Web enabled controls
  - Fault notification
  - Variable speed flow centers minimize pumping power

- **Unico System**
  - Green Series air handlers with ECM blower motors
  - Even temperatures floor to ceiling
  - National Trust for Historic Preservation

Key Features

[Logo: The Unico System]

[Logo: Water-Furnace]
Historic Fitch Tavern

• **Ground Loop Design**
  • 4 450’ Boreholes 1¼” pipe
  • 3” Main header pipe to basement
  • 175’ per ton of capacity

• **Controls**
  • HBX ECO-600 Geothermal reset control
  • Honeywell THM8320 thermostats
  • Honeywell Redlink wireless outdoor sensor
  • Honeywell Redlink internet gateway
Historic Fitch Tavern

- Eliminate fossil fuel
- Reduce carbon footprint
- Restore historic exterior
- Increase occupant comfort
- More control over individual living areas
- Remote access
- Equipment monitoring
- Improve efficiency of home

Success!
The Pierce Arrow Lofts
Geothermal Conversion
The Building

- 158,000 sqft
- Build in 1908
- It is one of the 2 only historic buildings in the United States with a concrete Barrel Roof.
- It served as the administration building for the Pierce arrow production facility from 1908-1938.
- In 1974 added to the National Register of Historic Places.
The Conversion

- 127 Apartments
- 7,500 Sqft Restaurant
- Completely heated and cooled by Geothermal
- 100% of the Domestic Hot Water Supplied by Geothermal
Geothermal System

Challenges

- Dense Urban Environment
- Efficient System Design
- Load Balancing
Dense Urban Environment and the Loopfield

- 50 Boreholes
- 350ft Deep spaced 20ft apart
- Closed Loop 1 ½ HDPE U-Bend
- Graphite enhanced grout
Efficient System Design

- 3 independent operating Flow-Centers
- pumping power is less than 3% of the system power consumption
- Reduced Pressure Loss by shortening average run out and connection Lengths
Efficient System Design
the Flowcenters

- ECM Driven Variable Speed Pump
- Automatic adjustment of Flowrate based on System back pressure
Efficient System Design – the Flowcenters

- Primary/Secondary Loop Setup
- ECM Driven Variable Speed Pump
- Automatic adjustment of Flowrate based on System back pressure
Load Balancing with DHW Generation

- Balancing the Loads avoids temperature drift of the loopfield
- It enables to reduce the loopfield size
Load Balancing with DHW Generation

- 2 Stage Design
- Average COP of 3.4 vs 2.9
- Increased Redundancy
Geothermal System

Recap

- 333 Tons of Heating and Cooling Load
- Closed Loop system with 50 – 350ft deep Boreholes
- 3 Flowcenter
- 147 Forced Air Heatpumps
- 6 - 5Ton Vapor Injection High Temperature Water-Water Units
- 8 - 162 Gallon High Efficiency Storage Tanks
Recognition and Impact

• Supported with $400,000 Rebate from NYSERDA

“Many thanks to the New York Geothermal Energy Organization for facilitating this morning’s legislators tour of The Pierce Arrow Lofts, a beautiful showcase for renewable energy, with a geothermal system that illustrates our potential for energy independence...”

NYS Assemblyman William Conrad
Thank You
Top Jobs: 240 Markland
Industry leading, vertically integrated, geo-exchange solutions provider with 20 years organizational expertise.

Delivered over 400 projects, accounting for over 50% of the systems delivered in Ontario.

Experience with large-scale residential, commercial and institutional new builds and retrofits.
Project Collaborators
The Project - 240 Markland

Owner: Carttera Management Inc
Location: 240 Markland Dr, Toronto
Project Delivery: Design-Build-Operate

**Retrofit Program:**
10 storey & 135K-sq.ft/12.5K-sq.m
1,305 kBH/382 kW_{th} & 105 RT/363 kW_{th}

**Planned Program:**
9 storey and 205K-sq.ft/18.7K-sq.m
3,525 kBH/1,033 kW_{th} & 245 RT/846 kW_{th}

**Themes:**
- Fully electrify heating w/ retrofit
- Community energy asset.
- Turnkey – DBO
Retrofit Program

- 12,382 sqm GFA
- Roof redone with 4” insulation
- Double pane windows
- MUA system replacement
- 3” exterior insulation
- WS heat pumps with ERV
Planned Building Program

- 18,660 sqm GFA
- TED1: 50kWh/m²
- AUXILIARY HEAT INJECTION/REJECTION
- WS HEAT PUMPS WITH ERV
Ground Heat Exchanger Selection

