Thermal Energy Networks: An Overview and Project Examples
“In order to decarbonize the State’s building stock by mid-century, New York will have to quickly move beyond a building-by-building approach to a neighborhood-by-neighborhood approach, developing carbon neutral communities.”

– NYSERDA Strategic Outlook (2022-2025)

Success would mean:

> Develop and maintain new clean energy infrastructure
> Establishing a transition strategy for utilities to shift to being clean thermal energy providers as we downsize gas systems
> Leverage unique position of municipalities and utilities to scale business models in partnership with existing market players
> Create new clean, high-paying energy jobs in construction and maintenance of loop systems
> Provide lower operating cost to residents and businesses with less strain on the electric grid during peak times
What’s a district-style configuration?

**Individual-Building-style**

**District-style:** Neighboring buildings are linked via connector pipes to share thermal resources.
When to consider a district-style approach

> Group of buildings with a variety of heating and cooling loads
  - Mixed use developments
  - Healthcare facilities
  - College campuses
  - Residential complexes
  - Downtown core with office, commercial, residential buildings

> Proximity to a viable thermal resource
  - Land space for boreholes / ground coupling
  - Water pipes or sewer mains
  - Waste heat from industrial facility or datacenter
  - Surface water: rivers, lakes, ponds
NYSERDA support (PON 4614)

Purpose
> Funding support for project sites to determine feasibility of a district-style heat pump approach, perform a detailed design, and construct a system

Eligibility
> Project sites with 2 or more buildings and a combined conditioned space of at least 40,000 sqft or 10 or more buildings of any size
> System Benefits Charge (SBC) payers and non-SBC payers, including affordable housing, State/City agency buildings, and sites on Long Island
> Preference for supporting Disadvantaged Communities (DACs), Environmental Justice Communities (EJCs), Low-to-Moderate Income (LMI) customers
> Upcoming due dates to competitive solicitation:

<table>
<thead>
<tr>
<th>Round #</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposal Due Date</td>
<td>11/15/2022</td>
<td>2/8/2023</td>
<td>5/10/2023</td>
<td>8/9/2023</td>
<td>11/15/2023</td>
</tr>
</tbody>
</table>
PON 4614 funding categories

Category A
“Scoping Study”
Assess feasibility of numerous options
(small, medium, large; technology X, Y, Z)
The “What” Question
Output is a preferred option
Max award: $100K

Category B
“Detailed Design Study”
Drill-down on preferred option
(create blueprints, obtain bid prices)
The “How” Question
Output is a shovel-ready project
Max award: $500K

Category C
“Construction”
Max award: $4M
PON 4614 projects

- Round #1-5 projects
- 39 project sites
- Project factsheets / summaries on website
**CONSTRUCTION**
- Two nodes at non-abutting redevelopment zones: City of Troy
- Entire city: City of Oneonta
- Central core downtown: City of Syracuse
- A few adjacent blocks with low-rise buildings: City of Utica
- A handful of single family homes in conjunction with a nearby commercial building: Northland Community in Buffalo
- Rochester District Heating Cooperative
- Existing and new buildings at SUNY Oneonta owned by DASNY and SUNY
- Cluster of residential and commercial buildings in downtown Albany: Sheridan Hollow
- Office buildings in lower Manhattan using Hudson River for thermal resource: Brookfield Place
- Cluster of residential, office, and retail buildings in Ithaca
- Mix of buildings in Southeast Albany using Hudson River for thermal resource
- Cluster of single family homes in Ithaca

**FEASIBILITY**
- A few adjacent blocks with low-rise buildings and high-rise towers: Innovation Queens
- Redevelopment of industrial buildings at Oneonta Railyards
- Large cluster of residential buildings using surface water in Long Island City

**DESIGN**
- Camps lacking district thermal: The Children’s Village in Dobbs Ferry
- Campuses with existing district steam: Rockefeller Center
- Campuses with some existing district steam and some thermally-islanded buildings: Barnard College in Manhattan
- Campuses with existing district steam in midst of conversion to hot water: University of Rochester
- Campus lacking district thermal: Phelps Hospital in Sleepy Hollow
- Campuses looking at pilot (subset of buildings): Syracuse University, Wagner College in Staten Island
- Campus looking at numerous mini-districts (nodes): Pratt Institute in Brooklyn
- Campus looking to leverage MTA pumped water: Spring Creek Towers (formerly known as Starrett City) in Brooklyn
- Campus looking to leverage surface water body as thermal resource: Masonic Temple in New Rochelle
- campuses with existing steam: SUNY Oswego
- Campus with mix of existing systems including steam and WSHPs: Houghton College
- Campus in Niskayuna

**Multiple Owners**

** Existing **
- New mixed-use buildings: Greenpoint, Brooklyn development
- New affordable housing, mixed-used: LCOR Coney Island

**New Construction/Gut Rehab**
- New construction on campus with residential and office buildings: Watchtower Bible and Tract Society
- New mixed-use buildings in Harlem
- Gut rehab mixed-use buildings repurposing large industrial tanks for thermal storage in Syracuse

**FEASIBILITY**
- New construction mixed-use buildings looking to leverage surface water body as thermal resource: Pratt Landing in New Rochelle
- New construction mixed-use buildings looking to leverage hybrid (ground source, air source, wastewater) as thermal resource: Gowanus Green in Brooklyn, The Peninsula in The Bronx, Fleet Financial in Queens
- Gut rehab mixed-use buildings looking to leverage surface water body as thermal resource: Silo City in Buffalo
- New construction using Flushing Bay as thermal resource: Willets Point in Queens

**Single Owner**
- New mixed-use buildings: Greenpoint, Brooklyn development
- New affordable housing, mixed-used: LCOR Coney Island

**Construcion**
- New construction on campus with residential and office buildings: Watchtower Bible and Tract Society
- New mixed-use buildings in Harlem
- Gut rehab mixed-use buildings repurposing large industrial tanks for thermal storage in Syracuse

**FEASIBILITY**
- New construction mixed-use buildings looking to leverage surface water body as thermal resource: Pratt Landing in New Rochelle
- New construction mixed-use buildings looking to leverage hybrid (ground source, air source, wastewater) as thermal resource: Gowanus Green in Brooklyn, The Peninsula in The Bronx, Fleet Financial in Queens
- Gut rehab mixed-use buildings looking to leverage surface water body as thermal resource: Silo City in Buffalo
- New construction using Flushing Bay as thermal resource: Willets Point in Queens

**Design**
- New construction on campus with residential and office buildings: Watchtower Bible and Tract Society
- New mixed-use buildings in Harlem
- Gut rehab mixed-use buildings repurposing large industrial tanks for thermal storage in Syracuse

**Feasibility**
- New construction mixed-use buildings looking to leverage surface water body as thermal resource: Pratt Landing in New Rochelle
- New construction mixed-use buildings looking to leverage hybrid (ground source, air source, wastewater) as thermal resource: Gowanus Green in Brooklyn, The Peninsula in The Bronx, Fleet Financial in Queens
- Gut rehab mixed-use buildings looking to leverage surface water body as thermal resource: Silo City in Buffalo
- New construction using Flushing Bay as thermal resource: Willets Point in Queens
Next steps

- Share results of PON 4614 Scoping Studies
- Continue outreach to municipalities, campus-owners, and affordable housing
- Utility Thermal Energy Networks and Jobs Act signed on 7/5/22
  - Work with utilities to identify pilot opportunities, define ownership models

- Attending the NESEA BuildingEnergy NYC conference on 9/15?
  - **Session**: Breaking Ground on Geothermal and Thermal Energy Networks: A Pathway for Urban Areas
Thank You

Sue Dougherty
sue.dougherty@nyserda.ny.gov
518-862-1090 x3127
1515 SURF AVENUE
Near Coney Island waterfront
463 Unit Multi-Family Housing
139 Affordable Units
11,000 ft² Ground Floor Retail

Developer: LCOR
Architect: Studio V Architecture
MEP Engineer: MGE Engineering
Geothermal Design Builder: Ecosave

- Elimination of 12,000 MBH of fossil fuel boilers for heating and domestic hot water
- Eliminated 800 Ton cooling tower for water source heat pump system
- Elimination of gas fired pool heater
- 60% + Energy savings versus base ASHRAE 90.1 2016 design for multi-family housing
- All Electric New Construction Multi-family Facility

NYSERDA Award under Category C – Construction - $1,621,019

Raymond Johnson PE
Executive VP Engineering & Construction
Largest Geothermal Heat Pump Project in NYC – All Electric HVAC

- Extended range horizontal and vertical water source heat pumps
- CO$_2$ heat pump DHW heating system
- Dedicated heat pump DOAS system with heat recovery wheels
- Swimming pool serves as a heat sink providing free heat
- Construction commenced September 2021
- Anticipated project completion Spring 2024

Geothermal Closed Vertical Loop Drilling

- Cooling Dominant Multi-family Housing Complex
- Total 153 well borefield with 20 feet spacing
- 500 feet vertical borefield depth
- Construction below foundation of housing complex
ADVANTAGES OF COMMUNITY GEOTHERMAL HEAT PUMP LOOPS