Retrofit Building

<table>
<thead>
<tr>
<th></th>
<th>Cooling</th>
<th>Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal Capacity [kW\textsubscript{th}]</td>
<td>363</td>
<td>382</td>
</tr>
<tr>
<td>Geothermal Energy Production [MWh\textsubscript{th}]</td>
<td>1,086</td>
<td>1,719</td>
</tr>
<tr>
<td>Ground-side Energy [kW\textsubscript{th}]</td>
<td>343,268</td>
<td>427,368</td>
</tr>
</tbody>
</table>

New Building

<table>
<thead>
<tr>
<th></th>
<th>Cooling</th>
<th>Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal Capacity [kW\textsubscript{th}]</td>
<td>846</td>
<td>1,033</td>
</tr>
<tr>
<td>Geothermal Energy Production [MWh\textsubscript{th}]</td>
<td>792</td>
<td>1,144</td>
</tr>
<tr>
<td>Ground-side Energy [kW\textsubscript{th}]</td>
<td>924,185</td>
<td>850,974</td>
</tr>
</tbody>
</table>

© 2023 Geosource Energy Inc. All Rights Reserved.
Ground Heat Exchanger Selection

Combined System

<table>
<thead>
<tr>
<th>Basis of Design Loads on the GHX</th>
<th>Cooling</th>
<th>Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal Capacity [kW_{th}]</td>
<td>1,209</td>
<td>1,415</td>
</tr>
<tr>
<td>Geothermal Energy Production [MWh_{th}]</td>
<td>1,086</td>
<td>1,719</td>
</tr>
<tr>
<td>Ground-side Energy [kW_{th}]</td>
<td>1,267,453</td>
<td>1,278,342</td>
</tr>
</tbody>
</table>

**Annual Ground Imbalance:**
Heating dominate - 14,644 kWh overcool of ground and a imbalance of -0.9%.

**Active Ground Balance:**
Dual purpose auxiliary systems installed for flexibility in the planned program.
Ground Heat Exchanger Solution

- Vertical Borefield design
  - 4.25" boreholes up to 850’
- Combined system size: 113 bh @ 850’
- 17.5' spacing preferred, 15' can be squeezed
- 113 boreholes at 17.5' spacing:
  - 3,215 sqm (13,280 sqft)
Project Goals & Constraints

- GHX size: 113 Boreholes
  - 2,400sqm- 3,200sqm

- Site Area: 12,700sqm

- CONSTRAINTS
  - Partially Occupied Retrofit serviced by May 2022
  - Uninterrupted Service
  - Mature trees

- Working area 1,250 sqm
  - Potential for vertical boreholes at 15’ spacing: 59
Our Solution
Angled Drilling Technology

CUSTOM GPS ALIGNMENT SYSTEM

25° Maximum Tilt Angle
Angled Drilling Implementation

- BOREHOLES UTILIZE PREVIOUSLY UNATTAINABLE GROUND VOLUME
- ANGLED HOLE PLACEMENT AT PERIMETER OF WORKING AREA
- MINIMUM SURFACE SPACING OF 0.75m
- 70% REQUIRED SURFACE AREA REDUCTION

© 2023 Geosource Energy Inc. All Rights Reserved.
Geothermal Mechanical Station

- NEW BUILD PLATE & FRAME HX
- RETROFIT PLATE & FRAME HX
- SUPPLY TO HX
- AIR/DIRT SEPARATOR
- RETURN FROM HX
- PARALLEL CIRCULATION PUMPS
  - Sensorless pump technology
  - Demand-based pumping
Control & Data Acquisition

Control Strategy:
- Feed Forward Demand-Based Pumping
- Merged GHX and Pump Performance Maps

Data Acquisition & Analytics:
- System Performance Logged on 5-min Intervals for 30+ years
- Data Analytics and Trends Available on Site and Remotely

Future Functionality:
- Dynamic Thermal Balance Management, via Thermal Imbalance Setpoint
- Future Machine Learning to Optimize System Performance Map
Project Delivery Model

**Asset Ownership:**
Carttera Owned Geothermal System, Capex Funded and Full Operational Savings Retained

**Asset Delivery:**
Geosource Design-Built System, with Partners Rathco ENG and Armstrong Fluid Technology

**Operational Support:**
Geosource Retained to Operate the Asset, on Carttera’s behalf.
Including Building Operator Training, Monitor System Status, and Provide Semi Annual Performance Reports with Recommendations