- Geothermal Heat Pump Loops provide highest HVAC system efficiencies and lowest operations and maintenance cost.
- Premium HVAC technology for electrification and net zero emissions.
- Community GHP loops provide scale to reduce installation cost.
- Buildings with diverse heating and cooling load profile provide diversity to balance, optimize and downsize borefield sizing.
- Provides fuel diversity and reduces summer electric peak.
- DHW Heat pumps in multi-family buildings enables balancing and reducing borefield sizing in cooling dominant buildings.
- GHP district loop can free up prime real estate inside building and on roof.
- Quieter operation and more reliable system with highest efficiencies.
DESIGN & IMPLEMENTATION

CHALLENGES

Constrained footprint

• Borefield below buildings and garage
• Loops and manifolds between concrete foundation elements.
• Project Scheduling critical
• Surveying critical
  • Ensure drilling is done in correct locations
  • Maintain required separation from foundation elements
DESIGN & IMPLEMENTATION CHALLENGES

Winter Drilling
- Drilling and looping equipment freeze protection
- Freeze protection of installation

Inconsistent Geology
- Requires adaptation in drilling techniques and materials
- Drilling fluid and protective casing
- Drilling bits
PROJECT STATUS

Work Progress June to August 2022

• Fusing of 8-inch pipes
• Building construction progress above loops
• Pressurizing of geothermal loops
• Backfilling after installing loops
LESSONS LEARNED

• New construction easier to adopt than retrofit existing system
• Accurate load modelling of building and bore-field for geothermal loop
• Optimal facility have load diversity
• Facilities who consider life time operations & maintenance in lieu of first cost
• Facilities located in States where state legislation and local laws drive decarbonization efforts
• Facilities which have corporate ESG, carbon/ emission reduction goals and want clean energy solutions
• District loops with diverse building heating and cooling loads are ideal for optimizing loop sizing

THANK YOU

Raymond Johnson PE
Executive VP Engineering & Construction
rjohnson@ecosavinc.com
Endurant Energy Status of PON 4614 works

8 projects In progress

• 6 projects completed to Final Report status
• 2 remaining projects with analysis completed being drafted into final reports
• Projects included
  • Retrofit of existing buildings
  • Multi-family buildings
  • Affordable Housing
  • University campus conversion

Geo solutions explored have included:
• 500' boreholes
• Energy piles
• Sewage Heat transfer
• Heat exchange using pumped water from MTA
• Most combined with ASHP’s
METHODOLOGY & APPROACH TO PON 4614
Develop & Understand Project scope

Developing a district energy concept

- Quantify the following costs and benefits against business-as-usual
  - Capital cost
  - Utility cost
  - Maintenance cost
  - Carbon emissions
  - Regulatory requirements
  - Additional value streams

- Thermal technologies considered:
  - Ground source heat pump
  - Air source heat pump
  - Wastewater heat exchange
  - Surface water exchange

- Additional technologies considered:
  - Solar PV
  - Battery Energy Storage
  - EV Charging
ESTABLISHING THE BASELINE
Modelling approach

- Space by space model using IES VE 2019 energy modelling software
- Generating Energy Models for each block in the development
- 8760 model of heating, cooling, and domestic hot water (DHW) demand for each building
Modelling results

Connected Load (kbtu)

-15,000
-10,000
-5,000
0
5,000
10,000

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

DHW Heating Cooling
Zero-carbon geo-exchange systems provide base-load heating & cooling

Geo-exchange systems with ground source heat pumps (GSHPs) comprise:

- **Heat exchanger**: plastic piping through which heat transfer fluid circulates
- **Heat pump**: mechanical equipment to accept or reject heat to/from the transfer fluid
- **Distribution system**: Moves energy from the heat pump to/from the building by circulating warmed or cooled air or water

Solar PV providing electricity to heat pumps ensures 100% renewable system

Heat recovery from wastewater
Decentralized plant

Pros:
- 2-pipe condenser loop distribution:
  - Reduced investment cost for site trenching and lateral piping
  - Reduced investment cost at building level
- Flexibility at building level:
  - Utilize 2-pipe distribution to spaces
  - Supplemental assets can be localized (ASHP)

Cons:
- Less opportunity for “true” simultaneous load
- Larger investment in equipment:
  - Less opportunity for economies of scale
  - Redundancy/resiliency requirements localized
- Increased potential for maintenance (more compressors)
Central plant

**Pros:**
- Economies of scale on plant equipment
- More efficient dispatch of plant assets
- Reduced maintenance (fewer compressors to service)
- Greatest opportunity for simultaneous load

**Cons:**
- Requires greater existing space allocation or new building
- 4-pipe distribution:
  - Increased investment cost for site trenching and lateral piping
  - Increased investment cost at building level
- Increased opportunity for thermal losses in distribution
MECHANICAL EQUIPMENT CONCEPTS
Equipment dispatch strategy - energy pile solution

### Annual Load Served by Each Asset (Building A, B, & C)

<table>
<thead>
<tr>
<th></th>
<th>Simultaneous</th>
<th>Geothermal</th>
<th>ASHP</th>
<th>Electric Boiler</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal Demand</strong></td>
<td>CLG</td>
<td>HTG</td>
<td>CLG</td>
<td>HTG</td>
</tr>
<tr>
<td><strong>% Annual Load Served</strong></td>
<td>31%</td>
<td>21%</td>
<td>47%</td>
<td>42%</td>
</tr>
</tbody>
</table>

### Connected Load (kbtu)

- **Electric Boiler**
- **ASHP**
- **GSHP**

Legend:
- **DHW**
- **Heating**
- **Cooling**
KEY FINDINGS
Endurant Energy Status of PON 4614 works

Key findings reported when using ground sourced heat pump solutions

**Business as Usual (Gas fired Boilers & variable refrigerant flow(VRF) cooling)**
- Electrical usage increases moderately when displacing Gas in new build
- 31% CO2 Savings
- 44% OPEX Savings based on 30year lifecycle cost

**Business as Usual (All electric building)**
- Electrical usage dropped between 44 and 50% when using GSHP compared to all VRF(ASHP)
- 47-53% CO2 Savings
- 30 - 53% OPEX Savings based on 30year lifecycle cost

**Business as Usual (retrofit and steam)**
- Electrical usage increased substantially on renovation of existing buildings in one case by 1430%
- Up to 70% CO2 Savings
- 43% OPEX Savings based on 30year lifecycle cost
Endurant Energy Status of PON 4614 works

Key findings – Feedback from Developers

Despite studies demonstrating significant advantages of ground source heat pump solutions
• Clean heat Incentives play a key role in making solutions economically viable
• VRF solutions and package terminal heat pumps remain a preferred go to solution
• Early adopter concerns about a solution not used or installed before by Developers team
• Regulatory hurdles seem insurmountable in some cases
  • District loops crossing over highways and sidewalks
  • Heat from sewage
  • Lake/ river loop solutions
# Geothermal and VRF Comparison

<table>
<thead>
<tr>
<th>Metric</th>
<th>Geo</th>
<th>VRF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capital Cost</strong></td>
<td>🟢</td>
<td>🟡</td>
</tr>
<tr>
<td></td>
<td>Geothermal capital costs are higher, however additional incentive availability supports rapid project paybacks</td>
<td></td>
</tr>
<tr>
<td><strong>Futureproof</strong></td>
<td>🟢</td>
<td>🟠</td>
</tr>
<tr>
<td></td>
<td>Hydronic distribution is the most futureproof distribution system and high efficiencies hedge against future carbon and utility demand costs and possible phase down of VRF refrigerants over next decade</td>
<td></td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td>🟢</td>
<td>🟡</td>
</tr>
<tr>
<td></td>
<td>A hybrid geothermal system achieves a 45% reduction in energy consumption compared to VRF with domestic hot water (DHW) boiler</td>
<td></td>
</tr>
<tr>
<td><strong>Carbon Savings</strong></td>
<td>🟢</td>
<td>🟡</td>
</tr>
<tr>
<td></td>
<td>A hybrid geothermal system achieves a 45% reduction in carbon emissions compared to VRF with DHW boiler</td>
<td></td>
</tr>
<tr>
<td><strong>Toxicity</strong></td>
<td>🟢</td>
<td>🟥</td>
</tr>
<tr>
<td></td>
<td>VRF circulates toxic refrigerants through residential spaces, whereas hydronic systems circulate water through residential spaces</td>
<td></td>
</tr>
<tr>
<td><strong>Innovation</strong></td>
<td>🟢</td>
<td>🟡</td>
</tr>
<tr>
<td></td>
<td>Energy piles are an incredibly cost-effective innovation that yields a significant benefit to project operations and the community</td>
<td></td>
</tr>
<tr>
<td><strong>Operating Cost</strong></td>
<td>🟢</td>
<td>🟡</td>
</tr>
<tr>
<td></td>
<td>The efficiencies of a geothermal system support utility cost savings and maintenance savings</td>
<td></td>
</tr>
<tr>
<td><strong>Metering</strong></td>
<td>🟠</td>
<td>🟢</td>
</tr>
<tr>
<td></td>
<td>VRF systems have better packaged metering products, however hydronic systems can also be fitted to meter consumption</td>
<td></td>
</tr>
</tbody>
</table>

Note: The comparison assumes a geothermal system with hydronic distribution
Grid Demands as NYC Electrifies

Concern if we do not see greater uptake of geothermal solutions and sticking to the usual!

- VRF solutions and package terminal heat pumps remain a preferred go to solution
- Our study showed electrical usage dropped between 44 and 50% when using GSHP compared to all VRF(ASHP)

THANK YOU

Tony Amis, Senior Vice President of Business Development

tamis@endurant.com